Nelson Complex WWTF and Service Area

Long Term Capital Improvement Plan

Summary Report

May 18, 2020

JOHNSON COUNTY KANSAS
Wastewater

HDR WCS ENGINEERING "Optimization Specialists" ch2m

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Executive Summary

ES – 1 Introduction

The Nelson Complex service area consists of the Nelson Complex Wastewater Treatment Facility (WWTF) and two main tributary basins - Turkey Creek (SMTC) and Mission Main (MTM1). The service area, located in northeast Johnson County, is approximately bounded by 47th Street to the north, 95th Street to the south, Pflumm Road to the west, and State Line Road to the east. Metcalf Avenue roughly divides the two basins, Turkey Creek to the west and Mission Main to the east.

The WWTF was constructed in phases, beginning in the 1940's. A significant portion of its facilities are at or near the end of their useful service life. The treatment technology currently in place is not capable of meeting future water quality standards.

The collection system was also constructed with technologies that are now outdated. As a result, it experiences significant issues related to limitations in wet weather capacity. In addition, the system contains four satellite peak excess flow treatment facilities (PEFTFs) which discharge directly to adjacent waterways during significant wet weather events after primary treatment and disinfection.

In 2018, Johnson County Wastewater (JCW) commissioned HDR, in association with CH2M and WCS, to determine the optimum solution to these issues and develop a long term capital improvement plan for the Nelson Complex service area. This study aided JCW and KDHE in negotiating the current and future Nelson WWTF permits, including planning for the future elimination of the PEFTFs. The current Nelson WWTF permit, effective March 1, 2020 is included in Appendix A.

In addition to the Nelson Complex service area, JCW has many other system needs that also require large investments. It has been recognized that these investments need to be prioritized in order to achieve maximum benefit per dollar spent. They also need to be scheduled over time in a manner that is financially sustainable for JCW and its ratepayers. To meet these objectives, JCW initiated a system-wide integrated planning process. The Nelson Watershed Long Term Capital Improvement Plan summarized in this report defined the recommended plan for the service area. Determination of the priority and schedule for each piece of the plan was completed through the integrated planning process. The results of this process is presented in a separate document entitled "JCW Integrated Management Plan, Phase 1".

ES – 2 Approach

The evaluation was performed under two inter-related authorizations, one for the WWTF and one for the collection system.

The WWTF evaluation included the following:

- Determination of flows, loadings, and probable future effluent limits

- Process analysis and life cycle cost comparison to determine the preferred treatment process
- Evaluation of other ancillary needs such as staff and vehicle space requirements
- Siting of new facilities, construction logistics, and interim operational strategies to maintain plant operations during construction
- Evaluation of improvements to pump stations that contribute flow to the WWTF

The collection system evaluation included the following:

- Modeling of the collection system to define wet weather flows and identify hydraulic limitations
- Use of optimization technology to determine the optimum combination of system improvements among infiltration/inflow (I/I) reduction, relief sewers, system storage, and pumping capacity improvements to convey wet weather flows to treatment
- Evaluation of the costs and benefits of treatment at upgraded PEFTFs versus conveyance to centralized auxiliary treatment at the WWTF
- Determination of water quality impacts for the various improvement strategies

ES – 3 Findings

The key findings and recommendations of the evaluation were as follows:

Treatment:

- The existing WWTF should be upgraded to a state-of-the-art Biological Nutrient Removal (BNR) facility sized for an average daily flow of 15 MGD and a peak hydraulic capacity of 45 MGD
- The WWTF will also include an auxiliary treatment train to treat wet weather flows from the collection system above 45 MGD up to 122 MGD at full build-out
    - A proposed site plan for the upgraded facility is shown in Figure ES-1
- The projected capital cost of the WWTF upgrade in 2018 dollars is $353 Million. It is anticipated that construction will take place from 2024 through 2028. The cost of the facility projected to the midpoint of construction in 2026 is $447 Million.

Collection System:

- An overall optimized wet weather management strategy was determined for the collection system. This consisted of the following:
    - Flow reduction through I/I reduction and system storage
    - Elimination of the PEFTFs
    - Relief/replacement gravity sewers to convey flows to the main pump stations (Rock Creek, Belinder, and Turkey Creek)

    - Pump station and forcemain capacity improvements to convey the flow to auxiliary treatment at the WWTF
    - The collection system improvements plan is shown in Figure ES-2
- The projected capital cost for the collection system improvements in 2018 dollars is $228 Million.
- The collection system improvements need to be prioritized along with other JCW system-wide investments and scheduled over time in a manner that is financially sustainable for JCW and its ratepayers. To meet these objectives, JCW has initiated a system-wide integrated planning process. The scheduling of the Nelson improvements will be determined through this process and presented in a subsequent report entitled “JCW Integrated Management Plan.”

Figure ES-1: Nelson Complex WWTF Proposed Site Plan

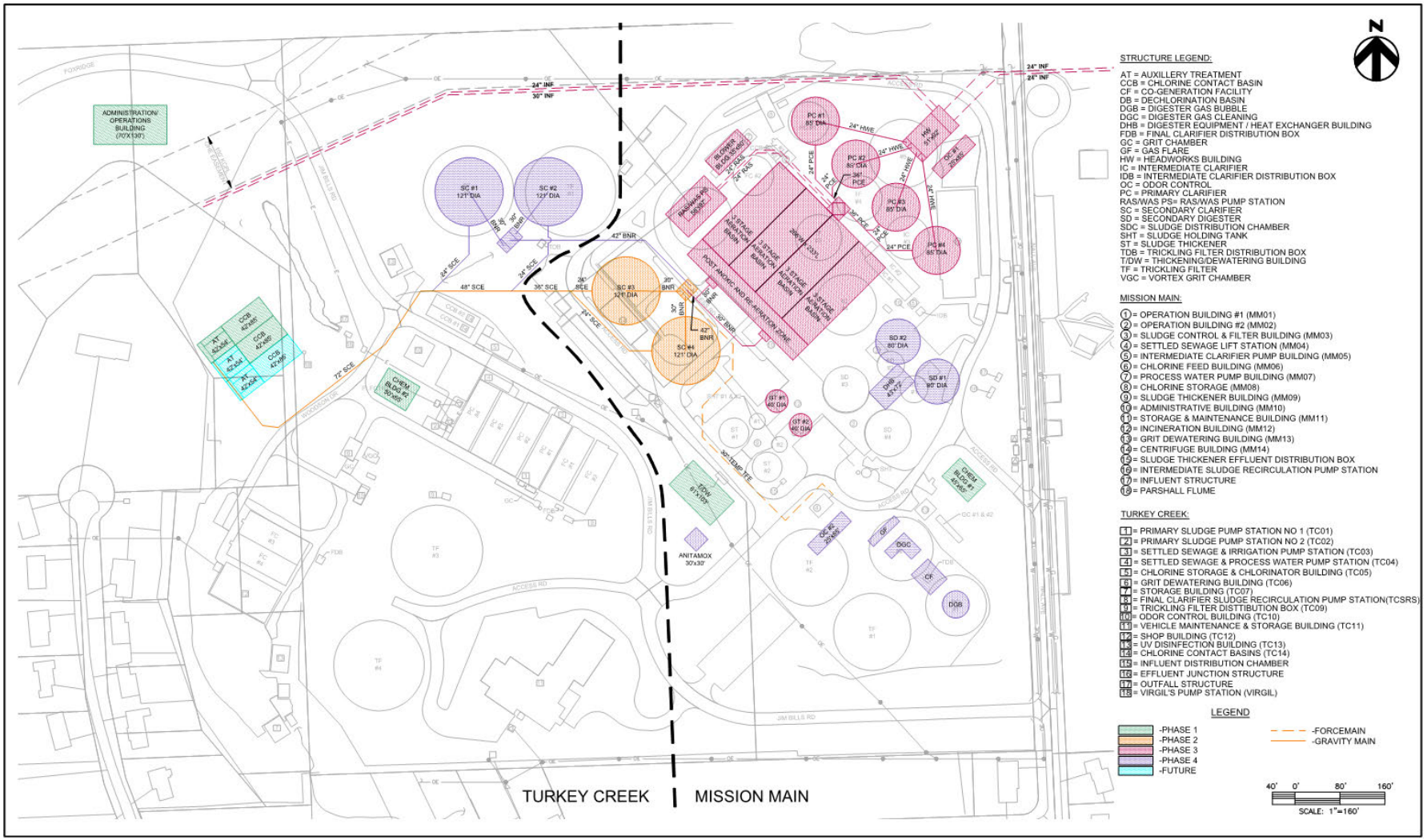
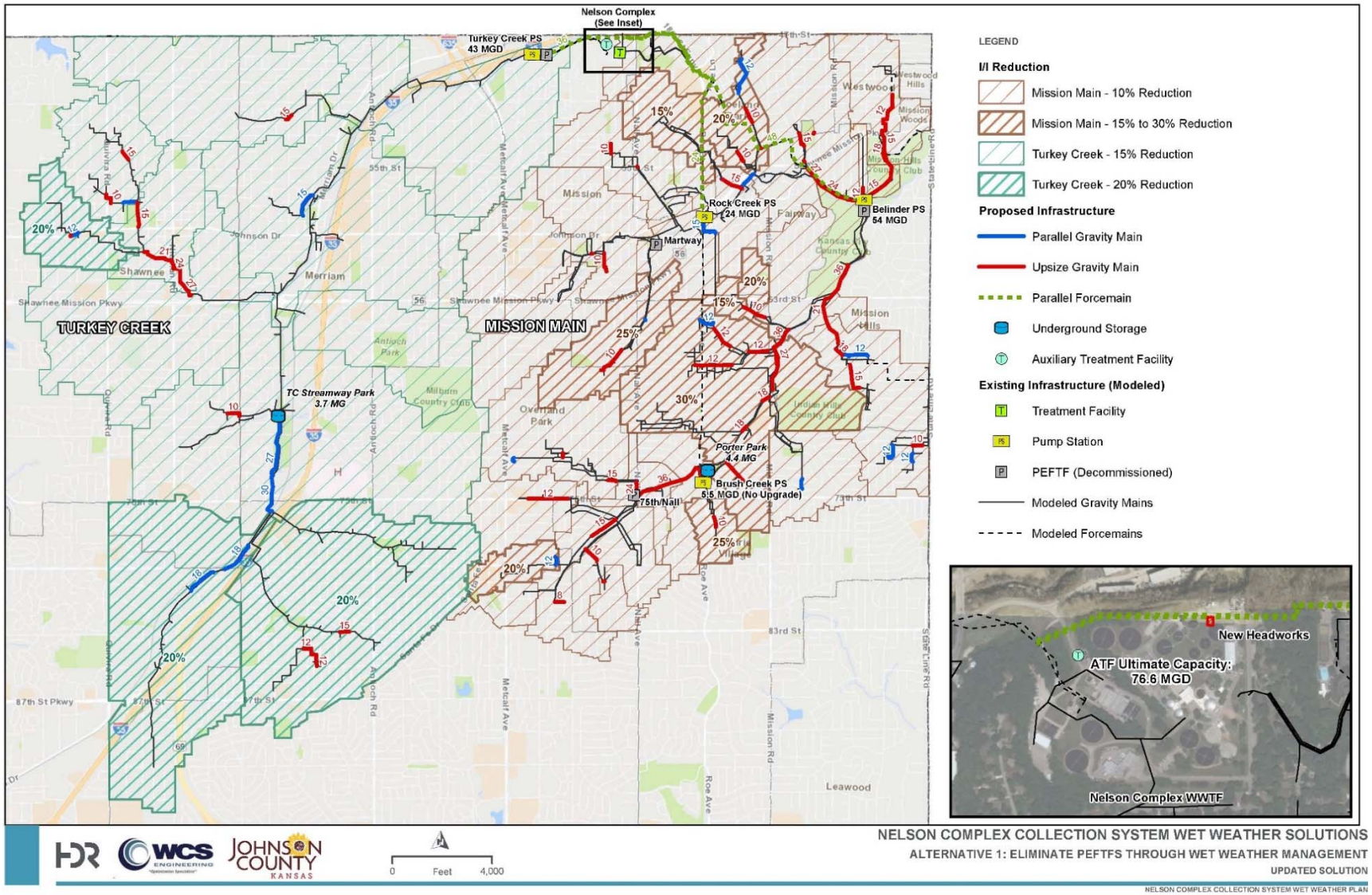


Figure ES-2: Nelson Complex Collection System Improvements Plan



1 Introduction

In 2018, Johnson County Wastewater (JCW) commissioned HDR to develop a long-term capital improvement plan for the Nelson Complex Wastewater Treatment Facility (WWTF) and its tributary service area. This objective was carried out under two separate, but inter-related, engineering services agreements. The first, M.K. Nelson Complex WWTF Improvements Facility Plan, was completed in association with CH2M, while the second, the Nelson Complex Collection System Wet Weather Plan Development and Optimization, was completed in association with WCS.

Each of these planning studies was performed through a series of Technical Memorandums (TMs). For the WWTF Study, the TMs focused on identifying the preferred treatment scheme, addressing site constraints and logistics associated with maintaining the operations during construction, and developing a project cost, schedule and implementation plan. For the Collection System Study, the TMs focused on determining the optimum combination of wet weather capacity enhancement improvements among “relief sewers”, infiltration and inflow (I/I) reduction, system storage, and enhanced remote treatment at Peak Excess Flow Treatment Facilities (PEFTFs) versus conveyance (pumping) to centralized treatment. A key issue to be addressed in the Collection Study was the long-term fate of the PEFTFs – eliminate them and convey wet weather flows to centralized treatment at the WWTF, or upgrade and retain them.

As mentioned, these two studies were inter-dependent in terms of the economics of treating wet weather flows - centralized at the WWTF versus remotely at upgraded PEFTFs. They are also interrelated from a regulatory and water quality perspective, in that each possible combination of improvements has its own unique impact on water quality.

The investments identified in these studies are large. In addition, JCW has many other system needs that also require large investments. It has been recognized that these investments need to be prioritized through an integrated planning process that takes into account all of JCW’s system needs. Therefore, the Nelson Watershed Long Term Capital Improvement Plan determined what needs to be done, however, determining the priority of each piece of the plan and when it is to be done was deferred to a separate initiative. The results of this initiative are presented in a separate document, i.e. the JCW Integrated Management Plan. The Integrated Management Plan prioritized all of JCW’s system needs based on fulfillment of their Mission Statement.

In the following sections of this Summary Report, each TM is discussed separately, with a summary of its purpose, key findings, and conclusions. The individual TMs are included as Appendices to this Summary Report.

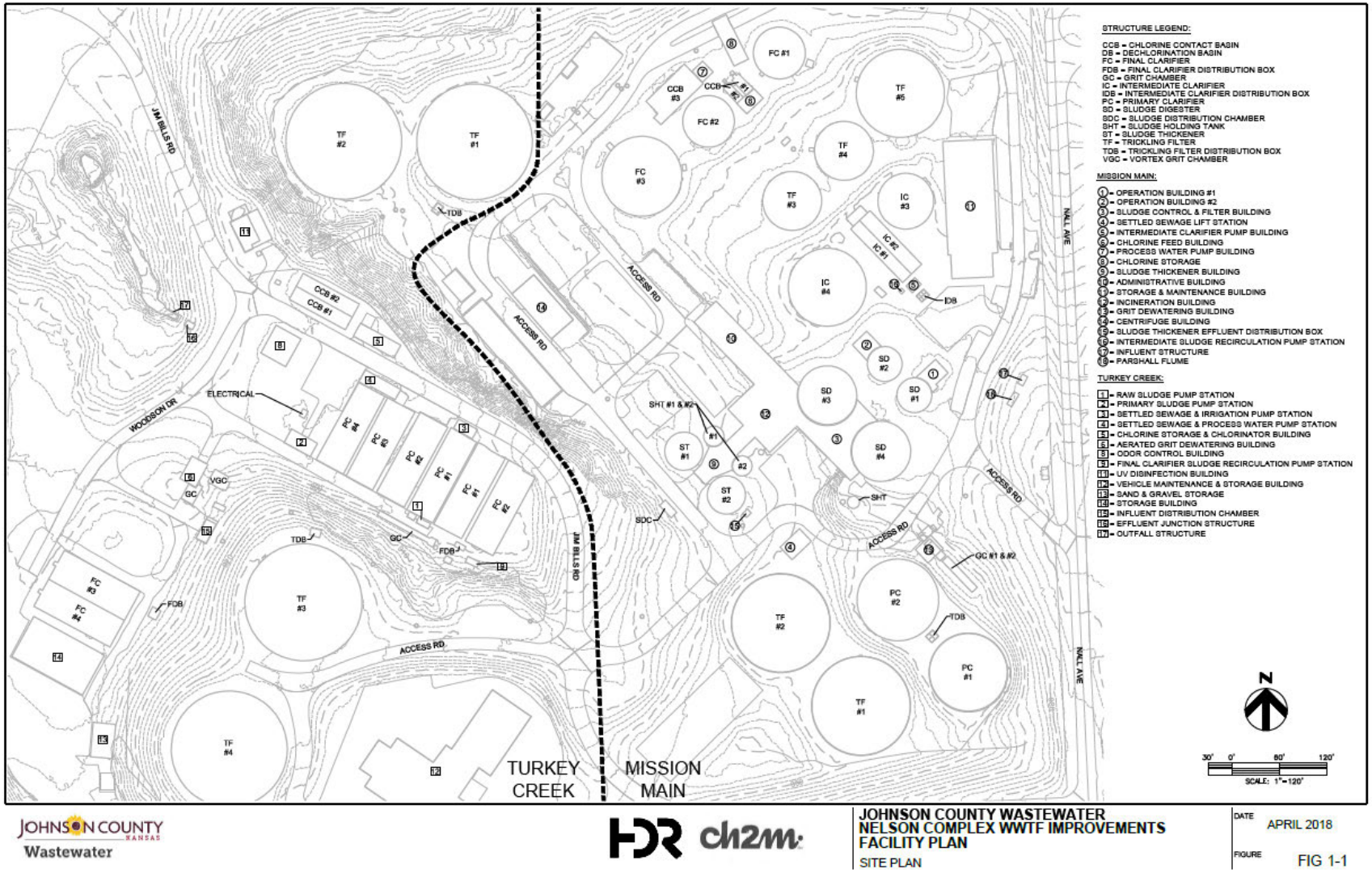
2 M.K. Nelson Complex WWTF Treatment Facility Plan

2.1 Task 1, TM 1 – Basis of Analysis (Appendix A1)

2.1.1 Background

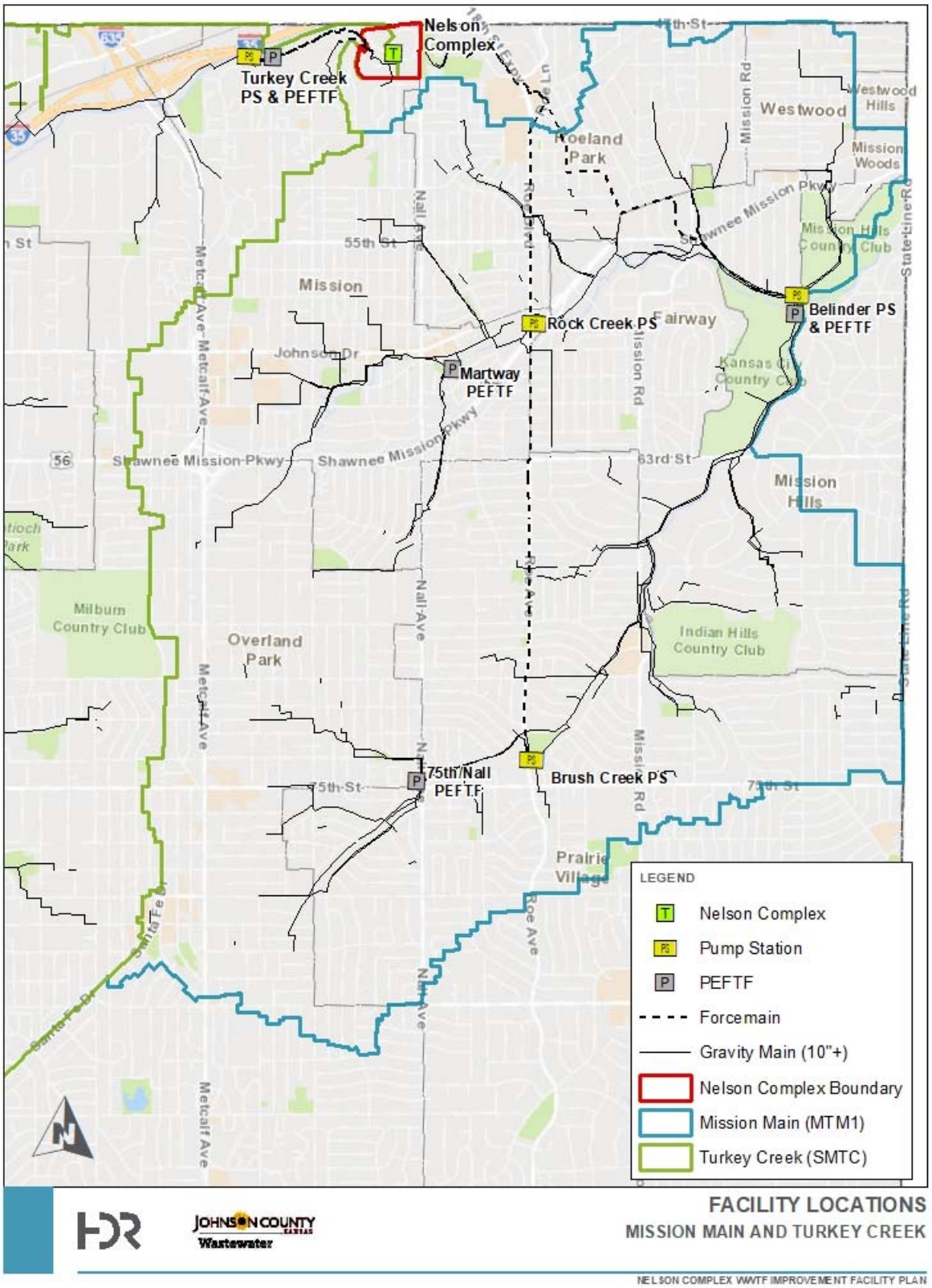
The Nelson Wastewater Treatment Facility (WWTF) Complex is comprised of two separate treatment trains, referred to as Mission Main (originally Mission Township Main Sewer District 1) and Turkey Creek (originally Shawnee Mission Turkey Creek). These were originally two separate WWTFs sharing a common site. They have since been consolidated into a single facility, the Nelson Complex (NC), with two distinct process trains that share common disinfection and solids processing facilities and a single permitted outfall. A site plan of the existing facility is shown in Figure 1.

Figure 1: Nelson Complex Site Plan



The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two WWTF trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations (PSs). The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or which discharge directly from the collection system to the creek after providing primary treatment and disinfection. Figure 2 shows the location of the major pump stations and PEFTFs within the watersheds.

Figure 2: Major Pump Station and PEFTF Facilities



The WWTF and the satellite PSs and PEFTFs face a number of significant challenges. Some of the facilities at the WWTF and at the satellite locations have been in service since the late 1940s. Many of the facilities are well beyond their useful life and the costs for repair and rehabilitation (R&R) to keep them operational are becoming problematic. More stringent discharge limits for ammonia and phosphorous are part of the current permit, plus there are new concentration-based goals for nitrogen and phosphorous. The existing trickling filter technology cannot meet these limits, and replacement with a state-of-the-art technology such as biological nutrient removal (BNR) will be required. Implementing a new treatment scheme at the existing WWTF will be challenging in that space is limited and new facilities will have to be constructed while the existing plant remains in operation.

The objectives of TM 1 – Basis of Analysis are as follows:

- Confirm the configuration, major equipment, capacities, and general condition of facilities at the WWTF, major PSs, and PEFTFs.
- Confirm design flows for the WWTF, major PSs, and PEFTFs.
- Establish influent loadings to the WWTF based on historical data and the limited influent sampling program.
- Develop a process model, input design flows and loads into the model, and obtain a mass balance for the liquid and solids processes.

TM 1 will ensure that all subsequent work in the facility planning effort will be based on a complete, accurate understanding of existing conditions.

2.1.2 Facility Descriptions

The WWTF and each major pump station and PEFTF were visited and observations noted. Existing record drawings, reports, and other information was compiled and reviewed. The following categories of information were summarized for each facility:

- Process and/or flow scheme
- Recent or ongoing upgrades
- Availability of utility service, including electric, gas, water, and communications.
- Equipment list with quantities and capacities
- Deficiencies

Reference is made to TM1 for detailed information on existing facilities.

2.1.3 Influent Flows and Loadings

Historical data was reviewed and from this was derived design flows and loadings for the WWTF. These are presented in Table 1. The peak hour flow information in this table reflects the capacities of the pump stations that serve the WWTF. Refer to the collection system study for further discussion of wet weather flows.

Table 1: Design Flows and Loads for the Nelson Complex

Parameter	Metric	Proposed Mission Main	2009 Mission Main	Proposed Turkey Creek	2009 Turkey Creek
Flow (mgd)	Annual Average	7	7	8	8
	Maximum Month	9	7	10	8
	Peak Hour	25	25	27	27
Load Peaking Factor	MM/AA (lbs)	1.3	1.2	1.3	1.2
BOD_5	Annual Average (mg/L)	150	190	150	190
	Annual Average (ppd)	8,757	11,092	10,008	12,677
	Maximum Month (mg/L)	152	228	156	228
	Maximum Month (ppd)	11,384	13,311	13,010	15,212
TSS	Annual Average (mg/L)	195	245	173	245
	Annual Average (ppd)	11,384	14,303	11,509	16,346
	Maximum Month (mg/L)	197	294	179	294
	Maximum Month (ppd)	14,799	17,164	14,962	19,616
VSS	Annual Average (mg/L)	170	211	153.75	211
	Annual Average (ppd)	9,925	12,318	10,258	14,078
	Maximum Month (mg/L)	172	253	160	253
	Maximum Month (ppd)	12,902	14,770	13,336	16,880
TKN	Annual Average (mg/L)	30	28	26	28
	Annual Average (ppd)	1,751	1,635	1,751	1,868
	Maximum Month (mg/L)	30	34	27	34
	Maximum Month (ppd)	2,277	1,985	2,277	2,268
NH_3 -N	Annual Average (mg/L)	16	17	18	17
	Annual Average (ppd)	934	992	1,201	1,134
	Maximum Month (mg/L)	16	20	19	20
	Maximum Month (ppd)	1,214	1,168	1,561	1,334
TP	Annual Average (mg/L)	3.4	5.0	2.9	5.0
	Annual Average (ppd)	198	292	195	334
	Maximum Month (mg/L)	3.4	6.0	3.0	6.0
	Maximum Month (ppd)	258	350	254	400

2.1.4 Process Model

A process model was created and calibrated for the existing WWTF. Additional limited influent sampling was performed to help support the modeling. This sample data was obtained under Task 10, and is presented and discussed in TM 1.

2.2 Task 2, TM 2 – Regulatory Evaluation (Appendix A2)

2.2.1 Purpose

The purpose of the TM 2 is to establish target discharge limits to facilitate planning for upgrades to the Nelson Complex WWTF. The TM also addresses potential future regulatory implications and issues concerning the implementation of auxiliary treatment and its impact on effluent quality.

2.2.2 Target Discharge Limits

The existing facility's permit limits were reviewed, as were applicable regulatory drivers including EPA's 2013 ammonia criteria, the Kansas Nutrient Reduction Plan, and the 2017 Lower Kansas River TMDL. Proposed discharge limits were developed and are shown in Table 2. These were reviewed with KDHE, and their concurrence obtained.

Table 2: Current Target Permit Limitation for Outfall 001 at the Nelson Complex WWTF

Parameters		Unit	Current Limits	Target Limits
Carbonaceous Biochemical Oxygen Demand (5-Day)				
	Weekly Average	mg/L	40	40
	Monthly Average	mg/L	25	25
Total Suspended Solids				
	Weekly Average	mg/L	45	45
	Monthly Average	mg/L	30	30
Dissolved Oxygen				
	Minimum Weekly Average	mg/L	6.0	6.0
Total Residual Chlorine (TRC)				
	Daily Maximum	mg/L	11*	11*
pH				
	Range	SU	6.0 – 9.0	6.0 – 9.0
Ammonia (as N)				
January	Daily Maximum	mg/L	--	11.5
	Monthly Average	mg/L	10.4	1.8
February	Daily Maximum	mg/L	--	13.0
	Monthly Average	mg/L	10.0	2.0
March	Daily Maximum	mg/L	--	12.5
	Monthly Average	mg/L	6.4	1.9
April	Daily Maximum	mg/L	--	9.1
	Monthly Average	mg/L	6.6	1.5
May	Daily Maximum	mg/L	--	7.5
	Monthly Average	mg/L	4.9	1.3
June	Daily Maximum	mg/L	--	5.7 (4.8)†
	Monthly Average	mg/L	3.9	1.0 (0.9)†
July	Daily Maximum	mg/L	--	4.5 (3.8)†
	Monthly Average	mg/L	3.1	0.9 (0.8)†
August	Daily Maximum	mg/L	--	4.5 (3.8)†
	Monthly Average	mg/L	3.3	0.9 (0.8)†
September	Daily Maximum	mg/L	--	5.5 (4.6)†
	Monthly Average	mg/L	4.0	1.0 (0.9)†
October	Daily Maximum	mg/L	--	6.3
	Monthly Average	mg/L	6.7	1.1
November	Daily Maximum	mg/L	--	8.4
	Monthly Average	mg/L	9.1	1.4
December	Daily Maximum	mg/L	--	10.4
	Monthly Average	mg/L	11.3	1.7
Total Phosphorus - TMDL-Based Limit				
	Annual Rolling Average	lbs/day	--	125.31
Nitrate				
	Annual Rolling Average	mg/L	--	10
Nutrient Removal Goals				
	Total Phosphorus – Annual Average Goal	mg/L	--	1.0
	Total Nitrogen – Annual Average Goal	mg/L	--	10
Fecal coliform,‡				
	Monthly Geometric Average	cfu/100 mL	200	--
E. coli				
Summer (Apr – Oct)	Monthly Geometric Average	cfu/100 mL	--	262
	Weekly Geometric Average	cfu/100 mL	--	4,348
Winter (Nov – Mar)	Monthly Geometric Average	cfu/100 mL	--	2,358
	Weekly Geometric Average	cfu/100 mL	--	--

*The current acceptable quantification level for TRC in wastewater is 100 ug/L. Test results in excess of the quantification level would be considered a violation of the permit limit. TRC limits only apply if disinfection is by chlorination.

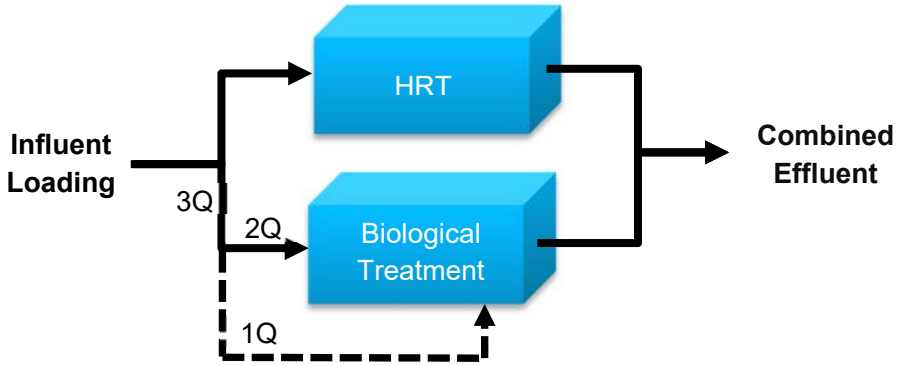
†Ammonia limits in parentheses based on a pH of 7.8. All other ammonia limits based on an assumed pH of 7.7.

‡Fecal coliform criteria are no longer applicable in Kansas and have been replaced with *E. coli* criteria.

2.2.3 Auxiliary Treatment

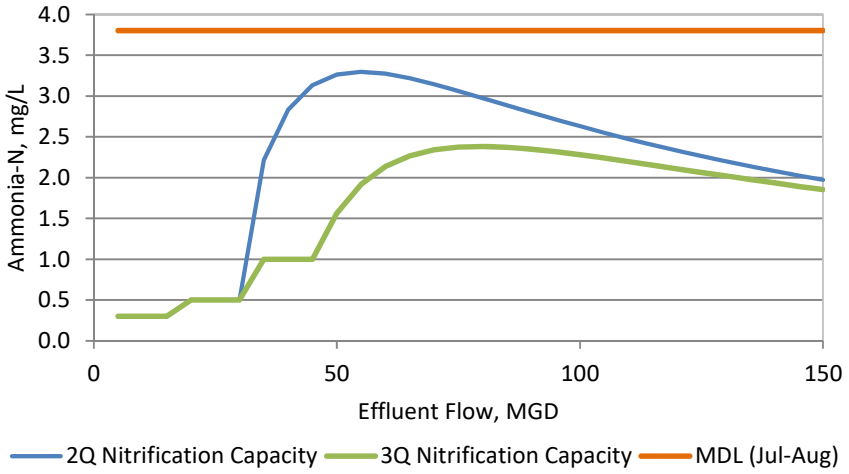
An evaluation was performed to determine the feasibility of implementing high rate treatment (HRT) for wet weather flows at Nelson. In a typical HRT scheme, wet weather flows exceeding 3Q are diverted around the biological treatment train as demonstrated in Figure 3.

Figure 3: Conceptual Diagram of Wet Weather Management Strategy using High Rate Treatment



The limiting factor is typically the effluent ammonia value, since HRT technologies typically do not remove ammonia. An algorithm was prepared to evaluate this based on Nelson influent data. The result is presented in Figure 4.

Figure 4: Estimated Ammonia Effluent Quality under a Range of Flows at the Nelson Complex Assuming the Use of High Rate Treatment



A comparison of this figure with the daily maximum ammonia values in Table 2 demonstrates that HRT is feasible at the Nelson Complex.

2.3 Task 3, TM 3 – Alternative Screening (Appendix A3)

2.3.1 Purpose

The purpose of TM 3 was to identify a range of potentially feasible dry and wet weather treatment alternatives and to screen these alternatives to generate a short list for further detailed evaluation. The screening was performed based on non-economic criteria.

2.3.2 Initial List of Alternatives

The initial list of dry weather alternatives included:

- Alternative 1: Suspended Growth BNR with Enhanced Biological Phosphorus Removal (EBPR)
- Alternative 2: Integrated Fixed-Film Activated Sludge (IFAS) with EBPR
- Alternative 3: 2-Stage Suspended Growth BNR with Chemical Phosphorus Removal (Chem-P)

The initial list of wet weather alternatives included:

- Alternative 1: Disc Filtration
- Alternative 2: Step-Feed and Traditional Blending
- Alternative 3: Chemically Enhanced Primary Treatment (CEPT)
- Alternative 4: Ballasted Flocculation
- Alternative 5: CEPT and Step-Feed BNR

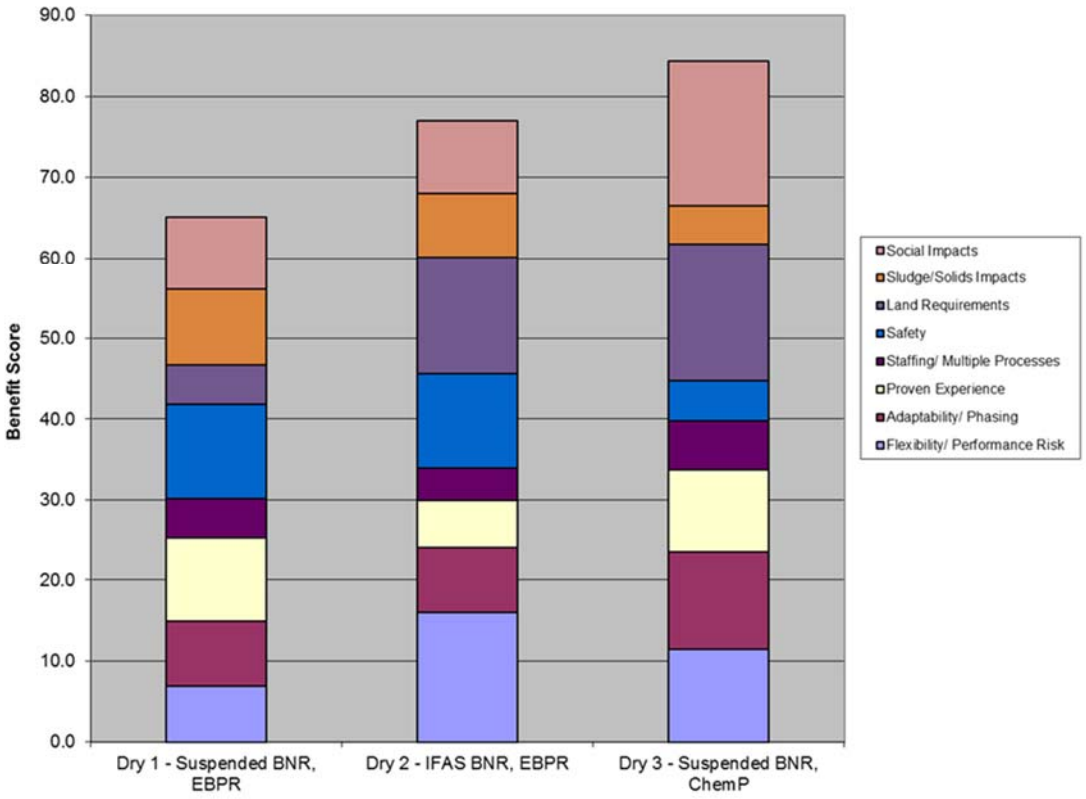
For each alternative, the following was generated:

- Schematic of the treatment process
- Discussion of the alternative with respect to the qualitative criteria
- Discussion surrounding modifications of the alternative to meet potential future Limits of Technology (LOT) criteria.

2.3.3 Alternative Ranking

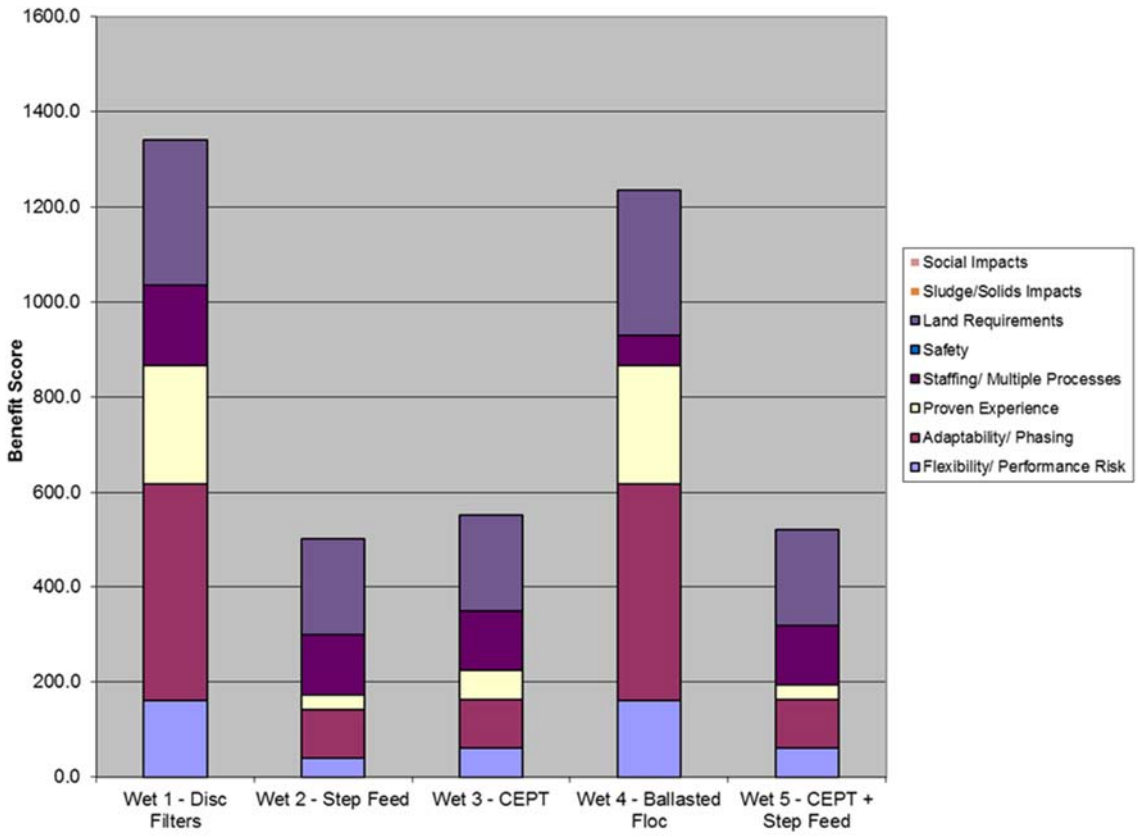
The non-economic ranking criteria was weighted based on relative importance to JCW, and each alternative was scored based on the weighted criteria. The resulting benefit scores are presented in Figure 5 and Figure 6.

Figure 5: Dry Weather Alternatives Total Weighted Benefit Scores



It was decided to carry all three dry weather alternatives forward for detailed analysis.

Figure 6: Wet Weather Alternatives Total Weighted Benefit Scores



The list of five wet weather alternatives was screened to three for further analysis:

- Alternative 1 – Disc Filtration
- Alternative 3 – CEPT
- Alternative 4 – Ballasted Flocculation

2.4 Task 4, TM 4 – Alternative Evaluation (Appendix A4)

2.4.1 Purpose

The purpose of TM 4 was to provide a detailed process and economic evaluation of the dry and wet weather alternatives and to ultimately select the preferred treatment scheme based on a comparative triple-bottom line analysis.

2.4.2 Dry Weather Alternatives

Each retained alternative was further developed to include Preliminary Treatment - fine screening and grit removal, Primary Treatment – primary clarifiers, Disinfection – sodium hypochlorite followed by sodium bisulfite for de-chlorination, Solids Processing – thickening, digestion, dewatering, and Sidestream Treatment – deammonification.

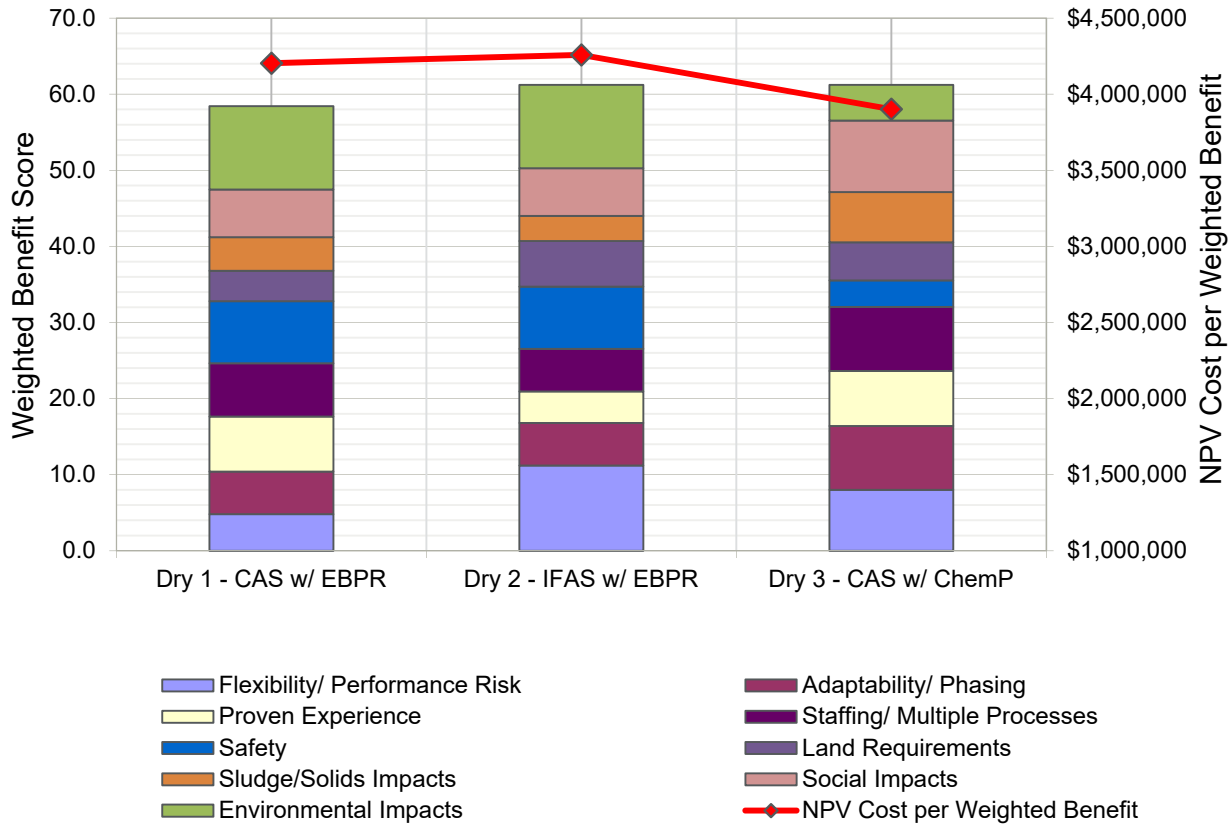
Process modeling was then performed to determine unit process sizes. The results were then subject to lifecycle cost evaluation. The results are presented in Table 3.

Table 3: Dry Weather Alternatives Life-Cycle Cost Comparison

Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
Total Capital Cost	$150,240,000	$158,290,000	$142,060,000
Year 1 O&M	$5,606,000	$6,020,000	$5,692,000
20-year NPV O&M	$89,769,000	$96,428,000	$91,164,000
Total 20-year NPV	**$245,620,000**	**$260,740,000**	**$238,920,000**

The cost per Weighted Benefit score is presented in Figure 7.

Figure 7: Dry Weather Alternatives NPV Cost per Weighted Benefit



Alternative Dry 1 – CAS with EBPR was selected as the preferred "reference" alternative due to its commonality with processes at other JCW facilities, and because it has the largest footprint and would thus provide for the worst case from a siting evaluation standpoint.

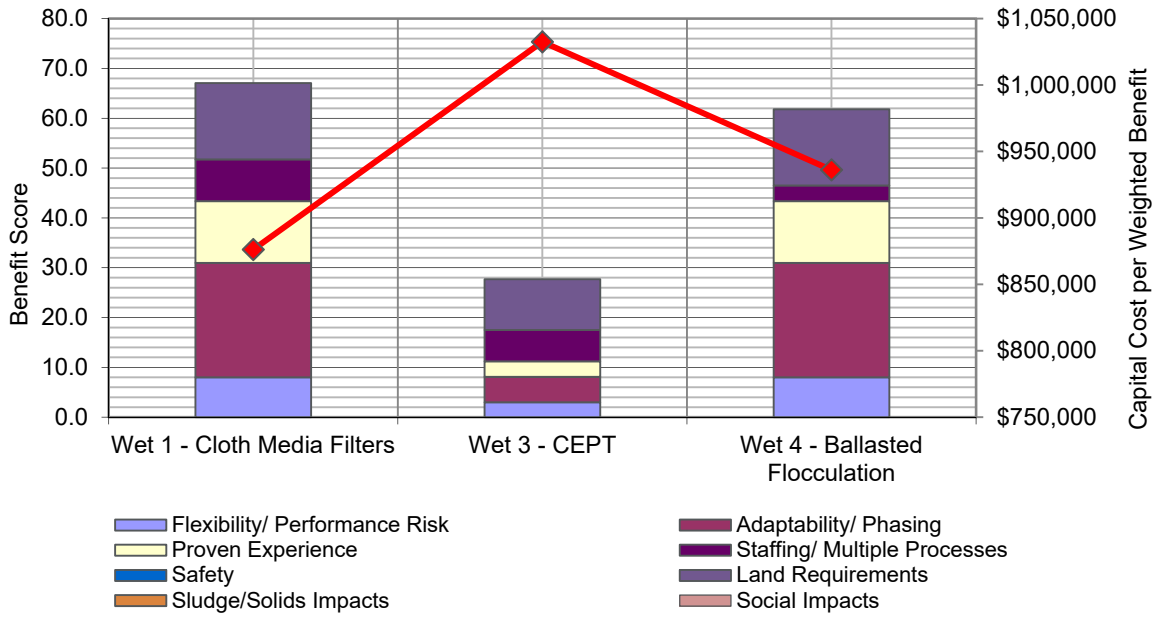
2.4.3 Wet Weather Alternatives

The wet weather alternatives were further developed to include disinfection with sodium hypochlorite followed by sodium bisulfite. Modeling was then performed to determine unit process sizes. At this stage of the overall study effort, preliminary findings from the collection system study indicated that peak wet weather flow from the collection system could be on the order of 140 mgd. Therefore, the wet weather sizing was based on 140 - 45 (3Q) = 95 mgd. The alternatives were subject to a cost analysis. Operations and Maintenance (O&M) costs were not included in the comparative analysis due to the infrequent use of the wet weather facilities. The results of the analysis are presented in Table 4 and the Cost per Weighted Benefit score is presented in Figure 8.

Table 4: Wet Weather Alternatives Opinions of Capital Cost

Component	Wet 1 – Cloth Disk	Wet 3 - CEPT	Wet 4 – Ballasted Floc
Wet Weather Treatment	$29,740,000	$12,510,000	$29,230,000
Wet Weather Disinf (CCB)	$3,830,000	$3,830,000	$3,830,000
Subtotal Construction Cost	$33,570,000	$16,340,000	$33,060,000
Contingency	$13,430,000	$6,540,000	$13,220,000
Non-Construction Costs	$11,750,000	$5,720,000	$11,570,000
Total Capital Cost	**$58,750,000**	**$28,600,000**	**$57,860,000**

Figure 8: Wet Weather Alternatives Cost Weighted Benefit Score



Alternative 1 – Disc Filtration was elected as the preferred wet weather alternative.

2.4.4 Preliminary Site Considerations

Due to limited space on site for new facilities, it was recognized that a phased construction approach would be required. The most likely approach would be to demolish the Mission Main intermediate clarifiers, second stage tricking filters, and final clarifiers to make room for the new facilities. In the interim, to partially compensate for this lack of treatment capability, CEPT would be implemented to improve the performance of the Turkey Creek and first stage Mission Main facilities. Phasing and interim operation are discussed in greater detail in TM 5.

It was decided that the initial construction would include 15 mgd dry weather train capable of handling up to 45 mgd (3Q) peak, with 7 mgd of auxiliary treatment to bring the total capacity to 52 mgd, which corresponds to the peak flow that can currently be conveyed to the facility from its tributary pump stations.

2.5 Task 5 – Collection System Facility Evaluation and Optimization Support

Task 5 entailed development of cost information in support of the collection system optimization. Specifically, costs were developed for the pump stations, PEFTFs and auxiliary treatment. In alternatives where PEFTFs would be retained as part of the long-term plan, it

was assumed that significant upgrades in treatment technology would be required. The PEFTF preliminary designs and costs were based on coarse screening, disk filters, chlorination and dechlorination. The same process scheme was also used for preliminary design and costing of auxiliary treatment.

Cost information was developed in three phases in support of the collection system optimization:

- Initially, general cost curves were developed for each type of facility over a range of sizes. This allowed the optimization process to consider a wide range of different combinations and sizes of facilities to help narrow the focus of the optimization.
- Next, more detailed, site specific cost curves were developed, which allowed the optimization process to further narrow the field to the top two alternatives.
- Finally, sizing calculations, layouts, quantities, and costs were developed to support evaluation of the top two alternatives.

The results of this effort are presented in the Collection System TMs. The outcome is also discussed to a limited extent in TM 5 of this WWTF Study.

2.6 Task 6, TM 5 – Project Development

2.6.1 Purpose

The purpose of TM 5 is twofold.

First, the treatment scheme identified in TM 4 was developed into a fully defined capital improvement project, taking into considerations site specific challenges and logistics. This included the pump stations that pump to the WWTF.

Second, as previously discussed, TM 5 documents the outcome of the sizing and cost estimating for the PEFTFs and major pump stations, performed in support of the collection system optimization.

2.6.2 WWTF Dry Weather Train Development

Three alternative site layouts were developed and evaluated with respect to operational considerations, phasing and scheduling considerations, interim operations, and comparative costs. The selected alternative, to be constructed in four phases represented by color coding, is shown in Figure 9.

A construction schedule for this alternative is shown in Table 5.

Figure 9: Optimized Site Layout Alternative

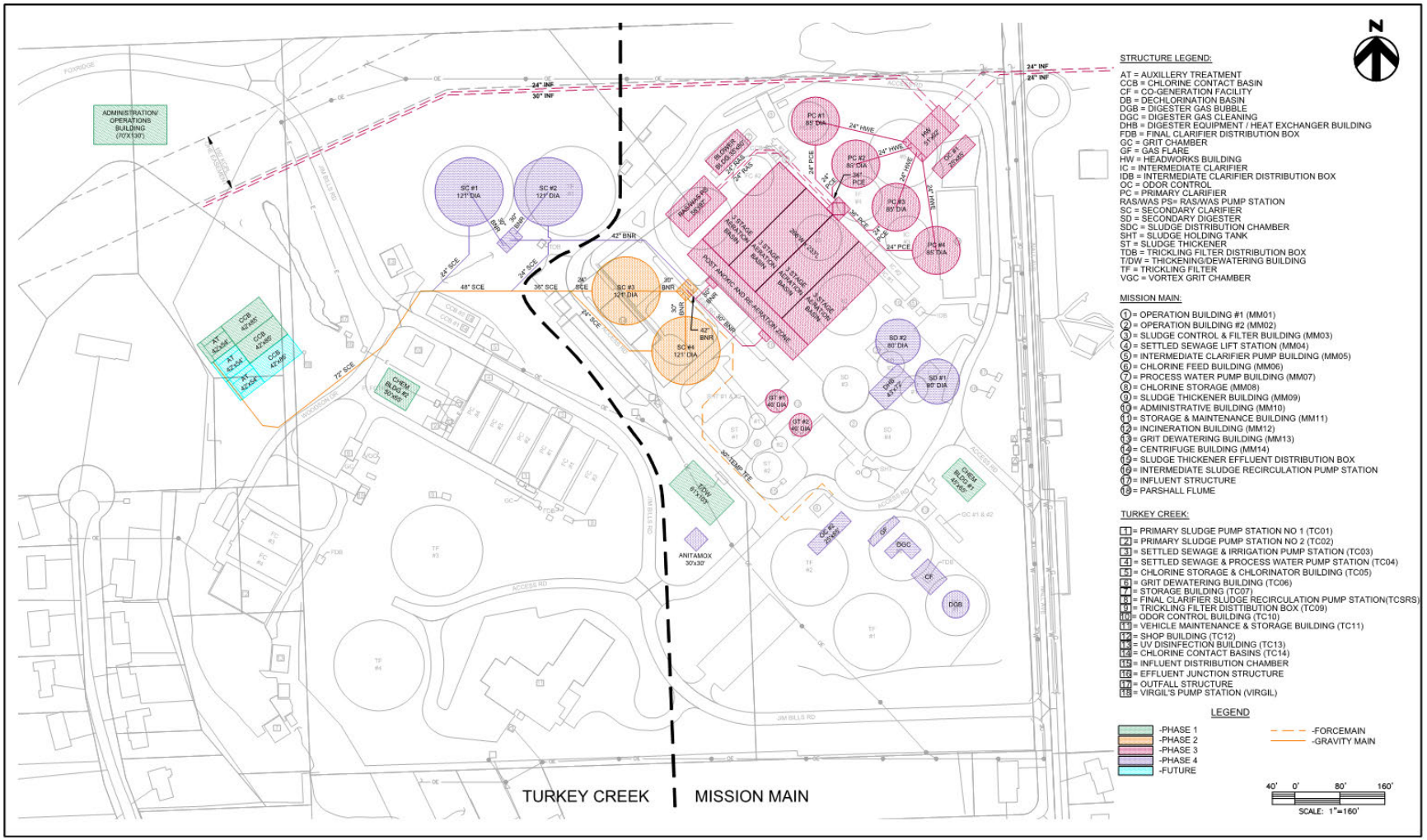


Table 5: Optimized Site Layout – Conceptual Schedule

Site Layout Alternative #4 - "Optimized" Combined Liquid Train

Item	Months	2024												2025												2026												2027												2028												2029											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1. Demo Admin/Incinerator Building and SD's #1 and #2	8	1	2	3	4	5	6	7	8																																																																	
2. Construct AT and CCB	8	1	2	3	4	5	6	7	8																																																															
3. Construct Thickening / Dewatering Building (assumes SD's demo'd 1st)	10				1	2	3	4	5	6	7	8	9	10																																																										
4. Demo Dewatering Building	3														1	2	3																																																						
5. Construct SC's #1 and #2, Modify SSLS #4	9																	1	2	3	4	5	6	7	8	9																																													
6. Institute CEPT (excludes construction)	27																										1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27																							
7. Demo upper MM site	6																										1	2	3	4	5	6																																												
8. Construct HW, PC's, BNR Train, RAS PS	24																													1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24																							
9. Tie-in TC, BE and RC FM's to new HW	18																																			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																							
10. Demo TC and remaining MM facilities	12																																																						1	2	3	4	5	6	7	8	9	10	11	12											
11. Construct SC's #3 - #4 (assumes MM PC's, TF's and TC TF's #1-#2 demo'd 1st	9																																																								1	2	3	4	5	6	7	8	9											
12. Construct additional solids facilities (assumes MM PC's, TF's and TC TF's #	9																																																								1	2	3	4	5	6	7	8	9											

Key: AT = Auxiliary Treatment, BE = Belinder, CCB = Chlorine Contact Basin, CEPT = Chemically Enhanced Primary Treatment, SC = Secondary Clarifier, RAS PS = Return Activated Sludge Pump Station, HW = Headworks, IPS = Intermediate Pump Station, MM = Mission Main, PC = Primary Clarifier, RC = Rock Creek, SSLS = Settled Sewage Lift Station, TC = Turkey Creek, TF = Trickling Filter, WW = Wet Weather

2.6.3 Balance of Process Facilities

This section focused on odor control, refining the BNR basin design, auxiliary treatment and disinfection, and solids processing.

A three-phased approach was identified for auxiliary treatment and disinfection so that the system could be expanded in modules as PEFTFs are abandoned and the wet weather flow conveyed to the WWTF.

The selected biosolids processing scheme consists of primary sludge and WAS thickening, anaerobic digestion, dewatering followed by land application, with deammonification side stream treatment for the centrate.

2.6.4 WWTF Support Facilities

This section focused on facilities to house administrative, and operation and maintenance (O&M) staff, and their respective equipment and support systems. The following facility needs were determined:

- Existing Infrastructure Engineering and O&M Management – a stand-alone building located near the Foxridge Drive entrance was envisioned, approximately 9000 square feet (SF), that would house all engineering staff, including New Development, as well as O&M Management. It would include office space for up to 32 staff members, room for expansion, conference rooms, and a large training room.
- Plant O&M – the existing Line Maintenance Building, approximately 17,000 SF, would be repurposed and refurbished to house plant O&M staff and their vehicles.
- Line Maintenance and Repair – approximately 30,000 SF will be provided to accommodate staff, training/break/conference rooms, and vehicle/equipment parking.

2.6.5 Whole Facility Cost Estimate

The opinion of probable cost for the facility, in both 2018 dollars and projected to the 2026 mid-point of construction, is shown in Table 6.

Table 6: Nelson Complex WWTF and Dry Weather Pumping Cost Estimates, 2018 Dollars

	Estimated Cost
Treatment Facility	$ 328,165,000
Dry Weather Pump Stations / FM Extensions	
• Turkey Creek	$ 5,026,000
• Belinder	$ 3,569,000
• Rock Creek	$ 15,444,000 (1)
• Lamar	$ 730,000
Sub-Total	**$ 24,769,000**
Total	**$ 352,934,000 (2018)**
Total	**$ 447 million (2026** mid-point)
(1) Includes $4 million in provisions for future wet weather conveyance.	

2.6.6 Wet Weather Collection System Facilities – Pump Stations and PEFTFs

The collection system study optimization process resulted in two primary alternatives, one in which the PEFTFs were eliminated and the wet weather flow pumped to the WWTF for auxiliary treatment, and one in which the PEFTFs were retained and upgraded. Each alternative also included I/I reduction, relief sewers, forcemains, and system storage. However, this TM 5 only focused on PEFTFs and pump stations, and the resulting findings were incorporated into the comparative analysis presented in the collection system study. For each facility, sizing calculations, layouts, and cost estimates were prepared. A summary of the sizing and costs follows:

Alternative 1 Eliminate PEFTFs Through Wet Weather Management – Wet Weather Pump Station Upgrades

- Turkey Creek PS – upgrade from 27 mgd to 45 mgd at cost of $8.0 Million
- Rock Creek PS – upgrade from 12 mgd to 24 mgd at cost of $16.98 Million (includes replacement of dry weather PS noted in Table 6, and future improvements for wet weather PS not included in initial project)
- Belinder PS – upgrade from 10.6 mgd to 54 mgd at cost of $25.7 Million

Alternative 2 Retain PEFTFs with Enhanced High Rate Treatment

- Turkey Creek – 15.2 mgd at cost of $17.0 Million
- Martway – 12 mgd at cost of $15.0 Million
- 75th & Nall – 15 mgd at cost of $17.6 Million
- Belinder – 42 mgd at cost of $37.4 Million

The recommended solution from the collection system study was to eliminate the PEFTFs.

2.6.7 Asset Renewal Needs

The WWTF and pump station improvements will not be completed and operational until 2029. Also, the PEFTFs may remain in service for several years until they can be decommissioned. The age of these facilities is such that some near term asset renewal is required to keep them operational until they can be replaced or eliminated. Approximately $42 Million in near term asset renewal needs have been identified, of which approximately $10 Million would be at the WWTF and the remainder at the pump stations and PEFTFs. See TM 5 for details.

3 Collection System Wet Weather Plan Development and Optimization

3.1 TM 1 – Basis of Analysis

3.1.1 Purpose

The purpose of TM 1 was to document the basis of analysis that would be used to guide the subsequent work on the Collection System Wet Weather Plan, including collection system hydraulic modeling, water quality modeling, and the optimization process. The objectives of TM 1 – Basis of Analysis were to:

- Describe the existing service area and confirm attributes of major facilities
- Define the inputs and assumptions used in the preliminary alternatives analysis and optimization (e.g. design storm, acceptable level of surcharge, etc.)
- Establish the collection system study approach for preliminary optimization.

3.1.2 Description of Existing Service Area

The Nelson Complex service area consists of two main tributary watersheds - Turkey Creek (SMTC) and Mission Main (MTM1). The service area is approximately bounded by 47th Street to the north, 95th Street to the south, Pflumm Road to the west, and State Line Road to the east. Metcalf Avenue roughly divides the two watersheds, Turkey Creek to the west and Mission Main to the east.

The Turkey Creek basin contains approximately 245 miles of active gravity mains, ranging from 8” to 48”, and 2 miles of active forcemains. The sewers within this watershed generally flow from southwest to northeast to one (1) major interceptor, the Turkey Creek Interceptor. This interceptor flows to the Turkey Creek Pump Station and PEFTF, where flow can either be pumped to the Nelson Complex for treatment or be diverted to the PEFTF.

The Turkey Creek basin contains one (1) major pump station, Turkey Creek PS, and three (3) smaller pump stations, County Line, Lamar and Virgil’s. Nearly the entire watershed flows to the Turkey Creek Pump Station and PEFTF. Major facilities within the Turkey Creek Watershed are presented in Figure 10.

The Mission Main basin contains approximately 242 miles of active gravity mains, ranging from 8” to 48”, and 9 miles of active forcemains. The sewers within this watershed generally flow from southwest to northeast to two (2) major interceptors, Rock Creek and Brush Creek. Both interceptors contain sections of parallel sewer.

There are several inter-connected facilities within the Mission Main basin. The key facilities include three (3) pump stations (Rock Creek, Brush Creek, and Belinder) and three (3) PEFTFs (Martway, 75th Street/Nall, and Belinder). The basin also includes four (4) smaller pump stations – Granthurst, Mission Woods, Swatzell View, and Roe Village. Major facilities within the Mission Main basin are presented in Figure 11.

Figure 10: Turkey Creek Basin and Major Facilities

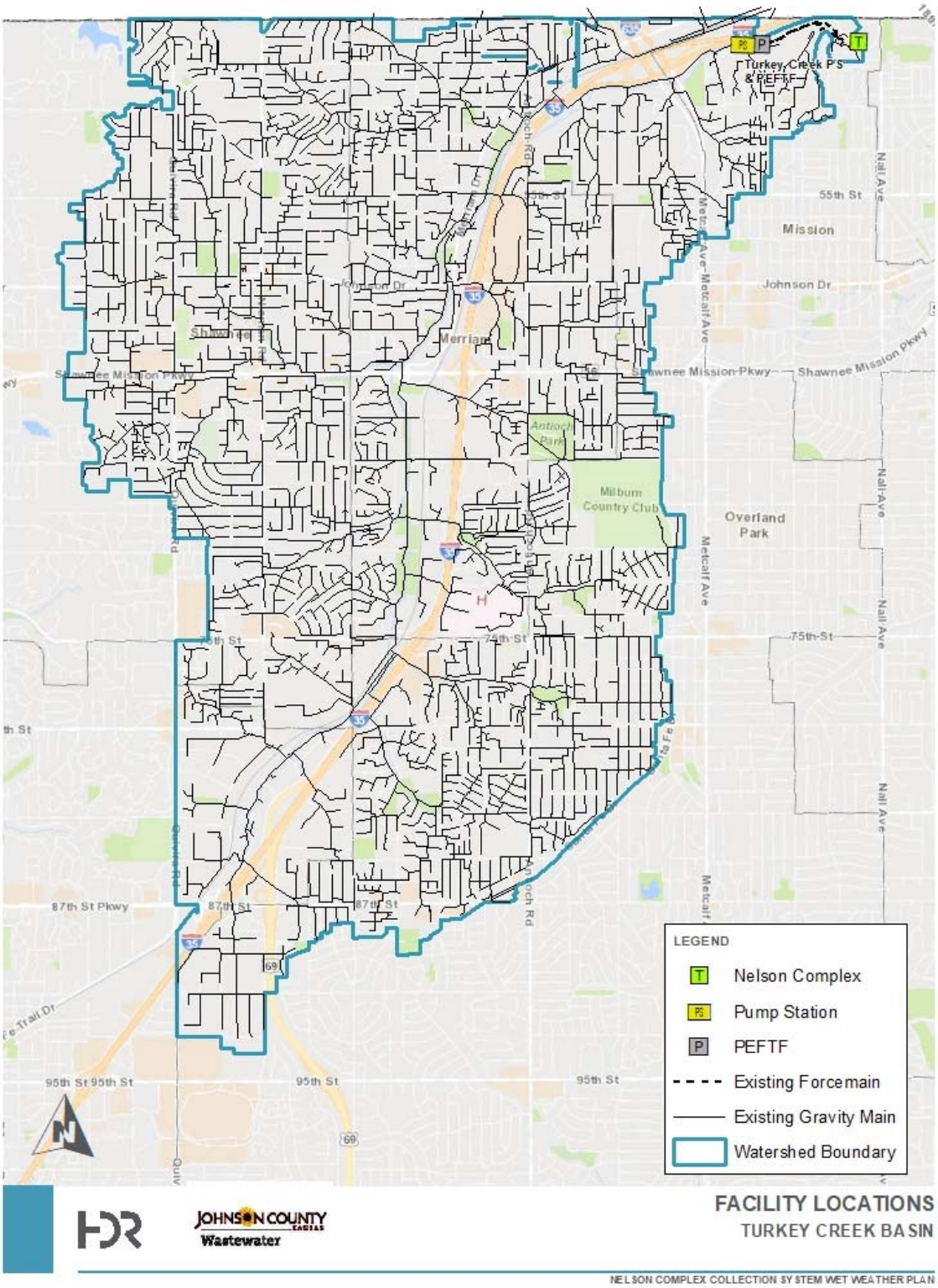
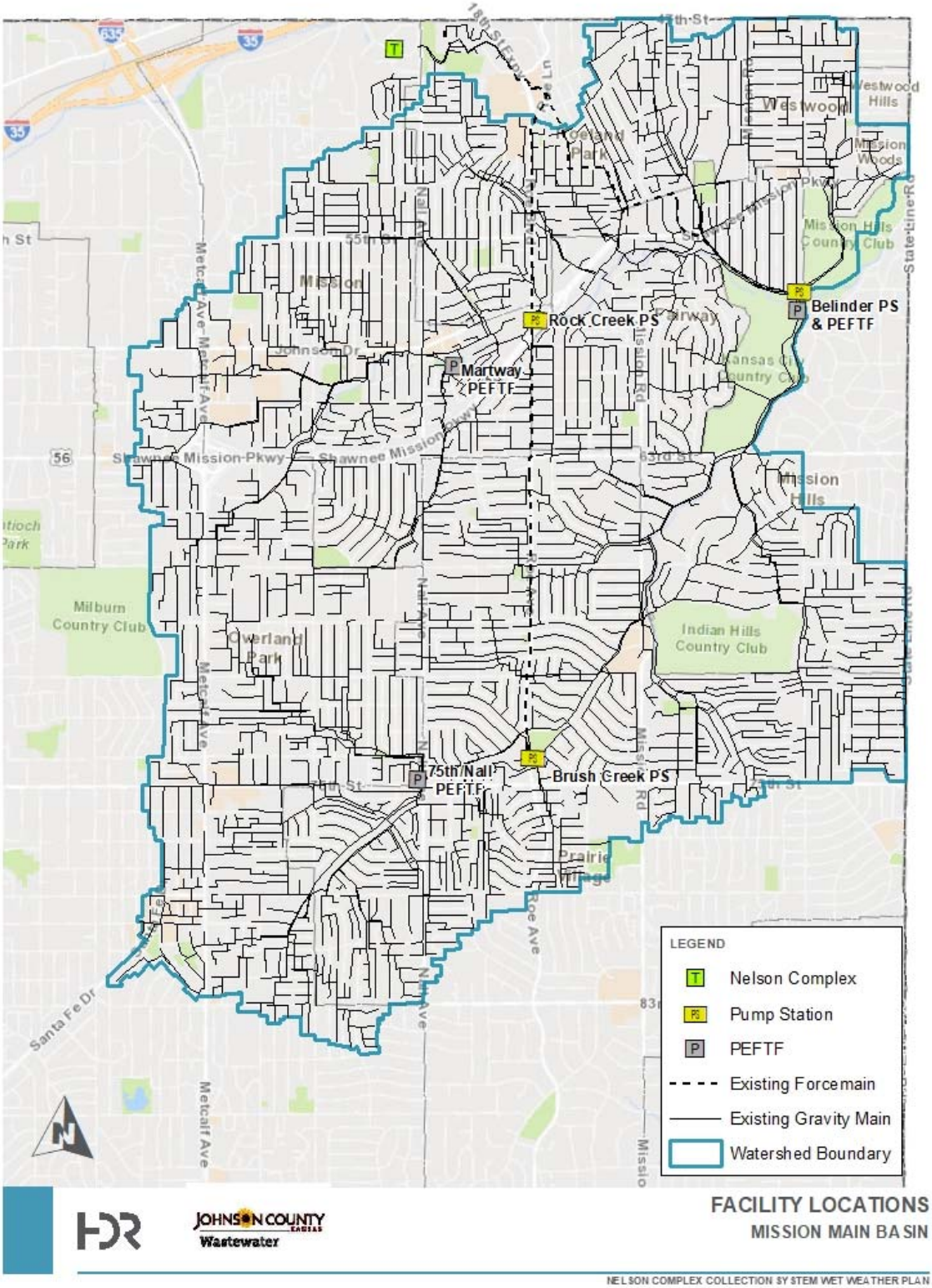


Figure 11: Mission Main Basin and Major Facilities

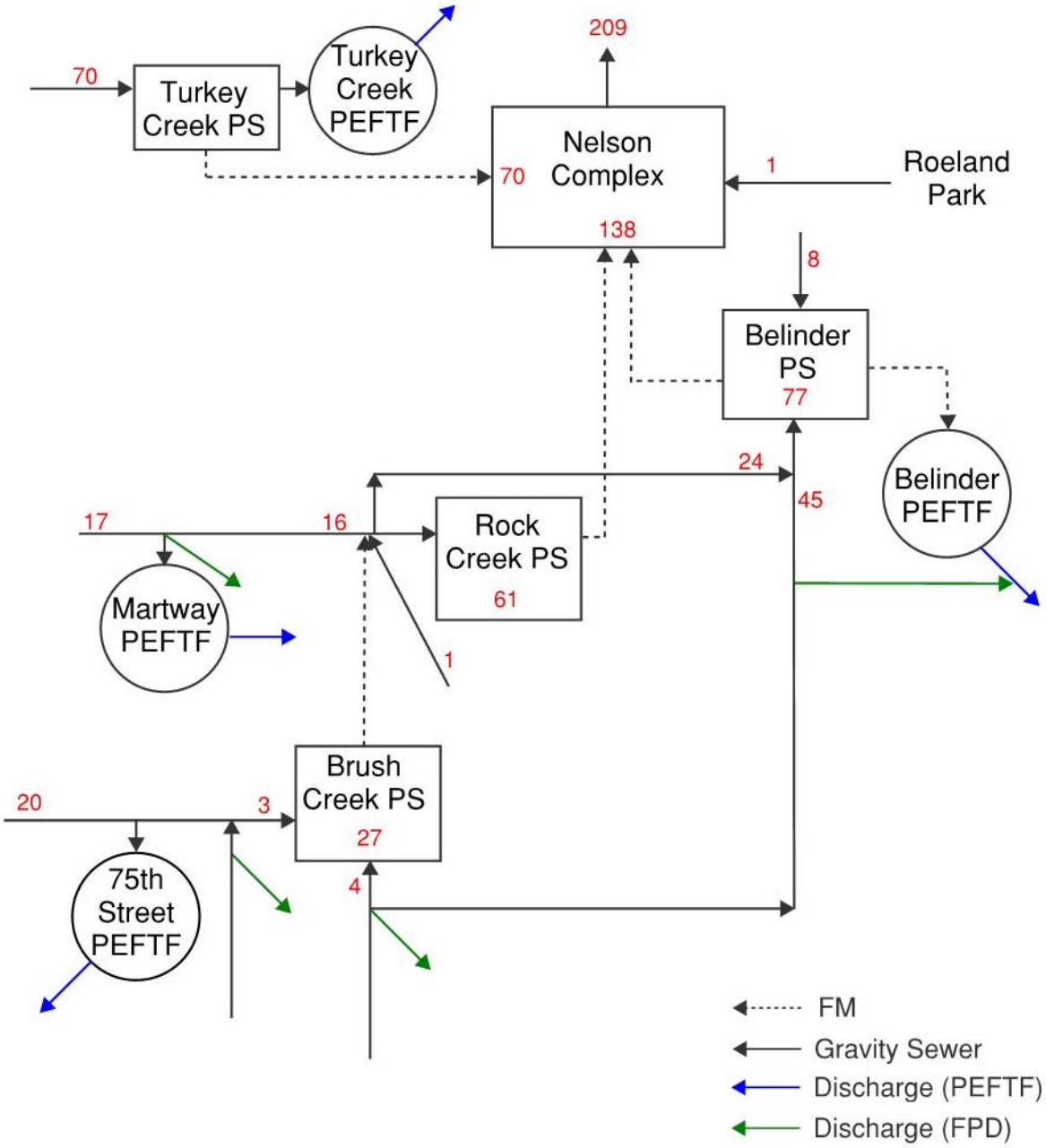


Capacity constraints exist throughout the collection system during wet weather. To understand the magnitude of peak flows at critical points in the system, an approximation of the 10-year, 24 hour "existing unrestricted flow" from the collection system tributary to each satellite facility was developed. "Existing unrestricted" is the peak flow that would occur if there was no upstream flow reduction (storage or I/I removal), and the pipes were of sufficient size that all flows would be conveyed to the facility with any upstream surcharging or overflows. These flows are presented in Table 7 and shown schematically in Figure 12.

Table 7: Nelson Complex Unrestricted Flow (10-Year, 24-Hr Storm Event)

Reach/Item	Description	Flow (MGD)
	Brush Creek Pump Station Service Area	
1	US of 75th & Nall	20
2	DS of 75th & Nall and US of Brush Creek	7
3	Total, Brush Creek Pump Station Service Area	27
	Rock Creek Pump Station Service Area	
4	US of Martway	17
5	DS of Martway and US of Rock Creek	16
6	To Rock Creek from South	1
7	Total, Rock Creek Pump Station Service Area	34
8	Total, Rock Creek and Brush Creek PS Service Areas	61
	Belinder Pump Station Service Area	
9	DS of Brush Creek and US of Belinder	45
10	DS of Rock Creek and US of Belinder	24
11	To Belinder from North	8
12	Total, Belinder Pump Station Service Area	77
13	**Total, Mission Main Service Area**	**138**
14	**Total, Turkey Creek Service Area**	**70**
15	Total, Roeland Park Service Area	1
15	**Nelson Complex Total**	**209**

Figure 12: Nelson Complex Unrestricted Flow (10-Year, 24-Hr Storm Event)



3.1.3 Collection System Study Approach

This study was completed using a holistic basin-wide approach to define improvements needed in order for JCW to manage peak wet weather flows. Optimization, an iterative process utilizing specialized optimization software was used to help determine the most cost-effective set of improvements. The optimization software was used in conjunction with a calibrated hydraulic model to evaluate the optimum combination of the potential improvement alternatives needed to achieve a specific level of service design criteria. WCS Engineering, a specialist in capital improvement plan (CIP) optimization, led the optimization portion of this process with collaboration from HDR and JCW.

The primary phases of the study are summarized as follows:

- Hydraulic Model Update
- Preliminary Optimization
- Alternatives Screening and Refinement
- Refined Optimization
- Water Quality Modeling
- Alternatives Development and Evaluation
- Prioritization and Implementation Plan Development (completed through the Integrated Management Plan)

3.2 TM 2 – Hydraulic Model Update

3.2.1 Purpose

Hydraulic models were previously developed for the Mission Main and Turkey Creek basins using the InfoWorks ICM hydraulic modeling platform by Innovyze. Since the model networks were last updated, JCW has continued to make improvements to their collection system and update their sewer records in AIMS. Prior to use for capacity analysis in this study, the models were reviewed and updated to incorporate major network updates. This updated model was used for capacity assessment and formed the basis of the SWMM model used for optimization.

In addition to the capacity assessment and optimization model, HDR developed a closely related long-term model to more accurately estimate flows for long-term simulations, which were used for water quality modeling efforts (documented in TM 5).

The purpose of TM 2 was to document the hydraulic model review and update, existing conditions analysis, and the model conversion from InfoWorks ICM to SWMM for use in the optimization.

3.2.2 Hydraulic Model Network Updates

The entire gravity system was reviewed and updated in order to incorporate data for assets that have been constructed, realigned, rehabilitated, or abandoned since the last model update. Pump station and PEFTF configuration and operations were also verified and updated as necessary. Updates to the model were made based on several data sources

including GIS data, as-builts and record drawings, previous reports, site visits, and interviews with JCW staff.

3.2.3 Modeled System Performance

The updated capacity assessment models were used to evaluate existing system capacity during the 1-year, 5-year, and 10-year design storms. The model results identified areas of surcharging pipes and manhole flooding. Results are presented in Table 8 as a percentage of the total system.

Table 8: Existing Conditions Gravity Network Modeled Results

Category	1-Year Event	5-Year Event	10-Year Event
% of Manholes Flooded	0.04%	0.7%	1.8%
% of Overcapacity Pipes	2.2%	5.7%	7.3%
% of Pipes Surcharged Due to Conditions Downstream	3.5%	10.3%	13.4%

An indicator of system capacity is whether the PEFTFs activate during a storm event. The model indicates that all of the PEFTFs activate during the 1-year event, as shown in Table 9.

Table 9: Existing Conditions PEFTF Activation Results

Facility	1-Year Event		5-Year Event		10-Year Event	
	Max Overflow (MGD)	Overflow Volume (MG)	Max Overflow (MGD)	Overflow Volume (MG)	Max Overflow (MGD)	Overflow Volume (MG)
Turkey Creek PEFTF	22.0	6.9	22.0	15.0	22.0	19.9
75th / Nall PEFTF	17.9	2.0	20.0	4.7	20.0	6.4
Martway PEFTF	10.0	1.6	17.2	3.8	17.5	4.9
Belinder PEFTF	33.2	10.6	48.0	18.6	53.4	23.4

3.2.4 Model Conversion for Optimization

The Nelson Complex is divided into two calibrated network models (Turkey Creek and Mission Main) modelled in InfoWorks ICM. The optimization is run using EPA SWMM Version 5.1, which required the ICM models to be converted to SWMM, trimmed and combined to create one Nelson Complex SWMM model.

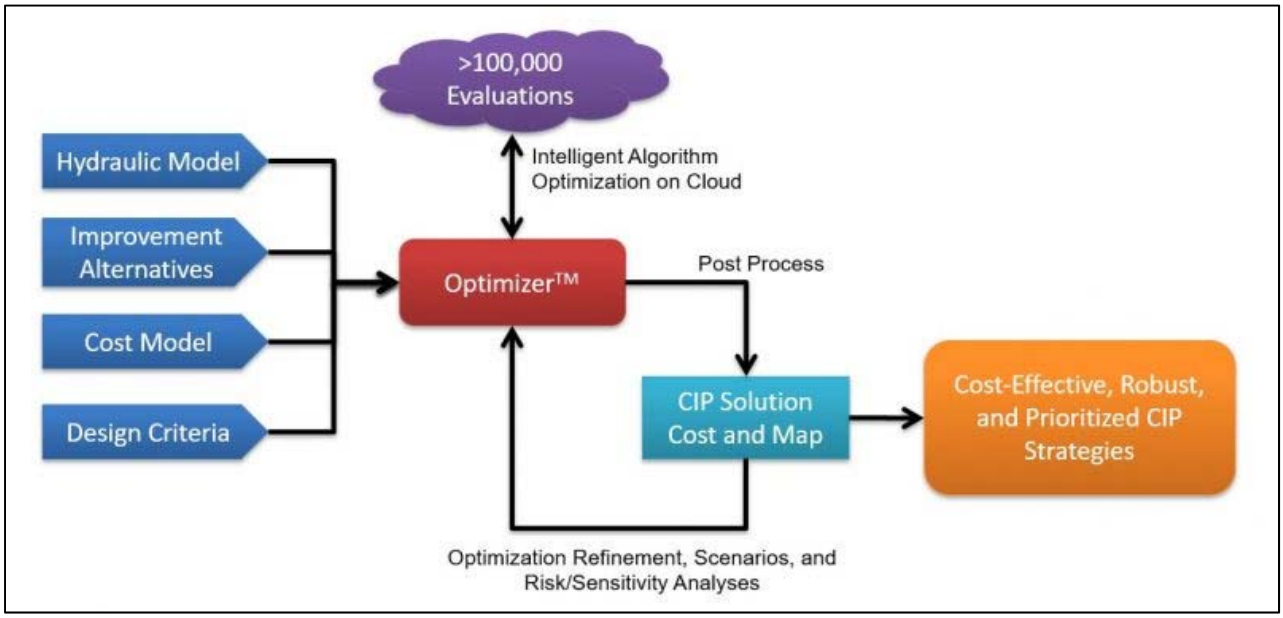
The SWMM model was trimmed to only include elements downstream of capacity deficiencies based on the 10-yr design storm flows (i.e. the trimmed model includes all sewer mains that require improvements in the worst-case design scenario irrespective of pipe size). Upon completion of the conversion and trimming process, network inflows and outflows were compared for both models to validate total flow volume in the models. The validation process confirmed that the SWMM model was producing similar results to the ICM models and was suitable for use in optimization

3.3 TM 3 – Preliminary Optimization & Alternatives Screening

3.3.1 Description of Optimization Process

Optimizer WCS, a cloud-based software solution was used as the platform for the optimization process. For this study, optimization was used as a tool in the planning process to identify the most cost-effective and reasonable combination of system improvements that will meet JCW's desired level of service. The optimization process is iterative, meaning it begins by identifying general trends and gets more specific as iterations are performed and user inputs are refined. This process is shown schematically in Figure 13.

Figure 13: Optimization Process Schematic



The following steps were performed, which will be described in more detail in the subsequent sections:

- Preliminary Optimization (TM 3)
- Alternatives Screening and Cost Refinement (TM 3)
- Refined Optimization (TM 4)
- Alternatives Development and Evaluation (TM 6)
- Prioritization and Implementation Plan Development (completed through the Integrated Plan)

3.3.2 Purpose

The purpose of TM 3 was to document the preliminary optimization approach, results from the preliminary optimization, alternatives screening, and cost refinements that were used in the subsequent refined optimization.

3.3.3 Preliminary Optimization Approach

During preliminary optimization, all feasible alternatives were included in the analysis in order to complete a thorough evaluation of alternatives and complete the following objectives:

- Investigate a wide range of scenarios and sensitivities to identify consistent trends
- Evaluate potential level of service scenarios to establish incremental costs to achieve varying levels of service and identify common/divergent improvements required among scenarios
- Identify key assumptions/alternatives that require further refinement and screening prior to the refined optimization
- Identify and screen likely sites for major improvements projects (e.g. storage facilities)
- Identify which cost assumptions are most sensitive, so they can be further refined in the refined optimization analysis.

Three scenarios were evaluated during preliminary optimization. Scenarios 1A and 1B represent two different wet weather management strategies (eliminating or upgrading PEFTFs) that provide the same required level of service (LOS). Scenario 2 represents a lower LOS scenario utilizing the same wet weather management strategy as Scenario 1A.

- Scenario 1A ("Base Case") - In the base case, it is assumed that the PEFTFs will eventually be eliminated and not available for use during any wet weather event. This scenario required a minimum LOS of 10 years for the collection system and a minimum LOS of 5 years for major facilities. In place of the PEFTFs, it is assumed that a Facility Protection Device (FPD) would be in place at each major remaining facility and may activate to protect the public and JCW facilities for events greater than the 5-year storm. Scenario 1A was termed "All Options, No PEFTFs" in this TM.
- Scenario 1B ("PEFTFs Remain") – In this scenario, it is assumed that the PEFTFs will be upgraded and remain in service indefinitely. Like Scenario 1A, a 10 year minimum LOS for the collection system and a 5 year minimum LOS for facilities was required. Scenario 1B was termed "All Options, PEFTFs Remain" in this TM.
- Scenario 2 requires a 10 year minimum LOS for the collection system and a 1 year minimum LOS for facilities. In this scenario, like the Base Case, it is assumed that the PEFTFs will be eliminated. Scenario 2 was termed "All Options, No PEFTFs – 10/1" in this TM.

The optimization process was used to determine the most economical combination of improvements necessary to meet the LOS requirements set forth in each scenario. The results of the preliminary optimization were used to identify which alternatives and costs needed further evaluation and refinement. These updated alternatives and refined costs were later used for refined optimization.

3.3.4 Preliminary Optimization Design Criteria and Assumptions

A summary of the design criteria and assumptions used in preliminary optimization is shown in Table 10. It describes the ranges and constraints assigned to each optimization alternative.

Table 10: Preliminary Optimization Design Criteria and Assumptions

Category	Design Criteria and Assumptions
Parallel Pipe Options	Pipe diameter alternatives ranging from 1' to 6'. Capital costing based on gravity sewer cost tables with increased costs included for trenchless crossings.
Storage Facilities	All preliminary options considered will be assumed as below ground storage. Capital costing utilized the same cost curve for each potential site.
Linear/Tunnel Storage	Pipe diameter alternatives ranging from 3' to 12' with same cost methodology used for gravity sewers.
Pump Station Upgrades	Pump Station upgrades utilized the same cost curve for each facility during Preliminary Optimization.
Force Main	A maximum velocity of no more than 6 fps was assumed, beyond that a new or parallel force main will be required.
I/I Reduction Option	Typical Comprehensive Rehab Strategy assumed (cost effective rehabilitation of pipes, manholes, and disconnection of building direct connections). I/I reduction was considered for each individual meter basin and was allowed to range from 5% to 30% reduction. Costs curves specific for Mission Main and Turkey Creek basins were developed from the Pilot Study findings.
WWTF	Auxiliary Treatment Facility cost curve was developed based on recent similar projects, sized up to the maximum flow that could be conveyed to the facility if no upstream flow reductions were implemented.
PEFTF Upgrades	PEFTF upgrades utilized the same cost curve for each facility during Preliminary Optimization.
Surcharge	Surcharge limited to 10 feet below the ground surface. Localized variances will be identified near facilities and shallow lines (e.g. creek crossing) and will be addressed on a case-by-case basis.
Present Value Costing	20-yr cost analysis period – Based on most recent OMB Circular A-94 Appendix C.

3.3.5 Preliminary Optimization Results

The 20-yr Net Present Value (NPV) total costs for each preliminary optimization scenario are summarized in Table 11.

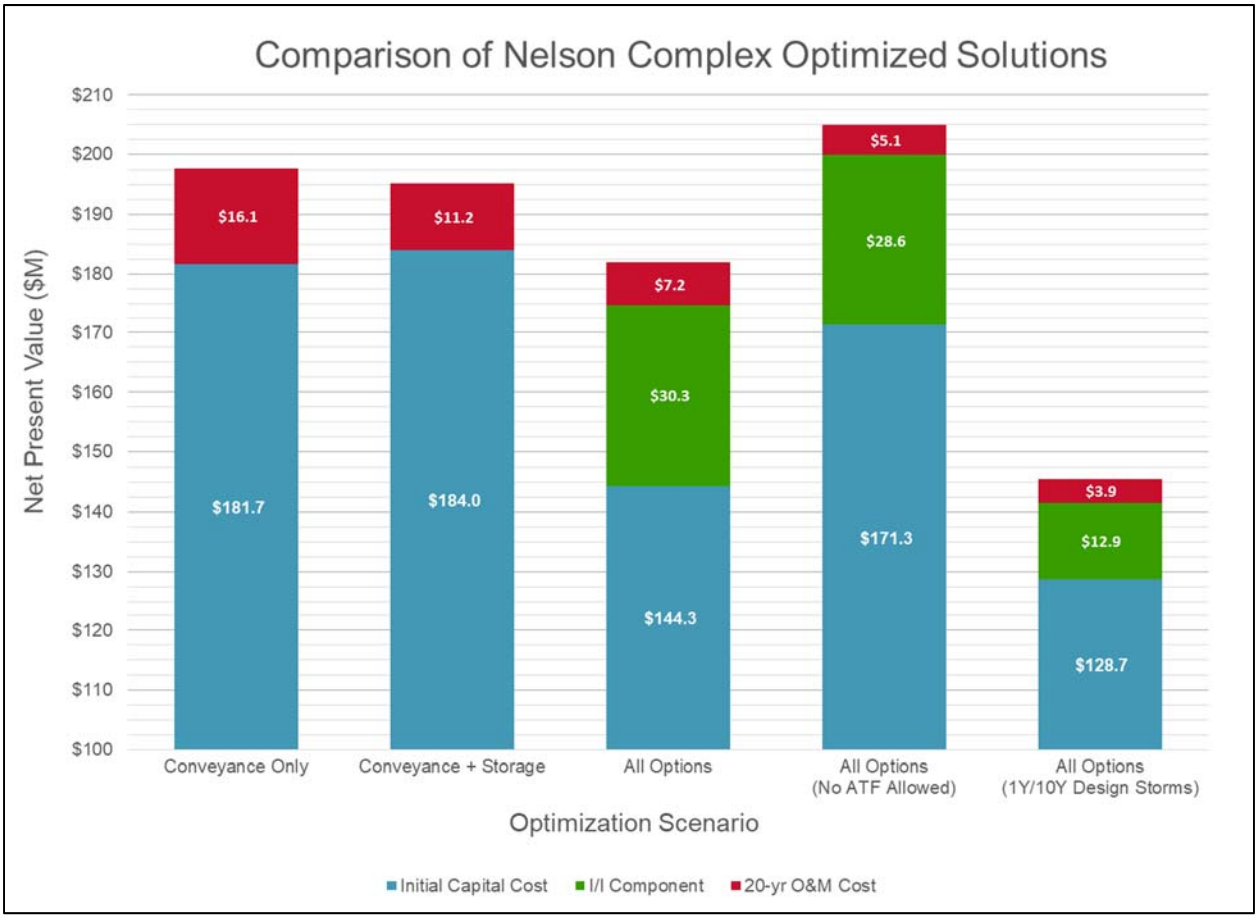
Table 11: Preliminary Optimization Scenario Costs

Optimization Scenario	20-Yr NPV Total Cost ($M)[1]
Scenario 1A - Conveyance Only (10/5 Year Design Storms)	$ 197.8
Scenario 1A - Conveyance and Storage Only (10/5 Year Design Storms)	$ 195.2
Scenario 1A - All Options (10/5 Year Design Storms)	$ 181.9
Scenario 1B - PEFTFs Remain (No ATF Allowed)	$ 205.0
Scenario 2 - All Options (10/1 Year Design Storms)	$ 145.5

[1] Costs do not include operation and maintenance costs that are common among alternatives.

The net present value estimated for each preliminary optimization scenario, itemized by capital cost, I/I reduction cost, and O&M cost, are presented in Figure 14.

Figure 14: Comparison of Preliminary Optimized Solutions



3.3.6 Key Trends and Sensitivities

The intent of preliminary optimization was to identify key trends among improvement alternatives, identify alternatives that should be screened for further evaluation, and to identify sensitivities that require additional input prior to refined optimization. The preliminary optimization demonstrated several key trends.

- Inclusion of an Auxiliary Treatment Facility (ATF) in the wet weather management strategy was a key factor in reducing total costs; all scenarios including an ATF were significantly more cost effective than those that did not allow for auxiliary treatment. It was determined in the companion WWTF study that auxiliary treatment would be feasible at the Nelson Complex WWTF. The range of potential design flows determined during preliminary optimization were utilized in the WWTF for the siting and phasing evaluation.
- The total costs for the various combinations of alternatives evaluated in preliminary optimization were relatively close. The differential among the various combinations of conveyance, storage, and I/I reduction alternatives was approximately 10%.
- Preliminary optimization identified similar sets of improvement alternatives in Turkey Creek characterized by a remote storage facility along the interceptor, I/I reduction in the upper reaches, and an expansion to the Turkey Creek Pump Station to convey wet weather flows to an ATF along with gravity conveyance improvements.
- Preliminary optimization of Mission Main identified storage near Rock Creek and Brush Creek Pump Stations, along with an expansion to Belinder Pump Station to convey wet weather flows to an ATF. Gravity conveyance improvements and extensive I/I reduction were also included in all alternatives. It was noted that the costs to expand Rock Creek and Brush Creek Pump Stations were only slightly higher than the cost of storage at these stations.

3.3.7 Alternatives Screening and Refinement

For preliminary optimization, simplifying assumptions were made for each alternative in order to formulate the optimization and gain initial insights into the performance of all potential wet weather management strategies. The analysis utilized a general unit cost curve for each type of facility and did not limit the volume or storage or extent of capacity upgrades allowable at each facility.

The following sub-sections describe the alternatives screening and cost refinement process. The refined optimization (described in TM 4) utilized the site and facility specific improvement costs developed during this task.

3.3.7.1 Storage Facilities

During preliminary optimization, underground storage was considered at all major facilities and at reasonable remote locations within the collection system. Each site was assumed to have unlimited capacity and storage volumes were unconstrained. Several locations were selected for storage during preliminary optimization. During alternatives screening, these locations, and others, were evaluated for acquisition and construction feasibility and maximum storage capacity available.

Some storage options initially selected were determined to not be feasible, including shallow underground storage at Belinder Pump Station and at the site adjacent to Rock Creek Pump Station. For refined optimization, six (6) locations were selected and approved by JCW to be considered in the refined optimization.

3.3.7.2 Pump Station and Forcemain Improvements

For preliminary optimization, pump station upgrades utilized the same cost curve for each facility. All pump station upgrades were assumed to be expansions of the existing facilities. During alternatives screening and cost refinement, a separate cost curve was developed for each of the major pump stations. The design assumptions and cost curves were developed by the WWTF study team to ensure the same approaches were utilized for mechanical and electrical equipment in each study.

Forcemain upgrades were considered in conjunction with each pump station curve. For each facility, a flow breakpoint was defined, beyond which a new wet weather facility must be constructed. Additional breakpoints were determined at flow rates where additional improvement costs would be incurred.

3.3.7.3 Gravity Capacity Improvements

For preliminary optimization, it was assumed that all selected gravity main improvements would be parallel relief sewers. During alternatives screening, each length of improvements was evaluated; if the parallel option was determined to be infeasible, the segment was recommended to be upsized in place.

3.3.7.4 I/I Reduction Strategy

The optimization evaluated potential I/I reduction that could be achieved from the cost effective rehabilitation of public sector assets and the disconnection of private sector sources. For preliminary optimization, the maximum I/I reduction option considered for each basin was 30% based on the typical comprehensive strategy adopted by JCW. During the alternatives screening, the results of JCW's ongoing asset renewal efforts were used to project a basin-wide baseline I/I reduction for each basin. It was determined that 10% reduction in Mission Main and 15% reduction in Turkey Creek would be representative of the baseline I/I reduction JCW can expect to achieve through the public sector asset management program.

For refined optimization, the appropriate public sector baseline I/I reduction (10% or 15%) was applied to each basin. Up to a total of 30% reduction, inclusive of public and private I/I reduction, was still considered for individual portions of each basin to identify areas where private I/I reduction may be cost-effective.

3.3.7.5 PEFTF Upgrades

Site specific cost curves for PEFTF upgrades were developed to be used in refined optimization. The design assumptions and cost curves were developed by the WWTF study team to ensure the same approaches were utilized for mechanical and electrical equipment in each study.

While PEFTFs were not selected in the preliminary optimization unless auxiliary treatment was disallowed from the scenario, the additional restrictions on storage sites and allowable volumes increased the likelihood that PEFTFs may become a more cost-effective option during refined optimization.

3.4 TM 4 – Refined Optimization

3.4.1 Purpose

The results of the preliminary optimization were used to identify alternatives and costs needing further evaluation and refinement. The refined optimization took into account the updated alternatives and cost refinements made during the alternatives screening process, described in Section 3.3. The purpose of TM 4 was to document the refined optimization approach and present results.

3.4.2 Refined Optimization Approach

Based on the alternatives screening and cost refinement presented in TM 3, the following refinements were made to the optimization inputs during the Refined Optimization:

- Gravity pipe replacement alternatives were included in place of some of the parallel pipe alternatives based on an assessment of construction feasibility and asset condition.
- The location and maximum size (volume) of allowable underground storage facilities were refined based on feasibility assessments. Storage at Belinder, Turkey Creek, and Rock Creek was constrained to tunnel storage.
- A baseline level of I/I reduction (15% in Turkey Creek and 10% in Mission Main) was applied in all optimization scenarios. This level of I/I reduction represents the projected I/I reduction achieved from rehabilitation of pipes and manholes through JCW's Collection System Asset Management Program. (CSAMP).
- The ATF approach was modified such that the initial 7 MGD (above the 45 MGD WWTF throughput) would be included in the WWTF cost estimate. 52 MGD was considered to be the baseline WWTF flow for the optimization; costs for any additional ATF capacity were included in the optimization.
- Site-specific cost curves were developed for each major pump station and PEFTF based on recent local HDR projects.
- Pump station and forcemain cost curves were modified to account for the anticipated higher elevation of the receiving facilities associated with the proposed WWTF upgrades.

The intent of refined optimization analysis was the following:

- Identify cost-effective, feasible improvement strategies using the refined unit costs and alternative constraints identified during the Alternatives Screening
- Demonstrate the additional cost to implement alternative wet weather management approaches that do not include auxiliary treatment
- Identify key sensitivities to further evaluate during alternatives development and evaluation for inclusion in the long-term basin plan (documented in TM 6).

3.4.3 Refined Optimization Results

This section presents the preferred solutions resulting from the refined optimization for the PEFTF Elimination and PEFTF Retention alternatives considered.

The solution cost summary for the preferred optimization scenario to eliminate the PEFTFs is presented in Table 12.

Table 12: Cost Summary of Optimized PEFTF Elimination Alternative

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) [1]	20-yr NPV Total Cost ($M) [1]
Gravity Sewers	28.80	-	**28.80**
Pumping Station Upgrades	37.77	6.71	**44.48**
Force Mains	18.06	-	**18.06**
Underground Storage Facilities	40.38	0.11	**40.49**
Linear Storages	-	-	**-**
PEFTF Upgrades	-	-	**-**
Baseline I/I Reduction	30.00	-	**30.00**
Additional I/I Reduction	13.89	-	**13.89**
Auxiliary Treatment Facility	40.76	4.50	**45.26**
TOTAL	**209.65**	**11.32**	**220.97**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

In Turkey Creek, the preferred PEFTF elimination solution is characterized by:

- Approximately 8,600 LF of parallel gravity main and 7,000 LF of replace/upsize gravity main
- Upgrade of the Turkey Creek PS to 43.2 MGD with a parallel 36” forcemain (3,500 LF)
- Two underground storage facilities:
  - Turkey Creek Collection System (southern site) – 2.1 MG
  - Turkey Creek Collection System (northern site) – 0.8 MG
- A selected overall I/I reduction in Turkey Creek of 17%

In Mission Main, the preferred solution without PEFTFs is characterized by:

- Approximately 7,600 LF of parallel gravity main and 30,800 LF of replace/upsize gravity main
- Upgrade of the Belinder PS to 53.5 MGD with a parallel 48” forcemain (10,600 LF)
- Upgrade of the Rock Creek PS to 24.3 MGD with a parallel 24” forcemain (7,000 LF)
- Brush Creek underground storage facility – 4.4 MG
- A selected overall I/I reduction in Mission Main of 15%

The solution cost summary for the preferred PEFTF retention alternative is presented in Table 13.

Table 13: Cost Summary of Optimized PEFTF Retention Alternative

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) [1]	20-yr NPV Total Cost ($M) [1]
Gravity Sewers	27.12	-	**27.12**
Pumping Station Upgrades	-	-	**-**
Force Mains	-	-	**-**
Underground Storage Facilities	20.91	0.05	**20.96**
Linear Storages	-	-	**7.42**
PEFTF Upgrades	55.21	6.61	**61.82**
Baseline I/I Reduction	30.00	-	**30.00**
Additional I/I Reduction	9.49	-	**9.49**
Auxiliary Treatment Facility	-	-	**-**
TOTAL	**142.72**	**6.66**	**156.80**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

The optimized solutions to retain or eliminate the PEFTFs have very similar overall strategies, except at the major facilities. The major improvements included in the PEFTF retention scenario that differ from the solution to elimination the PEFTFs are as follows:

- The Turkey Creek PS upgrade is exchanged for a PEFTF treatment upgrade
- The Belinder PS upgrade is exchanged for a PEFTF treatment upgrade
- The Rock Creek PS upgrade is exchanged for linear tunnel storage
- The Brush Creek storage is exchanged for a PEFTF treatment upgrade at 75th/Nall
- The ATF upgrade is not required, as peak excess flows would be treated at the upgraded PEFTFs.

The refined optimization solutions are presented in Figure 15 and Figure 16 for Alternative 1 and Alternative 2, respectively.

Figure 15: Refined Optimized Solution for Alternative 1 – Eliminate PEFTFs through Wet Weather Management

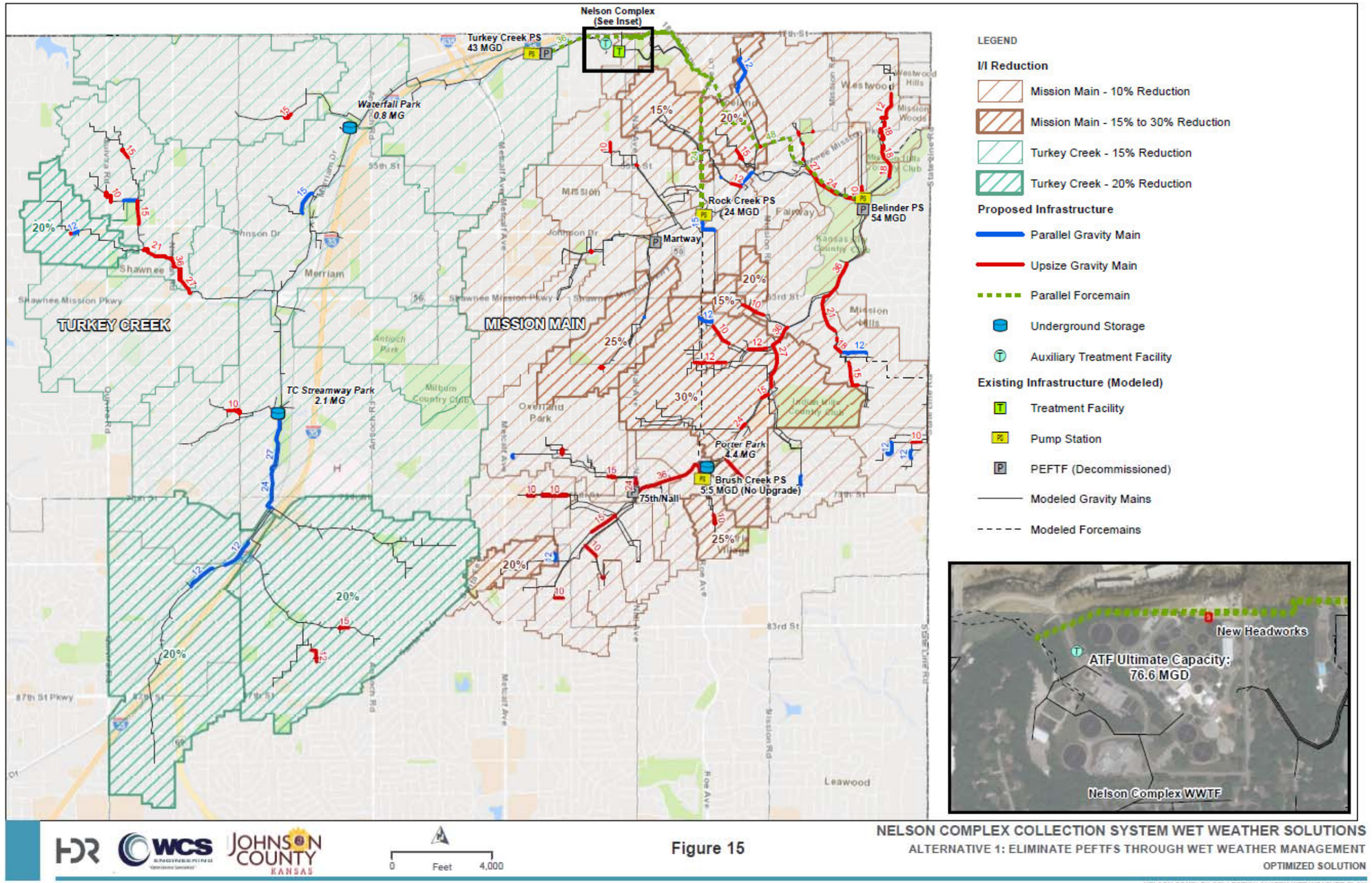


Figure 16: Refined Optimized Solution for Alternative 2 - Retain PEFTFs with Enhanced High Rate Treatment

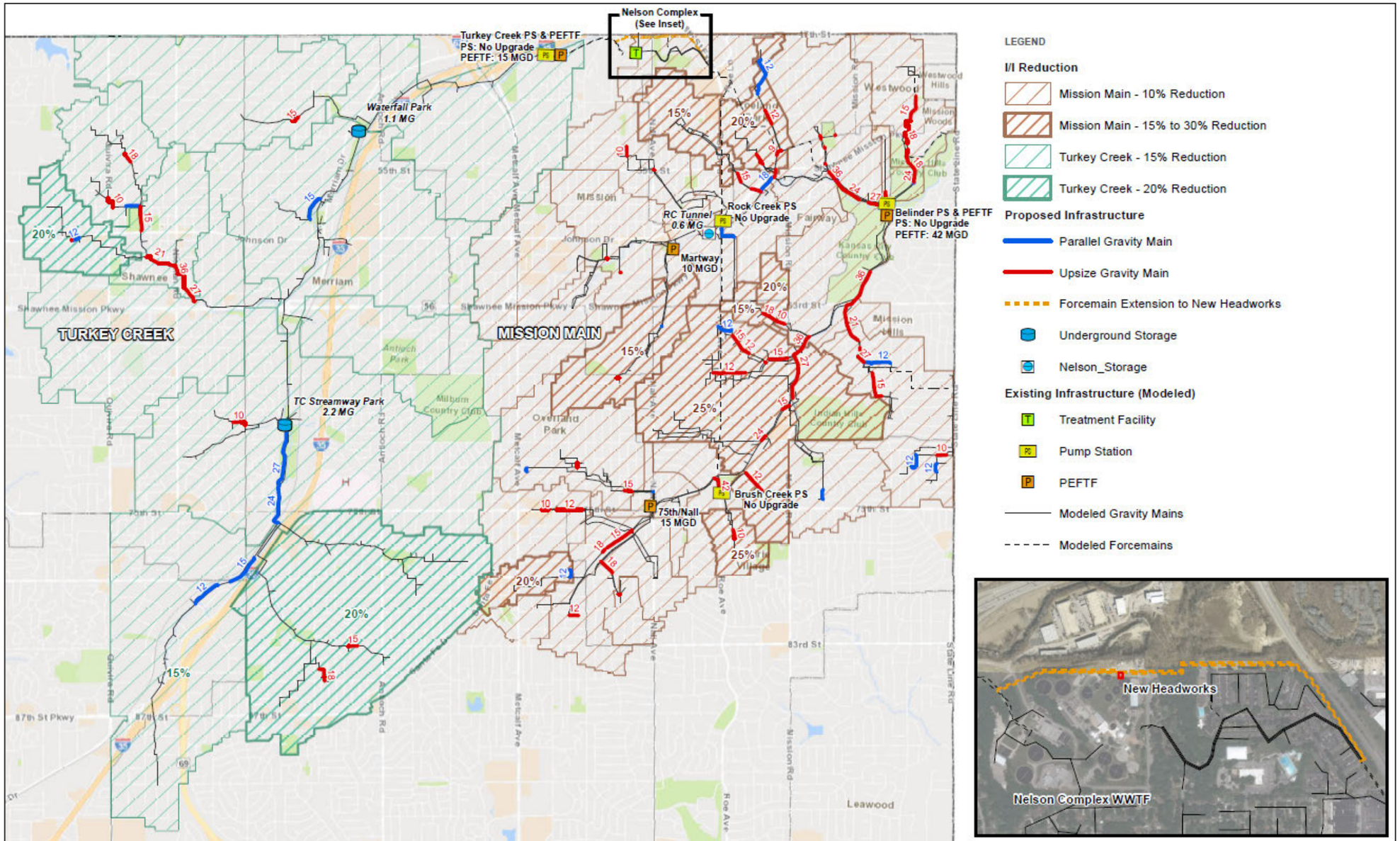


Figure 16

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS
ALTERNATIVE 2: RETAIN PEFTFS WITH ENHANCED HIGH RATE TREATMENT
OPTIMIZED SOLUTION

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN

The refined optimization analysis identified several key trends:

- For the PEFTF Elimination scenarios, inclusion of an Auxiliary Treatment Facility (ATF) in the wet weather management strategy was a key factor in reducing total costs; all scenarios including an ATF were significantly more cost effective than those that did not allow for auxiliary treatment. If auxiliary treatment is not implemented, costs will be increased by approximately $80 Million. In addition to monetary costs, the solutions without auxiliary treatment includes improvements that would be very challenging or impossible to construct in dense residential areas.
- The PEFTF Retention solution is less costly than the PEFTF Elimination solution.
- The I/I cost sensitivity analysis demonstrated that the overall strategy is not sensitive to the cost of additional private sector I/I reduction (beyond baseline public sector reduction) and that the I/I targets in some sub-basins can be adjusted without significantly affecting the overall strategy. This indicates that in general, areas identified for private I/I reduction may be shifted to other areas in the basin if this is determined to be advantageous during implementation. If private I/I reduction efforts are more costly than anticipated (within reason), the overall strategy will not be significantly affected.
- The I/I effectiveness sensitivity analysis indicated that the overall strategy is sensitive to lower I/I reduction effectiveness. This indicates that if I/I reduction efforts are not successful in reducing peak flows, the pump station and storage facility projects will need to be modified to handle greater peak flows and project phasing may need to be adjusted accordingly. Ongoing I/I reduction efforts should therefore be monitored and the overall strategy re-evaluated as necessary throughout the execution of the long-term plan.

The optimization analyses identified the preferred cost effective wet weather management strategies for each basin. The major improvement projects were further refined in the Alternatives Development and Evaluation task, documented in Section 3.6.

3.5 TM 5 – Water Quality Modeling

3.5.1 Purpose

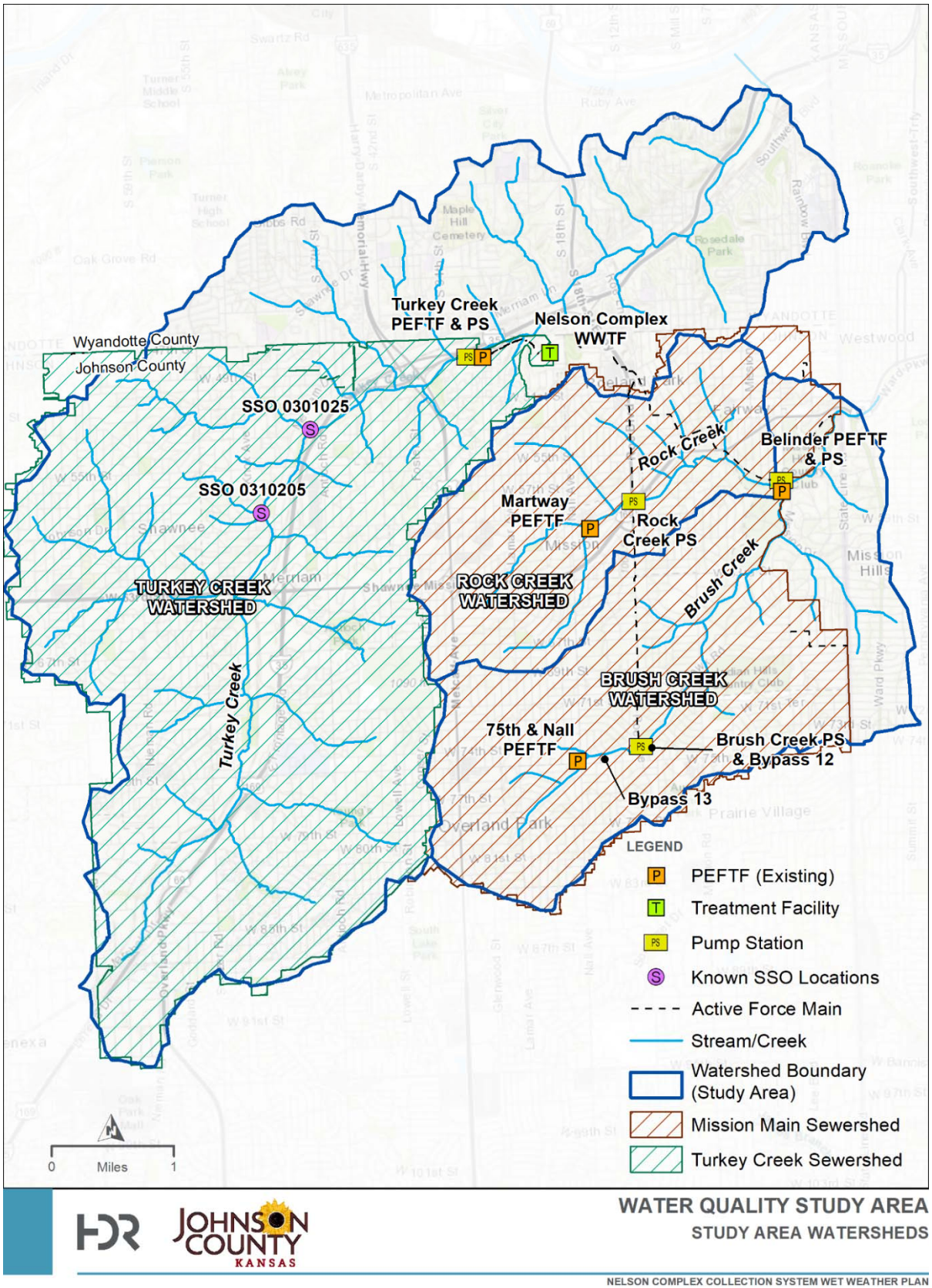
The purpose of TM 5 was to characterize water quality impacts on receiving waters from various wet weather management alternatives associated with the Nelson Complex. Wet weather alternatives evaluated as part of this study included the following:

- Baseline Conditions – This alternative represents current conditions and includes the existing collection system and the Nelson Complex WWTF discharges.
- Eliminating all PEFTFs – This alternative includes capacity improvements to eliminate PEFTF discharges and address SSOs and in-system bypasses up to JCW's level of service criteria. This alternative also includes upgrades to the Nelson Complex WWTF, including replacing the existing trickling filter system with a biological nutrient removal (BNR) treatment facility and ATF.

- Collection System Improvements and Facility Upgrades – This alternative includes PEFTF enhancements to improve disinfection and reduce total residual chlorine (TRC). It also includes capacity improvements to address SSOs and in-system bypasses and upgrades to the Nelson Complex WWTF. Upgrades to the Nelson Complex WWTF include replacing the existing trickling filter system with a BNR treatment facility and ATF.

The scope of this study was limited to water quality impacts associated with the aforementioned alternatives within the Turkey and Brush Creek watersheds (Figure 17). Characterization of water quality impacts was also limited to the following parameters: *Escherichia coli* (*E. coli*), total residual chlorine (TRC), ammonia as nitrogen (ammonia-N), total phosphorus (TP), and total nitrogen (TN).

Figure 17: Water Quality Study Area



3.5.2 Water Quality Modeling Results

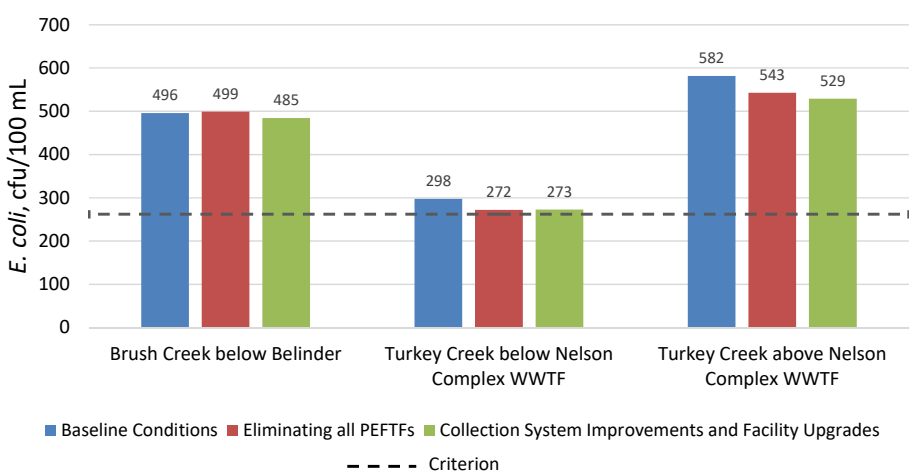
Water quality impacts associated with each of the alternatives were simulated using the Storm Water Management Model (SWMM) version 5 watershed model. Model results suggest that pollutant loadings from PEFTFs, SSOs, and in-system bypasses potentially pose some risk to human health and aquatic toxicity, but impacts are generally minor relative to stormwater runoff and other watershed sources. The model also shows that the Nelson Complex WWTF represents the largest source of nutrient and ammonia loading within the Turkey Creek watershed. More specific findings relative to each modeled parameter are described below.

3.5.2.6 *E. coli*

The model results show that the majority of bacteria loading (i.e., approximately 70% or more), as represented by *E. coli*, is from stormwater runoff or other watershed sources not explicitly modeled (e.g., instream resuspension). SSOs and in-system bypasses constitute the second highest source of modeled bacteria loading within the study area; whereas, contributions from sources that disinfect (i.e., PEFTFs and the Nelson Complex WWTF) are relatively minor.

On a concentration basis, modeled levels of *E. coli* appear most elevated downstream of SSOs and in-system bypasses during major storm events. However, the model demonstrates that implementing capacity improvements to reduce SSOs and in-system bypasses would have minimal impacts on monthly *E. coli* geometric means. Considering July 2010, which represents one of the worst model months with respect to elevated levels of *E. coli*, the monthly geometric mean would decrease less than 10% if all discharges from PEFTFs, SSOs, and in-system bypasses were eliminated (Figure 18).

Figure 18: E. coli Geometric Means Projected by the Model for Alternative Scenarios in July 2010

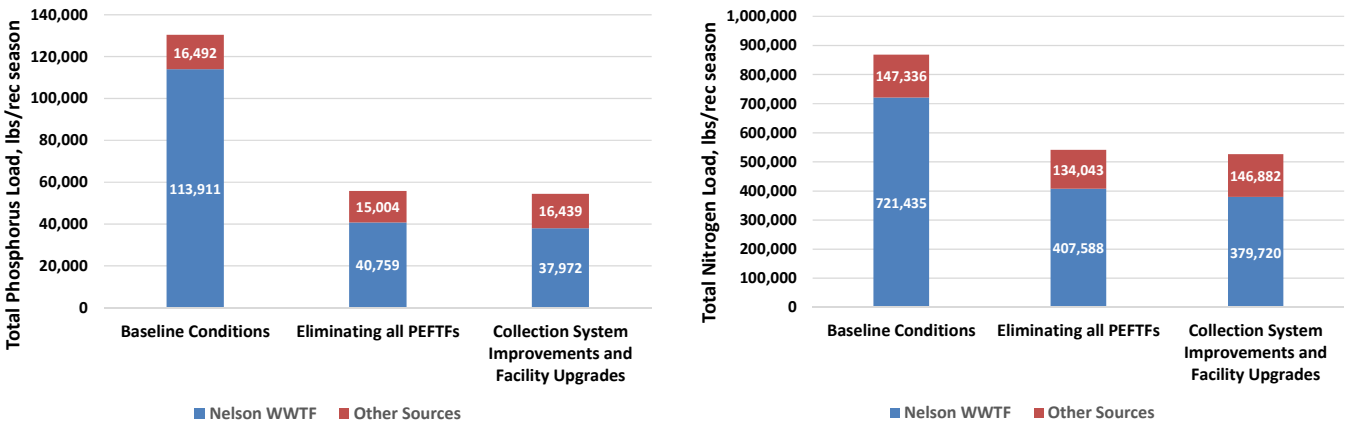


(Note: The *E. coli* criterion is a recreational season (April – October) geometric mean and is not directly comparable to the monthly geometric mean values shown here.)

3.5.2.7 Total Phosphorus and Total Nitrogen

Nutrient loadings modeled within the Turkey Creek and Brush Creek study area, as measured by TP and TN, were primarily comprised of the discharge from the Nelson Complex WWTF. For the 2010 recreational season modeling period, nutrient loadings from the Nelson Complex WWTF represented approximately between 80 and 90% of all modeled loadings. Stormwater and other watershed sources not explicitly modeled (e.g., streambank erosion) represented approximately between 10 and 20% of the total nutrient loadings. Comparatively, PEFTFs, SSOs, and in-system bypasses represented approximately 2 to 3% of the nutrient loading in the model. The model further demonstrated that if nutrient removal is implemented at the Nelson Complex WWTF, TP and TN loadings within the study area could be reduced by approximately 58% and 39%, respectively (Figure 19). Reductions to nutrient loading from eliminating PEFTFs and collection system improvements would be relatively minimal.

Figure 19: 2010 Recreational Season (April – October) Nutrient Loadings Projected by the Model for Alternative Scenarios

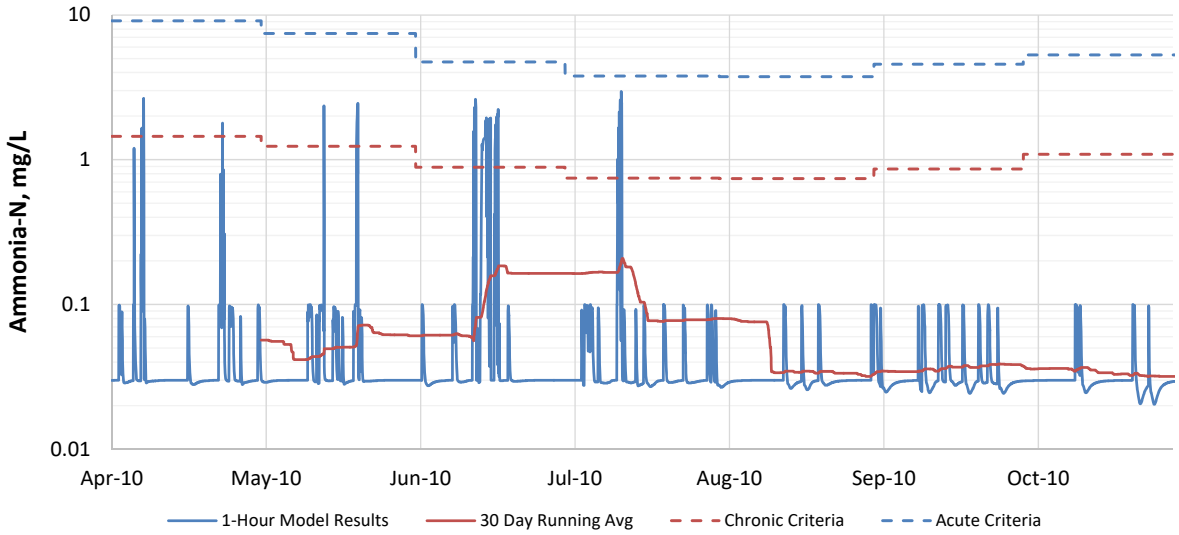


(Note: Alternatives to baseline conditions include implementing nutrient removal at the Nelson Complex WWTF.)

3.5.2.8 Ammonia Nitrogen

The model supported findings by the Kansas Department of Health and Environment (KDHE) that Turkey Creek is impaired for ammonia-N downstream of the Nelson Complex WWTF. It also shows that improved ammonia-N removal is needed at the Nelson Complex WWTF to attain the ammonia-N criteria. Exceedances of ammonia-N criteria were not observed in the model elsewhere within the Turkey Creek and Brush Creek study area. However, instream ammonia-N concentrations approached the acute criterion below the 75th & Nall and Turkey Creek PEFTFs during isolated summer wet weather events, based on conservative model assumptions that do not account for local breakpoint chlorination (Figure 20). Breakpoint chlorination refers to local oxidation from chlorine used for disinfection, which can contribute to lowering ammonia-N levels.

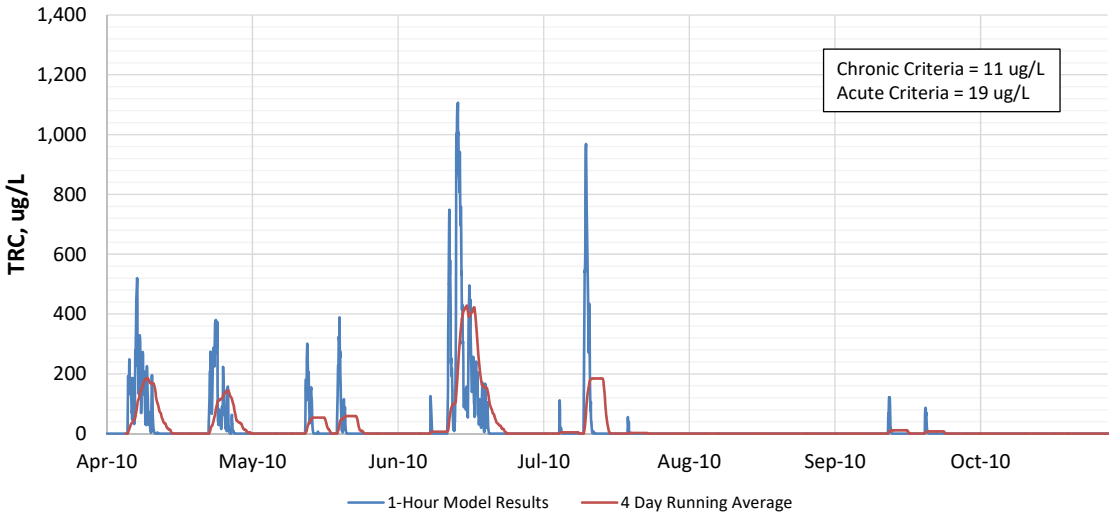
Figure 20: Modeled Ammonia Concentrations in Brush Creek below the 75th & Nall PEFTF for Baseline Conditions in 2010



3.5.2.9 Total Residual Chlorine

The primary sources of TRC included within the model were the Turkey Creek and Belinder PEFTFs, which currently use chlorine for disinfection, but do not dechlorinate. Modeled levels of TRC significantly exceed the state criterion downstream of these facilities following wet weather events (Figure 21). TRC levels typically peak soon after stormwater runoff recedes as the PEFTFs continue to discharge.

Figure 21: Modeled Total Residual Chlorine Concentrations in Brush Creek below the Belinder PEFTF for Baseline Conditions in 2010



3.5.3 Water Quality Priorities

Results of this study are ultimately intended to help JCW prioritize capital improvement decisions. To support this effort, water quality issues were prioritized to protect human health and aquatic life. Priority considerations included types of pollutants, nature of discharges, impacts to receiving streams, and JCW's ability to address the issue. For example, the study results indicate stormwater runoff and other nonpoint sources are the largest contributor of bacteria loading, but stormwater management falls outside JCW's area of responsibility. Therefore, stormwater runoff is not prioritized here. From these considerations, water quality priorities are discussed below in descending order of importance.

- ***Ammonia toxicity and nutrient impacts from the Nelson Complex WWTF*** – With an average daily dry weather flow (ADDF) of 15 mgd, the Nelson Complex WWTF exerts significant influence over water quality in Turkey Creek. Because the facility is not designed to meet KDHE's revised ammonia criteria for the protection of freshwater mussels, Turkey Creek is currently impaired for ammonia per KDHE's 2018 303(d) List and as demonstrated by the SWMM model. Additionally, the Nelson Complex WWTF is the largest contributor of nutrient loading in the study area and is identified as a contributing source in KDHE's 2017 Lower Kansas River Phosphorus TMDL.
- ***TRC toxicity and bacteria impacts from current PEFTF operations*** – Modeled TRC levels significantly exceed the criterion downstream of the Turkey Creek and Belinder PEFTFs following wet weather events. Exceedances of the TRC criterion are due to the fact that neither of these facilities currently dechlorinate. Additionally, modeled bacteria levels periodically spike downstream of all four PEFTFs due to variable disinfection quality. However, variable disinfection performance appears to

have little impact on the *E. coli* recreational season geomean, which is used by KDHE to assess recreation use attainment.

- ***Bacteria impacts from the Turkey Creek SSOs and Bypass 12*** – The model suggests that bacteria levels increase several orders of magnitude downstream of the Turkey Creek SSOs and Bypass 12 following large wet weather events. However, discharges from the Turkey Creek SSOs and Bypass 12 are relatively infrequent and have little impact on the *E. coli* recreational season geomean, which is used by KDHE to assess recreation use attainment.

3.6 TM 6 – Alternative Development and Evaluation

3.6.4 Purpose

Two primary solutions were developed through the optimization process - Alternative 1: Eliminate PEFTFs through Wet Weather Management and Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment. Each optimized solution provides a comprehensive list of capital projects and associated expenditures necessary to achieve the LOS requirements.

In order to further increase confidence in the major CIP expenditures recommended in the optimization, detailed planning level costs were developed for the underground storage alternatives, major gravity interceptor projects, pump stations and associated forcemains, and PEFTF treatment upgrades (for Alternative 2). Additional factors, including construction feasibility, operational and maintenance needs, and water quality, were also evaluated in order to conduct a triple bottom line analysis and provide the most practical set of recommendations.

The purpose of TM 6 was to document the alternatives development process, present updated alternatives and their associated costs, and summarize the triple bottom line evaluation.

3.6.5 Development of Major Capital Projects

3.6.5.1 Storage Facilities

Three (3) underground storage facilities were selected during refined optimization, two smaller facilities along the Turkey Creek interceptor and one larger facility in the Mission Main basin near Brush Creek Pump Station). Note that the sites discussed in this report are open areas that could potentially accommodate an underground storage facility; JCW does currently own the necessary property or easements to construct these facilities.

Consolidation of the two facilities on the Turkey Creek interceptor into one larger facility would reduce both operational challenges and maintenance requirements. Based on feedback from JCW during the February 4, 2019 workshop, one larger facility would be the preferred alternative. Therefore, consolidation of storage at the upstream location (south site) was included and evaluated with the options herein. Based on JCW preference, the cost estimates for all underground storage were also updated to reflect a gravity-in, pump out configuration.

A summary of selected underground storage facilities for Alternative 1 is presented in Table 14. Alternative 2 would require only storage at the South Turkey Creek site. Brush Creek storage would be exchanged for the upgraded 75th/Nall PEFTF in Alternative 2.

Table 14: Summary of Selected Storage Facilities

Facility	Storage Volume (MG)	Pump Station Capacity (MGD)	Capital Cost ($M)
South Turkey Creek Storage (1)	3.7	3.7	24.6
North Turkey Creek Storage (1)	-	-	-
Brush Creek Storage	4.4	4.4	24.1
TOTAL			**48.7**

(1) The Turkey Creek required storage was consolidated to one location at the south site, removing the need for the northern storage location.

3.6.5.2 Gravity Interceptors

Both localized gravity capacity improvements and major interceptor projects were selected in the optimization. Four (4) major interceptor projects were further evaluated for construction feasibility and refined cost estimating, two (2) in Turkey Creek and two (2) in Mission Main. Field visits were conducted to evaluate each existing alignment in greater detail and site specific details were incorporated to further refine costs. A summary of the major interceptor projects is shown in Table 15; all costs are shown in 2018 dollars.

Table 15: Summary of Gravity Main Improvements

Project	Improvement Length (LF)	Diameter Range (in)	Capital Cost ($M)
Turkey Creek Interceptor	6,650	18-30	5.1
Turkey Creek – Nieman Road Trunk	2,300	21-27	2.3
Brush Creek Interceptor	3,600	36-48	3.75
Belinder Interceptor	4,450	27-36	4.9
TOTAL	**17,000**	**18-48**	**16.05**

3.6.5.3 Pump Stations

Three (3) major pump stations were selected for upgrade during the refined optimization process, Turkey Creek, Rock Creek, and Belinder Pump Stations (PS). Brush Creek PS was not selected for upgrade due to the recommendation to store peak flows near the pump station, which resulted in no increase in peak flow to Brush Creek PS. As part of the alternative refinement process, more detailed screening and pumping improvements at each pump station site were evaluated to develop more refined improvement costs. A summary of the selected pump station upgrade is shown in Table 16; all costs are shown in 2018 dollars.

Table 16: Summary of Selected Pump Station Upgrades

Facility	Pump Station Total Capacity (MGD)	Capital Cost ($M)
Turkey Creek PS	43	8.02
Rock Creek PS [1]	24	16.98
• DW Conveyance (Phase 1)	12	11.44
• Initial WW Conveyance (Phase 1)	0	4.00
• Future WW Conveyance (Phase 2)	12	1.54
Belinder PS	54	25.66
TOTAL	**121**	**50.66**

[1] Includes replacement of the existing station to address asset renewal needs. Initial dry and wet weather conveyance costs associated with the new facility will be incurred when the new dry weather pump station is constructed, coinciding with the new WWTF, as described in the WWTF study. The future wet weather conveyance costs would be incurred when Martway PEFTF is decommissioned, and include the addition of wet weather pumps and associated electrical improvements.

3.6.5.4 Forcemains

Corresponding with the major pump station upgrades, three (3) parallel forcemains were selected during refined optimization:

- Turkey Creek PS: New 36-inch main, abandon existing 24-inch main
- Rock Creek PS: Parallel 24-inch main
- Belinder PS: Parallel 48-inch main

Field visits were conducted to evaluate each forcemain alignment in greater detail during alternatives development. Site specific details were incorporated to further refine costs (all costs are shown in 2018 dollars). Minimum depths were assumed for the forcemain installation. The conceptual alignments were set to avoid existing utilities and maintain appropriate separations where possible. A summary of the selected forcemain upgrades is shown in Table 17.

Table 17: Summary of Selected Forcemain Upgrades

Facility	Total Alignment Length (LF)	Diameter (in)	Capital Cost ($M)
Turkey Creek Forcemain	4,100	36	3.64
Rock Creek Forcemain	9,600	24	5.82
Belinder Forcemain	13,800	48	16.80
TOTAL	**27,500**	**24-48**	**26.26**

3.6.5.5 ATF

Auxiliary Treatment Facility costs for each phase of construction were developed through the WWTF study, and incorporated into the final cost estimate for the collection system.

3.6.6 Updated Alternative Costs

Total updated costs (in 2018 dollars) for Alternative 1 are presented in Table 18. The increase in cost from refined optimization was driven largely by the increased forcemain length for the Rock Creek and Belinder parallel mains and construction challenges, particularly along the Belinder forcemain alignment.

Table 18: Alternative 1 - Updated Cost Estimate Comparison

Cost Item	Total Nelson - Optimization Costs ($M)	Total Nelson - Updated Costs ($M)
Gravity Sewers	28.80	31.87
Pumping Station Upgrades (1)	37.77	39.21
Force Mains	18.06	26.26
Underground Storage Facilities	40.38	48.69
Linear Storage	-	-
PEFTF Upgrades	-	-
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	13.89	13.89
ATF Phases 1 – 3 (2)	40.76	37.52
Total, Capital Costs	**209.65**	**227.44**
Comparative O&M Increase	11.32	11.32
Total, with Incremental O&M Life Cycle Costs	**220.97**	**238.76**

(1) Includes portion of new Rock Creek pump station (constructed with treatment plant) attributable to wet weather conveyance.

(2) The WWTF project will include the construction of 7 mgd of auxiliary treatment capacity. These costs are included in the WWTF cost estimate. Future phases of ATF construction will coincide with the decommissioning of PEFTFs, resulting in increases in peak flow conveyed to the WWTF.

Total refined costs for Alternative 2 are presented in Table 19. The increase in costs from refined optimization was driven primarily by increased capital cost to upgrade the Belinder PEFTF.

Table 19: Preferred PEFTF Upgrade Alternative - Updated Cost Estimate Comparison

Cost Item	Total Nelson Optimization Costs ($M)	Total Nelson Updated Costs ($M)
Gravity Sewers	27.12	29.76
Pumping Station Upgrades [1]	-	-
Force Mains	-	-
Underground Storage Facilities	27.51	24.59
Linear Storage	-	-
PEFTF Upgrades	55.21	87.05
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	9.49	9.49
ATF Phases 1 - 3	-	-
Total, Capital Costs	**149.33**	**187.49**
Comparative O&M Increase	6.67	6.67
Total, with Incremental O&M Life Cycle Costs	**156.00**	**194.16**

[1] Includes portion of new Rock Creek pump station (constructed with treatment plant) attributable to wet weather conveyance.

A comparison of updated costs (in 2018 dollars) is presented in Table 20.

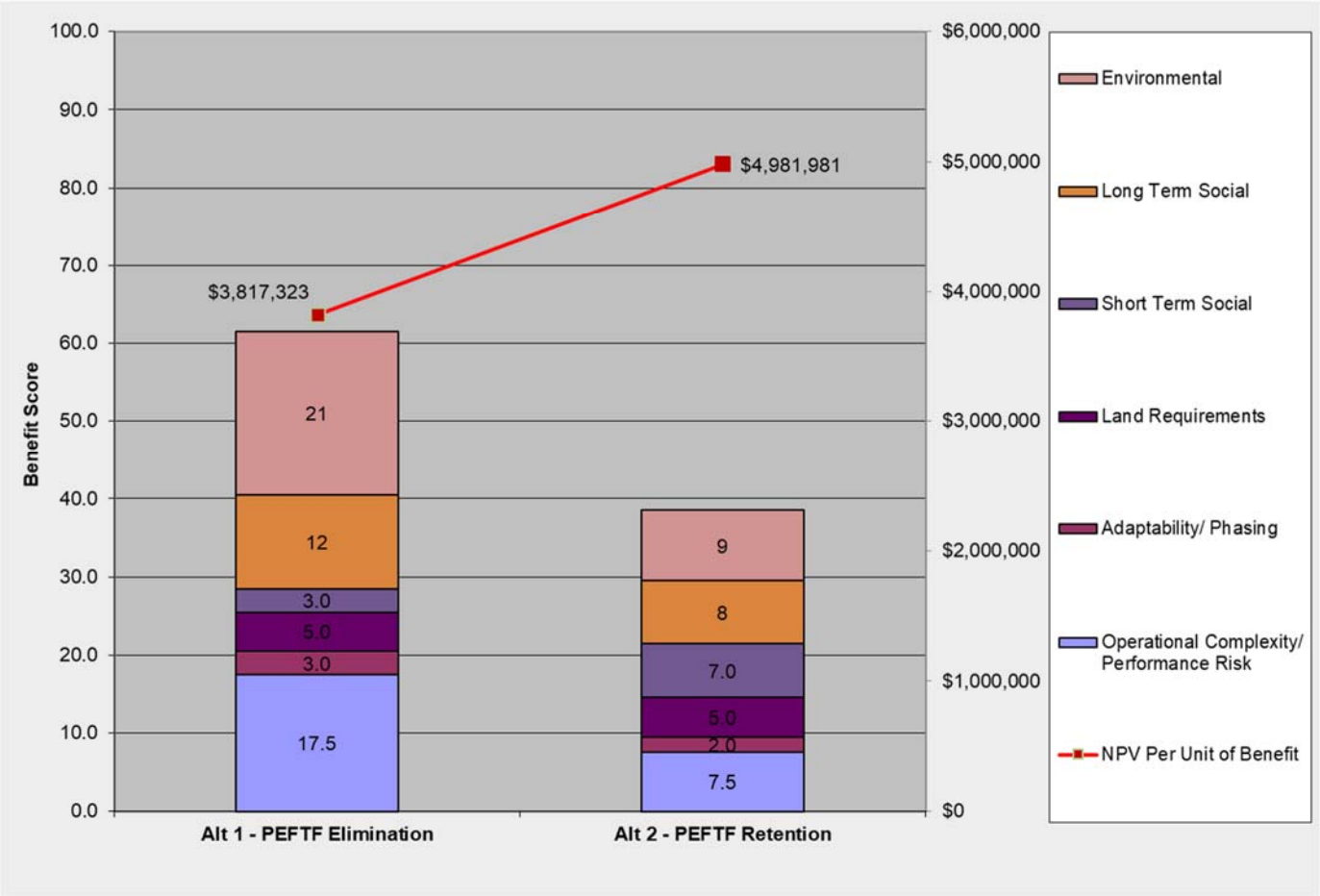
Table 20: Alternative 1 and 2 - Comparison of Updated Costs

Cost Item	Alternative 1 – Eliminate PEFTFs	Alternative 2 – Retain PEFTFs
Gravity Sewers	31.87	29.76
Pumping Station Upgrades [1]	39.21	-
Force Mains	26.26	-
Underground Storage Facilities	48.69	24.59
Linear Storages	-	-
PEFTF Upgrades	-	87.05
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	13.89	9.49
ATF Phases 1 - 3	37.52	-
Total, Capital Costs	**227.44**	**187.49**
Comparative O&M Increase	11.32	6.67
Total, with Incremental O&M Life Cycle Costs	**238.76**	**194.16**

3.6.7 Triple Bottom Line Evaluation and Selected Alternative

A triple bottom line evaluation was performed in conjunction with JCW staff to evaluate non-quantitative characteristics of the PEFTF Elimination and PEFTF Upgrade alternatives. The resulting Alternative Weighted Cost per Benefit scoring is shown in Figure 22.

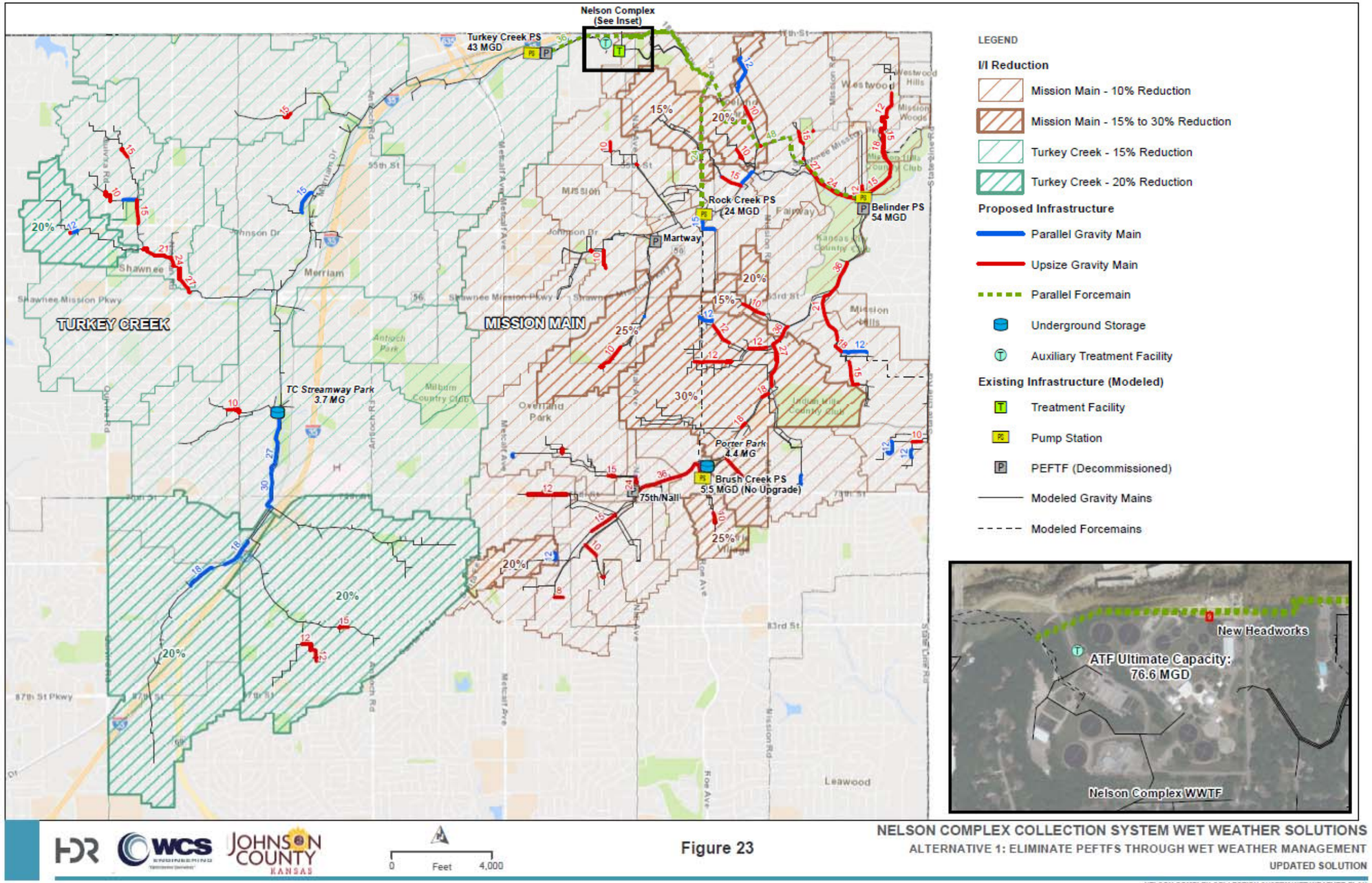
Figure 22: Alternative Weighted Cost Benefit Scoring



The Triple Bottom Line evaluation helped determine that Alternative 1 (PEFTF Elimination) has a lower cost to non-economic benefit ratio. Although the NPV of Alternative 1 is higher than Alternative 2, Alternative 1 provides better overall value to JCW when non-economic factors are taken into consideration.

Alternative 1, PEFTF Elimination was selected by JCW as the preferred wet weather management alternative. The improvements included in Alternative 1 are shown in Figure 23 on the following page.

Figure 23: Selected Wet Weather Management Solution for Nelson Complex – PEFTF Elimination



4 Summary

The capital investments required to upgrade the Nelson Complex WWTF and tributary collection system are large: $350 Million for the WWTF and $230 Million for the collection system, both figures in 2018 dollars.

In addition to the Nelson Complex service area, JCW has many other system needs that also require large investments. It has been recognized that these investments need to be prioritized in order to achieve maximum benefit per dollar spent. They also need to be scheduled over time in a manner that is financially sustainable for JCW and its ratepayers. To meet these objectives, JCW initiated a system-wide integrated planning process, and the scheduling of the Nelson improvements was determined through this process.

In summary, the Nelson Watershed Long Term Capital Improvement Plan has determined what needs to be done, however determination of the priority and schedule for each piece of the plan was completed through the integrated planning process. The results of this process is presented in a separate document entitled “JCW Integrated Management Plan, Phase 1”.

Appendix A Nelson WWTF Permit

Kansas Permit No.: M-KS45-0001

Federal Permit No.: KS0055492

KANSAS WATER POLLUTION CONTROL PERMIT AND AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Pursuant to the Provisions of Kansas Statutes Annotated 65-164 and 65-165, the Federal Water Pollution Control Act as amended, (33 U.S.C. 1251 et seq; the "Act"),

Owner:	Johnson County Wastewater
Owner's Address:	11811 S. Sunset Drive, Suite 2500 Olathe, Kansas 66061
Facility Name:	Nelson Complex Wastewater Treatment Plant
Facility Location:	N½, NE¼, Section 5, Township 12S, Range 25E Johnson County, Kansas Latitude: 39.041937 Longitude: -94.651852
Outfall Location:	NE¼, NW¼, NE¼, Section 5, Township 12S, Range 25E Latitude: 39.044112 Longitude: -94.654205
Receiving Stream:	Turkey Creek
Basin:	Kansas River Basin

is authorized to discharge from the wastewater treatment facility described herein, in accordance with permit limitations and monitoring requirements as set forth herein.

This permit shall become effective March 1, 2020, will supersede all previous permits and/or agreements in effect between the Kansas Department of Health and Environment and the permittee, and will expire January 31, 2025.

EXISTING FACILITY DESCRIPTION

Mission Township M.S.D. #1

1. Bar Screen & Grit Chamber
2. Primary Clarifiers (2)
3. Primary Trickling Filters (2)
4. Intermediate Clarifiers (4)
5. Secondary Trickling Filters (3)
6. Final Clarifiers (3)
7. Chlorination with Sodium Hypochlorite
8. Sludge Thickening & Holding Tanks
9. Sludge Dewatering
10. Design Flow = 7.0 MGD

Turkey Creek M.S.D. #1

1. Bar Screen & Grit Chambers
2. Primary Clarifiers (4)
3. Trickling Filters (4)
4. Final Clarifiers (4)
5. Chlorination with Sodium Hypochlorite
6. Sludge Thickening & Holding Tanks
7. Sludge Dewatering
8. Design Flow = 8.0 MGD

Dechlorination with sodium bisulfite prior to discharge through common Outfall 001A1

Peak Instantaneous Hydraulic Design Flow through Facility = 52 MGD

FUTURE UPGRADED FACILITY DESCRIPTION

See Page 2

FUTURE UPGRADED FACILITY DESCRIPTION (continued)

1. Mechanical Bar Screens
2. Grit Removal
3. Primary Sedimentation
4. BNR Activated Sludge Treatment Basins
5. Final Sedimentation
6. Anaerobic Digestion followed by Land Application of Biosolids
7. Dual Purpose Filters
8. Chlorination/Dechlorination
9. Effluent Re-aeration
10. Dry Weather Design Flow = 15 MGD
11. Peak Instantaneous Hydraulic Design Flow through Activated Sludge System = 45 MGD
12. Peak Instantaneous Hydraulic Design Flow through Facility = 52 MGD Initially (Approximately 122 MGD at Final Phase of Peak Flow Expansion)

Lee A. Norman MD

Secretary, Kansas Department of Health and Environment

February 21, 2020
Date

A. EFFLUENT LIMITS AND MONITORING REQUIREMENTS

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in this permit. The permit limits shall become effective on the dates specified herein. Such discharges shall be controlled, limited, and monitored by the permittee as specified. There shall be no discharge of floating solids or visible foam in other than trace amounts.

Monitoring reports shall be submitted on or before the 28th day of the following month. In the event no discharge occurs, written notification is still required.

Parameter(s)	Final Limits	Measurement Frequency	Sample Type
Monitoring Location 001AG (EDMR code: INF001AG) - Influent to Mission Township Treatment Plant			
Biochemical Oxygen Demand (5-Day)-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Suspended Solids-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Phosphorus (as P)-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Kjeldahl Nitrogen (as N)-mg/l	Monitor	3 Times/Week	24-Hour Composite
Monitoring Location 002AG (EDMR code: INF002AG) - Influent to Turkey Creek Treatment Plant			
Biochemical Oxygen Demand (5-Day)-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Suspended Solids-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Phosphorus (as P)-mg/l	Monitor	3 Times/Week	24-Hour Composite
Total Kjeldahl Nitrogen (as N)-mg/l	Monitor	3 Times/Week	24-Hour Composite

Parameter(s)	Interim Limits	Final Limits[5]	Measurement Frequency	Sample Type
Outfall 001A1 (EDMR code: EFF001A1) - Effluent at Nelson Complex Combined Outfall				
Carbonaceous Biochemical Oxygen Demand (5-Day) [1]			3 Times/Week	24-Hour Composite
Weekly Average-mg/l	40	40		
Monthly Average-mg/l	25	25		
Total Suspended Solids [1]			3 Times/Week	24-Hour Composite
Weekly Average-mg/l	45	45		
Monthly Average-mg/l	30	30		
pH - Standard Units	6.0-9.0	6.0-9.0	5 Times/Week	Grab

A. EFFLUENT LIMITS AND MONITORING REQUIREMENTS (continued)

Parameter(s)	Interim Limits	Final Limits[5]	Measurement Frequency	Sample Type
Dissolved Oxygen - mg/l				
Weekly Average (Minimum)	6.0	6.0	5 Times/Week	Grab
Ammonia (as N) - mg/l			3 Times/Week	24-Hour Composite
January				
Daily Maximum	-	24.1		
Monthly Average	10.4	3.6		
February				
Daily Maximum	-	27.5		
Monthly Average	10.0	3.9		
March				
Daily Maximum	-	25.7		
Monthly Average	6.4	3.5		
April				
Daily Maximum	-	25.2		
Monthly Average	6.6	2.8		
May				
Daily Maximum	-	16.3		
Monthly Average	4.9	2.0		
June				
Daily Maximum	-	13.9		
Monthly Average	3.9	1.7		
July				
Daily Maximum	-	7.4		
Monthly Average	3.1	1.1		
August				
Daily Maximum	-	6.2		
Monthly Average	3.3	1.0		
September				
Daily Maximum	-	9.8		
Monthly Average	4.0	1.4		
October				
Daily Maximum	-	15.1		
Monthly Average	6.7	2.1		
November				
Daily Maximum	-	26.2		
Monthly Average	9.1	3.1		
December				
Daily Maximum	-	24.1		
Monthly Average	11.3	3.6		

A. EFFLUENT LIMITS AND MONITORING REQUIREMENTS (continued)

E.coli - Colonies per 100 ml			3 Times/Week	Grab
April through October				
Weekly Geometric Average	4348	4348		
Monthly Geometric Average	262	262		
November through March				
Monthly Geometric Average	2358	2358		
Total Phosphorus (as P)[4]			Once Monthly	24-Hour Composite
Monthly Avg. Concentration - mg/l	Monitor	Monitor		
Monthly Avg. Load - lbs/day	Monitor	Monitor		Calculated[3]
Nitrate(NO_3)+Nitrite(NO_2) as N-mg/l[2]	Monitor	Monitor	Once Monthly	24-Hour Composite
Total Kjeldahl Nitrogen as N - mg/l[2]	Monitor	Monitor	Once Monthly	24-Hour Composite
Total Nitrogen (as N)(TKN + NO_3 + NO_2)[2,4]			Once Monthly	Calculated[3]
Monthly Avg. Concentration - mg/l	Monitor	Monitor		
Monthly Avg. Load - mg/l	Monitor	Monitor		
Total Residual Chlorine - µg/l [6]				
Daily Maximum	11	11	Daily	Grab
Whole Effluent Toxicity	See Supplemental Condition H.1			
Priority Pollutant Scan	See Supplemental Condition H.2			
Flow - MGD	Monitor	Monitor	Daily	Meter

Annual Rolling Average 001TT (EDMR code: AAC001TT) - Annual Rolling Average Calculations at Effluent Outfall 001A1

Total Phosphorus (as P)[4]			Once Monthly	Calculated[3]
Annual Avg. Concentration - mg/l	Monitor	Monitor		
Annual Avg. Load - lbs/day	Monitor	125.31[5]		
Total Nitrogen (as N)[4]			Once Monthly	Calculated[3]
Annual Avg. Concentration - mg/l	Monitor	Monitor		
Annual Avg. Load - lbs/day	Monitor	Monitor		

1 Minimum removal of 85% required for Total Suspended Solids and Biochemical Oxygen Demand (5-Day) based on monthly average influent and effluent concentrations.

2 Permittee shall sample for these tests on the same day. The Minimum Reportable Limit (MRL) for TKN is 1 mg/l and for nitrate + nitrite is 0.1 mg/l. Values less than the MRL shall be reported using the less than sign (<) with the MRL value but for purposes of calculating and reporting the total nitrogen result, less than values shall be defaulted to zero.

A. EFFLUENT LIMITS AND MONITORING REQUIREMENTS (continued)

3 The values for parameters shown as "Calculated" will be calculated by the on-line eDMR program. The values cannot be entered into the on-line eDMR program by the permittee. In addition to these calculated values, for parameters with Annual Average reporting requirements, the permittee will see monthly average values calculated by the eDMR program and displayed in the raw data tables. The monthly average parameter short name and (parameter code) for total phosphorus is T-P MA (KS665) and for total nitrogen is T.N2 MA (KS600) in lbs/day. The monthly averages are required intermediary calculated values used for purposes of calculating the Annual Averages and are shown for purposes of checking those calculations. The Annual Average calculations are for a rolling 12-month time period calculated on a monthly basis.

4 See Special Conditions.

5 See Schedule of Compliance.

6 This test is required only if disinfection is by chlorination. Permittee shall conduct testing for total residual chlorine according to the methods prescribed in 40 CFR Part 136. The current acceptable quantification level for total residual chlorine in wastewater is 100 micrograms/L. Test results in excess of the quantification level are violations of the permit limits.

B. STANDARD CONDITIONS

In addition to the specified conditions stated herein, the permittee shall comply with the attached Standard Conditions dated March 1, 2018.

C. SPECIAL CONDITIONS

1. NUTRIENT REMOVAL

This facility was not designed to achieve nutrient removal. The permittee should strive to operate the treatment facility to maximize the level of nutrient removal to achieve the following goals as annual average target effluent levels from the mechanical plant:

Total Nitrogen (as N) - mg/l	≤	10.0 as an annual average goal
Total Phosphorus (as P) - mg/l	≤	1.0 as an annual average goal
Total Phosphorus (as P) - lbs/day	≤	125.31 as an annual average limit

These target values for concentration (mg/l) are not to be considered as effluent limits for this permit. KDHE reserves the right to reopen this permit to impose limits for nutrients pursuant to Kansas law when such criteria are adopted in the Kansas Surface Water Quality Standards.

A TMDL for Total Phosphorus has been adopted in the Kansas Surface Water Quality Standards, and the value for Total Phosphorus mass (lbs/day) is a limit to be imposed through the Special Condition and Schedule of Compliance of this permit. The annual averages are for a rolling 12-month time period calculated on a monthly basis.

2. Flow through the Facility

For the Final Limits applicable to the Future Upgraded Facility after the new construction is placed into service, a portion of the peak wet-weather influent flow shall be spilt directly to filtration and disinfection once flow has been maximized through the activated sludge treatment units at a level which does not cause a washout of activated sludge biomass or other process upsets (see Future Upgraded Facility Description design flow thresholds). The use of the axillary wet weather flow treatment configuration is not an in-plant diversion and not subject to Standard Conditions 7, 8, and 9.

D. SCHEDULE OF COMPLIANCE

Johnson County Wastewater has submitted to KDHE an Integrated Management Plan (IMP) dated September 2019 to address system-wide wastewater infrastructure needs. KDHE has concurred with the IMP through correspondence dated October 21, 2019 and has agreed to use the IMP and KDHE-approved updates when making future regulatory decisions, including compliance schedules. Within 1 year following the substantial completion of the project to upgrade the Nelson Complex WWTF as addressed in the IMP and Consent Order 19-E-5 BOW, the permittee shall achieve compliance with the final permit limits for Outfall 001A1 and Annual Rolling Average Outfall 001TT. The first monthly average value for the Annual Rolling Average Outfall 001TT shall be the 13th month after substantial completion.

E. SLUDGE DISPOSAL

Sludge disposal shall be in accordance with the 40 CFR Part 503 sludge regulations.

F. PRETREATMENT PROGRAM

The permittee shall implement and administer the pretreatment program in accordance with the General Pretreatment Regulations 40 CFR Part 403, as approved by the Kansas Department of Health and Environment and the Environmental Protection Agency.

G. ADDITIONAL INFORMATION

EPA has promulgated a final rule requiring regulated entities to report DMR data electronically. Also, KAR 28-16-63 requires permittees to report NPDES data in a form required by KDHE. KDHE has developed electronic reporting tools to assist permittees in complying with the EPA electronic reporting rule and KAR 28-61-63. Unless a waiver has been approved by KDHE, permittees are required to submit reports electronically.

H. BIOMONITORING AND PRIORITY POLLUTANTS

1. Whole Effluent Toxicity

a. Chronic Whole Effluent Toxicity (WET) testing shall be conducted on a 24-hr composite sample from Outfall 001A1 once in calendar year 2021 and once in calendar year 2023. The 25% Inhibition Concentration, IC25, shall be equal to or greater than 96% effluent. Test results less than 96% are violations of this permit. The test procedures shall use the seven day static renewal test method in accordance with the EPA document, Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, fourth edition, October 2002 using test organisms *Pimephales promelas* (fathead minnow) and *Ceriodaphnia dubia* (water flea) within a dilution series containing 0%, 25%, 50%, 75%, 96%, and 100% effluent. KDHE reserves the right to increase or decrease testing frequency based upon compliance history and toxicity testing results.

b. If the WET test results indicate the IC25 is equal to or greater than 96% effluent, the effluent has passed the toxicity test Samples results shall be submitted to kdhe.dmr4kdhe@ks.gov within 30 days of receipt of the results.

c. If the WET test results indicate the IC25 is less than 96% effluent, the effluent has failed the toxicity test and the permittee shall immediately notify KDHE by telephone at (785) 296-5517 and submit to KDHE a copy of the test report within five days of receipt of the information. KDHE reserves the right to require the permittee to take such actions as are reasonable to identify and remedy any identified or predicted toxic conditions in the receiving stream outside of the mixing zone which is caused by the permittee's effluent.

H. BIOMONITORING AND PRIORITY POLLUTANTS (continued)

d. Permittee shall also test a portion of the same effluent sample used for the WET test for the following substances (required minimum reportable limit are in parenthesis):

Antimony (10 µg/L)*	Nickel (10 µg/L)*
Arsenic (10 µg/L)*	Selenium (5 µg/L)*
Beryllium (5 µg/L)*	Silver (2 µg/L)*
Cadmium (2 µg/L)*	Thallium (10 µg/L)*
Chromium (10 µg/L)*	Zinc (20 µg/L)*
Copper (10 µg/L)*	Ammonia as "N" (0.2 mg/l)
Lead (5 µg/L)*	Total Hardness as CaCO3 mg/l
Mercury (0.2 µg/L-Cold Vapor Method)	pH

* Parameter shall be tested and reported as "total recoverable" metals.

e. Permittee shall coordinate sampling for this test with other monitoring requirements of this permit and may use the test results to satisfy this and other corresponding testing requirements. The permittee shall use a laboratory approved by KDHE for Whole Effluent Toxicity testing.

2. Priority Pollutant Scan

Permittee shall conduct a Priority Pollutant Scan on the effluent from Outfall 001A1 for the parameters listed in Table I, Priority Pollutant Scan, on the following pages. The Priority Pollutant Scan shall be conducted once in calendar year 2020, once in calendar year 2022, and once in calendar year 2024. Samples results shall be submitted to kdhe.dmr4kdhe@ks.gov within 30 days of receipt of the results.

Sample type shall be 24-hour composites except for Volatiles which shall be a grab sample. See Biomonitoring and Priority Pollutants H.1.d. for minimum detection limits for certain metals in the Priority Pollutant Scan.

Table I - Priority Pollutant Scan*

Metals (µg/l)
- Total Antimony
- Total Arsenic
- Total Beryllium
- Total Cadmium
- Total Chromium
- Total Copper
- Total Lead
- Total Mercury
- Total Nickel
- Total Selenium
- Total Silver
- Total Thallium
- Total Zinc

Pesticides (µg/l)
- Aldrin
- Alpha-BHC**
- Beta-BHC**
- Gamma-BHC**
- Delta-BHC**
- Chlordane
- 4,4-DDT
- 4,4-DDD
- 4,4-DDE
- Dieldrin
- Alpha-endosulfan
- Beta-endosulfan
- Endosulfan sulfate
- Endrin
- Endrin aldehyde
- Heptachlor
- Heptachlor epoxide
- Toxaphene

Polychlorinated Biphenyls (µg/l)
- PCB-1242
- PCB-1254
- PCB-1221
- PCB-1232
- PCB-1248
- PCB-1260
- PCB-1016

Base/Neutral (µg/l)
- Acenaphthene
- Acenaphthylene
- Anthracene
- Benzidine
- Benzo(a) anthracene
- Benzo(a)pyrene
- Benzo(k)fluoranthene
- Benzo (ghi) perylene
- Benzo (b) fluoranthene
- Bis(2-chloroethoxy)methane
- Bis(2-chloroethyl)ether
- Bis(2-ethylhexyl)phthalate
- Bis(2-chloroisopropyl) ether
- 1,2-diphenylhydrazine
- Fluoranthene
- Fluorene
- Nitrobenzene
- N-nitrosodimethylamine
- N-nitrosodi-n-propylamine
- N-nitrosodiphenylamine
- Phenanthrene
- Pyrene
- 1,2,4-trichlorobenzene
- 4-bromophenyl phenyl ether
- Butyl benzyl phthalate
- 2-chloronaphthalene
- 4-chlorophenyl phenyl ether
- Chrysene
- Dibenzo(a,h) anthracene
- 1,2-dichlorobenzene
- 1,3-dichlorobenzene
- 1,4-dichlorobenzene
- 3,3-dichlorobenzidine
- Dimethyl phthalate
- Diethyl phthalate
- Di-n-butyl phthalate
- 2,4-dinitrotoluene
- 2,6-dinitrotoluene
- Di-n-octyl phthalate
- Hexachlorobenzene
- Hexachlorobutadiene
- Hexachlorocyclopentadiene
- Hexachloroethane
- Indeno (1,2,3-cd) pyrene
- Naphthalene
- Isophorone

Acid Compounds (µg/l)
- 2-chlorophenol
- 2,4-dichlorophenol
- 2,4-dimethylphenol
- 2,4-dinitrophenol
- 2-nitrophenol
- 4-nitrophenol
- Parachlorometa cresol
- Pentachlorophenol
- Phenol
- 4,6-dinitro-o-cresol
- 2,4,6-trichlorophenol

Volatiles (µg/l)
- Acrolein
- Acrylonitrile
- Benzene
- Bromoform
- Carbon Tetrachloride
- Chlorobenzene
- Chlorodibromomethane
- Chloroethane
- 2-chloroethylvinyl ether
- Chloroform
- Dichlorobromomethane
- 1,1-dichloroethane
- 1,2-dichloroethane
- 1,1-dichloroethylene
- 1,2-dichloropropane
- 1,3-dichloropropylene
- Ethylbenzene
- Methyl bromide
- Methyl chloride
- Methylene chloride
- 1,1,2,2-tetrachloroethane
- Tetrachloroethylene
- Toluene
- 1,2 trans-dichloroethylene
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- Trichloroethylene
- Vinyl chloride

Miscellaneous
- Total Cyanide (mg/l)***
- ~~Asbestos (cnt/l)~~
- ~~2,3,7,8-TCDD (Dioxin) (µg/l)~~

* Testing not required for pollutants with a strike-through.

** Scientific name is hexachlorocyclohexane

*** The total cyanide analysis must include preliminary treatment of the sample to avoid NO_2^- interference. See Standard Methods for the Examination of Water and Wastewater, 22nd Edition, 4500-CN^- B. Preliminary Treatment of Samples.

STANDARD CONDITIONS FOR
KANSAS WATER POLLUTION CONTROL AND
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMITS

1. Representative Sampling and Discharge Monitoring Report Submittals:

A. Samples and measurements taken as required herein shall be representative of the quality and quantity of the monitored discharge. Test results shall be recorded for the day the samples were taken. If sampling for a parameter was conducted across more than one calendar day, the test results may be recorded for the day sampling was started or ended. All samples shall be taken at the locations designated in this permit, and unless specified, at the outfall/monitoring location(s) before the wastewater joins or is diluted by any other water or substance.

B. Monitoring results shall be recorded and reported on forms acceptable to the Division and submitted no later than the 28th day of the month following the completed reporting period. Signed and certified copies of other reports, required herein, prepared in accordance with KAR 28-16-59, may be faxed to 785.559.4257, e-mailed as scanned attachments to kdhe.dmr4kdhe@ks.gov , or sent by U.S. mail to:

Kansas Department of Health & Environment
Bureau of Water-Technical Services Section
1000 SW Jackson Street, Suite 420
Topeka, KS 66612-1367

2. Definitions:

A. Unless otherwise specifically defined in this permit, the following definitions apply:

1. The "Daily Maximum" is the total discharge by weight or average concentration, measurement taken, or value calculated during a 24-hour period. The parameter, pH, is limited as a range between and including the values shown.

2. The "Weekly Average" is the arithmetic mean of the value of test results from samples collected, measurements taken, or values calculated during four monitoring periods in each month consisting of calendar days 1-7, 8-14, 15-21 and 22 through the end of the month.

3. The "Monthly Average", other than for E. coli bacteria, is the arithmetic mean of the value of test results from samples collected, measurements taken, or values calculated during a calendar month. The monthly average is determined by the summation of all calculated values or measured test results divided by the number of calculated values or test results reported for that parameter during the calendar month. The monthly average for E. coli bacteria is the geometric average of the value of the test results from samples collected in a calendar month. The geometric average can be calculated by using a scientific calculator to multiply all the E. coli test results together and then taking the nth root of the product where n is the number of test results. Non-detect values shall be reported using the less than symbol (<) and the minimum detection or reportable value. To calculate average values, non-detects shall be defaulted to zero (or one for geometric averages). Greater than values shall be reported using the greater than symbol (>) and the reported value. To calculate average values, the greater than reported value shall be used in the averaging calculation.

B. A "grab sample" is an individual sample collected in less than 15 minutes. A "composite sample" is a combination of individual samples in which the volume of each individual sample is proportional to the flow, or the sample frequency is proportioned to the flow rate over the sample period, or the sample frequency is proportional to time.

C. The terms "Director", "Division", and "Department" refer to the Director, Division of Environment, Kansas Department of Health, and Environment, respectively.

D. "Severe property damage" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of an in-plant diversion. Severe property damage does not mean economic loss caused by delays in production.

E. "Bypass" means the intentional diversion of waste streams from any portion of the treatment facility.

3. Schedule of Compliance: No later than 14 calendar days following each date identified in the "Schedule of Compliance," the permittee shall submit via mail, e-mail or fax per paragraph 1.B above, either a report of progress or, in the case of specific action being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements, or, if there are no more scheduled requirements, when such noncompliance will be corrected.

4. Test Procedures: All analyses required by this permit shall conform to the requirements of 40 CFR Part 136, unless otherwise specified, and shall be conducted in a laboratory accredited by the Department. For each measurement or sample, the permittee shall record the exact place, date, and time of measuring/sampling; the date and time of the analyses, the analytical techniques or methods used, minimum detection or reportable level, and the individual(s) who performed the measuring/sampling and analysis and, the results. If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved procedures, the results shall be included in the Discharge Monitoring Report form required in 1.B. above. Such increased frequencies shall also be indicated.

5. Change in Discharge: All discharges authorized herein shall be consistent with the permit requirements. The discharge of any pollutant not authorized by this permit or of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of this permit. Any anticipated facility expansions, production or flow increases, or production or wastewater treatment system modifications which result in a new, different, or increased discharge of pollutants shall be reported to the Division at least one hundred eighty (180) days before such change.

6. Facilities Operation: The permittee shall always properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the requirements of this permit and Kansas and Federal law. Proper operation and maintenance also include adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the requirements of this permit. The permittee shall take all necessary steps to minimize or prevent any adverse impact to human health or the environment resulting from noncompliance with any effluent limits specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge. When necessary to maintain compliance with the permit requirements, the permittee shall halt or reduce those activities under its control which generate wastewater routed to this facility.

7. Incidents:

"Collection System Diversion" means the diversion of wastewater from any portion of the collection system.

"In-Plant Diversion" means routing the wastewater around any treatment unit in the treatment facility through which it would normally flow.

"In-Plant Flow Through" means an incident in which the wastewater continues to be routed through the equipment even though full treatment is not being accomplished because of equipment failure for any reason.

"Spill" means any discharge of wastewater, sludge or other materials from the treatment facility other than effluent or as more specifically described by other "Incidents" terms.

"Upset" means an exceptional incident in which there is unintentional and temporary noncompliance or anticipated noncompliance with permit effluent limits because of factors beyond the reasonable control of the permittee, as described by 40 C.F.R. 122.41(n).

8. Diversions not Exceeding Limits: The permittee may allow any diversion to occur which does not cause effluent limits to be exceeded, but only if it also is for essential maintenance to assure efficient operation. Such diversions are not subject to the Incident Reporting requirements shown below.

9. Prohibition of an In-Plant Diversion: Any in-plant diversion from facilities necessary to maintain compliance with this permit is prohibited, except: (a) where the in-plant diversion was unavoidable to prevent loss of life, personal injury, or severe property damage; (b) where there were no feasible alternatives to the in-plant diversion, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime and (c) the permittee submitted a notice as required in the Incident Reporting paragraph below. The Director may approve an anticipated in-plant diversion, after considering its adverse effects, if the Director determines that it will meet the three conditions listed above.

10. Incident Reporting: The permittee shall report any unanticipated collection system diversion, in-plant diversion, in-plant flow through occurrences, spill, upset, or any violation of a permitted daily maximum limit within 24 hours from the time the permittee became aware of the incident. A written submission shall be provided within 5 days of the time the permittee became aware of the incident. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times; and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance. An Incident Report form is available at www.kdheks.gov/water/tech.html.

    For an anticipated incident or any planned changes or activities in the permitted facility that may result in noncompliance with the permit requirements, the permittee shall submit written notice, if possible, at least ten days before the date of the event.

    For other noncompliance, the above information shall be provided with the next Discharge Monitoring Report.

11. Removed Substances: Solids, sludges, filter backwash, or other pollutants removed in the course of treatment of water shall be utilized or disposed of in a manner acceptable to the Division.

12. Power Failures: The permittee shall provide an alternative power source sufficient to operate the wastewater control facilities or otherwise control pollution and all discharges upon the loss of the primary source of power to the wastewater control facilities.

13. Right of Entry: The permittee shall allow authorized representatives of the Division of Environment or the Environmental Protection Agency upon the presentation of credentials, to enter upon the permittee's premises where an effluent source is located, or in which are located any records required by this permit, and at reasonable times, to have access to and copy any records required by this permit, to inspect any facilities, monitoring equipment or monitoring method required in this permit, and to sample any influents to, discharges from or materials in the wastewater facilities.

14. Transfer of Ownership: The permittee shall notify the succeeding owner or controlling person of the existence of this permit by certified letter, a copy of which shall be forwarded to the Division. The succeeding owner shall secure a new permit. This permit is not transferable to any person except after notice and approval by the Director. The Director may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary.

15. Records Retention: Unless otherwise specified, all records and information resulting from the monitoring activities required by this permit, including all records of analyses and calibration and maintenance of instruments and recordings from continuous monitoring instruments, shall be retained for a minimum of 3 years, or longer if requested by the Division. Biosolids/sludge records and information are required to be kept for a minimum of 5 years, or longer if requested by the Division. Groundwater monitoring data, including background samples results, shall be kept for the life of the facility regardless of ownership.

16. Availability of Records: Except for data determined to be confidential under 33 USC Section 1318, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Effluent data shall not be considered confidential. Knowingly making any false statement on any such report or tampering with equipment to falsify data may result in the imposition of criminal penalties as provided for in 33 USC Section 1319 and KSA 65-170c.

17. Permit Modifications and Terminations: As provided by KAR 28-16-62, after notice and opportunity for a hearing, this permit may be modified, suspended or revoked or terminated in whole or in part during its term for cause as provided, but not limited to those set forth in KAR 28-16-62 and KAR 28-16-28b through g. The permittee shall furnish to the Director, within a reasonable amount of time, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish upon request, copies of all records required to be kept by this permit. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

18. Toxic Pollutants: Notwithstanding paragraph 17 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified at such effluent standards) is established under 33 USC Section 1317(a) for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition. Nothing in this permit relieves the permittee from complying with federal toxic effluent standards as promulgated pursuant to 33 USC Section 1317.

19. Administrative, Civil and Criminal Liability: The permittee shall comply with all requirements of this permit. Except as authorized in paragraph 9 above, nothing in this permit shall be construed to relieve the permittee from administrative, civil or

criminal penalties for noncompliance as provided for in KSA 65-161 et seq., and 33 USC Section 1319.

20. Oil and Hazardous Substance Liability: Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject to under 33 USC Section 1321 or KSA 65-164 et seq. A municipal permittee shall promptly notify the Division by telephone upon discovering crude oil or any petroleum derivative in its sewer system or wastewater treatment facilities.

21. Industrial Users: A municipal permittee shall require any industrial user of the treatment works to comply with 33 USC Section 1317, 1318 and any industrial user of storm sewers to comply with 33 USC Section 1308.

22. Property Rights: The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights nor any infringements of or violation of federal, state, or local laws or regulations.

23. Operator Certification: The permittee shall, if required, ensure the wastewater facilities are under the supervision of an operator certified by the Department. If the permittee does not have a certified operator or loses its certified operator, appropriate steps shall be taken to obtain a certified operator as required by KAR 28-16-30 et seq.

24. Severability: The provisions of this permit are severable. If any provision of this permit or any circumstance is held invalid, the application of such provision to other circumstances and the remainder of the permit shall not be affected thereby.

25. Removal from Service: The permittee shall inform the Division at least three months before a pumping station, treatment unit, or any other part of the treatment facility permitted by this permit is to be removed from service and shall make arrangements acceptable to the Division to decommission the facility or part of the facility being removed from service such that the public health and waters of the state are protected.

26. Duty to Reapply: A permit holder wishing to continue any activity regulated by this permit after the expiration date, must apply for a new permit at least 180 days prior to expiration of the permit.

27. Publicly owned treatment works (POTWs): All POTWs shall provide adequate notice to the Director of the following per 40 CFR 122.42(b):

    A. Any new introduction of pollutants into the POTW from a non-domestic source which would be subject to section 301 or 306 of the CWA ; and

    B. Any substantial change in the volume or character of pollutants being introduced into a POTW by a non-domestic source.

    C. For purposes of this paragraph, adequate notice shall mean within 30 days of the POTW being aware of the introduction of pollutants and shall include information on the quality and quantity of influent introduced into the POTW, and any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

28. POTW regulated pretreatment program requirements: For POTWs with an approved pretreatment program, the POTW shall:

    A. Identify, in terms of character and volume of pollutants, any Significant Industrial Users discharging into the POTW subject to Pretreatment Standards under section 307(b) of CWA and 40 CFR part 403.

    B. Provide to KDHE and EPA a written technical evaluation of the need to develop new local limits or revise existing local limits under 40 CFR 403.5(c)(1).

29. This permit may be reopened and modified if KDHE and/or EPA determines the permittee shall develop and approved pretreatment program that complies with 40 CFR, Part 403.

Nelson Complex WWTF Improvements Facility Plan

Technical Memorandum #1
Basis of Analysis

August 2018

FINAL

JOHNSON COUNTY KANSAS
Wastewater

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Appendices

Appendix A In-Plant Pumping Capacities and Unit Process Sizing

Appendix B Drawings

Appendix C Enhanced Sampling Results

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ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CPES	CH2M Parametric Cost Estimating System
COD	Chemical Oxygen Demand
DLSMB	Douglas L. Smith Middle Basin
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
FPD	Facility Protection Device
GPD	Gallons per Day
gpm	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
mgal	Million Gallons
mgd	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/L	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NCAC	New Century Air Center
NH3-N	Ammonia Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
O&M	Operation and Maintenance

PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
Pro2D^2	Professional Process Design and Dynamics Whole Plant Simulator by CH2M
PS	Pump Station
R&R	Repair and Rehabilitation
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

1 Introduction

1.1 Background

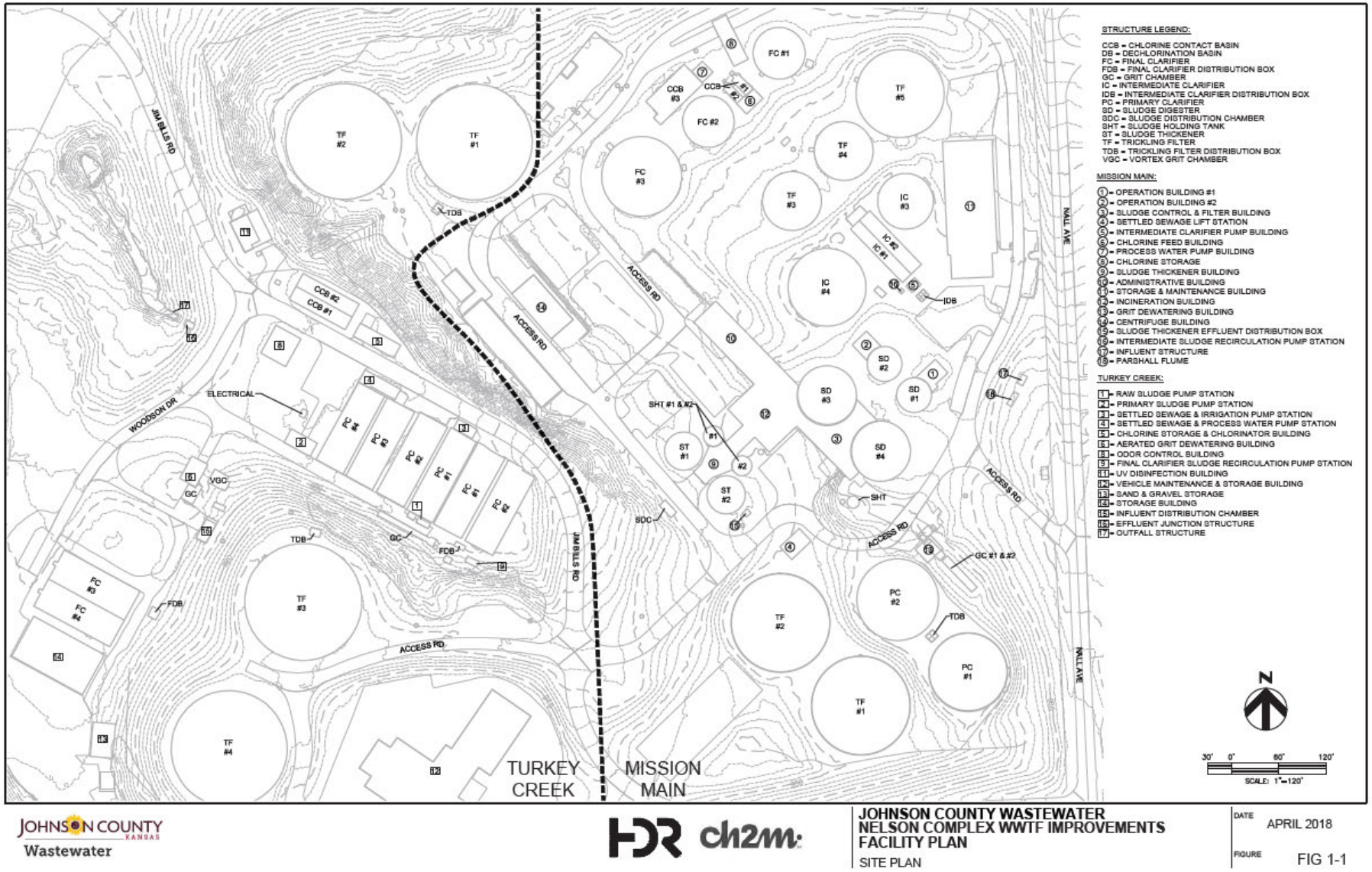
The Myron K. Nelson Wastewater Treatment Complex (Nelson Complex) is comprised of two separate treatment trains, referred to as Mission Main (originally Mission Township Main Sewer District 1, MTM1) and Turkey Creek (originally Shawnee Mission Turkey Creek, SMTC). These were originally two separate wastewater treatment facilities (WWTFs) sharing a common site. They have since been consolidated into a single facility with two distinct process trains that share a common disinfection and biosolids facilities and a single permitted outfall. A site plan of the existing facility is shown in Figure 1-1.

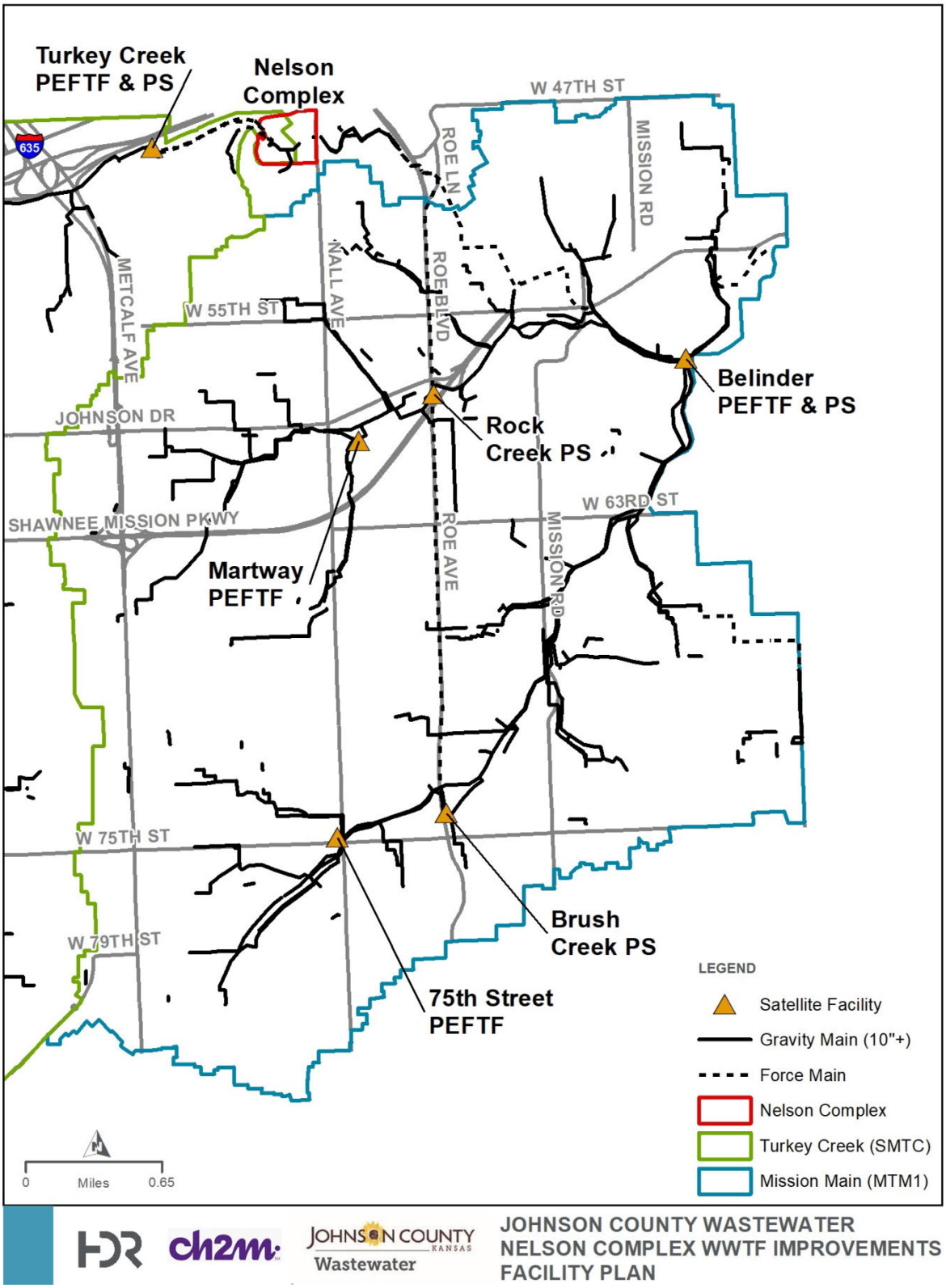
The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two WWTF trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or which discharge directly from the collection system to the creek after providing primary treatment and disinfection. Figure 1-2 shows the location of the pump stations and PEFTFs within the watersheds. In the Mission Main watershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flows to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow to the WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the WWTF. On the Turkey Creek side, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the WWTF.

The WWTF and the satellite PSs and PEFTFs face a number of significant challenges. These can generally be categorized into three main categories:

- *Sustainability* – some of the facilities at the WWTF and at the satellite locations have been in service since the late 1940s. By all accounts, many of the facilities are well beyond their useful life and the costs for repair and rehabilitation (R&R) to keep them operational are becoming problematic. Figures of up to $40 million in R&R have been cited as necessary to keep just the existing WWTF serviceable for the next 10 – 15 years.
- *Regulatory Compliance* – more stringent discharge limits are anticipated with the WWTF's next permit cycle, including ammonia and possibly nitrogen and phosphorus. The existing trickling filter technology cannot meet these limits, and replacement with a state-of-the-art technology such as a biological nutrient removal (BNR) treatment facility will be required. In addition, the collection system wet weather issues will need to be addressed, and a long-term solution to the PEFTFs determined.
- *Siting and Logistics* – implementing a new treatment scheme at the existing WWTF will be challenging in that space is limited and new facilities will have to be constructed while the existing plant remains in operation. A further complication is that the Mission Main and Turkey Creek portions of the plant are on two separate hydraulic gradients, and the desire for the new facility, both economically and operationally, is to have a single hydraulic gradient. Similarly, space is limited at the pump stations and PEFTFs, with these being located in heavily developed residential and commercial areas, and improvements would have to be made while the facilities remain in service

Figure 1-1: Site Plan





HDR ch2m JOHNSON COUNTY KANSAS Wastewater

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN

Figure 1-2: Satellite Facilities

1.2 Purpose and Scope

The MK Nelson WWTF Improvements Facility Plan will be one of several study efforts that collectively will determine the optimum plan for the Nelson Complex and watershed. Other contributing studies include:

1.2.1 The M.K. Nelson Nutrient Removal Pre-Design Study (2009)

This was completed pursuant to a letter from USEPA, Region 7 to JCW dated December 4, 2007. The purpose of the study was to determine the cost and feasibility of upgrades to meet nutrient goals for nitrogen and phosphorus. This current study will draw from the 2009 study where appropriate.

1.2.2 Nelson Complex and Middle Basin Treatment Facilities Solids Handling Study (ongoing)

A portion of this study has identified a long term plan for implementation of anaerobic digestion for the Nelson Complex. The findings of this study will be incorporated into the current Facility Plan.

1.2.3 Nelson Complex Service Area, EPA 308(a) Response Document

A request pursuant to Section 308(a) of the Clean Water Act was received by JCW on December 4, 2007. The request related primarily to the PEFTFs. This triggered extensive study of the collection system culminating in an initial response document submitted in 2009 with a follow up document in 2015. The current study will draw from these documents where appropriate.

> Note: There are a number of regulatory drivers impacting the Nelson facilities and watershed. While they have been mentioned briefly here, they will be discussed in greater detail in Technical Memorandum No. 2 – Regulatory Considerations.

1.2.4 M.K. Nelson Complex Collection System Wet Weather Plan Development and Optimization

This study will take place simultaneously with the Facility Plan and the two studies will be highly interdependent. The Facility Plan scope includes evaluating improvements and associated costs for each of the PSs and PEFTFs. This information will be used to determine the optimum plan for the collection system. This in turn may impact the WWTF if auxiliary treatment is found to be part of the optimum plan. These two studies will also be complementary in supporting development of a regulatory and permitting strategy that addresses the entire Nelson watershed.

The primary objectives of the M.K. Nelson WWTF Improvements Facility Plan and its subsequent implementation are:

- Replace obsolete facilities with appropriate technology consistent with current and anticipated water quality standards.
- Support the collection system optimization in determining the optimum wet weather management plan.
- Negotiate a discharge permit and phased implementation plan.
- Develop life cycle program costs and rate impacts.
- Negotiate implementation schedule to balance rate impacts with regulatory objectives.

This Facility Plan will set the stage for the Nelson Complex WWTF upgrade project, for which design is currently expected to begin in 2022, with construction beginning in 2024.

This Facility Plan will consist of seven technical memoranda (TMs):

- TM 1 – Basis of Analysis
- TM 2 – Regulatory Consideration
- TM 3 – Alternative Screening
- TM 4 – Alternative Evaluation
- TM 5 – Collection System Facility Evaluation and Optimization Support
- TM 6 – Project Development
- TM 7 – Financial Evaluation

A Supplemental Task 10 – Limited Influent Sampling Program, and Supplemental Task 11 – Near Term Wet Weather Operational Improvements are also included.

The objectives of TM 1 – Basis of Analysis are as follows:

- Confirm the configuration, major equipment, capacities, and general condition of facilities at the WWTF, PSs, and PEFTFs.
- Confirm design flows for the WWTF, PSs, and PEFTFs.
- Establish influent loadings to the WWTF based on historical data and the limited influent sampling program.
- Develop a process model, input design flows and loads into the model, and obtain a pseudo mass balance for the liquid and solids processes.

TM 1 will ensure that all subsequent work in the facility planning effort will be based on a complete, accurate understanding of existing conditions.

2 Existing Facilities

2.1 WWTF Liquids Processing

As discussed previously, the Mission Main and Turkey Creek WWTF's essentially function as two separate facilities prior to combining ahead of ultraviolet (UV) disinfection and discharge. Mission Main is a 2-stage trickling filter plant with primary, intermediate, and final clarification, while Turkey Creek is a single stage trickling filter plant with primary and final clarification. Process schematics of both treatment trains are show in Figure 2-1. The facility descriptions and noted capacities listed in the National Pollutant Discharge Elimination System (NPDES) permit, Kansas Permit No. M-KS45-0001, are as follows:

FACILITY DESCRIPTION:

Mission Township M.S.D. #1

1. Bar Screen & Grit Chamber
2. Primary Clarifiers (2)
3. Primary Trickling Filters (2)
4. Intermediate Clarifiers (4)
5. Secondary Trickling Filters (3)
6. Final Clarifiers (3)
7. Sludge Thickening & Holding Tanks
8. Sludge Dewatering
9. Design Flow = 7.0 mgd

Turkey Creek M.S.D. #1

1. Bar Screen & Grit Chamber
2. Primary Clarifiers (4)
3. Trickling Filters (4)
4. Final Clarifiers (4)
5. Sludge Thickening & Holding Tanks
6. Sludge Dewatering
7. Design Flow = 8.0 mgd

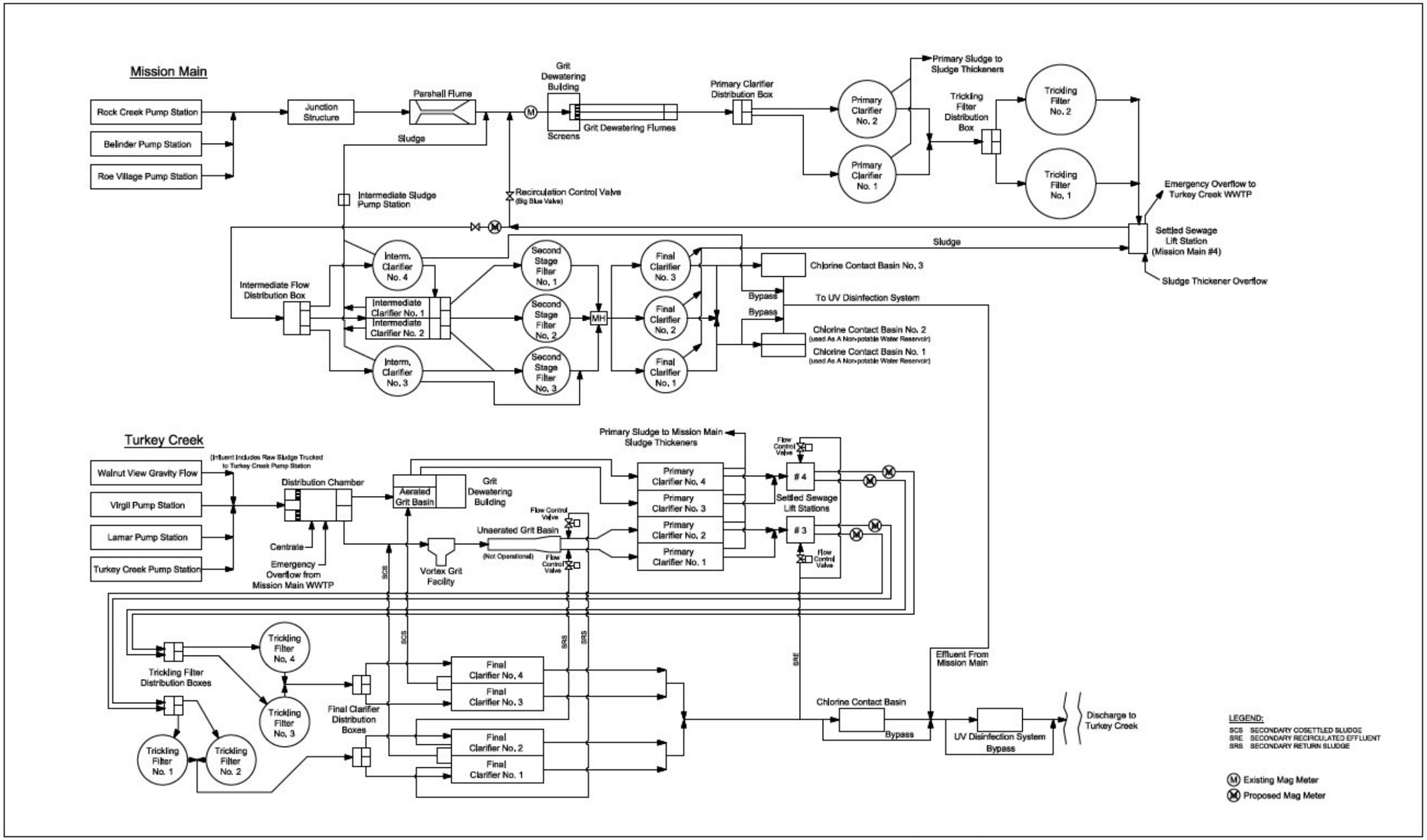
Disinfection through common Outfall 001:

Primary: UV Disinfection
Backup: Chlorination with hypochlorite and dechlorination with bisulfite

There is some cross flow between the two process trains. During peak flow periods, excess flow "overflows" at Mission Main Building 4 (Settled Sewage Pump Station) and is conveyed to the Turkey Creek Distribution Chamber. In addition, centrate from the full plant biosolids dewatering process normally flows to the Turkey Creek Distribution Chamber, but can also be directed to the Mission Main Settled Sewage Pump Station.

Detailed information on the unit processes have been included in the Appendices. Appendix A includes in-plant pumping capacities and unit process dimensional information. Appendix B includes a site piping plan depicting major liquid process piping as well as hydraulic profiles for each process train. As discussed earlier, Mission Main and Turkey Creek operate on distinctly different hydraulic profiles. Mission Main's influent structure is at elevation 984.5 while Turkey Creek is at 908.5. Both trains utilize intermediate pumping, with Turkey Creek's lift being significantly greater than at Mission Main.

Figure 2-1: Process Schematics of Both Treatment Trains



Recent, ongoing, and near future initiatives impacting the liquid process facilities include:

- Turkey Creek Wastewater Treatment Facility Hydraulic, Grit and Clarifier Evaluation, completed by HDR in 2017, identified a number of hydraulic imbalances and bottlenecks throughout the process train that were limiting Turkey Creek's ability to operate at its design hydraulic capacity. While the decision was made to defer a number of the needed improvements until this Facility Plan is completed, the following initiatives are proceeding:

    - SMTC-CO39A – Equipment Purchase – complete chain and scrapper mechanism for all 8 clarifiers
    - SMTC-CO39B – Equipment Installation – installation of equipment purchased under CO39A
    - SMTC-CO39C – Flow Isolation – Influent Distribution Structure and Unaerated Grit Basin (gate replacement)
    - SMTC-CO39D – Flow Isolation – Aerated Grit Basin (gate replacement)

- Nelson Complex Disinfection Evaluation, CDM, 2016 - considered a variety of disinfection options including chlorine, peracetic acid, and multiple UV options employing varying degrees of chemical supplementation.

- Nelson Complex Disinfection Chemical System Improvements Design Memorandum, CDM, 2016 - Sets forth criteria for the upgrade of the hypochlorite and bisulfite facilities at both Mission Main and Turkey Creek.

- Other projects that JCW envisions undertaking in the next five years include:
    - A SCADA project (in 5 year CIP) in which the existing network will be expanded to critical facilities, including:
        - MM Building 13 – influent metering and screening
        - MM Building 4 – settled sewage pumping
        - MM Disinfection – chemical storage and feed
        - TC Buildings 3 and 4 – settled sewage pumping
        - TC Disinfection – chemical storage and feed
    - A MM clarifier rehabilitation project (in 5 year CIP), focusing on Intermediate Clarifiers 3 and 4 and Final Clarifiers 2 and 3
    - MM Building 4 – settled sewage pump rehabilitation
    - TC Building 9 – vortex grit chamber rehabilitation
    - Miscellaneous roofing projects

2.2 WWTF Solids Processing

The solids processing facilities are common to both Turkey Creek and Mission Main. Primary and secondary solids from the clarifiers at each treatment train are pumped to the Sludge Thickeners. From there, the thickened solids are transferred to the Sludge Holding Tanks, pumped to the Centrifuge Building (Mission Main Building 14 on Figure 1-1) for dewatering, and the dewatered cake is disposed of through landfill. In addition, thickened waste activated sludge (TWAS) from Blue River Main (BRM) and New Century Air Center (NCAC) is transported to Nelson and fed into either the Sludge Holding Tanks and/or into a manhole upstream of the Turkey Creek PS. Other solids

facilities consist of 4 anaerobic digesters and an incinerator facility that have been mothballed for years, although recently one of the digesters, Digester No. 3, has been converted to a sludge storage/mixing tank. The locations of the Nelson solids facilities are show on prior Figure 1-1 and dimensional information is included in Appendix A.

Recent, ongoing, and near future initiatives impacting the Solids Facilities include:

- CMSD Contract 20 – Nelson Complex Solids Handling Improvements – completed in 2017, including rehabilitation of the gravity thickeners, conversion of Digester 3 to a pre-dewatering storage and mixing tank, dewatering centrifuge rehabilitation, and polymer system upgrades.

- Nelson Complex and Middle Basin Treatment Facilities Solids Handling Study, HDR/CH2M, 2018 (nearing completion at the time of this TM writing) is focused on eliminating dependency on landfilling and providing greater system wide capacity and redundancy for managing biosolids and FOG. Improvements contemplated for Nelson include phasing of the reestablishment of anaerobic digestion by refurbishing Digesters 3 and 4, replacing small Digesters 1 and 2 with new large Digesters 5 and 6, adding a FOG receiving station, and implementing biogas reuse through cogeneration. The most likely plan will be to perform a first phase in which one large digester is brought on line prior to the plant upgrade, with the remainder of the improvements being completed as part of the whole plant BNR upgrade.

2.3 WWTF Administrative/Support Facilities

The Nelson Complex includes five administrative/support facilities that must be accounted for in the plant upgrade:

- Administration Building (MM #10) – houses Existing Infrastructure (EI) engineering staff and Operation and Maintenance (O&M) management personnel.

- Storage and Maintenance Building (MM #11) – houses plant O&M staff and includes a vehicle/equipment maintenance area.

- Sludge Control and Filter Building (MM #3) – currently used to house system wide ground maintenance equipment and crews.

- Vehicle Maintenance and Storage Building (TC #11) – houses some EI engineering and O&M staff, and provides enclosed parking and maintenance bays for Line Maintenance trucks.

- Storage Building (TC #12) – houses line construction staff, provides storage for parts and supplies, and houses line repair equipment.

In addition, the Household Hazardous Waste facility is currently located in the Nelson Complex grounds, across the access drive from the Centrifuge Building.

Other activities taking place at the Nelson Complex which are not directly related to wastewater treatment include:

- Gasoline filling station
- CNG filling station
- Occasional JoCo Environmental E-Waste recycling events
- Third-party radio tower

All of these facilities and uses will need to be taken into account in planning for the future plant upgrade.

2.4 WWTF Utility Services

The Nelson Complex is served by three public utilities; electric, natural gas, and water. In addition, a complete SCADA network is being implemented based on past and future projects. Figure 2-2 shows the location(s) and sizing for each of these, and a discussion of each follows:

2.4.1 Electrical

The Nelson Complex is served by KCPL. There are multiple electrical utility meters on the facility and the services for each are summarized as follows:

Turkey Creek is fed from two 12.47kV KCPL circuits, 6843 and 6823. Two 1,000kVA 12.47kV/480V utility-owned transformers step the voltage down to 480V. These transformers feed a 3000A main-tie-main switchgear that provides power to MCCs and power panels via underground duct bank located throughout the Turkey Creek facility. The switchboard contains an automatic transfer system that transfers the load to the alternate feed on loss of power.

Mission Main is fed from two 12.47kV KCPL circuits, 6843 and 6823. Two 1,000kVA 12.47kV/480V utility-owned transformers step the voltage down to 480V. These transformers feed a 1600A main-tie-main switchgear that provides power to MCCs and power panels via underground duct bank located throughout the Mission Main facility. The switchboard does not contain an automatic transfer system, and requires manual intervention on loss of a utility feed. Figure 2-2 shows the location of the switchgear and underground duct bank, and the one Line diagrams for these two facilities are shown in Figure B-4 in Appendix B.

The Centrifuge Building is fed from a single 12.47kV KCPL circuit, 6854. One 500kVA, 12.47kV/480V utility-owned transformer steps the voltage down to 480V. This transformer feeds a Centrifuge Building MCC, MCC-CB. There is currently no existing standby power for this building.

The Vehicle Maintenance and Storage Building is fed from a single 12.47kV KCPL circuit. One 150kVA 12.47kV/120/208V utility-owned transformer steps the voltage down to 120/208V. This transformer feeds a Service Entrance Panel S1. Panel S1 consists of one main circuit breaker and two feeder circuit breakers with a lug attaching it to Service Entrance Panel S2. Panel S2 consists of four feeder breakers which serve the loads of the Vehicle and Maintenance Storage Building. There is currently no existing standby power for this building.

The Compressed Natural Gas Facility is fed from three overhead utility lines stepped down by three single-phase, 25kVA, 12.47kV-480V utility-owned transformers. These transformers feed the 480V CNG Power Panel which serves the loads of the CNG Facility. There is currently no existing standby power for this facility.

The Hazardous Household Waste Facility is fed from a single 12.47kV KCPL circuit. One 50kVA, 12.47kV-120/240V utility-owned transformer steps the voltage down to 120/240V. The secondary side of the transformer feeds three disconnect switches. These three disconnect switches feed four lighting panels which serve the loads of the Hazardous Household Waste Facility. There is currently no existing standby power for this facility.

Building 12 and Building 7 within Turkey Creek WWTF are fed from a single 12.47kV KCPL circuit. One 25kVA, 12.47kV-120/240V utility-owned transformer steps the voltage down to 120/240V. The secondary side of the transformer feeds a disconnect switch on the outside of Building 12. The feed from this disconnect switch is split and routed to lighting panels in Building 12 and Building 7. There is currently no existing standby power for these buildings.

Additionally there is an overhead electrical transmission main the borders the north edge of the Nelson Complex site. Construction within the limits of this easement will be avoided. Locations for proposed facilities will take this easement into account.

2.4.2 Natural Gas

Natural Gas service for the Nelson Complex WWTF is provided by Kansas Gas Service. As shown on Figure 2-2, the facility is served by separate 3” and 4” gas service laterals which enter the site from the east and southeast, respectively.

2.4.3 Water

Potable water service for the Nelson Complex is provided by WaterOne. As shown on Figure 2-2, there are two water service entrances for the facility. The primary water supply is through a 4” water line which enters the site from the east via a 24” water main. An additional 2.5” water service line enters on the southeast site of the WWTF along with an 8” FPW line.

2.4.4 Communications

The existing SCADA system at the Nelson Complex currently only incorporates a portion of the process equipment at Mission Main (MM) and a minor amount of the process equipment at TC WWTF. JCW’s overall end goal for the SCADA system at the Nelson Complex is to automate the processes, communicate information, and collect data for historical review and analysis.

The existing fiber optic infrastructure at the Nelson Complex was installed in the late 1990s under Contract 28. The condition of the existing fiber has eroded over time and some of the fiber has been replaced as part of the Solids Handling Improvements project (CMSD-C020). The existing SCADA system is not fully integrated between the various buildings and facilities within the Nelson Complex.

There are several projects performed recently or are currently under contract by JCW for improvements to the fiber optic infrastructure and SCADA system:

- JCW Business Operations and Planning
  - Installation of new fiber optic cable along the north side of the WWTF by the fence line. This cable is part of the County wide fiber network and extends out from the TCPS on the west end and through Roeland Park on the east end. Part of this fiber network creates an on-site loop and enables a communication path around the plant site to the other facilities. This cable consists of 144 fibers, single mode

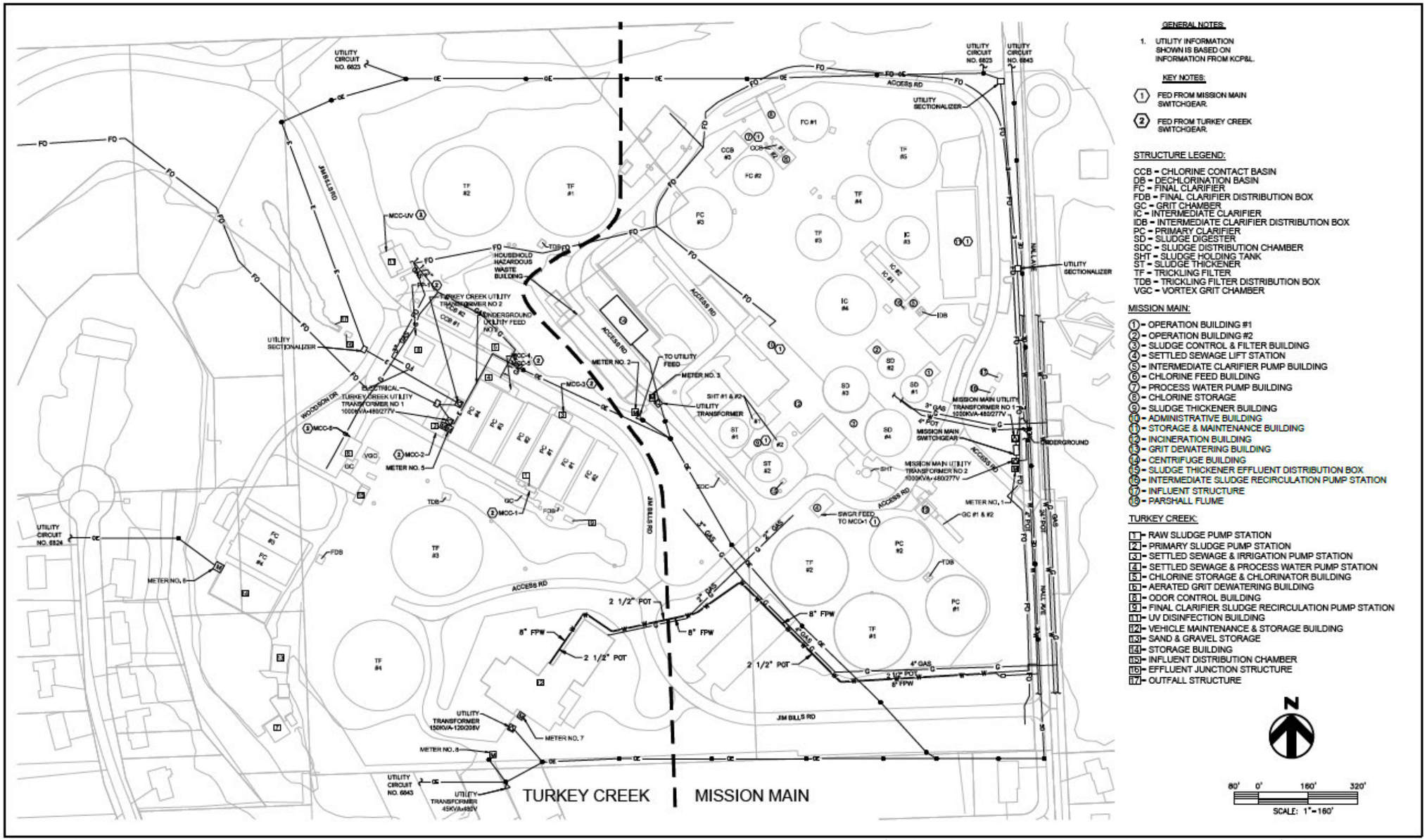
type and connects MM Building 10 to MM Building 3. The on-site fiber also extends to the three plant entrance gates.

- Contract No. 20 (CMSD-C020)
  - Installation of new 12 pair (24 fiber) multimode fiber optic cable from MM 14 to the Sludge Thickening Building No. 9 (MM 09) and from MM 09 to the electrical room in the Digester Building No. 3 (MM 03) and on to the Administration Building (MM 10) to enable remote connectivity.
  - Installation of new 12 pair fiber optic cable from MM 14 to the TC UV Building (TC 13) to enable programming of UV system and TCPS with the on-site SCADA system at a later date.
  - Replacement of the existing fiber optic cable from TC 13 to MM 14 with new multimode fiber optic cable (24 count). A patch panel and thin client workstation inside TC 13 will also be installed.
  - Installation of a new network rack in the MM 03 Electrical Room. The network rack will contain two network switches (JCW typically utilizes Moxa network switches), two Proficy iFix Servers, one iHistorian server, one Proficy terminal server, one fiber optic patch panel, one Category 5e/6 patch panel, an uninterruptable power supply (UPS), and a KVM unit.
  - Two thin clients (Proficy iFix Runtime) will be located on the face of the control panel in the MM 14 control room and on the face of the new control panel in the MM 03 electrical room.
  - A new server management station will be provided for administration, engineering, and maintenance functions to interface with the servers in the network rack.
- TC 13 has a fiber patch panel which connects the FRPS and Lamar Pump Station

Turkey Creek WWTF currently does not have a SCADA system for monitoring and control of the processes within its facility. The intent is to eventually connect TC WWTF to the server in MM 03 via TC 13. When this is completed, operators would be able to remotely monitor and interface with the process at TC WWTF and collect data for historical analysis.

The TC Settled Sewage Pump Station Building No. 4 (SSPS 4) houses a remote telemetry unit (RTU). It contains a Siemens Intralink LC2000-A, which transmits signals to the Douglas L. Smith Middle Basin (DLSMB) WWTF via a CalAmp Viper radio. The DLSMB WWTF has a software autodialer used for remote alarm notification. Multimode fiber optic cable 6 pair (12 strand) is wired from TC13 to the RTU. Any new critical alarms that require remote notification would be sent to this RTU to be transmitted to DLSMB WWTF. Additionally, MM 4 has an RTU panel that provides pump station information from MM 4 to SCADA.

Figure 2-2: Facility Utility Services



JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN
SITE UTILITIES

DATE APRIL 2018
FIGURE FIG 2-2

2.5 Satellite Facilities

Figure 1-2 identified the major pump stations and PEFTFs in the Nelson Complex watershed. These will be discussed in detail in Section 5 of this report. A brief overview of their components and capacities follows:

2.5.1 75th and Nall PEFTF

1. Coarse Screening
2. Pumps (2 @ 7,000 gpm, each)
3. Disinfection
    a. Chlorination with Sodium Hypochlorite
    b. Holding Basin @ 0.56 mgal
    c. Dechlorination with Sodium Bisulfite
4. Firm Capacity = 10.0 mgd (20 mgd with 2 duty pumps, 0 standby)

2.5.2 Brush Creek Pump Station

1. Coarse Screening
2. Dry Weather Pumps (2 @ 1,500 gpm, each)
3. Wet Weather Pumps (2 @ 3,800 gpm, each)
4. Forcemain: 10,778 LF of 16-inch
5. Firm Capacity = 5.5 mgd (via 1 duty wet weather pump)

2.5.3 Martway PEFTF

1. Coarse Screening
2. Pumps (2 @ 7,000 gpm)
3. Disinfection
    a. Chlorination with Sodium Hypochlorite
    b. Holding Basin @ 0.57 mgal
    c. Dechlorination with Sodium Bisulfite
4. Firm Capacity = 10.0 mgd (20 mgd with 2 duty pumps, 0 standby)

2.5.4 Rock Creek Station

1. Coarse Screening
2. Pumps (4 @ 2766 gpm, each)
3. Forcemain: 7,069 LF of 24-inch
4. Firm Capacity = 12.0 mgd (3 duty pumps, 1 standby)

2.5.5 Belinder Pump Station and PEFTF

<u>Pump Station</u>

1. Coarse Screening
2. Dry Weather Pumps (2 @ 1,900 gpm, each)
3. Wet Weather Pumps (2 @ 3,600 gpm, each)
4. Forcemains
    a. 10,969 LF of 24-inch (active)
    b. 13,625 LF of 16-inch (abandoned)
5. Firm Capacity = 10.6 mgd (via 2 duty 3,600 gpm pumps, 2 standby 1,900 gpm pumps)

<u>PEFTF</u>

1. Pumps (2 @ 14,600 gpm, each)

2. Disinfection
    a. Chlorination with Sodium Hypochlorite
    b. Holding Basin @ 0.90 mgal
3. Firm Capacity = 21 mgd (42 mgd with 2 duty pumps, 0 standby)

2.5.6 Turkey Creek Pump Station and PEFTF

Pump Station

1. Coarse Screening
2. Pumps (4 @ 6,250 gpm, each)
3. Forcemain
    a. 3,580 LF of 24-inch
    b. 3,512 LF of 30-inch
4. Firm Capacity = 27 mgd (Limited to 21 mgd due to WWTF restriction)

PEFTF

1. Coarse Screening
2. Pumps (2 @ 7,639 gpm, each)
3. Disinfection
    d. Chlorination with Sodium Hypochlorite
    e. Holding Basin @ 0.4 mgal
4. Firm Capacity = 11 mgd (22 mgd with 2 duty pumps, 0 standby)

Several smaller pump stations are situated in the Nelson Complex watershed. These include:

- Mission Main Sub-Watershed
    - Roe Village
    - Granthurst
    - Mission Woods
    - Swatzell View
- Turkey Creek Sub-Watershed
    - Virgil's
    - Lamar
    - County Line

These are primarily small stations serving small, isolated areas, and are outside the scope of this study.

Initiatives planned or underway affecting the satellite facilities include the following:

- MTM Contract 73: Belinder, 75th & Nall, and Brush Creek Miscellaneous Repairs – currently under design, focusing primarily on repair of building superstructure architectural features.
- MTM Contract 74: Equipment Replacement – currently under design
    - Rock Creek PS – screen and pump replacement and relocation of electrical building
    - Martway PEFTF – gate, pump, and chemical storage and feed equipment replacement
    - 75th & Nall PEFTF – pump replacement
- Belinder PS/PEFTF: replacement/rehabilitation of screens, pumps, and electrical. In early planning stage.
- SMTC-C037: Turkey Creek Pump Station Improvements - Currently under final design

3 Flows and Loadings

3.1 Hydraulic Flows

3.1.1 WWTF

Mission Main flows are pumped to the facility primarily by the Belinder PS, with a capacity of 10.6 mgd, and the Rock Creek PS, with a capacity of 12.0 mgd. Additional influent flow is conveyed from the Roe Village PS, which accounts for less than 1.0 mgd.

According to the 2014 B&V hydraulic study, the Mission Main treatment train has a design hydraulic capacity of 25 mgd, although historical peak flows of up to 26 mgd were recorded in 2016. All influent flow from the satellite facilities are combined with the recirculation flow within the Settled Sewage Lift Station (MM#4). The recirculated flow typically includes gravity thickener overflow and cosettled sludge from the final clarifiers, and accounts for as much as 5 mgd during peak flow conditions. The pumps within MM#4 are not able to convey the combined influent flow and recirculation flow, and the excess flow is conveyed to the Turkey Creek treatment train via a 24" emergency overflow line.

The permitted average day capacity of Mission Main is 7.0 mgd. Over the years 2010 through 2017, annual average daily flows (AADF) have ranged from 5.5 mgd in 2012 to 8.2 mgd in 2010, the variation being largely due to precipitation totals.

Turkey Creek flows are pumped to the facility primarily by the Turkey Creek PS (also referred to as Foxridge Pump Station) with a capacity of 27 mgd. The total combined pumping rate of the TCPS exceeds the hydraulic capacity of the facility, which is limited to approximately 21 mgd due to several restrictions and imbalances between treatment trains resulting from the declining condition of the facilities.

The permitted average day capacity of Turkey Creek is 8.0 mgd. Over the years 2010 through 2017, AADF's have ranged from 5.7 mgd in 2012 to 9.0 mgd in 2010, the variation being largely due to precipitation totals.

The current combined rated peak hydraulic flow for the Mission Main and Turkey Creek facilities as referenced in the 2009 Pre-design Study is 52 mgd, which results in a peaking factor of approximately 3.5. Future plant improvements will likely involve a biological process which typically limits peak factors to between 3-4 to 1, although this limitation is dependent on the specific biological process selected, including provisions for addressing peak flows such as step feed. Hydraulic design flows for the new facility, assuming the goal of combining Mission Main and Turkey Creek into a single process scheme is achieved, will be as follows:

Average Daily Flow = 15.0 mgd
Peak Hour Flow = 52.0 mgd*

*Peak Flow dependent on process selected

Any flow greater than the above arriving at the plant would likely need to be processed through auxiliary treatment or peak shaving storage.

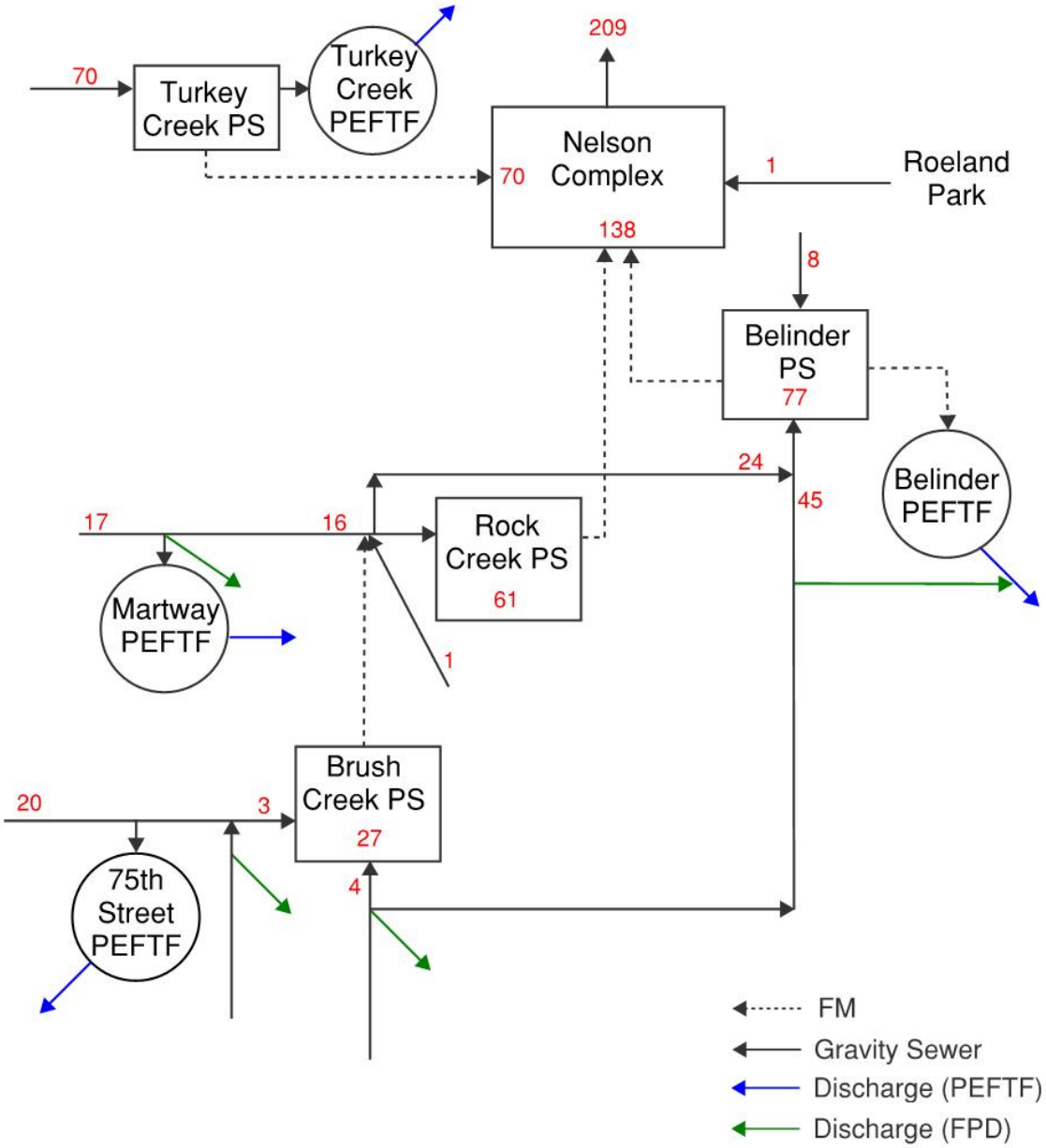
3.1.2 Satellite Facilities

Existing flows throughout the collection system will be evaluated in detail in the Collection System Wet Weather Plan Development and Optimization Study. That study will also determine the future design capacities of the satellite facilities, as well as any wet weather facilities at the WWTF. Therefore, this Facility Plan will largely defer to that study with respect to existing and future collection system and satellite facility flows. However, the Facility Plan scope does include development of cost curves, for use in the Wet Weather Optimization. These curves will need to cover the range of flows to which each facility could possibly be exposed, to establish upper and lower flow limits, or constraints, for the optimization algorithm. Therefore, it is instructive to include in this TM, an approximation of the "existing unrestricted flow" from the collection system tributary to each satellite facility as this would represent the upper limit of flow range for that facility. "Existing unrestricted" is the flow that would occur if there was no upstream flow reduction (storage or I/I removal), and the pipes were of sufficient size that all flows would be conveyed to the facility with any upstream surcharging or overflows. These flows are presented in Table 3-1 and shown graphically in Figure 3-1.

Table 3-1: Unrestricted Flows (10 YR, 24 HR Storm Event)

Reach/ Item	Description	Flow (mgd)
	Brush Creek PS Service Area	
1.	US of 75th & Nall	20
2.	DS of 75th & Nall and US of Brush Creek	7
3.	Total, US of Brush Creek (Reach 1 & 2)	27
	Rock Creek PS Service Area	
4.	US of Martway	17
5.	DS of Martway and US of Rock Creek	16
6.	To Rock Creek from South	1
7.	Total, Rock Creek PS Service Area (Reach 4, 5 & 6)	34
8.	Total, Rock Creek and Brush Creek PS Service Areas (Reach 3 and 7)	
	Belinder PS Service Area	
9.	DS of Brush Creek and US of Belinder	45
10.	DS of Rock Creek and US of Belinder	24
11.	To Belinder from North	8
12.	Total, Belinder PS Service Area	77
13.	**Total, Mission Main Service Area**	**138**
14.	**Total, Turkey Creek Service Area**	**70**
15.	Total, Roeland Park Service Area	1
16.	**Nelson Complex Total**	**209**

Figure 3-1: Unrestricted Flows (10 YR, 24 HR Storm Event)



3.2 Treatment Facility Flows and Loadings

Daily plant operating data from January 1, 2014 to December 31, 2017 was analyzed to establish historical loading characteristics at the Turkey Creek and Mission Main WWTFs. The primary parameters analyzed included influent flow, biochemical oxygen demand (BOD_5), total suspended solids (TSS), volatile suspended solids (VSS), alkalinity, total phosphorous (TP), total kjeldal nitrogen (TKN), and ammonia nitrogen (NH_3-N). As noted above, historical influent flow data was analyzed for a longer period between 2010 and 2017 to evaluate broader trends in influent flows.

Thickened waste activated sludge (TWAS) is hauled from the BRM, Tomahawk, and NCAC WWTFs to the Nelson Complex for solids processing. Previous practice for TWAS from these sources was to discharge them into the Turkey Creek collection system. In current practice, most of these sources are discharged to the Sludge Holding Tank at the solids processing facility. Sludge discharged into the Turkey Creek collection system increase the apparent loading on that facility and complicates analysis of historical loading to the Turkey Creek WWTF.

3.2.1 Historical Mission Main and Turkey Creek Influent Flows

Flow data was analyzed from 2010 to 2017 to assess the growth potential within the collection system and to verify that the most recent 4 years of flow and loading data are representative of normal plant loading conditions. Table 3-2 summarizes annual average flows and compares the 8-year average (2010-2017) to the most recent 4-year average (2014-2017).

Table 3-2: Turkey Creek and Mission Main Average Annual Influent Flows

Time period	Mission Main WWTF (mgd)	Turkey Creek WWTF (mgd)	Nelson Facility Total (mgd)
2010	8.2	9.0	17.2
2011	6.6	6.4	13.0
2012	5.5	5.7	11.2
2013	7.1	7.0	14.1
2014	6.3	6.3	12.9
2015	7.0	8.0	15.0
2016	6.3	7.5	13.8
2017	6.6	7.2	13.8
2010-2017	6.7	7.1	13.8
2014-2017	6.6	7.3	13.9

The annual averages presented in Table 3-2 demonstrate that flows to the WWTFs are variable based on precipitation, but remained relatively stable, which confirms negligible growth in wastewater production within the collection systems. The observation of negligible increases in growth aligns with expectations as sewersheds for both WWTFs are near build out conditions. In addition, the flow data demonstrates that the most recent four years of data does not represent disproportionately dry nor wet conditions. As such, the most recent 4-year period is likely representative of normal plant loading conditions.

On a long-term average basis, both plants are normally operating within the design average flow values as defined in their NPDES permit for the Nelson Complex WWTF, namely 7.0 mgd for Mission Main WWTF and 8.0 mgd for Turkey Creek WWTF.

3.2.2 Historical Mission Main Loads

Historical loadings to the Mission Main WWTF were analyzed for the period from January 1, 2014 to December 31, 2017. The average day and maximum 30-day running average (maximum month) loadings for each year are summarized in Table 3-3. The maximum month in each year represents the 30-day period that exhibited the maximum BOD_5 loading. All other influent parameters listed under the maximum month were correlated to this 30-day BOD_5 period. Each of these other parameters may exhibit individual larger mass contributions than what is defined for the maximum month, but maximum month BOD_5 loading was selected because conceptual level biological treatment system sizing is typically driven by BOD_5 mass loading. Consideration to individual influent parameter peaking factors and relationships to BOD_5 should be further evaluated during preliminary design as design concepts are refined.

Table 3-3: Mission Main WWTF 2014-2017 Influent Loading

	Flow (mgd)	BOD_5 (lb/d)	TSS (lb/d)	VSS (lb/d)	TKN (lb/d)	NH_3 (lb/d)	TP (lb/d)
2014							
Max Month[1]	8.8	12,620	15,151	12,973	1,884	976	255
Average Day	6.3	9,152	11,816	10,031	1,721	888	202
MM/AD[2]	1.4	1.4	1.3	1.3	1.1	1.1	1.3
2015							
Max Month	4.4	9,510	11,050	9,909	1,496	650	179
Average Day	7.0	7,765	9,875	8,548	1,458	781	162
MM/AD	0.6	1.2	1.1	1.2	1.0	0.8	1.1
2016							
Max Month	6.3	8,262	9,650	8,404	1,783	860	212
Average Day	6.3	7,337	9,534	8,324	1,607	878	175
MM/AD	1.0	1.1	1.0	1.0	1.1	1.0	1.2
2017							
Max Month	11.2	13,137	15,343	14,458	3,140	1,020	297
Average Day	6.6	8,864	11,484	10,163	1,810	896	201
MM/AD	1.7	1.5	1.3	1.4	1.7	1.1	1.5
2014-2017 Average							
Max Month	7.7	10,882	12,799	11,436	2,076	877	236
Average Day	6.6	8,280	10,677	9,266	1,649	861	185
MM/AD	1.2	1.3	1.2	1.2	1.2	1.0	1.3

Notes:

1. 30-day time period that produced maximum BOD load
2. Peaking factors are calculated on mass loading

Maximum month loading can be driven by increased concentrations or increased influent flows. In 2015 and 2016, peaking factors were driven by increased concentrations, whereas 2014 and 2017 were primarily driven by increased flows. BOD_5 peaking factors range from 1.1, observed in 2016 to

1.5, observed in 2017. Extreme variations in influent concentrations were not expected given that a majority of the collection system contribution originates from domestic and commercial sources. However, the 2017 maximum month exhibits higher peaking factors relative to other years. Analysis of the data during that period suggests that the 30-day period captured the tail end of a wet-weather event, with later days exhibiting higher than average concentrations.

The average peaking factors range between 1.2 to 1.3, which is expected for WWTFs receiving primarily domestic wastewater. It is recommended that a peaking factor of 1.3 is utilized in conceptual design.

3.2.3 Historical Turkey Creek Loads

Turkey Creek WWTF influent load characterization is impacted by the discharge of hauled thickened sludge into the collection system. The quantity of sludge hauled to the Turkey Creek collection system has varied over the years, and is expected to have a significant impact on the historical data's representation of influent conditions. The discharge of these sludges compromises the analysis of historical data and misrepresents WWTF loadings from domestic, commercial, and industrial users. As such, establishment of future design loadings requires careful consideration of the impact of these hauled sludges.

Historical loadings to the Turkey Creek WWTF were also analyzed for the period from January 1, 2014 to December 31, 2017. The average day and maximum 30-day running average loadings for each year are summarized in Table 3-4. As was noted with the Mission Main WWTF, the maximum month correlates to the 30-day period with the highest BOD_5 loading.

Table 3-4: Turkey Creek WWTF 2014-2017 Influent Loading

	Flow *(mgd)*	BOD_5 *(lb/d)*	TSS *(lb/d)*	VSS *(lb/d)*	TKN *(lb/d)*	NH_3 *(lb/d)*	TP *(lb/d)*
2014							
Max Month[1]	6.3	13,643	15,349	12,606	NA[3]	1,565	NA[3]
Average Day	6.3	10,590	12,295	10,829	1,829	1,391	203
MM/AD[2]	1.0	1.3	1.2	1.2	NA[3]	1.1	NA[3]
2015							
Max Month	8.7	17,018	17,767	17,134	2,513	1,941	281
Average Day	8.0	12,878	15,603	13,679	2,072	1,467	236
MM/AD	1.1	1.3	1.1	1.3	1.2	1.3	1.2
2016							
Max Month	8.6	17,973	22,374	19,670	2,975	1,497	326
Average Day	7.5	15,011	18,602	15,880	2,589	1,400	326
MM/AD	1.2	1.2	1.2	1.2	1.1	1.1	1.0
2017							
Max Month	8.6	19,006	22,100	18,341	2,926	1,301	425
Average Day	7.2	12,419	15,587	13,302	2,217	1,543	285
MM/AD	1.2	1.5	1.4	1.4	1.3	0.8	1.5
2014-2017 Average							
Max Month	8.1	16,910	19,397	16,938	2,805	1,576	344
Average Day	7.3	12,724	15,522	13,422	2,177	1,450	262

MM/AD	1.1	1.3	1.3	1.3	1.2	1.1	1.2

Notes:

1. 30-day time period that produced maximum BOD load
2. Peaking factors are calculated on mass loading
3. Sufficient data not available for 30-day load determination

The year with the lowest amount of off-site sludge hauled to the Nelson Complex was 2014, in which a higher proportion of the sludge was hauled to the Middle Basin WWTF. The periods of reduced hauled sludge produce a significant impact on WWTF loading, which can be seen in Table 3-4 by comparing the increased average BOD_5, TSS, and VSS. In 2017, while all off-site sludge was hauled to the Nelson Complex, provisions were made to begin introducing many of the loads directly into solids handling (sludge storage) rather than unloading all into the collection system. Continued migration towards discharging into the solids holding tanks will provide better characterization of actual loading conditions, which will provide additional clarity in future loading projections. Additionally, the noted higher loadings for 2016 to 2017 could be partially due to higher constituent concentrations in the centrate return to the TC influent structure where it would have been captured through influent sampling.

Even with the contribution of hauled TWAS, maximum month peaking factors observed at the Turkey Creek WWTF are similar to what was observed at the Mission Main WWTF. As such, a peaking factor of 1.3 is also recommended for the Turkey Creek WWTF.

3.2.4 Design Loads

Information from the analysis of historical loadings, peaking factors, and enhanced sampling data were used to establish design loading conditions. The resulting influent loadings recommended for use as the basis of analysis in this evaluation are presented in Table 3-5. For reference, the loading values utilized in the M.K. Nelson Nutrient Removal Pre-Design Study (2009) are also included. Additional data acquisition and analysis are recommended prior to design of future upgrades to the Nelson Complex to confirm the assumptions made regarding Turkey Creek influent characteristics.

Design loads were defined by applying the calculated average day concentration from the historical data analysis to the design average flow. Maximum month loads were established by applying the identified peaking factor to the design average loading condition. Maximum month concentrations were back calculated using the established maximum month flow. As mentioned, the analysis of historical loading conditions for the Turkey Creek WWTF was severely skewed by the TWAS hauling. The contribution of TWAS was accounted for in the historical average loadings by applying a 25 percent reduction, which corresponds to the average reduction noted during enhanced sampling when TWAS was not being discharged.

Table 3-5: Design Flows and Loads for the Nelson Complex

Parameter	Metric	Proposed Mission Main	2009 Mission Main	Proposed Turkey Creek	2009 Turkey Creek
Flow (mgd)	Annual Average	7	7	8	8
	Maximum Month	9	7	10	8
	Peak Hour	25	25	27	27
Load Peaking Factor	MM/AA (lbs)	1.3	1.2	1.3	1.2
BOD_5	Annual Average (mg/L)	150	190	150	190
	Annual Average (ppd)	8,757	11,092	10,008	12,677
	Maximum Month (mg/L)	152	228	156	228
	Maximum Month (ppd)	11,384	13,311	13,010	15,212
TSS	Annual Average (mg/L)	195	245	173	245
	Annual Average (ppd)	11,384	14,303	11,509	16,346
	Maximum Month (mg/L)	197	294	179	294
	Maximum Month (ppd)	14,799	17,164	14,962	19,616
VSS	Annual Average (mg/L)	170	211	153.75	211
	Annual Average (ppd)	9,925	12,318	10,258	14,078
	Maximum Month (mg/L)	172	253	160	253
	Maximum Month (ppd)	12,902	14,770	13,336	16,880
TKN	Annual Average (mg/L)	30	28	26	28
	Annual Average (ppd)	1,751	1,635	1,751	1,868
	Maximum Month (mg/L)	30	34	27	34
	Maximum Month (ppd)	2,277	1,985	2,277	2,268
NH_3 -N	Annual Average (mg/L)	16	17	18	17
	Annual Average (ppd)	934	992	1,201	1,134
	Maximum Month (mg/L)	16	20	19	20
	Maximum Month (ppd)	1,214	1,168	1,561	1,334
TP	Annual Average (mg/L)	3.4	5.0	2.9	5.0
	Annual Average (ppd)	198	292	195	334
	Maximum Month (mg/L)	3.4	6.0	3.0	6.0
	Maximum Month (ppd)	258	350	254	400

4 Process Model

4.1 Process Model Selection

CH2M's process model: Professional Process Design and Dynamics (Pro2D^2) was used to simulate the Mission Main and Turkey Creek WWTFs. Pro2D^2 is whole plant simulator that has the capability to integrate process and design information to evaluate existing systems or size new ones." Whole plant" means that the model is not limited to just biological processes, but can also evaluate and/or design primary treatment units as well as secondary treatment units including clarification systems, some tertiary systems and digestion systems. The results of Pro2D^2 have been verified for its accuracy over the past 20 years

Pro2D^2 is constructed within Microsoft® Excel platform. Pro2D^2 includes a modified version of the International Water Association (IWA) Activated Sludge Model (ASM) 2d and a modified version of IWA's Anaerobic Digestion Model (ADM) No. 1; both of which are industry standards for modeling, designing, and evaluating biological treatment. Pro2D^2 can also simulate either carrier based (IFAS, MBBR) or fixed (Trickling Filter) media based biofilms. Up to 65 wastewater components can be tracked within Pro2D^2 through each unit process using kinetic and stoichiometric parameters. In addition, in the absence of meaningful constituent data, the model can calibrate typical parameters – such as BOD_5 and TSS. Typical model outputs include simulated effluent flow, loads, and concentrations (i.e., a material balance on constituents), oxygen transfer requirements, sludge production, estimated chemical usages, estimated energy usage, unit process sizes, etc. The software is also equipped with additional modules for dynamic process simulations, secondary clarifier solids flux analysis, and anaerobic digestion.

The Pro2D^2 model can be tied directly to CH2M's Parametric Cost Estimating System (CPES), which is a conceptual design and cost estimating tool that generates detailed conceptual design layouts including material quantification. The CPES tool is used for master planning, as it generates quick and accurate detailed cost estimates for each of the conceptual alternatives evaluated.

4.2 Enhanced Sampling

Enhanced sampling programs are used to develop detailed wastewater characterization (also known as fractionation), which is a critical step to producing an effective, predictive wastewater process model. Characterization is the assessment of the WWTF influent, and final effluent composition, with a focus on COD, BOD_5, and VSS fractions. Characterization of influent COD consists of determining the soluble, colloidal, particulate, and non-biodegradable soluble fractions of the total influent COD. Coagulation and filtration steps are used to estimate soluble, colloidal, and particulate influent COD, and WWTF effluent soluble COD is used to estimate the influent soluble non-biodegradable COD. Detailed characterization of these parameters are critical parts of estimating removal performance, energy requirements, biosolids production rates, nutrient recycling impacts and is especially important to evaluating the potential for biological phosphorus removal. Accurate fractionation allows for a reliable process model simulation and provides increased confidence in its predictions. It is also important to understand situations that may alter the influent wastewater characteristics and the impacts these altered fractions may have on process performance.

Enhanced sampling and analyses of the Mission Main and Turkey Creek WWTFs occurred between February 14th and February 27th, 2018. Enhanced sampling was conducted on the influent and

effluent of Turkey Creek and Mission Main WWTFs, and on the TWAS from BRM and the NCAC. Sampling results are included in Attachment C.

During the period of enhanced sampling, dry weather flows were observed, which suggests that influent constituents would likely be at higher concentrations than historical annual averages. Figure 4-1 compares the influent flows during the enhanced sampling to the 2014 to 2017 average day flow.

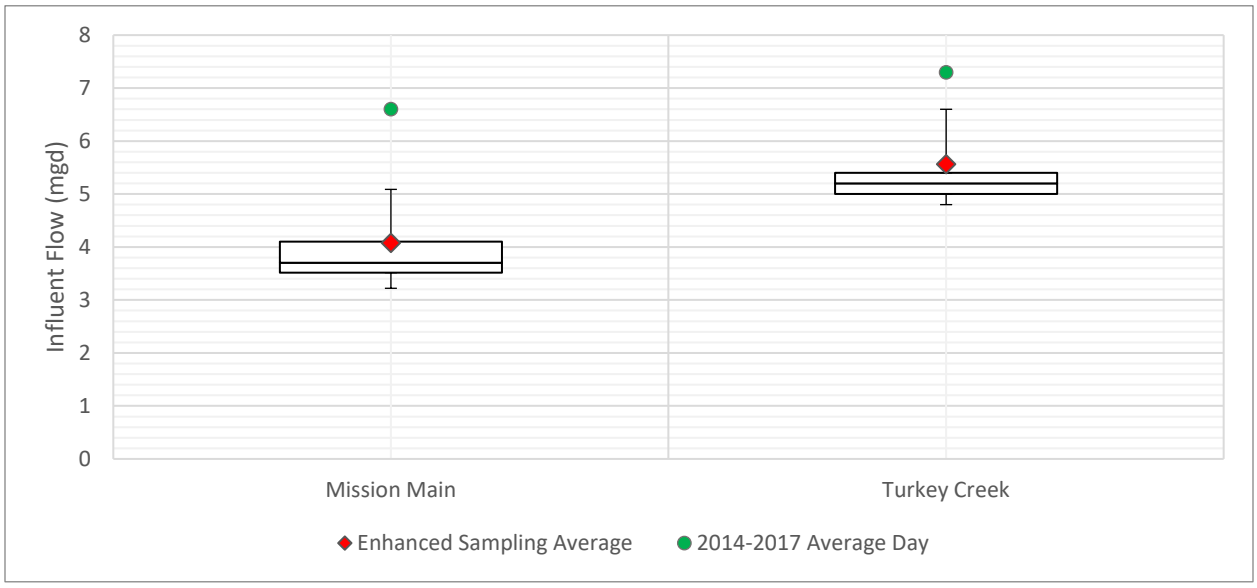


Figure 4-1: Enhanced Sampling Influent Flows

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum flow observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the special sampling average (February 14th to February 27th). The green circle represents the 2014 to 2017 average day flow.

TWAS from BRM and NCAC is intermittently discharged into the Turkey Creek collection system, which complicates influent characterization for that source. During the enhanced sampling period, much of the hauled sludge was unloaded to the sludge storage tanks. However, some hauling trucks are required to dump into a manhole due to an inability to access the storage tanks. Table 4-1 represents the unloading location for each truck hauling solids to the Nelson Complex during the enhanced sampling period. On five of the thirteen days of enhanced sampling, TWAS was not discharged into the collection system. These five days help to clarify the characterization of the Turkey Creek Influent.

Table 4-1: Hauled TWAS to Nelson Complex

Date	Total Tankers to Nelson Complex	Tankers discharging to Turkey Creek Manhole	Tankers discharging to Sludge Holding Tanks
02/14/2018	10	4	6
02/15/2018	7	4	3
02/16/2018	4		4
02/17/2018			
02/18/2018	4		4
02/19/2018	10	4	6
02/20/2018	1	1	
02/21/2018	14	4	10
02/22/2018	7	4	3
02/23/2018	8	4	4
02/24/2018			
02/25/2018	4		4
02/26/2018	8	4	4
02/27/2018	7	3	4
02/28/2018	4	4	

Figure 4-2 and Figure 4-3 represent the variation of influent COD fractionation and correlation of COD to TSS for the Mission Main and Turkey Creek influents. Enhanced sampling results and key relationships are further summarized in Table 4-2.

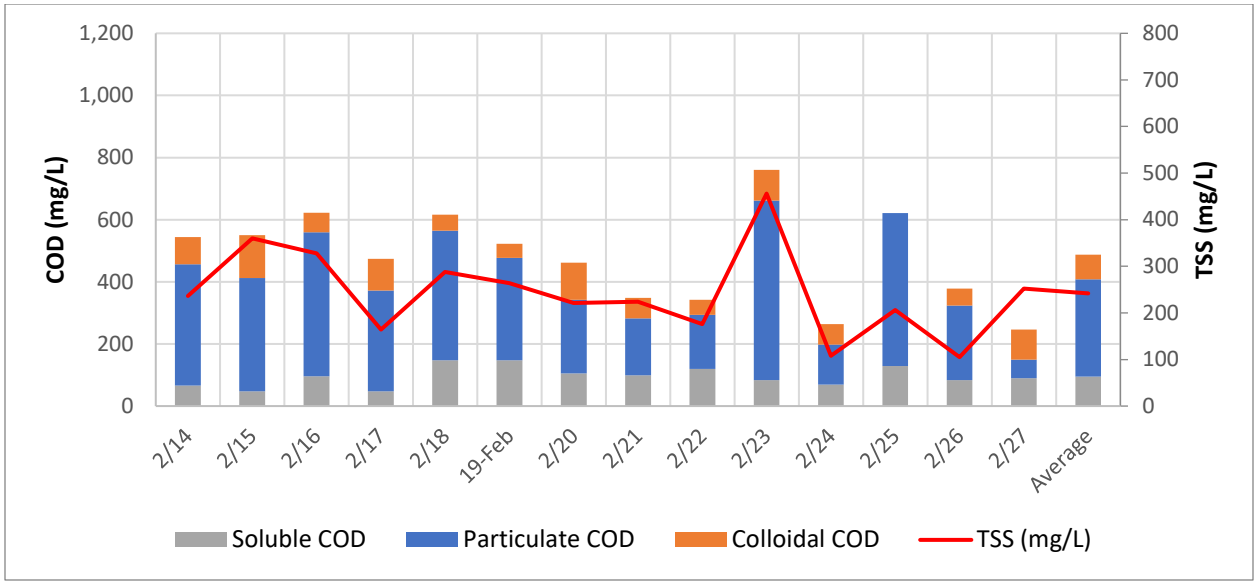


Figure 4-2: Mission Main Influent COD Fractionation and TSS Concentration

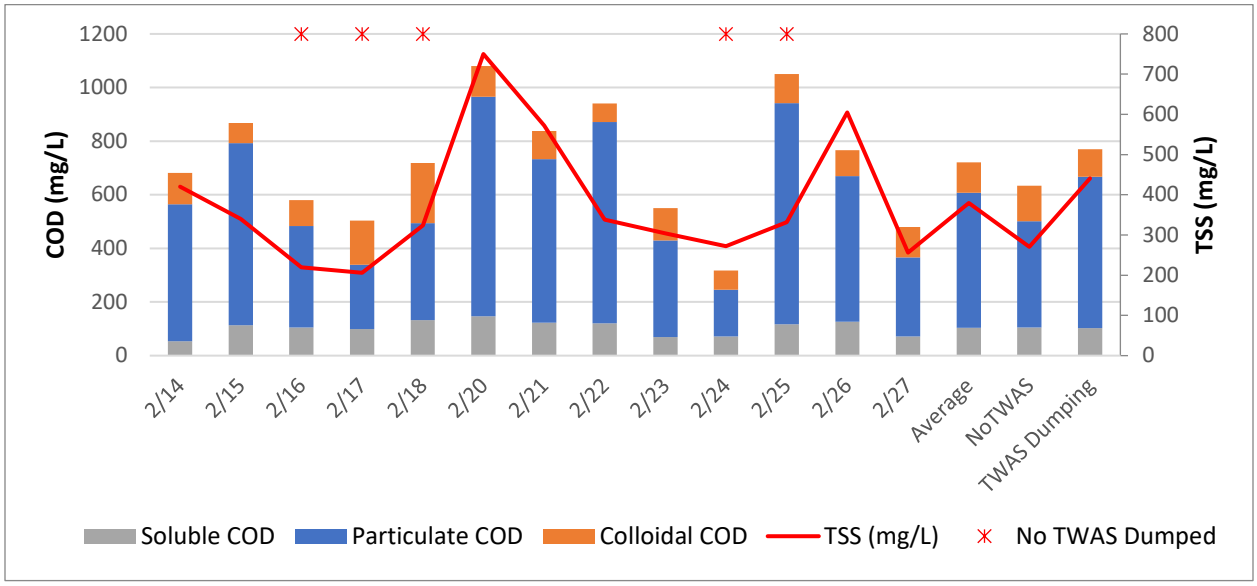


Figure 4-3: Turkey Creek Influent COD Fractionation and TSS Concentration

Understanding the COD fractionation is important when evaluating long-term and intermediate treatment strategies. For example, an influent with highly soluble COD would be an advantage for future biological nutrient removal processes, but would indicate that implementation of chemical enhanced primary treatment (CEPT) may not provide substantial benefits. Conversely, implementation of CEPT can be advantageous if higher concentrations of colloidal and particulate COD are present, which can be removed through sedimentation. The average colloidal COD fraction for Mission Main and Turkey Creek is between 15 and 20%, which indicates that CEPT could be a viable COD reduction strategy for interim compliance and long-term treatment.

Through analysis of Figure 4-2 and Figure 4-3, it can be noted that in most cases increased TSS concentrations coincide with higher calculated particulate COD concentrations. It is also noticed that the proportion of colloidal and soluble COD remain relatively consistent. The impact of increased TSS on particulate COD fractions is most notable within the Turkey Creek influent, where periods of TWAS dumping typically coincide with increased TSS and particulate COD.

Table 4-2: Select Enhanced Sampling Results

Parameter	Mission Main	Turkey Creek			BRM TWAS	NCAC TWAS
	Average	Average	No TWAS	With TWAS	Average	Average
Concentrations						
COD, mg/L	473	721	634	769	24,520	56,800
BOD, mg/L	205	343	240	400	NA	NA
TSS, mg/L	242	380	271	441	15,200	29,000
TKN, mg/L	36	41	37	43	1,084	1,485
TP, mg/L	5.1	6	5	7	379	508
Relationships						
COD/BOD	2.34	2.27	2.59	2.09	NA	NA
$COD_{filt}/BOD_{fil}t$	2.56	2.51	2.49	2.51	NA	NA
VSS/TSS	89%	84%	85%	84%	76%	80%
NH_3/TKN	69%	62%	67%	60%	NA	NA
PO_4/TP	41%	37%	43%	34%	NA	NA
BOD/TP	40.9	55.6	46.0	61.0	NA	NA
BOD/TKN	5.8	8.6	6.7	9.6	NA	NA
COD Speciation (%)						
Soluble	20%	14%	17%	13%	NA	NA
Colloidal	16%	16%	21%	13%	NA	NA
Particulate	64%	70%	62%	73%	NA	NA
No. of Days	14	13	5	8	10	10

The COD to BOD_5 ratio is an indicator of the amount of influent carbon that is readily available for biological utilization. Typical wastewater COD to BOD_5 ratios for raw influent are in the range of 2 to 3, with lower values representing more degradable wastewaters. The COD to BOD_5 ratios observed in the Turkey Creek and Mission Main influents are near the middle of the typical range, which suggests there is a sizable particulate fraction of COD that is slowly degradable. Through larger anaerobic selector zones, particulate COD can be fermented and utilized in biological nutrient removal. The orthophosphate (PO_4-P) to TP ratio represents the reactive influent phosphorus fraction. The NH_3 to TKN is used in modeling to adjust ammonia or TKN in conjunction with changes made to the other parameter. The ratios observed for PO_4-P/TP and NH_3/TKN are within typical ranges observed of other conventional municipal WWTF influents. Although process modeling will be used to evaluate the potential for biological phosphorus removal, the BOD to total phosphorus ratio is used as an indication as to whether there is sufficient carbon for biological phosphorus removal. A rule of thumb is a BOD_5/TP ratio of at least 20 and ideally 30 or more is desirable. The observed influent BOD_5 to TP meets this criterion. To ensure sufficient carbon is available for phosphorus and nitrogen removal, it is suggested that a BOD_5 to TKN ratio of between 6 to 8 is also maintained. The Mission Main influent BOD_5 to TKN is slightly lower than what is desired for biological nutrient removal. Conversely, the Turkey Creek influent has a BOD_5 to TKN within the acceptable range.

4.3 Process Model Calibration

Development of the process model was based on using historic data and the special sampling data for data not typically monitored. The modeling development followed the five key steps of the Good Modeling Practice Unified Protocol outlined by Guidelines for Using Activated Sludge Models (IWA, 2014), which recognizes the following steps:

1. **Project Definition**. Included with this step is identification of the objectives of the modelling project, assignment of responsibilities, and identification of constraints. In this project, the objective was identified as development of a model to simulate phasing of improvements
2. **Data Collection and Reconciliation.** The focus of this step is to collect, assess, and if necessary reconcile historical WWTF data sets in order to utilize their information in process model calibration simulation projects. Sections 3.2 and 4.2 of this TM describe the process used to support this project.
3. **Plant Model Setup.** This step involves configuring the plant model through translation of real world data into model inputs. This step includes the development of the model layout to represent actual process flow diagrams and unit process sizes, selection of the model structure (i.e. which biological matrix to utilize), and setting up model outputs. Plant model set-up requires checks of the general functionality of the model to ensure it produces feasible outputs.
4. **Calibration and Validation**. Model calibration is the process of modifying input parameters until simulation results fall within an acceptable error to the observed range. Calibration relies heavily on information obtained from Step 2 and through specialized wastewater characterization. Validation is the process of performing simulation tests with additional observed data sets to confirm the predicted results
5. **Simulation and Results Interpretation.** This step includes use of the model to evaluate treatment alternatives and phasing approaches. This step will be covered in future technical evaluations.

4.3.1 Plant Model Setup

The Pro2D^2 process model for this project was adapted from work completed on the 2009 Nutrient Evaluation. The process model contains Turkey Creek and Mission Main processes, as well as future solids process upgrades. Future solids processes were disabled for calibration, but left in the model for future evaluations. The Turkey Creek process flow diagram includes primary clarifiers, trickling filters, and final clarifiers (contained within trickling filter unit process). The Mission Main process flow diagram includes primary clarifiers, 1st stage trickling filters, intermediate clarifiers, 2nd stage trickling filters, and final clarifiers (contained within 2nd stage trickling filter unit process). Unit process set points and recycle flows were based on performance observed during the special sampling. Most notably, the Mission Main recycle flow was set to 11 mgd. Figure 4-4 provides a screen shot of the Pro2D^2 process flow diagram.

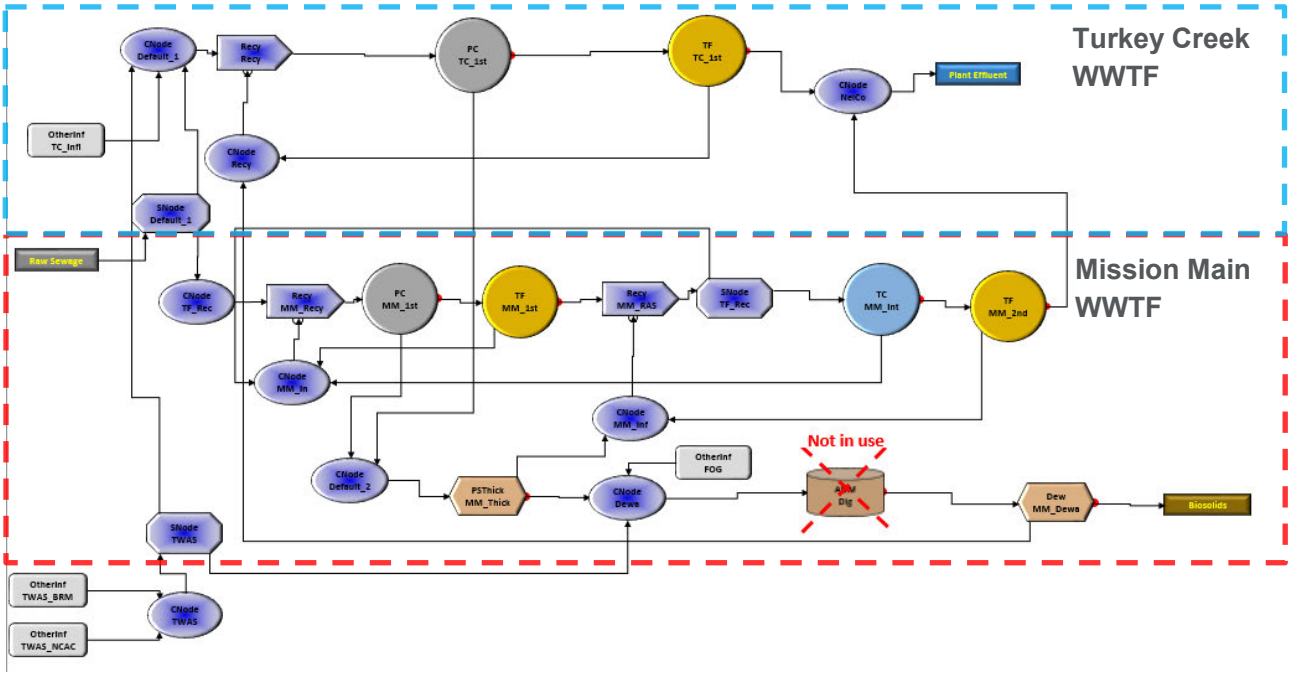


Figure 4-4: Pro2D^2 Process Flow Diagram

4.3.2 Calibration

Process model calibration and validation focuses on taking the results from enhanced sampling and combining them with the observed historical performance data to create a representative steady state model of the WWTFs. Stop criteria (or calibration limits) are developed through the project definition and review of historical data. The stop criteria chosen depends on the final application of the model. For a planning level effort, stop criteria are established as having the simulated values that represent the mean values within a 15 percent margin of error. Operating data from February 1st, 2018 through March 14th, 2018 supplemented the enhanced sampling data for calibration.

As the primary purpose of the Nelson Complex process model is to evaluate the phasing of improvements, the stop criteria focused on creating representative unit process performance. Figures 4-5 through 4-7 represent the predicted Mission Main unit process performance, and Figures 4-8 and 4-9 represent predicted Turkey Creek unit process performance. Overall Nelson Complex solids production is shown in Figure 4-10. During the period of enhanced sampling there were 9-days of centrifuge feed data that had solids concentrations reported at an order of magnitude higher than historical averages (i.e. 30% TSS vs 3% TSS). To understand solids data irregularities, three data reconciliation strategies were evaluated and are displayed in Figure 4-10. Reconciliation methods included removing the 9 outlier days, correcting the TSS by reducing them by an order of magnitude, and utilizing a 7-day running average with corrected TSS concentrations. The 7-day running average is most suitable for comparison because it averages solids production over periods where centrifuges are not operated, which allows for direct comparison to the results from the steady-state Pro2D^2 simulations.

A process model capable of representing the enhanced sampling data and observed operational data was created. Process model validation was also performed to confirm the predictive capabilities on an independent data set. Validation is further discussed in a later section and in Appendix D.

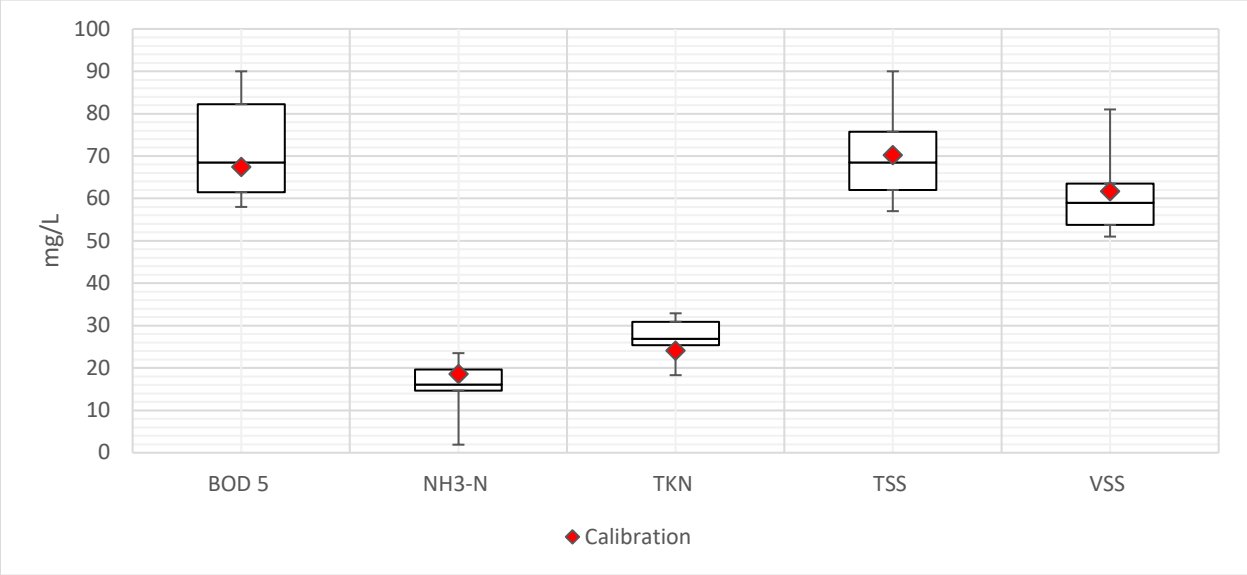


Figure 4-5: Mission Main Primary Effluent

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

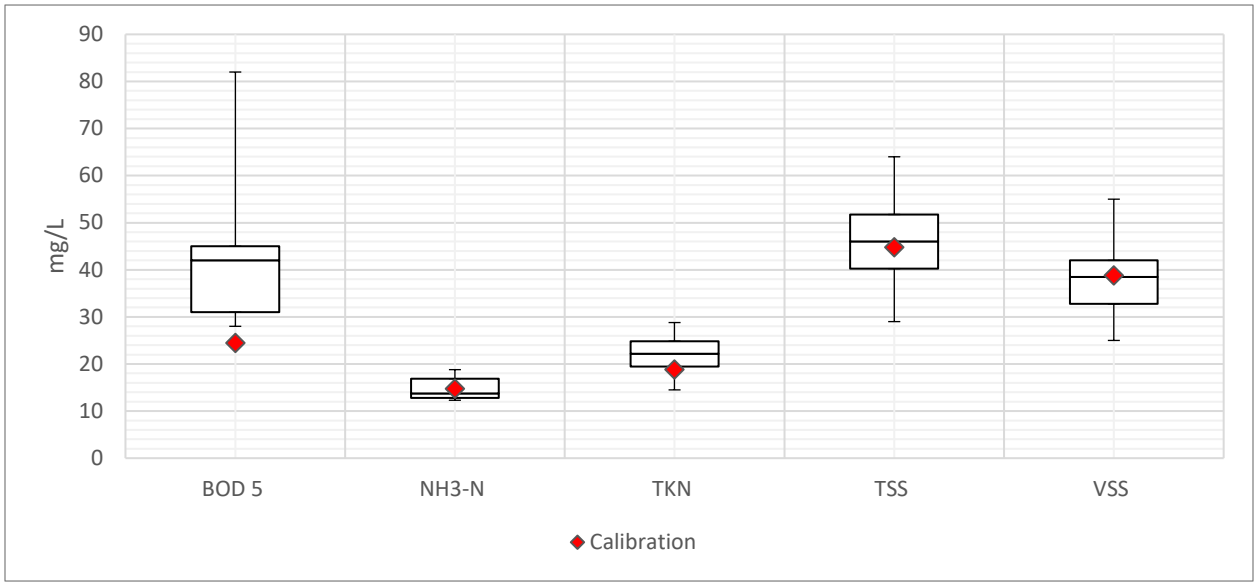


Figure 4-6: Mission Main Intermediate Clarifier

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

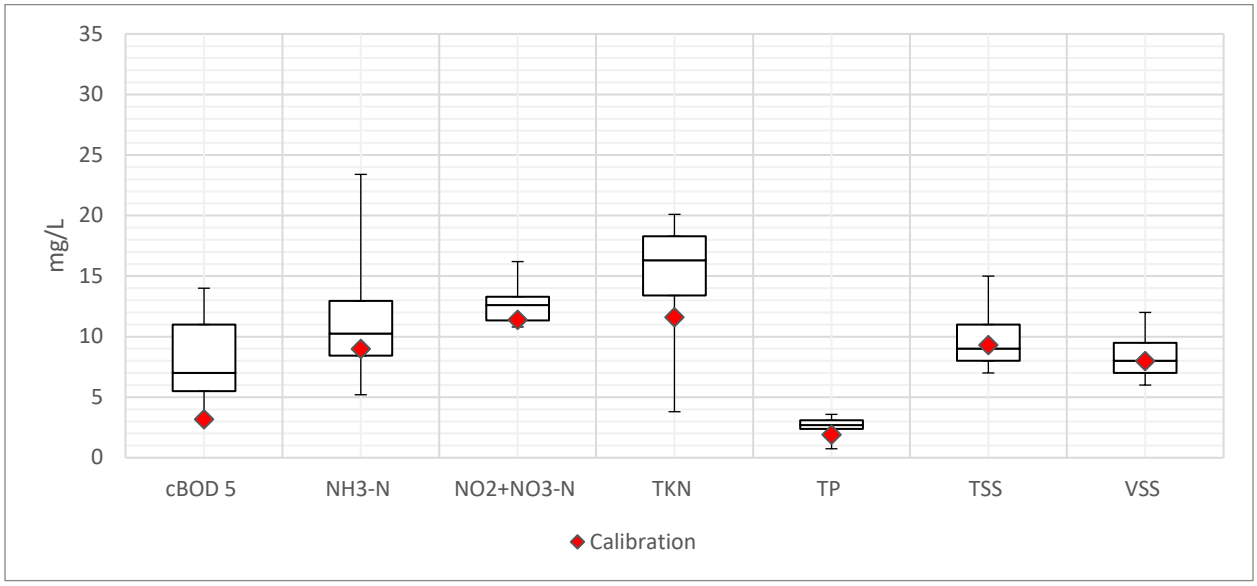


Figure 4-7: Mission Main Effluent

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

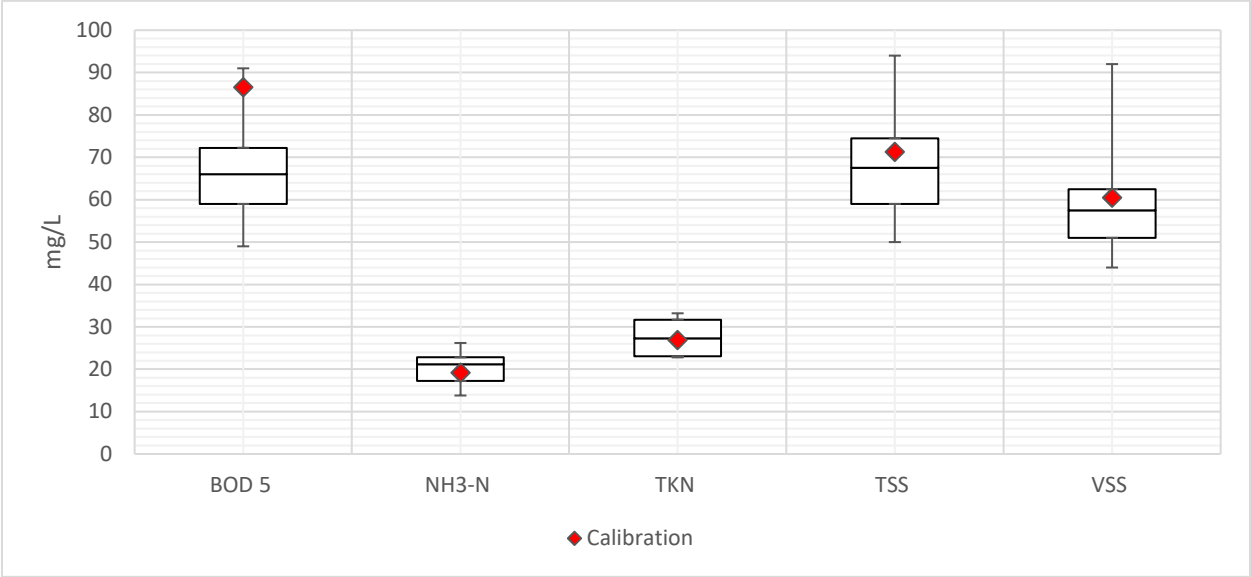


Figure 4-8: Turkey Creek Primary Effluent

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

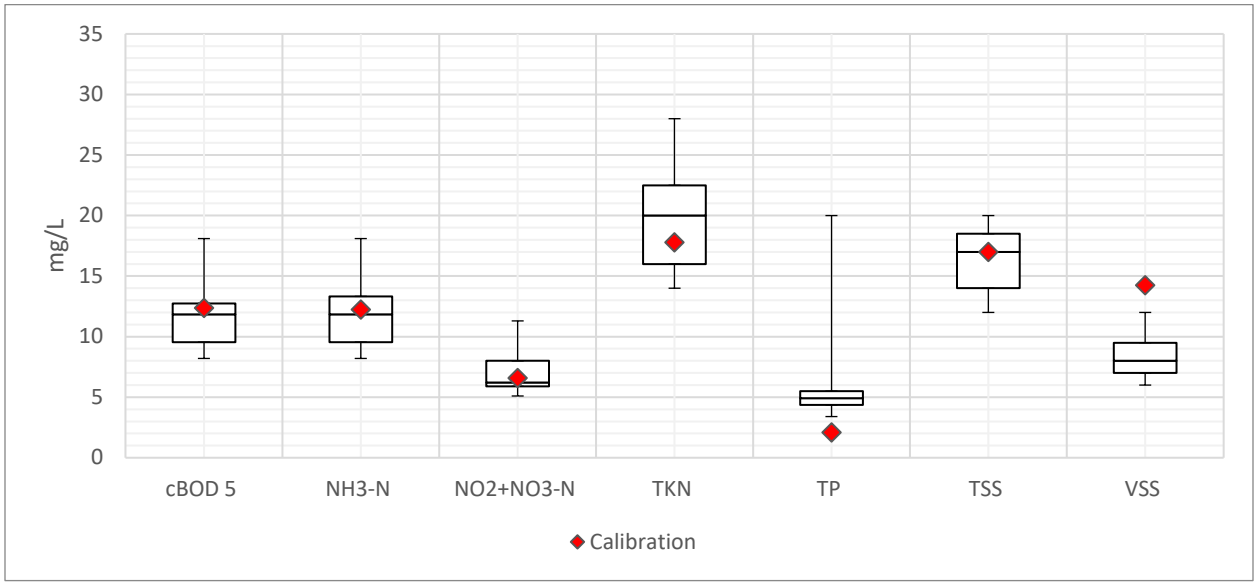


Figure 4-9: Turkey Creek Effluent

The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

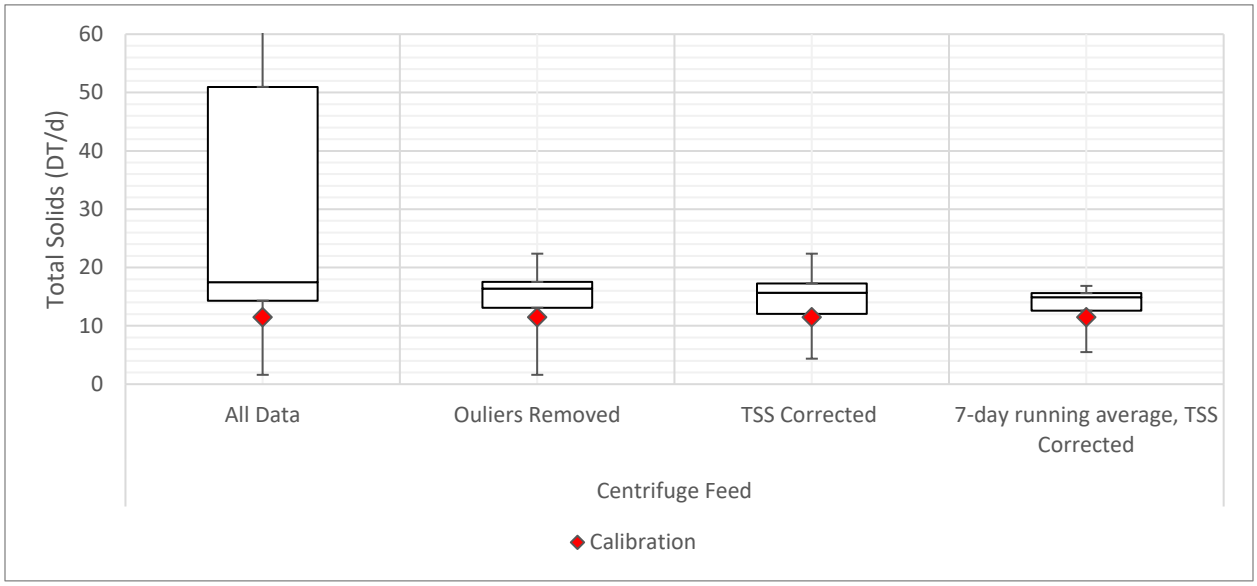


Figure 4-10: Nelson Complex Solids Production

The solids nelson complex solids production is represented by the feed to the centrifuge. All columns of data represent the same period, but with different levels of data cleaning performed. "Outliers removed" removed periods where TSS concentrations were an order of magnitude higher than historical performance. "TSS Corrected" modified the high TSS concentrations by reducing them by a factor of 10 to be in line with historical observations. "7-day running average" was included because it averages solids production over weekend days where the centrifuges are not operated. The box and whisker plots represent data observed between February 1st and March 14th, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady state calibrated value.

4.3.3 Validation

Process model validation involves establishing the predictive capability of the process model through evaluation of an independent data set not used in the calibration. No modifications to calibrated model parameters (i.e. biological rates, influent fractionation, etc.) occur during validation. In this instance, the calibrated process model was validated with observed operational data between April 21, 2017 through June 9th, 2017. This period includes the observed maximum month VSS loading, which occurred between May 5th, 2017 and June 3rd, 2017.

Results from the validation are shown in Appendix D. With exception of the Mission Main first stage trickling filter effluent ammonia concentration, the calibrated process model sufficiently predicted unit process performance at the Mission Main and Turkey Creek WWTFs. Based on the calibration and validation steps, the current Pro2D^2 process model provides a level of accuracy commensurate with the current planning level study.

5 Satellite Facilities

5.1 75th and Nall PEFTF

The 75th and Nall PEFTF is located at 7490 Nall Avenue, in Overland Park, Kansas. The PEFTF operates in conjunction with the Brush Creek PS to handle wet weather flows for the southern-most portion of the Mission Main watershed. Figures 5-1 and 5-2 show the PEFTF's site plan and flow schematic. The PEFTF consists of the following main components:

- 2 Vertical Turbine Pumps (10 mgd, 40 hp motors, VFD driven)
- Firm Capacity = 10.0 mgd (20 mgd with 2 duty pumps, 0 standby)
- 1 Manual Bar Screen (6' wide, 2.0" bar spacing)
- 4 Sodium Hypochlorite Tanks
- 2 Sodium Bisulfite Tanks

During wet weather conditions when the wet well level within the Brush Creek PS reaches a level set point of 9.5', a gate is closed within the Diversion Structure at the 75th and Nall PEFTF. Once closed, the gate limits flow to the Brush Creek PS which results in the weir located within the Diversion Structure to be overtopped, sending excess flow to the 75th and Nall PEFTF. Wet weather flows go through manual coarse bar screening and are pumped via turbine pumps into the below grade PEFTF where it is chlorinated prior to discharge. When the volume of the PEFTF is exceeded, flows overtop the effluent weir and are discharged to Brush Creek.

The site's existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne via a 12" water main which parallels Nall Avenue Two 4" service lines enter the site; one is dedicated for fire protection and the other serves the facility's potable and service water demands. The facility's natural gas service is provided by Kansas Gas Service via a 6" gas main along Nall Avenue. A 1.5" gas line enters the site from the southeast where it is metered prior to entering on the east side of the structure.

Electrical service is provided by KCPL via one 12.47kV utility-owned overhead line stepped down by a 150kVA, 12.47kV-480V pole mount transformer. Service entrance conductors route from the secondary side of the utility-owned transformer to a main service disconnect switch with 400A rated fuses. The main service disconnect switch is connected to the normal side of an automatic transfer switch (ATS). Standby power is provided by a 156.2kVA standby generator.

There is an existing RTU with HMI at the site which communicates critical alarms to the DLSMB WWTF control room. There is no main PLC control panel; the level transmitters and associated controls are mounted on the MCC to control pump operation.

Initiatives underway affecting the 75th and Nall PEFTF include MTM Contracts 73 and 74, which generally include the following improvements:

- Equipment replacement, including new pumps with 60 hp motors and associated VFDs
- New Bioxide storage and feed equipment
- Misc. repair of building superstructure architectural features

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will

further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the 75th and Nall PEFTF will be considered as part of that evaluation:

- The existing PEFTF pumps are not able to convey their design pumping capacity of 20 mgd. It is anticipated that the new pumps, once replaced as part of Contract 74, will address this issue.
- Gate position within the Diversion Structure can be changed remotely, but the system responds very slowly making it difficult to control flows.
- The electrical manhole for the main circuit to the pump station has notably settled, which could be putting pressure on the incoming circuits putting the pump station at risk for a power outage in the future
- Lack of a main PLC limits versatility in programming the pump operation and level control.

Figure 5-1: 75th and Nall Site Plan

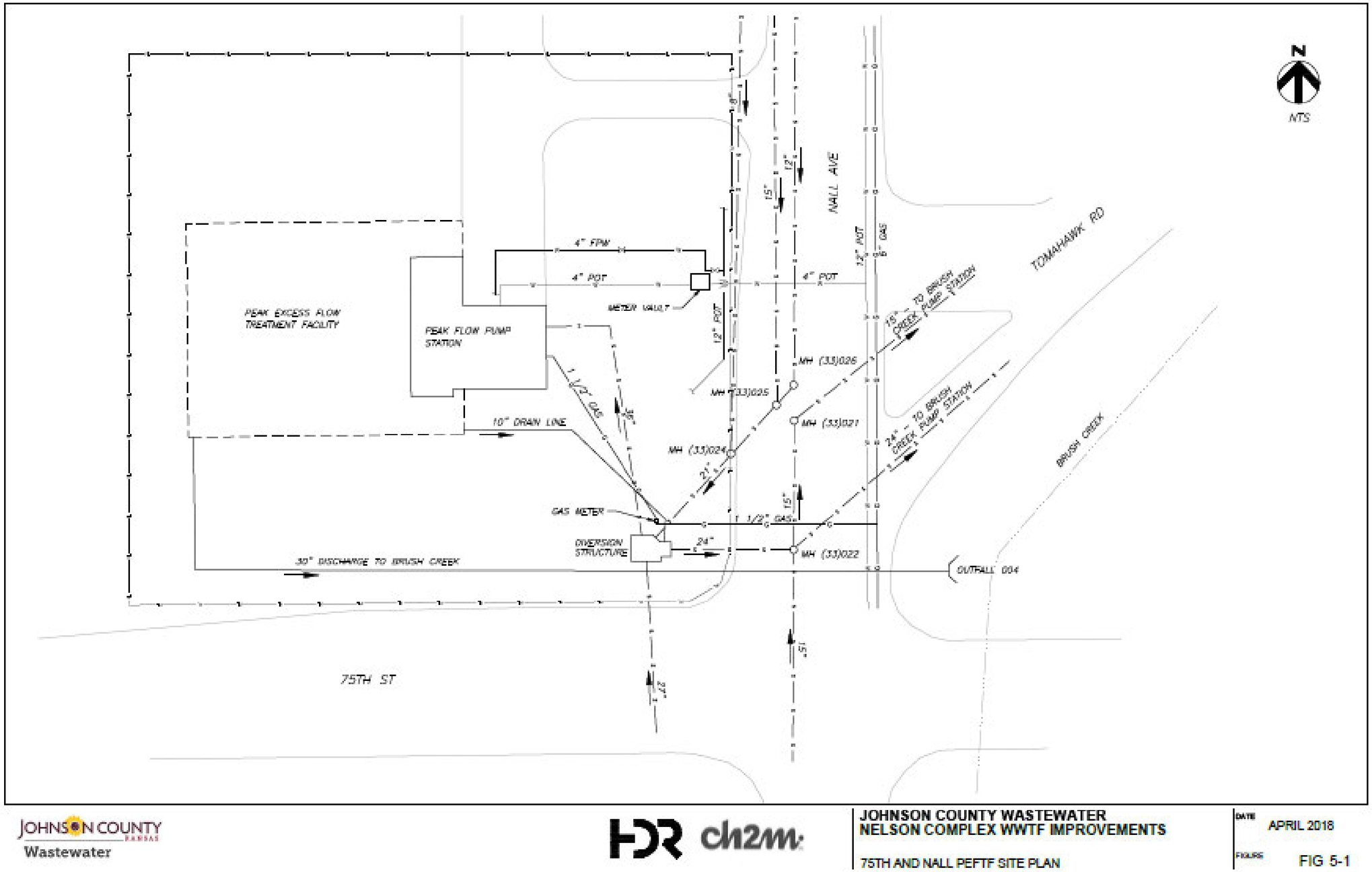
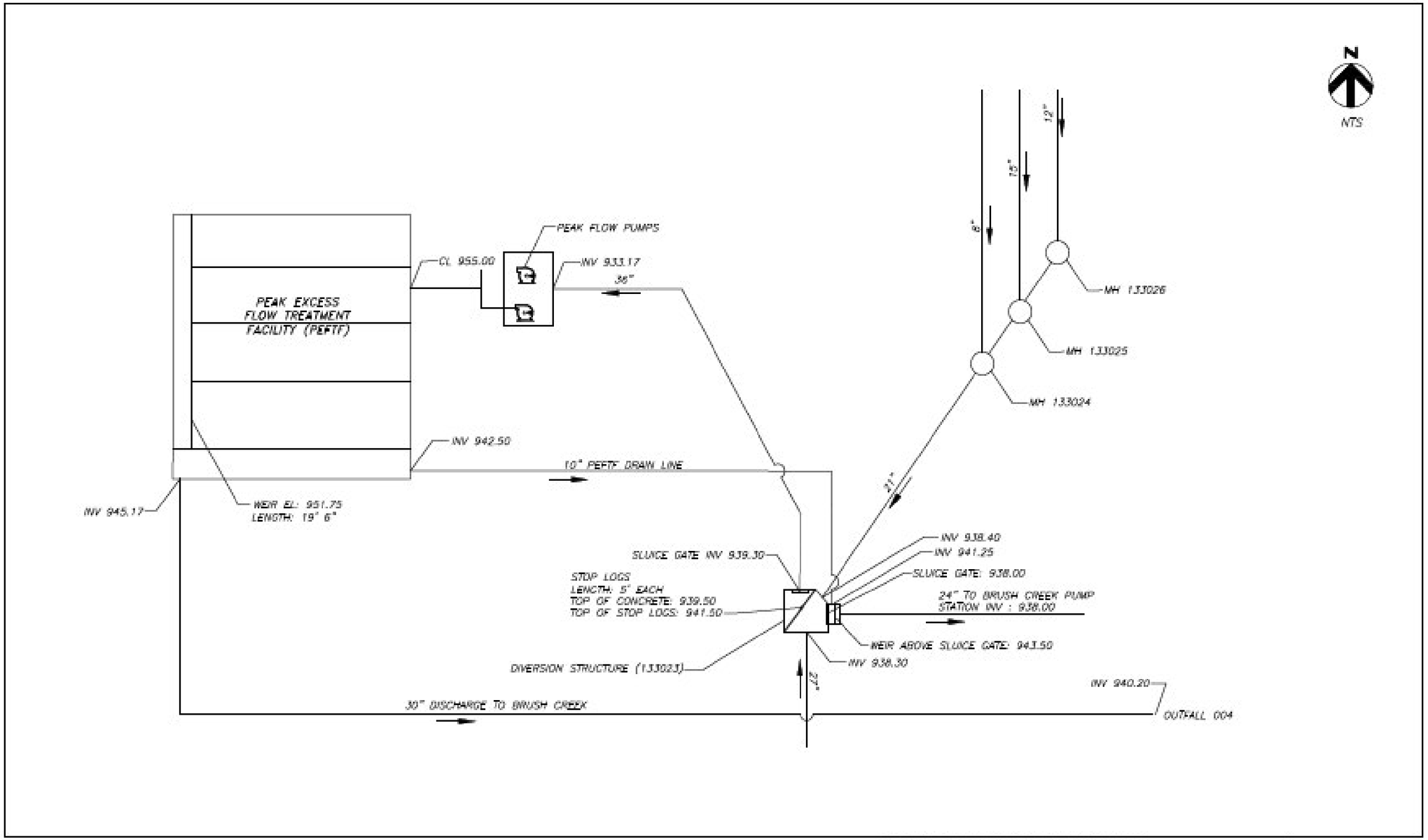


Figure 5-2: 75th and Nall Flow Schematic



JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS

75TH AND NALL PEFTF FLOW SCHEMATIC

DATE APRIL 2018

FIGURE FIG 5-2

5.2 Brush Creek Pump Station

The Brush Creek PS is located at 7401 Roe Avenue in Prairie Village, Kansas. Flow enters the facility through multiple gravity sewer mains which range in sizes from 8” to 24” and combine in Manhole (33)002 immediately upstream of the pump station. Figures 5-3 and 5-4 show the facility’s site plan and flow schematic. The pump station consists of the following main components:

- 4 Dry Pit End Suction Pumps
    - 2 large (5.5 mgd* @ 150’ TDH), 200 hp motors, driven by RVSS drives
    - 2 small (2.2 mgd* @ 74’ TDH), 50 hp motors, driven by across-the-line starters
- Firm Capacity = 5.5 mgd* (via 1 large or two small pumps)
- 1 Mechanical Bar Screen (Multi-rake, 1” bar spacing)
- 1 Grinder
- 16” Forcemain, 10,778 LF

*Rated capacity per pump. Refer to pump curves in Appendix E.

During dry weather conditions, flows from each of the sewer mains are combined in Manhole (33)002 and conveyed to the pump station through a 24” pipe. After entering the pump station, it is directed through a grinder prior to entering the wet well. At higher flows, a weir is overtopped and the additional flow is directed to the mechanical bar screen and into the wet well. The dry pit pumps are used to convey the flow through a 16” forcemain which discharges to the Diversion Structure adjacent to the Rock Creek PS.

When the total influent flow exceeds the pumping capacity of the pumps, the water level within the wet well rises to a level setpoint of 9.5’ which triggers a gate to close at the 75th and Nall Diversion Structure. As discussed in Section 5.1, the gate limits the flow to the Brush Creek PS by diverting flow to the 75th and Nall PEFTF. If the water level continues to rise at Brush Creek PS, the flow will surcharge into the upstream Manhole (30)015 and enter into a 10” line which diverts flow to the Belinder PS. The pump station is also protected by a 24” Facility Protection Device (FPD) via Manhole (33)030 which is installed to prevent flooding at the pump station and in the upstream collection system during peak storm events.

The site’s existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne via an 8” water main that runs along Roe Avenue. A 1” water service connection enters the site and provides the potable and service water demands for the pump station. A 4” natural gas main also parallels Roe Avenue and provides gas service for the pump station via a 1” line. Both the potable water and the natural gas enter the pump station from the north side of the structure as shown on Figure 5-3.

Electrical service is provided by KCPL via one 12.47kV utility owned overhead line stepped down by a 150kVA, 12.47kV-480V pole mount transformer. Service entrance conductors route from the secondary side of the utility-owned transformer to a 400A main service disconnect switch. The main service disconnect switch is connected to the normal side of an automatic transfer switch (ATS). Another utility feed similarly sized is connected to a backup 400A service disconnect switch and connected to the emergency side of the ATS. The ATS feeds MCC-1A which is main-lugged to feed MCC-1B.

There is an existing RTU at the site which communicates critical alarms to the DLSMB WWTF control room. There is no main PLC control panel. A level transmitter and its associated controls are mounted in a level control panel to control pump operation, as well as the control gate within the Diversion Structure at the 75th and Nall PEFTF.

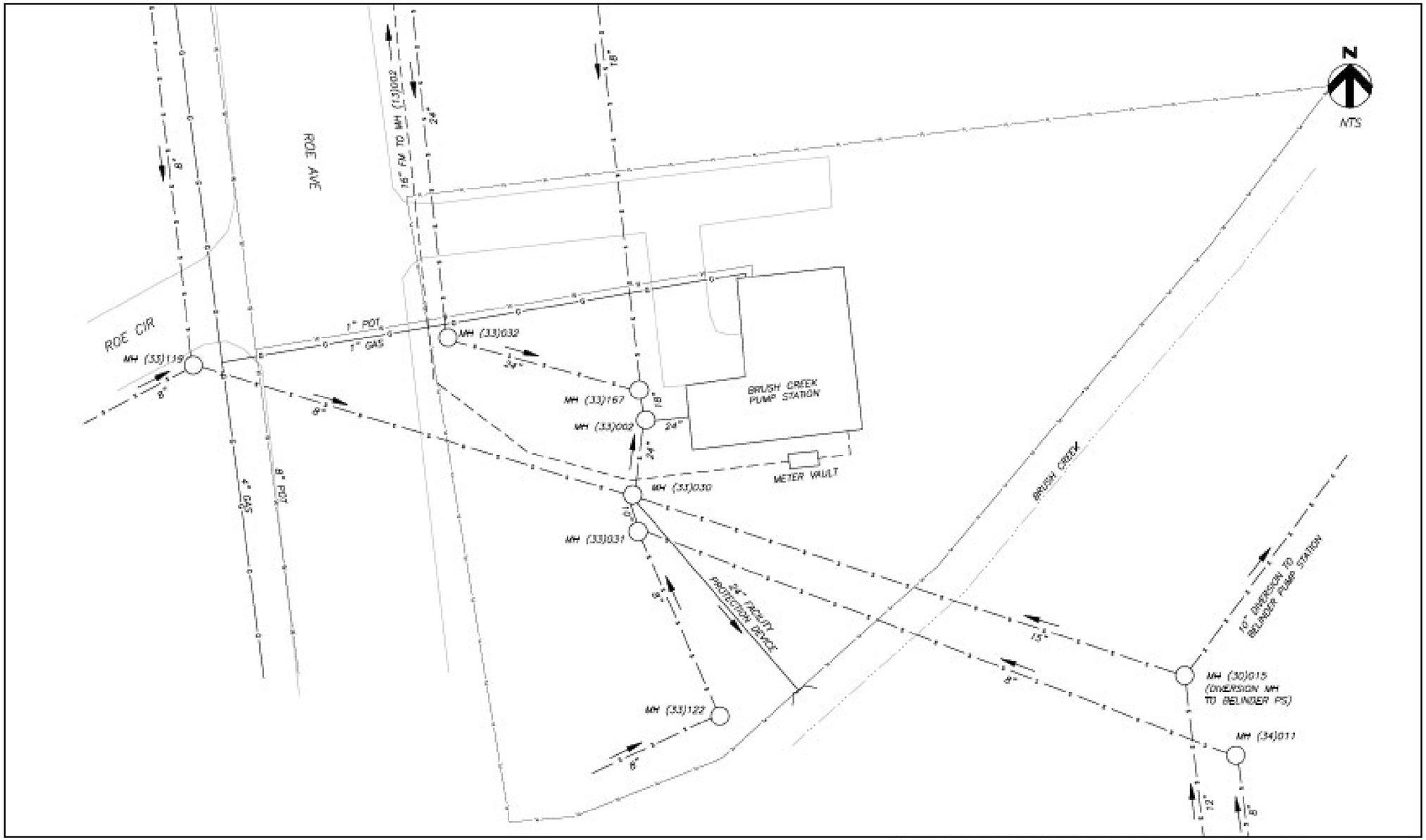
Initiatives underway affecting the Brush Creek PS include MTM Contracts 73, which generally include the following improvements:

- Improved ventilation of Screen Room
- Addition of hazardous gas detection and alarms
- Misc. repair of building superstructure architectural features

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the Brush Creek PS will be considered as part of that evaluation:

- Grinders may create issues for future Nelson solids digestion improvements and should be evaluated.
- Screen is not used frequently since operations staff has to manually lift screenings into a dumpster. There is no good way to get dumpster pick up incorporated. Evaluate means to facilitate screenings removal to allow for potential for screen to be primary device.
- Pump drywell is very tight, no room for improvements. Consideration for moving pump discharge valves to new exterior adjacent vault should be considered.
- Control valves have issues, not fully closing, causing back flow conditions
- Pumps and soft starters are old and should be considered for replacement
- Only 2 small or 1 large pumps can be in service at any given time, due to electrical service limitation as well as flow restriction at Rock Creek PS.
- JCW indicated this facility is outside of 5 year CIP which may be an issue
- Upstream MH (33)005 at intersection of Tomahawk Pkwy and Roe Ave. contains an overflow weir which diverts flow away from Brush Creek Pump Station and to Belinder PS. It was confirmed, via video footage, that the stop plates within the manhole are absent.
- Lack of a main PLC limits versatility in programming the pump operation and level control.
- The ATS, MCCs, RTU and control panels are located in the process area that has a garage door. If the garage door is left open for extended periods of time, this exposes the electrical equipment to the exterior environment. A separate electrical room for the electrical and controls equipment should be considered.

Figure 5-3: Brush Creek Pump Station Site Plan



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BRUSH CREEK PUMP STATION SITE PLAN

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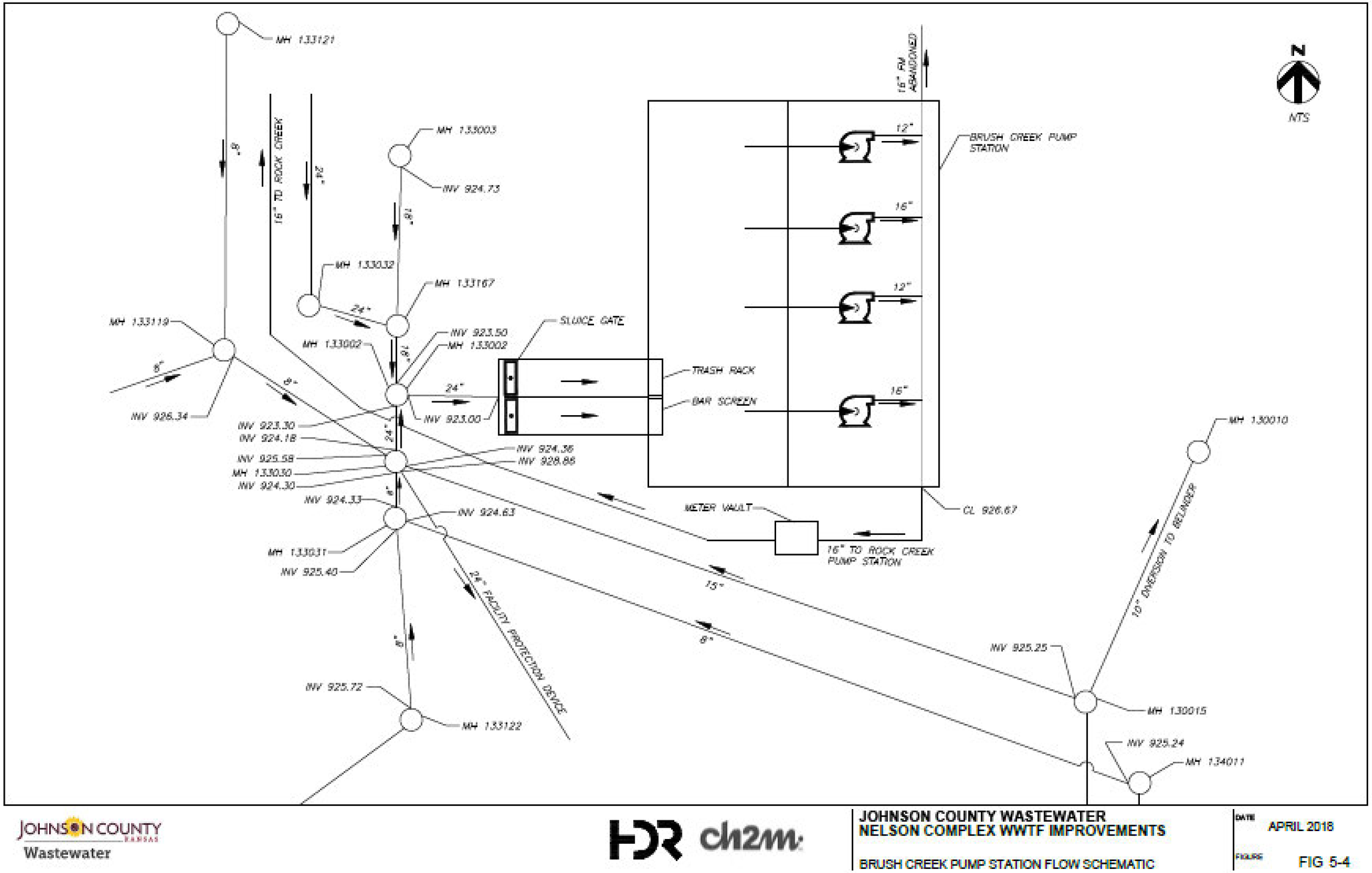
FIGURE FIG 5-3

Figure 5-4: Brush Creek Pump Station Flow Schematic



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BRUSH CREEK PUMP STATION FLOW SCHEMATIC

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FIGURE FIG 5-4

5.3 Martway PEFTF

The Martway PEFTF is located at 5395 Martway Street in Mission, Kansas. Figures 5-5 and 5-6 show the PEFTF's site plan and flow schematic. The PEFTF consists of the following main components:

- 2 Vertical Turbine Pumps (10 mgd @ 20.8' TDH), 40 hp motors, VFD driven
- Firm Capacity = 10.0 mgd (20 mgd with 2 duty pumps, 0 standby)
- 1 Manual Bar Screen (6' wide, 2.0" bar spacing)
- 4 Sodium Hypochlorite Tanks
- 2 Sodium Bisulfite Tanks
- Bioxide Odor Control

The Martway PEFTF operates in conjunction with the Rock Creek PS to relieve excess flows and protect downstream facilities from flooding. During wet weather conditions when the wet well level within the Rock Creek PS reaches a level set point of 9.5', a gate is closed within the Diversion Structure, which directs excess flows to the Martway PEFTF. Wet weather flows go through manual coarse bar screening and are pumped via turbine pumps into the PEFTF holding basin where it is chlorinated and dechlorinated. When the volume of the PEFTF is exceeded, flows overtop the effluent weir and are discharged to Rock Creek. The Diversion Structure also contains an additional 36" FPD which provides additional protection from surcharge. When the total flow to the Diversion Structure exceeds the pumping capacity, the 36" pipe will divert flows to Rock Creek.

The site's existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne and enters the site from the north via a 4" water service lateral which is routed around the west side of the adjacent bowling alley. A 2" natural gas service lateral follows a similar alignment, but enters the west face of the structure near the Diversion Structure.

Electrical service is provided by KCPL via one 12.47kV utility owned overhead line stepped down by a 150kVA, 12.47kV-480V pole mount transformer. Service entrance conductors route from the secondary side of the utility-owned transformer to a main service disconnect switch with 300A rated fuses. The main service disconnect switch is connected to the normal side of an automatic transfer switch (ATS). Backup power is provided by a standby generator.

There is an existing RTU at the site which is equipped with an HMI. The RTU communicates critical alarms to the Douglas L. Smith Middle Basin Treatment Facility control room. There is no main PLC control panel; the level transmitters and associated controls are mounted on the MCC to control pump operation.

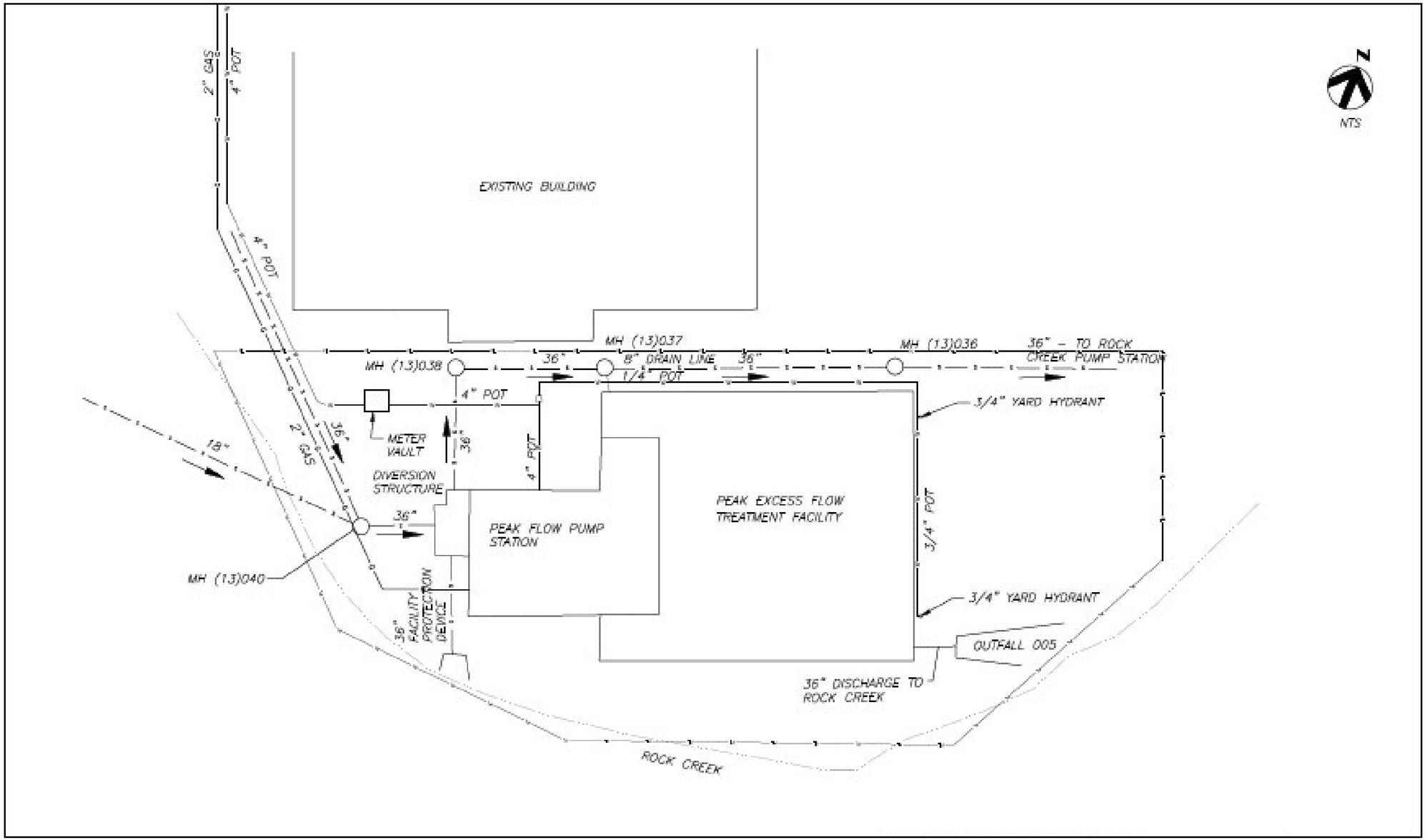
Initiatives underway affecting the Martway PEFTF include MTM Contract 74, which generally includes the following improvements:

- Repairs to vertical turbine pumps, including new 50 hp motors, VFDs, and replacement of Pump #2 impeller.
- Updates to chemical delivery, storage, and dosing
- Improvements to the Diversion Structure gates
- Misc. electrical and HVAC improvements

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the Martway PEFTF will be considered as part of that evaluation:

- Martway PEFTF is under utilized during peak storm events. The flow split at the Diversion Structure should optimize flow directed to the PEFTF during peak storm events, rather than sending that flow to Rock Creek PS
- Gate position can be changed remotely, but the system responds very slowly. Control method should be evaluated to address issues associated with response times.
- Existing 40 hp pumps are not able to meet the pump station's permitted capacity. Prior testing from the manufacturer indicated larger motors would be required. It is anticipated for this issue to be addressed following implementation of the pump improvements/repairs outlined in the ongoing construction improvements project.
- Lack of a main PLC limits versatility in programming the pump operation and level control.

Figure 5-5: Martway PEFTF Site Plan



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MARTWAY PEFTF SITE PLAN

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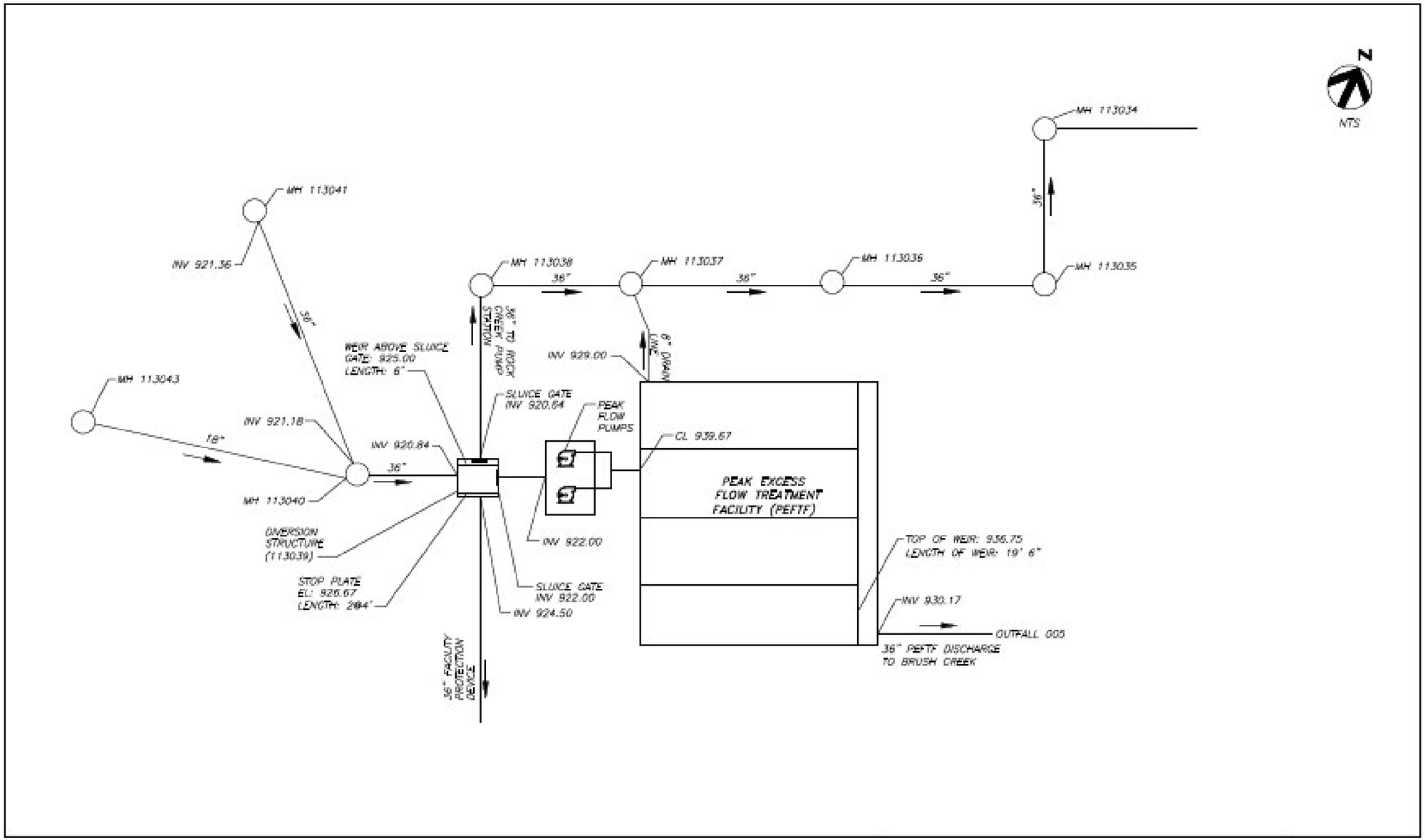
FIGURE FIG 5-5

Figure 5-6: Martway PEFTF Flow Schematic



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MARTWAY PEFTF FLOW SCHEMATIC

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FIGURE FIG 5-6

5.4 Rock Creek Pump Station

The Rock Creek PS is located at 5701 Roe Avenue in Mission, Kansas. The facility receives flow from a 42” interceptor from the west and a 16” forcemain from the Brush Creek PS. Figures 5-7 and 5-8 show the facility’s site plan and flow schematic. The pump station consists of the following main components:

- 4 Dry Pit End Suction Pumps (4.0 mgd* @ 150’ TDH, each)
    - 200 hp motors each
    - 2 driven by VFD’s, 2 driven by RVSS’s
- Firm Capacity = 12.0 mgd*
- 2 Mechanical Bar Screen (Climber, 0.75” bar spacing)
- 1 Conveyor
- 24” Forcemain, 7,069 LF

*Rated capacity per pump. Refer to pump curves in Appendix E.

During dry weather conditions, flows from the 42” interceptor from the west and the 16” forcemain from Brush Creek PS are combined in Manhole (13)002. A 42” pipe conveys the combined flow to the Rock Creek PS where it is directed through the mechanical bar screens prior to entering the wet well. The dry pit pumps are used to convey the flow through a 24” forcemain which discharges to a manhole near the Nelson WWTF.

When the total influent flow exceeds the pumping capacity of the pumps, the water level within Manhole (13)002 rises and overtops the overflow weir. Flows that overtop the weir bypass the Rock Creek PS and are sent to the Belinder PS through a 24” pipe. The 24” pipe transitions to an 18” pipe downstream of the Diversion Structure and provides limited capacity in conveying flow to the Belinder PS. This results in further surcharging within the Diversion Structure upstream of the Rock Creek PS. The total influent flow to the Rock Creek PS can also be limited by utilizing the Martway PEFTF. As discussed in Section 5.3, the pump station wet well has a level setpoint of 9.5’ that will trigger a gate to close at the Martway PEFTF Diversion Structure. The gate can then be modulated open in attempt to control flows directed to Rock Creek.

The site’s existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne and enters the site from the west via a 12” water main. A 1” natural gas line also enters from the west via a 6” gas main and is provided by Kansas Gas Service.

Electrical service is provided by KCPL via one 12.47kV utility-owned overhead line stepped down by a 750kVA, 12.47kV-480V pole mount transformer. Service entrance conductors route from the secondary side of the utility-owned transformer to a 1000A main service disconnect switch. The main service disconnect switch is connected to the switchboard which powers all of the pump station’s electrical loads. JCW personnel reports that KCPL owns and maintains an automatic/manual re-closer upstream of the pump station service disconnect which switches power between two different utility feeds. KCPL recently switched the re-closer from the manual to the automatic position in the Fall of 2017.

There is an existing RTU at the site which communicates critical alarms to the DLSMB WWTF control room. There is no main PLC control panel. The level transmitter and its associated controls

are mounted in a level control panel to control pump operation, as well as the control gate within the Influent Structure at the Martway PEFTF.

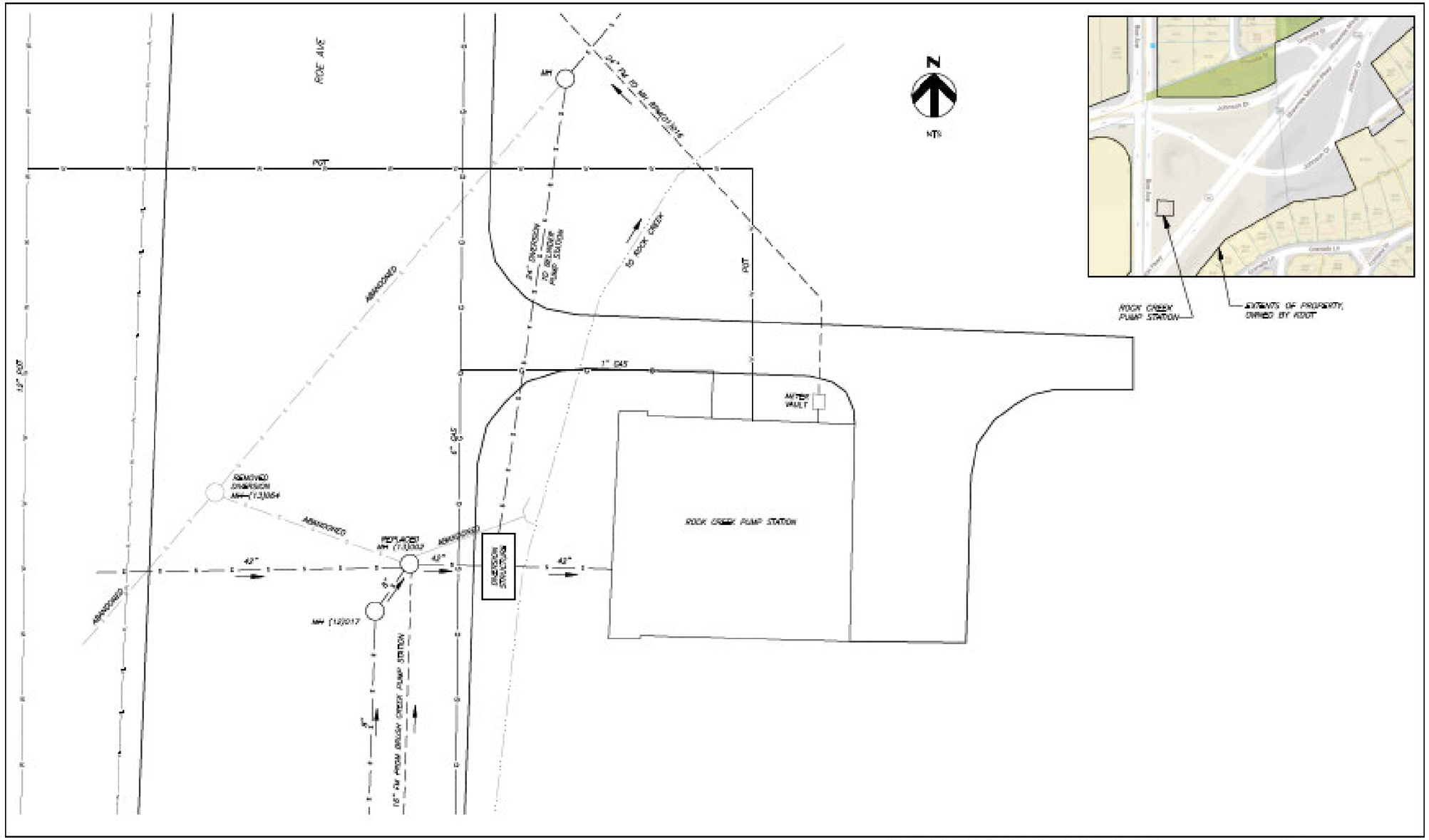
Initiatives underway affecting the Rock Creek PS include MTM Contracts 74, which generally includes the following improvements:

- Replace screening equipment
- Replace pump drives with new VFDs.
- Updates to dry well drainage system.
- Construct new electrical room with a new electrical service and backup power supply.
- Misc. electrical, structural, and architectural improvements.

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the Rock Creek PS will be considered as part of that evaluation:

- Facility does not have a backup power supply. It is anticipated for this to be addressed during the upcoming improvements project as part of the new electrical room construction.
- Diversion Structure
    - The gate on the line into Rock Creek PS is currently not functional.
    - The weir elevation of the overflow is set very close to the Rock Creek PS floor elevation which puts the pump station at a higher risk of flooding. Consideration has been given to removing 1 more stop log to increase flow to Belinder PS and decrease flow to the Rock Creek PS. However, the downstream diversion pipe is flat and provides limited conveyance capacities to the Belinder PS.
- MH in the street under the bridge is the low spot and surcharges, creates driving hazard in that area.
- Discharge flow meter is not functional and the forcemain material transitions from concrete to ductile iron pipe, then back again. JCW is unsure of concrete pipe condition.
- Install a PLC to provide versatility in programming the pump operation and consolidate the level controls currently located on the end of the MCC.

Figure 5-7: Rock Creek Pump Station Site Plan



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ROCK CREEK PUMP STATION SITE PLAN

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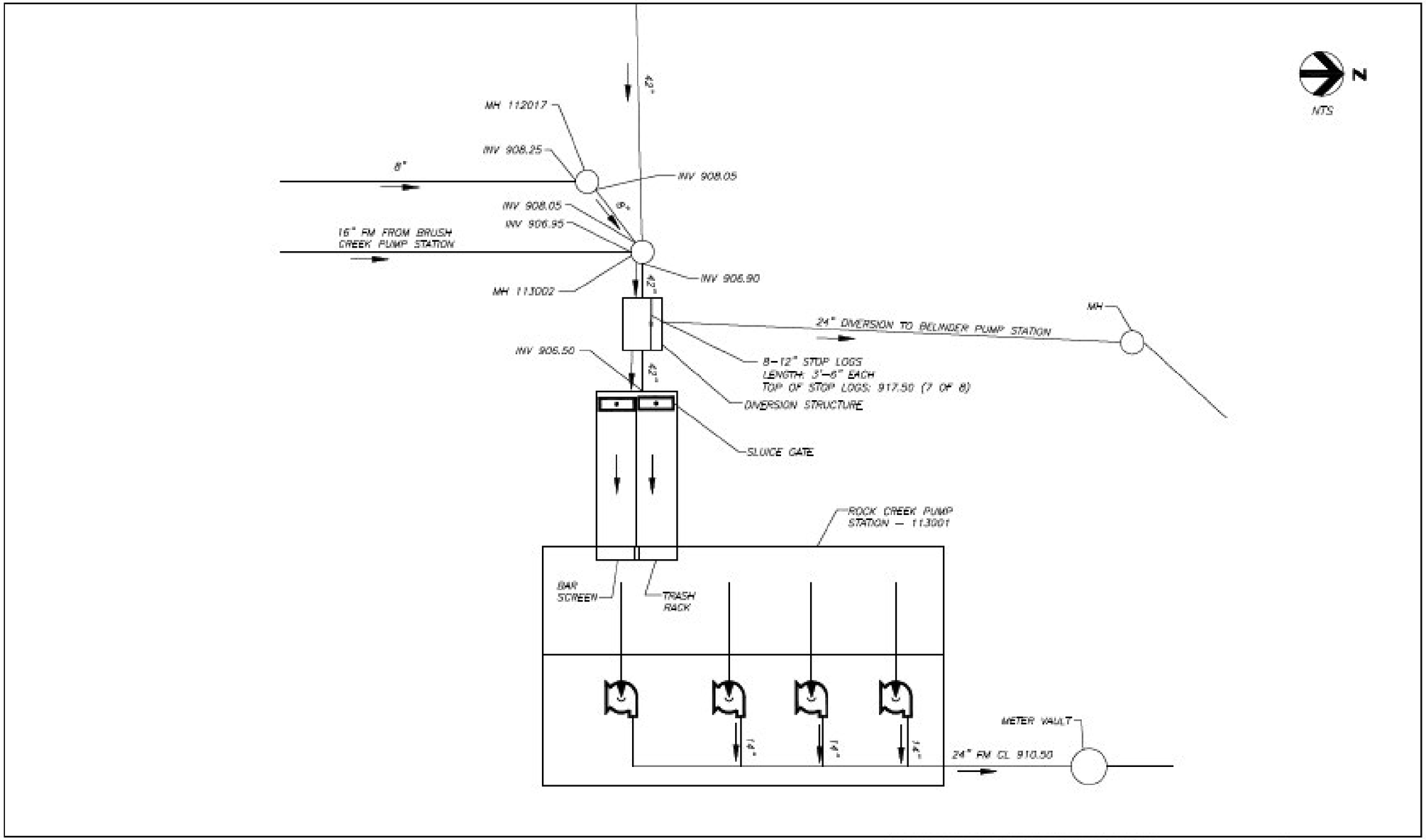
FIGURE FIG 5-7

Figure 5-8: Rock Creek Pump Station Flow Schematic



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ROCK CREEK PUMP STATION FLOW SCHEMATIC

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FIGURE FIG 5-8

5.5 Belinder Pump Station and PEFTF

The Belinder PS is located at 5700 Belinder Avenue in Fairway, Kansas. Flow enters the facility through multiple gravity sewer mains which range in sizes from 18” to 36” and combine in Junction Box (03)002 prior to the pump station. Figures 5-9 and 5-10 show the pump station’s site plan and flow schematic. The pump station consists of the following main components:

- 4 Dry Pit End Suction Pumps
    - 2 large (5.2 mgd* @ 183’ TDH), 250 hp motors, VFD driven
    - 2 small (2.7 mgd* @ 183’ TDH), 200 hp motors, VFD driven
- Firm Capacity = 10.6 mgd*
- 2 Mechanical Bar Screens (Climber type, 4’ wide, 1.5” bar spacing)
- 1 Compactor (Screw Press Type)
- 24” Forcemain, 10,969 LF @ 24” (16” Forcemain out of service)

*Rated capacity per pump. Refer to pump curves in Appendix E.

The dry weather pumps can be controlled through two control modes, A and B. Operators indicated that Mode A is typically used, which assigns two of the smaller pumps and one large pump as the duty pumps. The other large pump is assigned as standby. Pumped flows exit the pump station to the southwest where it is metered by a 16” magnetic type flow meter in a separate vault adjacent to the pump station. After metering, the forcemain expands to a 24” and conveys flow to a discharge manhole near the Nelson Complex. In addition to the 24” forcemain is a second 16” which conveys flow to a separate discharge manhole near the Nelson Complex. JCW staff reported that the 16” forcemain has not been in service for several years due to concerns with its condition.

The Belinder PEFTF is located on the same site as the pump station. The PEFTF is situated to the south of the pump station and is also shown on Figures 5-9 and 5-10. The PEFTF consists of the following main components:

- 2 Vertical Turbine Pumps
    - 20 mgd, 100 hp motors, constant speed
- Firm Capacity = 21 mgd (42 mgd with 2 duty pumps, 0 standby)
- 2 Manual Bar Racks (4’ wide, 2.0” bar spacing)
- Holding Basin Volume: ~900,000 gal. (120’x145’x7’)
- 2 Sodium Hypochlorite Tanks
- Bioxide Odor Control

During wet weather conditions, excess flows are diverted to the wet weather pump station by overtopping a control weir in the upstream Diversion Structure and are conveyed to the wet weather pump station wet well. Wet weather flows are pumped via turbine pumps into the below grade PEFTF where it is chlorinated prior to discharge. When the volume of the PEFTF is exceeded, flows overtop the effluent weir and are discharged to Brush Creek.

The collection system just upstream of the PEFTF located to the south contains a FPD at MH (03)028. This MH is also shown on Figures 5-9 and 5-10. When flow within the collection system surcharge to reach the overflow invert within the MH, they are metered and then directed to the PEFTF discharge structure and combined with discharge from the PEFTF and then metered again. There is also a storm water inlet structure located on the south side of the PEFTF and discharges

storm water downstream of the PEFTF discharge weirs. This connection results in metering of combined storm water and PEFTF flow when PEFTF storage capacity is exceeded.

The site's existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne and enters the site from the south through a 4" service lateral which is fed from a 6" water main. An additional 1.5" potable water service lateral is also fed to the PS from the south. For natural gas service, a 1" gas service line is fed from a 4" natural gas main and also enters the site from the south, paralleling the potable water lines.

Electrical service is provided by KCPL via two 12.47kV lines #J10-611 and #J10-612. The service is metered on the primary at 12.47KV. Utility line #J10-611 feeds Transformer R52 and then loop feeds Transformer R54. Utility line #J10-612 feeds Transformer R51 and then loop feeds Transformer R53. Transformers R51 and R52 are 750kVA and step the voltage down to 480V. These transformers feed into a main-tie-main switchboard that provides power to MCC-1 and MCC-2 which feed the dry weather pumps. Transformers R53 and R54 are 300kVA and step the voltage down to 480V and feed into an Automatic Transfer Switch (ATS). The ATS feeds into another ATS that can select between the utility source or the standby generator This ATS feeds into the pump station's critical loads on MCC-3 which provide power to the wet weather pumps.

There is an existing RTU at the site which communicates critical alarms to the DLSMB WWTF control room via an existing radio system installed in 2010. There is a main PLC control panel that contains a GE Fanuc 90-30 PLC which monitors and controls pump operation. The PLC panel has an HMI for viewing pump status, wetwell levels, bar screen status and alarms.

Initiatives underway affecting the Belinder PS include the following improvements:

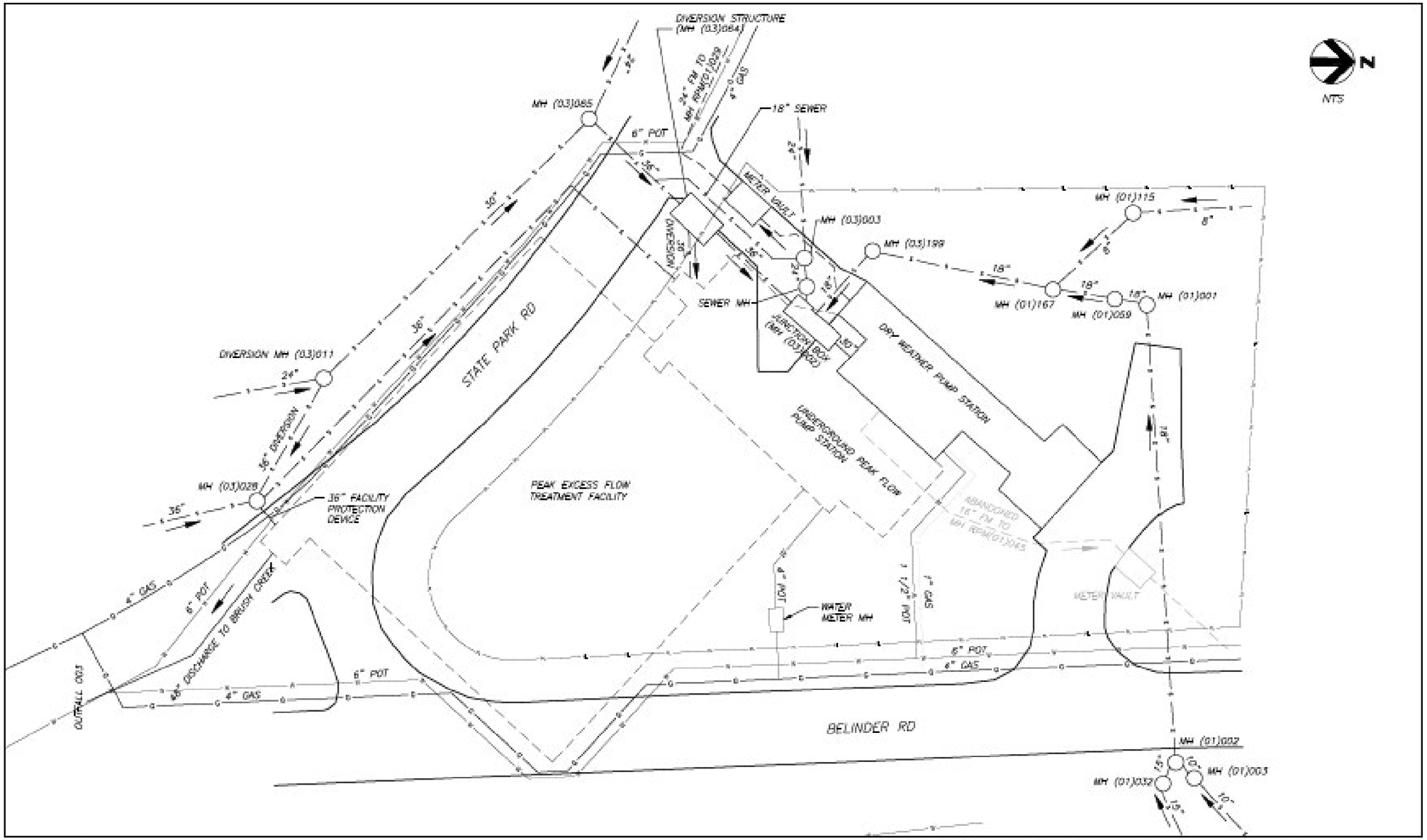
- Replace JCW owned transformers with utility owned transformers.
- Conversion of service from primary metered to secondary metered.

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the Belinder PS and PEFTF will be considered as part of that evaluation:

- Control of the dry weather pumps is complicated due to having different sized pumps. Staff would prefer a common pump size/capacity which would simplify the control modes and provide more operational flexibility with balancing pump run times.
- Electrical junction boxes are not in an accessible location and should be relocated to a more serviceable area, such as the mezzanine level.
- Wet weather pump motors are too low and subject to damage from flooding.
- Ingress/Egress for lower pump area is non-compliant with current building code.
- Dry weather bar screens and screen compactor are near the end of their useful life and should be considered for replacement.
- An apparent flow restriction between the Diversion Structure and the dry weather wet well is causing the PEFTF to be used before the dry weather pumping capacity is reached. Staff noted that excessive grit settlement within the Diversion Structure could be causing the issue.

- Existing storm water connection downstream of the PEFTF discharge weir causes metering of storm water flows. Evaluate alternatives for removing storm water connection.
- Future regulation may require the addition of sodium bisulfite storage and feed equipment.
- Wet weather wet well dewatering pumps are not reliable and in need of replacement.
- Rooms/areas within PS are not up to code with respect to NFPA 820 code.
- PEFTF dewatering pump was recently replaced with a new grinder type pump but has been historically subject to frequent clogging/breakdowns, forcing staff to use a portable pump for dewatering. This may require a change in pump type or the addition of maceration type equipment upstream of pumping.

Figure 5-9: Belinder Pump Station Site Plan



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BELINDER PUMP STATION & PEFTF SITE PLAN

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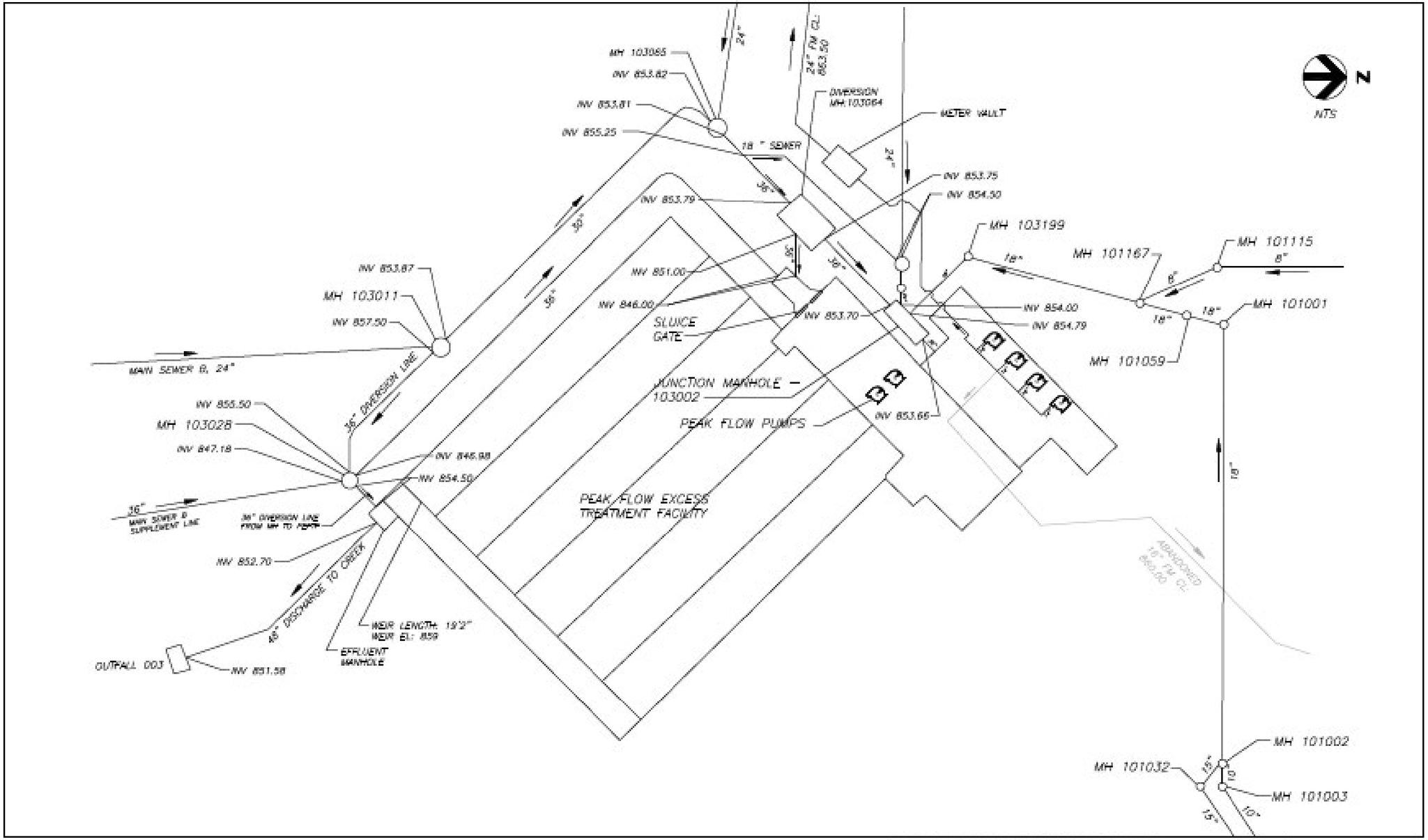
FIGURE FIG 5-9

Figure 5-10: Belinder Pump Station Flow Schematic



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BELINDER PUMP STATION AND PEFTF FLOW SCHEMATIC

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FIGURE FIG 5-10

5.6 Turkey Creek Pump Station and PEFTF

The Turkey Creek PS is located at 6700 Foxridge Dr. in Mission, Kansas. Flow enters the facility through a 42” gravity sewer main into the Influent Structure adjacent to the Dry Weather PS. Figures 5-11 and 5-12 show the pump station’s site plan and flow schematic. The pump station consists of the following main components:

- 4 Dry Pit End Suction Pumps (9 mgd* @ 108’ TDH), 300 hp motors
    - 2 VFD driven
    - 2 RVSS driven
- Firm Capacity: 27 mgd* (3 duty pumps, 1 standby)
    - Currently limited to approximately 21 mgd due to hydraulic restrictions at the Nelson Complex.
- 2 Mechanical Bar Screens (Climber type, 6’ wide, 1.0” bar spacing)
- 2 Washer/Compactors
- 2 Forcemains
    - 3,580 LF @ 24”
    - 3,512 LF @ 30”

*Rated capacity per pump. Refer to pump curves in Appendix E.

During dry weather conditions, flows are directed through the coarse mechanical bar screens prior to entering the wet well. The dry weather pumps have a common 24” discharge header which exits the structure to the north and south. The two forcemains are routed to a common flow meter vault and convey flow to the Nelson WWTF. Downstream of the flow meter vault, the northern-most forcemain transitions to a 30” line while the southern-most forcemain remains a 24”. The forcemains can be isolated by operating the forcemain isolation valves of the pumps’ common discharge header, but typical operation requires both forcemains to be in service.

The wet weather pump station and PEFTF are located on the same site as the dry weather pump station. The PEFTF is situated to the east of the dry weather pump station and is also shown on Figures 5-11 and 5-12. The wet weather pump station and PEFTF consist of the following main components:

- 2 Vertical Turbine Pumps
    - 11 mgd @ 29’ TDH, 100 hp motors, constant speed
- Firm Capacity: 11 mgd (22 mgd with 2 duty pumps, 0 standby)
- 1 Manual Bar Rack (6’ wide, 1.0” bar spacing)
- Holding Basin Volume: ~405,000 gal. (90’ diameter x 8.5’ SWD)
- 2 Sodium Hypochlorite Tanks

During wet weather conditions, excess flows are diverted to the wet weather pump station and PEFTF by overtopping a control weir in the Influent Structure and are conveyed to the wet weather pump station through a 42” pipe. Wet weather flows are directed through a manual bar rack to the wet well where it the sodium hypochlorite is injected. The vertical turbine pumps convey the flow to the PEFTF holding basin. When the volume of the PEFTF is exceeded, flows overtop the effluent weir and are discharged to Turkey Creek.

The site's existing utilities include potable water, natural gas, and electric. Potable water is provided by WaterOne and enters the site from the south via a 4" water service lateral fed from a 12" water main. A 1.5" natural gas line also enters from the south from a 4" gas main which is provided by Kansas Gas Service.

The pump station is fed from two 12.47kV KCPL circuits, 6843 and 6823. Two 12.47kV/480V utility owned transformers step the voltage down to 480V. These transformers feed into a 2000A main-tie-main switchgear. The switchboard contains an automatic transfer system that transfers the load to the alternate feed on loss of power. The switchgear feeds the four dry weather pumps, MCC-1 and MCC-3. The dry weather pump station loads are powered from MCC-1, and the wet weather pump station loads are powered from MCC-3.

There are two existing RTUs at the site which communicate critical alarms to the DLSMB WWTF control room. One is dedicated to the dry weather pump station and the other is dedicated to the wet weather pump station. There is a main PLC control panel located in the Electical Building that contains a GE Fanuc VersaMax PLC which monitors and controls the dry weather pump operation. The PLC panel has an HMI for viewing dry weather pump status, wetwell levels, bar screen status and alarms. There is also an HMI screen in the dry weather pump station electrical room for local monitoring and control in this building.

The TCPS communicates with the Nelson Complex via fiber from the GE PLC panel. The purpose of this fiber connection is two-fold. First, the RTU's use the fiber to connect to the radio network at the Nelson Complex for communication with the DLSMB. The second purpose is to allow monitoring of the TCPS flows at local displays in the UV Building at the Nelson Complex. The intent is for this fiber connection to connect to the Nelson Complex future SCADA system.

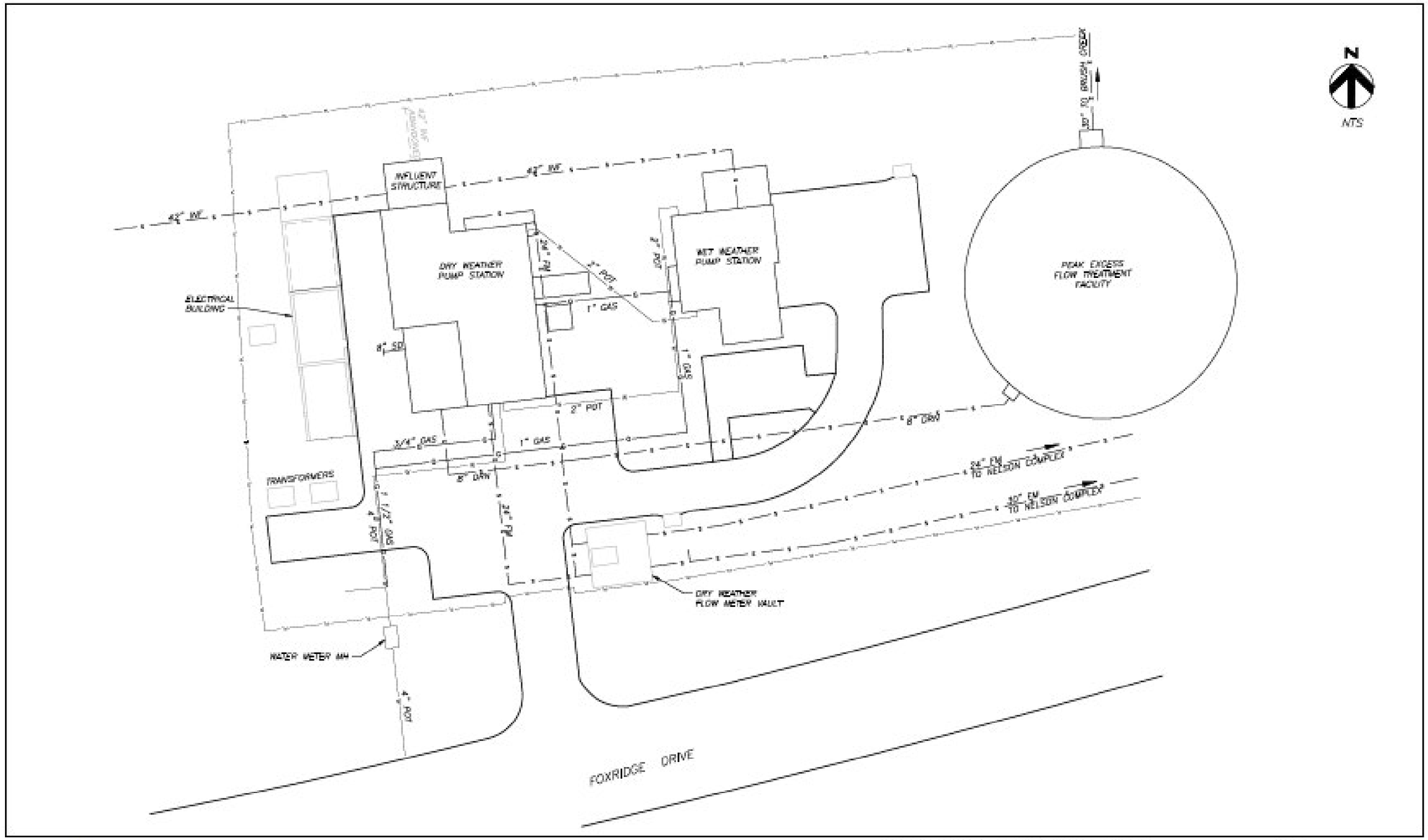
Initiatives underway affecting the Turkey Creek PS and PEFTF include SMTC Contract 37, which generally includes the following improvements:

- Replace dry weather screens and washer/compactors.
- Replace dry weather pump drives with new VFDs.
- Replace wet weather pumps and provide new VFDs.
- Replace chemical storage and feed equipment.
- NFPA 820 compliance upgrades.
- Installation of a PLC control panel with HMI in the wet weather pump station.
- Misc. electrical, structural, architectural, and site/civil improvements.

Based upon the information obtained from prior technical reports, site visits, and discussions with JCW staff, various facility issues/equipment deficiencies have been identified. Subsequent TMs will further evaluate these issues in conjunction with those identified at other satellite facilities and provide recommendations for potential future improvements that aim to optimize the conveyance and treatment of all flows within the service area of the Nelson Complex. The following major issues at the Turkey Creek PS and PEFTF will be considered as part of that evaluation:

- Combined pumping capacity (dry weather and wet weather pump stations) are not able to convey the unrestricted flow for the Turkey Creek watershed.
- Future regulation may require the addition of sodium bisulfite storage and feed equipment.

Figure 5-11: Turkey Creek Pump Station and PEFTF Site Plan



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TURKEY CREEK PUMP STATION SITE PLAN

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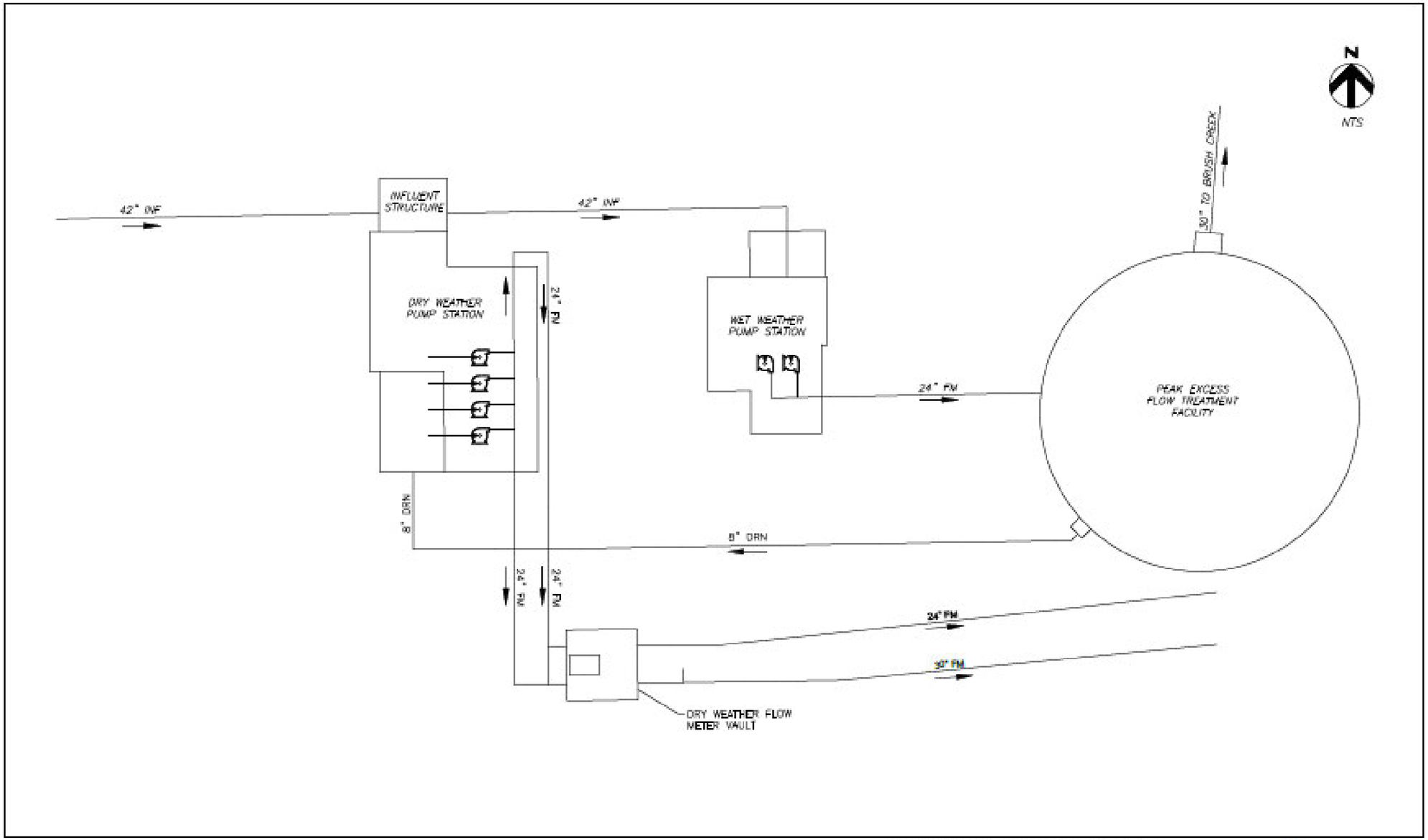
FIGURE FIG 5-11

Figure 5-12: Turkey Creek Pump Station and PEFTF Flow Schematic



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TURKEY CREEK PUMP STATION FLOW SCHEMATIC

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FIGURE FIG 5-12

6 Economic Analysis Assumptions

The economic analysis of alternatives considered in the Facility Plan will be based on the following assumptions:

- Planning horizon for facilities = 20 years
  - Design in 2022 - 2023
  - Construction in 2024 through 2027
  - First year of operation to begin January 2028

- Economic analysis for comparison of alternatives = Net Present Value (NPV) in 2018 dollars
  - Nominal discount rate (includes effects of inflation) = 2.20%/year [20-year value from Office of Management and Budget Circular No. A-94, revised February 2018]
  - Real discount rate (excludes effects of inflation) = 0.20%/year [20-year value from Office of Management and Budget Circular No. A-94, revised February 2018]

- Labor Costs
  - $33/hr including benefits

- Electrical Costs
  - $0.10/kW

- Chemical Costs
  - Ferric Chloride at 40% - $1.30/lb
  - Dry Polymer - $1.50/lb
  - Sodium Hypochlorite, Bulk at 10-15% - $0.87/gallon
  - Sodium Bisulfite, Bulk at 40% - $0.18/gallon
  - Sodium Hydroxide, Bulk at 50% - $2.52/gallon

- Sludge Disposal Costs
  - Contract land application, at $37/wet ton, based on full conversion to anaerobic digestion

Note: All costs in 2018 $'s.

Appendix A In-Plant Pumping Capacities and Unit Process Sizing

Table A-6-1: In-Plant Pumping Facility Capacities

TURKEY CREEK WWTF PUMP INFORMATION					
Pump Station	**Pump Number**	**Capacity (gpm)**	**TDH (ft)**	**HP**	**Station Firm Capacity (gpm)**
Primary Sludge Pump Station Building #1 (From 1A, 1B, & 2 Primary)	1	≈ 100	--	15	--
	2	≈ 100	--	15	--
	3	≈ 100	--	15	--
					200
Primary Sludge Pump Station Building #2 (From 3 & 4 Primary)	1	≈ 100	--	15	--
	2	≈ 100	--	15	--
					100
Settled Sewage Pump Station Building #3 (Primary Effluent to Splitter Tower for 1 & 2 Trickling Filters)	1	4750	85	150	--
	2	4750	85	150	--
	3	4750	85	150	--
					9500
Settled Sewage Lift Station #4 (Primary Effluent to Splitter Tower for 3 & 4 Trickling Filters)	1	4750	80	150	--
	2	4750	80	150	--
	3	4750	80	150	--
					9500
Sludge Recirculation Pump Station Near Final Clarifiers #1 & #2 (From Finals back to Vortex Grit Building)	1	200	--	--	--
	2	200	--	--	--
					200

MISSION MAIN WWTF PUMP INFORMATION					
Pump Station	**Pump Number**	**Capacity (gpm)**	**TDH (ft)**	**HP**	**Station Firm Capacity (gpm)**
Settled Sewage Lift Station Building #4 (Trickling Filters 1 & 2 to Intermediate Splitter at Building 5)	1	11,900	41	150	--
	2	11,900	41	150	--
	3	5400	38	75	--
	4	5400	38	75	--
					22,700
Intermediate Clarifier Sludge Pump Station – Building #5 (Pump Back to MH ahead of Grit Structure)	1	190	--	5	--
	2	190	--	5	--
					190
Sludge Recirculation Pump Station Near Final Clarifiers #1 & #2 (From Finals back to Vortex Grit Building)	1	200	35	5	--
	2	200	35	5	200
					200

Table A-6-2: Physical Size Characteristics of Liquid Process Facilities

TURKEY CREEK WWTF CLARIFIERS AND TRICKLING FILTERS		
Item	**Diameter or L X W (ft)**	**Structure Side Depth (ft)**
Primary Clarifier #1	125.33 x 42	10.2
Primary Clarifier #2	125.33 x 42	10.2
Primary Clarifier #3	121.33 x 43	10.2
Primary Clarifier #4	121.33 x 43	10.2
Trickling Filter #1	160	11.58
Trickling Filter #2	160	11.08
Trickling Filter #3	160	11.75
Trickling Filter #4	160	11.75
Final Clarifier #1	122 x 42	9.75
Final Clarifier #2	122 x 42	Varies – 9.75 to 11.25
Final Clarifier #3	118 x 43	10.25
Final Clarifier #4	118 x 43	10.25
Chlorine Contact Basin #1	165 x 40	8.5
Chlorine Contact Basin #2	165 x 40	8.5

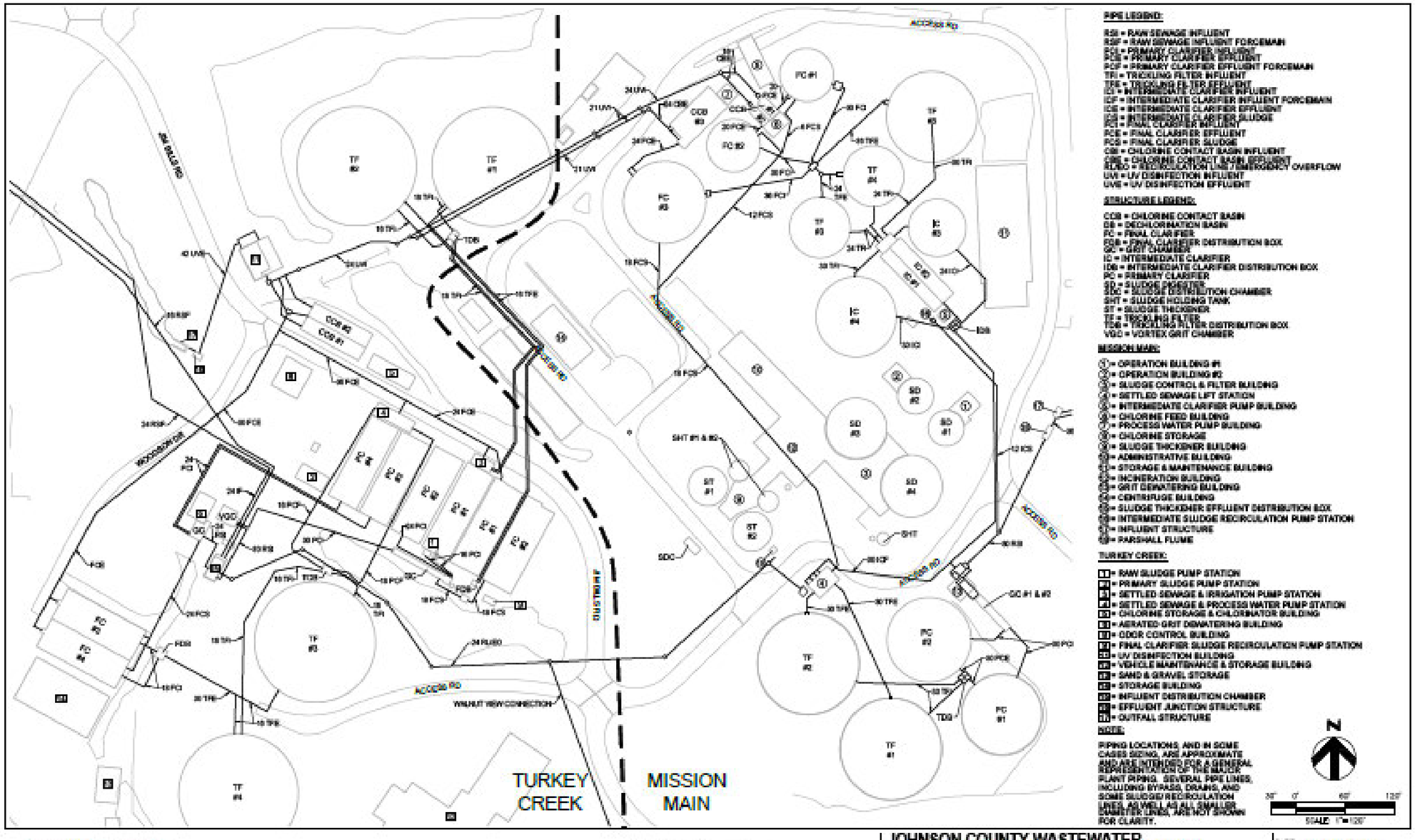
MISSION MAIN WWTF CLARIFIERS AND TRICKLING FILTERS		
Item	**Diameter or L X W (ft)**	**Structure Side Depth (ft)**
Primary Clarifier #1	100	10.2
Primary Clarifier #2	100	10.2
Trickling Filter #1	135	Varies – 11.25 to 12.5
Trickling Filter #2	135	Varies – 11.25 to 12.5
Intermediate Clarifier #1	108 x 16.67	Varies – 8.42 to 8.92
Intermediate Clarifier #2	108 x 16.67	Varies – 8.42 to 8.92
Intermediate Clarifier #3	70	8.5
Intermediate Clarifier #4	100	9
Trickling Filter #3	80	12.5
Trickling Filter #4	80	12.5
Trickling Filter #5	120	11.5
Final Clarifier #1	65	6.42
Final Clarifier #2	65	6.42
Final Clarifier #3	110	10.25
Final Clarifier #4	118 x 43	8.17
Chlorine Contact Basin #1	30 x 16	9.0
Chlorine Contact Basin #2	30 x 16	9.0
Chlorine Contact Basin #3	70 x 34	11.0

Table A-6-3: Physical Size Characteristics of Solids Facilities

Item	Diameter (ft)	Structure Side Depth (ft)
Sludge Thickener #1	25	10
Sludge Thickener #2	25	10
Sludge Holding Tank #1	12.5	20
Sludge Holding Tank #2	12.5	20
Sludge Digester #1	22.5	25
Sludge Digester #2	22.5	25
Sludge Digester #3	40	27
Sludge Digester #4	40	27

Note: Centrifuge Building includes two centrifuges which processes an estimated 210,000 lbs/week of biosolids (one centrifuge x 6,000 lbs/hr x 7 hr/day x 5 days/week).

Appendix B Drawings



JOHNSON COUNTY KANSAS Wastewater

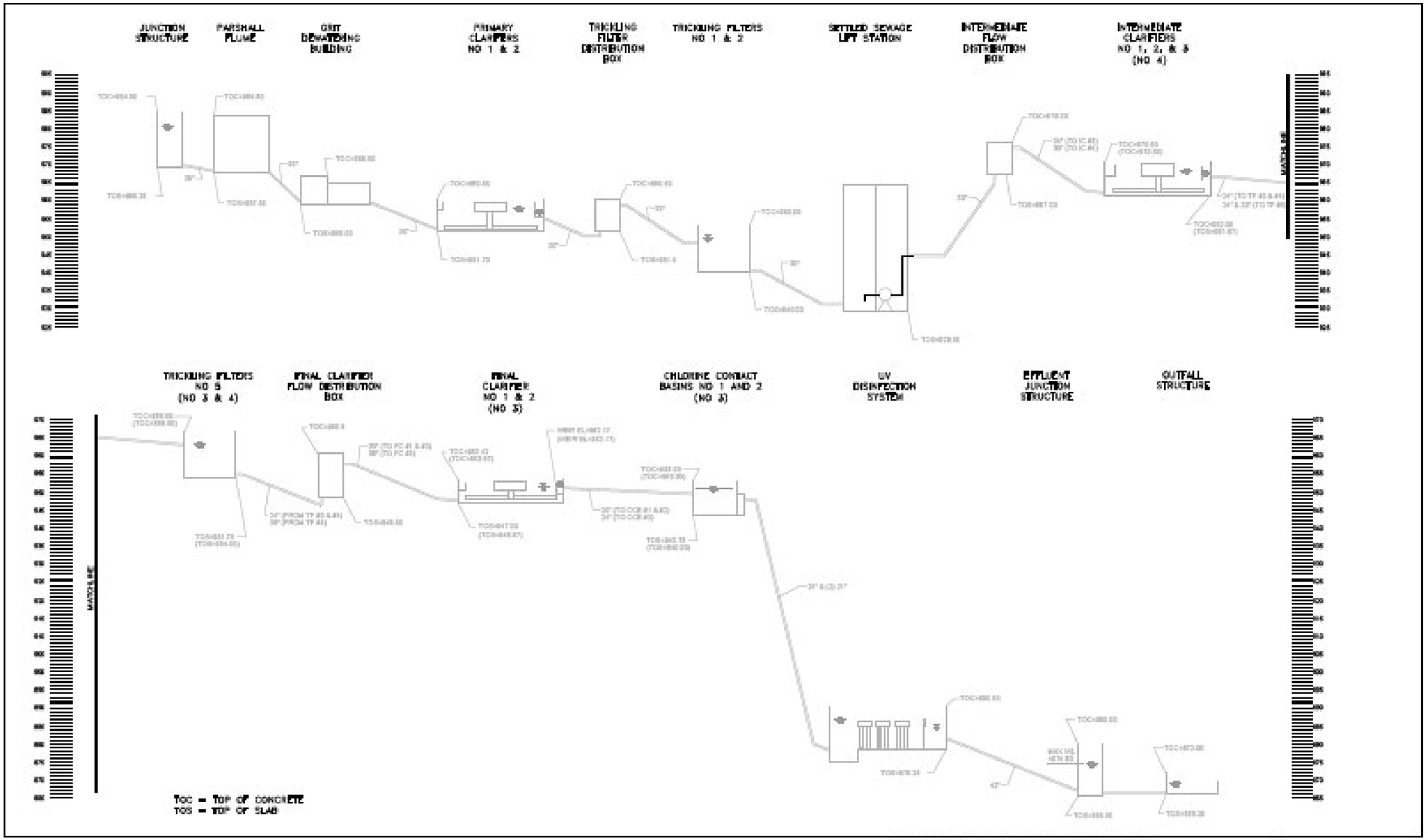
HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN

MAJOR YARD PIPING PLAN

DATE APRIL 2018

FIGURE FIG B-1



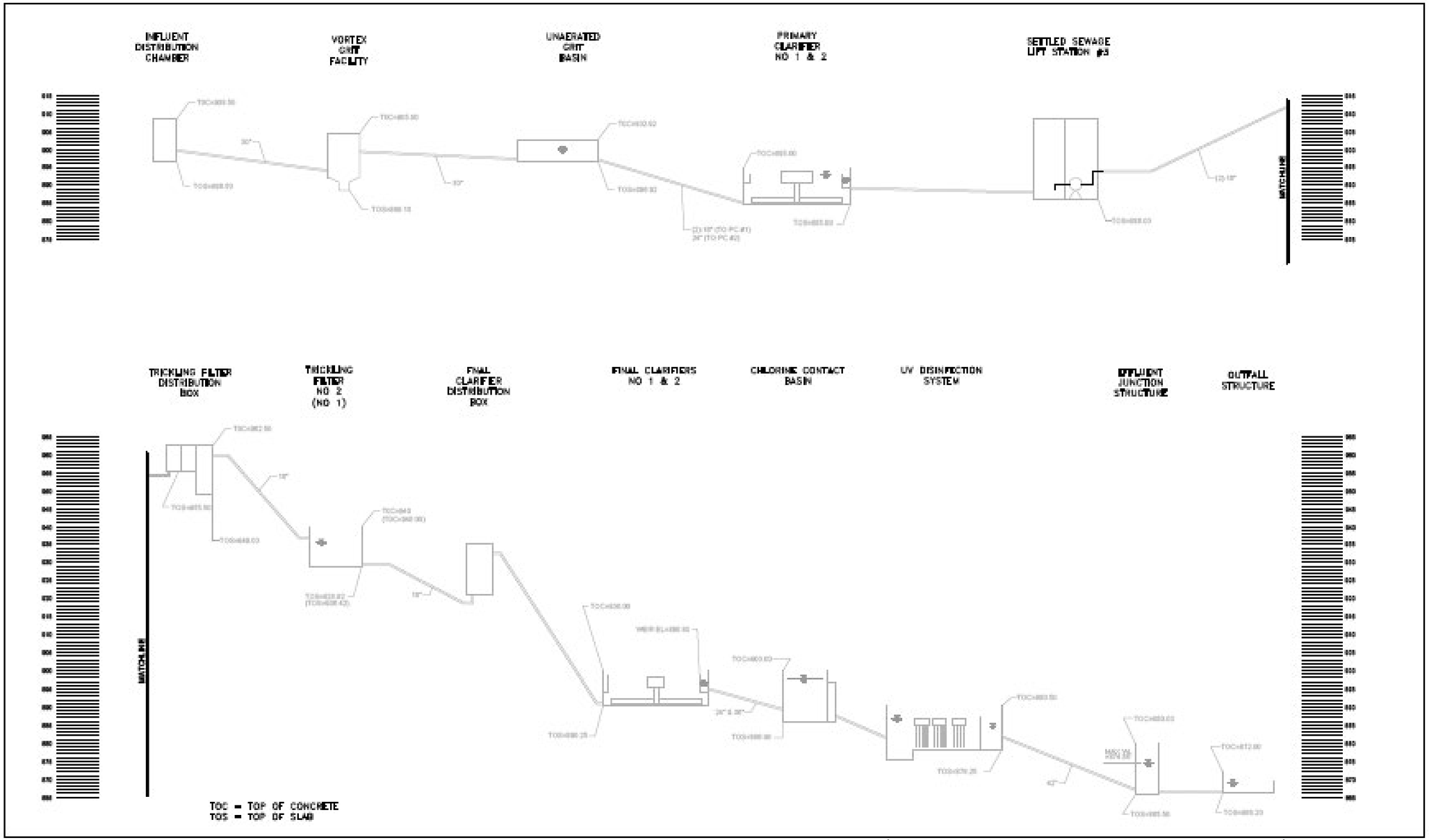
JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS FACILITY PLAN
MISSION MAIN HYDRAULIC PROFILE

DATE APRIL 2018

FIGURE FIG B-2



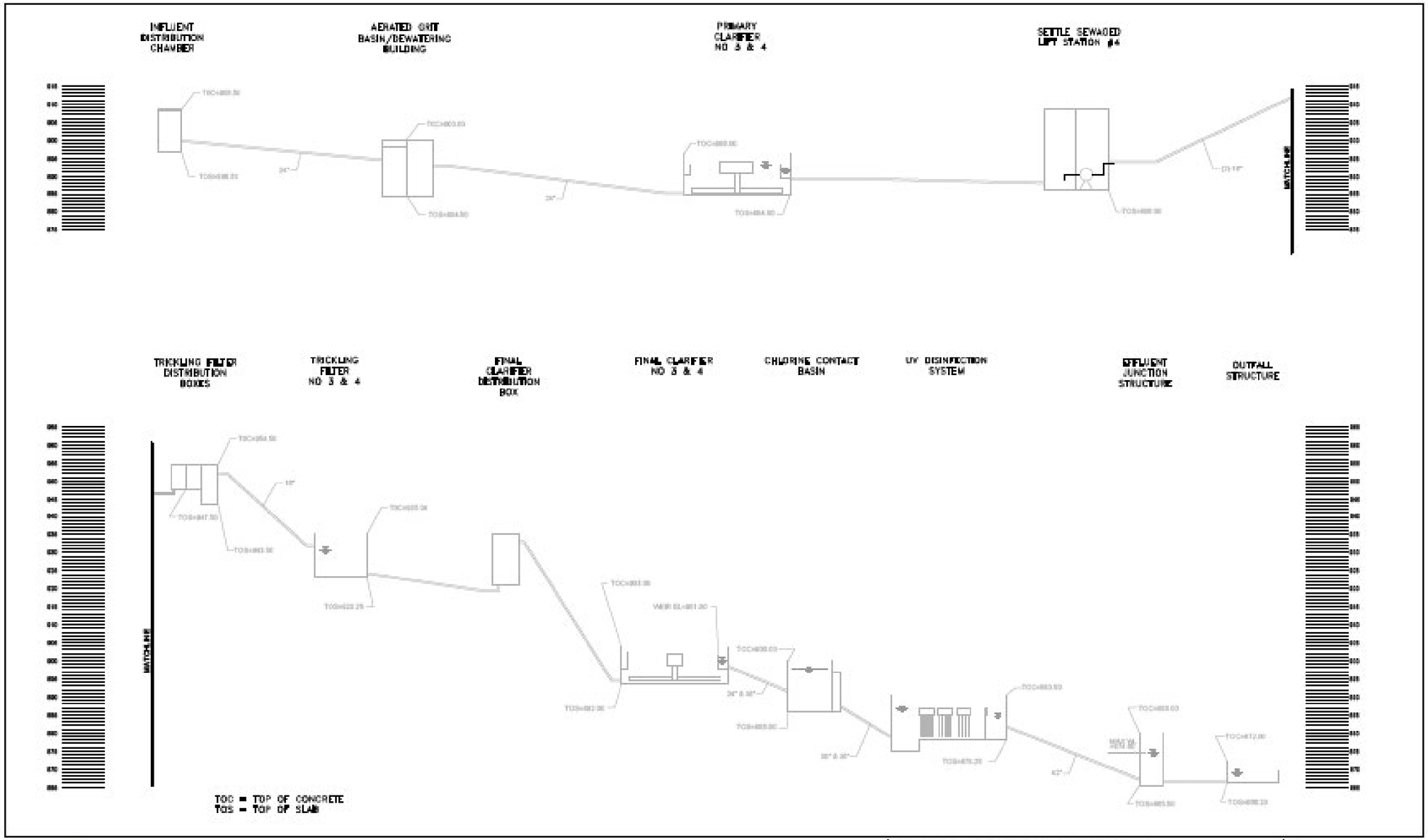
JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN
TURKEY CREEK HYDRAULIC PROFILE A

DATE APRIL 2018

FIGURE FIG B3-A



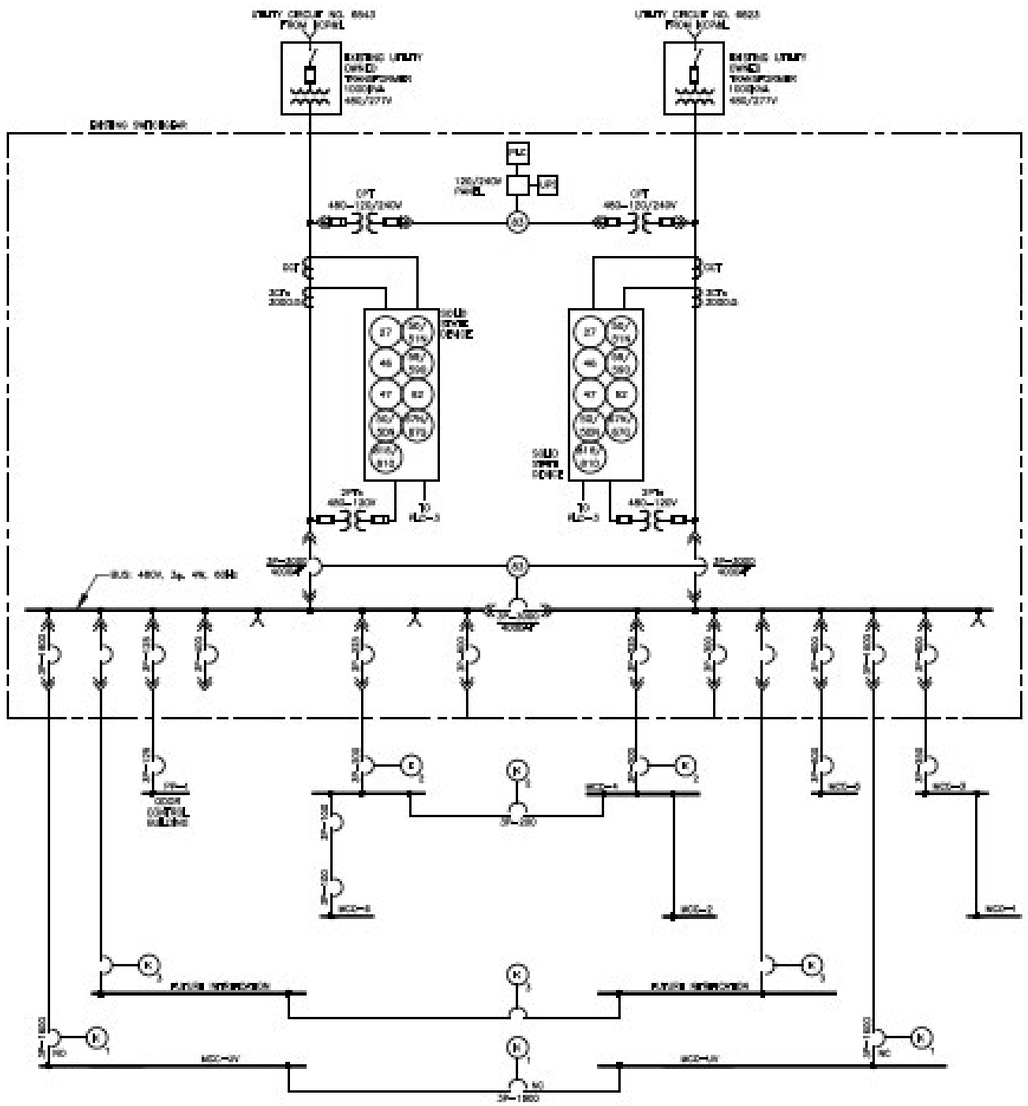
JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN
TURKEY CREEK HYDRAULIC PROFILE B

DATE APRIL 2018

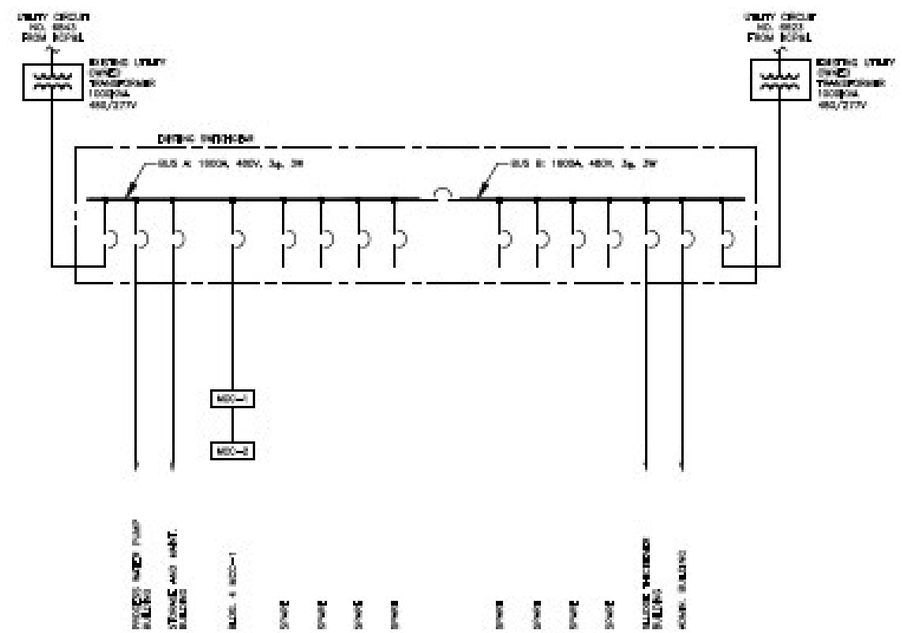
FIGURE FIG B3-B



EXISTING TURKEY CREEK MAIN SWITCHGEAR ONE-LINE DIAGRAM

GENERAL NOTES:

1. LOAD INFORMATION AND CONFIGURATION FOR EXISTING EQUIPMENT ARE BASED ON RECORD DRAWINGS AND INFORMATION PROVIDED BY OWNER.
2. UTILITY INFORMATION FOR EXISTING EQUIPMENT IS BASED ON DATA PROVIDED BY KCP&L.



EXISTING MISSION MAIN SWITCHGEAR ONE-LINE DIAGRAM

JOHNSON COUNTY KANSAS Wastewater

HDR ch2m

JOHNSON COUNTY WASTEWATER
NELSON COMPLEX WWTF IMPROVEMENTS
FACILITY PLAN
ONE-LINE DIAGRAMS

DATE APRIL 2018

FIGURE FIG B-4

Appendix C: Enhanced Sampling Results

Table C.4: Mission Main WWTF Enhanced Sampling Results

Parameter	Feb. 14	Feb. 15	Feb. 16	Feb. 17	Feb. 18	Feb. 19	Feb. 20	Feb. 21	Feb. 22	Feb. 23	Feb. 24	Feb. 25	Feb. 26	Feb. 27
Influent														
pH (Field) (SU)	7.4	7.7	7.6	7.3	7.2	7.6	7.5	7.4	7.5	7.7	7.5	7.3	7.5	7.3
Alk (mg/L)	230	263	260	243	247	250	222	246	269	256	218	258	245	250
BOD 5 (mg/L)	277	275	216	174	272	221	180	196	174	298	118	182	114	171
BOD 5 (Sol) (mg/L)	64	95	67	66	82	68	56	54	60	56	42	58	55	68
COD (ff) (mg/L)	66	48	96	48	147	147	105	99	120	84	69	129	84	90
COD (mg/L)	544	550	622	474	616	522	462	348	342	760	264	492	378	246
COD (Sol) (mg/L)	153	186	159	150	198	192	225	165	168	183	135		138	186
NH3-N (mg/L)	28.4	27.2	30.8	24.4	26.1	28.3	21.6	24.2	18.4	25.2	17	19.4	22.4	20.5
NO2+NO3-N (mg/L)	0.8	2	0.3	1.2	0.8	0.3	2.8	2.3	2.1	0.3	1.8	1.9	1.7	0.3
PO4-P (mg/L)	2.55	2.53	2.76	2.1	2.43	2.03	1.5	1.8	1.87	2.61	1.33	1.53	1.91	1.91
TKN (mg/L)	47.8	52.5	45.9	43.7	48.9	38.3	25.2	31.2	20.1	48.8	23.3	29	25.3	30
TP (mg/L)	6.09	6.88	5.69	5.26	5.84	4.97	3.93	3.98	4.99	8.54	2.78	3.93	5.08	3.48
TSS (mg/L)	236	360	328	164	288	264	221	224	176	456	108	206	105	252
VSS (mg/L)	220	315	300	154	266	236	190	206	158	380	92	188	92	224
Effluent														
pH (Field) (SU)	7.4	7.8			7.6		7.8		7.7			7.5		7.4
Alk (mg/L)	134	130			120		129		130			144		132
cBOD 5 (mg/L)	6	6			11		14		14			5		4
COD (ff) (mg/L)	60	33			21		102		75					72
COD (mg/L)	99	123			99		90		69			87		99
COD (Sol) (mg/L)	87	75			105		75		111			57		75
E. coli (MPN/100mL)	63							10						
NH3-N (mg/L)	13.4	11.8			9.4		11.8		8.9			6.3		7.7
NO2+NO3-N (mg/L)	13.5	12.7			13.1		10.8		11.6			10.8		12.4
TKN (mg/L)	19.4	16.9					94.6		14.8			10.8		13.4
TP (mg/L)	3.58	3.2					2.66		2.86			2.17		2.36
TSS (mg/L)	7	12			11		7		11			8		9
VSS (mg/L)	6	10			8		7		7			7		8

Table C.5: Turkey Creek WWTF Enhanced Sampling Results

Parameter	Feb. 14	Feb. 15	Feb. 16	Feb. 17	Feb. 18	Feb. 20	Feb. 21	Feb. 22	Feb. 23	Feb. 24	Feb. 25	Feb. 26	Feb. 27
Influent													
pH (Field) (SU)	7.3	7.6	7.5	7.4	7	7.9	7.5	7.4	7.4	7.7	7.7	7.6	7.4
Alk (mg/L)	230	230	246	222	211	232	238	226	224	248	234	235	242
BOD 5 (mg/L)	530	314	216	241	312	500	550	425	160	158	271	396	381
BOD 5 (Sol) (mg/L)	71	96	97	101	159	96	90	84	54	46	94	86	86
COD (ff) (mg/L)	54	114	105	99	132	147	123	120	69	72	117	126	72
COD (mg/L)	682	868	580	504	718	1080	838	940	550	318	1050	766	480
COD (Sol) (mg/L)	171	189	201	264	356	261	228	189	189	144	225	222	186
NH3-N (mg/L)	27.8	25.6	28.8	33.1	24	28.2	24.2	21.7	21.7	15.8	21.1	26.9	21.2
NO2+NO3-N (mg/L)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3
PO4-P (mg/L)	2.96	2.7	3.02	2.68	2.85	1.95	2.52	1.51	1.6	1.15	2.06	2.04	2.34
TKN (mg/L)	53.3	60.5	45.8	42.9	44.2	35.8	51.1	30.5	34.8	25	27	43.8	35.6
TP (mg/L)	8.3	7	6.21	5.58	6.78	9.08	9.1	3.82	5.24	2.87	5.34	8.31	4.78
TSS (mg/L)	420	340	220	206	324	750	572	338	304	272	332	605	256
VSS (mg/L)	384	315	158	190	264	480	436	278	292	245	292	424	252
TWAS Dumped?	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Effluent													
pH (Field) (SU)	7.3		7.6		7.5	7.7			7.6		7.4		7.5
Alk (mg/L)	174		160		152	150			166		159		174
cBOD 5 (mg/L)	14		14		18	20			22		12		15
COD (ff) (mg/L)	60		57		45	33			111		90		42
COD (mg/L)	138		144		159	93			117		108		75
COD (Sol) (mg/L)	72		87		87	114			117		63		57
E. coli (MPN/100mL)	10						10						
NH3-N (mg/L)	15.25		15.9		12.1	13.5			12.6		8.4		13.6
NO2+NO3-N (mg/L)	6.2		8.2		5.8	6.2			6		5.1		5.2
TKN (mg/L)	23.5		23.4		20.3	19			21.2		13.8		24.9
TP (mg/L)	5.57		5.48		5.52	4.06			4.73		3.4		4.93
TSS (mg/L)	15		20		25	14			28		26		19
VSS (mg/L)	14		17		20	12			20		20		17

Table C.6: NCAC and BRM TWAS Enhanced Sampling Results

Parameter	Feb. 14	Feb. 15	Feb. 16	Feb. 19	Feb. 20	Feb. 21	Feb. 22	Feb. 23	Feb. 26	Feb. 27
NCAC										
pH (Field) (SU)	7.3	7.2	7.2	7.4	7.2	6.9	7.2	7.3	7.2	7.3
Alk (mg/L)	409	367	414	338	382	360	431	352	305	316
COD (mg/L)	24,600	27,800	38,600	25,500	22,800	22,200	17,100	24,900	20,100	21,600
NO2+NO3-N (mg/L)	0.12	7.5	22.5	16.5	19.7	21	23.9	13.6	13	23.2
PO4-P (mg/L)	1.05	1.44	0.76	1.17	1.24	0.77	0.63	0.64	0.50	0.44
TKN (mg/L)	572	1,310	1,460	1,270	1,250	1,080	869	1,180	852	992
TP (mg/L)	288	380	509	477	381	395	313	394	337	313
TSS (mg/L)	16,000	16,000	16,000	15,000	15,000	14,000	16,000	15,000	15,000	14,000
VSS (mg/L)	12,288	12,304	12,368	11,385	11,310	10,682	12,240	11,475	11,265	10,514
BRM										
pH (Field) (SU)	6	6.4	5.9	6.3	6.1	5.8	5.9	5.5	6	6.3
Alk (mg/L)	372	291	580	528	614	614	610	510	430	628
COD (mg/L)	49,100	59,900	61,400	60,500	73,000	52,700	48,200	60,200	52,100	50,900
NO2+NO3-N (mg/L)	0.4	0.3	0.6	0.3	0.4	0.7	1.2	0.6	0.5	0.9
PO4-P (mg/L)	29	50.7	13	47	22.9	29.6	23	16.8	5.44	8.86
TKN (mg/L)	1,070	1,320	1,960	2,630	1,170	1,320	1,380	1,480	1,120	1,400
TP (mg/L)	513	567	583	795	420	426	429	463	464	424
TSS (mg/L)	29,000	37,000	30,000	37,000	30,000	30,000	30,000	10,000	28,000	29,000

Appendix D: Process Model Validation

The calibrated process model was validated with observed operational data between April 21, 2017 through June 19th, 2017. This period includes the observed maximum month VSS loading, which occurred between May 5th, 2017 and June 3rd, 2017. Figures D.1 through D.3 represent Mission Main WWTF unit process performance, and Figures D.4 and D.5 represent Turkey Creek WWTF unit process performance.

With exception of the Mission Main first stage trickling filter effluent ammonia concentration, the calibrated process model sufficiently predicted unit process performance at the Mission Main and Turkey Creek WWTFs. Based on the calibration and validation steps, the current Pro2D[2] process model provides a level of accuracy commensurate with the current planning level study.

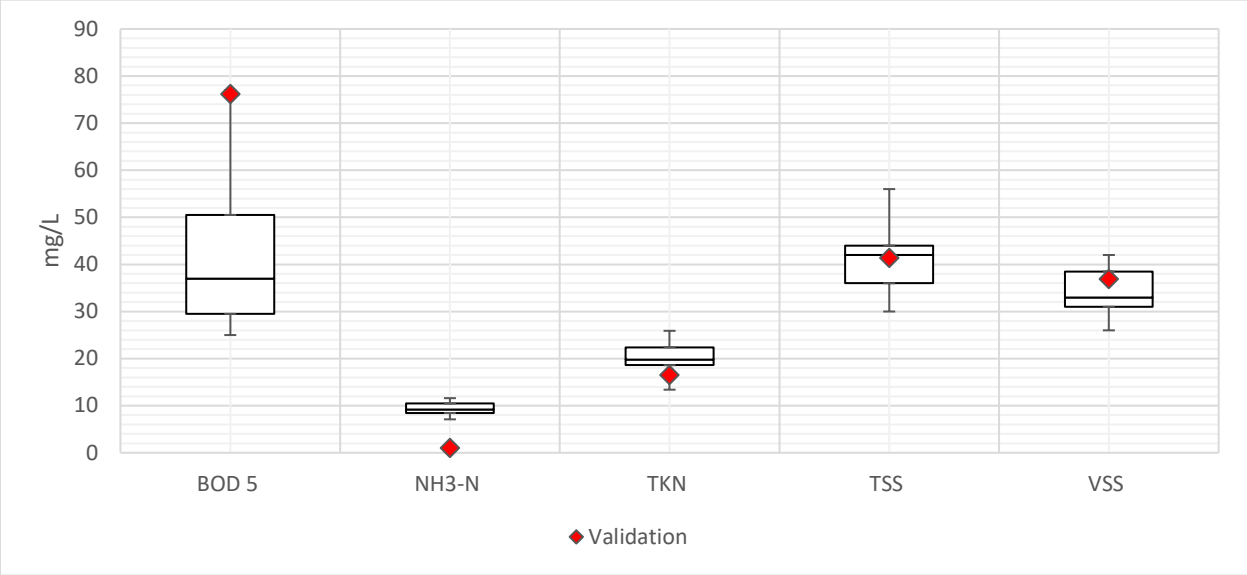


Figure D.13: Mission Main Primary Effluent

The box and whisker plots represent data observed between April 21, 2017 through June 19, 2017, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady-state validation value.

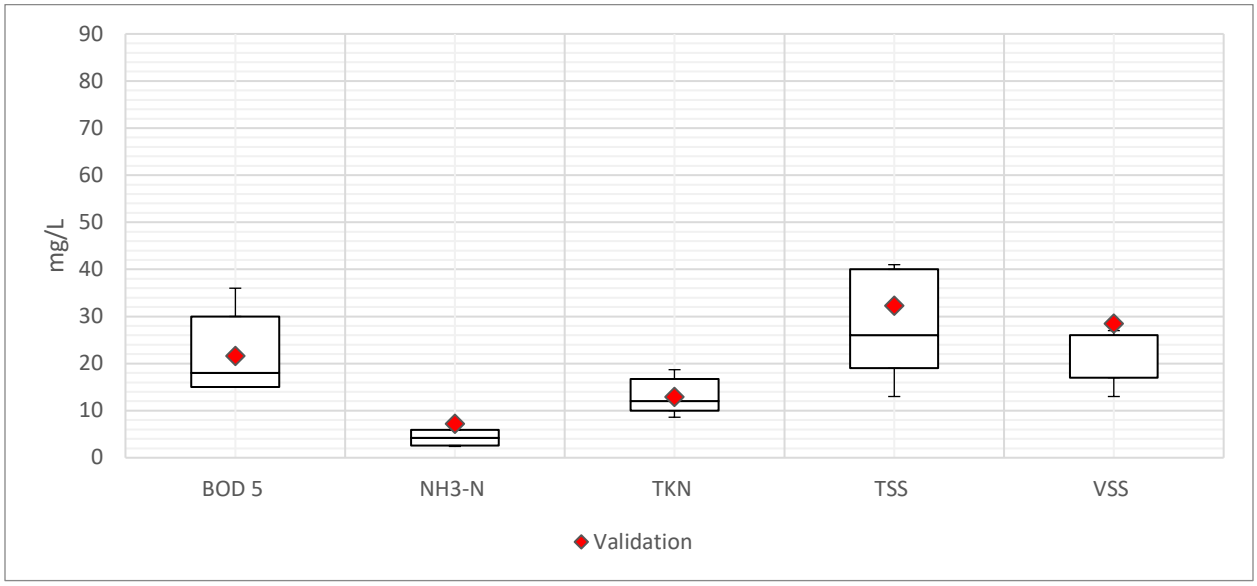


Figure D.14: Mission Main Intermediate Clarifier

The box and whisker plots represent data observed between April 21, 2017 through June 19, 2017, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady-state validation value.

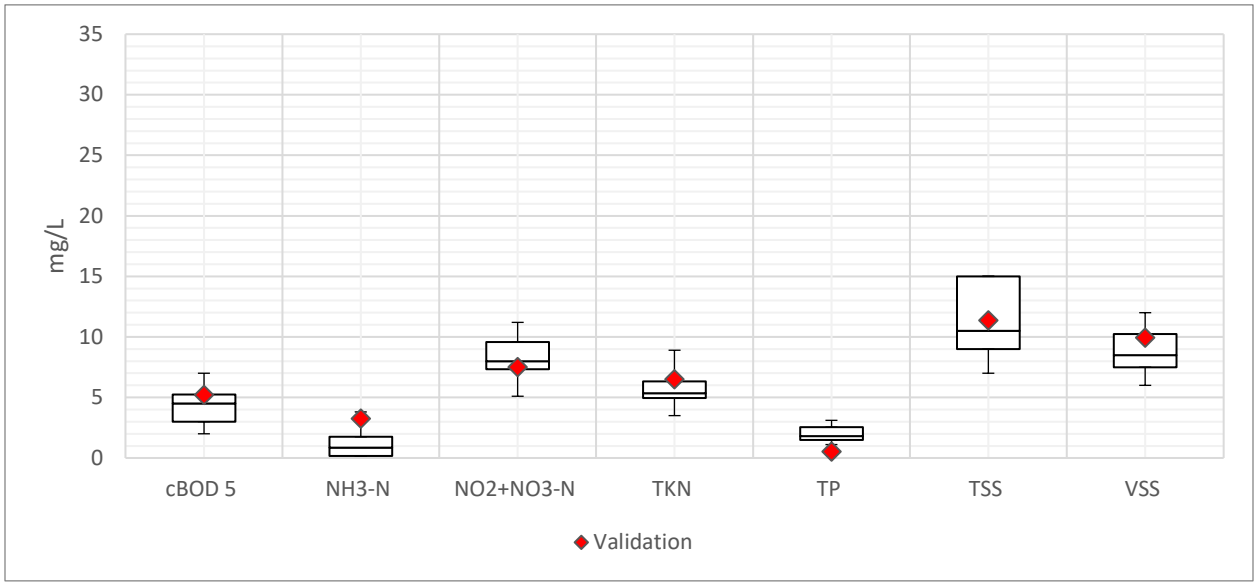


Figure D.15: Mission Main Effluent

The box and whisker plots represent data observed between April 21, 2017 through June 19, 2017, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady-state validation value.

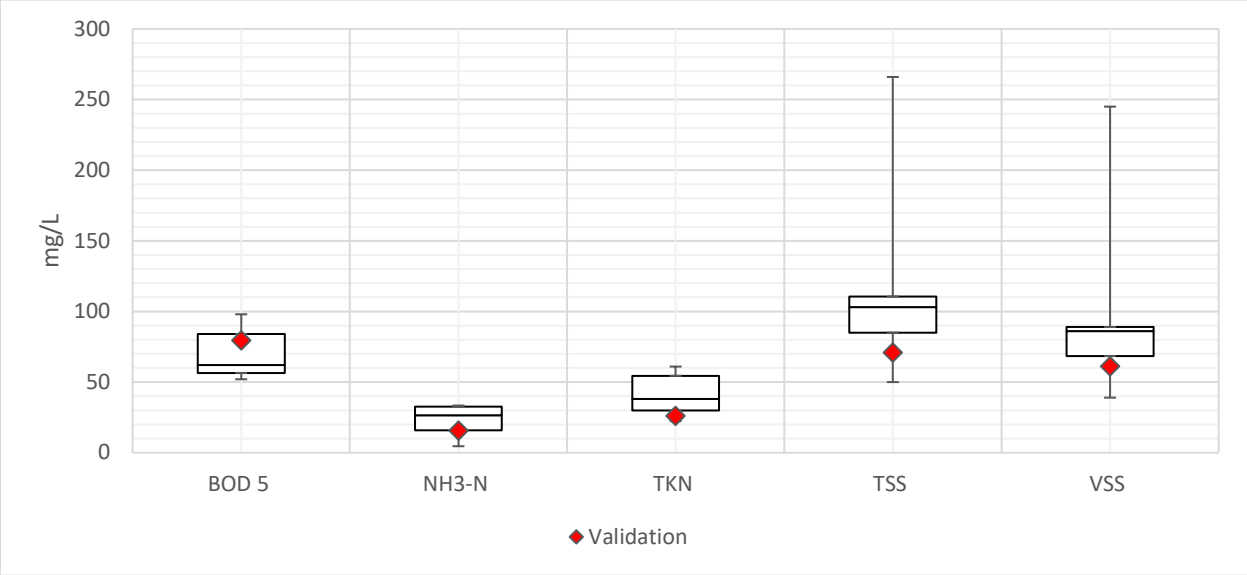


Figure D.16: Turkey Creek Primary Effluent

The box and whisker plots represent data observed between April 21, 2017 through June 19, 2017, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the lower boundary of the box represents the 25th percentile. The red diamond represents the steady-state validation value.

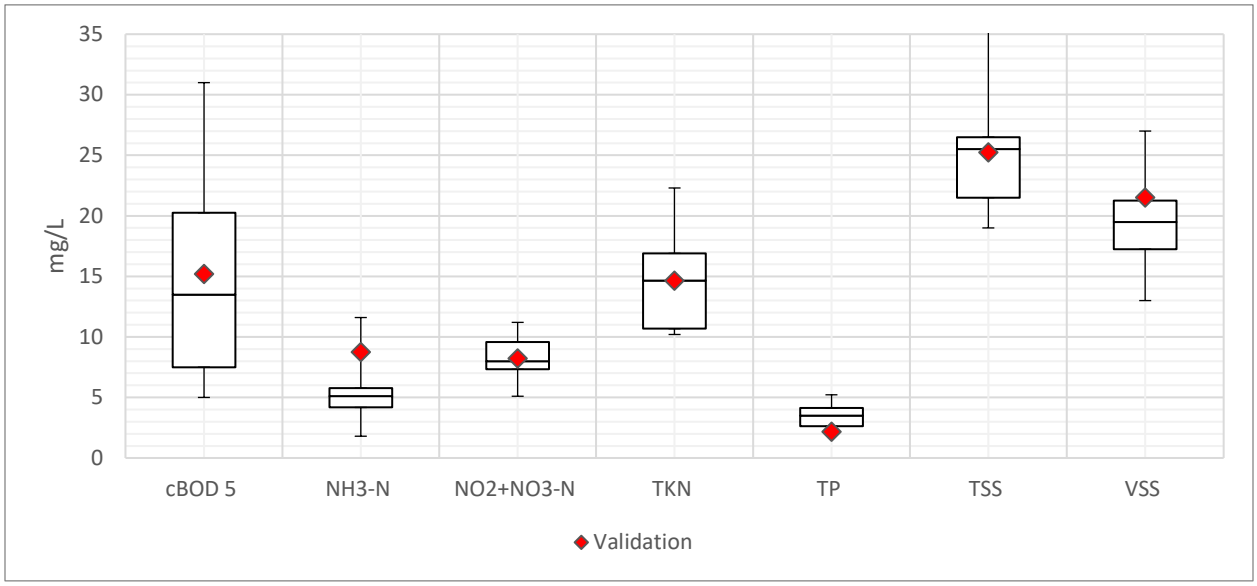


Figure D.17: Turkey Creek Effluent

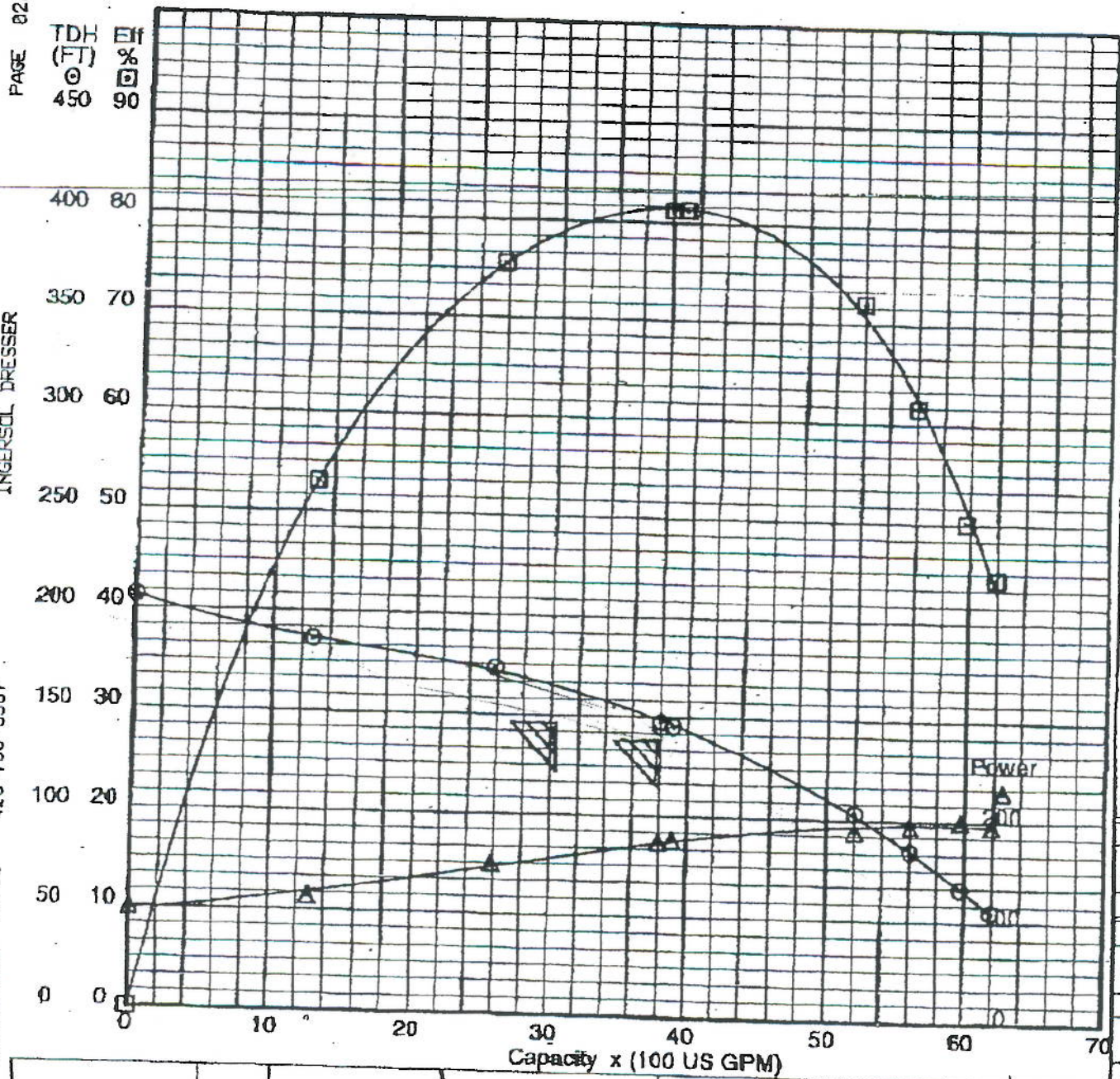
The box and whisker plots represent data observed between April 21, 2017 through June 19, 2017, with the upper and lower bars represents the maximum and minimum value observed, respectively. The upper boundary of the box represents the 75th percentile, the middle of the box represents the median (50th percentile), and the boundary portion of the box represents the 25th percentile. The red diamond represents the steady state validation value.

Appendix E Pump Curves

PUMPS 2 & 4

BC1

01/03/2002 17:05 410-756-3567 PAGE 02/03



FLOWSERVE PUMP DIV
TANEYTOWN, MD
PUMP TEST DATA

RPM	GPM	TDH	BHP	Eff
887	0.0	116.7	42.3	0.0
884	959.0	104.6	47.8	53.0
877	1918.0	95.7	61.9	75.6
875	2817.6	81.1	71.0	61.3
874	2888.7	79.7	71.6	61.3
870	3836.0	56.1	75.4	72.1
[illegible]	4126.4	45.8	77.6	61.6
869	4298.2	36.0	79.8	50.1
868	4556.4	30.0	77.6	44.4

I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 10MFC21 PUMP 0201MS001815-1

James Bird
REGISTERED PROFESSIONAL ENGINEER
STATE OF OHIO, E-37620

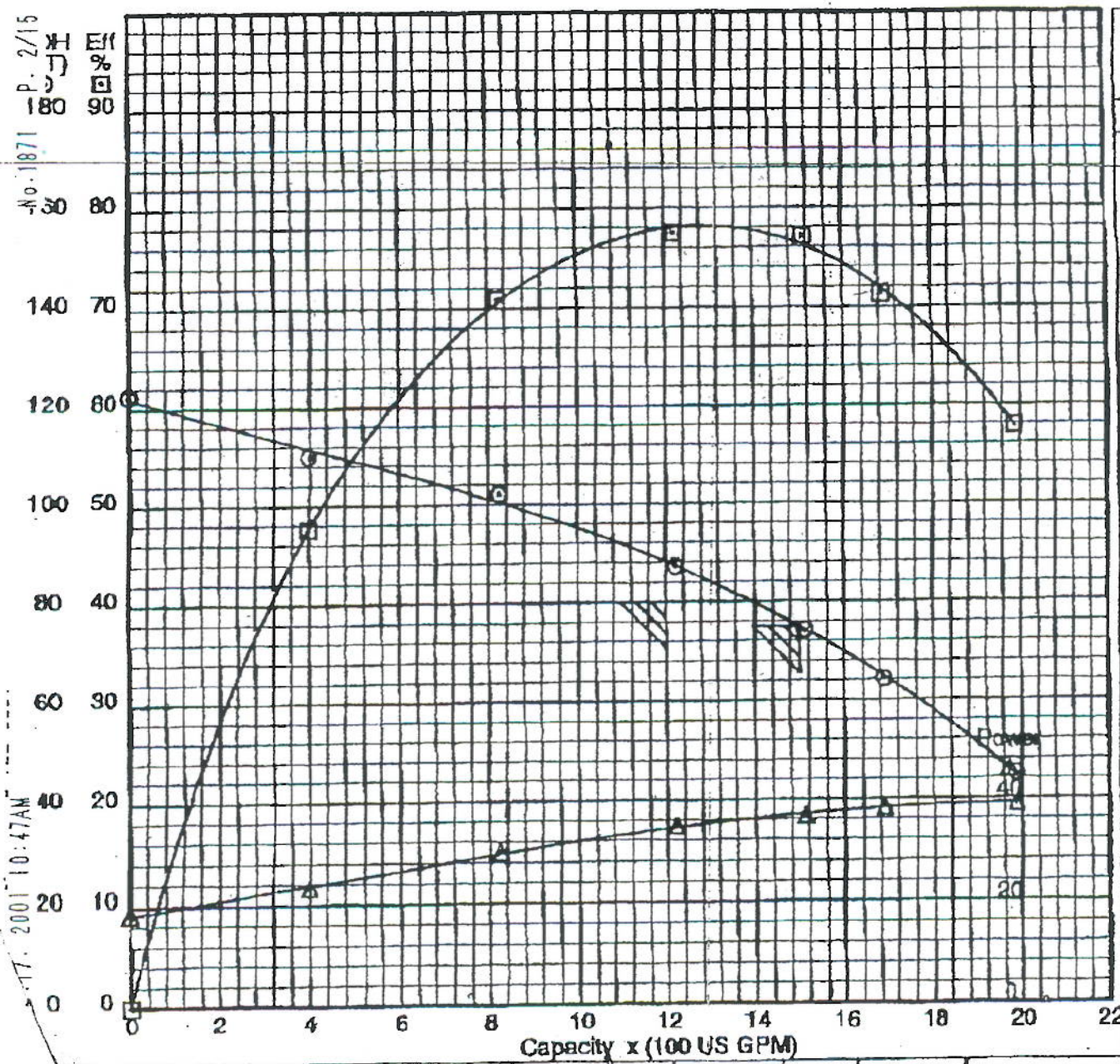
SP.GR.: 1.000

CASING DATA		
CAST IRON MATERIAL	- FINISH	- TONGUE
IMPELLER DATA		
CAST IRON MATERIAL	1-A FINISH	DEBURR DISC. TIPS
		20.20"
PATT. NO.	COMB. NO.	DIA

10MFC21	1	S001815	0201MS001815-1	09JAN02	SPA		50H/900R,#21	12 MAG	1180	T-S001815-1A
PUMP	STAGES	ORDER NO	SERIAL NO	DATE	TEST	APPROVED	TEST DRIVER	VENTURI	PLOTTED	CURVE NO

Jan. 10. 2002 8:02AM No. 2754 P. 3/7

PUMPS 1 & 3 BCPS



FLOWSERVE PUMP DIV
TANEYTOWN, MD
PUMP TEST DATA

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1192	403.4	112.2	24.0	47.8
1190	831.6	105.3	30.6	70.8
1190	1232.3	89.8	35.5	77.4
1188	1522.7	75.2	37.6	77.1
1188	1589.5	65.1	39.2	71.3
1188	2000.0	45.5	39.8	57.8

I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 6MFC16 PUMP 0112MS001814-1

12-17-1

SP.GR.: 1.000

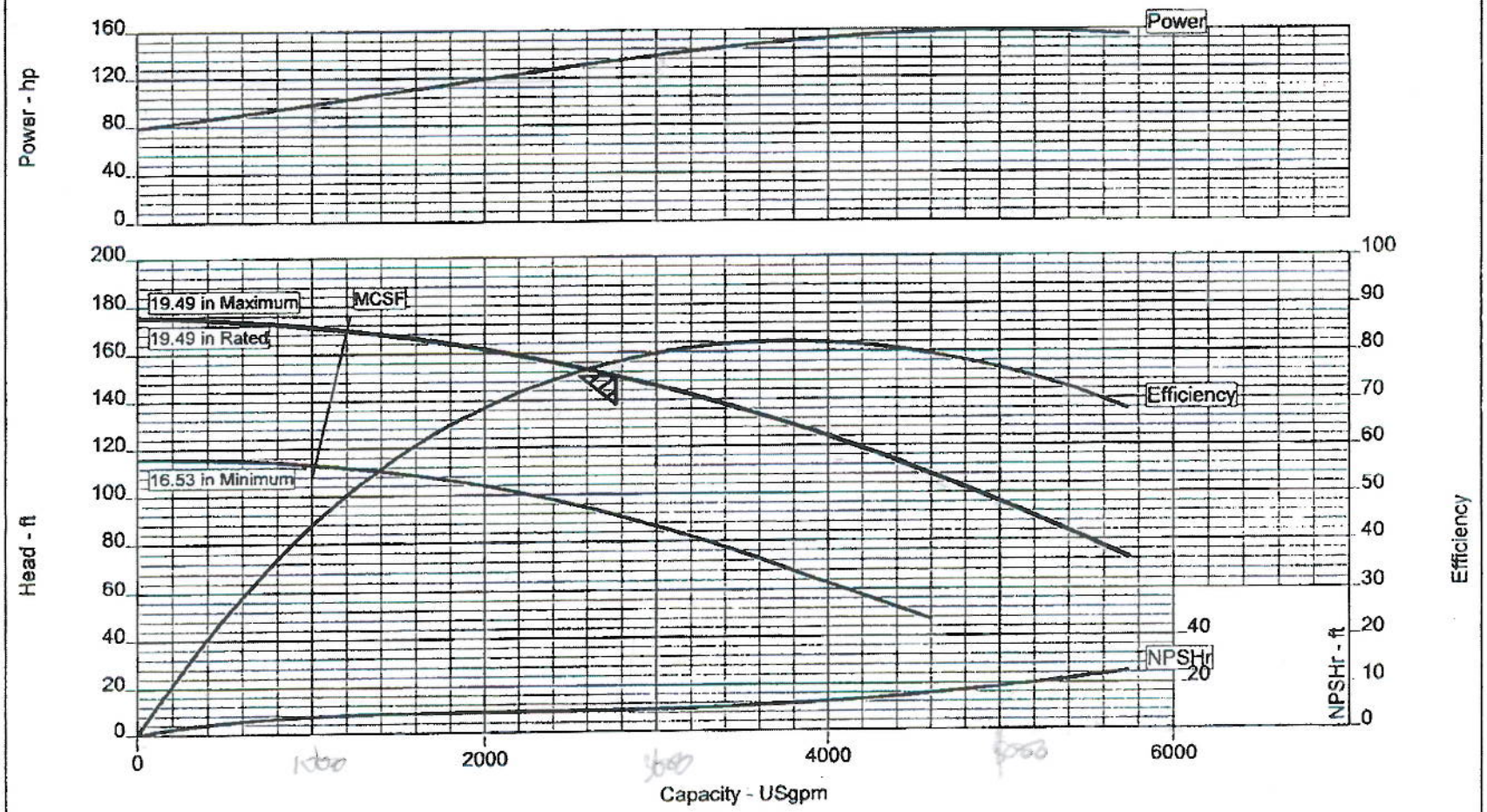
CASING DATA		
CAST IRON MATERIAL	FINISH	TONGUE
IMPELLER DATA		
CAST IRON MATERIAL	1-A FINISH	DEBURR DISC. TIPS
		15.47"
PATT. NO.	COMB. NO.	DIA

6MFC16	1	S001814	0112MS001814-1	13DEC01	SPA		50H/1200R, #22	12 MAG	1180	T-S001814-1A

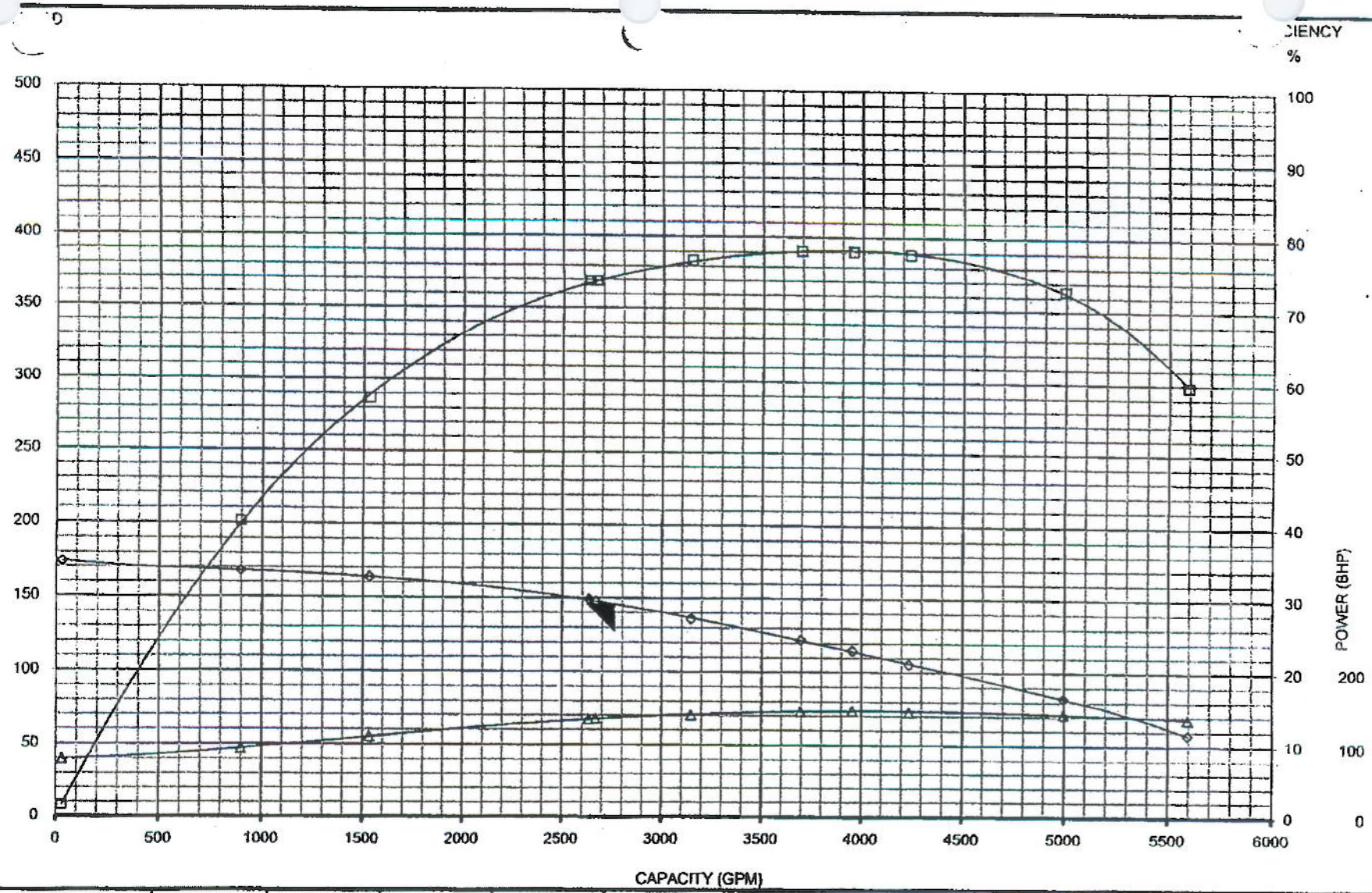
RCF

Customer	: Foley	FLOWSERVE Pump Division		Pump size & type	: 8MSX20A
Item number	: S003032			Based on curve no.	: 87144416A
Service	:			Number of stages	: 1
Vendor reference	: 3038-30020	Capacity	: 2766.0 USgpm	Specific gravity	: 1.000
Date	: November 17, 2003	Head	: 150.00 ft	Pump speed	: 1160 rpm

CURVES ARE APPROXIMATE. PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS, CAPACITY, HEAD, AND EFFICIENCY.

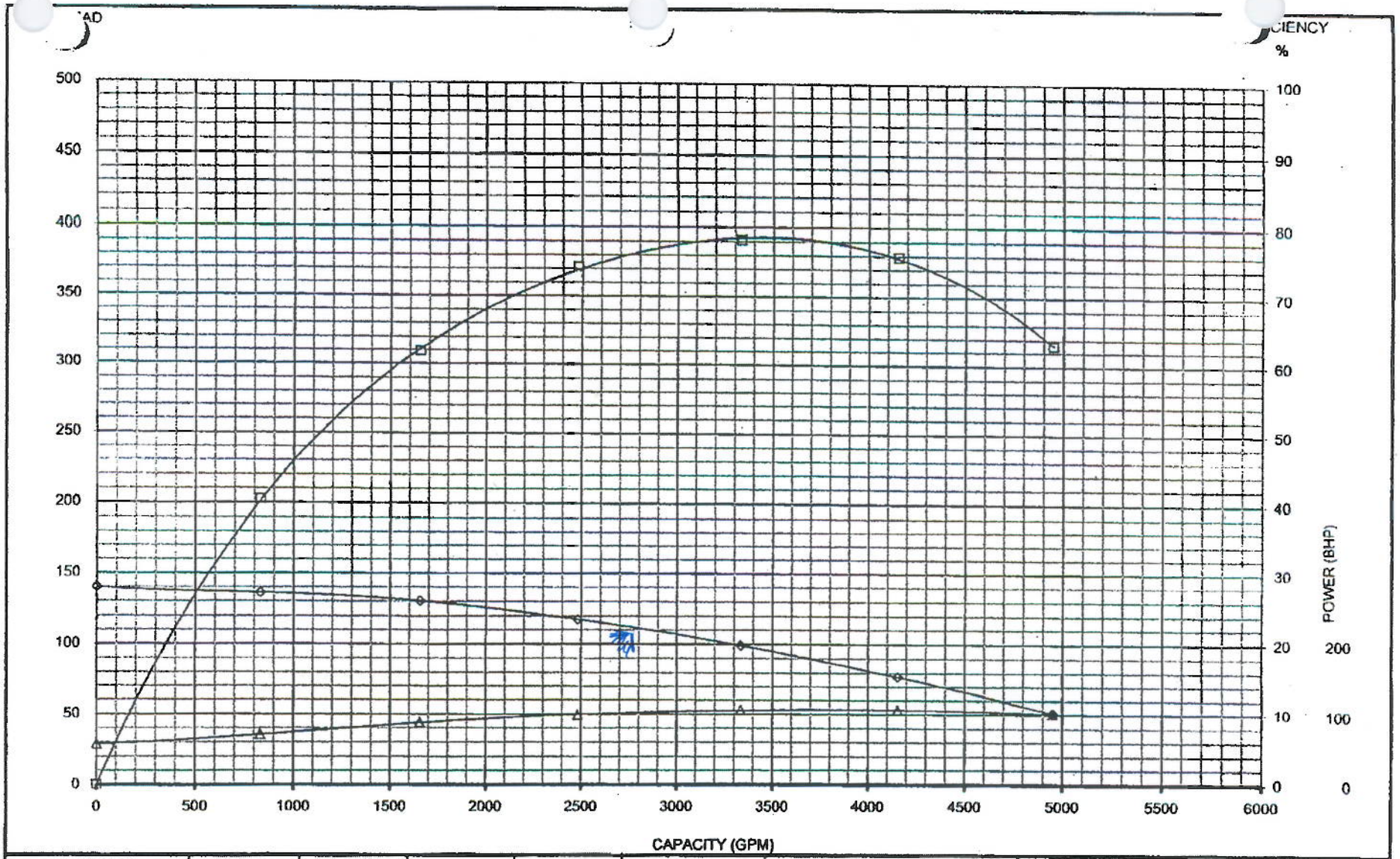


Windows Hydraulic Selection V3.00, Output Module V2.36



04M00066 SERIAL NO.	S3032 ORDER NO.	8MSX20 MODEL	1 STAGES	MSX TEST LOOP	PUMP TYPE OF TEST	JOB TEST MOTOR	12 MAG FLOW METER	04/28/04 DATE TESTED	1CS CURVE NO

CASING DATA	IMPELLER DATA		CONDITIONS OF SERVICE		
CAST IRON MATERIAL	CAST IRON MATERIAL	1A FINISH	2766 GPM FLOW	147 FT HEAD	I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 04M00066
1A FINISH	19.63 DIAMETER		1 SG	1160 RPM SPEED	
N/A TONGUE	DEBURR TIP			76 TEMP. (F)	FLOWSERVE™



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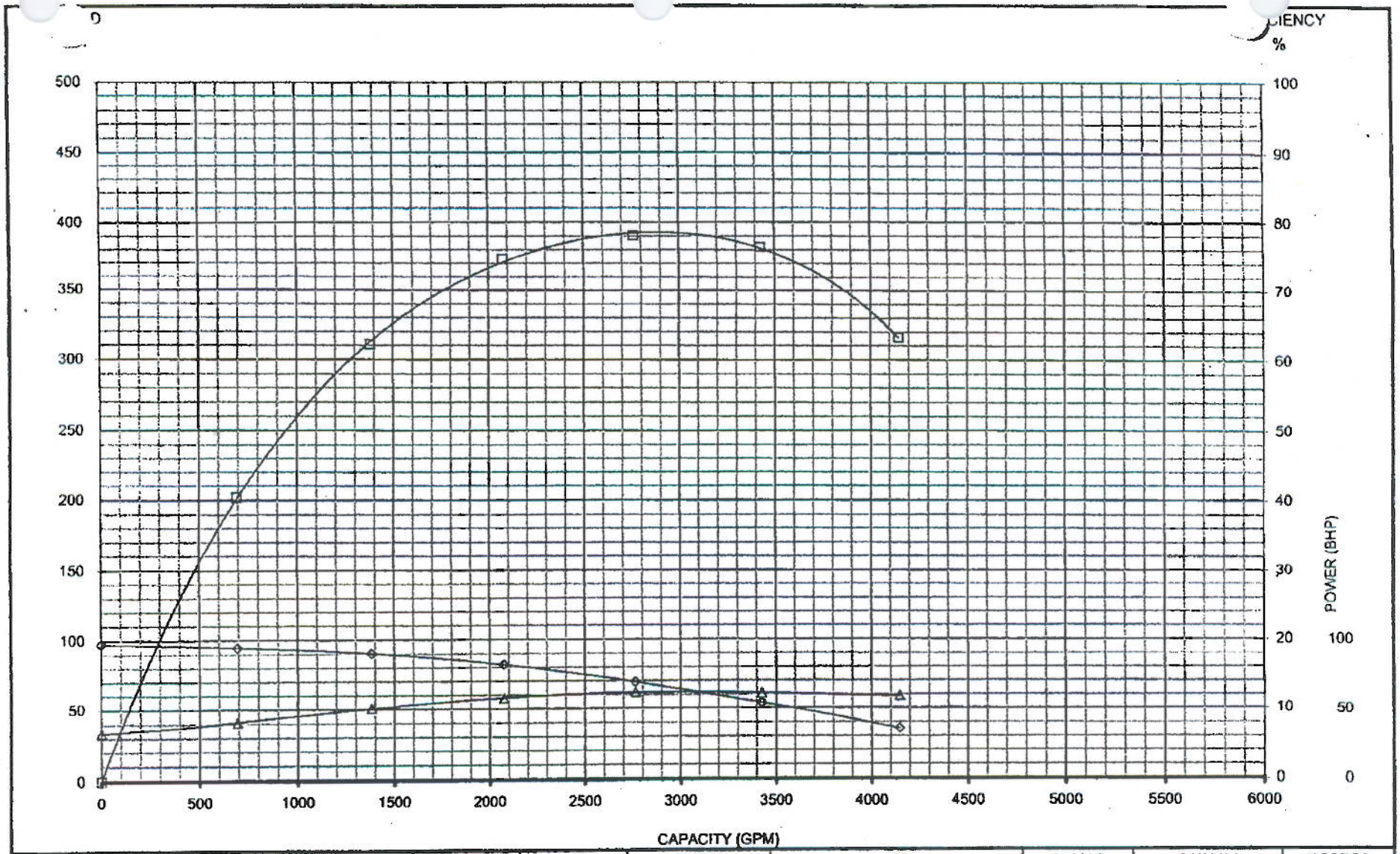
CASING DATA	IMPELLER DATA		CONDITIONS OF SERVICE		
CAST IRON MATERIAL	CAST IRON MATERIAL	1A FINISH	GPM FLOW	FT HEAD	I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 04M00066
1A FINISH	19.63 DIAMETER		1 SG	1044 RPM SPEED	R. A. S.
N/A TONGUE	DEBURR TIP			76 TEMP. (F)	54 Hz

FLOWSERVE



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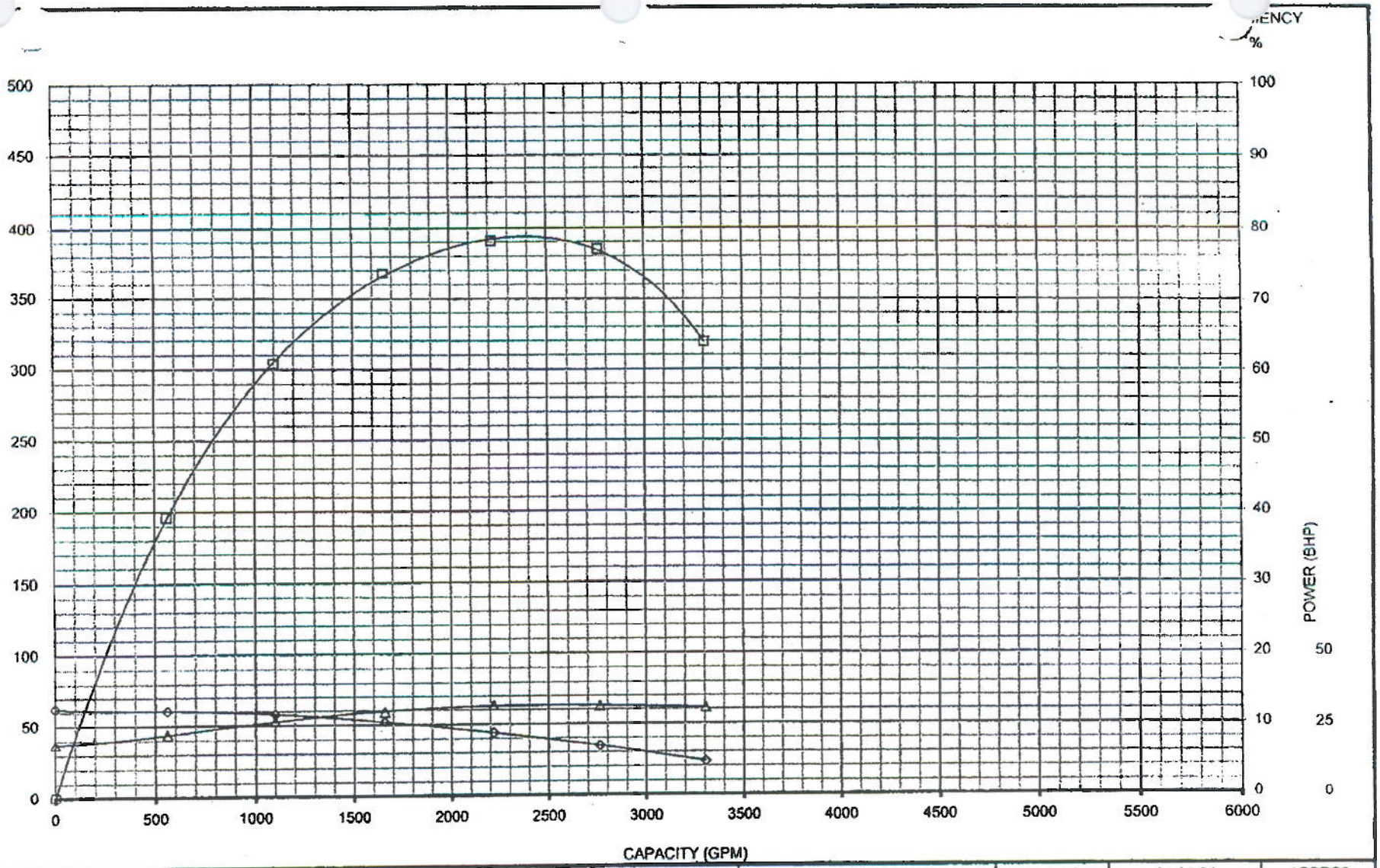
CASING DATA	IMPELLER DATA		CONDITIONS OF SERVICE		
CAST IRON MATERIAL	CAST IRON MATERIAL	1A FINISH	GPM FLOW	FT HEAD	I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 04M00066
1A FINISH	19.63 DIAMETER		1 SG	870 RPM SPEED	
N/A TONGUE	DEBURR TIP			76 TEMP. (F)	45 Hz

FLOWSERVE



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CASING DATA	IMPELLER DATA		CONDITIONS OF SERVICE		
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1A FINISH	19.63 DIAMETER		1 SG	696 RPM SPEED	
N/A TONGUE	DEBURR TIP			76 TEMP. (F)	36 Hz

FLOWSERVE

Fairbanks Morse
Pentair Water

Certified Pump Performance Curve

Serial Number:	1665786-1_DIV
Project Number:	064083
Test Date:	12/2/2008

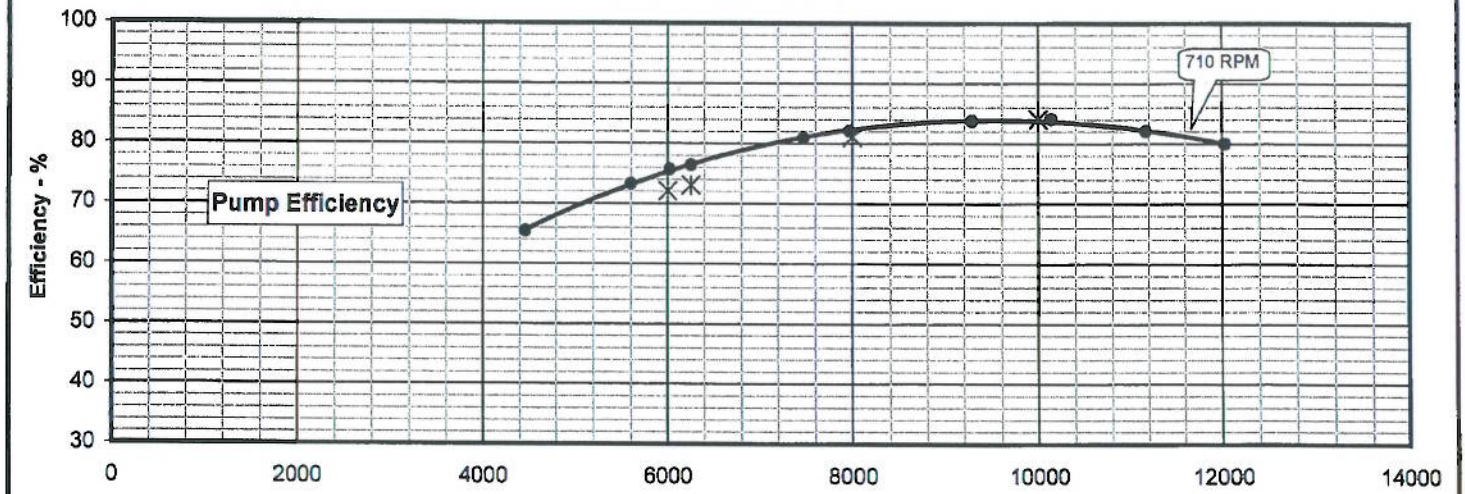
Guaranteed Values				
GPM	6250	6000	8000	10000
HEAD	106	110	98	86
RPM	710	710	710	710
Eff.	73	72	81	84

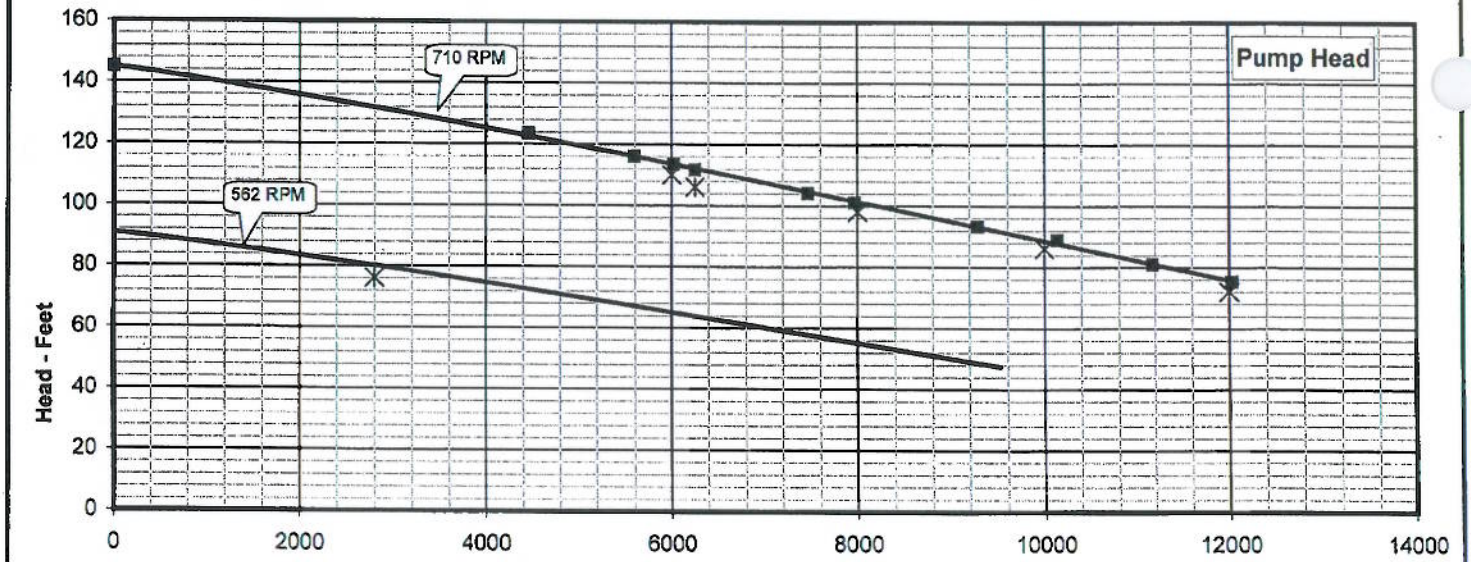
Size-Model	14	C5722	CCV
Impeller:	L16C1AK0220F		
Impeller Dia:	29.00		
Driver:	JOB MOTOR	HP:	300
RPM:	710	Stages:	1

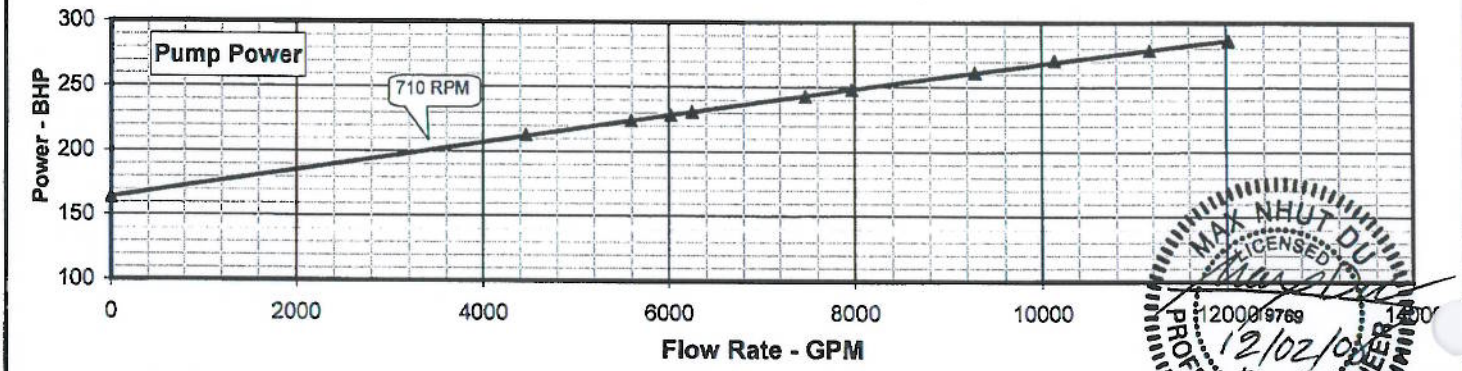
Certified By: Max Du P.E. 12/02/08
Product Engineer Date

Reduces Spd.	
GPM	2800
HEAD	76

Reduces speed (562 RPM) head curve shown is per Affinity Law.







MAX NHUT DU
LICENSED
12/02/08
KANSAS
PROFESSIONAL ENGINEER

Fairbanks Morse
Pentair Water

Certified Pump Performance Curve

Serial Number:	1665786-0
Project Number:	064083
Test Date:	11/6/2008

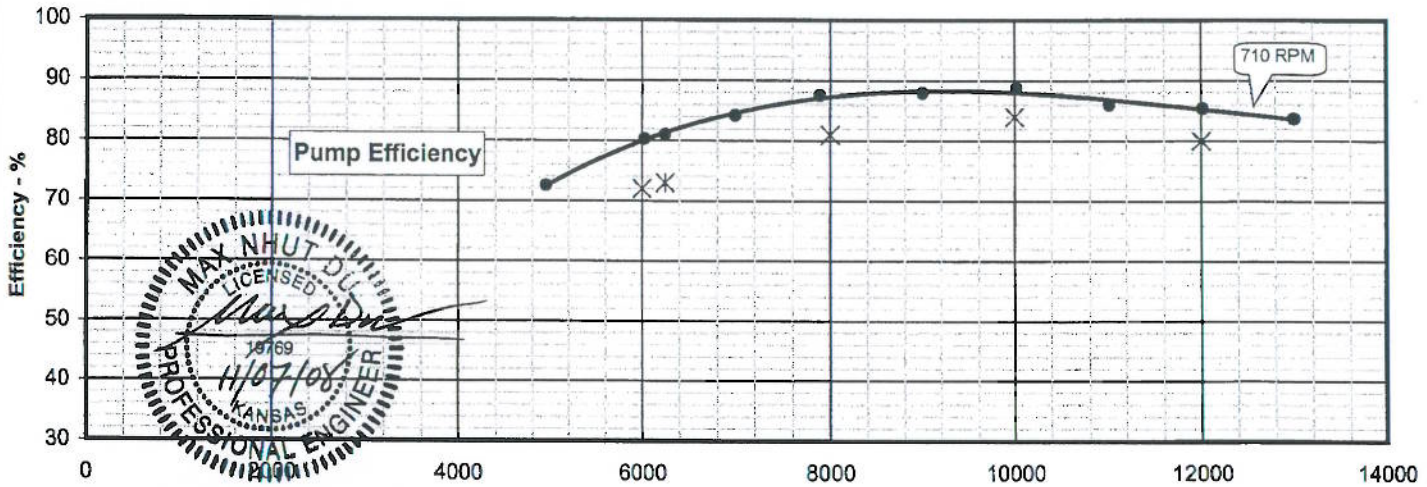
Guaranteed Values				
GPM	6250	6000	8000	10000
HEAD	106	110	98	86
Eff	73	72	81	84
RPM	710	710	710	710

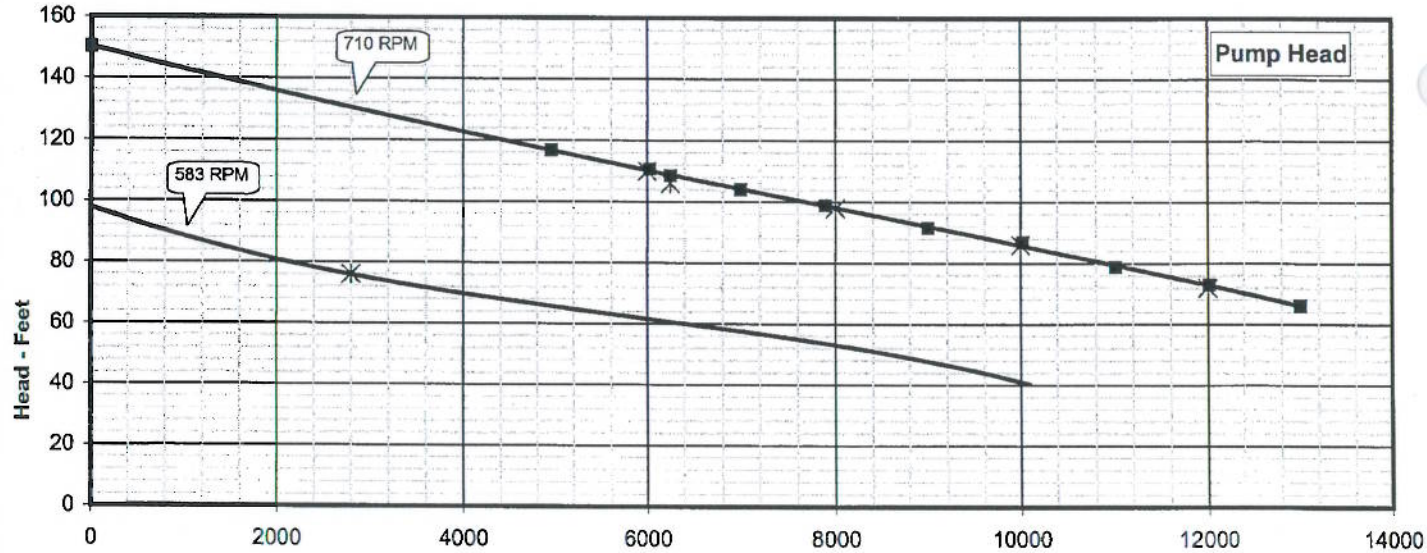
Size-Model	14	C5722	CCW	
Impeller:	L16C1AK0220F			
Impeller Dia:	29.00"			
Driver:	JOB MOTOR		HP:	300
RPM:	710	Stages:	1	

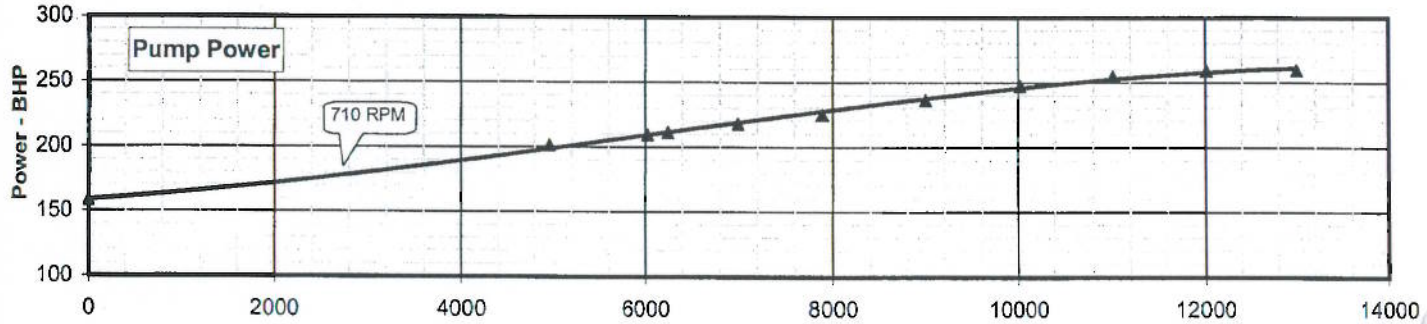
Certified By: Max Du P.E. 11/07/08
Product Engineer Date

Reduces Spd.	
GPM	2800
HEAD	76

Reduces Speed Test was at 573 RPM. 583 RPM head curve shown is per Affinity Law.







Fairbanks Morse
Pentair Water

Certified Pump Performance Curve

Serial Number:	1665786-2_DIV
Project Number:	064083
Test Date:	1/9/2009

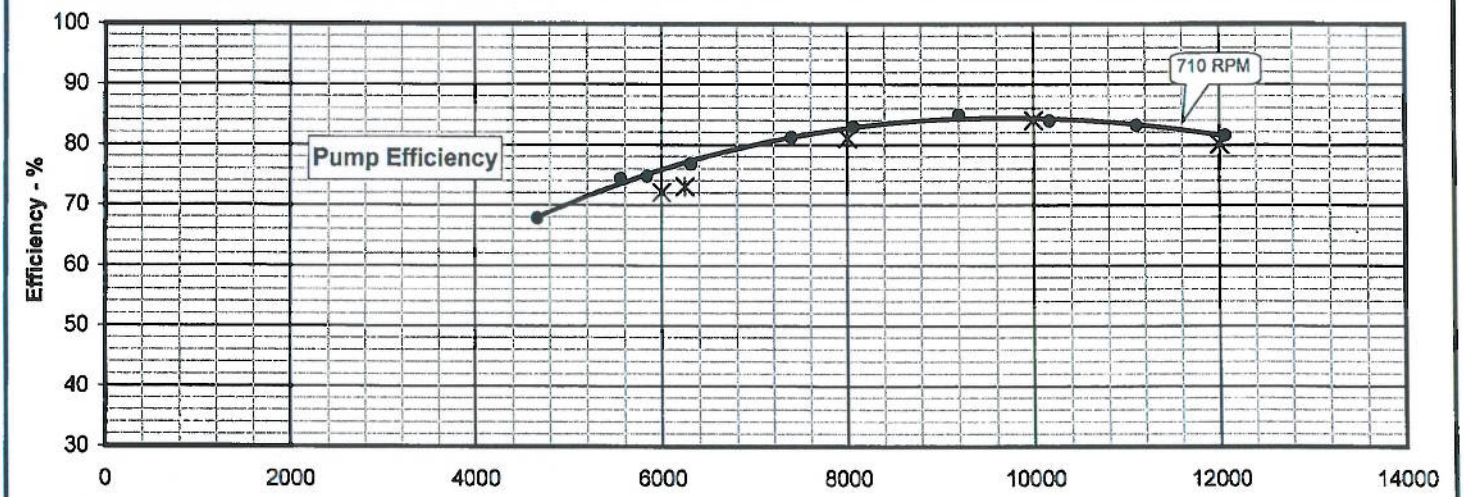
Guaranteed Values				
GPM	6250	6000	8000	10000
HEAD	106	110	98	86
RPM	710	710	710	710
EFF	73	72	81	84

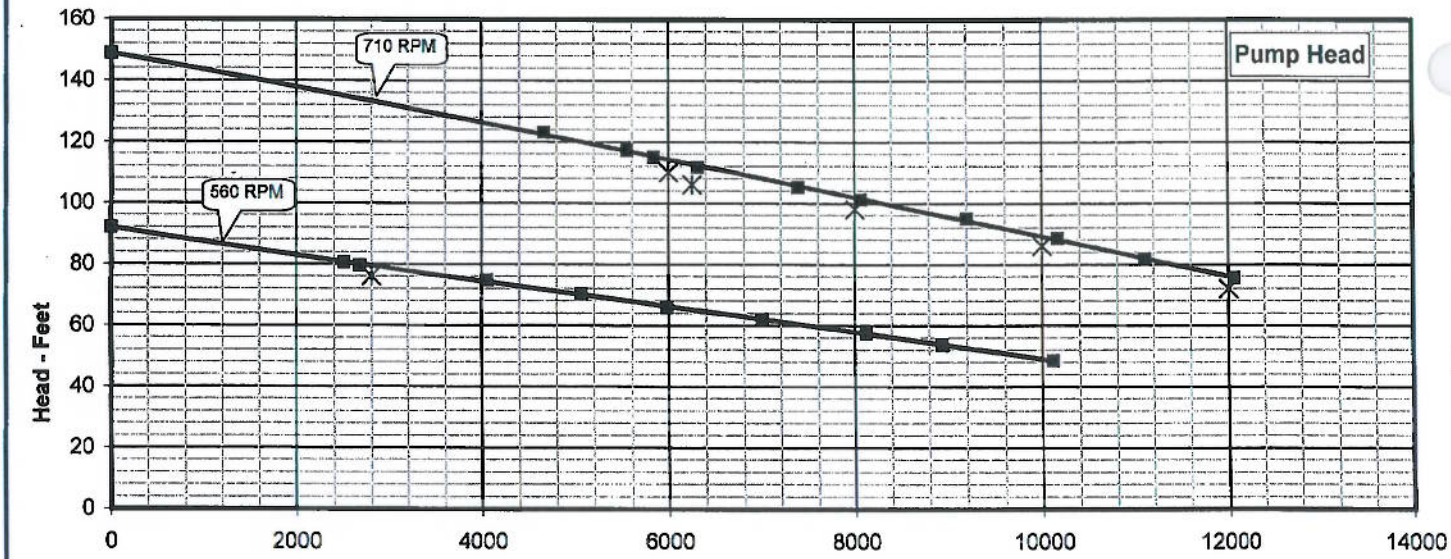
Size-Model	14	C5722	CCW	
Impeller:	L16C1AK0220F			
Impeller Dia:	29.00			
Driver:	JOB MOTOR		HP:	300
RPM:	710	Stages:	1	

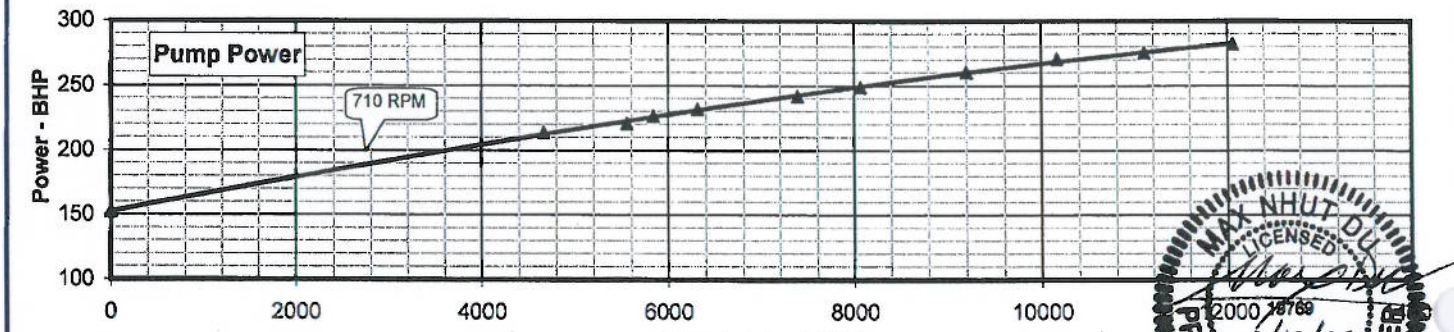
Reduces Spd.	
GPM	2800
HEAD	76

Reduce speed was tested with Factory VFD

Certified By: *Max Du P.E.* — Product Engineer — 1/10/2008 — Date







MAX NHUT DU
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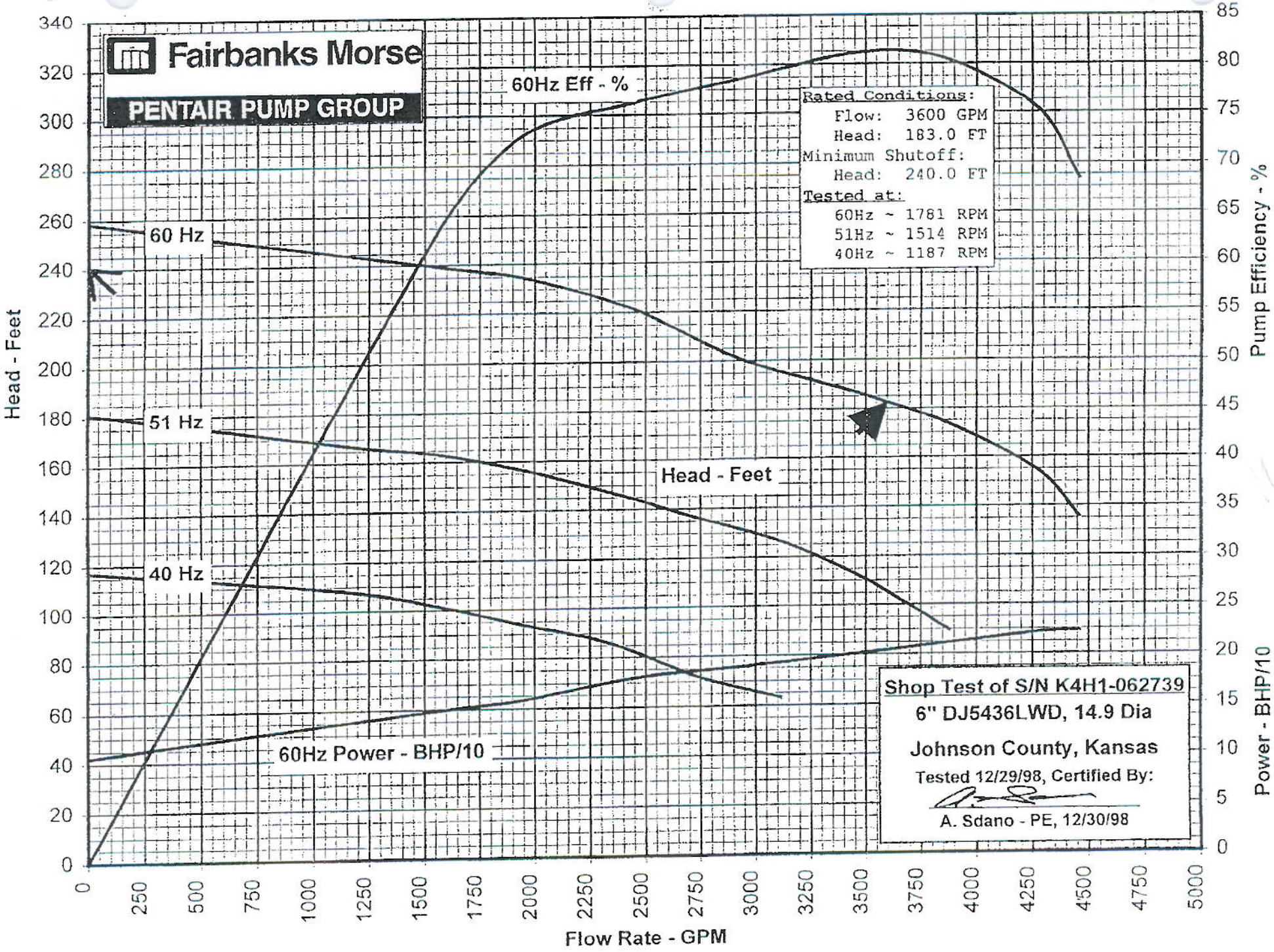
12000 18769
1/10/09
KANSAS
PROFESSIONAL ENGINEER

Pumps 2 & 4


Fairbanks Morse
PENTAIR PUMP GROUP
60Hz Eff - %
Rated Conditions:
Flow: 3600 GPM
Head: 183.0 FT
Minimum Shutoff:
Head: 240.0 FT
Tested at:
60Hz ~ 1781 RPM
51Hz ~ 1514 RPM
40Hz ~ 1187 RPM
60 Hz
51 Hz
40 Hz
Head - Feet
60Hz Power - BHP/10
Shop Test of S/N K4H1-062739
6" DJ5436LWD, 14.9 Dia
Johnson County, Kansas
Tested 12/29/98, Certified By:
A. Sdano - PE, 12/30/98
Head - Feet
Pump Efficiency - %
Power - BHP/10
Flow Rate - GPM
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
250
500
750
1000
1250
1500
1750
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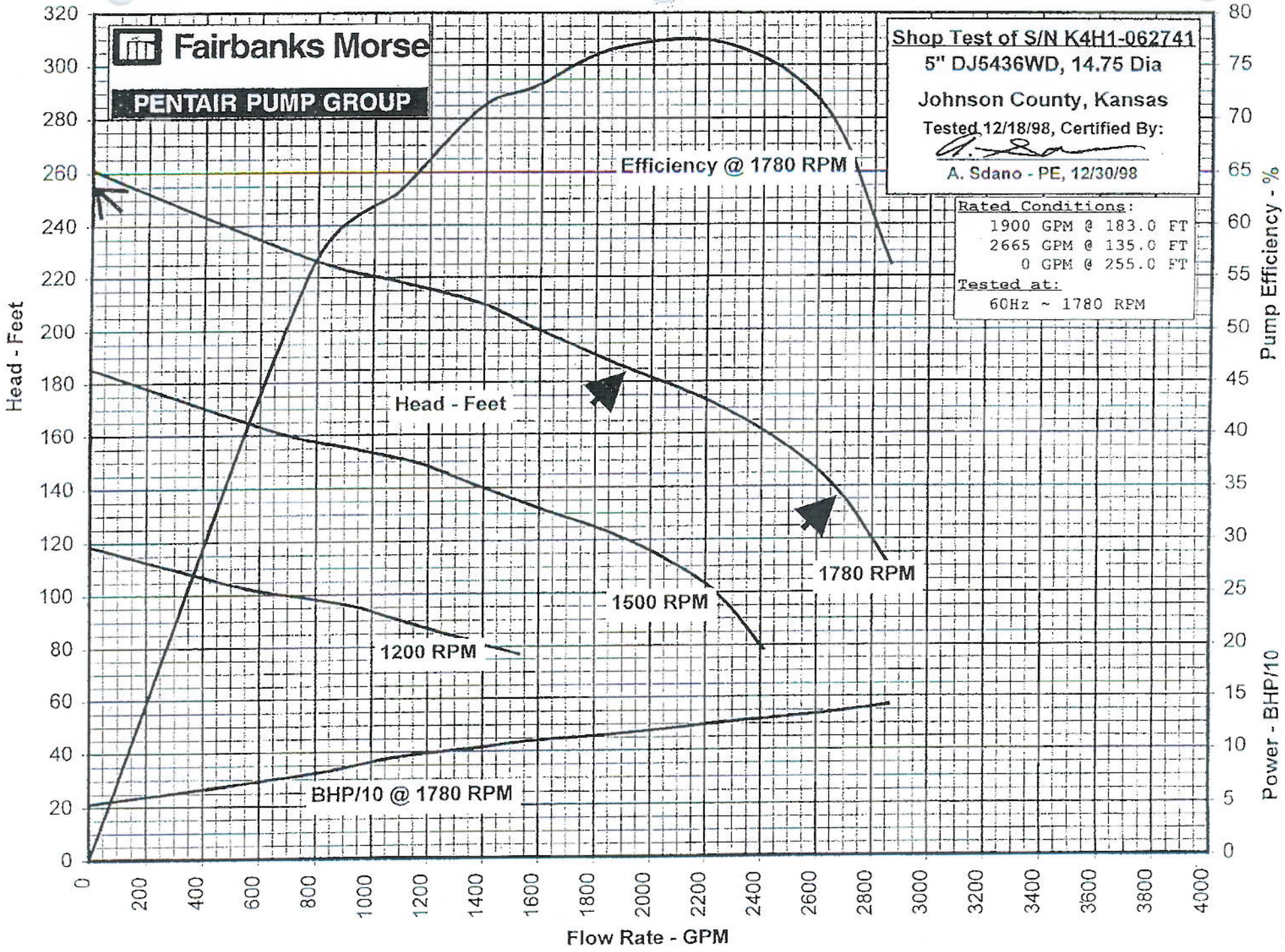
2250
2500
2750
3000
3250
3500
3750
4000
4250
4500
4750
5000

PUMPS 1 & 3


Fairbanks Morse
PENTAIR PUMP GROUP
Shop Test of S/N K4H1-062741
5" DJ5436WD, 14.75 Dia
Johnson County, Kansas
Tested 12/18/98, Certified By:
A. Sdano - PE, 12/30/98
Rated Conditions:
1900 GPM @ 183.0 FT
2665 GPM @ 135.0 FT
0 GPM @ 255.0 FT
Tested at:
60Hz ~ 1780 RPM
Efficiency @ 1780 RPM
Head - Feet
1780 RPM
1500 RPM
1200 RPM
BHP/10 @ 1780 RPM
Head - Feet
Pump Efficiency - %
Power - BHP/10
Flow Rate - GPM
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000

Fairbanks Morse Pump

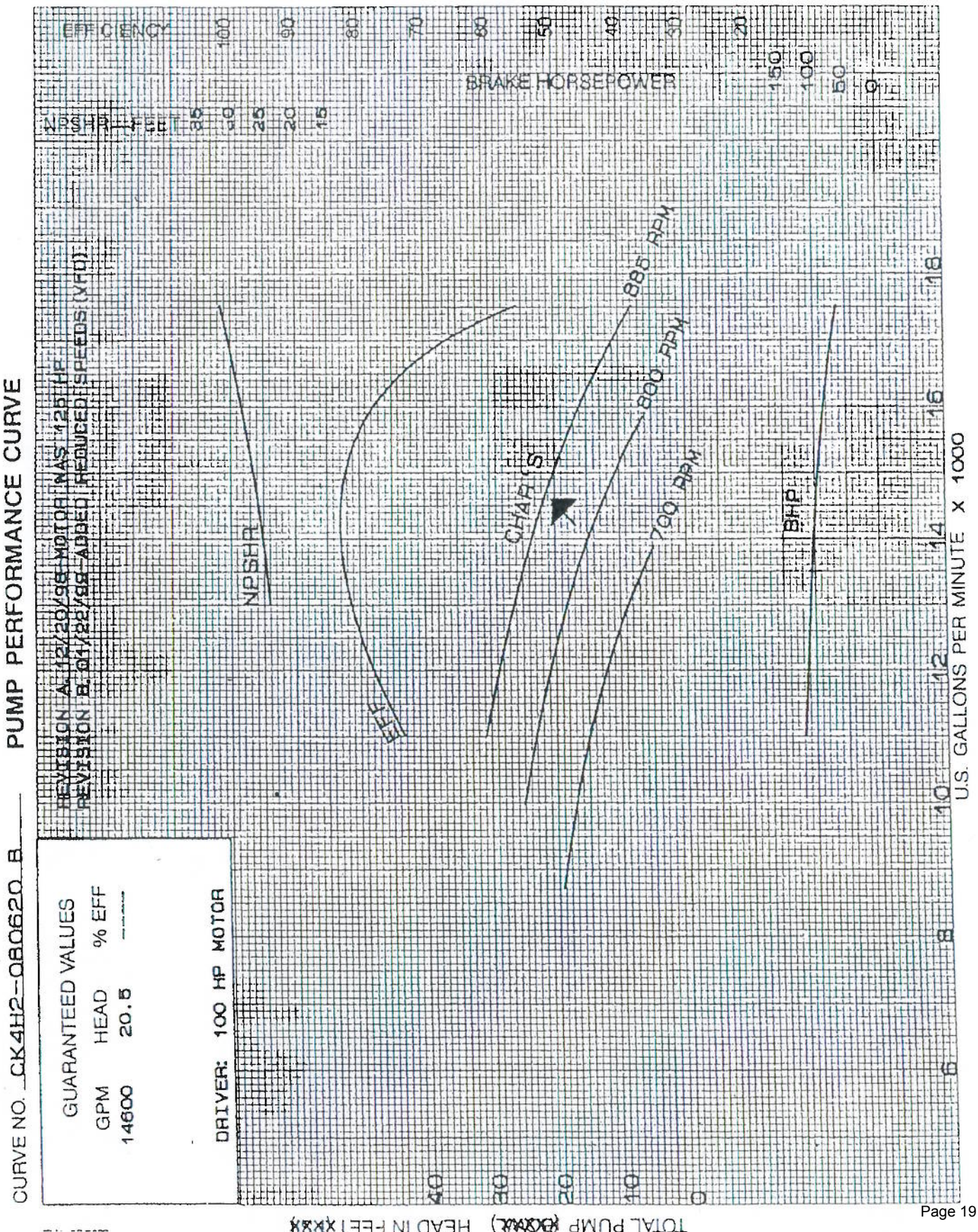
A Member of Pentair Pump Group

SUBMITTAL CURVE

THIS CURVE IS BASED ON ACTUAL TEST PERFORMANCE OF A SIMILAR PUMP. ONLY THE INDICATED POINT(S) IS GUARANTEED.

NO. STAGES ONE
REFERENCE ORIGSUB
PLOTTED BY JCM
DATE 1/22/99

SIZE-MODEL 24-8211AE
IMPELLER DES. A-357-3
IMPELLER DIA. (R1) STD"
RPM(S) 885 (AS NOTED)



Nelson Complex WWTF Improvements Facility Plan Technical Memorandum #2 Regulatory Evaluation

September 2018

FINAL

JOHNSON COUNTY KANSAS

Wastewater

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Appendix A Current and Target Effluent Limitations for Outfall 001 at the Nelson Complex

ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
EPA	Environmental Protection Agency
GPD	Gallons per Day
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KDHE	Kansas Department of Health and Environment
MGD	Million Gallons per Day
mg/l	Milligrams/liter
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NH3-N	Ammonia Nitrogen
PEFTF	Peak Excess Flow Treatment Facility
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WWTF	Wastewater Treatment Facility

1 Introduction

The Nelson Complex Wastewater Treatment Facility (WWTF) is comprised of two separate process trains, referred to as Mission Main (originally Mission Township Main Sewer District No. 1) and Turkey Creek (originally Shawnee Mission Turkey Creek Main Sewer District No. 1). These were originally two separate WWTFs sharing a common site. They have since been consolidated into a single facility, the Nelson Complex, with two distinct process trains that share a common disinfection and biosolids facilities and a single permitted outfall.

Some of the facilities at the WWTF and at the satellite Peak Excess Flow Treatment Facilities (PEFTF's) locations have been in service since the 1950s and are in need of repair and rehabilitation. In addition, more stringent discharge limits are anticipated with the WWTF's next permit cycle, including ammonia nitrogen, nitrogen, and phosphorus limits or goals. The existing trickling filter technology cannot meet these limits or goals, and replacement with a more advanced technology such as biological nutrient removal (BNR) will be required. Johnson County Wastewater (JCW) is pursuing necessary WWTF and collection system upgrades to address these issues and have enlisted the help of HDR Engineering (HDR), CH2M, and WCS Engineering (Project Team) to develop a long-term plan. An initial step of the plan is to establish discharge limits to serve as the basis of study, design, and ultimately permitting through water quality analysis and discussion with the Kansas Department of Health and Environment (KDHE).

The purpose of this memorandum is to establish target discharge limits to facilitate planning for upgrades to the Nelson WWTF. This memorandum also addresses potential future regulatory implications and the potential impact of implementing auxiliary treatment on effluent quality in comparison to projected permit limits.

2 Target Discharge Limits

Permit discharge limits are set based on technology or water quality-based requirements. The purpose of water quality-based discharge limits is to protect designated waterbody uses and limit degradation of existing water quality. For purposes of planning, target discharge limits are provided below for those parameters that are considered most likely to have numeric limits. Target discharge limits were estimated best on currently available information and may differ from the final permit. Final discharge limitations will be determined by KDHE.

5-Day Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) - The target $CBOD_5$ limits are not anticipated to change from the existing permit (Appendix Table A-1). The target $CBOD_5$ limits are consistent with technology-based effluent limitations (TBELs) requirements at Title 40 of the Code of Federal Regulations (CFR) 125.3(a), which specify that such limits are based on secondary treatment standards. The required secondary treatment standards for 5-day biochemical oxygen demand (BOD_5) are 30 mg/L as a 30-day average and 45 mg/L as a 7-day average. A $CBOD_5$ of 5 mg/L less than the BOD_5 limit is considered equivalent to a BOD_5.

Total Suspended Solids (TSS) - The target TSS limits are not anticipated to change from the existing permit (Appendix Table A-1). The target TSS limits are consistent with TBELs requirements at Title 40 of the CFR 125.3(a), which specify that such limits are based on

secondary treatment standards. The required secondary treatment standards for TSS are 30 mg/L as a 30-day average and 45 mg/L as a 7-day average.

Dissolved Oxygen (DO) - The existing permit includes a minimum weekly average DO limit of 6.0 mg/L. KDHE previously determined that this is necessary to protect the instream DO criterion of 5.0 mg/L in Turkey Creek. It is anticipated that KDHE will likely retain 6.0 mg/L as a minimum weekly average limit for DO (Appendix Table A-1).

Total Residual Chlorine (TRC) – The target TRC limits are not anticipated to change from the existing permit (Appendix Table A-1). The existing and target TRC limit of 11 ug/L as a daily maximum is based on meeting KDHE's chronic criterion of 11 ug/L. However, TRC monitoring would only be required if disinfection is by chlorination. Additionally, the target TRC limit is below the current acceptable quantification level of 100 ug/L for total chlorine in wastewater. Therefore, compliance with the TRC limit will be based on keeping the concentration below this level. Test results in excess of the quantification level would represent a permit violation.

pH - The target pH limits are not anticipated to change from the existing permit (Appendix Table A-1). The target pH limits are consistent with TBELs requirements at Title 40 of the CFR 125.3(a), which specify that such limits are based on secondary treatment standards. Secondary treatment standards require a pH range of 6.0 to 9.0.

Ammonia - In 2013, EPA finalized new water quality criteria recommendations for ammonia. The updated criteria recommendations were based on new toxicity data which demonstrate that some organisms, particularly some species of gill-breathing snails and freshwater mussels, are more sensitive to ammonia than other organisms in the national toxicity dataset used in previous criteria recommendations. In February 2018, KDHE approved a rulemaking that incorporated the EPA recommendations into the state water quality standards. The target ammonia limits presented in Appendix Table A-1, which reflect these revisions, will result in a significant reduction to the current average monthly limits (AML). Additionally, KDHE will impose a maximum daily limit (MDL) for ammonia, which is not currently included in the Nelson permit.

Estimated water quality-based ammonia limits depend on mixing assumptions, which dictate how much dilution may be used to calculate the ammonia wasteload allocation. Mixing assumptions are described below:

- *Mixing flow* - The AML is based on meeting the chronic criterion at the edge of the mixing zone (MZ) and the maximum daily limit (MDL) is based on meeting the acute criterion at the edge of the zone of initial dilution (ZID). The MZ and ZID flows for ammonia are based on the 30-day consecutive low-flow value having a 10-year recurrence interval (30Q10). Turkey Creek lacks a USGS gage station for calculating the 30Q10, but KDHE previously assumed a 30Q10 default value of 1 cubic feet per second (cfs). The same 1 cfs assumption was assumed here.
- *Effluent discharge* - Available dilution is typically evaluated based on the discharge design flow of a facility. The Nelson WWTF has a discharge design flow of 15 million gallons per day (or 23.3 cfs).

- *Mixing zone allowance* - In cases where the ratio of the receiving stream low flow to effluent discharge design flow on the permit is less than 3:1, the default MZ consists of 100% of the stream flow. The 30Q10 flow (1 cfs) is less than the effluent discharge design flow of 23.3 cfs; therefore, 100% mixing was assumed.
- *Zone of initial dilution allowance* - Per KDHE guidance, the ZID can comprise no more than 10% of the volume of the MZ immediately below the discharge point. Therefore, the ZID was assumed to be 10% of the MZ.
- *Background ammonia concentration* - Ambient background ammonia data were not available for Turkey Creek. Therefore, consistent with the existing permit, a default background concentration of 0.15 mg/L was assumed.

Water quality-based ammonia limits are also dependent on pH and temperature assumptions, which drive chronic and acute-based ammonia criteria. Based on preliminary discussions with KDHE, it was determined that for the purposes of planning, pH assumptions should be based on monitoring station SC204 (Indian Creek at Kansas City). KDHE indicated that station SC204 available data exhibit 7.7 as a median and 7.8 as a 75th percentile value. KDHE's recommendation is to evaluate process alternatives based upon two sets of pH assumptions, with 1) a single pH value of 7.7 year-round and 2) using a pH value of 7.8 during the summer months and 7.7 during the remainder of the year. Average monthly temperatures are based on continuous data collected at USGS monitoring station 38552009442000 (Indian Creek at College Blvd). Average monthly temperatures calculated from station SC204, pH assumptions and corresponding chronic and acute ammonia criteria are shown in Table 1 below. Target ammonia limits after taking into account mixing assumptions are presented in Appendix Table A1.

Table 1. Monthly Temperature and pH Assumptions and Corresponding Chronic and Acute Ammonia Nitrogen Criteria

	Temperature (°C)	pH (SU)	Chronic Criterion (mg/L)	Acute Criterion (mg/L)
January	4.4	7.7	1.7	11.4
February	4.2	7.7	1.9	12.9
March	8.5	7.7	1.9	12.5
April	13.9	7.7	1.4	9.1
May	18.2	7.7	1.2	7.4
June	22.4	7.7 (7.8)	1.0 (0.9)	5.6 (4.7)
July	26.0	7.7 (7.8)	0.8 (0.7)	4.5 (3.8)
August	25.8	7.7 (7.8)	0.8 (0.7)	4.5 (3.8)
September	22.6	7.7 (7.8)	1.0 (0.9)	5.4 (4.6)
October	15.8	7.7	1.1	6.3
November	10.8	7.7	1.4	8.3
December	5.9	7.7	1.6	10.4

Total Phosphorus and Total Nitrogen - KDHE does not currently have stream nutrient criteria for total phosphorus (TP) or total nitrogen (TN), but since 2004 has made significant efforts to decrease nutrient loadings to surface waters. The Kansas Surface Water Nutrient Reduction Plan, which was published on December 29, 2004, requires new and significantly upgraded mechanical wastewater treatment plants to implement processes to reduce the amount of phosphorus and nitrogen in effluent discharges. The plan targets a TP and TN goal of 1.5 mg/L

and 8 mg/L, respectively. However, KDHE has been more recently accepted alternative TP and TN goals of 1 mg/L and 10 mg/L based upon utility preferences, respectively. These alternate goals are recommended as target values for the Nelson WWTF permit (Appendix Table A-1).

In addition to the Kansas Surface Water Nutrient Reduction Plan, KDHE imposes nutrient controls at some facilities through Total Maximum Daily Loads (TMDLs). TMDLs are used to determine pollutant loadings and associated reductions that will restore water quality in an impaired waterbody. Although KDHE has no specific stream nutrient criteria, a phosphorus TMDL was finalized in 2017 for the Lower Kansas River based on an interpretive threshold value of 0.201 mg/L. The TMDL wasteload allocations for mechanical treatment facilities located in the basin including the Nelson WWTF are based on the following phases:

- Phase I – 1.0 mg

The Phase II wasteload allocation would only apply if the biological community in the lower Kansas River fails to respond to the Phase I reduction of TP. However, Phase I of the TMDL is scheduled to be implemented from 2019 through 2039, so Phase II reductions would not commence until 2040.

The TP wasteload allocation in the Lower Kansas River TMDL is expressed in terms of pounds per day based on the Phase I TP concentration of 1.0 mg/L and the the permitted design flow. Specifically, the TMDL includes a TP wasteload allocation of 125.31 lbs/day for the Nelson WWTF. KDHE has indicated that the TP wasteload allocation in the Nelson WWTF permit will be expressed as an annual rolling average limit (Appendix Table A-1).

The hypoxic zone in the Gulf of Mexico is characterized by low levels of oxygen and is estimated to cover approximately 8,800 square miles. EPA attributes the hypoxic zone to a variety of factors including excessive nutrients loading from the Mississippi River Basin. Although the Kansas Surface Water Nutrient Reduction Plan is largely intended to address this issue, a nutrient TMDL for the Mississippi River Basin states remains a possibility. If such a TMDL were developed, numeric TP and TN limits would likely be required based upon KDHE permitting practices. However, as numeric TP limits will already apply to the Nelson Complex, the primary implication for JCW would be the addition of numeric TN limits. It is unclear what the limits would be, but they could be commensurate with the limits of technology (LOT). KDHE currently considers a TN limit of 3 mg/L and a TP limit of 0.3 mg/L equivalent to LOT. The timeline for such limits is unclear, but is unlikely to occur within the next several permit cycles.

Nitrate - KDHE applies a nitrate criterion of 10 mg/L (expressed as nitrate-nitrogen) for protection of domestic supply waters. Since Turkey Creek is designated for drinking water protections, KDHE will include a 10 mg/L nitrate limit that will be expressed as an annual rolling average (Appendix Table A-1).

***E. coli* -** Per KDHE guidance (KDHE 2014), a discharger is required to meet primary contact recreation for bacteria at the end-of-pipe in urban streams or in surface waters designated for primary contact recreation. Turkey Creek is in a relatively urbanized area and is designated for

Class B Primary Contact Recreation (PCR) use protections in the Kansas Surface Water Quality Standards. Streams designated for Class B PCR use protections have the following seasonal *Escherichia coli* (*E. coli*) criteria:

- April – October: 262 cfu/100 mL (geometric mean)
- November – March: 2,358 cfu/100 mL (geometric mean)

The above referenced seasonal criteria are targeted as the average monthly limit to be expressed as a geometric mean (Appendix Table A-1). Additionally, an average weekly limit of 4,348 cfu/100mL, expressed a geometric mean, will also apply during the April through October period based on KDHE permitting practices. An average weekly limit is not anticipated for the November through March period.

3 Potential Future Criteria

In accordance with Section 303 of the Clean Water Act (CWA) and 40 CFR 131.20, states are required to review their water quality standards regulations at least once every three years. During each triennial review, states must appropriately modify existing rules or adopt rules based on newly available information, science, and federal promulgations. Newly adopted state rules must be approved by EPA before becoming effective for CWA purposes. A summary of relevant potential future regulations is summarized below:

Updated *E. coli* Bacteria Criteria - In 2012, EPA updated ambient water quality criteria recommendations for recreational waters. The revised recommendations limit the acceptable illness rate upon which the criteria are based to 0.8 percent and no longer provide allowances for different use intensity and higher risks. They also include recommendations for use of a statistical threshold value (STV). The STV approximates the 90th percentile of the water quality distribution and is intended to be a value that should not be exceeded by more than 10% of the samples used to calculate the geometric mean.

Currently, KDHE applies separate geometric mean *E. coli* criteria for Class A (Swimming Beach), Class B (Public Access) and Class C (Restricted Area) primary contact waters. Under EPA's new recommendations a single set of criteria would apply to all primary contact waters, which would include a geometric mean of 126 cfu/100 mL with a STV of 410 cfu/100 mL. The existing *E. coli* criterion for Turkey Creek is 262 cfu/100 mL from April through October and 2,358 cfu/100 mL from November through March. It is unclear how the revised *E. coli* criteria would be implemented in a permit, but could result in a limit of 126 cfu/100 mL as a monthly geometric average and a daily or weekly limit of 410 cfu/100 mL. At this time, however, KDHE has not adopted the revised bacteria criteria, and revising the current criteria would necessitate statutory changes due to the fact that recreational criteria are addressed in KSA 82a-2001. While this could change, it is assumed that the revised *E. coli* limits will not apply for at least 10 years.

Coliphage Criteria – EPA is developing Recreational Water Quality Criteria (RWQC) for coliphage as a viral indicator of fecal contamination in ambient water. There is evidence to suggest that coliphages, which are a subset of bacteriophages (i.e., viruses that infect bacteria),

are better indicators of human health risk than traditional fecal bacteria. Epidemiological studies over the past 30 years show that viruses are the microorganism group predominantly driving the illnesses associated with primary contact in recreational waters impacted by human sources. Concerns with traditional fecal indicator bacteria (FIB) as use for criteria include:

- FIB do not persist in the environment or through disinfection treatments as long as viruses,
- FIB do not show consistent correlations with viruses, and
- FIB do not contribute to the majority of illnesses associated with primary contact recreation.

To address these issues, EPA is currently moving to develop coliphage criteria. Coliphage-based criteria may have operational implications for wastewater treatment facilities as UV disinfection alone may not be sufficiently effective at typical dosage rates. This may lead to larger UV facilities or replacement or coupling with other disinfection (e.g., chlorine).

EPA could publish draft ambient water quality criteria for coliphage as early as late 2018 with the final proposal occurring in the 2020-2021 timeframe. However, EPA has recently indicated that proposed criteria could be delayed by several years. In addition, finalization of the rule may not be until late 2025 due to EPA's extended response to comments provided during the rulemaking process. Adoption of the new criteria by KDHE could take several more years as it may require Legislative action to amend state law due to the fact that recreational criteria are addressed in KSA 82a-2001. However, KDHE has shown no interest in adopting coliphage criteria under its own authority. Therefore, coliphage-based criteria do not appear likely anytime within the next 10 years.

Human Health Criteria - In 2015, EPA updated water quality criteria intended to protect public health for 94 chemical pollutants. These updates reflected the latest scientific information and policies related to fish consumption rates, body weight, drinking water intake, health toxicity values, bioaccumulation factors, and relative source contributions. KDHE has indicated that they intend to adopt the new criteria in an upcoming rulemaking. At this time, it is anticipated that adoption of EPA's updated water quality criteria will not likely result in new or revised permit limits.

4 Auxiliary Treatment Permit Compliance Evaluation

An evaluation was performed to determine the regulatory feasibility of using advanced high rate treatment (HRT), also known as auxiliary treatment, to manage wet weather flows at the Nelson WWTF. If constructed, auxiliary treatment would be used for treating peak wet weather flows in excess of three times the average daily flow (ADF) (hereinafter referred to as 3Q), thereby reducing peak flows through the biological treatment process (Figure 1).

For this preliminary evaluation, it was assumed that peak flows greater than 3Q would undergo auxiliary treatment and be combined with biologically treated flows prior to disinfection and discharge. For flows less than 3Q, two different scenarios were considered. The first scenario assumes that influent to the biological train is controlled through a step feed process. Under this scenario, flows up to 2Q are directed through the biological train and nitrified while flows between 2Q and 3Q are routed around aeration and recombined near the end of biological treatment basin as shown in the figure below. The second scenario assumes that flows up to 3Q are directed through the biological train and are fully nitrified.

Although there are significant economic advantages to using auxiliary treatment or step feed without complete nitrification, these wet weather treatment strategies can impact ammonia effluent quality as nitrification is not achieved through the HRT or step feed process. A preliminary evaluation of effluent quality was performed for comparison to potential ammonia permit limitations, as this parameter may be the most challenging to meet during wet weather conditions. Further evaluation of potential permit limit exceedances for ammonia and other parameters will be performed as process alternatives and flow management scenarios are refined.

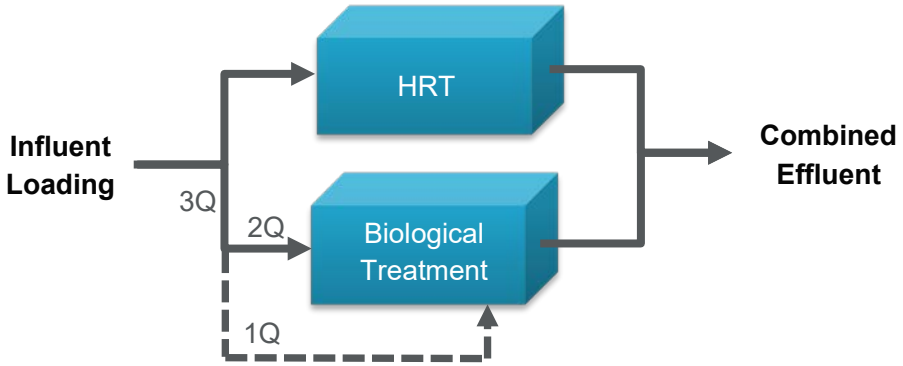

Figure 1. Conceptual Diagram of Wet Weather Management Strategy using High Rate Treatment

For purposes of evaluating projected effluent quality with respect to MDLs, a preliminary evaluation of the wet weather treatment strategy presented above was conducted based on a limited data assessment presented in the Basis of Analysis Technical Memorandum (TM 1). A key assumption obtained from TM 1 is that maximum monthly influent ammonia loading to the Nelson Complex WWTF is 2,775 lbs/day. This assumption is preliminary and should continue to be refined with

additional data and analysis. Another preliminary assumption is that the effluent quality of nitrification performance decreases with increasing flow such that ammonia concentrations equal 0.3 mg/L for flows below 1Q, 0.5 mg/L for flows between 1Q and 2xQ, and 1.0 mg/L for flows above 2Q. Based on these preliminary assumptions, ammonia effluent quality was estimated over a range of flows using the equation below:

$$\mathrm{NH3N_{effluent}} = \frac{(\mathrm{NH3N\ Influent\ Load}) \times \left(\frac{\mathrm{Q_{HRT}}}{\mathrm{Q_{HRT}} + \mathrm{Q_{Bio}}}\right) + ([\mathrm{NH3N_{Bio}}] \times \mathrm{Q_{Bio}})}{\mathrm{Q_{HRT}} + \mathrm{Q_{Bio}}}$$

$NH3N_{effluent}$ is the ammonia nitrogen effluent concentration discharged from Outfall 001, Q_{HRT} is the flow through auxiliary treatment or step feed, Q_{Bio} is flow through biological treatment designed for complete nitrification, and $NH3N_{Bio}$ is the nitrified ammonia effluent concentration with biological treatment.

Results of this analysis suggest the estimated maximum ammonia effluent would peak at approximately 3.3 mg/L for 2Q and at approximately 2.4 mg/L for 3Q (Figure 2). In comparison, the lowest estimated MDL for ammonia is 3.8 mg/L (Appendix Table A1). This suggests that the ammonia MDL will not likely be exceeded at either 2Q or 3Q nitrification capacity, but additional data and analysis are needed to verify model assumptions.

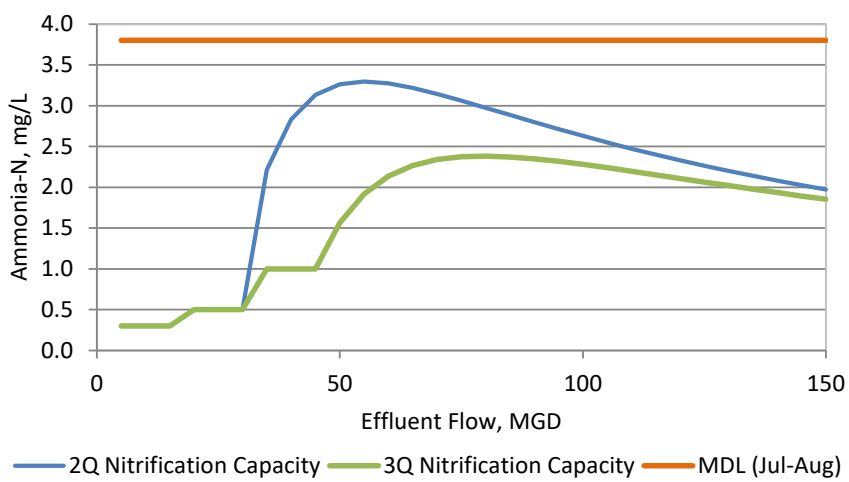

Figure 2. Estimated Ammonia Effluent Quality under a Range of Flows at the Nelson Complex Assuming the use of High Rate Treatment

For purposes of evaluating projected effluent quality with respect to AMLs, influent ammonia assumptions were based on influent flow and ammonia data collected from 2014 through 2017. Note that this analysis was limited to this timeframe since this was the only period with frequent influent ammonia data. Additionally, in order to assess the potential impact of eliminating all peak excess flow treatment facilities (PEFTFs), an alternate set of flows were considered based on estimated PEFTF flows. As a result, four sets of assumptions were assessed based on 2Q versus 3Q nitrification capacity and with and without PEFTF flows. Results of this analysis suggest that exceedances of the AML with nitrification capacity limited to 2Q would likely be infrequent (Figure 3).

Between 2014 and 2017 the projected average monthly ammonia concentration exceeded the AML once based on 2Q nitrification capacity and eliminating all PEFTFs. With 3Q nitrification capacity, there were no projected exceedances between 2014 and 2017.

Results of these analyses will require further analysis based on projected continuous flows under different scenarios. Influent flows will be estimated as part of the collection system study for both an optimized system and assuming maximum potential auxiliary treatment capacity. Collection of additional influent ammonia loading data is also recommended to provide more conclusive analyses.

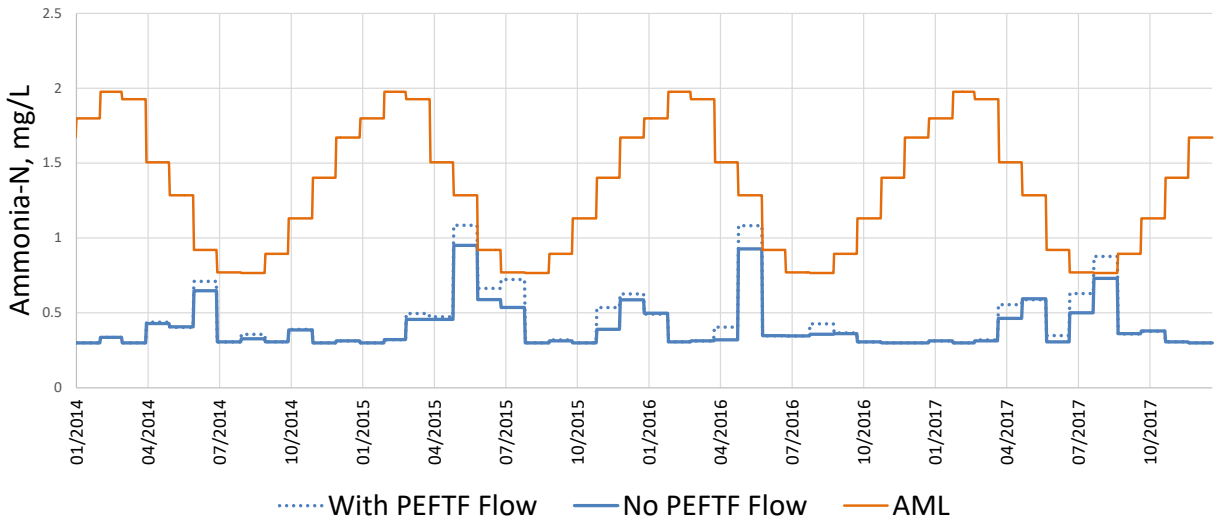

Figure 3. Projected Average Monthly Ammonia Concentration at the Nelson Complex Assuming the Nitrification Capacity of 2Q

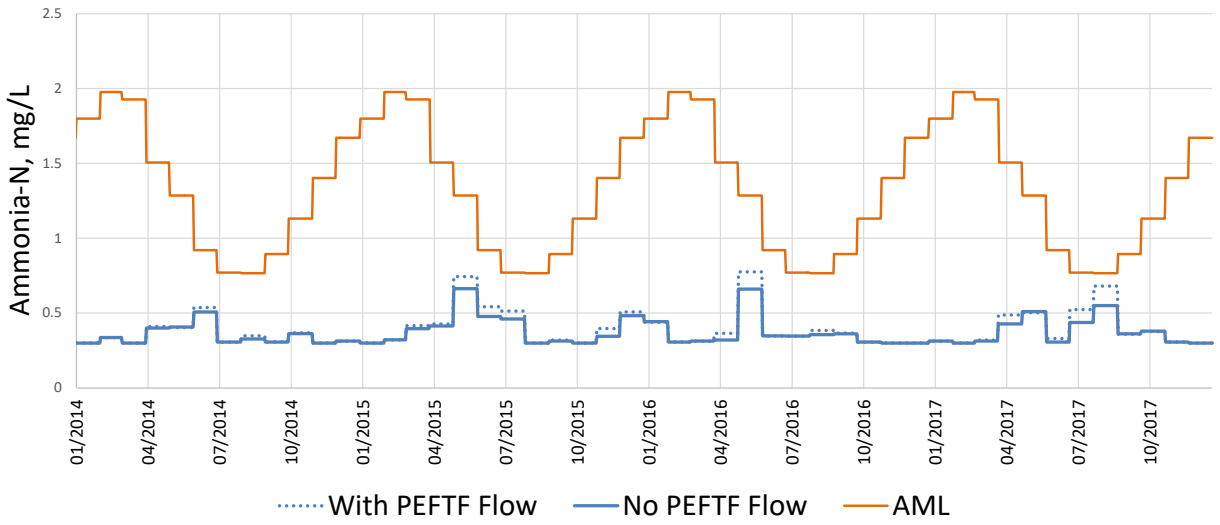

Figure 4. Projected Average Monthly Ammonia Concentration at the Nelson Complex Assuming Nitrification Capacity of 3Q

Appendix A
Current and Target Effluent Limitations for Outfall 001 at the Nelson Complex

Table A-1. Current and Target Permit Limitations for Outfall 001 at the Nelson Complex WWTF

Parameters		Unit	Current Limits	Target Limits
Carbonaceous Biochemical Oxygen Demand (5-Day)				
	Weekly Average	mg/L	40	40
	Monthly Average	mg/L	25	25
Total Suspended Solids				
	Weekly Average	mg/L	45	45
	Monthly Average	mg/L	30	30
Dissolved Oxygen				
	Minimum Weekly Average	mg/L	6.0	6.0
Total Residual Chlorine (TRC)				
	Daily Maximum	mg/L	11*	11*
pH				
	Range	SU	6.0 – 9.0	6.0 – 9.0
Ammonia (as N)				
January	Daily Maximum	mg/L	--	11.5
	Monthly Average	mg/L	10.4	1.8
February	Daily Maximum	mg/L	--	13.0
	Monthly Average	mg/L	10.0	2.0
March	Daily Maximum	mg/L	--	12.5
	Monthly Average	mg/L	6.4	1.9
April	Daily Maximum	mg/L	--	9.1
	Monthly Average	mg/L	6.6	1.5
May	Daily Maximum	mg/L	--	7.5
	Monthly Average	mg/L	4.9	1.3
June	Daily Maximum	mg/L	--	5.7 (4.8)†
	Monthly Average	mg/L	3.9	1.0 (0.9)†
July	Daily Maximum	mg/L	--	4.5 (3.8)†
	Monthly Average	mg/L	3.1	0.9 (0.8)†
August	Daily Maximum	mg/L	--	4.5 (3.8)†
	Monthly Average	mg/L	3.3	0.9 (0.8)†
September	Daily Maximum	mg/L	--	5.5 (4.6)†
	Monthly Average	mg/L	4.0	1.0 (0.9)†
October	Daily Maximum	mg/L	--	6.3
	Monthly Average	mg/L	6.7	1.1
November	Daily Maximum	mg/L	--	8.4
	Monthly Average	mg/L	9.1	1.4
December	Daily Maximum	mg/L	--	10.4
	Monthly Average	mg/L	11.3	1.7
Total Phosphorus - TMDL-Based Limit				
	Annual Rolling Average	lbs/day	--	125.31
Nitrate				
	Annual Rolling Average	mg/L	--	10
Nutrient Removal Goals				
	Total Phosphorus – Annual Average Goal	mg/L	--	1.0
	Total Nitrogen – Annual Average Goal	mg/L	--	10
Fecal coliform,‡				
	Monthly Geometric Average	cfu/100 mL	200	--
E. coli				
Summer (Apr – Oct)	Monthly Geometric Average	cfu/100 mL	--	262
	Weekly Geometric Average	cfu/100 mL	--	4,348
Winter (Nov – Mar)	Monthly Geometric Average	cfu/100 mL	--	2,358
	Weekly Geometric Average	cfu/100 mL	--	--

*The current acceptable quantification level for TRC in wastewater is 100 ug/L. Test results in excess of the quantification level would be considered a violation of the permit limit. TRC limits only apply if disinfection is by chlorination.

†Ammonia limits in parentheses based on a pH of 7.8. All other ammonia limits based on an assumed pH of 7.7.

‡Fecal coliform criteria are no longer applicable in Kansas and have been replaced with *E. coli* criteria.

Nelson Complex WWTF Improvements Facility Plan

Technical Memorandum #3 Alternatives Screening

August 2018

FINAL

JOHNSON COUNTY KANSAS
Wastewater

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ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CPES	CH2M Parametric Cost Estimating System
COD	Chemical Oxygen Demand
DLSMB	Douglas L. Smith Middle Basin
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
FPD	Facility Protection Device
GPD	Gallons per Day
gpm	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
mgal	Million Gallons
mgd	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/L	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NCAC	New Century Air Center
NH3-N	Ammonia Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
O&M	Operation and Maintenance

PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
Pro2D^2	Professional Process Design and Dynamics Whole Plant Simulator by CH2M
PS	Pump Station
R&R	Repair and Rehabilitation
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
SVI	Sludge Volume Index
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

1 Introduction

1.1 Background

The Facility Plan for the improvements to the Myron K. Nelson Wastewater Treatment Complex (Nelson Complex) will be one of several study efforts that collectively will determine the best strategy for the treatment facility and its contributing watershed. The purpose of this Technical Memorandum (TM) is to provide an analysis of a range of dry and wet weather treatment alternatives available as upgrades to the plant based on short and long-term effluent requirements, and screen these alternatives to a short list for further detailed evaluation. The screening and evaluation will be performed initially with an assumed wet weather flow component, with the selected wet weather treatment component sizing finalized once the collection system optimization has been completed.

1.2 Basis of Analysis

1.2.1 Current Design Flows and Loads

The Nelson Complex consists of the Mission Main Wastewater Treatment Facility (WWTF) and the Turkey Creek WWTF, which function as two separate facilities prior to combining ahead of dechlorination and discharge. Mission Main WWTF is a 2-stage trickling filter plant with primary, intermediate, and final clarification, while Turkey Creek WWTF is a single-stage trickling filter plant with primary and final clarification. The adopted flows and loads to be addressed for the Nelson Complex are discussed in detail in TM 1 – Basis of Analysis and summarized below.

Table 1: Design Flows and Loading for the Nelson Complex

Table	Metric	Proposed Nelson Complex
Flow (MGD)	Design Annual Average	15
	Design Peak Hour	52[1]
BOD_5	Annual Average (ppd)	18,765
TSS	Annual Average (ppd)	22,893
VSS	Annual Average (ppd)	20,183
TKN	Annual Average (ppd)	3,502
NH_3 -N	Annual Average (ppd)	2,135
TP	Annual Average (ppd)	393

[1]This flow represents the design flow to be handled through primary and secondary treatment. The design peak hour flow is based on an assumed 3.5:1 relationship to design average flow, as discussed in the 2009 Pre-design Study.

Flow above the design peak hour flow will be handled through dedicated wet weather treatment strategies. The initial total peak hour wet weather flow to be assumed will be 140 million gallons per day (mgd). This value is based on the 5-year unrestricted flow of 187 mgd, with a 30 percent reduction for infiltration and inflow (I/I) reduction.

1.2.2 Regulatory Discharge Limits

TM 2 – Regulatory Evaluation discussed the near-term target discharge limits, also referred to as biological nutrient removal (BNR) limits, which are anticipated in the next permit cycle. In addition, more stringent discharge limits that are anticipated for long-term planning were also discussed;

these limits refer to limit of technology (LOT) treatment levels. Limits and goals in the next permit cycle include ammonia, nitrogen, and phosphorous. A summary of these anticipated limits and goals is presented in Table 2. The existing trickling filters will be unable to meet many of the limits or goals, prompting replacement with a more advanced treatment facility.

Table 2: Projected Effluent Discharge Limits for the Nelson Complex

Parameter	BNR Limit or Goal		LOT Limit or Goal	
	Monthly Average	Weekly or Daily Average	Monthly Average	Weekly or Daily Average
$cBOD_5$, mg/L	25	40	25	40
TSS, mg/L	30	45	30	45
NH_3 -N, mg/L[1]	0.8	3.8	0.8	3.8
Nitrate, mg/L[2]	10	-	10	-
TN, mg/L[2]	10	-	3	-
TP, mg/L[2]	1.0	-	0.3	-

[1]Most restrictive month at pH of 7.8 – July.
[2]Average Annual Goal

2 Qualitative Screening Criteria

Potential qualitative screening criteria were presented and reviewed at Workshop No. 1. This list was consolidated to the following eight criteria that were determined to be most relevant to Johnson County Wastewater (JCW).

Table 3: Qualitative Criteria for Nelson Complex Alternatives Analysis

Criterion	Description
Flexibility/Performance Risk	How well is the alternative able to successfully deal with fluctuations of flow and load; e.g., number of "tools" available to respond to changing conditions? Is it resistant to upset conditions? How extensive are the ramifications if all or part of the process fails? Does it provide adequate reliability and redundancy?
Adaptability/Phasing	How easily can the process/alternative be upgraded for future conditions or requirements? How easily can the alternative be phased in to meet needs over time in a cost-effective fashion?
Proven Experience	How proven is the technology/alternative in terms of actual operating experience while meeting similar performance requirements, number of successful installations in the USA, equivalent size of installations? Will the technology be more likely to receive regulatory/EPA approval?
Staffing/Multiple Processes	How well does the alternative match with existing operational staff in terms of numbers, capabilities, procedures, and experience? Does the alternative incorporate additional unit processes?
Land Requirements	How well does the alternative fit on the available site? Is it constructible within the available site?
Sludge/Solids Impacts	How well does alternative minimize sludge handling efforts? Does the alternative produce more sludge or make sludge handling or sludge disposal/reuse more difficult? How extensive are the impacts on the planned biosolids management approach with regards to quantity and quality?
Social Impacts	How well does the alternative prevent off-site impacts for traffic, noise, odors, visual, etc. (excluding construction impacts)? Can these impacts be easily mitigated? Does the alternative provide better effluent quality or other beneficial environmental impacts?
Safety	How well does the alternative minimize safety risks? Additional chemical storage and handling increases safety risks.

3 Dry Weather Treatment Alternatives

3.1 Background

Dry weather treatment alternatives consist of the liquid processes designed to treat normal flow conditions up to a maximum month flow of 19 mgd. Liquid processes include preliminary treatment, primary treatment, secondary treatment, final clarification, tertiary treatment, and disinfection. In addition, processes utilized for sidestream mitigation of nutrients are also considered. Secondary treatment processes will rely on biological nutrient removal (BNR) whenever possible. Some of the BNR processes considered will incorporate enhanced biological phosphorus removal (EBPR), while others will rely on chemical addition for phosphorus removal.

3.2 Alternatives Evaluated

Based on prior evaluations for the Nelson Complex and Tomahawk Creek WWTF, three representative dry weather alternatives were identified as most appropriate for evaluation. Each of these alternatives include base configurations to meet near term effluent limits and improvements to meet future potential LOT limits. The three process alternatives chosen include:

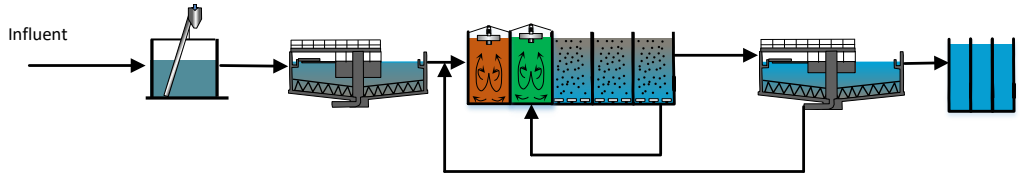
1. Alternative 1: Suspended Growth BNR System with EBPR
2. Alternative 2: Integrated fixed-film activated sludge (IFAS) BNR with EBPR,
3. Alternative 3: 2-Stage Suspended growth BNR with Chemical Phosphorus Removal

Each alternative is presented in the following exhibits. These exhibits include the following:

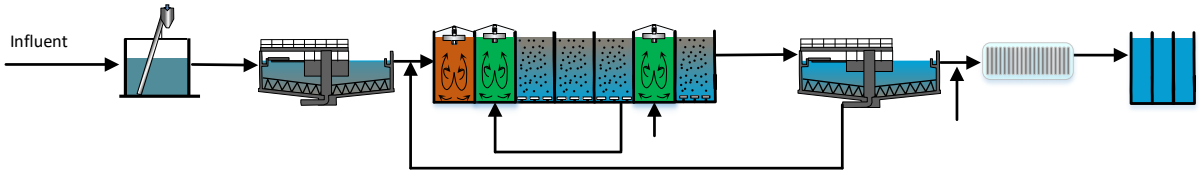
- Schematic of the treatment process for the alternative
- Discussion of the alternative with respect to the qualitative criteria shown in Table 3
- Discussion surrounding modifications of the alternative to meet LOT criteria.

Alternative 1: Suspended Growth BNR System with EBPR

Initial 3-Stage Suspended Growth BNR w/o Tertiary Treatment (BNR Limits)



LOT Expansion to 5-Stage Suspended Growth BNR with Tertiary Treatment



A 3-stage BNR-AS system would be constructed initially for biological nitrogen and phosphorus removal to BNR treatment levels. For LOT treatment levels, the BNR-AS sludge system would be expanded to 5-stage with carbon source feed to the post-anoxic stage for additional TN removal and filtration with upstream coagulant addition after the final clarifiers for polishing the final effluent TP values.

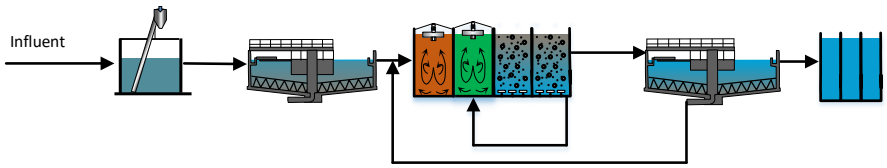
ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	Suspended growth with adequate solids retention time (SRT) can handle fluctuations in loads. Fluctuations in flows can be accommodated by oversizing clarifiers. Nitrification organisms tend to be the least resistant to upset conditions.
Adaptability/Phasing	The hydraulic grade line can be planned to allow for future LOT stages. All chemical feed can be postponed to LOT phase.
Proven Experience	Activated sludge is the most commonly used process for nutrient removal. 3-stage activated sludge processes (i.e. A^2O, MUCT, VIP) are more common than 5-stage processes (i.e. 5-stage Bardenpho).
Staffing/Multiple Process	Matching processes used at other JCW facilities that accomplish BNR treatment, such as the Tomahawk Creek WWTF under construction, provides consistency for staff knowledge and experience requirements. Activated sludge requires more operational monitoring/expertise than fixed-film processes. Biological P removal requires additional operational monitoring/expertise.
Land Requirements	Suspended growth only basins are a relatively compact technology, but do require a larger footprint than IFAS.
Sludge/Solids Impacts	Can be expected that activated sludge process will generate significantly more solids production than existing TF process. Maximizing biological P removal will generate less solids than relying only on chemical P removal. Tertiary filter backwash from expansion for LOT requirements will increase solids to be managed.
Social Impacts	Additional traffic and noise due to methanol and coagulant delivery for LOT in the future. Maximizing biological phosphorus removal reduces quantity of coagulant required for tertiary chemical P removal. Primary treatment will remain as an odor source. Potential for increased odors from anaerobic and anoxic zones in BNR treatment trains.
Safety	Onsite supplemental carbon poses a fire risk in LOT scenarios. TP polishing with coagulants requires handling of corrosive chemicals.

Comments

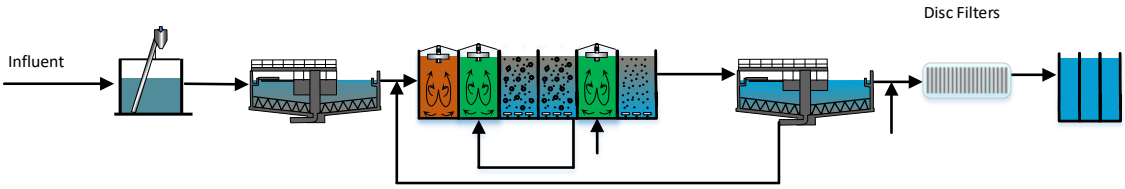
Chemical and power requirements for LOT requirements would increase operating costs. All new facilities would be constructed as three parallel trains minimum.

Alternative 2: IFAS BNR System with EBPR

Initial 3-IFAS w/o Tertiary Treatment (BNR Limits)



LOT Expansion to 5-Stage IFAS BNR with Tertiary Treatment



A 3-stage BNR-IFAS system would be constructed initially for nitrogen and phosphorus removal to BNR treatment levels. The aerobic zones contain suspended biofilm carriers to increases the residence time of nitrifiers in the system and decrease footprint. For LOT treatment levels, the IFAS system would be expanded to 5-stage with carbon source feed to the post-anoxic stage for additional TN removal. LOT treatment levels would include filtration with upstream coagulant addition for enhanced TP removal.

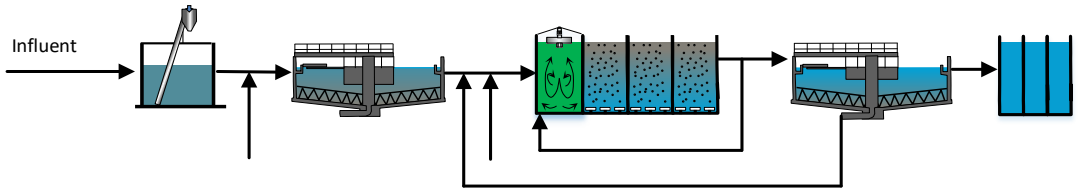
ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	IFAS systems can handle fluctuations in loads. Compared to suspended growth, IFAS systems are not capable of handling the same peak flows due to flow restrictions in the media retainers. Resiliency of nitrification organisms is increased by increasing the apparent SRT using biofilm carriers. Overloading organics into aerobic biofilms zones can lead to overgrowth of heterotrophs on biofilm carriers reducing nitrification efficacy.
Adaptability/Phasing	The hydraulic grade line can be planned to allow for future LOT stages. All chemical feed can be postponed to LOT phase.
Proven Experience	IFAS is a proven technology, but not as commonly implemented as conventional suspended growth activated sludge.
Staffing/Multiple Process	IFAS is not used at other JCW facilities. IFAS is generally a simpler/more resistant technology compared to suspended growth activated sludge.
Land Requirements	IFAS Systems have approximately 30% less land requirements compared to suspended growth. Final clarifiers for IFAS based systems are smaller than comparable suspended growth systems due to reduced MLSS concentrations and solids loading rates.
Sludge/Solids Impacts	An IFAS based system would generate the greatest mass of solids. The bulk MLSS SRT in an IFAS System is between 3-5 days. The reduced SRT results in 15 to 20% more solids production as compared to a suspended growth system. Tertiary filter backwash from expansion for LOT requirements will increase solids to be managed.
Social Impacts	Additional traffic and noise due to methanol and coagulant delivery for LOT in future. Maximizing biological phosphorus removal reduces quantity of coagulant required for tertiary chemical P removal. Primary treatment will remain as an odor source. Potential for increased odors from anaerobic and anoxic zones in BNR treatment trains.
Safety	Onsite supplemental carbon poses a fire risk in LOT scenarios. TP polishing with coagulants requires handling of corrosive chemicals.

Comments

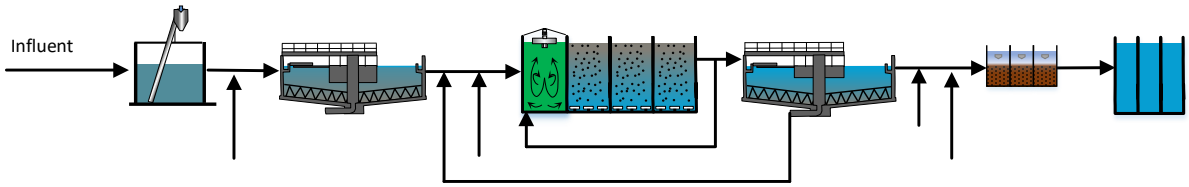
Chemical and power requirements for LOT requirements would increase operating costs. All new facilities would be constructed as three parallel trains minimum.

Alternative 3: 2-Stage BNR with Chemical Phosphorus Removal

Initial 2-Stage Suspended Growth BNR w/o Tertiary Treatment (BNR Limits)



LOT Expansion to Denitrifying Tertiary Filters



Initial construction to meet BNR limits would consist of a 2-stage system, such as the Modified Ludzack-Ettinger (MLE) Process for biological nitrogen removal. Phosphorus removal is achieved through chemical phosphorus removal dosing primary clarifiers. For LOT treatment levels, a denitrifying filter would be added. The denitrifying filter would be fed supplemental carbon to increase TN removal and a coagulant for additional TP removal.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	With adequate SRT, a two-stage process can handle fluctuations in flows and loads. Nitrification organisms are more easily impacted in suspended growth compared to IFAS systems. Chemical phosphorus removal with chemical pacing can provide consistent TP removal.
Adaptability/Phasing	The hydraulic grade line can be planned to allow for future LOT stages. All chemical feed can be postponed to LOT phase.
Proven Experience	Two-stage systems for nitrogen removal and chemical phosphorus removal are proven technologies.
Staffing/Multiple Process	Chemical phosphorus removal requires less operator attention compared to biological phosphorus removal. 2-stage systems are also simpler to operate and contain less components compared to 3 and 5-stage systems.
Land Requirements	For BNR Limits, a 2-stage system will have lower land requirements compared to 3-stage systems. For a comparable hydraulic capacity, denitrifying filters will occupy more land than disc filters because denitrifying filters are vertically oriented and cannot be stacked, unlike disc filters which are stacked in a horizontal orientation. Denitrifying filters also operate at a lower hydraulic loading rate which increases their overall footprint. Considering the bioreactor expansion and disc filter addition required for Alternatives 1 and 2 and the denitrifying filter addition for Alternative 3, it is expected that land requirements for Alternative 3 will less than Alternative 1 and similar to Alternative 2 at LOT.
Sludge/Solids Impacts	Chemical phosphorus removal increases sludge production relative to biological phosphorus removal. It is also anticipated that this alternative will produce similar solids quantities as the IFAS based alternative. Tertiary filter backwash for LOT requirements will increase solids to be managed.

Social Impacts	Additional traffic and noise due coagulant delivery with initial BNR limits. Traffic further increases for methanol and additional coagulant delivery for LOT in future. Unless ferric chloride is fed prior to primary treatment, primary clarifiers will remain as an odor source.
Safety	Onsite methanol is a fire risk in LOT scenarios. Chemical phosphorus removal results in increased handling of corrosive chemicals. LOT scenarios further increase coagulant use.
Comments Chemical and power requirements for LOT would increase operating costs. All new facilities would be constructed as three parallel trains minimum.	

3.3 Alternative Commonalities

The dry weather treatment strategies share common processes and process considerations. The recommended approaches for these shared processes is dependent upon factors such as site availability, constructability, preliminary process modelling, and the chosen wet-weather strategy. As such, most of the commonalities will be further evaluated during the detailed evaluation, with some decisions delayed until preliminary engineering occurs for the Nelson Complex.

3.3.1 Preliminary Treatment

Preliminary treatment, which consists of influent screening and grit removal, will be included for all alternatives. As each of the preliminary treatment processes can be designed with various degrees of removal efficiencies, the specific processes chosen will be dependent upon the selected dry and wet weather processes. Key considerations for the selection of preliminary treatment technologies will be anticipated performance, site requirements, downstream process requirements, capital cost, and operation and maintenance costs. These processes will be further evaluated with the selected alternatives.

3.3.2 Primary Treatment

Primary treatment will be included with all alternatives. Primary treatment alternatives being evaluated include primary clarification, primary filtration (no clarification), and primary clarification followed by primary filtration. In addition, chemically enhanced primary treatment may be considered to increase the allowable loading rate to primary clarification and reduce primary clarifier land requirements.

Conventional primary clarification (no chemical addition) is the baseline condition for all alternatives. The main driver for utilization of primary filtration without primary clarification is to reduce footprint requirements for primary treatment. The drivers to utilize primary clarification followed by primary filtration include: increasing TSS removal efficiency, reducing secondary treatment loading, and carbon redirection for BNR carbon augmentation (i.e. primary sludge fermentation) or increased digester gas production. Primary treatment will be further evaluated with the selected alternatives.

3.3.3 Sidestream Management

Sidestream treatment processes are being considered for the phosphorus and nitrogen loads generated in anaerobic digestion that would otherwise be routed to the mainstream liquid treatment process. In addition, return activated sludge (RAS) denitrification/fermentation is being evaluated as methods to improve EBPR and nitrogen removal performance.

3.3.3.1 SIDESTREAM NITROGEN MANAGEMENT

Handling the additional ammonium in sidestreams can be accomplished in several ways including deammonification (suspended or attached growth), post aerobic digestion (PAD), and nitrification/denitrification through the aeration basins. The traditional approach would be to nitrify

and denitrify this loading in the aeration basins, but the ability to achieve this is dependent on the availability of carbon to denitrify the additional sidestream nitrogen load and protect EBPR performance, and the presence of sufficient alkalinity for the increased nitrification in the aeration basins. The selection of the appropriate sidestream nitrogen management approach should be completed during the preliminary design of the Nelson Complex. For comparative purposes, incorporation of an attached growth deammonification process, such as Veolia Water Technologies ANITA™ Mox will be included as a representative technology with all dry weather treatment alternatives.

3.3.3.2 SIDESTREAM PHOSPHORUS MANAGEMENT

Anaerobic digestion of waste activated sludge from an EBPR process results in the release of large amounts of phosphorus. The increased release of phosphorus can result in the formation of nuisance precipitates (i.e. struvite, brushite, and vivianite) in the anaerobic digesters and on dewatering equipment. Furthermore, without sufficient carbon available, sidestream loads sent back to the secondary treatment process can result in reductions of effluent performance. Sidestream phosphorus can be mitigated through coagulant addition or the intentional formation of struvite. When struvite is intentionally formed, it can be harvested through a process such as Ostara® or left in the biosolids matrix through a process such as CNP's Airprex®.

The selection of the appropriate phosphorus mitigation strategy will be further evaluated in the detailed alternatives evaluation with the chosen dry weather treatment alternative.

3.3.3.3 RAS DENITRIFICATION OR FERMENTATION

RAS denitrification and fermentation are two similar processes that condition the RAS to increase the stability of the secondary treatment processes. In RAS denitrification, RAS is sent to a mixed and unaerated tank to reduce nitrate concentrations. Reduced RAS nitrate concentrations decrease effluent total nitrogen concentrations and increase the stability of EBPR by reducing the mainstream carbon utilized for denitrification. RAS fermentation is a slight modification in which anaerobic/fermentative conditions are achieved in a portion of the RAS through increased retention time and/or the supplementation of easily fermentable substrate. RAS fermentation selects for discrete phosphorus removal organisms capable of fermenting other biomasses. This fermentation step increases the amount of carbon available and creates a more stable EBPR process. The appropriateness of RAS denitrification or fermentation will be evaluated with the selected dry weather alternative.

3.3.4 Tertiary Treatment

Tertiary treatment is likely required to meet future phosphorus LOT limits. Tertiary cloth media filtration was utilized as the representative technology. Other possible technologies that should be evaluated as part of the pre-design engineering study could include tertiary membrane filtration, tertiary ballasted flocculation (i.e. Actiflo®), or media filtration.

3.3.5 Disinfection

Disinfection alternatives being considered include sodium hypochlorite disinfection, peracetic acid addition (PAA), and ultraviolet (UV) disinfection. The detailed evaluation of the appropriate process will be developed through later portions of this study. Given the potential concerns with inadequate Coliphage inactivation through UV disinfection, space for a disinfection contact basin will be included with all alternatives.

3.3.6 Site Constraints

Two important considerations for unit process selection will be space availability and the feasibility of phasing improvements. Space concerns may be alleviated through process intensification such as implementation of IFAS-based approaches or innovative technologies (I.e. Membrane Aerated Biofilm Reactors) or implementation of non-conventional approaches (i.e. primary filtration vs. primary clarification).

Phasing of the proposed improvements will be dependent on the ability to remove existing processes while maintaining permit compliance and the potential to re-use existing infrastructure. Efforts will be made to identify an approach that maintains simple hydraulic grade lines and utilizes existing infrastructure to the degree that makes sense. However, the phasing approach may require the implementation of intermediate pump stations and abandonment of unit processes that could otherwise be utilized.

3.3.7 Innovative Technologies

As the industry evolves, advancements and new technologies are introduced that have an opportunity to increase process performance, intensify unit processes, and reduce operational costs. Innovative technologies that have the potential for implementation at the Nelson Complex include membrane aerated biofilm reactors, mainstream anammox, or short cut nitrogen removal. While these processes are very promising, they are not ready to serve as a reference technology in terms of performance, cost, or site requirements. These and other innovative technologies should be revisited by the design engineer prior to implementation.

4 Wet Weather Treatment Alternatives

4.1 Background

Wet weather events bring large volumes of dilute flow to wastewater treatment plants. Typically, it is neither cost effective nor feasible to treat all dilute flow through secondary treatment systems. The goals of the wet weather treatment strategies are to protect the secondary treatment systems from overloads and flooding and to provide sufficient treatment such that combined flows maintain effluent compliance. Most wet weather strategies provide treatment to the excess flow that cannot be treated in secondary treatment or serve to maximize short term flow that can be processed through secondary treatment (i.e. step-feed).

Current wet weather peaks to the Nelson Complex are limited by hydraulic restrictions of the processes at the WWTF. The existing pump stations are throttled back to protect the WWTF and excess flow is conveyed to the Peak Excess Flow Treatment Facilities (PEFTF's) for treatment. If the PEFTF's are removed and pump stations are evaluated, the Nelson Complex may see increases in peak wet weather flow. Determination of the flows that may reach the WWTF is ongoing. Once complete, this analysis will provide more clarity on future wet weather flows. Wet weather treatment alternatives will be screened and evaluated initially based on the 5-year return interval with 30% I/I removal, which corresponds to 140 mgd. It is further assumed that 52 mgd of this total would be routed through dry weather treatment, with the 88 mgd balance receiving wet weather treatment.

4.2 Alternatives Evaluated

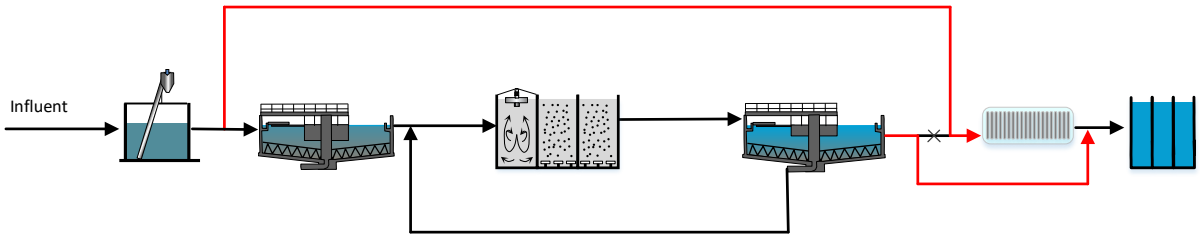
Five representative wet weather alternatives were identified for evaluation for the Nelson Complex, as follows:

1. Alternative 1: Wet-weather filtration
2. Alternative 2: Step-feed and traditional blending
3. Alternative 3: Chemically enhanced primary treatment
4. Alternative 4: Wet-weather ballasted flocculation
5. Alternative 5: Chemically enhanced primary treatment and step-feed BNR

Each alternative is presented in the following exhibits. These exhibits include the following:

- Schematic of the treatment process for the alternative
- Discussion of the alternative with respect to the qualitative criteria shown in Table 3
- Discussion surrounding modifications of the alternative to meet LOT criteria.

Alternative 1: Disc Filtration



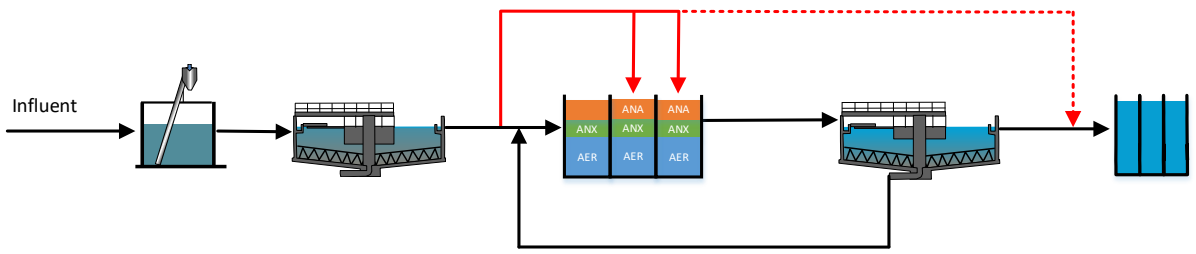
Disc filtration would be sized for near-term wet weather flows with space available for ultimate unrestricted flows. During wet weather flows, the disc filters would be fed by coarse screened influent. The disc filters could be used as tertiary filtration during dry weather flows (dual-use) if required to meet permit limits, such as for LOT effluent requirements and increased solids removal. Coagulant addition can be provided to increase removal efficiencies. In this scenario, primary clarifiers and secondary treatment would be sized for dry weather flows.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	Incorporation of disc filtration creates an easy transition from BNR to LOT limits. The use of disc filtration provides increased TSS removal compared to other wet-weather alternatives.
Adaptability/Phasing	The hydraulic grade line can be planned to incorporate additional disc filtration units for future wet weather flows. Incorporation of disc filtration eases the transition to LOT for dry weather alternatives.
Proven Experience	Disc filters are commonly used for tertiary treatment. Wet-weather applications in which these filters provide an equivalent to primary treatment are not as common, but have been successfully implemented at other facilities.
Staffing/Multiple Process	Dual purpose disc filtration is a process planned for the Tomahawk Creek WWTF, which would provide consistency for staff knowledge and experience requirements. Disc filters are easy to operate compared to other processes.
Land Requirements	Utilization of disc filtration for wet weather treatment will increase associated land requirements.
Sludge/Solids Impacts	As wet weather treatment technologies are implemented for short durations, there will be negligible impacts on solids production amongst the wet-weather treatment alternatives.
Social Impacts	Disc filtration provides high quality effluent. Disc filtration is not expected to impact odor production.
Safety	Disc filtration would require the use of chemicals, albeit reduced quantity compared to CEPT alternatives. Coagulants utilized with disc filtration are typically corrosive.

Comments

Implementation of disc filtration may require implementation of an intermediate pump station, which would increase costs and maintenance requirements. Disc filtration does not substantially reduce soluble nitrogen or BOD in the wet weather flow.

Alternative 2: Step-Feed BNR



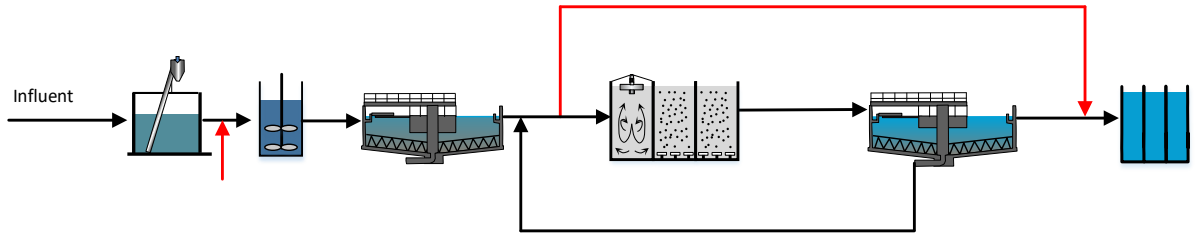
Step-feed BNR can be used to increase the short-term capacity of the BNR system. Step-feed would be accomplished feeding a portion of the primary effluent to a number of discharge locations along the activated sludge process with each feed point at a separate anaerobic zone followed by anoxic and oxic zones. Step-feed is effective for wet weather treatment up to a certain peaking factor usually established by final clarifier loadings, with the remaining flows sent through disinfection only. Primary effluent flows in excess of the peaking factor are diverted around secondary treatment. Peaking factors of 10:1 have been achieved at some treatment plants. Final clarifiers and primary clarifiers are designed for wet weather flows.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	Incorporation of step-feed increases wet weather operational flexibility. Step-feed BNR reduces the chance of biomass washout and protects sensitive nitrifier biomass. Extended step-feed into the final aerobic zone can promote the growth of filamentous organisms, which can result in increased Sludge Volume Indexes (SVI's).
Adaptability/Phasing	For the most cost-effective approach, step-feed should be implemented during initial construction. Phased implementation of step-feed can be challenging if proper provisions were not incorporated in initial construction. Implementing step-feed would delay the need for and the size of dedicated wet weather treatment facilities.
Proven Experience	Step-feed is a commonly implemented wet-weather strategy throughout the industry.
Staffing/Multiple Process	Although typically highly automated, more operations interface with step-feed systems over traditional activated sludge systems. Step-feed for wet weather treatment is not utilized at other JCW facilities, resulting in an increased learning requirement for operations staff. Step-feed requires minimal maintenance.
Land Requirements	Step-feed implementation requires increased clarifier capacity. The additional space for step-feed BNR may be comparable to auxiliary technologies, but the overall impact on land requirements will be assessed once preliminary bioreactor sizing is conducted using the calibrated process model.
Sludge/Solids Impacts	Step-feed results is not expected to substantially impact solids production.
Social Impacts	Step-feed does not substantially impact odors. Step-feed BNR provides full treatment to wet-weather flows, compared to auxiliary treatment or CEPT, which do not provide biological contact.
Safety	No additional chemicals are handled with step-feed, which reduces the need to store chemicals until LOT limits are required. Flows above the step-feed peaking factor will have increased disinfectant requirements, resulting in increased disinfectant use.

Comments

Step-feed during wet weather events provides some potential for reduction of soluble BOD and nitrogen components. Flow above the step-feed peaking factor is only treated to a primary equivalent level and may have regulatory impacts in the future. Tertiary treatment of the dry weather flow is not shown for clarity, but will be required as described by the dry weather treatment alternatives.

Alternative 3: Chemically Enhanced Primary Treatment



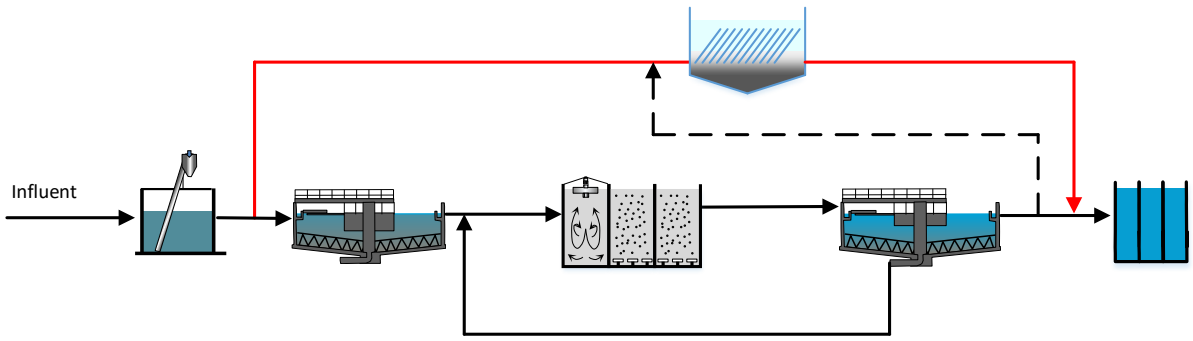
Chemically enhanced primary treatment (CEPT) involves the addition of a coagulant ahead of primary treatment to increase TSS, colloidal components, and phosphate removal efficiencies. Efficiently operating CEPT processes can achieve 70 to 80% TSS reduction. In wet weather operation, all preliminary treatment effluent is treated through chemically-enhanced primary treatment. Primary effluent above the dry weather design flow is diverted around secondary treatment prior to disinfection. Primary clarifiers are designed for wet weather flows and chemical assistance and final clarifiers are designed for dry weather flows.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	CEPT is a flexible process that can use a variety of polymers and coagulants to optimize performance goals. CEPT protects the secondary treatment process by limiting flow through the process. Operational risks result from insufficient performance resulting in non-compliance of some parameters in the effluent. If used continuously and not just for wet weather treatment, CEPT can also optimize dry-weather treatment performance and reduce energy costs.
Adaptability/Phasing	CEPT is a highly adaptable process modification that can be implemented following construction of the initial facility, provided primary clarifiers are appropriately sized and configured.
Proven Experience	CEPT is becoming more commonly implemented for wet weather flow treatment throughout the industry.
Staffing/Multiple Process	CEPT can be a highly automated process with minimal operator involvement. JCW has experience with CEPT at other facilities, which provides consistency for staff knowledge and experience requirements
Land Requirements	Increased land requirements for CEPT could result in increased land associated with the primary clarifiers. CEPT has likely the lowest land requirements of the wet weather alternatives evaluated
Sludge/Solids Impacts	As wet weather treatment technologies are implemented for short durations, there will be negligible impacts on solids production amongst the wet-weather treatment alternatives. CEPT results in increased primary sludge production. Primary sludge associated processes need to be designed for increased peak primary sludge production.
Social Impacts	Depending on the coagulant utilized, CEPT can reduce primary clarifier odor concerns.
Safety	CEPT increases the use of corrosive chemicals at the WWTF.

Comments

CEPT increases removal of colloidal and suspended BOD, TSS, sulfides, and phosphate. CEPT does not reduce soluble nitrogen components. Tertiary treatment for dry weather flow is not shown for clarity, but will be required as described by the dry weather treatment alternatives.

Alternative 4: Sidestream Ballasted Flocculation System



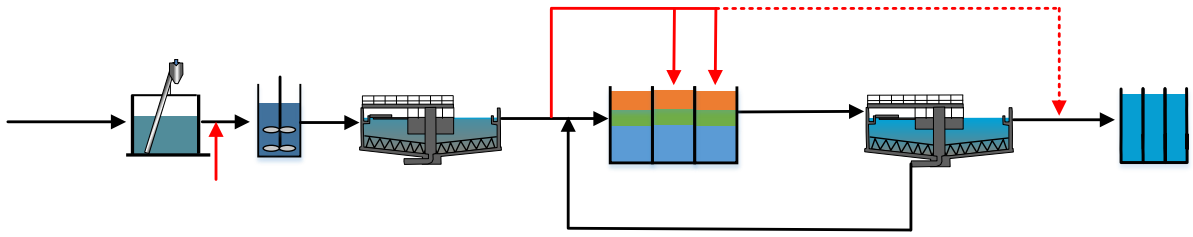
Ballasted flocculation would be sized for near-term wet weather flows with space available for ultimate unrestricted flows. During wet weather flows, the ballasted flocculation would be fed by preliminary treated effluent. For future LOT limits, ballasted flocculation system could be used as tertiary treatment during dry weather flows. In this scenario, final clarifiers and primary clarifiers would be sized for dry weather flows.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	Incorporation of ballasted flocculation allows for an easy transition from BNR to LOT limits. The use of ballasted flocculation provides TSS removal comparable to disc filtration.
Adaptability/Phasing	The hydraulic grade line can be planned to incorporate multiple ballasted flocculation units as wet weather flows become unrestricted. Ballasted flocculation has lower head requirements compared to disc filtration and may more easily fit into the hydraulic grade line without implementation of intermediate pumping.
Proven Experience	Ballasted flocculation is a commonly used for wet weather and tertiary treatment applications.
Staffing/Multiple Process	Ballasted flocculation is a more complex process compared to disc filtration. Keeping normally off-line equipment mechanically ready can be a challenge with the quantity of components associated with ballasted flocculation. Ballasted flocculation is not utilized at other JCW facilities, increasing the operational complexity due to multiple processes.
Land Requirements	Ballasted flocculation is a high rate process with low space requirements. Land requirements can be optimized if ballasted flocculation is also used for future LOT compliance.
Sludge/Solids Impacts	As wet weather treatment technologies are implemented for short durations, there will be negligible impacts on solids production amongst the wet-weather treatment alternatives.
Social Impacts	Ballasted flocculation provides high quality effluent in wet weather operation. Ballasted flocculation is not expected to impact odor production.
Safety	Ballasted flocculation increases chemical use compared to disc filtration and CEPT. Chemicals associated with ballasted flocculation are typically corrosive.

Comments

Ballasted flocculation sizing could be reduced if it was located down stream of primary treatment. However, this would require primary clarifier sizes to be increased in size to accommodate increased flows. Ballasted flocculation can be combined with biological contactors to increase regulatory acceptability. Routing of dry weather flows to ballasted flocculation is optional for BNR limits. Dry weather utilization of ballasted flocculation or additional tertiary treatment is required to meet LOT limits.

Alternative 5: CEPT and Step-Feed BNR



The CEPT and step-feed BNR approach merges alternatives 2 and 3. In this alternative, all flow is treated through chemically enhance primary treatment and flow up to a design peaking factor is routed through step-feed in the BNR process. Flow above the design peaking factor is diverted to disinfection. In this alternative, primary clarifiers are sized for wet weather flows, but would be smaller than step-feed without CEPT as in Alternative 2. Final clarifiers would be sized greater than dry weather flows, but less than step-feed only alternative.

ATTRIBUTE	COMMENTS
Flexibility/Performance Risk	Combining step-feed and CEPT increases the operational flexibility and reduces the associated risk compared to individual implementation of either strategy. If CEPT is continually utilized, the step-feed BNR reactor sizing could be reduced. The reduced bioreactor volume would provide nearly the same peaking factor that step-feed BNR would alone. If CEPT is only utilized in wet weather, then the allowable peaking factor would be increased compare to step-feed BNR alone. This alternative may alleviate the need for future auxiliary wet-weather treatment
Adaptability/Phasing	Step-feed should be implemented with initial construction. Provisions for CEPT can be incorporated at a later date.
Proven Experience	Both approaches are commonly implemented within the industry.
Staffing/Multiple Process	Step-feed operation involves highly automated systems and more operator involvement than traditional activated sludge systems. Step-feed is not utilized at other JCW facilities for wet weather treatment, resulting in an increased learning requirement for operations staff. Step-feed and CEPT require minimal maintenance.
Land Requirements	Other than CEPT alone, the combined approach results in the lowest land requirements associated with wet-weather treatment. Increased land requirements are associated with primary and final clarifier sizes.
Sludge/Solids Impacts	There will be negligible impacts on solids production amongst the wet-weather treatment alternatives. CEPT results in increased primary sludge production. Primary sludge associated processes need to be designed for increased peak primary sludge production.
Social Impacts	CEPT can reduce primary clarifier odor concerns. Step-feed BNR +CEPT provides full treatment to wet-weather flows, compared to auxiliary treatment or CEPT alone.
Safety	CEPT increases the use of corrosive chemicals at the WWTF.

Comments

CEPT increases removal of colloidal BOD, TSS, sulfides, and phosphate. Incorporation of step-feed results in some potential for soluble nitrogen removal. Increased peaking factors can be achieved in this combined approach compared to step-feed BNR alone.

4.3 Alternative Commonalities

Contrary to commonalities with the dry weather strategies, which primarily concerned process considerations, the commonalities associated with the wet-weather strategies result from planning for future peak flow conditions. As mentioned, peak flows to the Nelson Complex may increase if the PEFTFs are removed and raw pumping systems are upgraded. The processes of removing PEFTFs may occur in phases over an extended period of time as infiltration and inflow (I/I) reduction goals are achieved. The wet weather commonalities relate to management of these future flows.

4.3.1 Ultimate peak flow management

The wet-weather strategies presented aim to manage flows up to the previously discussed 5 - year return interval of 140 mgd. The evaluation of flows that may reach the WWTF is ongoing and includes assumptions on I/I reduction and the future utilization of PEFTFs within the collection system. If PEFTFs are removed more quickly or I/I reduction is not attained, future peak flows may be higher than projected. As such, space will be allocated for a future auxiliary treatment system to manage flows in excess of 140 mgd. Flows below 140 mgd will be mitigated as previously described.

Foot-print for the future auxiliary treatment system will be included in the final evaluation and is based on disc filtration, which is a proven high-rate technology currently being implemented by JCW at the Tomahawk Creek WWTF. Disc filtration is considered a representative technology because it is the most common high-rate system available at the time of this evaluation. As the industry continues to advance, more suitable or compact technologies may be identified that can replace the representative technology.

4.3.2 Storage Considerations

As the determination of the flows that may reach the WWTF is ongoing, the appropriateness and location of future storage will continue to be evaluated through this and future studies. No storage or equalization was included in the initial wet weather alternatives for the Nelson Complex.

5 Screening Criteria and Retained Alternatives

A screening workshop was completed on June 27th, 2018. The workshop consisted of presentation of the above alternatives, weighting of the screening criteria, and scoring against those screening criteria to select alternatives to retain for more detailed evaluation.

5.1 Weighting of Screening Criteria

The relative importance of the qualitative criteria was established in the workshop through a pair-wise comparison to force-rank the criteria and develop relative criterion scoring weights. It became apparent that both the applicable criteria, and criteria weighting, is different between dry weather alternatives and wet weather alternatives. Therefore, results of the relative weight scores for dry weather alternatives are presented in Table 4 and for wet weather alternatives, Table 5.

Table 4: Dry Weather Qualitative Screening Criteria Relative Weights

Criterion	Flexibility/ Performance Risk	Adaptability/ Phasing	Proven Experience	Staffing/Multiple Processes	Land Requirements	Sludge/Solids Impacts	Social Impacts	Safety	Total Scores	Weighting Percentage	Relative Weights
Flexibility/Performance Risk	A	6	7	8	7	8	6	6	48	15.6%	2.29
Adaptability/Phasing	5	B	7	8	5	7	4	6	42	13.6%	2.00
Proven Experience	4	4	C	8	3	4	3	5	31	10.1%	1.48
Staffing/Multiple Processes	3	3	3	D	2	3	2	5	21	6.8%	1.00
Land Requirements	4	6	8	9	E	8	8	8	51	16.6%	2.43
Sludge/Solids Impacts	3	4	7	8	3	F	3	5	33	10.7%	1.57
Social Impacts	5	7	8	9	3	8	G	7	47	15.3%	2.24
Safety	5	5	6	6	3	6	4	H	35	11.4%	1.67
TOTALS									**308**	**100%**	

Note: Minimum Score = 1, Maximum Score = 10

Table 5: Wet Weather Qualitative Screening Criteria Relative Weights

Criterion	Total Scores	Weighting Percentage	Relative Weights	Notes
Flexibility/Performance Risk	20	11.3%	20.00	For wet weather alternatives, was considered lower priority than proven experience. Score lowered accordingly.
Adaptability/Phasing	51	28.8%	51.00	With unknowns on magnitude and timing of future wet weather flows arriving at WWTF, adaptability and phasing capability is more important for these alternatives
Proven Experience	31	17.5%	31.00	
Staffing/Multiple Processes	21	11.9%	21.00	
Land Requirements	51	28.8%	51.00	
Sludge/Solids Impacts	1	0.6%	1.00	Not considered a decision factor for wet weather facilities that operate only occasionally
Social Impacts	1	0.6%	1.00	Not considered a decision factor for wet weather facilities that operate only occasionally
Safety	1	0.6%	1.00	Not considered a decision factor for wet weather facilities that operate only occasionally
TOTALS	**177**	**100%**		

5.2 Dry Weather Alternative Screening

The dry weather alternatives were scored using the qualitative screening criteria and a 1-10 benefit score:

1. Significantly negative impact
10. Significantly positive benefit

The scores and ranking for the alternatives are presented in Table 6.

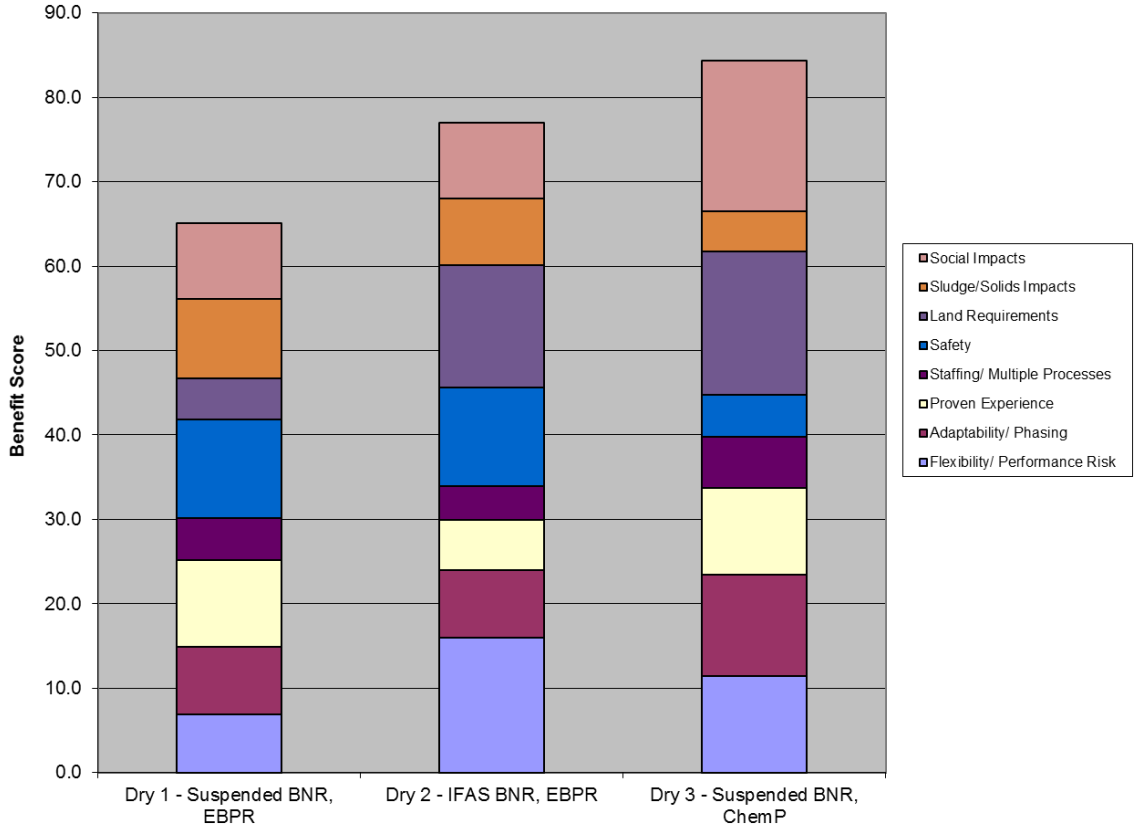
Table 6: Dry Weather Alternative Benefit Scoring

Alternative	Flexibility/ Performance Risk	Adaptability/ Phasing	Proven Experience	Staffing/Multiple Processes	Land Requirements	Sludge/Solids Impacts	Social Impacts	Safety	Unweighted Total Score	Unweighted Rank	Weighted Total Score	Weighted Rank
Dry 1 - Suspended BNR, EBPR	3	4	7	5	2	6	4	7	**38**	**3**	**65.10**	**3**
Dry 2 - IFAS BNR, EBPR	7	4	4	4	6	5	4	7	**41**	**2**	**76.95**	**2**
Dry 3 - Suspended BNR, ChemP	5	6	7	6	7	3	8	3	**45**	**1**	**84.38**	**1**

Note: Minimum Score = 1, Maximum Score = 10

On non-economic criteria, the two highest scoring alternatives were Alternative 2 and Alternative 3 as shown above and in Figure 1 below. However, Alternative 1 is expected to be the lowest cost if it is confirmed that the site can accommodate it. Therefore, all three (3) alternatives were retained for complete evaluation.

Figure 1: Dry Weather Alternatives Total Weighted Benefit Scores



5.3 Wet Weather Alternative Screening

The scores and ranking for the wet weather alternatives are presented in Table 7.

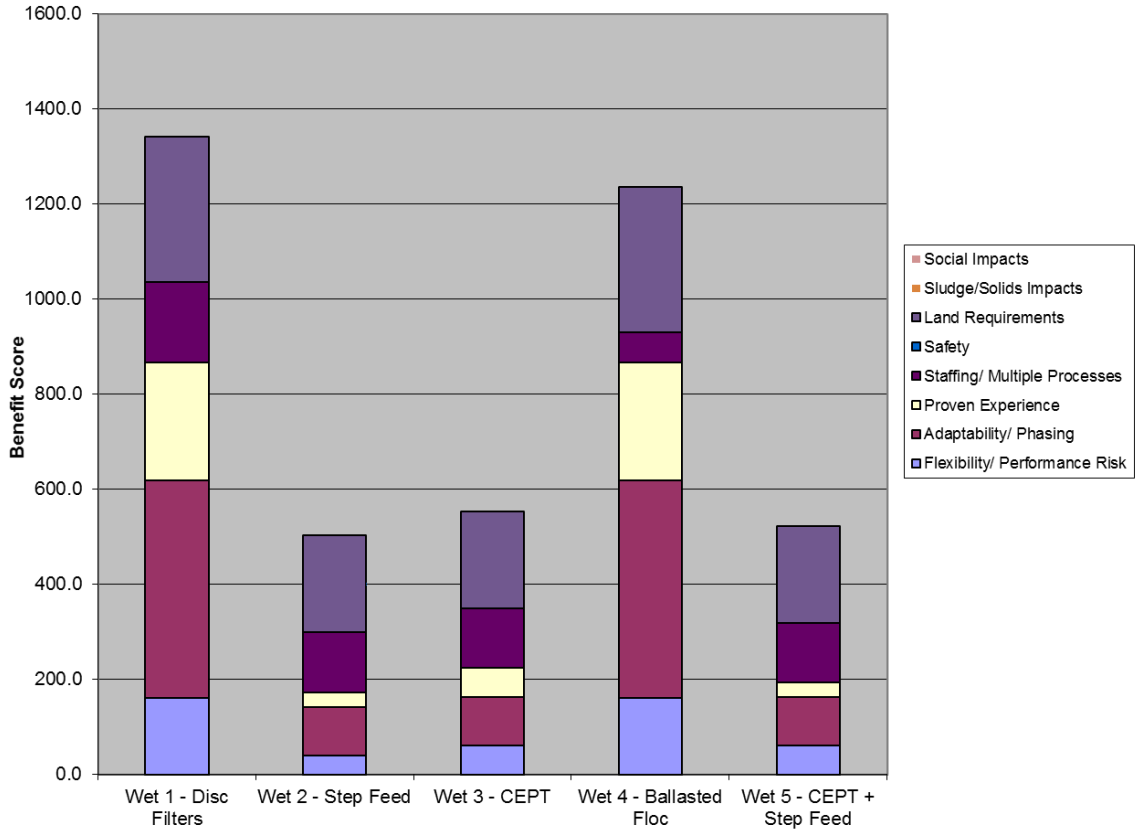
Table 7: Wet Weather Alternative Benefit Scoring

Alternative	Flexibility/ Performance Risk	Adaptability/ Phasing	Proven Experience	Staffing/Multiple Processes	Land Requirements	Sludge/Solids Impacts	Social Impacts	Safety	Unweighted Total Score	Unweighted Rank	Weighted Total Score	Weighted Rank
Wet 1 - Disc Filters	8	9	8	8	6	0	0	0	**39**	**1**	**1341.00**	**1**
Wet 2 - Step Feed	2	2	1	6	4	0	0	0	**15**	**5**	**503.00**	**5**
Wet 3 - CEPT	3	2	2	6	4	0	0	0	**17**	**3**	**554.00**	**3**
Wet 4 - Ballasted Floc	8	9	8	3	6	0	0	0	**34**	**2**	**1236.00**	**2**
Wet 5 - CEPT + Step Feed	3	2	1	6	4	0	0	0	**16**	**4**	**523.00**	**4**

Decision was made to retain wet weather filtration (Alternative 1) and ballasted flocculation (Alternative 4) and also CEPT (Alternative 3) to obtain a solid cost comparison to Alternatives 1 and

4. Step feed will only be included in dry weather alternatives to enhance performance under the 3:1 peaking factor.

Figure 2: Wet Weather Alternatives Total Weighted Benefit Scores



5.4 Retained Alternatives

The screening resulted in all three dry weather alternatives being carried into the final evaluation. The wet weather alternatives identified for more detailed evaluation included Alternative 1 – Disc Filtration, Alternative 3 – CEPT, and Alternative 4 – Ballasted Flocculation.

Nelson Complex WWTF Improvements Facility Plan

Technical Memorandum #4

Alternatives Selection

November 2018

FINAL

JOHNSON COUNTY KANSAS

Wastewater

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ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CPES	CH2M Parametric Cost Estimating System
COD	Chemical Oxygen Demand
CT	Concentration Time
DLSMB	Douglas L. Smith Middle Basin
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
FPD	Facility Protection Device
GPD	Gallons per Day
gpm	Gallons per Minute
HRT	Hydraulic Retention Time
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
mgal	Million Gallons
mgd	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/L	Milligrams/liter
MMADF	Maximum Month Average Daily Flow

MTM1	Mission Township Main Sewer District No. 1
NC	Nelson Complex
NCAC	New Century Air Center
NH3-N	Ammonia Nitrogen
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
Pro2D[2]	Professional Process Design and Dynamics Whole Plant Simulator by CH2M
PS	Pump Station
R&R	Repair and Rehabilitation
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
SVI	Sludge Volume Index
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultraviolet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

1. Introduction

1.1 Background

The Facility Plan for the improvements to the Myron K. Nelson Wastewater Treatment Complex (Nelson Complex) will be one of several study efforts that collectively determine the best strategy for the treatment facility and its contributing watershed. The purpose of this Technical Memorandum (TM #4) is to provide a detailed process and economic evaluation of the dry weather and wet weather alternatives retained from the prior alternative screening task documented in TM #3.

1.2 Basis of Analysis

1.2.1 Design Flows and Loads

The adopted design flows and loads for the Nelson Complex are discussed in detail in TM #1 – Basis of Analysis and summarized below.

Table 1: Design Flows and Loading for the Nelson Complex

Table	Annual Average		Maximum Month[2]		Peak/Flush	
	Conc. (mg/L)	Load (ppd)	Conc. (mg/L)	Load (ppd)	Conc. (mg/L)	Load (ppd)
Flow (MGD)[1]	15		19		52	
BOD_5	150	18,765	154	24,395	126	54,644
TSS	183	22,893	188	29,761	143	62,016
VSS	161	20,183	166	26,238	120	52,042
TKN	28	3,502	29	4,554	25	10,842
NH_3 -N	17.1	2,135	18	2,776	11	4,770
TP	3.1	393	3.2	512	2.9	1,258

[1]Peak hour flow treated at facility = 52 MGD. Peak Hour through dry weather treatment = 45 MGD.
[2]Flow at Maximum Month BOD Load, not maximum month flow.

1.2.2 Regulatory Discharge Limits

The near-term target discharge limits, also referred to as biological nutrient removal (BNR) limits, which are anticipated in the next permit cycle, and more stringent discharge limits, which are anticipated for long-term planning (referred to as Limits of Technology [LOT]), are discussed in detail in TM #2 – Regulatory Evaluation. A summary of these anticipated limits and goals is presented in Table 2.

Table 2: Projected Effluent Discharge Limits for the Nelson Complex

Parameter	Near-Term (BNR)		Long-Term (LOT)	
	Monthly Average	Weekly or Daily Average	Monthly Average	Weekly or Daily Average
$cBOD_5$, mg/L	25	40[3]	25	40[3]
TSS, mg/L	30	45[3]	30	45[3]
DO, mg/L	-	6[3] (minimum)	-	6[3] (minimum)
NH_3 -N, mg/L[1]	0.8	3.8[4]	0.8	3.8[4]
Nitrate, mg/L[2]	10	-	10[5]	-
TN, mg/L[2]	10	-	3	-
TP, mg/L[2]	1.0	-	0.3	-

[1]Most restrictive month at pH of 7.8 – July.
[2]Average Annual Goal
[3]Weekly Average Limit
[4]Daily Maximum Limit
[5]Nitrate limit may not be relevant with TN limit less than 10 mg/L

1.2.3 Effluent Ammonia Compliance Analysis

Based on analyses presented in TM #2, it is anticipated the ammonia limits will not likely be exceeded assuming a nitrification capacity of 3 times the ADDF of 15 mgd or 45 mgd (hereinafter referred to as 3Q). The analysis presented in TM #2 assumed that peak flows greater than 3Q would undergo auxiliary treatment and be combined with biologically treated flows prior to disinfection and discharge. Based on maximum month loading assumptions presented in Table 1 above, it was estimated that the maximum ammonia effluent would peak at approximately 2.4 mg/L assuming nitrification capacity of 3Q. It was also estimated that monthly average ammonia concentrations would remain below estimated average monthly limits (AMLs). Analyses based on an assumed 2Q nitrification capacity suggest a greater likelihood of exceeding AMLs, but such exceedances would likely be infrequent. However, collection of additional influent ammonia loading data is recommended to provide more conclusive results prior to the final design.

2. Dry Weather Treatment Alternatives

2.1 Background

Dry weather treatment alternatives consist of the liquid processes designed to treat normal flow conditions up to maximum month loadings and peak hour flows up to 45 mgd. Liquid processes include preliminary treatment, primary treatment, secondary treatment, tertiary treatment, and disinfection.

2.2 Retained Alternatives

TM #3 – Alternatives Screening identified three dry weather alternatives for consideration at the Nelson Complex. All three of the alternatives identified were retained for detailed evaluation. The process alternatives chosen include:

- Alternative 1: 3-Stage Conventional Activated Sludge (CAS) with Enhanced Biological Phosphorus Removal (EBPR)
- Alternative 2: Integrated fixed-film activated sludge (IFAS) with EBPR,
- Alternative 3: 2-Stage CAS with Chemical Phosphorus Removal

Each of these alternatives included base configurations to meet near term BNR effluent limits and improvements to meet future potential LOT limits. This evaluation considers requirements for near-term BNR limits only.

2.3 Design Criteria

With the exception of secondary treatment configurations and equipment, all three dry weather alternatives were comprised of common processes. Secondary treatment processes were sized utilizing the calibrated Pro2D[2] process model targeting similar effluent quality and factors of safety for each alternative. Design criteria were based on KDHE standards, with 10-States Standards and common design practices utilized where specific KDHE requirements do not exist. Generally, all mechanical equipment and pumps are supplied to provide firm capacity with one unit out of service. Structures are sized with multiple units to allow for maintenance activities. The following sections summarize the design criteria utilized in the process modelling and alternatives development.

2.3.1 Preliminary and Primary Treatment

The preliminary and primary treatment components and sizing are common to all three dry weather alternatives. Sizing criteria for preliminary and primary treatment are summarized in Table 3.

Table 3: Preliminary and Primary Treatment Design Criteria

Component	Units	Value
Influent Screens		
Screen Opening	mm	6
No. Screens	-	3 (2 duty, 1 standby)
Grit Removal		
Type		Headcell
No. of Units	-	2 (2 duty)
Primary Clarifiers		
Peak Hydraulic Loading Rate	gpd/sqft	2,000
No. of Units	-	4 (4 duty)
Diameter, each	feet	85

2.3.2 Secondary Treatment

Secondary treatment in IFAS and CAS processes is primarily comprised of aeration basins and final clarifiers. Both processes are heavily interconnected, with performance in one of the components

impacting the performance and capacity of the other. With the strong relationship between these two processes, design considerations of the combined system are evaluated rather than individual components. Design criteria of the secondary treatment process, as well as ancillary equipment is summarized in Table 4.

Table 4: Secondary Treatment Design Criteria

Component	Units	Value
Aeration Basins		
No. Trains	-	4 (duty 4)
No. Blowers	-	5 (4 duty, 1 standby)
Diffuser Type	-	Fine Bubble (Dry 1 and 3), Coarse Bubble (Dry 2)
Max Month MLSS	mg-TSS/L	3,000
Nitrified Mixed Liquor Recycle Rate	% influent	100 - 300
Secondary Clarifier		
Solids Loading Rate[1]	lbTSS/sqft-d	35
No. of Units	-	4 (duty 4)
RAS Capacity[2]	mgd	19
Diameter[2]	feet	121

[1]Calculated at max month MLSS, RAS = 19 mgd, and PHF = 45 mgd
[2]100% Max Month Flow

2.3.3 Disinfection

Disinfection facilities are sized for the initial influent PHF of 52 mgd utilizing sodium hypochlorite (NaOCl), with quenching completed utilizing Sodium Bisulfite ($NaHSO_3$). Design criteria is summarized in Table 5.

Table 5: Disinfection Design Criteria

Component	Units	Value
Disinfectant Concentration Time (CT)	$mgCl_2$*min	30
Hydraulic Retention Time (HRT)[1]	min	15
Chlorine Contact Basin Minimum Volume	MG	0.55
Primary Disinfectant	-	NaOCl
Dechlorination Chemical	-	$NaHSO_3$
Disinfectant Dose[2]	$mgCl_2$/L	6
Target Residual	$mgCl_2$/L	2
Chemical Storage[2]	Days	15

[1]Calculated at PHF = 52 mgd
[2]Average Day Chemical Use

2.3.4 Sludge Processing

Sludge processing consists of primary sludge thickening, primary sludge fermentation (Alt. 1 and Alt. 2 only), WAS thickening, solids digestion, and sludge dewatering. Design criteria is summarized in Table 6.

Table 6: Sludge Processing Design Criteria

Component	Units	Value
Primary Sludge Thickening/Fermentation		
Type	-	Gravity
No. Units[1]	-	3 (2 Existing)
Diameter, Fermenter	Feet	65
Thickened Sludge Concentration	%	4.5
Capture Rate	%	85
WAS Thickening		
Type	-	Gravity Belt Thickener
No. Units	-	3 (2 duty, 1 standby)
Thickened Sludge Concentration	%	5
Capture Rate	%	92
Anaerobic Digestion[2,3]		
Type	-	Mesophilic
No. Units	-	4 (3 Primary, 1 Secondary/Storage)
Digester Volume	MG	0.65 (each)
Dewatering[3]		
Type	-	Centrifuges
No. Units	-	3 (2 duty, 1 standby)
Cake Concentration	%	25
Capture Rate	%	92

[1]Alternative 3 does not include an additional unit
[2]From Solids Master Plan
[3]Included in process modeling, but not included in economic evaluation

2.3.5 Sidestream Management

Sidestream management for dewatering centrate was included in the process modeling but was not included in the economic comparison of alternatives because ultimate sizing of sidestream process will include additional load from offsite sludge hauled to the Nelson Complex. Process modelling assumed sidestream nitrogen loads were treated utilizing the Anitamox® deammonification process, which resulted in an ammonia removal of 80%.

Alternatives 1 and 2, which are associated with biological phosphorus removal, produce high concentrations of phosphate that need to be managed. Untreated sidestream phosphorus loads can represent as much as 40% of the total bioreactor phosphorus load, which can be problematic for phosphorus stability in plants with low organic loading. Additionally, untreated phosphate sidestream loads from biological phosphorus removal systems have the potential for detrimental struvite formation in the digestion process and on dewatering equipment. Selection of the appropriate phosphorus sidestream management process will be completed with the selected alternative. Initial evaluations assumed metal salt (i.e. ferric chloride) dosing at rates similar to the Douglas L. Smith Middle Basin (DLSMB) WWTF design conditions.

2.4 Sizing and Simulation Results

The calibrated Pro2D[2] process model was utilized to refine secondary treatment sizing, predict process performance at average day and max month conditions, and to support life-cycle cost considerations. Refined bioreactor sizing is summarized in Table 7. Predicted process performance for average day and max month conditions is summarized in Table 8 and Table 9, respectively. Under average day conditions, a temperature of 17 degrees Celsius was utilized. The temperature utilized for maximum month conditions was 13.5 degrees Celsius, which represented the lower range of temperatures observed during maximum month BOD loadings. Full Pro2D[2] process model results are included in Appendix A.

Table 7: Dry Weather Alternative Sizing Criteria

Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
Bioreactor Volume, MG	7.0	3.9	5.5
Zone Partitions			
Anaerobic, %	13	23	NA
Anoxic, %	17	31	27
Aerobic, %	70	26	73
DeOX/Reaeration,%	NA	20	NA
No. Aerobic Diffuser Grids Per Basin	4	2	4
Nitrified Mixed Liquor Recycle Rate, %	300	300	300
RAS Rate, %	100	100	75
Supplemental Carbon	Primary Sludge Fermentation	Primary Sludge Fermentation	None
Metal Salt Addition	Digested Sludge	Digested Sludge	Primary Clarifier and Activated Sludge

Table 8: Average Day Pro2D[2] Simulation Results

Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
MLSS, mg-TSS/L	1,834	2,043	1,838
Total SRT, Days[1]	8.25	4.50	8.00
Aerobic SRT, Days[1]	5.80	2.05	5.83
Effluent TP, mg-P/L	0.8	0.7	0.7
Effluent NH_3, mg-N/L	0.3	0.1	0.3
Effluent TN, mg-N/L	8.6	7.7	8.9
WAS Production, lb-TSS/d	11,118	12,909	8,705
Airflow, scfm	6,612	8,523	6,501

[1]Suspended growth biomass only. Does not include biomass on media carriers in Dry 2.

Table 9: Max Month Pro2D[2] Simulation Results

Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
MLSS, mg-TSS/L	2,987	2,993	2,980
Total SRT, Days[1]	10.5	5.0	10.3
Aerobic SRT, Days[1]	7.4	2.3	7.5
Effluent TP, mg-P/L	0.8	0.6	0.7
Effluent NH_3, mg-N/L	0.6	0.2	0.5
Effluent TN, mg-N/L	9.0	8.0	9.2
WAS Production, lb-TSS/d	14,262	17,110	10,998
Airflow, scfm	9,013	10,632	8,921

[1]Suspended growth biomass only. Does not include biomass on media carriers in Dry 2.

2.5 Qualitative Comparison

Assessment of qualitative criterion is a critical component in determining the most advantageous solution for the Nelson Complex. Qualitative differences between the alternatives help to inform the development and ranking non-economic weighting criteria utilized to evaluate the alternatives.

2.5.1 Advantages/Disadvantages

Qualitative advantages and disadvantages were discussed in TM #3 – Alternatives Screening. Key differences in advantages and disadvantages between the alternatives are summarized in Table 10.

Table 10: Dry Weather Qualitative Comparison Summary

Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry – CAS with Chem-P
Advantages		
Common to other JCW Facilities	Compact footprint	Doesn't rely on supplemental carbon
Reduced chemical addition	Nitrifiers protected	Reduced complexity
	Reduced chemical addition	
Disadvantages		
Requires supplemental carbon	Highest solids production	Highest chemical Use
Increased PO_4 in sidestream	Highest aeration demand	
Largest footprint	Requires supplemental carbon	
	Increased PO_4 in sidestream	

2.5.2 Non-Economic Criteria/Results

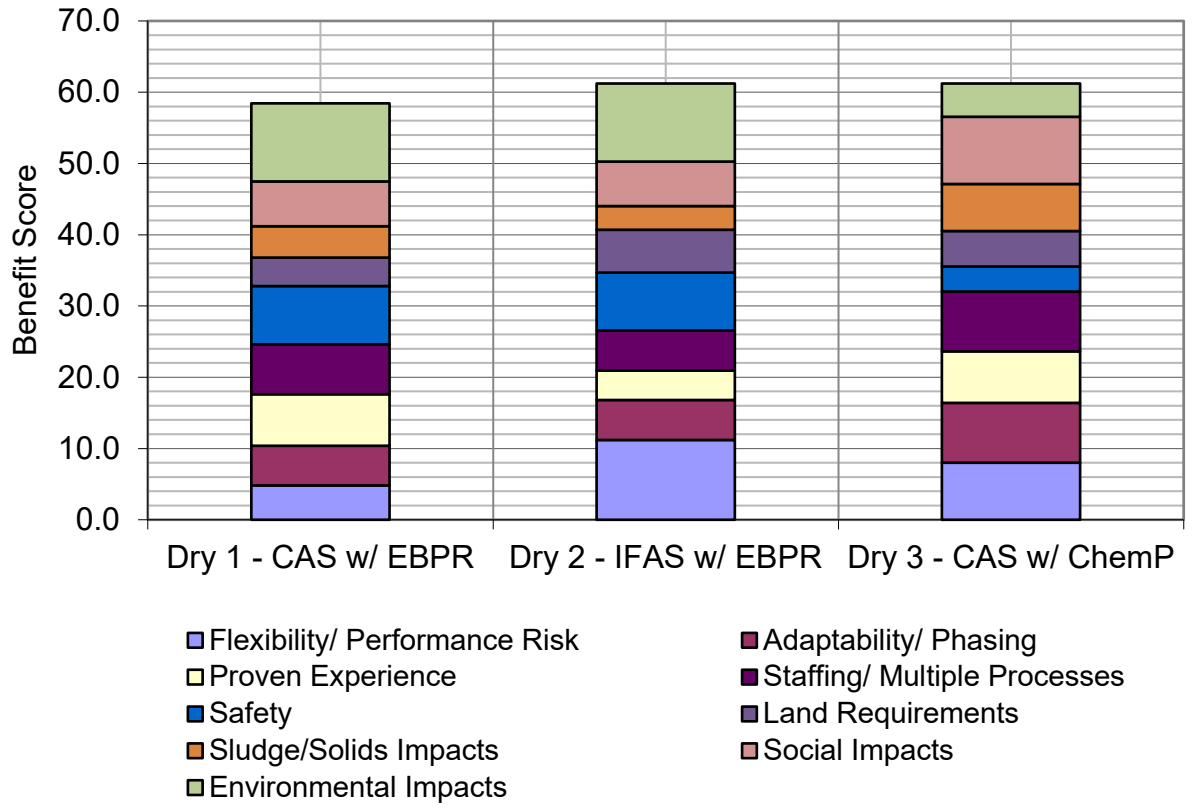
Non-economic screening criteria were developed in the June 27th, 2018 Screening Workshop and documented in TM #3 – Alternatives Screening. An important element of the non-economic criteria evaluation process is a "validation" of the results. The weighting of certain criteria was revisited during the Dry and Wet Weather Alternatives Evaluation Workshop on September 10th, 2018 and rankings for land requirements, sludge impacts, and social impacts were revised to account for results from the alternatives evaluation. Additionally, an Environmental Impacts criterion was added to allow for a triple bottom line analyses to be completed for the three alternatives. For the focus of this Facilities Plan, the Environmental Impacts criterion was agreed to be described as: "How well does the alternative minimize environmental impacts in terms of carbon footprint, ecosystem quality, and resource use?" In keeping with the philosophy of the triple bottom line analysis comparing economic, social, and environmental impacts, the weighted score of the added Environmental Impacts was assumed to be equal to the Social Impacts criterion as presented in Table 11 below, which is a modified version of TM #3 Table 4: Dry Weather Qualitative Screening Criteria Relative Weights.

Table 11: Modified Dry Weather Qualitative Screening Relative Weights

Criterion	Total Score	Weightings Percentage	Relative Weights
Flexibility/ Performance Risk	48	13.5%	1.60
Adaptability/ Phasing	42	11.8%	1.40
Proven Experience	31	8.7%	1.03
Staffing/ Multiple Processes	42	11.8%	1.40
Land Requirements	30	8.5%	1.00
Sludge/Solids Impacts	33	9.3%	1.10
Social Impacts	47	13.2%	1.57
Environmental Impacts	47	13.2%	1.57
Safety	35	9.9%	1.17
Totals	**355**	**100%**	

The revised scoring criteria is included in Appendix B and the modified total weighted benefit score is summarized in Figure 1. Dry 2 and 3 provide the greatest total benefit score2 although all three alternatives are within a 10 percent range.

Figure 1: Dry Weather Modified Total Weighted Benefit Score



2.6 Economic Analysis

The CH2M Parametric Cost Estimating System (CPES), supplemented with vendor quotes where appropriate, was used for estimating the capital and life-cycle costs of the alternatives. Opinions of probable cost generated from CPES are considered to be consistent with Class 5 estimates as defined by the Association for Advancement of Cost Engineering. As detailed engineering design has not been completed, the final opinion of probable cost of any project will depend on market conditions, site conditions, final project scope, schedule, and other variable factors. As a result, final project costs will vary from the estimates presented here. CPES has provisions for life-cycle cost assessment which considered chemical costs, process and building energy costs, equipment maintenance and replacement, solids disposal, as well as labor.

2.6.1 Factors/Assumptions

Development of the opinions of cost for the comparative analysis included liquid stream processes and thickening processes. Digestion, dewatering, and sidestream treatment were not included in the comparative cost as they are common to all alternatives and sizing of these facilities would need to include the impacts of external sludges hauled to the facility. Table 12 presents general markups common to the opinion of cost for all alternatives. Unit costs were presented in TM #1 – Basis of Analysis. Table 12 summarizes unit cost inputs into the life-cycle cost model.

Table 12: General Markup Components

Component	Value
Construction Related Markups[1]	
Sitework	9%
SCADA	9%
Yard Electrical	10%
Yard Piping	17%
Contractor Markups[2]	
Overhead and Profit	15%
Mobilization/Bond/Insurance	3%
Contingency[3]	40%
Non-Construction Related[4]	
Engineering	13%
Services During Construction and Startup	10%
JCW Project Administrative Fee	1.5%
Permitting	0.5%

[1]Applied to estimated construction cost.
[2]Applied to construction cost including construction related markups
[3]Applied to total construction estimate including markups
[4]Applied to total construction including markups and contingency

Table 13: Life Cycle Unit Cost Summary

Component	Value
Labor Costs	
Staff Increase	7
Total Staff	27
Dedicated Liquids Staff	20
Labor Cost (including benefits), $/hr	33
Chemical Costs	
40% Ferric Chloride, $/gallon	1.30
Dry Polymer, $/lb	1.50
10-15% Sodium Hypochlorite, $/gallon	0.87
40% Sodium Bisulfite, $/gallon	0.18
Solids	
Landfill (screenings and grit), $/Wet Ton	37
Land Application (Digested Sludge), $/Wet Ton	22
Digested Sludge Ferric, lb Fe/Dry Ton of TS[1]	10

[1]Dry 1 and Dry 2 only.

2.6.2 Opinion of Cost Results

Opinions of cost for each alternative are presented in Table 14, with detailed opinions of cost in Appendix C. Alternative 3 is estimated to be the lowest capital cost alternative while Alternative 2 is estimated to be the highest cost alternative. All alternatives are within 11% of each other, which falls within the accuracy at this level of cost estimating.

Table 14: Dry Weather Alternatives Opinion of Cost

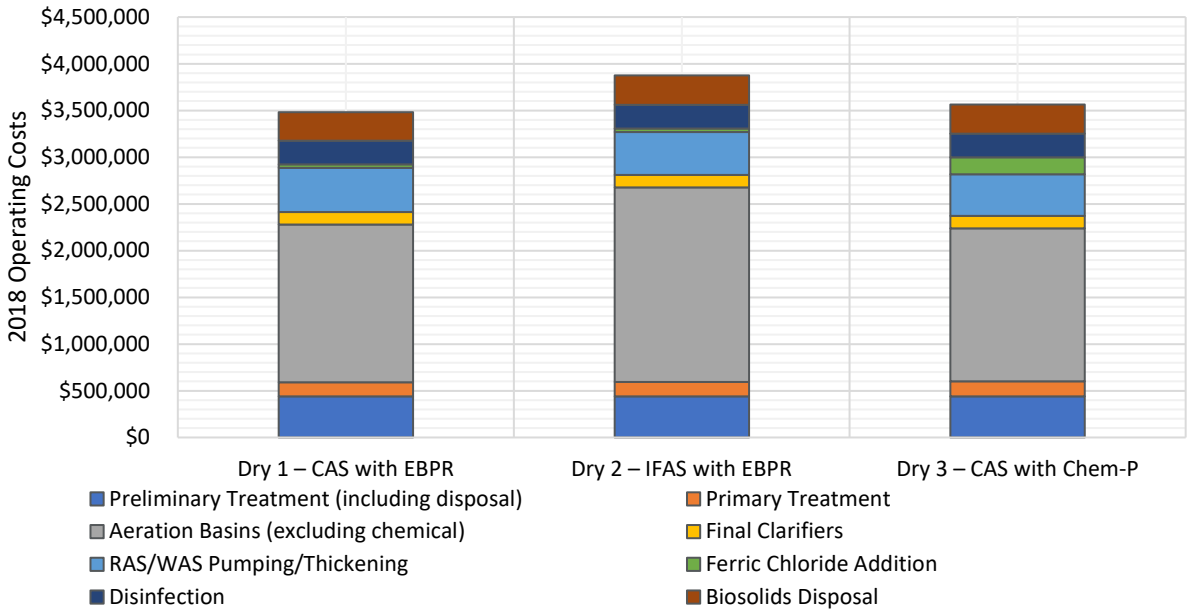
Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
Common to All Processes[1,2]	$39,540,000	$39,540,000	$39,540,000
Unique Processes[1,3]	$46,310,000	$50,910,000	$41,640,000
Total Construction Cost[1]	$85,850,000	$90,450,000	$81,180,000
Contingency (40%)	$34,340,000	$36,180,000	$32,470,000
Non-Construction Costs[4]	$30,050,000	$31,660,000	$28,410,000
Total Capital Cost	**$150,240,000**	**$158,290,000**	**$142,070,000**

[1]Includes Construction related markups
[2]Headworks, Primary Treatment, Secondary Clarifiers, Disinfection (excludes wet weather treatment cost)
[3]Aeration Basins, Blowers, RAS/WAS Pumping, Fermentation (Alt 1 and 2 only), Ferric Chloride Feed
[4]Includes 13% engineering, 10% Construction and Startup, 1.5% PAF, and 0.5% permitting

2.6.3 Life-Cycle Results

Contributions to annual costs are summarized in Figure 2. All alternatives have commonalities related to preliminary and primary treatment and include similar levels of solids handling costs. The primary differences in annual costs are related to the cost of aeration and ferric chloride addition. Alternative Dry 2 is projected to have the highest annual cost due to substantially higher aeration costs and slightly higher biosolids production. Alternative Dry 1 is projected to have the lowest annual costs, albeit just slightly lower than Alternative Dry 3.

Figure 2: Dry Weather Alternatives Year 1 Annual Cost Detail



Life-cycle costs are further summarized in Table 15, which demonstrates the projected 20-year net present value (NPV) for each alternative. Alternatives Dry 1 and Dry 3 are projected to have very similar NPVs, with alternative Dry 3 having lower capital costs. Alternative Dry 2 had the highest annual costs and opinion of capital cost, which results in the highest overall NPV.

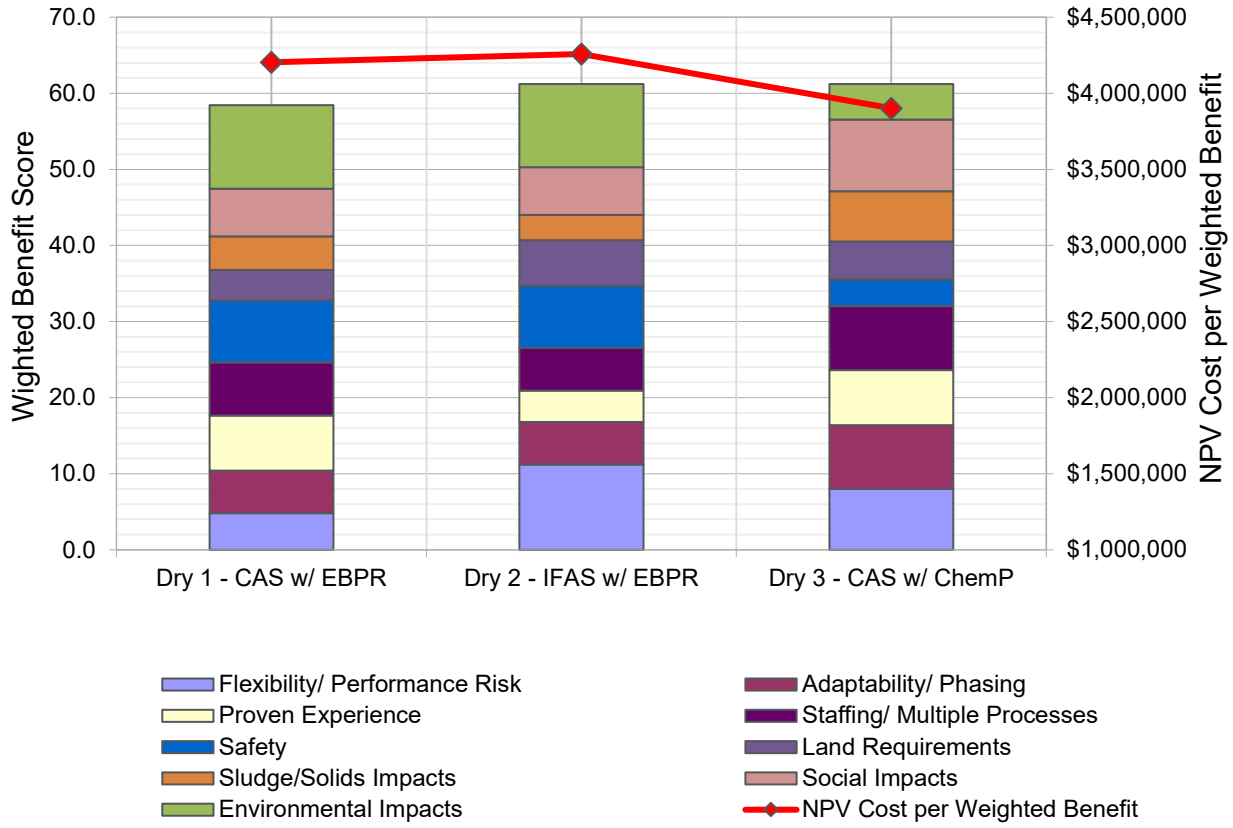
Table 15: Dry Weather Alternatives Life-Cycle Cost Comparison

Component	Dry 1 – CAS with EBPR	Dry 2 – IFAS with EBPR	Dry 3 – CAS with Chem-P
Total Capital Cost	$150,240,000	$158,290,000	$142,060,000
Year 1 O&M	$5,606,000	$6,020,000	$5,692,000
20-year NPV O&M	$89,769,000	$96,428,000	$91,164,000
Total 20-year NPV	**$245,620,000**	**$260,740,000**	**$238,920,000**

2.6.4 Cost-Benefit Analysis

Utilizing the non-economic criteria to weight the cost alternatives allows for the determination of the alternative that provides the best value option for the Nelson Complex. Figure 3 summarizes the projected 20-year net present value cost per weighted benefit score for each alternative. While the evaluation of life-cycle costs produced two alternatives that fell within 10 percent of each other, assessment of the NPV cost per weighted benefit indicates that all three alternatives are within a 10 percent range. Dry 3 provides the lowest cost per benefit score, but all three alternatives can be considered equivalent within the accuracy of analysis methodology.

Figure 3: Dry Weather Alternatives NPV Cost per Weighted Benefit



3. Wet Weather Alternatives

3.1 Background

Wet weather events bring large volumes of dilute influent flow to wastewater treatment facilities. Typically, it is neither cost effective nor feasible to treat all dilute flow through secondary treatment systems. The goals of the wet weather treatment strategies are to protect the secondary treatment systems from overloads and flooding and to provide sufficient treatment such that effluent compliance is maintained.

Current wet weather peak flows to the Nelson Complex are limited to 52 mgd by hydraulic capacity restrictions in the influent pump stations. Determination of future flows that may reach the WWTF is ongoing, but once complete this analysis will provide more clarity on future wet weather flows. At this time, wet weather treatment alternatives will be evaluated based on a peak flow of approximately 140 mgd. It is further assumed that 45 mgd of this total would be routed through dry weather treatment, with the 95 mgd balance receiving wet weather treatment.

3.2 Retained Alternatives

TM #3 – Alternatives Screening identified five wet weather alternatives for consideration at the Nelson Complex. The initial alternatives included:

- Alternative 1: Wet-weather filtration
- Alternative 2: Step-feed and traditional blending
- Alternative 3: Chemically enhanced primary treatment
- Alternative 4: Wet-weather ballasted flocculation
- Alternative 5: Chemically enhanced primary treatment and step-feed BNR

At the June 27th Screening Workshop three alternatives were selected for detailed evaluation. The retained alternatives include:

- Alternative 1 – Wet-weather filtration
- Alternative 3 – Chemically enhanced primary treatment
- Alternative 4 – Wet-weather ballasted flocculation

3.3 Design Criteria/Sizing Results

Auxiliary wet weather treatment systems operate intermittently and have operating and design criteria that are distinctly different from dry weather systems. Design loading conditions and sizing criteria for the retained wet weather alternatives are summarized in the following sections.

3.3.1 Loading Criteria

Design criteria for the auxiliary wet weather treatment systems were developed by analyzing Peak Excess Flow Treatment Facility (PEFTF) discharges between 2014 and 2017. During this period a total of 86 PEFTF discharges occurred in the Turkey Creek system and 109 occurred in the Mission Main system. For each PEFTF discharge event, the theoretical combined influent characteristics to the Nelson Complex were calculated assuming the PEFTF discharge volumes were sent to the Nelson Complex rather than being diverted to the PEFTFs. The combined influent characteristics were calculated by flow weighting the individual influents of the Mission Main Wastewater Treatment Facility (WWTF) and Turkey Creek WWTF utilizing the total flow in each collection system, which includes WWTF influent and PEFTF discharge flows. A supplement TM documenting the determination of wet weather flow characteristics has been included as Appendix D. Table 16 summarizes the resulting wet weather design criteria

Table 16: Peak Flow Design Criteria

Parameter	Moderate Wet Weather	Peak Wet Weather
Peak Flow	75 mgd (30 mgd to Auxillary treatment)	140 mgd (95 mgd to Auxillary treatment)
TSS	110 mg-TSS/L	65 mg-TSS/L
BOD	91 mg-BOD/L	56 mg-BOD/L
TKN	16.9 mg-N/L	12.3 mg-N/L
Ammonia	7.4 mg-N/L	3.8 mg-N/L
Total Phosphorus	1.8 mg-P/L	1.2 mg-P/L
Ortho-phosphate	0.4 mg-P/L	0.3 mg-P/L

3.3.2 Alternative 1 - Wet Weather Cloth Media Filtration

Cloth media filtration design criteria are represented in Table 17. The system was sized assuming the 24-disk AquaPrime® units manufactured by Aqua Aerobic Systems, which is the same system being implemented at the Tomahawk Creek WWTF. System sizing and development of the opinion of cost assumed a similar configuration to Tomahawk Creek WWTP, with filters contained in concrete basins and an above grade building over the pipe galleries operating with a design hydraulic loading rate in auxiliary mode of 5.1 gpm/sqft. At this hydraulic loading rate, five duty filters would be required for the 95 mgd peak wet weather flow. The system does not include chemical feed systems or storage facilities. In total, the cloth filter is anticipated to occupy a site footprint of 90 feet by 50 feet (4,500 square feet).

Table 17: Cloth Media Filtration Design Criteria

Parameter	Cloth Media Filters
Flow, mgd	95
Number of Units	5 duty, 0 Standby[1]
Online Filtration Area, ft^2	12,911
Hydraulic Loading Rate, gpm/ft^2	5.1
[1]The need for a standby unit should be evaluated as part of the pre-design effort	

Operating in auxiliary wet weather mode, the system is projected to remove 85% of influent TSS and produce a backwash volume equivalent to 5% of the forward flow, which will be returned to the Headworks. Dual purpose use of the cloth media filters could be pursued for tertiary phosphorus and TSS removal. Continued use would also likely extend cloth media life.

3.3.3 Alternative 3 - Chemically Enhanced Primary Treatment

Design criteria for the chemically enhanced primary treatment (CEPT) system is listed in Table 18. Dedicated CEPT facilities were included in addition to the dry weather primary clarifiers. Under peak wet weather events, successful implementation of surface overflow rates (SORs) greater than 4,500 gpd/sqft have been reported, however a more typical SOR for a peak flow clarifier of 3,400 gpd/sqft was utilized for planning purposes.

The wet weather CEPT process includes the clarifiers, dedicated metal salt and polymer chemical feed systems, a chemical storage building, chemical mixing and a dedicated sludge pump station to primary sludge thickeners. In addition to the space required for the clarifiers, the chemical storage building is estimated to have a site footprint of 35 feet x 75 feet (2625 square feet) for the chemical storage building.

CEPT is also projected to have a TSS removal of 85% when operating in auxiliary mode. In addition to TSS removal, CEPT will enhance colloidal BOD and phosphorus removal.

Table 18: CEPT Design Criteria

Parameter	Wet Weather Primaries
Flow (mgd)	95
Number of Units/Size	3, 109' dia
Online surface area (sf)	28,000
SOR (gpd/sf)	~3,400
Ferric dose	30-40 mg/L (as 40% FeCl3)
Polymer dose	1.5 mg/L

3.3.4 Alternative 4 - Ballasted Flocculation

Ballasted flocculation was estimated utilizing Veolia's Actiflo® system, which utilizes micro sand as a ballast versus magnetite, which is utilized in Evoqua's CoMag® version of ballasted flocculation. Ballasted flocculation system design criteria are represented in Table 19. The ballasted flocculation system includes uncovered concrete basins, chemical storage and ballast recovery building, and a waste sludge pump station. The site requirements for ballasted flocculation include 80 feet by 80 feet (6400 square feet) for the ballasted flocculation basins and 35 feet by 120 feet (4200 square feet) for chemical storage and ballast recovery.

Similar to CEPT, ballasted flocculation is projected to have a TSS removal of 85% and enhanced BOD and phosphorus removal. Ballasted flocculation can also be utilized for tertiary treatment of phosphorus. However, continued operation of ballasted flocculation will significantly increase operating costs due to high chemical requirements and does not have the positive impact of extended equipment life noted for cloth media filtration.

Table 19: Ballasted Flocculation Design Criteria

Parameter	Actiflo Sizing
Flow (mgd)	95
Number of Units/Size	3
Lamella SOR (gpm/sf)	60
Ferric dose	100 mg/L (range 60-150 as 40% FeCl3)
Polymer dose	1 mg/L (range 0.75 – 1.5 mg/L)
Ballast Addition	28 kg/hr

3.3.5 Disinfection

The disinfection system included in the dry weather alternatives was only intended to handle flows up to 52 mgd. Expansion of the chlorine contact basin was included as a common facility for all wet weather alternatives. The chlorine contact basin followed the same design criteria noted in Section 2.3.3. To maintain the minimum 15-minute HRT at peak hour flow of 140 mgd, a 750,000-gallon expansion of the chlorine contact basin would be needed.

3.4 Qualitative Comparison

Assessment of qualitative criteria is especially important for intermittently operating wet-weather processes because qualitative characteristics can help differentiate systems with increased reliability and operability, which is critical for peak flow management.

3.4.1 Advantages/Disadvantages

Qualitative advantages and disadvantages were discussed in TM #3 – Alternatives Screening. Key differences in advantages and disadvantages among the alternatives are summarized in Table 20.

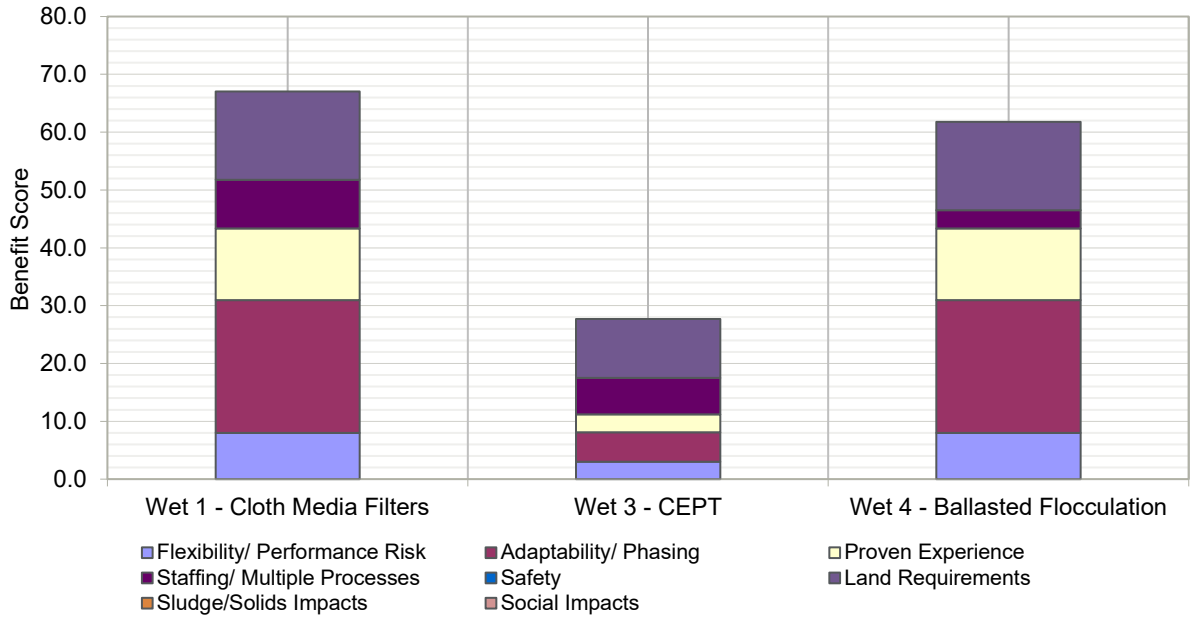
Table 20: Wet Weather Alternatives Qualitative Comparison Summary

Wet 1 – Cloth Disk	Wet 3 - CEPT	Wet 4 – Ballasted Floc
Advantages		
Common to other JCW Facilities	Low Energy	Compact Footprint
No chemical addition	Enhanced PO_4 and BOD removal	Enhanced PO_4 and BOD removal
Can serve as dual purpose for future dry weather tertiary removal of phosphorus	Simple operation	Can serve as dual purpose for future dry weather tertiary removal of phosphorus
Modular implementation		Modular implementation
Compact footprint		
Disadvantages		
Requires Cloth Media Replacement approximately every 10 years.	Largest Footprint	Highest chemical Use
PO_4 removal requires additional chemical	Requires chemical addition	
	No modular implementation	

3.4.2 Non-Economic Criteria/Results

Non-economic screening criteria were developed in the June 27th, 2018 Screening Workshop and documented in TM #3 – Alternatives Screening. The criteria and weighting were revisited during the Dry and Wet Weather Alternatives Evaluation Workshop on September 10th, 2018 and revised to remove the impact of non-applicable criteria, which were artificially increasing the total benefit score. No changes to the weighting of criteria was determined to be necessary. The benefit scoring is included in Appendix B and the total weighted benefit score is summarized in Figure 4.

Figure 4: Wet Weather Alternatives Total Benefit Scores



3.5 Economic Analysis

Opinions of cost for wet weather alternatives were developed utilizing the approach outlined for the dry weather alternatives with the same general markups identified in Table 12 also applied. Comparison of life-cycle costs for wet weather processes that operate intermittently require widespread assumptions surrounding the frequency of use, duration of wet weather events, influent concentrations, and chemical use. The number of assumptions significantly impact the relevance of the analysis. As such, wet weather alternatives are evaluated only on the opinion of installed capital cost.

3.5.1 Opinions of Capital Cost

Opinions of capital cost for the wet weather alternatives are presented in Table 21. Alternatives Wet 1 and Wet 4 have projected capital costs within 10 percent of each other, which is within the estimating error at this level of estimating. Alternative Wet 3 is projected to have the lowest capital cost.

Table 21: Wet Weather Alternatives Opinions of Capital Cost

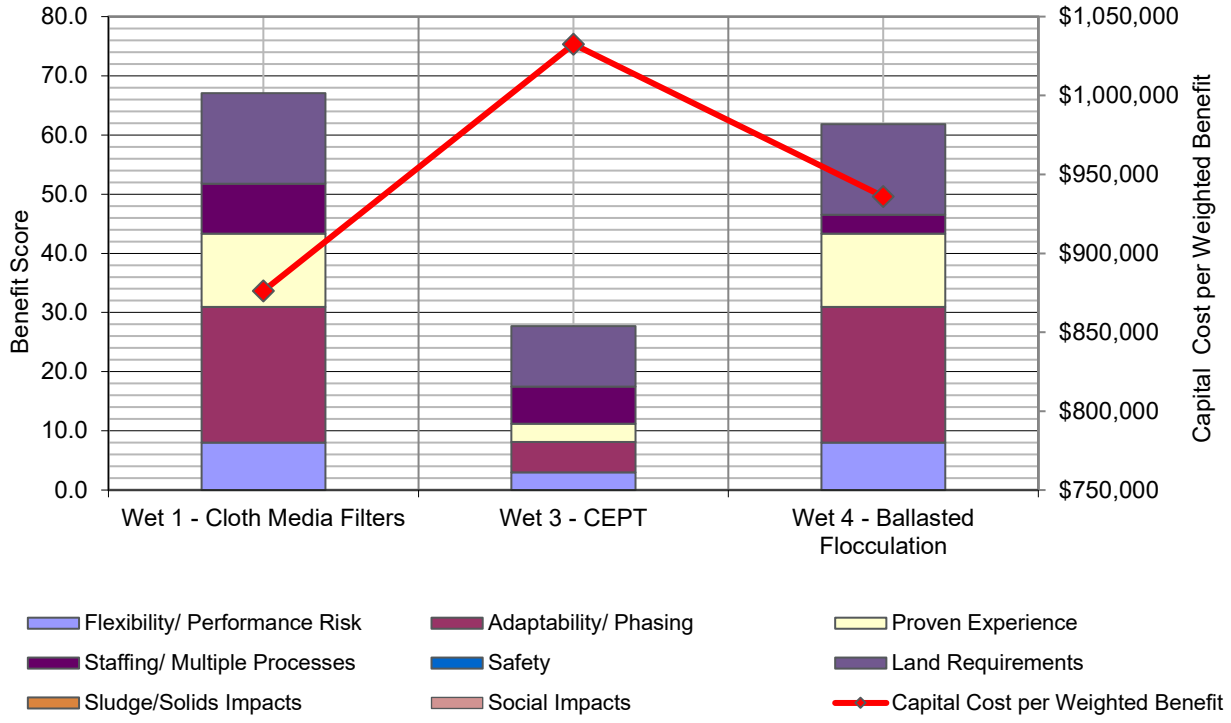
Component	Wet 1 – Cloth Disk	Wet 3 - CEPT	Wet 4 – Ballasted Floc
Wet Weather Treatment[1]	$29,740,000	$12,510,000	$29,230,000
Wet Weather Disinf (CCB)[1]	$3,830,000	$3,830,000	$3,830,000
Subtotal Construction Cost[1]	$33,570,000	$16,340,000	$33,060,000
Contingency	$13,430,000	$6,540,000	$13,220,000
Non-Construction Costs[2]	$11,750,000	$5,720,000	$11,570,000
Total Capital Cost	$58,750,000	$28,600,000	$57,860,000

[1]Includes Construction related markups
[2]Includes 13% engineering, 10% Construction and Startup, 1.5% PAF, and 0.5% permitting

3.5.2 Cost-Benefit Analysis

Wet weather alternatives were evaluated with similar methodology to dry weather alternatives, with the exception that the capital cost was utilized rather than the 20-year NPV. Alternative Wet 3 had the lowest capital cost but provides the highest cost-benefit score. As such, Alternative Wet 3 provides the lowest value score. Alternatives Wet 1 and Wet 4 had similar capital costs, but the cost-benefit score for Alternative Wet 1 is lower by more than 10 percent of Alternative Wet 4 score. As such, Alternative Wet 1 provides the best value for implementation at the Nelson Complex.

Figure 5: Wet Weather Alternatives Cost Weighted Benefit Score



4. Preliminary Site Considerations

As discussed in Section 2 of this TM, retained Alternative 1: 3-Stage CAS with EBPR represents the largest biological treatment footprint of the alternatives evaluated. In the June 27, 2018 TM #3 workshop, preliminary site layouts for each dry weather treatment alternative were presented. For conservatism, the layout presented for Alternative 1 was based on a 5-stage BNR configuration to address future LOT effluent requirements. A refined version of this layout is presented below in Figure 6. Although the layout is conceptual in nature, it demonstrates the feasibility of constructing this alternative on the existing site. Additional site layout alternatives and their associated constructability and impacts to operations will be evaluated further in upcoming TM 6.

Figure 6: Alternative 1, 5 Stage Configuration - Combined PC's, BNR, Separate FC's

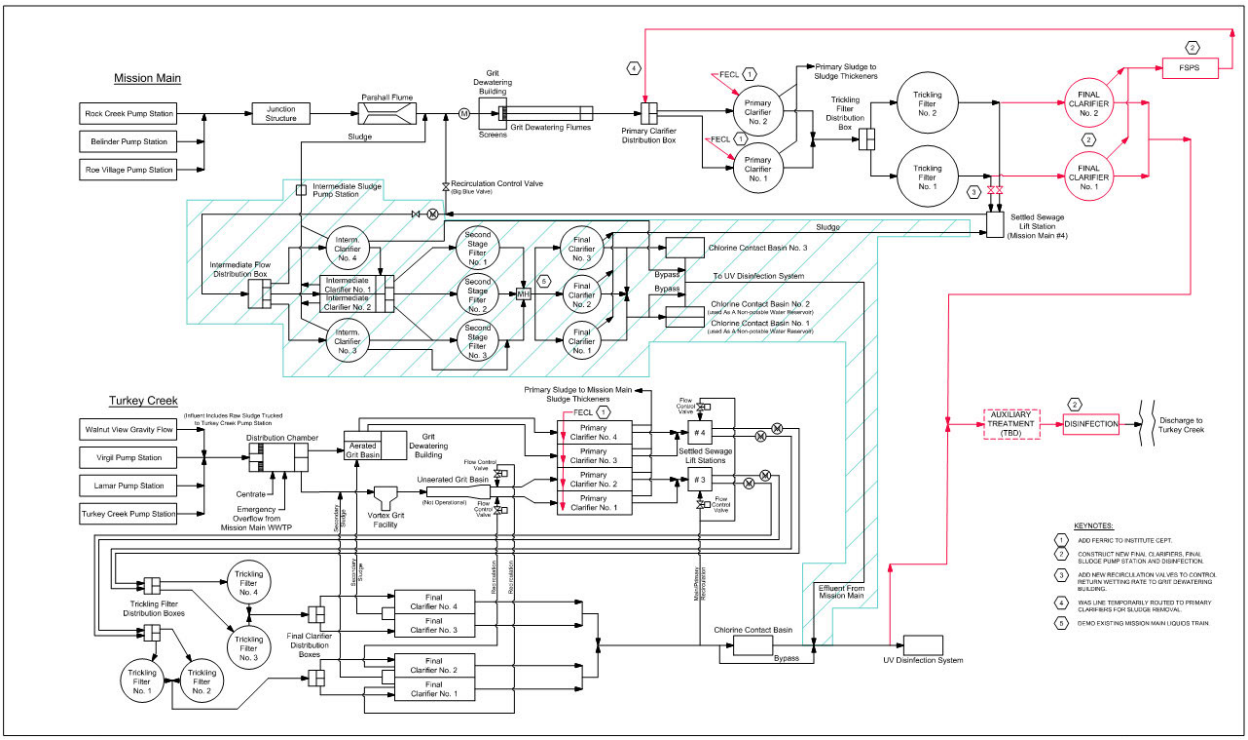
The initial layout consists of constructing a new combined Headworks Building in the northeast quadrant of the Mission Main site. As part of these improvements, the forcemains that convey wastewater from the off-site pumping stations to the Turkey Creek and Mission Main WWTFs will have to be redirected to the new building. Therefore, the location selected for the building will directly impact the required forcemain extension lengths as well as the required increase in pumping head for the Turkey Creek, Belinder and Rock Creek Pump Stations. In addition to the Headworks Building, the Primary Clarifiers and Biological Trains are also shown on the existing upper Mission Main site, while new Secondary Clarifiers and Final Sludge Pump Station would be constructed in the vicinity of the first stage Trickling Filters 1 and 2 on the lower Mission Main site.

The impact of constructability and sequencing is a critical factor with respect to maintaining adequate levels of plant operations when selecting a preferred layout. Below is a preliminary construction phasing scenario associated with this layout as well as a schematic as shown in Figure 7 of a possible interim operations scenario.

- Construct one (1) new Secondary Clarifier and new Final Sludge Pump Station in the vicinity of the Mission Main first stage Trickling Filters 1 and 2

- Construct temporary ferric chloride facilities and institute chemically enhanced primary treatment (CEPT) to improve BOD and TSS removal in the existing Mission Main Primary Clarifiers
- Construct interconnecting piping and valves to allow effluent from the Mission Main first stage Trickling Filters 1 and 2 to be directed to the new Secondary Clarifier
- Modify existing Mission Main Settled Sewage Lift Station 4 to pump only the required “wetting rate” flows for the Mission Main first stage Trickling Filters 1 and 2
- Demolish existing upper Mission Maim WWTF site downstream of Settled Sewage Lift Station 4
- Construct remainder of new liquid train unit processes
- Redirect off-site forcemains to discharge to new liquid train
- Construct additional solids facilities
- Demolish Mission Main Trickling Filters 1 and 2, Primary Clarifiers and Headworks Building
- Demolish Turkey Creek WWTP facilities

Figure 7: Interim Operation of the Mission Main Wastewater Treatment Facility



5. Recommendations

The following recommendations for dry and wet weather treatment processes have been developed based on the analysis of economic and non-economic criteria as well as through workshop activities.

Dry Weather Alternatives:

- Although Alternative Dry 1 – CAS with EBPR did not provide the most favorable cost-benefit score, it is associated with the largest footprint, and median capital cost. In addition, this is a common process to other JCW facilities. To increase implementation flexibility and ensure sufficient space is reserved at the site, this alternative should be carried into subsequent evaluations as the representative process.
- Alternative Dry 3 – CAS with Chem P provides the lowest and most advantageous cost-benefit score, but is within 10% of the other two alternatives. The alternative should be revaluated during preliminary design, as it may prove to be the most beneficial process because of lack of dependence on external or generated carbon for biological phosphorus removal.
- A refinement of the sizing in TM #6 of the representative dry weather alternative will consider
    - Sizing without sidestream treatment
    - Sizing for coldest month
    - Flow and temperature during the wettest 30-day period.

Wet Weather Alternatives:

- Alternative Wet 1 – Cloth Media Filtration provides the lowest cost-benefit score and will serve as the basis for additional analyses in TM #6.
- An initial auxiliary wet weather system with a minimum firm capacity of 7 mgd is recommended to enable treatment of the peak hour flow of 52 mgd.
- Phasing and sizing of additional auxiliary wet weather treatment modules will be dependent on the potential removal of PEFTFs in the collection system up to an estimated maximum of 95 mgd of treatment capacity.

Appendix A: Pro2D^2 Process Model Results

DRY 1 - CAS w/EBPR Average Day

Mass Balance for Average Flow Conditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (RecyI)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Gravity Primary Sludge Thickening Recycle (PSTR)	Main Bioreactor Influent (BI)	Main Bioreactor Other Influent (BOI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)
Flow (gallons/day)	8,000,000	6,999,184	14,999,184	14,999,184	399,794	15,398,975	15,398,975	15,220,099	148,700	15,220,099	148,700	30,588,897	14,996,442	14,996,442	178,876	372,357	178,876	30,176	372,357	24,513	1,000	1,000	1,000	57,689	57,689	57,689	57,689
Carbonaceous BOD_5 (lbs/day)	10,008	8,757	18,765	18,765	423	19,188	19,188	12,232	1,936	12,232	1,936	163,561	719	719	7,027	3,889	7,027	5,058	3,889	3,576	2	2	2	8,640	8,640	1,063	1,063
Particulate	6,227	4,817	11,044	11,044	73	11,118	11,118	4,450	844	4,450	844	6,023	24	24	6,668	143	6,668	4,782	143	132	1	1	1	4,917	4,917	1,027	1,027
Heterotrophs	13	11	24	24	239	262	262	105	6	105	6	122,091	490	490	157	2,904	157	33	2,904	2,672	0	0	0	2,705	2,705	0	0
Methanol Degraders	13	11	24	24	1	24	24	10	1	10	1	301	1	1	14	7	14	3	7	7	0	0	0	10	10	0	0
AOBs	11	10	21	21	52	73	73	29	2	29	2	6,314	25	25	44	150	44	9	150	138	0	0	0	147	147	0	0
NOBs	11	10	21	21	1	22	22	9	0	9	0	0	0	0	13	0	13	3	0	0	0	0	0	3	3	0	0
PAOs	7	6	13	13	49	62	62	24	1	24	1	26,013	104	104	36	619	36	8	619	569	0	0	0	577	577	0	0
PHA	1	1	2	2	5	7	7	3	0	3	0	2,691	11	11	4	64	4	1	64	59	0	0	0	60	60	0	0
Filtrate	3,725	3,892	7,617	7,617	3	7,620	7,620	7,603	1,082	7,603	1,082	128	63	63	89	2	89	220	2	0	1	1	1	221	221	36	36
COD (lbs/day)	25,877	22,327	48,204	48,204	2,654	50,858	50,858	31,695	4,436	31,695	4,436	539,572	6,740	6,740	19,164	12,724	19,164	14,727	12,724	11,609	4	4	4	26,348	26,348	14,972	14,972
Particulate Bio	10,835	8,381	19,216	19,216	100	19,315	19,315	7,730	1,466	7,730	1,466	10,479	42	42	11,585	249	11,585	8,305	249	229	2	2	2	8,541	8,541	1,438	1,438
Particulate Non-Bio	3,038	3,923	6,961	6,961	1,308	8,269	8,269	3,310	744	3,310	744	145,819	586	586	4,960	3,468	4,960	4,216	3,468	3,191	0	0	0	7,408	7,408	12,791	12,791
Decay Prod Aer/Anx	1,309	1,688	2,997	2,997	259	3,256	3,256	1,303	303	1,303	303	121,110	486	486	1,953	2,881	1,953	1,715	2,881	2,650	0	0	0	4,366	4,366	0	0
Decay Prod Anaerobic	0	0	0	0	28	28	28	11	3	11	3	0	0	0	17	0	17	14	0	0	0	0	0	14	14	348	348
Heterotrophs	17	15	31	31	317	348	348	139	8	139	8	161,986	651	651	209	3,853	209	44	3,853	3,545	0	0	0	3,589	3,589	0	0
Methanol Degraders	17	15	31	31	1	32	32	13	1	13	1	399	2	2	19	9	19	4	9	9	0	0	0	13	13	0	0
AOBs	17	15	31	31	76	107	107	43	2	43	2	9,272	37	37	64	221	64	14	221	203	0	0	0	217	217	0	0
NOBs	17	15	31	31	1	32	32	13	1	13	1	0	0	0	19	0	19	4	0	0	0	0	0	4	4	0	0
PAOs	17	15	31	31	143	174	174	70	4	70	4	74,951	301	301	104	1,783	104	22	1,783	1,640	0	0	0	1,662	1,662	0	0
PHA	2	2	4	4	12	15	15	6	0	6	0	6,149	25	25	9	146	9	2	146	135	0	0	0	137	137	0	0
Soluble Bio	1,511	2,869	4,380	4,380	3	4,382	4,382	4,332	42	4,332	42	217	106	106	51	3	51	9	3	0	0	0	0	10	10	5	5
VFA	243	443	686	686	1	687	687	679	1,740	679	1,740	2	1	1	8	0	8	353	0	0	0	0	0	353	353	27	27
Colloidal Bio	4,600	3,450	8,050	8,050	1	8,051	8,051	7,958	64	7,958	64	0	0	0	94	0	94	13	0	0	0	0	0	14	14	28	28
Soluble Non-Bio	3,105	1,116	4,222	4,222	405	4,626	4,626	4,572	45	4,572	45	9,187	4,504	4,504	54	112	54	9	112	7	0	0	0	17	17	333	333
Colloidal Non-Bio	1,150	383	1,533	1,533	0	1,533	1,533	1,516	15	1,516	15	0	0	0	18	0	18	3	0	0	0	0	0	3	3	0	0
TSS (lbs/day)	11,509	11,384	22,893	22,893	1,987	24,880	24,880	9,952	2,000	9,952	2,000	467,457	1,877	1,877	14,928	11,118,286	14,928	11,333	11,118	10,229	2	2	2	21,568	21,568	13,014	13,014
Biodegradable	7,900	6,556	14,456	14,456	75	14,531	14,531	5,816	1,103	5,816	1,103	7,911	32	32	8,715	188	8,715	6,249	188	173	1	1	1	6,426	6,426	1,083	1,083
Non-Biodegradable	2,390	3,070	5,460	5,460	1,019	6,479	6,479	2,593	583	2,593	583	114,242	459	459	3,886	2,717	3,886	3,303	2,717	2,500	0	0	0	5,804	5,804	10,015	10,015
Inorganic Particles	78	335	413	413	136	549	549	214	50	214	50	9,501	38	38	335	226	335	285	226	208	0	0	0	494	494	1,480	1,480
Decay Prod Aer/Anx	1,024	1,321	2,345	2,345	203	2,548	2,548	1,020	237	1,020	237	94,765	381	381	1,528	2,254	1,528	1,342	2,254	2,074	0	0	0	3,416	3,416	0	0
Decay Prod Anaerobic	0	0	0	0	22	22	22	9	2	9	2	0	0	0	13	0	13	11	0	0	0	0	0	11	11	273	273
Metal Hydroxide	46	41	87	87	10	97	97	39	9	39	9	1,714	7	7	58	41	58	50	41	38	0	0	0	87	87	87	87
Metal Absorbed Phosphate	0	0	0	0	10	10	10	4	4	4	4	1,778	7	7	6	42	6	22	42	39	0	0	0	61	61	77	77
Heterotrophs	13	11	24	24	248	272	272	109	6	109	6	126,750	509	509	163	3,015	163	35	3,015	2,774	0	0	0	2,808	2,808	0	0
Methanol Degraders	13	11	24	24	1	25	25	10	1	10	1	312	1	1	15	7	15	3	7	7	0	0	0	10	10	0	0
AOBs	13	11	24	24	59	83	83	33	2	33	2	7,255	29	29	50	173	50	11	173	159	0	0	0	169	169	0	0
NOBs	13	11	24	24	9	34	34	13	1	13	1	0	0	0	20	0	20	4	0	0	0	0	0	4	4	0	0
PAOs	13	11	24	24	112	136	136	54	3	54	3	58,647	236	236	82	1,395	82	17	1,395	1,283	0	0	0	1,301	1,301	0	0
PHA	1	1	2	2	7	9	9	4	0	4	0	3,690	15	15	6	88	6	1	88	81	0	0	0	82	82	0	0
Poly-P	4	3	7	7	78	85	85	34	0	34	0	40,890	164	164	51	973	51	0	973	895	0	0	0	895	895	0	0
VSS (lbs/day)	10,243	9,914	20,157	20,157	1,580	21,738	21,738	8,700	1,745	8,700	1,745	373,018	1,498	1,498	13,038	8,872	13,038	9,891	8,872	8,162	2	2	2	18,058	18,058	10,255	10,255
Biodegradable	7,110	5,900	13,010	13,010	68	13,078	13,078	5,234	993	5,234	993	7,120	29	29	7,844	169	7,844	5,628	169	156	1	1	1	5,787	5,787	974	974
Non-Biodegradable	2,139	2,763	4,902	4,902	922	5,824	5,824	2,331	524	2,331	524	102,818	413	413	3,493	2,445	3,493	2,969	2,445	2,250	0	0	0	5,220	5,220	9,013	9,013
Decay Prod Aer/Anx	922	1,188	2,110	2,110	183	2,293	2,293	918	213	918	213	85,289	343	343	1,375	2,029	1,375	1,208	2,029	1,866	0	0	0	3,074	3,074	0	0
Decay Prod Anaerobic	0	0	0	0	20	20	20	8	2	8	2	0	0	0	12	0	12	10	0	0	0	0	0	10	10	245	245
Metal Hydroxide	12	10	22	22	3	25	25	10	2	10	2	433	2	2	15	10	15	13	10	9	0	0	0	22	22	22	22
Heterotrophs	12	10	22	22	223	245	245	98	6	98	6	114,075	458	458	147	2,713	147	31	2,713	2,496	0	0	0	2,527	2,527	0	0
Methanol Degraders	12	10	22	22	1	23	23	9	1	9	1	281	1	1	14	7	14	3	7	6	0	0	0	9	9	0	0
AOBs	12	10	22	22	53	75	75	30	2	30	2	6,530	26	26	45	155	45	10	155	143	0	0	0	153	153	0	0
NOBs	12	10	22	22	1	23	23	9	1	9	1	0	0	0	14	0	14	3	0	0	0	0	0	3	3	0	0
PAOs	12	10	22	22	100	122	122	49	3	49	3	52,782	212	212	73	1,255	73	16	1,255	1,155	0	0	0	1,171	1,171	0	0
PHA	1	1	2	2	7	9	9	4	0	4	0	3,690	15	15	6	88	6	1	88	81	0	0	0	82	82	0	0
TKN (lbs/day)	1,751	1,751	3,502	3,502	206	3,708	3,708	3,155	137	3,155	137	26,804	442	442	554	630	554	416	630	572	0	0	0	989	989	989	989
NH_3-N (lbs-N/day)	1,201	934	2,135	2,135	91	2,226	2,226	2,200	61	2,200	61	87	42	42	26	1	26	12	1	0	0	0	0	13	13	496	496
Particulate Bio Org N	143	274	417	417	5	422	422	169	33	169	33	225	1	1	253	5	253	188	5	5	0	0	0	193	193	79	79
Non-Bio Part Org N	40	128	168	168	37	205	205	82	18	82	18	3,621	15	15	123	86	123	105	86	79	0	0	0	184	184	374	374
Decay Prod Aer/Anx	79	102	181	181	16	197	197	79	18	79	18	7,335	29	29	118	174	118	104	174	161	0	0	0	264	264	0	0
Decay Prod Anaerobic	0	0	0	0	2	2	2	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	21	21
Heterotrophs	1	1	2	2	19	21	21	8	0	8	0	9,810	39	39	13	233	13	3	233	215	0	0	0	217	217	0	0
Methanol Degraders	1	1	2	2	0	2	2	1	0	1	0	24	0	0	1	1	1	0	1	1	0	0	0	1	1	0	0
AOBs	1	1	2	2	5	6	6	3	0	3	0	562	2	2	4	13	4	1	13	12	0	0	0	13	13	0	0
NOBs	1	1	2	2	0	2	2	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
PAOs	1	1	2	2	9	11	11	4	0	4	0	4,539	18	18	6	108	6	1	108	99	0	0	0	101	101	0	0
Non-Bio Soluble Org. N	186	89	276	276	24	300	300	296	3	296	3	595	292	292	3	7	3	1	7	0	0	0	0	1	1	19	19
Non-Bio Colloidal Org. N	15	13	28	28	0	28	28	27	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	20	94	114	114	0	114	114	112	1	112	1	6	3	3	1	0	1	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	61	113	174	174	0	174	174	172	1	172	1	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	61	61	61	61	1	61	1	1,302	638	638	1	16	1	0	16	1	0	0	0	1	1	0	0
Total Nitrogen (lbs-N/day)	1,751	1,751	3,502	3,502	268	3,770	3,770	3,215	138	3,215	138	28,106	1,080	1,080	554	645	554	416	645	573	0	0	0	990	990	989	989
TP (lbs-P/day)	195	198	393	393	363	756	756	570	47	570	47	21,830	96	96	186	519	186	139	519	477	0	0	0	616	616	616	616
Bio Particulate	68	56	124	124	1	125	125	50	10	50	10	34	0	0	75	1	75	56	1	1	0	0	0	57	57	26	26
Non-Bio Particulate	20	26	47	47	21	67	67	27	6	27	6	1,185	5	5	40	28	40	34	28	26	0	0	0	60	60	228	228
Decay Prod Aer/Anx	26	34	60	60	5	65	65	26	6	26	6	2,422	10	10	39	58	39	34	58	53	0	0	0	87	87	0	0
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
Metal Absorbed	0	0	0	0	3	3	3	1	1	1	1	580	2	2	2	14	2	7	14	13	0	0	0	20	20	25	25
Heterotrophs	0	0	1	1	6	7	7	3	0	3	0	3,240	13	13	4	77	4	1	77	71	0	0	0	72	72	0	0
Methanol Degraders	0	0	1	1	0	1	1	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOBs	0	0	1	1	2	2	2	1	0	1	0	185	1	1	1	4	1	0	4	4	0	0	0	4	4	0	0
NOBs	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	0	0	1	1	3	3	3	1	0	1	0	1,499	6	6	2	36	2	0	36	33	0	0	0	33	33	0	0
Poly-P	1	1	2	2	24	26	26	11	0	11	0	12,660	51	51	16	301	16	0	301	277	0	0	0	277	277	0	0
Ortho-PO4	78	79	158	158	297	455	455	449	24	449	24	17	8	8	5	0	5	5	0	0	0	0	0	5	5	330	330
Alkalinity (lbs/day as $CaCO_3$)	14,687	12,851	27,539	27,539	1,844	29,382	29,382	29,041	284	29,041	284	43,273	21,215	21,215	341	527	341	58	527	35	2	2	2	99	99	2,658	2,658
H_2S (lbs/day)	401	350	751	751	0	751	751	742	7	742	7	0	0	0	9	0	9	1	0	0	0	0	0	2	2	24	24
Temperature (°C)	18	17	18	18	20	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	20	20	20	18	18	35	35
BOD_5 (mg/L)	150	150	150	150	127	149	149	96	1,560	96	1,560	641	6	5.75	4,707	1,251	4,707	20,086	1,251	17,482	220	220	220	17,947	17,947	2,207	2,207
COD (mg/L)	388	382	385	385	796	396	396	250	3,575	250	3,575	2,114	54	53.86	12,837	4,095	12,837	58,480	4,095	56,744	501	501	501	54,728	54,728	31,098	31,098
TSS (mg/L)	172	195	183	183	596	194	194	78	1,612	78	1,612	1,831	15	15.00	10,000	3,578	10,000	45,000	3,578	50,000	250	250	250	44,798	44,798	27,032	27,032
VSS (mg/L)	153	170	161	161	474	169	169	68	1,406	68	1,406	1,461	12	11.97	8,734	2,855	8,734	39,274	2,855	39,899	200	200	200	37,508	37,508	21,301	21,301
TKN (mg-N/L)	26	30	28	28	62	29	29	25	111	25	111	105	4	3.53	371	203	371	1,653	203	2,796	39	39	39	2,055	2,055	2,055	2,055
NH_3-N (mg-N/L)	18	16	17	17	27	17	17	17	49	17	49	0	0	0.34	17	0	17	49	0	0	30	30	30	27	27	1,031	1,031
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	0	0	0	18	0	0	0	0	0	0	5	5	5.10	0	5	0	0	5	5	0	0	0	2	2	0	0
Total Nitrogen (mg/L)	26	30	28	28	80	29	29	25	111	25	111	110	9	8.63	371	208	371	1,653	208	2,801	39	39	39	2,057	2,057	2,055	2,055
TP (mg-P/L)	3	3	3	3	109	6	6	4	38	4	38	86	1	0.77	125	167	125	551	167	2,333	8	8	8	1,280	1,280	1,280	1,280
Alkalinity (mg/L as $CaCO_3$)	220	220	220	220	553	229	229	229	229	229	229	170	170	169.51	229	170	229	229	170	170	250	250	250	205	205	5,520	5,520
H_2S (mg/L)	6	6	6	6	0	6	6	6	6	6	6	0	0	0.00	6	0	6	6	0	0	6	6	6	3	3	50	50

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DRY 1 - CAS w/EBPR Average Day

Mass Balance for Average Flow Condition

Constituent	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)	Biosolids to Disposal	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	5,739	23,676	5,739	347,844	51,950	51,950	28,274	51,950	399,794
Carbonaceous BOD_5 (lbs/day)	948	99	948	312	114	114	11	110	423
Particulate	945	56	945	11	82	82	6	62	73
Heterotrophs	0	6	0	232	0	0	1	6	239
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	36	0	12	0	0	4	40	52
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	49	0	0	0	0	49
PHA	0	0	0	5	0	0	0	0	5
Filtrate	4	1	4	1	32	32	1	2	3
COD (lbs/day)	13,451	1,256	13,451	1,116	1,521	1,521	283	1,539	2,654
Particulate Bio	1,323	72	1,323	20	115	115	7	80	100
Particulate Non-Bio	11,768	934	11,768	277	1,023	1,023	97	1,031	1,308
Decay Prod Aer/Anx	0	25	0	230	0	0	4	29	259
Decay Prod Anaerobic	320	25	320	0	28	28	3	28	28
Heterotrophs	0	8	0	308	0	0	1	9	317
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	53	0	18	0	0	5	58	76
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	143	0	0	0	0	143
PHA	0	0	0	12	0	0	0	0	12
Soluble Bio	1	0	1	2	5	5	0	0	3
VFA	3	1	3	0	25	25	1	1	1
Colloidal Bio	3	1	3	0	25	25	1	1	1
Soluble Non-Bio	33	137	33	104	300	300	163	300	405
Colloidal Non-Bio	0	0	0	0	0	0	0	0	0
TSS (lbs/day)	11,973	988	11,973	889	1,041	1,041	110	1,098	1,987
Biodegradable	996	55	996	15	87	87	5	60	75
Non-Biodegradable	9,214	731	9,214	217	801	801	70	801	1,019
Inorganic Particles	1,361	101	1,361	18	118	118	17	118	136
Decay Prod Aer/Anx	0	21	0	180	0	0	2	23	203
Decay Prod Anaerobic	251	20	251	0	22	22	2	22	22
Metal Hydroxide	80	6	80	3	7	7	1	7	10
Metal Absorbed Phosphate	71	6	71	3	6	6	1	6	10
Heterotrophs	0	6	0	241	0	0	1	7	248
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	41	0	14	0	0	4	45	59
NOBs	0	1	0	0	0	0	8	9	9
PAOs	0	0	0	112	0	0	0	0	112
PHA	0	0	0	7	0	0	0	0	7
Poly-P	0	0	0	78	0	0	0	0	78
VSS (lbs/day)	9,435	788	9,435	710	820	820	83	870	1,580
Biodegradable	896	49	896	14	78	78	5	54	68
Non-Biodegradable	8,292	658	8,292	196	721	721	68	726	922
Decay Prod Aer/Anx	0	17	0	162	0	0	3	20	183
Decay Prod Anaerobic	226	18	226	0	20	20	2	20	20
Metal Hydroxide	20	2	20	1	2	2	0	2	3
Heterotrophs	0	5	0	217	0	0	1	6	223
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	37	0	12	0	0	4	41	53
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	100	0	0	0	0	100
PHA	0	0	0	7	0	0	0	0	7
TKN (lbs/day)	487	86	487	58	502	502	62	149	206
NH_3-N (lbs-N/day)	49	41	49	1	447	447	49	90	91
Particulate Bio Org N	73	4	73	0	6	6	0	4	5
Non-Bio Part Org N	344	27	344	7	30	30	3	30	37
Decay Prod Aer/Anx	0	2	0	14	0	0	0	2	16
Decay Prod Anaerobic	19	2	19	0	2	2	0	2	2
Heterotrophs	0	0	0	19	0	0	0	1	19
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	3	0	1	0	0	0	4	5
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	9	0	0	0	0	9
Non-Bio Soluble Org. N	2	8	2	7	17	17	9	17	24
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	21	0	15	0	0	25	46	61
Total Nitrogen (lbs-N/day)	487	108	487	72	502	502	88	195	268
TP (lbs-P/day)	296	157	296	42	320	320	164	321	363
Bio Particulate	24	1	24	0	2	2	0	1	1
Non-Bio Particulate	210	16	210	2	18	18	2	18	21
Decay Prod Aer/Anx	0	1	0	5	0	0	0	1	5
Decay Prod Anaerobic	6	1	6	0	1	1	0	1	1
Metal Absorbed	23	2	23	1	2	2	0	2	3
Heterotrophs	0	0	0	6	0	0	0	0	6
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	1	0	0	0	0	0	1	2
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	3	0	0	0	0	3
Poly-P	0	0	0	24	0	0	0	0	24
Ortho-PO4	33	135	33	0	297	297	162	297	297
Alkalinity (lbs/day as $CaCO_3$)	264	616	264	492	2,393	2,393	736	1,352	1,844
H_2S (lbs/day)	2	0	2	0	22	22	0	0	0
Temperature (°C)	35	35	35	18	35	35	35	35	20
BOD_5 (mg/L)	19,799	503	19,799	108	264	264	47	255	127
COD (mg/L)	280,852	6,356	280,852	384	3,509	3,509	1,198	3,549	796
TSS (mg/L)	250,000	5,000	250,000	306	2,401	2,401	465	2,532	596
VSS (mg/L)	196,997	3,986	196,997	245	1,892	1,892	351	2,008	474
TKN (mg-N/L)	10,173	438	10,173	20	1,158	1,158	264	343	62
NH_3-N (mg-N/L)	1,031	207	1,031	0	1,031	1,031	207	207	27
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	107	0	5	0	0	107	107	18
Total Nitrogen (mg/L)	10,173	545	10,173	25	1,158	1,158	372	451	80
TP (mg-P/L)	6,188	796	6,188	14	738	738	695	741	109
Alkalinity (mg/L as $CaCO_3$)	5,520	3,118	5,520	170	5,520	5,520	3,118	3,118	553
H_2S (mg/L)	50	0	50	0	50	50	0	0	0

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DRY 1 - CAS w/EBPR Max Month

PS Ratio, TS

Mass Balance for Max MonthConditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (Recyl)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Gravity Primary Sludge Thickening Recycle (PSTR)	Main Bioreactor Influent (BI)	Main Bioreactor Other Influent (BOI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)
Flow (gallons/day)	10,000,000	8,998,951	18,998,951	18,998,951	324,379	19,323,334	19,323,334	19,090,894	193,231	19,090,894	193,231	38,375,020	18,994,407	18,994,407	232,439	289,718	232,439	39,208	289,718	31,446	1,000	1,000	1,000	73,653	73,653	73,653	73,653
Carbonaceous BOD_5 (lbs/day)	13,010	11,384	24,394	24,394	526	24,920	24,920	15,888	2,518	15,888	2,518	319,808	880	880	9,124	4,768	9,124	6,569	4,768	4,385	2	2	2	10,959	10,959	1,531	1,531
Particulate	8,098	6,262	14,360	14,360	97	14,457	14,457	5,786	1,096	5,786	1,096	12,887	32	32	8,671	192	8,671	6,212	192	177	1	1	1	6,393	6,393	1,478	1,478
Heterotrophs	16	14	30	30	291	321	321	128	7	128	7	235,834	586	586	192	3,517	192	41	3,517	3,235	0	0	0	3,276	3,276	0	0
Methanol Degraders	16	14	30	30	1	31	31	12	1	12	1	588	1	1	18	9	18	4	9	8	0	0	0	12	12	0	0
AOBs	14	13	27	27	63	90	90	36	2	36	2	11,974	30	30	54	179	54	11	179	164	0	0	0	176	176	0	0
NOBs	14	13	27	27	1	28	28	11	1	11	1	0	0	0	17	0	17	4	0	0	0	0	0	4	4	0	0
PAOs	8	8	16	16	63	79	79	31	2	31	2	53,058	132	132	46	791	46	10	791	728	0	0	0	738	738	0	0
PHA	1	1	2	2	6	8	8	3	0	3	0	5,293	13	13	5	79	5	1	79	73	0	0	0	74	74	0	0
Filtrate	4,843	5,059	9,902	9,902	4	9,906	9,906	9,879	1,409	9,879	1,409	173	86	86	120	1	120	286	1	0	1	1	1	288	288	54	54
COD (lbs/day)	33,640	29,026	62,665	62,665	3,338	66,003	66,003	41,097	5,771	41,097	5,771	1,090,055	8,656	8,656	24,907	16,166	24,907	19,136	16,166	14,798	4	4	4	33,947	33,947	19,689	19,689
Particulate Bio	14,089	10,896	24,985	24,985	130	25,115	25,115	10,052	1,904	10,052	1,904	22,420	56	56	15,063	334	15,063	10,789	334	308	2	2	2	11,103	11,103	2,101	2,101
Particulate Non-Bio	3,950	5,100	9,050	9,050	1,701	10,751	10,751	4,303	967	4,303	967	302,970	753	753	6,448	4,518	6,448	5,481	4,518	4,156	0	0	0	9,639	9,639	16,626	16,626
Decay Prod Aer/Anx	1,702	2,194	3,896	3,896	346	4,241	4,241	1,697	394	1,697	394	256,544	638	638	2,544	3,826	2,544	2,230	3,826	3,519	0	0	0	5,750	5,750	0	0
Decay Prod Anaerobic	0	0	0	0	38	38	38	15	3	15	3	1	0	0	23	0	23	19	0	0	0	0	0	19	19	470	470
Heterotrophs	21	19	40	40	386	425	425	170	10	170	10	312,711	777	777	255	4,663	255	54	4,663	4,290	0	0	0	4,344	4,344	0	0
Methanol Degraders	21	19	40	40	1	41	41	16	1	16	1	780	2	2	24	12	24	5	12	11	0	0	0	16	16	0	0
AOBs	21	19	40	40	93	132	132	53	3	53	3	17,584	44	44	79	262	79	17	262	241	0	0	0	258	258	0	0
NOBs	21	19	40	40	1	41	41	16	1	16	1	0	0	0	25	0	25	5	0	0	0	0	0	5	5	0	0
PAOs	21	19	40	40	182	222	222	89	5	89	5	152,878	380	380	133	2,280	133	28	2,280	2,097	0	0	0	2,126	2,126	0	0
PHA	2	2	5	5	14	19	19	8	0	8	0	12,094	30	30	11	180	11	2	180	166	0	0	0	168	168	0	0
Soluble Bio	1,964	3,729	5,694	5,694	2	5,696	5,696	5,628	57	5,628	57	293	145	145	69	2	69	12	2	0	0	0	0	13	13	8	8
VFA	316	576	891	891	2	893	893	883	2,261	883	2,261	2	1	1	11	0	11	459	0	0	0	0	0	459	459	41	41
Colloidal Bio	5,980	4,485	10,465	10,465	2	10,467	10,467	10,341	86	10,341	86	0	0	0	126	0	126	18	0	0	0	0	0	19	19	43	43
Soluble Non-Bio	4,037	1,451	5,488	5,488	439	5,927	5,927	5,856	59	5,856	59	11,777	5,829	5,829	71	89	71	12	89	10	0	0	0	22	22	401	401
Colloidal Non-Bio	1,495	498	1,993	1,993	0	1,993	1,993	1,969	20	1,969	20	0	0	0	24	0	24	4	0	0	0	0	0	4	4	0	0
TSS (lbs/day)	14,962	14,799	29,761	29,761	2,569	32,330	32,330	12,932	2,598	12,932	2,598	956,461	2,378	2,378	19,398	14,262,453	19,398	14,724	14,262	13,121	2	2	2	27,852	27,852	17,115	17,115
Biodegradable	10,274	8,523	18,797	18,797	98	18,895	18,895	7,562	1,433	7,562	1,433	16,928	42	42	11,333	252	11,333	8,118	252	232	1	1	1	8,354	8,354	1,582	1,582
Non-Biodegradable	3,107	3,991	7,098	7,098	1,324	8,423	8,423	3,371	758	3,371	758	237,354	590	590	5,052	3,539	5,052	4,294	3,539	3,256	0	0	0	7,551	7,551	13,017	13,017
Inorganic Particles	103	437	540	540	179	719	719	280	66	280	66	19,949	50	50	439	297	439	373	297	274	0	0	0	648	648	1,940	1,940
Decay Prod Aer/Anx	1,332	1,717	3,048	3,048	270	3,319	3,319	1,328	308	1,328	308	200,738	499	499	1,990	2,993	1,990	1,745	2,993	2,754	0	0	0	4,499	4,499	0	0
Decay Prod Anaerobic	0	0	0	0	29	29	29	12	3	12	3	1	0	0	18	0	18	15	0	0	0	0	0	15	15	368	368
Metal Hydroxide	58	52	110	110	13	123	123	49	11	49	11	3,467	9	9	74	52	74	63	52	48	0	0	0	110	110	110	110
Metal Absorbed Phosphate	0	0	0	0	12	12	12	5	5	5	5	3,628	9	9	7	54	7	28	54	50	0	0	0	78	78	98	98
Heterotrophs	16	15	31	31	302	333	333	133	7	133	7	244,688	608	608	200	3,649	200	42	3,649	3,357	0	0	0	3,399	3,399	0	0
Methanol Degraders	16	15	31	31	1	32	32	13	1	13	1	610	2	2	19	9	19	4	9	8	0	0	0	12	12	0	0
AOBs	16	15	31	31	72	103	103	41	2	41	2	13,759	34	34	62	205	62	13	205	189	0	0	0	202	202	0	0
NOBs	16	15	31	31	11	42	42	17	1	17	1	0	0	0	25	0	25	5	0	0	0	0	0	5	5	0	0
PAOs	16	15	31	31	143	174	174	70	4	70	4	119,623	297	297	104	1,784	104	22	1,784	1,641	0	0	0	1,663	1,663	0	0
PHA	1	1	3	3	9	11	11	5	0	5	0	7,256	18	18	7	108	7	1	108	100	0	0	0	101	101	0	0
Poly-P	5	4	9	9	106	115	115	46	0	46	0	88,460	220	220	69	1,319	69	0	1,319	1,214	0	0	0	1,214	1,214	0	0
VSS (lbs/day)	13,316	12,888	26,205	26,205	2,037	28,241	28,241	11,303	2,268	11,303	2,268	758,464	1,886	1,886	16,938	11,310	16,938	12,850	11,310	10,405	2	2	2	23,260	23,260	13,498	13,498
Biodegradable	9,246	7,671	16,917	16,917	89	17,006	17,006	6,806	1,290	6,806	1,290	15,235	38	38	10,200	227	10,200	7,311	227	209	1	1	1	7,523	7,523	1,424	1,424
Non-Biodegradable	2,782	3,592	6,374	6,374	1,199	7,572	7,572	3,031	681	3,031	681	213,618	531	531	4,542	3,185	4,542	3,860	3,185	2,931	0	0	0	6,792	6,792	11,715	11,715
Decay Prod Aer/Anx	1,198	1,545	2,743	2,743	243	2,987	2,987	1,195	277	1,195	277	180,665	449	449	1,791	2,694	1,791	1,571	2,694	2,479	0	0	0	4,050	4,050	0	0
Decay Prod Anaerobic	0	0	0	0	27	27	27	11	2	11	2	1	0	0	16	0	16	14	0	0	0	0	0	14	14	331	331
Metal Hydroxide	15	13	28	28	3	31	31	12	3	12	3	877	2	2	19	13	19	16	13	12	0	0	0	28	28	28	28
Heterotrophs	15	13	28	28	272	299	299	120	7	120	7	220,219	547	547	180	3,284	180	38	3,284	3,021	0	0	0	3,059	3,059	0	0
Methanol Degraders	15	13	28	28	1	29	29	11	1	11	1	549	1	1	17	8	17	4	8	8	0	0	0	11	11	0	0
AOBs	15	13	28	28	65	93	93	37	2	37	2	12,383	31	31	56	185	56	12	185	170	0	0	0	182	182	0	0
NOBs	15	13	28	28	1	29	29	12	1	12	1	0	0	0	17	0	17	4	0	0	0	0	0	4	4	0	0
PAOs	15	13	28	28	128	156	156	63	4	63	4	107,660	268	268	94	1,605	94	20	1,605	1,477	0	0	0	1,497	1,497	0	0
PHA	1	1	3	3	9	11	11	5	0	5	0	7,256	18	18	7	108	7	1	108	100	0	0	0	101	101	0	0
TKN (lbs/day)	2,277	2,244	4,521	4,521	254	4,775	4,775	4,068	177	4,068	177	53,581	603	603	707	792	707	531	792	723	0	0	0	1,254	1,254	1,254	1,254
NH_3-N (lbs-N/day)	1,561	1,214	2,775	2,775	112	2,887	2,887	2,852	79	2,852	79	183	91	91	35	1	35	16	1	0	0	0	0	17	17	614	614
Particulate Bio Org N	187	342	529	529	6	535	535	214	42	214	42	470	1	1	321	7	321	238	7	6	0	0	0	245	245	114	114
Non-Bio Part Org N	52	160	212	212	47	259	259	104	23	104	23	7,310	18	18	156	109	156	132	109	100	0	0	0	233	233	475	475
Decay Prod Aer/Anx	103	133	236	236	21	257	257	103	24	103	24	15,537	39	39	154	232	154	135	232	213	0	0	0	348	348	0	0
Decay Prod Anaerobic	0	0	0	0	2	2	2	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	28	28
Heterotrophs	1	1	2	2	23	26	26	10	1	10	1	18,939	47	47	15	282	15	3	282	260	0	0	0	263	263	0	0
Methanol Degraders	1	1	2	2	0	2	2	1	0	1	0	47	0	0	1	1	1	0	1	1	0	0	0	1	1	0	0
AOBs	1	1	2	2	6	8	8	3	0	3	0	1,065	3	3	5	16	5	1	16	15	0	0	0	16	16	0	0
NOBs	1	1	2	2	0	2	2	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
PAOs	1	1	2	2	11	13	13	5	0	5	0	9,259	23	23	8	138	8	2	138	127	0	0	0	129	129	0	0
Non-Bio Soluble Org. N	242	116	358	358	26	384	384	379	4	379	4	763	378	378	5	6	5	1	6	1	0	0	0	1	1	23	23
Non-Bio Colloidal Org. N	20	16	35	35	0	35	35	35	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	26	117	143	143	0	143	143	141	1	141	1	7	4	4	2	0	2	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	79	141	220	220	0	220	220	217	2	217	2	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	69	69	69	68	1	68	1	1,667	825	825	1	13	1	0	13	1	0	0	0	2	2	0	0
Total Nitrogen (lbs-N/day)	2,277	2,244	4,521	4,521	323	4,844	4,844	4,136	177	4,136	177	55,249	1,428	1,428	708	805	708	531	805	724	0	0	0	1,256	1,256	1,254	1,254
TP (lbs-P/day)	254	258	512	512	475	988	988	745	62	745	62	45,945	127	127	243	685	243	180	685	630	0	0	0	810	810	810	810
Bio Particulate	88	73	161	161	2	163	163	65	13	65	13	72	0	0	97	1	97	73	1	1	0	0	0	74	74	37	37
Non-Bio Particulate	26	34	61	61	27	88	88	35	8	35	8	2,467	6	6	53	37	53	45	37	34	0	0	0	78	78	298	298
Decay Prod Aer/Anx	34	44	78	78	7	85	85	34	8	34	8	5,131	13	13	51	77	51	45	77	70	0	0	0	115	115	0	0
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9
Metal Absorbed	0	0	0	0	4	4	4	2	2	2	2	1,183	3	3	2	18	2	9	18	16	0	0	0	25	25	32	32
Heterotrophs	0	0	1	1	8	9	9	3	0	3	0	6,254	16	16	5	93	5	1	93	86	0	0	0	87	87	0	0
Methanol Degraders	0	0	1	1	0	1	1	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOBs	0	0	1	1	2	3	3	1	0	1	0	352	1	1	2	5	2	0	5	5	0	0	0	5	5	0	0
NOBs	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	0	0	1	1	4	4	4	2	0	2	0	3,058	8	8	3	46	3	1	46	42	0	0	0	43	43	0	0
Poly-P	1	1	3	3	33	35	35	14	0	14	0	27,387	68	68	21	408	21	0	408	376	0	0	0	376	376	0	0
Ortho-PO4	102	104	206	206	389	595	595	588	32	588	32	26	13	13	7	0	7	6	0	0	0	0	0	7	7	433	433
Alkalinity (lbs/day as $CaCO_3$)	20,863	18,776	39,639	39,639	2,155	41,794	41,794	41,291	418	41,291	418	63,709	31,534	31,534	503	481	503	85	481	52	2	2	2	143	143	3,358	3,358
H_2S (lbs/day)	501	451	951	951	0	951	951	940	10	940	10	0	0	0	11	0	11	2	0	0	0	0	0	2	2	31	31
Temperature (°C)	14	14	14	14	18	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	20	20	20	14	14	35	35
BOD_5 (mg/L)	156	152	154	154	194	155	155	100	1,561	100	1,561	999	6	5.55	4,703	1,972	4,703	20,075	1,972	16,710	220	220	220	17,830	17,830	2,491	2,491
COD (mg/L)	403	386	395	395	1,233	409	409	258	3,579	258	3,579	3,404	55	54.60	12,840	6,686	12,840	58,481	6,686	56,390	501	501	501	55,227	55,227	32,032	32,032
TSS (mg/L)	179	197	188	188	949	200	200	81	1,611	81	1,611	2,987	15	15.00	10,000	5,899	10,000	45,000	5,899	50,000	250	250	250	45,312	45,312	27,843	27,843
VSS (mg/L)	160	171	165	165	752	175	175	71	1,406	71	1,406	2,368	12	11.89	8,732	4,678	8,732	39,272	4,678	39,649	200	200	200	37,842	37,842	21,959	21,959
TKN (mg-N/L)	27	30	29	29	94	30	30	26	109	26	109	167	4	3.80	365	328	365	1,622	328	2,754	39	39	39	2,041	2,041	2,041	2,041
NH_3-N (mg-N/L)	19	16	18	18	41	18	18	18	49	18	49	1	1	0.57	18	1	18	49	1	1	30	30	30	27	27	1,000	1,000
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	0	0	0	25	0	0	0	0	0	0	5	5	5.21	0	5	0	0	5	5	0	0	0	2	2	0	0
Total Nitrogen (mg/L)	27	30	29	29	119	30	30	26	110	26	110	173	9	9.01	365	333	365	1,622	333	2,759	39	39	39	2,043	2,043	2,041	2,041
TP (mg-P/L)	3	3	3	3	176	6	6	5	39	5	39	143	1	0.80	125	283	125	550	283	2,401	8	8	8	1,318	1,318	1,318	1,318
Alkalinity (mg/L as $CaCO_3$)	250	250	250	250	796	259	259	259	259	259	259	199	199	198.93	259	199	259	259	199	199	250	250	250	233	233	5,463	5,463
H_2S (mg/L)	6	6	6	6	0	6	6	6	6	6	6	0	0	0.00	6	0	6	6	0	0	6	6	6	3	3	50	50
															87%			87%							42%		

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DRY 1 - CAS w/EBPR Max Month

Mass Balance for Max Month Condition

Constituent	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)	Biosolids to Disposal	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	7,547	30,803	7,547	258,273	66,106	66,106	35,303	66,106	324,379
Carbonaceous BOD_5 (lbs/day)	1,365	129	1,365	382	166	166	15	143	526
Particulate	1,360	74	1,360	15	118	118	8	81	97
Heterotrophs	0	9	0	281	0	0	1	9	291
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	44	0	14	0	0	5	49	63
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	63	0	0	0	0	63
PHA	0	0	0	6	0	0	0	0	6
Filtrate	5	1	5	1	48	48	1	2	4
COD (lbs/day)	17,712	1,623	17,712	1,367	1,978	1,978	348	1,971	3,338
Particulate Bio	1,933	94	1,933	27	168	168	10	104	130
Particulate Non-Bio	15,296	1,214	15,296	361	1,330	1,330	126	1,339	1,701
Decay Prod Aer/Anx	0	34	0	306	0	0	6	40	346
Decay Prod Anaerobic	432	34	432	0	38	38	4	38	38
Heterotrophs	0	11	0	373	0	0	1	13	386
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	65	0	21	0	0	7	72	93
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	182	0	0	0	0	182
PHA	0	0	0	14	0	0	0	0	14
Soluble Bio	1	0	1	2	7	7	0	0	2
VFA	4	1	4	0	37	37	1	2	2
Colloidal Bio	4	1	4	0	38	38	1	2	2
Soluble Non-Bio	41	168	41	79	360	360	192	360	439
Colloidal Non-Bio	0	0	0	0	0	0	0	0	0
TSS (lbs/day)	15,745	1,285	15,745	1,141	1,369	1,369	143	1,428	2,569
Biodegradable	1,455	71	1,455	20	127	127	7	78	98
Non-Biodegradable	11,975	950	11,975	283	1,041	1,041	91	1,041	1,324
Inorganic Particles	1,784	133	1,784	24	155	155	22	155	179
Decay Prod Aer/Anx	0	28	0	239	0	0	3	31	270
Decay Prod Anaerobic	338	27	338	0	29	29	3	29	29
Metal Hydroxide	102	8	102	4	9	9	1	9	13
Metal Absorbed Phosphate	90	7	90	4	8	8	1	8	12
Heterotrophs	0	9	0	292	0	0	1	10	302
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	51	0	16	0	0	5	56	72
NOBs	0	1	0	0	0	0	10	11	11
PAOs	0	0	0	143	0	0	0	0	143
PHA	0	0	0	9	0	0	0	0	9
Poly-P	0	0	0	106	0	0	0	0	106
VSS (lbs/day)	12,418	1,024	12,418	905	1,080	1,080	108	1,132	2,037
Biodegradable	1,310	64	1,310	18	114	114	7	71	89
Non-Biodegradable	10,778	855	10,778	255	937	937	89	944	1,199
Decay Prod Aer/Anx	0	24	0	216	0	0	4	28	243
Decay Prod Anaerobic	304	24	304	0	26	26	3	27	27
Metal Hydroxide	26	2	26	1	2	2	0	2	3
Heterotrophs	0	8	0	263	0	0	1	9	272
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	46	0	15	0	0	5	51	65
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	128	0	0	0	0	128
PHA	0	0	0	9	0	0	0	0	9
TKN (lbs/day)	633	109	633	69	622	622	75	185	254
NH_3-N (lbs-N/day)	63	52	63	1	552	552	59	111	112
Particulate Bio Org N	104	5	104	1	9	9	1	5	6
Non-Bio Part Org N	437	34	437	9	38	38	4	38	47
Decay Prod Aer/Anx	0	2	0	19	0	0	0	2	21
Decay Prod Anaerobic	26	2	26	0	2	2	0	2	2
Heterotrophs	0	1	0	23	0	0	0	1	23
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	4	0	1	0	0	0	4	6
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	11	0	0	0	0	11
Non-Bio Soluble Org. N	2	10	2	5	21	21	11	21	26
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	27	0	11	0	0	31	57	69
Total Nitrogen (lbs-N/day)	633	136	633	80	622	622	106	242	323
TP (lbs-P/day)	391	210	391	55	419	419	211	420	475
Bio Particulate	34	2	34	0	3	3	0	2	2
Non-Bio Particulate	275	21	275	3	24	24	3	24	27
Decay Prod Aer/Anx	0	1	0	6	0	0	0	1	7
Decay Prod Anaerobic	9	1	9	0	1	1	0	1	1
Metal Absorbed	29	2	29	1	3	3	0	3	4
Heterotrophs	0	0	0	7	0	0	0	0	8
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	1	0	0	0	0	0	1	2
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	4	0	0	0	0	4
Poly-P	0	0	0	33	0	0	0	0	33
Ortho-PO4	44	181	44	0	389	389	208	389	389
Alkalinity (lbs/day as $CaCO_3$)	344	804	344	429	3,014	3,014	922	1,726	2,155
H_2S (lbs/day)	3	0	3	0	28	28	0	0	0
Temperature (°C)	35	35	35	14	35	35	35	35	18
BOD_5 (mg/L)	21,675	501	21,675	177	301	301	49	260	194
COD (mg/L)	281,218	6,314	281,218	634	3,585	3,585	1,180	3,572	1,233
TSS (mg/L)	250,000	5,000	250,000	529	2,482	2,482	485	2,589	949
VSS (mg/L)	197,167	3,983	197,167	420	1,957	1,957	366	2,052	752
TKN (mg-N/L)	10,048	425	10,048	32	1,127	1,127	256	335	94
NH_3-N (mg-N/L)	1,000	201	1,000	1	1,000	1,000	201	201	41
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	104	0	5	0	0	104	104	25
Total Nitrogen (mg/L)	10,048	529	10,048	37	1,127	1,127	361	439	119
TP (mg-P/L)	6,213	816	6,213	25	759	759	715	762	176
Alkalinity (mg/L as $CaCO_3$)	5,463	3,129	5,463	199	5,463	5,463	3,129	3,129	796
H_2S (mg/L)	50	0	50	0	50	50	0	0	0

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DRY 2 - IFAS w/EBPR Average Day

Mass Balance for Average Flow Conditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (Recyl)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Gravity Primary Sludge Thickening Recycle (PSTR)	Main Bioreactor Influent (BI)	Main Bioreactor Other Influent (BOI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)
Flow (gallons/day)	8,000,000	6,999,184	14,999,184	14,999,184	288,054	15,287,238	15,287,238	15,107,153	149,753	15,107,153	149,753	22,810,482	14,996,261	14,996,261
Carbonaceous BOD_5 (lbs/day)	10,008	8,757	18,765	18,765	520	19,285	19,285	12,272	1,953	12,272	1,953	148,033	1,111	1,111
Particulate	6,227	4,817	11,044	11,044	120	11,165	11,165	4,468	852	4,468	852	18,878	91	91
Heterotrophs	13	11	24	24	211	235	235	94	5	94	5	76,709	370	370
Methanol Degraders	13	11	24	24	1	24	24	10	1	10	1	230	1	1
AOBs	11	10	21	21	60	81	81	32	2	32	2	6,545	32	32
NOBs	11	10	21	21	1	22	22	9	0	9	0	0	0	0
PAOs	7	6	13	13	86	99	99	39	2	39	2	32,456	157	157
PHA	1	1	2	2	33	35	35	14	1	14	1	12,608	61	61
Filtrate	3,725	3,891	7,616	7,616	8	7,624	7,624	7,606	1,090	7,606	1,090	607	399	399
COD (lbs/day)	25,877	22,327	48,204	48,204	2,921	51,125	51,125	31,828	4,469	31,828	4,469	460,211	7,445	7,445
Particulate Bio	10,835	8,381	19,216	19,216	177	19,393	19,393	7,761	1,479	7,761	1,479	32,844	159	159
Particulate Non-Bio	3,038	3,923	6,961	6,961	1,319	8,280	8,280	3,314	745	3,314	745	106,754	515	515
Decay Prod Aer/Anx	1,309	1,688	2,997	2,997	241	3,238	3,238	1,296	302	1,296	302	79,580	384	384
Decay Prod Anaerobic	0	0	0	0	32	32	32	13	3	13	3	0	0	0
Heterotrophs	17	15	31	31	277	308	308	123	7	123	7	100,792	487	487
Methanol Degraders	17	15	31	31	1	32	32	13	1	13	1	302	1	1
AOBs	17	15	31	31	87	119	119	48	3	48	3	9,611	46	46
NOBs	17	15	31	31	1	33	33	13	1	13	1	0	0	0
PAOs	17	15	31	31	248	280	280	112	6	112	6	93,515	451	451
PHA	2	2	4	4	77	80	80	32	2	32	2	28,806	139	139
Soluble Bio	1,511	2,869	4,380	4,380	11	4,391	4,391	4,339	43	4,339	43	1,031	678	678
VFA	243	443	686	686	1	687	687	679	1,752	679	1,752	5	3	3
Colloidal Bio	4,600	3,450	8,050	8,050	1	8,052	8,052	7,957	65	7,957	65	0	0	0
Soluble Non-Bio	3,105	1,116	4,222	4,222	446	4,668	4,668	4,613	46	4,613	46	6,968	4,581	4,581
Colloidal Non-Bio	1,150	383	1,533	1,533	0	1,533	1,533	1,515	15	1,515	15	0	0	0
TSS (lbs/day)	11,509	11,384	22,893	22,893	2,155	25,048	25,048	10,019	2,010	10,019	2,010	388,885	1,877	1,877
Biodegradable	7,900	6,556	14,456	14,456	133	14,589	14,589	5,839	1,110	5,839	1,110	24,787	120	120
Non-Biodegradable	2,390	3,070	5,460	5,460	1,027	6,487	6,487	2,596	584	2,596	584	83,632	404	404
Inorganic Particles	78	335	413	413	143	556	556	217	51	217	51	7,036	34	34
Decay Prod Aer/Anx	1,024	1,321	2,345	2,345	189	2,534	2,534	1,014	236	1,014	236	62,269	301	301
Decay Prod Anaerobic	0	0	0	0	25	25	25	10	2	10	2	0	0	0
Metal Hydroxide	46	41	87	87	10	98	98	39	9	39	9	1,252	6	6
Metal Absorbed Phosphate	0	0	0	0	10	10	10	4	4	4	4	1,334	6	6
Heterotrophs	13	11	24	24	217	241	241	96	5	96	5	78,867	381	381
Methanol Degraders	13	11	24	24	1	25	25	10	1	10	1	236	1	1
AOBs	13	11	24	24	68	93	93	37	2	37	2	7,521	36	36
NOBs	13	11	24	24	10	34	34	14	1	14	1	0	0	0
PAOs	13	11	24	24	194	219	219	88	5	88	5	73,173	353	353
PHA	1	1	2	2	46	48	48	19	1	19	1	17,285	83	83
Poly-P	4	3	7	7	84	91	91	36	0	36	0	31,493	152	152
VSS (lbs/day)	10,243	9,914	20,157	20,157	1,724	21,882	21,882	8,758	1,757	8,758	1,757	315,039	1,521	1,521
Biodegradable	7,110	5,900	13,010	13,010	121	13,131	13,131	5,255	1,002	5,255	1,002	22,308	108	108
Non-Biodegradable	2,139	2,763	4,902	4,902	930	5,832	5,832	2,334	525	2,334	525	75,269	363	363
Decay Prod Aer/Anx	922	1,188	2,110	2,110	170	2,280	2,280	913	213	913	213	56,042	271	271
Decay Prod Anaerobic	0	0	0	0	23	23	23	9	2	9	2	0	0	0
Metal Hydroxide	12	10	22	22	3	25	25	10	2	10	2	317	2	2
Heterotrophs	12	10	22	22	195	217	217	87	5	87	5	70,980	343	343
Methanol Degraders	12	10	22	22	1	23	23	9	1	9	1	213	1	1
AOBs	12	10	22	22	62	84	84	33	2	33	2	6,769	33	33
NOBs	12	10	22	22	1	23	23	9	1	9	1	0	0	0
PAOs	12	10	22	22	175	197	197	79	4	79	4	65,855	318	318
PHA	1	1	2	2	46	48	48	19	1	19	1	17,285	83	83
TKN (lbs/day)	1,751	1,751	3,502	3,502	220	3,722	3,722	3,164	139	3,164	139	21,045	424	424
NH_3-N (lbs-N/day)	1,201	934	2,135	2,135	95	2,230	2,230	2,204	62	2,204	62	707	11	11
Particulate Bio Org N	143	274	417	417	7	424	424	170	34	170	34	707	3	3
Non-Bio Part Org N	40	128	168	168	38	206	206	82	19	82	19	2,656	13	13
Decay Prod Aer/Anx	79	102	181	181	15	196	196	78	18	78	18	4,820	23	23
Decay Prod Anaerobic	0	0	0	0	2	2	2	1	0	1	0	0	0	0
Heterotrophs	1	1	2	2	17	19	19	7	0	7	0	6,104	29	29
Methanol Degraders	1	1	2	2	0	2	2	1	0	1	0	18	0	0
AOBs	1	1	2	2	5	7	7	3	0	3	0	582	3	3
NOBs	1	1	2	2	0	2	2	1	0	1	0	0	0	0
PAOs	1	1	2	2	15	17	17	7	0	7	0	5,664	27	27
Non-Bio Soluble Org. N	186	89	276	276	26	302	302	298	3	298	3	450	296	296
Non-Bio Colloidal Org. N	15	13	28	28	0	28	28	27	0	27	0	0	0	0
Soluble Bio Org N	20	94	114	114	0	114	114	113	1	113	1	27	18	18
Colloidal Bio Org N	61	113	174	174	0	174	174	171	1	171	1	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	58	58	58	57	1	57	1	829	545	545
Total Nitrogen (lbs-N/day)	1,751	1,751	3,502	3,502	278	3,780	3,780	3,221	139	3,221	139	21,874	969	969
TP (lbs-P/day)	195	198	393	393	388	781	781	593	49	593	49	16,846	83	83
Bio Particulate	68	56	124	124	2	125	125	50	10	50	10	106	1	1
Non-Bio Particulate	20	26	47	47	21	68	68	27	6	27	6	878	4	4
Decay Prod Aer/Anx	26	34	60	60	5	65	65	26	6	26	6	1,592	8	8
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Metal Absorbed	0	0	0	0	3	3	3	1	1	1	1	435	2	2
Heterotrophs	0	0	1	1	6	6	6	2	0	2	0	2,016	10	10
Methanol Degraders	0	0	1	1	0	1	1	0	0	0	0	6	0	0
AOBs	0	0	1	1	2	2	2	1	0	1	0	192	1	1
NOBs	0	0	1	1	0	1	1	0	0	0	0	0	0	0
PAOs	0	0	1	1	5	6	6	2	0	2	0	1,870	9	9
Poly-P	1	1	2	2	26	28	28	11	0	11	0	9,750	47	47
Ortho-PO4	78	79	158	158	318	476	476	470	25	470	25	2	1	1
Alkalinity (lbs/day as $CaCO_3$)	14,687	12,851	27,539	27,539	1,806	29,345	29,345	28,999	287	28,999	287	32,941	21,656	21,656
H_2S (lbs/day)	401	350	751	751	0	751	751	742	7	742	7	0	0	0
Temperature (°C)	18	17	18	18	21	18	18	18	18	18	18	18	18	18
BOD_5 (mg/L)	150	150	150	150	216	151	151	97	1,563	97	1,563	778	9	8.87
COD (mg/L)	388	382	385	385	1,215	401	401	252	3,576	252	3,576	2,418	59	59.49
TSS (mg/L)	172	195	183	183	897	196	196	79	1,609	79	1,609	2,043	15	15.00
VSS (mg/L)	153	170	161	161	717	172	172	69	1,406	69	1,406	1,655	12	12.15
TKN (mg-N/L)	26	30	28	28	91	29	29	25	111	25	111	111	3	3.39
NH_3-N (mg-N/L)	18	16	17	17	40	17	17	17	49	17	49	0	0	0.09
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
NO_3-N (mg-N/L)	0	0	0	0	24	0	0	0	0	0	0	4	4	4.36
Total Nitrogen (mg/L)	26	30	28	28	116	30	30	26	112	26	112	115	8	7.75
TP (mg-P/L)	3	3	3	3	162	6	6	5	39	5	39	88	1	0.66
Alkalinity (mg/L as $CaCO_3$)	220	220	220	220	751	230	230	230	230	230	230	173	173	173.04
H_2S (mg/L)	6	6	6	6	0	6	6	6	6	6	6	0	0	0.00

Constituent	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)
Flow (gallons/day)	180,086	260,644	180,086	30,333	260,644	28,461	1,000	1,000	1,000	61,793	61,793	61,793	61,793
Carbonaceous BOD_5 (lbs/day)	7,083	4,901	7,083	5,110	4,901	4,503	2	2	2	9,619	9,619	1,296	1,296
Particulate	6,696	627	6,696	4,827	627	576	1	1	1	5,407	5,407	1,256	1,256
Heterotrophs	141	2,546	141	30	2,546	2,343	0	0	0	2,373	2,373	0	0
Methanol Degraders	15	8	15	3	8	7	0	0	0	10	10	0	0
AOBs	48	217	48	10	217	200	0	0	0	210	210	0	0
NOBs	13	0	13	3	0	0	0	0	0	3	3	0	0
PAOs	58	1,077	58	12	1,077	991	0	0	0	1,004	1,004	0	0
PHA	21	419	21	4	419	385	0	0	0	390	390	0	0
Filtrate	91	7	91	221	7	1	1	1	1	223	223	40	40
COD (lbs/day)	19,297	15,102	19,297	14,828	15,102	13,820	4	4	4	28,661	28,661	15,516	15,516
Particulate Bio	11,631	1,090	11,631	8,381	1,090	1,003	2	2	2	9,391	9,391	1,789	1,789
Particulate Non-Bio	4,966	3,544	4,966	4,221	3,544	3,260	0	0	0	7,483	7,483	12,847	12,847
Decay Prod Aer/Anx	1,942	2,642	1,942	1,712	2,642	2,430	0	0	0	4,143	4,143	0	0
Decay Prod Anaerobic	19	0	19	16	0	0	0	0	0	16	16	397	397
Heterotrophs	185	3,346	185	39	3,346	3,078	0	0	0	3,117	3,117	0	0
Methanol Degraders	19	10	19	4	10	9	0	0	0	13	13	0	0
AOBs	71	319	71	15	319	294	0	0	0	309	309	0	0
NOBs	20	0	20	4	0	0	0	0	0	4	4	0	0
PAOs	168	3,104	168	36	3,104	2,856	0	0	0	2,891	2,891	0	0
PHA	48	956	48	10	956	880	0	0	0	890	890	0	0
Soluble Bio	52	12	52	9	12	1	0	0	0	11	11	6	6
VFA	8	0	8	355	0	0	0	0	0	355	355	31	31
Colloidal Bio	95	0	95	13	0	0	0	0	0	14	14	32	32
Soluble Non-Bio	55	80	55	9	80	9	0	0	0	19	19	415	415
Colloidal Non-Bio	18	0	18	3	0	0	0	0	0	3	3	0	0
TSS (lbs/day)	15,029	12,909	15,029	11,392	12,909	11,876	2	2	2	23,274	23,274	13,433	13,433
Biodegradable	8,750	823	8,750	6,288	823	757	1	1	1	7,049	7,049	1,346	1,346
Non-Biodegradable	3,891	2,776	3,891	3,307	2,776	2,554	0	0	0	5,862	5,862	10,058	10,058
Inorganic Particles	339	234	339	288	234	215	0	0	0	504	504	1,551	1,551
Decay Prod Aer/Anx	1,520	2,067	1,520	1,339	2,067	1,902	0	0	0	3,241	3,241	0	0
Decay Prod Anaerobic	15	0	15	13	0	0	0	0	0	13	13	311	311
Metal Hydroxide	58	42	58	50	42	38	0	0	0	88	88	88	88
Metal Absorbed Phosphate	6	44	6	22	44	41	0	0	0	63	63	78	78
Heterotrophs	145	2,618	145	31	2,618	2,409	0	0	0	2,439	2,439	0	0
Methanol Degraders	15	8	15	3	8	7	0	0	0	10	10	0	0
AOBs	55	250	55	12	250	230	0	0	0	241	241	0	0
NOBs	20	0	20	4	0	0	0	0	0	4	4	0	0
PAOs	131	2,429	131	28	2,429	2,235	0	0	0	2,262	2,262	0	0
PHA	29	574	29	6	574	528	0	0	0	534	534	0	0
Poly-P	54	1,045	54	0	1,045	962	0	0	0	962	962	0	0
VSS (lbs/day)	13,124	10,457	13,124	9,956	10,457	9,621	2	2	2	19,582	19,582	10,566	10,566
Biodegradable	7,876	740	7,876	5,678	740	681	1	1	1	6,363	6,363	1,212	1,212
Non-Biodegradable	3,498	2,498	3,498	2,973	2,498	2,299	0	0	0	5,273	5,273	9,052	9,052
Decay Prod Aer/Anx	1,368	1,860	1,368	1,206	1,860	1,711	0	0	0	2,917	2,917	0	0
Decay Prod Anaerobic	14	0	14	11	0	0	0	0	0	12	12	280	280
Metal Hydroxide	15	11	15	13	11	10	0	0	0	22	22	22	22
Heterotrophs	130	2,356	130	28	2,356	2,168	0	0	0	2,195	2,195	0	0
Methanol Degraders	14	7	14	3	7	6	0	0	0	9	9	0	0
AOBs	50	225	50	11	225	207	0	0	0	217	217	0	0
NOBs	14	0	14	3	0	0	0	0	0	3	3	0	0
PAOs	118	2,186	118	25	2,186	2,011	0	0	0	2,036	2,036	0	0
PHA	29	574	29	6	574	528	0	0	0	534	534	0	0
TKN (lbs/day)	558	688	558	419	688	628	0	0	0	1,048	1,048	1,049	1,049
NH_3-N (lbs-N/day)	26	0	26	12	0	0	0	0	0	13	13	525	525
Particulate Bio Org N	254	23	254	190	23	22	0	0	0	212	212	97	97
Non-Bio Part Org N	124	88	124	105	88	81	0	0	0	186	186	379	379
Decay Prod Aer/Anx	118	160	118	104	160	147	0	0	0	251	251	0	0
Decay Prod Anaerobic	1	0	1	1	0	0	0	0	0	1	1	24	24
Heterotrophs	11	203	11	2	203	186	0	0	0	189	189	0	0
Methanol Degraders	1	1	1	0	1	1	0	0	0	1	1	0	0
AOBs	4	19	4	1	19	18	0	0	0	19	19	0	0
NOBs	1	0	1	0	0	0	0	0	0	0	0	0	0
PAOs	10	188	10	2	188	173	0	0	0	175	175	0	0
Non-Bio Soluble Org. N	4	5	4	1	5	1	0	0	0	1	1	24	24
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	1	0	1	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	2	0	2	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	1	9	1	0	9	1	0	0	0	1	1	0	0
Total Nitrogen (lbs-N/day)	559	697	559	419	697	629	0	0	0	1,049	1,049	1,049	1,049
TP (lbs-P/day)	189	559	189	140	559	514	0	0	0	655	655	655	655
Bio Particulate	75	4	75	57	4	3	0	0	0	60	60	32	32
Non-Bio Particulate	41	29	41	35	29	27	0	0	0	62	62	238	238
Decay Prod Aer/Anx	39	53	39	34	53	49	0	0	0	83	83	0	0
Decay Prod Anaerobic	0	0	0	0	0	0	0	0	0	0	0	8	8
Metal Absorbed	2	14	2	7	14	13	0	0	0	21	21	25	25
Heterotrophs	4	67	4	1	67	62	0	0	0	62	62	0	0
Methanol Degraders	0	0	0	0	0	0	0	0	0	0	0	0	0
AOBs	1	6	1	0	6	6	0	0	0	6	6	0	0
NOBs	0	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	3	62	3	1	62	57	0	0	0	58	58	0	0
Poly-P	17	324	17	0	324	298	0	0	0	298	298	0	0
Ortho-PO4	6	0	6	5	0	0	0	0	0	5	5	352	352
Alkalinity (lbs/day as $CaCO_3$)	346	376	346	58	376	41	2	2	2	106	106	2,852	2,852
H_2S (lbs/day)	9	0	9	1	0	0	0	0	0	2	2	26	26
Temperature (°C)	18	18	18	18	18	18	20	20	20	18	18	35	35
BOD_5 (mg/L)	4,713	2,253	4,713	20,188	2,253	18,958	220	220	220	18,652	18,652	2,514	2,514
COD (mg/L)	12,840	6,943	12,840	58,577	6,943	58,184	501	501	501	55,577	55,577	30,087	30,087
TSS (mg/L)	10,000	5,934	10,000	45,000	5,934	50,000	250	250	250	45,131	45,131	26,048	26,048
VSS (mg/L)	8,732	4,808	8,732	39,329	4,808	40,505	200	200	200	37,972	37,972	20,489	20,489
TKN (mg-N/L)	371	316	371	1,656	316	2,645	39	39	39	2,033	2,033	2,034	2,034
NH_3-N (mg-N/L)	17	0	17	49	0	0	30	30	30	26	26	1,017	1,017
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	4	0	0	4	4	0	0	0	2	2	0	0
Total Nitrogen (mg/L)	372	321	372	1,656	321	2,649	39	39	39	2,035	2,035	2,034	2,034
TP (mg-P/L)	126	257	126	554	257	2,166	8	8	8	1,270	1,270	1,270	1,270
Alkalinity (mg/L as $CaCO_3$)	230	173	230	230	173	173	250	250	250	205	205	5,531	5,531
H_2S (mg/L)	6	0	6	6	0	0	6	6	6	3	3	50	50

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DRY 2 - IFAS w/EBPR Average Day

Mass Balance for Average Flow Condition

Constituent	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)	Biosolids to Disposal	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	5,923	24,214	5,923	232,183	55,870	55,870	31,656	55,870	288,054
Carbonaceous BOD_5 (lbs/day)	1,160	110	1,160	398	137	137	12	122	520
Particulate	1,156	64	1,156	50	101	101	7	70	120
Heterotrophs	0	6	0	204	0	0	1	7	211
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	38	0	17	0	0	4	42	60
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	86	0	0	0	0	86
PHA	0	0	0	33	0	0	0	0	33
Filtrate	4	1	4	6	36	36	1	2	8
COD (lbs/day)	13,876	1,304	13,876	1,282	1,640	1,640	334	1,639	2,921
Particulate Bio	1,646	81	1,646	87	143	143	8	90	177
Particulate Non-Bio	11,819	939	11,819	283	1,028	1,028	97	1,036	1,319
Decay Prod Aer/Anx	0	26	0	211	0	0	5	30	241
Decay Prod Anaerobic	366	29	366	0	32	32	3	32	32
Heterotrophs	0	8	0	268	0	0	1	9	277
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	56	0	26	0	0	6	62	87
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	248	0	0	0	0	248
PHA	0	0	0	77	0	0	0	0	77
Soluble Bio	1	0	1	10	5	5	0	0	11
VFA	3	1	3	0	28	28	1	1	1
Colloidal Bio	3	1	3	0	29	29	1	1	1
Soluble Non-Bio	40	163	40	71	375	375	213	375	446
Colloidal Non-Bio	0	0	0	0	0	0	0	0	0
TSS (lbs/day)	12,358	1,010	12,358	1,033	1,075	1,075	112	1,123	2,155
Biodegradable	1,239	62	1,239	66	108	108	6	68	133
Non-Biodegradable	9,254	735	9,254	222	805	805	70	805	1,027
Inorganic Particles	1,427	106	1,427	19	124	124	18	124	143
Decay Prod Aer/Anx	0	21	0	165	0	0	2	23	189
Decay Prod Anaerobic	286	23	286	0	25	25	2	25	25
Metal Hydroxide	81	6	81	3	7	7	1	7	10
Metal Absorbed Phosphate	72	6	72	4	6	6	1	6	10
Heterotrophs	0	7	0	209	0	0	1	7	217
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	44	0	20	0	0	4	48	68
NOBs	0	1	0	0	0	0	9	10	10
PAOs	0	0	0	194	0	0	0	0	194
PHA	0	0	0	46	0	0	0	0	46
Poly-P	0	0	0	84	0	0	0	0	84
VSS (lbs/day)	9,721	803	9,721	837	845	845	84	888	1,724
Biodegradable	1,115	56	1,115	59	97	97	6	61	121
Non-Biodegradable	8,328	661	8,328	200	724	724	68	730	930
Decay Prod Aer/Anx	0	18	0	149	0	0	3	21	170
Decay Prod Anaerobic	257	20	257	0	22	22	2	23	23
Metal Hydroxide	20	2	20	1	2	2	0	2	3
Heterotrophs	0	6	0	188	0	0	1	6	195
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	40	0	18	0	0	4	44	62
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	175	0	0	0	0	175
PHA	0	0	0	46	0	0	0	0	46
TKN (lbs/day)	513	90	513	60	536	536	71	160	220
NH_3-N (lbs-N/day)	50	41	50	0	474	474	54	95	95
Particulate Bio Org N	89	4	89	2	8	8	0	5	7
Non-Bio Part Org N	349	28	349	7	30	30	3	31	38
Decay Prod Aer/Anx	0	2	0	13	0	0	0	2	15
Decay Prod Anaerobic	22	2	22	0	2	2	0	2	2
Heterotrophs	0	1	0	16	0	0	0	1	17
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	3	0	2	0	0	0	4	5
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	15	0	0	0	0	15
Non-Bio Soluble Org. N	2	9	2	5	22	22	12	22	26
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	21	0	8	0	0	28	49	58
Total Nitrogen (lbs-N/day)	513	111	513	68	536	536	99	210	278
TP (lbs-P/day)	312	161	312	45	343	343	183	344	388
Bio Particulate	29	1	29	0	3	3	0	2	2
Non-Bio Particulate	219	17	219	2	19	19	2	19	21
Decay Prod Aer/Anx	0	1	0	4	0	0	0	1	5
Decay Prod Anaerobic	7	1	7	0	1	1	0	1	1
Metal Absorbed	23	2	23	1	2	2	0	2	3
Heterotrophs	0	0	0	5	0	0	0	0	6
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	1	0	1	0	0	0	1	2
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	5	0	0	0	0	5
Poly-P	0	0	0	26	0	0	0	0	26
Ortho-PO4	34	138	34	0	318	318	180	318	318
Alkalinity (lbs/day as $CaCO_3$)	273	637	273	335	2,579	2,579	833	1,471	1,806
H_2S (lbs/day)	2	0	2	0	23	23	0	0	0
Temperature (°C)	35	35	35	18	35	35	35	35	21
BOD_5 (mg/L)	23,460	542	23,460	205	293	293	47	261	216
COD (mg/L)	280,714	6,454	280,714	662	3,517	3,517	1,266	3,514	1,215
TSS (mg/L)	250,000	5,000	250,000	533	2,305	2,305	425	2,408	897
VSS (mg/L)	196,651	3,974	196,651	432	1,813	1,813	320	1,904	717
TKN (mg-N/L)	10,372	444	10,372	31	1,150	1,150	267	344	91
NH_3-N (mg-N/L)	1,017	204	1,017	0	1,017	1,017	204	204	40
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	106	0	4	0	0	106	106	24
Total Nitrogen (mg/L)	10,372	550	10,372	35	1,150	1,150	373	450	116
TP (mg-P/L)	6,317	796	6,317	23	735	735	692	737	162
Alkalinity (mg/L as $CaCO_3$)	5,531	3,154	5,531	173	5,531	5,531	3,154	3,154	751
H_2S (mg/L)	50	0	50	0	50	50	0	0	0

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DRY 2 - IFAS w/EBPR Max Month

Mass Balance for Max Month Conditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (Recyl)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Gravity Primary Sludge Thickening Recycle (PSTR)	Main Bioreactor Influent (BI)	Main Bioreactor Other Influent (BOI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)
Flow (gallons/day)	10,000,000	8,998,951	18,998,951	18,998,951	267,720	19,266,673	19,266,673	19,032,305	194,896	19,032,305	194,896	28,743,353	18,994,104	18,994,104
Carbonaceous BOD_5 (lbs/day)	13,010	11,384	24,394	24,394	709	25,103	25,103	15,961	2,546	15,961	2,546	283,604	1,343	1,343
Particulate	8,098	6,262	14,360	14,360	166	14,526	14,526	5,814	1,109	5,814	1,109	36,427	121	121
Heterotrophs	16	14	30	30	298	328	328	131	7	131	7	150,744	499	499
Methanol Degraders	16	14	30	30	1	31	31	12	1	12	1	420	1	1
AOBs	14	13	27	27	79	106	106	43	2	43	2	13,158	44	44
NOBs	14	13	27	27	1	28	28	11	1	11	1	0	0	0
PAOs	8	8	16	16	110	126	126	49	3	49	3	57,459	190	190
PHA	1	1	2	2	47	49	49	20	1	20	1	24,782	82	82
Filtrate	4,843	5,059	9,902	9,902	7	9,909	9,909	9,881	1,422	9,881	1,422	615	406	406
COD (lbs/day)	33,640	29,026	62,665	62,665	3,813	66,479	66,479	41,353	5,823	41,353	5,823	848,291	9,426	9,426
Particulate Bio	14,089	10,896	24,985	24,985	244	25,228	25,228	10,097	1,926	10,097	1,926	63,377	210	210
Particulate Non-Bio	3,950	5,100	9,050	9,050	1,716	10,766	10,766	4,309	969	4,309	969	194,445	644	644
Decay Prod Aer/Anx	1,702	2,194	3,896	3,896	311	4,206	4,206	1,683	393	1,683	393	140,280	465	465
Decay Prod Anaerobic	0	0	0	0	45	45	45	18	4	18	4	1	0	0
Heterotrophs	21	19	40	40	392	431	431	173	10	173	10	198,071	656	656
Methanol Degraders	21	19	40	40	1	41	41	16	1	16	1	551	2	2
AOBs	21	19	40	40	116	156	156	62	4	62	4	19,322	64	64
NOBs	21	19	40	40	2	41	41	16	1	16	1	0	0	0
PAOs	21	19	40	40	316	355	355	142	8	142	8	165,559	548	548
PHA	2	2	5	5	108	113	113	45	3	45	3	56,623	188	188
Soluble Bio	1,964	3,729	5,694	5,694	7	5,701	5,701	5,632	58	5,632	58	1,043	689	689
VFA	316	576	891	891	2	894	894	883	2,280	883	2,280	5	3	3
Colloidal Bio	5,980	4,485	10,465	10,465	2	10,467	10,467	10,340	87	10,340	87	0	0	0
Soluble Non-Bio	4,037	1,451	5,488	5,488	551	6,039	6,039	5,966	61	5,966	61	9,015	5,957	5,957
Colloidal Non-Bio	1,495	498	1,993	1,993	0	1,993	1,993	1,969	20	1,969	20	0	0	0
TSS (lbs/day)	14,962	14,799	29,761	29,761	2,838	32,599	32,599	13,039	2,616	13,039	2,616	717,996	2,378	2,378
Biodegradable	10,274	8,523	18,797	18,797	184	18,981	18,981	7,597	1,444	7,597	1,444	47,830	158	158
Non-Biodegradable	3,107	3,991	7,098	7,098	1,335	8,434	8,434	3,375	759	3,375	759	152,321	504	504
Inorganic Particles	103	437	540	540	185	725	725	283	66	283	66	12,858	43	43
Decay Prod Aer/Anx	1,332	1,717	3,048	3,048	243	3,291	3,291	1,317	307	1,317	307	109,765	364	364
Decay Prod Anaerobic	0	0	0	0	35	35	35	14	3	14	3	1	0	0
Metal Hydroxide	58	52	110	110	13	124	124	49	11	49	11	2,236	7	7
Metal Absorbed Phosphate	0	0	0	0	13	13	13	5	5	5	5	2,392	8	8
Heterotrophs	16	15	31	31	307	338	338	135	8	135	8	154,985	513	513
Methanol Degraders	16	15	31	31	1	32	32	13	1	13	1	431	1	1
AOBs	16	15	31	31	91	122	122	49	3	49	3	15,119	50	50
NOBs	16	15	31	31	12	43	43	17	1	17	1	0	0	0
PAOs	16	15	31	31	247	278	278	111	6	111	6	129,545	429	429
PHA	1	1	3	3	65	68	68	27	2	27	2	33,974	113	113
Poly-P	5	4	9	9	108	117	117	47	0	47	0	56,539	187	187
VSS (lbs/day)	13,316	12,888	26,205	26,205	2,276	28,481	28,481	11,399	2,287	11,399	2,287	583,537	1,932	1,932
Biodegradable	9,246	7,671	16,917	16,917	166	17,083	17,083	6,837	1,305	6,837	1,305	43,047	143	143
Non-Biodegradable	2,782	3,592	6,374	6,374	1,209	7,583	7,583	3,035	682	3,035	682	137,089	454	454
Decay Prod Aer/Anx	1,198	1,545	2,743	2,743	219	2,962	2,962	1,186	277	1,186	277	98,789	327	327
Decay Prod Anaerobic	0	0	0	0	32	32	32	13	3	13	3	0	0	0
Metal Hydroxide	15	13	28	28	3	31	31	13	3	13	3	566	2	2
Heterotrophs	15	13	28	28	276	304	304	122	7	122	7	139,486	462	462
Methanol Degraders	15	13	28	28	1	29	29	11	1	11	1	388	1	1
AOBs	15	13	28	28	82	110	110	44	2	44	2	13,607	45	45
NOBs	15	13	28	28	1	29	29	12	1	12	1	0	0	0
PAOs	15	13	28	28	222	250	250	100	6	100	6	116,591	386	386
PHA	1	1	3	3	65	68	68	27	2	27	2	33,974	113	113
TKN (lbs/day)	2,277	2,244	4,521	4,521	283	4,804	4,804	4,089	179	4,089	179	38,413	563	563
NH_3-N (lbs-N/day)	1,561	1,214	2,775	2,775	122	2,897	2,897	2,862	80	2,862	80	54	35	35
Particulate Bio Org N	187	342	529	529	9	537	537	215	43	215	43	1,331	4	4
Non-Bio Part Org N	52	160	212	212	48	260	260	104	23	104	23	4,697	16	16
Decay Prod Aer/Anx	103	133	236	236	19	255	255	102	24	102	24	8,496	28	28
Decay Prod Anaerobic	0	0	0	0	3	3	3	1	0	1	0	0	0	0
Heterotrophs	1	1	2	2	24	26	26	10	1	10	1	11,996	40	40
Methanol Degraders	1	1	2	2	0	2	2	1	0	1	0	33	0	0
AOBs	1	1	2	2	7	9	9	4	0	4	0	1,170	4	4
NOBs	1	1	2	2	0	2	2	1	0	1	0	0	0	0
PAOs	1	1	2	2	19	22	22	9	0	9	0	10,027	33	33
Non-Bio Soluble Org. N	242	116	358	358	32	390	390	386	4	386	4	583	385	385
Non-Bio Colloidal Org. N	20	16	35	35	0	35	35	35	0	35	0	0	0	0
Soluble Bio Org N	26	117	143	143	0	143	143	142	1	142	1	26	17	17
Colloidal Bio Org N	79	141	220	220	0	220	220	217	2	217	2	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	70	70	70	70	1	70	1	1,070	707	707
Total Nitrogen (lbs-N/day)	2,277	2,244	4,521	4,521	353	4,874	4,874	4,159	180	4,159	180	39,482	1,270	1,270
TP (lbs-P/day)	254	258	512	512	501	1,013	1,013	767	64	767	64	30,562	103	103
Bio Particulate	88	73	161	161	2	163	163	65	13	65	13	204	1	1
Non-Bio Particulate	26	34	61	61	28	88	88	35	8	35	8	1,595	5	5
Decay Prod Aer/Anx	34	44	78	78	6	84	84	34	8	34	8	2,806	9	9
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Metal Absorbed	0	0	0	0	4	4	4	2	2	2	2	780	3	3
Heterotrophs	0	0	1	1	8	9	9	3	0	3	0	3,961	13	13
Methanol Degraders	0	0	1	1	0	1	1	0	0	0	0	11	0	0
AOBs	0	0	1	1	2	3	3	1	0	1	0	386	1	1
NOBs	0	0	1	1	0	1	1	0	0	0	0	0	0	0
PAOs	0	0	1	1	6	7	7	3	0	3	0	3,311	11	11
Poly-P	1	1	3	3	33	36	36	14	0	14	0	17,504	58	58
Ortho-PO4	102	104	206	206	410	616	616	608	33	608	33	3	2	2
Alkalinity (lbs/day as $CaCO_3$)	20,863	18,776	39,639	39,639	2,210	41,849	41,849	41,340	423	41,340	423	48,493	32,045	32,045
H_2S (lbs/day)	501	451	951	951	0	951	951	940	10	940	10	0	0	0
Temperature (°C)	14	14	14	14	19	14	14	14	14	14	14	14	14	14
BOD_5 (mg/L)	156	152	154	154	317	156	156	100	1,565	100	1,565	1,182	8	8.47
COD (mg/L)	403	386	395	395	1,707	413	413	260	3,580	260	3,580	3,536	59	59.46
TSS (mg/L)	179	197	188	188	1,270	203	203	82	1,608	82	1,608	2,993	15	15.00
VSS (mg/L)	160	171	165	165	1,019	177	177	72	1,406	72	1,406	2,433	12	12.19
TKN (mg-N/L)	27	30	29	29	127	30	30	26	110	26	110	160	4	3.55
NH_3-N (mg-N/L)	19	16	18	18	55	18	18	18	49	18	49	0	0	0.22
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
NO_3-N (mg-N/L)	0	0	0	0	32	0	0	0	0	0	0	4	4	4.46
Total Nitrogen (mg/L)	27	30	29	29	158	30	30	26	110	26	110	165	8	8.01
TP (mg-P/L)	3	3	3	3	224	6	6	5	39	5	39	127	1	0.65
Alkalinity (mg/L as $CaCO_3$)	250	250	250	250	989	260	260	260	260	260	260	202	202	202.16
H_2S (mg/L)	6	6	6	6	0	6	6	6	6	6	6	0	0	0.00

Constituent	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)
Flow (gallons/day)	234,368	233,097	234,368	39,472	233,097	37,723	1,000	1,000	1,000	80,195	80,195	80,195	80,195
Carbonaceous BOD_5 (lbs/day)	9,234	6,749	9,234	6,658	6,749	6,205	2	2	2	12,869	12,869	1,973	1,973
Particulate	8,713	868	8,713	6,285	868	799	1	1	1	7,088	7,088	1,911	1,911
Heterotrophs	197	3,592	197	42	3,592	3,305	0	0	0	3,347	3,347	0	0
Methanol Degraders	19	10	19	4	10	9	0	0	0	13	13	0	0
AOBs	64	314	64	14	314	288	0	0	0	302	302	0	0
NOBs	17	0	17	4	0	0	0	0	0	4	4	0	0
PAOs	74	1,369	74	16	1,369	1,260	0	0	0	1,275	1,275	0	0
PHA	30	591	30	6	591	543	0	0	0	550	550	0	0
Filtrate	122	5	122	288	5	1	1	1	1	290	290	62	62
COD (lbs/day)	25,126	20,057	25,126	19,303	20,057	18,390	4	4	4	37,705	37,705	20,660	20,660
Particulate Bio	15,131	1,510	15,131	10,913	1,510	1,389	2	2	2	12,309	12,309	2,761	2,761
Particulate Non-Bio	6,457	4,634	6,457	5,489	4,634	4,263	0	0	0	9,753	9,753	16,686	16,686
Decay Prod Aer/Anx	2,523	3,343	2,523	2,225	3,343	3,075	0	0	0	5,301	5,301	0	0
Decay Prod Anaerobic	27	0	27	23	0	0	0	0	0	23	23	564	564
Heterotrophs	259	4,720	259	55	4,720	4,342	0	0	0	4,397	4,397	0	0
Methanol Degraders	24	13	24	5	13	12	0	0	0	17	17	0	0
AOBs	94	460	94	20	460	424	0	0	0	443	443	0	0
NOBs	25	0	25	5	0	0	0	0	0	5	5	0	0
PAOs	213	3,945	213	45	3,945	3,630	0	0	0	3,675	3,675	0	0
PHA	68	1,349	68	14	1,349	1,241	0	0	0	1,256	1,256	0	0
Soluble Bio	69	8	69	12	8	1	0	0	0	14	14	9	9
VFA	11	0	11	462	0	0	0	0	0	462	462	48	48
Colloidal Bio	127	0	127	18	0	0	0	0	0	19	19	50	50
Soluble Non-Bio	73	73	73	12	73	12	0	0	0	25	25	543	543
Colloidal Non-Bio	24	0	24	4	0	0	0	0	0	4	4	0	0
TSS (lbs/day)	19,559	17,110	19,559	14,824	17,110	15,741	2	2	2	30,571	30,571	17,798	17,798
Biodegradable	11,384	1,140	11,384	8,185	1,140	1,049	1	1	1	9,238	9,238	2,078	2,078
Non-Biodegradable	5,058	3,630	5,058	4,300	3,630	3,339	0	0	0	7,640	7,640	13,063	13,063
Inorganic Particles	442	306	442	376	306	282	0	0	0	659	659	2,003	2,003
Decay Prod Aer/Anx	1,974	2,616	1,974	1,741	2,616	2,406	0	0	0	4,148	4,148	0	0
Decay Prod Anaerobic	21	0	21	18	0	0	0	0	0	18	18	441	441
Metal Hydroxide	74	53	74	63	53	49	0	0	0	112	112	112	112
Metal Absorbed Phosphate	8	57	8	28	57	52	0	0	0	81	81	100	100
Heterotrophs	202	3,693	202	43	3,693	3,398	0	0	0	3,441	3,441	0	0
Methanol Degraders	19	10	19	4	10	9	0	0	0	14	14	0	0
AOBs	73	360	73	15	360	331	0	0	0	347	347	0	0
NOBs	26	0	26	6	0	0	0	0	0	6	6	0	0
PAOs	167	3,087	167	35	3,087	2,840	0	0	0	2,876	2,876	0	0
PHA	41	810	41	9	810	745	0	0	0	753	753	0	0
Poly-P	70	1,347	70	0	1,347	1,240	0	0	0	1,240	1,240	0	0
VSS (lbs/day)	17,082	13,906	17,082	12,959	13,906	12,793	2	2	2	25,757	25,757	14,053	14,053
Biodegradable	10,246	1,026	10,246	7,393	1,026	944	1	1	1	8,340	8,340	1,871	1,871
Non-Biodegradable	4,548	3,267	4,548	3,866	3,267	3,005	0	0	0	6,872	6,872	11,757	11,757
Decay Prod Aer/Anx	1,777	2,354	1,777	1,567	2,354	2,166	0	0	0	3,733	3,733	0	0
Decay Prod Anaerobic	19	0	19	16	0	0	0	0	0	16	16	397	397
Metal Hydroxide	19	13	19	16	13	12	0	0	0	28	28	28	28
Heterotrophs	182	3,324	182	39	3,324	3,058	0	0	0	3,097	3,097	0	0
Methanol Degraders	17	9	17	4	9	9	0	0	0	12	12	0	0
AOBs	66	324	66	14	324	298	0	0	0	312	312	0	0
NOBs	17	0	17	4	0	0	0	0	0	4	4	0	0
PAOs	150	2,778	150	32	2,778	2,556	0	0	0	2,588	2,588	0	0
PHA	41	810	41	9	810	745	0	0	0	753	753	0	0
TKN (lbs/day)	715	905	715	536	905	828	0	0	0	1,365	1,365	1,366	1,366
NH_3-N (lbs-N/day)	35	0	35	16	0	0	0	0	0	17	17	674	674
Particulate Bio Org N	322	32	322	242	32	29	0	0	0	271	271	147	147
Non-Bio Part Org N	156	112	156	133	112	103	0	0	0	236	236	480	480
Decay Prod Aer/Anx	153	202	153	135	202	186	0	0	0	321	321	0	0
Decay Prod Anaerobic	2	0	2	1	0	0	0	0	0	1	1	34	34
Heterotrophs	16	286	16	3	286	263	0	0	0	266	266	0	0
Methanol Degraders	1	1	1	0	1	1	0	0	0	1	1	0	0
AOBs	6	28	6	1	28	26	0	0	0	27	27	0	0
NOBs	1	0	1	0	0	0	0	0	0	0	0	0	0
PAOs	13	239	13	3	239	220	0	0	0	223	223	0	0
Non-Bio Soluble Org. N	5	5	5	1	5	1	0	0	0	2	2	31	31
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	2	0	2	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	3	0	3	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	1	9	1	0	9	1	0	0	0	2	2	0	0
Total Nitrogen (lbs-N/day)	716	914	716	536	914	830	0	0	0	1,367	1,367	1,366	1,366
TP (lbs-P/day)	246	728	246	182	728	670	0	0	0	852	852	852	852
Bio Particulate	98	5	98	74	5	4	0	0	0	78	78	48	48
Non-Bio Particulate	53	38	53	45	38	35	0	0	0	80	80	306	306
Decay Prod Aer/Anx	50	67	50	45	67	62	0	0	0	106	106	0	0
Decay Prod Anaerobic	1	0	1	0	0	0	0	0	0	0	0	11	11
Metal Absorbed	2	19	2	9	19	17	0	0	0	26	26	32	32
Heterotrophs	5	94	5	1	94	87	0	0	0	88	88	0	0
Methanol Degraders	0	0	0	0	0	0	0	0	0	0	0	0	0
AOBs	2	9	2	0	9	8	0	0	0	9	9	0	0
NOBs	0	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	4	79	4	1	79	73	0	0	0	73	73	0	0
Poly-P	22	417	22	0	417	384	0	0	0	384	384	0	0
Ortho-PO4	7	0	7	7	0	0	0	0	0	7	7	454	454
Alkalinity (lbs/day as $CaCO_3$)	509	393	509	86	393	64	2	2	2	156	156	3,663	3,663
H_2S (lbs/day)	12	0	12	2	0	0	0	0	0	2	2	33	33
Temperature (°C)	14	14	14	14	14	14	20	20	20	14	14	35	35
BOD_5 (mg/L)	4,721	3,469	4,721	20,213	3,469	19,709	220	220	220	19,228	19,228	2,948	2,948
COD (mg/L)	12,846	10,310	12,846	58,597	10,310	58,415	501	501	501	56,338	56,338	30,869	30,869
TSS (mg/L)	10,000	8,795	10,000	45,000	8,795	50,000	250	250	250	45,678	45,678	26,593	26,593
VSS (mg/L)	8,733	7,148	8,733	39,339	7,148	40,636	200	200	200	38,485	38,485	20,998	20,998
TKN (mg-N/L)	365	465	365	1,627	465	2,632	39	39	39	2,040	2,040	2,041	2,041
NH_3-N (mg-N/L)	18	0	18	49	0	0	30	30	30	25	25	1,007	1,007
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	4	0	0	4	4	0	0	0	2	2	0	0
Total Nitrogen (mg/L)	366	470	366	1,627	470	2,636	39	39	39	2,043	2,043	2,041	2,041
TP (mg-P/L)	126	374	126	553	374	2,128	8	8	8	1,273	1,273	1,273	1,273
Alkalinity (mg/L as $CaCO_3$)	260	202	260	260	202	202	250	250	250	233	233	5,473	5,473
H_2S (mg/L)	6	0	6	6	0	0	6	6	6	3	3	50	50

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DRY 2 - IFAS w/EBPR Max Month

Mass Balance for Max Month Condition 8.186853014

Constituent	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)	Biosolids to Disposal	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	7,848	31,678	7,848	195,373	72,347	72,347	40,668	72,347	267,720
Carbonaceous BOD_5 (lbs/day)	1,764	149	1,764	544	209	209	17	166	709
Particulate	1,758	88	1,758	69	153	153	9	97	166
Heterotrophs	0	10	0	287	0	0	1	11	298
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	49	0	25	0	0	5	54	79
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	110	0	0	0	0	110
PHA	0	0	0	47	0	0	0	0	47
Filtrate	6	1	6	4	56	56	2	3	7
COD (lbs/day)	18,473	1,711	18,473	1,666	2,187	2,187	436	2,147	3,813
Particulate Bio	2,540	111	2,540	121	221	221	12	123	244
Particulate Non-Bio	15,351	1,219	15,351	371	1,335	1,335	126	1,345	1,716
Decay Prod Aer/Anx	0	37	0	267	0	0	6	43	311
Decay Prod Anaerobic	519	41	519	0	45	45	4	45	45
Heterotrophs	0	13	0	378	0	0	1	14	392
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	72	0	37	0	0	7	80	116
NOBs	0	1	0	0	0	0	0	2	2
PAOs	0	0	0	316	0	0	0	0	316
PHA	0	0	0	108	0	0	0	0	108
Soluble Bio	1	0	1	7	8	8	0	0	7
VFA	5	1	5	0	43	43	1	2	2
Colloidal Bio	5	1	5	0	45	45	1	2	2
Soluble Non-Bio	53	215	53	61	490	490	275	490	551
Colloidal Non-Bio	0	0	0	0	0	0	0	0	0
TSS (lbs/day)	16,374	1,322	16,374	1,369	1,424	1,424	147	1,469	2,838
Biodegradable	1,912	85	1,912	91	166	166	8	93	184
Non-Biodegradable	12,018	954	12,018	290	1,045	1,045	91	1,045	1,335
Inorganic Particles	1,842	137	1,842	25	160	160	23	160	185
Decay Prod Aer/Anx	0	31	0	209	0	0	3	33	243
Decay Prod Anaerobic	406	32	406	0	35	35	3	35	35
Metal Hydroxide	103	8	103	4	9	9	1	9	13
Metal Absorbed Phosphate	92	7	92	5	8	8	1	8	13
Heterotrophs	0	10	0	295	0	0	1	11	307
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	56	0	29	0	0	5	62	91
NOBs	0	1	0	0	0	0	11	12	12
PAOs	0	0	0	247	0	0	0	0	247
PHA	0	0	0	65	0	0	0	0	65
Poly-P	0	0	0	108	0	0	0	0	108
VSS (lbs/day)	12,929	1,053	12,929	1,112	1,124	1,124	111	1,164	2,276
Biodegradable	1,721	76	1,721	82	150	150	8	84	166
Non-Biodegradable	10,817	859	10,817	261	941	941	89	948	1,209
Decay Prod Aer/Anx	0	26	0	188	0	0	5	30	219
Decay Prod Anaerobic	365	29	365	0	32	32	3	32	32
Metal Hydroxide	26	2	26	1	2	2	0	2	3
Heterotrophs	0	9	0	266	0	0	1	10	276
Methanol Degraders	0	0	0	1	0	0	0	0	1
AOBs	0	51	0	26	0	0	5	56	82
NOBs	0	1	0	0	0	0	0	1	1
PAOs	0	0	0	222	0	0	0	0	222
PHA	0	0	0	65	0	0	0	0	65
TKN (lbs/day)	677	116	677	76	689	689	90	206	283
NH_3-N (lbs-N/day)	66	53	66	0	608	608	69	122	122
Particulate Bio Org N	135	6	135	3	12	12	1	6	9
Non-Bio Part Org N	441	35	441	9	38	38	4	39	48
Decay Prod Aer/Anx	0	2	0	16	0	0	0	3	19
Decay Prod Anaerobic	31	2	31	0	3	3	0	3	3
Heterotrophs	0	1	0	23	0	0	0	1	24
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	4	0	2	0	0	0	5	7
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	19	0	0	0	0	19
Non-Bio Soluble Org. N	3	12	3	4	28	28	16	28	32
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	28	0	7	0	0	36	63	70
Total Nitrogen (lbs-N/day)	677	144	677	84	689	689	126	270	353
TP (lbs-P/day)	411	209	411	58	442	442	234	443	501
Bio Particulate	44	2	44	0	4	4	0	2	2
Non-Bio Particulate	282	22	282	3	25	25	3	25	28
Decay Prod Aer/Anx	0	1	0	5	0	0	0	1	6
Decay Prod Anaerobic	10	1	10	0	1	1	0	1	1
Metal Absorbed	30	2	30	1	3	3	0	3	4
Heterotrophs	0	0	0	8	0	0	0	0	8
Methanol Degraders	0	0	0	0	0	0	0	0	0
AOBs	0	1	0	1	0	0	0	2	2
NOBs	0	0	0	0	0	0	0	0	0
PAOs	0	0	0	6	0	0	0	0	6
Poly-P	0	0	0	33	0	0	0	0	33
Ortho-PO4	44	179	44	0	410	410	230	410	410
Alkalinity (lbs/day as $CaCO_3$)	358	824	358	330	3,304	3,304	1,057	1,881	2,210
H_2S (lbs/day)	3	0	3	0	30	30	0	0	0
Temperature (°C)	35	35	35	14	35	35	35	35	19
BOD_5 (mg/L)	26,935	563	26,935	333	346	346	50	274	317
COD (mg/L)	282,056	6,472	282,056	1,022	3,622	3,622	1,284	3,555	1,707
TSS (mg/L)	250,000	5,000	250,000	839	2,358	2,358	433	2,433	1,270
VSS (mg/L)	197,405	3,981	197,405	682	1,862	1,862	327	1,927	1,019
TKN (mg-N/L)	10,340	439	10,340	47	1,141	1,141	265	341	127
NH_3-N (mg-N/L)	1,007	202	1,007	0	1,007	1,007	202	202	55
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	105	0	4	0	0	105	105	32
Total Nitrogen (mg/L)	10,340	544	10,340	51	1,141	1,141	370	446	158
TP (mg-P/L)	6,272	791	6,272	36	731	731	688	733	224
Alkalinity (mg/L as $CaCO_3$)	5,473	3,115	5,473	202	5,473	5,473	3,115	3,115	989
H_2S (mg/L)	50	0	50	0	50	50	0	0	0

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DRY 3 - CAS w/ ChemP Average Day

Mass Balance for Average Flow Conditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (Recyl)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Main Bioreactor Influent (BI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)
Flow (gallons/day)	8,000,000	6,999,184	14,999,184	14,999,184	457,838	15,457,023	15,457,023	15,246,091	15,246,091	26,680,734	14,996,470	14,996,470
Carbonaceous BOD_5 (lbs/day)	10,008	8,757	18,765	18,765	1,686	20,451	20,451	12,311	12,311	156,294	777	777
Particulate	6,227	4,817	11,044	11,044	1,253	12,298	12,298	4,864	4,864	6,251	29	29
Heterotrophs	13	11	24	24	277	301	301	115	115	142,137	652	652
Methanol Degraders	13	11	24	24	3	27	27	10	10	323	1	1
AOBs	11	10	21	21	63	84	84	32	32	7,007	32	32
NOBs	11	10	21	21	3	24	24	9	9	0	0	0
PAOs	7	6	13	13	2	15	15	5	5	438	2	2
PHA	1	1	2	2	0	2	2	1	1	30	0	0
Filtrate	3,725	3,892	7,617	7,617	84	7,701	7,701	7,275	7,275	108	60	60
COD (lbs/day)	25,877	22,327	48,204	48,204	5,844	54,048	54,048	31,931	31,931	478,223	6,714	6,714
Particulate Bio	10,835	8,381	19,216	19,216	2,145	21,361	21,361	8,449	8,449	10,876	50	50
Particulate Non-Bio	3,038	3,923	6,961	6,961	2,090	9,051	9,051	3,519	3,519	136,097	624	624
Decay Prod Aer/Anx	1,309	1,688	2,997	2,997	571	3,568	3,568	1,368	1,368	122,397	562	562
Decay Prod Anaerobic	0	0	0	0	35	35	35	14	14	1	0	0
Heterotrophs	17	15	31	31	368	399	399	153	153	188,697	866	866
Methanol Degraders	17	15	31	31	4	35	35	14	14	429	2	2
AOBs	17	15	31	31	92	123	123	47	47	10,289	47	47
NOBs	17	15	31	31	5	36	36	14	14	0	0	0
PAOs	17	15	31	31	6	37	37	14	14	1,261	6	6
PHA	2	2	4	4	1	4	4	2	2	69	0	0
Soluble Bio	1,511	2,869	4,380	4,380	51	4,431	4,431	4,370	4,370	174	98	98
VFA	243	443	686	686	9	695	695	685	685	9	5	5
Colloidal Bio	4,600	3,450	8,050	8,050	84	8,134	8,134	7,354	7,354	0	0	0
Soluble Non-Bio	3,105	1,116	4,222	4,222	369	4,590	4,590	4,528	4,528	7,924	4,454	4,454
Colloidal Non-Bio	1,150	383	1,533	1,533	16	1,549	1,549	1,401	1,401	0	0	0
TSS (lbs/day)	11,509	11,384	22,893	22,893	4,445	27,338	27,338	10,935	10,935	409,198	1,877	1,877
Biodegradable	7,900	6,556	14,456	14,456	1,612	16,068	16,068	6,349	6,349	8,202	38	38
Non-Biodegradable	2,390	3,070	5,460	5,460	1,630	7,091	7,091	2,757	2,757	106,616	489	489
Inorganic Particles	78	335	413	413	93	506	506	189	189	7,310	34	34
Decay Prod Aer/Anx	1,024	1,321	2,345	2,345	446	2,791	2,791	1,070	1,070	95,773	439	439
Decay Prod Anaerobic	0	0	0	0	28	28	28	11	11	0	0	0
Metal Hydroxide	46	41	87	87	150	237	237	254	254	18,751	86	86
Metal Absorbed Phosphate	0	0	0	0	104	104	104	109	109	15,192	70	70
Heterotrophs	13	11	24	24	288	312	312	120	120	147,650	677	677
Methanol Degraders	13	11	24	24	3	28	28	11	11	336	2	2
AOBs	13	11	24	24	71	96	96	37	37	8,051	37	37
NOBs	13	11	24	24	13	38	38	14	14	0	0	0
PAOs	13	11	24	24	4	29	29	11	11	987	5	5
PHA	1	1	2	2	0	3	3	1	1	41	0	0
Poly-P	4	3	7	7	1	8	8	3	3	287	1	1
VSS (lbs/day)	10,243	9,914	20,157	20,157	3,723	23,880	23,880	9,401	9,401	335,637	1,540	1,540
Biodegradable	7,110	5,900	13,010	13,010	1,451	14,462	14,462	5,714	5,714	7,382	34	34
Non-Biodegradable	2,139	2,763	4,902	4,902	1,472	6,375	6,375	2,479	2,479	95,955	440	440
Decay Prod Aer/Anx	922	1,188	2,110	2,110	402	2,512	2,512	963	963	86,195	395	395
Decay Prod Anaerobic	0	0	0	0	25	25	25	10	10	0	0	0
Metal Hydroxide	12	10	22	22	38	60	60	64	64	4,742	22	22
Heterotrophs	12	10	22	22	259	281	281	108	108	132,885	610	610
Methanol Degraders	12	10	22	22	3	25	25	10	10	302	1	1
AOBs	12	10	22	22	65	87	87	33	33	7,246	33	33
NOBs	12	10	22	22	3	25	25	10	10	0	0	0
PAOs	12	10	22	22	4	26	26	10	10	888	4	4
PHA	1	1	2	2	0	3	3	1	1	41	0	0
TKN (lbs/day)	1,751	1,751	3,502	3,502	313	3,815	3,815	3,185	3,185	23,664	436	436
NH_3-N (lbs-N/day)	1,201	934	2,135	2,135	122	2,257	2,257	2,227	2,227	70	39	39
Particulate Bio Org N	143	274	417	417	49	466	466	184	184	233	1	1
Non-Bio Part Org N	40	128	168	168	50	219	219	85	85	3,276	15	15
Decay Prod Aer/Anx	79	102	181	181	35	216	216	83	83	7,413	34	34
Decay Prod Anaerobic	0	0	0	0	2	2	2	1	1	0	0	0
Heterotrophs	1	1	2	2	22	24	24	9	9	11,428	52	52
Methanol Degraders	1	1	2	2	0	2	2	1	1	26	0	0
AOBs	1	1	2	2	6	7	7	3	3	623	3	3
NOBs	1	1	2	2	0	2	2	1	1	0	0	0
PAOs	1	1	2	2	0	2	2	1	1	76	0	0
Non-Bio Soluble Org. N	186	89	276	276	22	297	297	293	293	513	289	289
Non-Bio Colloidal Org. N	15	13	28	28	0	28	28	25	25	0	0	0
Soluble Bio Org N	20	94	114	114	1	115	115	113	113	5	3	3
Colloidal Bio Org N	61	113	174	174	2	175	175	159	159	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	61	61	61	60	60	1,199	674	674
Total Nitrogen (lbs-N/day)	1,751	1,751	3,502	3,502	374	3,876	3,876	3,245	3,245	24,863	1,110	1,110
TP (lbs-P/day)	195	198	393	393	191	584	584	348	348	12,481	84	84
Bio Particulate	68	56	124	124	14	138	138	53	53	34	0	0
Non-Bio Particulate	20	26	47	47	14	60	60	23	23	894	4	4
Decay Prod Aer/Anx	26	34	60	60	11	71	71	27	27	2,448	11	11
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0
Metal Absorbed	0	0	0	0	34	34	34	36	36	4,955	23	23
Heterotrophs	0	0	1	1	7	8	8	3	3	3,774	17	17
Methanol Degraders	0	0	1	1	0	1	1	0	0	9	0	0
AOBs	0	0	1	1	2	2	2	1	1	206	1	1
NOBs	0	0	1	1	0	1	1	0	0	0	0	0
PAOs	0	0	1	1	0	1	1	0	0	25	0	0
Poly-P	1	1	2	2	0	3	3	1	1	89	0	0
Ortho-PO4	78	79	158	158	107	265	265	203	203	48	27	27
Alkalinity (lbs/day as $CaCO_3$)	14,687	12,851	27,539	27,539	1,287	28,825	28,825	27,841	27,841	32,253	18,128	18,128
H_2S (lbs/day)	401	350	751	751	0	751	751	0	0	0	0	0
Temperature (°C)	18	17	18	18	20	18	18	18	18	18	18	18
BOD_5 (mg/L)	150	150	150	150	441	159	159	97	97	702	6	6
COD (mg/L)	388	382	385	385	1,530	419	419	251	251	2,148	54	54
TSS (mg/L)	172	195	183	183	1,163	212	212	86	86	1,838	15	15
VSS (mg/L)	153	170	161	161	974	185	185	74	74	1,507	12	12
TKN (mg-N/L)	26	30	28	28	82	30	30	25	25	106	3	3.49
NH_3-N (mg-N/L)	18	16	17	17	32	18	18	18	18	0	0	0.32
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0.00
NO_3-N (mg-N/L)	0	0	0	0	16	0	0	0	0	5	5	5.38
Total Nitrogen (mg/L)	26	30	28	28	98	30	30	26	26	112	9	8.87
TP (mg-P/L)	3	3	3	3	50	5	5	3	3	56	1	0.67
Alkalinity (mg/L as $CaCO_3$)	220	220	220	220	337	223	223	219	219	145	145	145
H_2S (mg/L)	6	6	6	6	0	6	6	0	0	0	0	0

Constituent	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)
Flow (gallons/day)	210,932	249,696	210,932	39,857	249,696	19,192	1,000	1,000	1,000	62,048	62,048	62,048	62,048	5,789	23,881
Carbonaceous BOD_5 (lbs/day)	8,202	3,323	8,202	6,905	3,323	3,057	2	2	2	9,967	9,967	1,230	1,230	1,099	109
Particulate	7,823	133	7,823	6,650	133	122	1	1	1	6,776	6,776	1,191	1,191	1,096	62
Heterotrophs	185	3,024	185	158	3,024	2,782	0	0	0	2,939	2,939	0	0	0	7
Methanol Degraders	16	7	16	14	7	6	0	0	0	20	20	0	0	0	0
AOBs	52	149	52	44	149	137	0	0	0	181	181	0	0	0	39
NOBs	15	0	15	13	0	0	0	0	0	13	13	0	0	0	1
PAOs	8	9	8	7	9	9	0	0	0	15	15	0	0	0	0
PHA	1	1	1	1	1	1	0	0	0	2	2	0	0	0	0
Filtrate	101	1	101	19	1	0	1	1	1	21	21	39	39	4	1
COD (lbs/day)	22,118	10,076	22,118	18,632	10,076	9,206	4	4	4	27,851	27,851	14,929	14,929	13,452	1,220
Particulate Bio	13,590	231	13,590	11,551	231	213	2	2	2	11,771	11,771	1,673	1,673	1,539	79
Particulate Non-Bio	5,661	2,895	5,661	4,812	2,895	2,663	0	0	0	7,476	7,476	12,515	12,515	11,514	910
Decay Prod Aer/Anx	2,200	2,604	2,200	1,870	2,604	2,395	0	0	0	4,266	4,266	0	0	0	28
Decay Prod Anaerobic	22	0	22	19	0	0	0	0	0	19	19	399	399	367	29
Heterotrophs	246	4,014	246	209	4,014	3,693	0	0	0	3,902	3,902	0	0	0	9
Methanol Degraders	22	9	22	18	9	8	0	0	0	27	27	0	0	0	0
AOBs	76	219	76	65	219	201	0	0	0	266	266	0	0	0	57
NOBs	22	0	22	19	0	0	0	0	0	19	19	0	0	0	1
PAOs	23	27	23	19	27	25	0	0	0	44	44	0	0	0	0
PHA	3	1	3	2	1	1	0	0	0	4	4	0	0	0	0
Soluble Bio	60	2	60	11	2	0	0	0	0	13	13	6	6	1	0
VFA	9	0	9	2	0	0	0	0	0	2	2	29	29	3	1
Colloidal Bio	102	0	102	19	0	0	0	0	0	20	20	32	32	3	1
Soluble Non-Bio	63	74	63	12	74	6	0	0	0	18	18	275	275	26	106
Colloidal Non-Bio	19	0	19	4	0	0	0	0	0	4	4	0	0	0	0
TSS (lbs/day)	17,603	8,705	17,603	14,968	8,705	8,008	2	2	2	22,983	22,983	13,129	13,129	12,079	996
Biodegradable	10,213	174	10,213	8,681	174	160	1	1	1	8,845	8,845	1,257	1,257	1,157	60
Non-Biodegradable	4,435	2,268	4,435	3,769	2,268	2,087	0	0	0	5,857	5,857	9,797	9,797	9,014	712
Inorganic Particles	317	156	317	270	156	143	0	0	0	414	414	414	414	381	28
Decay Prod Aer/Anx	1,721	2,037	1,721	1,463	2,037	1,874	0	0	0	3,338	3,338	0	0	0	23
Decay Prod Anaerobic	17	0	17	14	0	0	0	0	0	14	14	312	312	287	23
Metal Hydroxide	408	399	408	347	399	367	0	0	0	714	714	714	714	657	52
Metal Absorbed Phosphate	175	323	175	154	323	297	0	0	0	452	452	635	635	584	46
Heterotrophs	193	3,141	193	164	3,141	2,890	0	0	0	3,053	3,053	0	0	0	7
Methanol Degraders	17	7	17	14	7	7	0	0	0	21	21	0	0	0	0
AOBs	59	171	59	50	171	158	0	0	0	208	208	0	0	0	44
NOBs	23	0	23	20	0	0	0	0	0	20	20	0	0	0	1
PAOs	18	21	18	15	21	19	0	0	0	34	34	0	0	0	0
PHA	2	1	2	1	1	1	0	0	0	2	2	0	0	0	0
Poly-P	5	6	5	4	6	6	0	0	0	10	10	0	0	0	0
VSS (lbs/day)	15,122	7,140	15,122	12,854	7,140	6,569	2	2	2	19,427	19,427	10,411	10,411	9,578	795
Biodegradable	9,192	157	9,192	7,813	157	144	1	1	1	7,961	7,961	1,131	1,131	1,041	54
Non-Biodegradable	3,987	2,041	3,987	3,389	2,041	1,878	0	0	0	5,268	5,268	8,818	8,818	8,112	641
Decay Prod Aer/Anx	1,549	1,834	1,549	1,317	1,834	1,687	0	0	0	3,004	3,004	0	0	0	19
Decay Prod Anaerobic	15	0	15	13	0	0	0	0	0	13	13	281	281	259	20
Metal Hydroxide	103	101	103	88	101	93	0	0	0	181	181	181	181	166	13
Heterotrophs	173	2,827	173	147	2,827	2,601	0	0	0	2,748	2,748	0	0	0	6
Methanol Degraders	15	6	15	13	6	6	0	0	0	19	19	0	0	0	0
AOBs	53	154	53	45	154	142	0	0	0	187	187	0	0	0	40
NOBs	16	0	16	13	0	0	0	0	0	13	13	0	0	0	1
PAOs	16	19	16	14	19	17	0	0	0	31	31	0	0	0	0
PHA	2	1	2	1	1	1	0	0	0	2	2	0	0	0	0
TKN (lbs/day)	630	496	630	510	496	452	0	0	0	963	963	963	963	433	81
NH_3-N (lbs-N/day)	31	1	31	6	1	0	0	0	0	7	7	532	532	50	41
Particulate Bio Org N	297	5	297	252	5	5	0	0	0	257	257	89	89	82	4
Non-Bio Part Org N	136	70	136	116	70	64	0	0	0	180	180	301	301	277	22
Decay Prod Aer/Anx	133	158	133	113	158	145	0	0	0	258	258	0	0	0	2
Decay Prod Anaerobic	1	0	1	1	0	0	0	0	0	1	1	24	24	22	2
Heterotrophs	15	243	15	13	243	224	0	0	0	236	236	0	0	0	1
Methanol Degraders	1	1	1	1	1	1	0	0	0	2	2	0	0	0	0
AOBs	5	13	5	4	13	12	0	0	0	16	16	0	0	0	3
NOBs	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0
PAOs	1	2	1	1	2	1	0	0	0	3	3	0	0	0	0
Non-Bio Soluble Org. N	4	5	4	1	5	0	0	0	0	1	1	16	16	1	6
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	1	11	1	0	11	1	0	0	0	1	1	0	0	0	21
Total Nitrogen (lbs-N/day)	631	508	631	510	508	453	0	0	0	964	964	963	963	433	102
TP (lbs-P/day)	236	265	236	200	265	243	0	0	0	444	444	444	444	311	70
Bio Particulate	85	1	85	72	1	1	0	0	0	73	73	29	29	27	1
Non-Bio Particulate	37	19	37	32	19	17	0	0	0	49	49	82	82	76	6
Decay Prod Aer/Anx	44	52	44	37	52	48	0	0	0	85	85	0	0	0	1
Decay Prod Anaerobic	0	0	0	0	0	0	0	0	0	0	0	8	8	7	1
Metal Absorbed	57	105	57	50	105	97	0	0	0	147	147	207	207	190	15
Heterotrophs	5	80	5	4	80	74	0	0	0	78	78	0	0	0	0
Methanol Degraders	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
AOBs	2	4	2	1	4	4	0	0	0	5	5	0	0	0	1
NOBs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0
Poly-P	2	2	2	1	2	2	0	0	0	3	3	0	0	0	0
Ortho-PO4	3	0	3	0	0	0	0	0	0	0	0	117	117	11	45
Alkalinity (lbs/day as $CaCO_3$)	385	302	385	73	302	23	2	2	2	102	102	2,009	2,009	187	295
H_2S (lbs/day)	0	0	0	0	0	0	0	0	0	0	0	26	26	2	0
Temperature (°C)	18	18	18	18	18	18	20	20	20	18	18	35	35	35	35
BOD_5 (mg/L)	4,659	1,595	4,659	20,759	1,595	19,085	220	220	220	19,248	19,248	2,375	2,375	22,751	548
COD (mg/L)	12,564	4,835	12,564	56,016	4,835	57,480	501	501	501	53,785	53,785	28,831	28,831	278,419	6,121
TSS (mg/L)	10,000	4,177	10,000	45,000	4,177	50,000	250	250	250	44,383	44,383	25,355	25,355	250,000	5,000
VSS (mg/L)	8,590	3,426	8,590	38,643	3,426	41,012	200	200	200	37,517	37,517	20,105	20,105	198,233	3,989
TKN (mg-N/L)	358	238	358	1,532	238	2,822	39	39	39	1,859	1,859	1,859	1,859	8,956	404
NH_3-N (mg-N/L)	18	0	18	18	0	0	30	30	30	13	13	1,028	1,028	1,028	206
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	5	0	0	5	5	0	0	0	2	2	0	0	0	107
Total Nitrogen (mg/L)	358	244	358	1,533	244	2,828	39	39	39	1,861	1,861	1,859	1,859	8,956	511
TP (mg-P/L)	134	127	134	601	127	1,519	8	8	8	857	857	857	857	6,441	351
Alkalinity (mg/L as $CaCO_3$)	219	145	219	219	145	145	250	250	250	197	197	3,880	3,880	3,880	1,482
H_2S (mg/L)	0	0	0	0	0	0	6	6	6	0	0	50	50	50	0

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DRY 3 - CAS w/ ChemP Average Day

Mass Balance for Average Flow Condition

Constituent	Biosolids to Disposal	Gravity Primary Sludge Thickening Recycle (PSTR)	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	5,789	171,075	230,504	56,258	56,258	32,378	56,258	457,838
Carbonaceous BOD_5 (lbs/day)	1,099	1,297	267	131	131	13	122	1,686
Particulate	1,096	1,174	11	95	95	7	69	1,253
Heterotrophs	0	28	242	0	0	1	7	277
Methanol Degraders	0	2	1	0	0	0	0	3
AOBs	0	8	12	0	0	4	43	63
NOBs	0	2	0	0	0	0	1	3
PAOs	0	1	1	0	0	0	0	2
PHA	0	0	0	0	0	0	0	0
Filtrate	4	82	1	35	35	1	2	84
COD (lbs/day)	13,452	3,485	870	1,477	1,477	269	1,489	5,844
Particulate Bio	1,539	2,038	19	134	134	9	88	2,145
Particulate Non-Bio	11,514	849	232	1,001	1,001	99	1,009	2,090
Decay Prod Aer/Anx	0	330	208	0	0	5	33	571
Decay Prod Anaerobic	367	3	0	32	32	3	32	35
Heterotrophs	0	37	321	0	0	1	10	368
Methanol Degraders	0	3	1	0	0	0	0	4
AOBs	0	11	18	0	0	6	63	92
NOBs	0	3	0	0	0	0	1	5
PAOs	0	3	2	0	0	0	0	6
PHA	0	0	0	0	0	0	0	1
Soluble Bio	1	49	2	5	5	0	0	51
VFA	3	8	0	26	26	1	1	9
Colloidal Bio	3	83	0	29	29	1	1	84
Soluble Non-Bio	26	51	68	250	250	144	250	369
Colloidal Non-Bio	0	16	0	0	0	0	0	16
TSS (lbs/day)	12,079	2,641	696	1,050	1,050	111	1,107	4,445
Biodegradable	1,157	1,532	14	101	101	6	66	1,612
Non-Biodegradable	9,014	665	181	784	784	72	784	1,630
Inorganic Particles	381	48	12	33	33	5	33	93
Decay Prod Aer/Anx	0	258	163	0	0	2	25	446
Decay Prod Anaerobic	287	3	0	25	25	2	25	28
Metal Hydroxide	657	61	32	57	57	5	57	150
Metal Absorbed Phosphate	584	27	26	51	51	5	51	104
Heterotrophs	0	29	251	0	0	1	8	288
Methanol Degraders	0	3	1	0	0	0	0	3
AOBs	0	9	14	0	0	4	49	71
NOBs	0	3	0	0	0	9	10	13
PAOs	0	3	2	0	0	0	0	4
PHA	0	0	0	0	0	0	0	0
Poly-P	0	1	0	0	0	0	0	1
VSS (lbs/day)	9,578	2,268	571	833	833	88	883	3,723
Biodegradable	1,041	1,379	13	91	91	6	60	1,451
Non-Biodegradable	8,112	598	163	705	705	70	711	1,472
Decay Prod Aer/Anx	0	232	147	0	0	3	23	402
Decay Prod Anaerobic	259	2	0	22	22	2	23	25
Metal Hydroxide	166	15	8	14	14	1	15	38
Heterotrophs	0	26	226	0	0	1	7	259
Methanol Degraders	0	2	1	0	0	0	0	3
AOBs	0	8	12	0	0	4	44	65
NOBs	0	2	0	0	0	0	1	3
PAOs	0	2	2	0	0	0	0	4
PHA	0	0	0	0	0	0	0	0
TKN (lbs/day)	433	120	44	530	530	68	148	313
NH_3-N (lbs-N/day)	50	25	1	483	483	56	97	122
Particulate Bio Org N	82	44	0	7	7	0	5	49
Non-Bio Part Org N	277	20	6	24	24	2	24	50
Decay Prod Aer/Anx	0	20	13	0	0	0	2	35
Decay Prod Anaerobic	22	0	0	2	2	0	2	2
Heterotrophs	0	2	19	0	0	0	1	22
Methanol Degraders	0	0	0	0	0	0	0	0
AOBs	0	1	1	0	0	0	4	6
NOBs	0	0	0	0	0	0	0	0
PAOs	0	0	0	0	0	0	0	0
Non-Bio Soluble Org. N	1	3	4	14	14	8	14	22
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	1	0	0	0	0	0	1
Colloidal Bio Org N	0	2	0	0	0	0	0	2
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	1	10	0	0	29	50	61
Total Nitrogen (lbs-N/day)	433	121	55	530	530	97	198	374
TP (lbs-P/day)	311	36	22	132	132	64	134	191
Bio Particulate	27	13	0	2	2	0	1	14
Non-Bio Particulate	76	6	2	7	7	1	7	14
Decay Prod Aer/Anx	0	7	4	0	0	0	1	11
Decay Prod Anaerobic	7	0	0	1	1	0	1	1
Metal Absorbed	190	9	8	17	17	2	17	34
Heterotrophs	0	1	6	0	0	0	0	7
Methanol Degraders	0	0	0	0	0	0	0	0
AOBs	0	0	0	0	0	0	1	2
NOBs	0	0	0	0	0	0	0	0
PAOs	0	0	0	0	0	0	0	0
Poly-P	0	0	0	0	0	0	0	0
Ortho-PO4	11	1	0	106	106	61	106	107
Alkalinity (lbs/day as $CaCO_3$)	187	312	279	1,822	1,822	401	696	1,287
H_2S (lbs/day)	2	0	0	23	23	0	0	0
Temperature (°C)	35	18	18	35	35	35	35	20
BOD_5 (mg/L)	22,751	908	139	279	279	48	260	441
COD (mg/L)	278,419	2,441	452	3,146	3,146	995	3,171	1,530
TSS (mg/L)	250,000	1,850	362	2,237	2,237	410	2,358	1,163
VSS (mg/L)	198,233	1,589	297	1,774	1,774	326	1,881	974
TKN (mg-N/L)	8,956	84	23	1,129	1,129	250	316	82
NH_3-N (mg-N/L)	1,028	18	0	1,028	1,028	206	206	32
NO_2-N (mg/L)	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	0	5	0	0	107	107	16
Total Nitrogen (mg/L)	8,956	85	28	1,129	1,129	357	423	98
TP (mg-P/L)	6,441	25	11	282	282	237	285	50
Alkalinity (mg/L as $CaCO_3$)	3,880	219	145	3,880	3,880	1,482	1,482	337
H_2S (mg/L)	50	0	0	50	50	0	0	0

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DRY 3 - CAS w/ ChemP Max Month

Mass Balance for Max Month Conditions

Constituent	Raw Wastewater (RW)	MissionM Other Influent (OInf)	Influent Combined Discharge	Recy Recycle Influent (Recyl)	Recy Recycled Stream (Recycle)	Recy Combined Recycle Effluent (RecyE)	Main Primary Influent (PI)	Main Primary Effluent (PE)	Main Bioreactor Influent (BI)	Main Secondary Clarifier Influent (SI)	Main Secondary Clarifier Effluent (SE)	Plant Effluent (PLE)
Flow (gallons/day)	10,000,000	8,998,951	18,998,951	18,998,951	463,680	19,462,631	19,462,631	19,186,947	19,186,947	33,577,243	18,994,416	18,994,416
Carbonaceous BOD_5 (lbs/day)	13,010	11,384	24,394	24,394	2,175	26,569	26,569	15,942	15,942	304,120	947	947
Particulate	8,098	6,262	14,360	14,360	1,639	16,000	16,000	6,326	6,326	13,117	37	37
Heterotrophs	16	14	30	30	335	365	365	139	139	275,238	784	784
Methanol Degraders	16	14	30	30	4	34	34	13	13	630	2	2
AOBs	14	13	27	27	77	104	104	40	40	13,413	38	38
NOBs	14	13	27	27	4	31	31	12	12	0	0	0
PAOs	8	8	16	16	3	19	19	6	6	1,460	4	4
PHA	1	1	2	2	0	2	2	1	1	116	0	0
Filtrate	4,843	5,059	9,902	9,902	113	10,015	10,015	9,406	9,406	145	82	82
COD (lbs/day)	33,640	29,026	62,665	62,665	7,526	70,192	70,192	41,310	41,310	969,953	8,633	8,633
Particulate Bio	14,089	10,896	24,985	24,985	2,805	27,789	27,789	10,987	10,987	22,821	65	65
Particulate Non-Bio	3,950	5,100	9,050	9,050	2,719	11,770	11,770	4,567	4,567	285,128	812	812
Decay Prod Aer/Anx	1,702	2,194	3,896	3,896	750	4,646	4,646	1,775	1,775	261,167	744	744
Decay Prod Anaerobic	0	0	0	0	48	48	48	18	18	1	0	0
Heterotrophs	21	19	40	40	444	484	484	185	185	365,398	1,040	1,040
Methanol Degraders	21	19	40	40	5	45	45	17	17	836	2	2
AOBs	21	19	40	40	113	152	152	58	58	19,696	56	56
NOBs	21	19	40	40	6	45	45	17	17	0	0	0
PAOs	21	19	40	40	9	49	49	19	19	4,207	12	12
PHA	2	2	5	5	1	5	5	2	2	266	1	1
Soluble Bio	1,964	3,729	5,694	5,694	68	5,761	5,761	5,680	5,680	235	133	133
VFA	316	576	891	891	12	904	904	891	891	11	6	6
Colloidal Bio	5,980	4,485	10,465	10,465	113	10,578	10,578	9,472	9,472	0	0	0
Soluble Non-Bio	4,037	1,451	5,488	5,488	413	5,901	5,901	5,817	5,817	10,185	5,761	5,761
Colloidal Non-Bio	1,495	498	1,993	1,993	21	2,014	2,014	1,804	1,804	0	0	0
TSS (lbs/day)	14,962	14,799	29,761	29,761	5,772	35,533	35,533	14,213	14,213	835,036	2,378	2,378
Biodegradable	10,274	8,523	18,797	18,797	2,108	20,905	20,905	8,257	8,257	17,209	49	49
Non-Biodegradable	3,107	3,991	7,098	7,098	2,122	9,220	9,220	3,578	3,578	223,358	636	636
Inorganic Particles	103	437	540	540	122	662	662	246	246	15,353	44	44
Decay Prod Aer/Anx	1,332	1,717	3,048	3,048	587	3,635	3,635	1,389	1,389	204,356	582	582
Decay Prod Anaerobic	0	0	0	0	37	37	37	14	14	1	0	0
Metal Hydroxide	58	52	110	110	197	308	308	342	342	37,796	108	108
Metal Absorbed Phosphate	0	0	0	0	135	135	135	146	146	30,778	88	88
Heterotrophs	16	15	31	31	348	379	379	145	145	285,914	814	814
Methanol Degraders	16	15	31	31	4	35	35	13	13	654	2	2
AOBs	16	15	31	31	88	119	119	45	45	15,412	44	44
NOBs	16	15	31	31	16	47	47	18	18	0	0	0
PAOs	16	15	31	31	7	38	38	15	15	3,292	9	9
PHA	1	1	3	3	0	3	3	1	1	160	0	0
Poly-P	5	4	9	9	2	11	11	4	4	754	2	2
VSS (lbs/day)	13,316	12,888	26,205	26,205	4,832	31,036	31,036	12,207	12,207	684,895	1,950	1,950
Biodegradable	9,246	7,671	16,917	16,917	1,897	18,815	18,815	7,431	7,431	15,488	44	44
Non-Biodegradable	2,782	3,592	6,374	6,374	1,916	8,289	8,289	3,216	3,216	201,022	572	572
Decay Prod Aer/Anx	1,198	1,545	2,743	2,743	528	3,272	3,272	1,250	1,250	183,920	524	524
Decay Prod Anaerobic	0	0	0	0	34	34	34	13	13	1	0	0
Metal Hydroxide	15	13	28	28	50	78	78	87	87	9,559	27	27
Heterotrophs	15	13	28	28	313	341	341	130	130	257,323	733	733
Methanol Degraders	15	13	28	28	4	31	31	12	12	589	2	2
AOBs	15	13	28	28	79	107	107	41	41	13,871	39	39
NOBs	15	13	28	28	4	32	32	12	12	0	0	0
PAOs	15	13	28	28	6	34	34	13	13	2,963	8	8
PHA	1	1	3	3	0	3	3	1	1	160	0	0
TKN (lbs/day)	2,277	2,244	4,521	4,521	392	4,913	4,913	4,106	4,106	47,395	592	592
NH_3-N (lbs-N/day)	1,561	1,214	2,775	2,775	154	2,929	2,929	2,888	2,888	146	82	82
Particulate Bio Org N	187	342	529	529	63	592	592	234	234	477	1	1
Non-Bio Part Org N	52	160	212	212	64	276	276	107	107	6,660	19	19
Decay Prod Aer/Anx	103	133	236	236	45	281	281	108	108	15,817	45	45
Decay Prod Anaerobic	0	0	0	0	3	3	3	1	1	0	0	0
Heterotrophs	1	1	2	2	27	29	29	11	11	22,130	63	63
Methanol Degraders	1	1	2	2	0	3	3	1	1	51	0	0
AOBs	1	1	2	2	7	9	9	4	4	1,193	3	3
NOBs	1	1	2	2	0	3	3	1	1	0	0	0
PAOs	1	1	2	2	1	3	3	1	1	255	1	1
Non-Bio Soluble Org. N	242	116	358	358	24	383	383	377	377	660	374	374
Non-Bio Colloidal Org. N	20	16	35	35	0	36	36	32	32	0	0	0
Soluble Bio Org N	26	117	143	143	2	145	145	143	143	6	3	3
Colloidal Bio Org N	79	141	220	220	2	222	222	199	199	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	0	0	0	0	70	70	70	69	69	1,524	862	862
Total Nitrogen (lbs-N/day)	2,277	2,244	4,521	4,521	463	4,984	4,984	4,175	4,175	48,919	1,454	1,454
TP (lbs-P/day)	254	258	512	512	236	748	748	439	439	25,298	106	106
Bio Particulate	88	73	161	161	18	179	179	68	68	70	0	0
Non-Bio Particulate	26	34	61	61	18	78	78	30	30	1,869	5	5
Decay Prod Aer/Anx	34	44	78	78	15	93	93	36	36	5,223	15	15
Decay Prod Anaerobic	0	0	0	0	1	1	1	0	0	0	0	0
Metal Absorbed	0	0	0	0	44	44	44	48	48	10,038	29	29
Heterotrophs	0	0	1	1	9	10	10	4	4	7,308	21	21
Methanol Degraders	0	0	1	1	0	1	1	0	0	17	0	0
AOBs	0	0	1	1	2	3	3	1	1	394	1	1
NOBs	0	0	1	1	0	1	1	0	0	0	0	0
PAOs	0	0	1	1	0	1	1	0	0	84	0	0
Poly-P	1	1	3	3	1	3	3	1	1	233	1	1
Ortho-PO4	102	104	206	206	128	334	334	250	250	60	34	34
Alkalinity (lbs/day as $CaCO_3$)	20,863	18,776	39,639	39,639	1,518	41,157	41,157	39,755	39,755	48,505	27,439	27,439
H_2S (lbs/day)	501	451	951	951	0	951	951	0	0	0	0	0
Temperature (°C)	14	14	14	14	17	14	14	14	14	14	14	14
BOD_5 (mg/L)	156	152	154	154	562	164	164	100	100	1,085	6	6
COD (mg/L)	403	386	395	395	1,945	432	432	258	258	3,461	54	54
TSS (mg/L)	179	197	188	188	1,492	219	219	89	89	2,980	15	15
VSS (mg/L)	160	171	165	165	1,249	191	191	76	76	2,444	12	12
TKN (mg-N/L)	27	30	29	29	101	30	30	26	26	169	4	3.73
NH_3-N (mg-N/L)	19	16	18	18	40	18	18	18	18	1	1	0.52
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0.00
NO_3-N (mg-N/L)	0	0	0	0	18	0	0	0	0	5	5	5.44
Total Nitrogen (mg/L)	27	30	29	29	120	31	31	26	26	175	9	9.17
TP (mg-P/L)	3	3	3	3	61	5	5	3	3	90	1	0.67
Alkalinity (mg/L as $CaCO_3$)	250	250	250	250	392	253	253	248	248	173	173	173
H_2S (mg/L)	6	6	6	6	0	6	6	0	0	0	0	0

Constituent	Main Primary Sludge (PSD)	Main WAS	Gravity Primary Sludge Thickener Influent (PSTI)	Gravity Thickened Primary Sludge (PST)	GBT WAS Thickener Influent (TWASI)	GBT Thickened WAS (TWAS)	FOG Other Influent (OInf)	BRM_TWAS Other Influent (OInf)	NCAC_TWAS Other Influent (OInf)	Sludge Combined Discharge	Meso Anaerobic Digester Influent (AnDI)	Meso Anaerobic Digester Effluent (AnDE)	BFP Dewatering Influent (DWI)	BFP Dewatered Sludge (DWE)	Anitamox Deammonification Waste (DeammonSt)
Flow (gallons/day)	275,683	192,617	275,683	52,092	192,617	24,248	1,000	1,000	1,000	79,340	79,340	79,340	79,340	7,620	31,060
Carbonaceous BOD_5 (lbs/day)	10,708	4,004	10,708	9,012	4,004	3,683	2	2	2	12,701	12,701	1,773	1,773	1,583	142
Particulate	10,231	173	10,231	8,697	173	159	1	1	1	8,859	8,859	1,714	1,714	1,577	82
Heterotrophs	225	3,625	225	192	3,625	3,335	0	0	0	3,527	3,527	0	0	0	10
Methanol Degraders	21	8	21	18	8	8	0	0	0	25	25	0	0	0	0
AOBs	64	177	64	54	177	163	0	0	0	217	217	0	0	0	48
NOBs	19	0	19	16	0	0	0	0	0	16	16	0	0	0	1
PAOs	10	19	10	9	19	18	0	0	0	27	27	0	0	0	0
PHA	1	2	1	1	2	1	0	0	0	3	3	0	0	0	0
Filtrate	135	1	135	26	1	0	1	1	1	27	27	59	59	6	1
COD (lbs/day)	28,882	12,698	28,882	24,325	12,698	11,634	4	4	4	35,971	35,971	19,668	19,668	17,744	1,576
Particulate Bio	17,772	301	17,772	15,106	301	276	2	2	2	15,389	15,389	2,446	2,446	2,250	104
Particulate Non-Bio	7,387	3,755	7,387	6,279	3,755	3,455	0	0	0	9,735	9,735	16,260	16,260	14,959	1,182
Decay Prod Aer/Anx	2,871	3,440	2,871	2,440	3,440	3,165	0	0	0	5,606	5,606	0	0	0	38
Decay Prod Anaerobic	29	0	29	25	0	0	0	0	0	25	25	536	536	494	39
Heterotrophs	299	4,813	299	254	4,813	4,428	0	0	0	4,682	4,682	0	0	0	13
Methanol Degraders	28	11	28	23	11	10	0	0	0	34	34	0	0	0	0
AOBs	94	259	94	80	259	239	0	0	0	319	319	0	0	0	70
NOBs	28	0	28	24	0	0	0	0	0	24	24	0	0	0	1
PAOs	30	55	30	26	55	51	0	0	0	77	77	0	0	0	0
PHA	3	4	3	3	4	3	0	0	0	6	6	0	0	0	0
Soluble Bio	82	1	82	15	1	0	0	0	0	17	17	9	9	1	0
VFA	13	0	13	2	0	0	0	0	0	3	3	43	43	4	1
Colloidal Bio	136	0	136	26	0	0	0	0	0	27	27	49	49	5	1
Soluble Non-Bio	84	58	84	16	58	7	0	0	0	24	24	325	325	31	127
Colloidal Non-Bio	26	0	26	5	0	0	0	0	0	5	5	0	0	0	0
TSS (lbs/day)	23,007	10,998	23,007	19,563	10,998	10,118	2	2	2	29,687	29,687	17,281	17,281	15,898	1,296
Biodegradable	13,355	227	13,355	11,352	227	208	1	1	1	11,564	11,564	1,838	1,838	1,691	78
Non-Biodegradable	5,787	2,942	5,787	4,919	2,942	2,706	0	0	0	7,626	7,626	12,729	12,729	11,710	925
Inorganic Particles	416	202	416	353	202	186	0	0	0	540	540	540	540	497	37
Decay Prod Aer/Anx	2,246	2,692	2,246	1,909	2,692	2,476	0	0	0	4,386	4,386	0	0	0	31
Decay Prod Anaerobic	23	0	23	19	0	0	0	0	0	19	19	420	420	386	31
Metal Hydroxide	554	498	554	471	498	458	0	0	0	929	929	929	929	854	67
Metal Absorbed Phosphate	236	405	236	208	405	373	0	0	0	580	580	825	825	759	60
Heterotrophs	234	3,766	234	199	3,766	3,464	0	0	0	3,663	3,663	0	0	0	10
Methanol Degraders	22	9	22	18	9	8	0	0	0	26	26	0	0	0	0
AOBs	73	203	73	62	203	187	0	0	0	249	249	0	0	0	55
NOBs	29	0	29	25	0	0	0	0	0	25	25	0	0	0	1
PAOs	23	43	23	20	43	40	0	0	0	60	60	0	0	0	0
PHA	2	2	2	2	2	2	0	0	0	4	4	0	0	0	0
Poly-P	7	10	7	6	10	9	0	0	0	15	15	0	0	0	0
VSS (lbs/day)	19,744	9,021	19,744	16,783	9,021	8,299	2	2	2	25,087	25,087	13,723	13,723	12,625	1,034
Biodegradable	12,020	204	12,020	10,217	204	188	1	1	1	10,408	10,408	1,654	1,654	1,522	70
Non-Biodegradable	5,203	2,648	5,203	4,422	2,648	2,436	0	0	0	6,859	6,859	11,456	11,456	10,539	833
Decay Prod Aer/Anx	2,022	2,422	2,022	1,719	2,422	2,229	0	0	0	3,948	3,948	0	0	0	27
Decay Prod Anaerobic	21	0	21	18	0	0	0	0	0	18	18	378	378	348	27
Metal Hydroxide	140	126	140	119	126	116	0	0	0	235	235	235	235	216	17
Heterotrophs	211	3,389	211	179	3,389	3,118	0	0	0	3,297	3,297	0	0	0	9
Methanol Degraders	19	8	19	17	8	7	0	0	0	24	24	0	0	0	0
AOBs	66	183	66	56	183	168	0	0	0	224	224	0	0	0	49
NOBs	20	0	20	17	0	0	0	0	0	17	17	0	0	0	1
PAOs	21	39	21	18	39	36	0	0	0	54	54	0	0	0	0
PHA	2	2	2	2	2	2	0	0	0	4	4	0	0	0	0
TKN (lbs/day)	808	618	808	652	618	565	0	0	0	1,218	1,218	1,218	1,218	562	101
NH_3-N (lbs-N/day)	41	1	41	8	1	0	0	0	0	9	9	659	659	63	52
Particulate Bio Org N	378	6	378	321	6	6	0	0	0	327	327	128	128	118	5
Non-Bio Part Org N	173	88	173	147	88	81	0	0	0	227	227	380	380	349	28
Decay Prod Aer/Anx	174	208	174	148	208	192	0	0	0	339	339	0	0	0	2
Decay Prod Anaerobic	2	0	2	2	0	0	0	0	0	2	2	32	32	30	2
Heterotrophs	18	291	18	15	291	268	0	0	0	284	284	0	0	0	1
Methanol Degraders	2	1	2	1	1	1	0	0	0	2	2	0	0	0	2
AOBs	6	16	6	5	16	14	0	0	0	19	19	0	0	0	4
NOBs	2	0	2	1	0	0	0	0	0	1	1	0	0	0	0
PAOs	2	3	2	2	3	3	0	0	0	5	5	0	0	0	0
Non-Bio Soluble Org. N	5	4	5	1	4	0	0	0	0	2	2	18	18	2	7
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soluble Bio Org N	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Colloidal Bio Org N	3	0	3	1	0	0	0	0	0	1	1	0	0	0	0
NO_2-N (lbs-N/day)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (lbs-N/day)	1	9	1	0	9	1	0	0	0	1	1	0	0	0	27
Total Nitrogen (lbs-N/day)	809	627	809	652	627	566	0	0	0	1,219	1,219	1,218	1,218	562	128
TP (lbs-P/day)	309	333	309	262	333	306	0	0	0	568	568	568	568	408	87
Bio Particulate	111	1	111	94	1	1	0	0	0	95	95	42	42	38	2
Non-Bio Particulate	48	25	48	41	25	23	0	0	0	64	64	107	107	98	8
Decay Prod Aer/Anx	57	69	57	49	69	63	0	0	0	112	112	0	0	0	1
Decay Prod Anaerobic	1	0	1	1	0	0	0	0	0	1	1	11	11	10	1
Metal Absorbed	77	132	77	68	132	122	0	0	0	189	189	269	269	248	19
Heterotrophs	6	96	6	5	96	89	0	0	0	94	94	0	0	0	0
Methanol Degraders	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0
AOBs	2	5	2	2	5	5	0	0	0	6	6	0	0	0	1
NOBs	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PAOs	1	1	1	1	1	1	0	0	0	2	2	0	0	0	0
Poly-P	2	3	2	2	3	3	0	0	0	5	5	0	0	0	0
Ortho-PO4	4	0	4	0	0	0	0	0	0	0	0	140	140	13	55
Alkalinity (lbs/day as $CaCO_3$)	571	278	571	108	278	35	2	2	2	149	149	2,438	2,438	234	351
H_2S (lbs/day)	0	0	0	0	0	0	0	0	0	0	0	33	33	3	0
Temperature (°C)	14	14	14	14	14	14	20	20	20	14	14	35	35	35	35
BOD_5 (mg/L)	4,654	2,491	4,654	20,731	2,491	18,202	220	220	220	19,182	19,182	2,678	2,678	24,886	547
COD (mg/L)	12,553	7,899	12,553	55,953	7,899	57,491	501	501	501	54,327	54,327	29,705	29,705	279,019	6,080
TSS (mg/L)	10,000	6,842	10,000	45,000	6,842	50,000	250	250	250	44,836	44,836	26,099	26,099	250,000	5,000
VSS (mg/L)	8,582	5,612	8,582	38,605	5,612	41,010	200	200	200	37,888	37,888	20,725	20,725	198,524	3,988
TKN (mg-N/L)	351	385	351	1,500	385	2,792	39	39	39	1,839	1,839	1,839	1,839	8,840	391
NH_3-N (mg-N/L)	18	1	18	18	1	1	30	30	30	13	13	995	995	995	200
NO_2-N (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	5	0	0	5	5	0	0	0	2	2	0	0	0	104
Total Nitrogen (mg/L)	351	390	351	1,500	390	2,798	39	39	39	1,841	1,841	1,839	1,839	8,840	495
TP (mg-P/L)	135	207	135	604	207	1,511	8	8	8	858	858	858	858	6,408	336
Alkalinity (mg/L as $CaCO_3$)	248	173	248	248	173	173	250	250	250	225	225	3,682	3,682	3,682	1,355
H_2S (mg/L)	0	0	0	0	0	0	6	6	6	0	0	50	50	50	0

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DRY 3 - CAS w/ ChemP Max Month

Mass Balance for Max Month Condition 7.949181132

Constituent	Biosolids to Disposal	Gravity Primary Sludge Thickening Recycle (PSTR)	GBT WAS Thickening Recycle (TWASR)	BFP Dewatering Recycle (DWR)	Anitamox Deammonification Influent (DeammonI)	Anitamox Deammonification Effluent (DeammonE)	AMX_OF Combined Discharge	Recy Combined Discharge
Flow (gallons/day)	7,620	223,592	168,368	71,720	71,720	40,659	71,720	463,680
Carbonaceous BOD_5 (lbs/day)	1,583	1,695	321	191	191	17	159	2,175
Particulate	1,577	1,535	14	137	137	9	91	1,639
Heterotrophs	0	34	290	0	0	1	11	335
Methanol Degraders	0	3	1	0	0	0	0	4
AOBs	0	10	14	0	0	5	53	77
NOBs	0	3	0	0	0	0	1	4
PAOs	0	2	2	0	0	0	0	3
PHA	0	0	0	0	0	0	0	0
Filtrate	6	110	1	53	53	2	3	113
COD (lbs/day)	17,744	4,557	1,063	1,925	1,925	330	1,906	7,526
Particulate Bio	2,250	2,666	24	196	196	11	115	2,805
Particulate Non-Bio	14,959	1,108	300	1,301	1,301	129	1,311	2,719
Decay Prod Aer/Anx	0	431	275	0	0	7	45	750
Decay Prod Anaerobic	494	4	0	43	43	4	43	48
Heterotrophs	0	45	385	0	0	1	15	444
Methanol Degraders	0	4	1	0	0	0	0	5
AOBs	0	14	21	0	0	8	78	113
NOBs	0	4	0	0	0	0	2	6
PAOs	0	5	4	0	0	0	0	9
PHA	0	1	0	0	0	0	0	1
Soluble Bio	1	66	1	8	8	0	0	68
VFA	4	10	0	39	39	1	2	12
Colloidal Bio	5	110	0	44	44	1	2	113
Soluble Non-Bio	31	68	51	294	294	167	294	413
Colloidal Non-Bio	0	21	0	0	0	0	0	21
TSS (lbs/day)	15,898	3,452	880	1,382	1,382	144	1,440	5,772
Biodegradable	1,691	2,003	18	147	147	8	86	2,108
Non-Biodegradable	11,710	868	235	1,018	1,018	93	1,018	2,122
Inorganic Particles	497	62	16	43	43	6	43	122
Decay Prod Aer/Anx	0	337	215	0	0	3	35	587
Decay Prod Anaerobic	386	3	0	34	34	3	34	37
Metal Hydroxide	854	83	40	74	74	7	74	197
Metal Absorbed Phosphate	759	37	32	66	66	6	66	135
Heterotrophs	0	35	301	0	0	1	11	348
Methanol Degraders	0	3	1	0	0	0	0	4
AOBs	0	11	16	0	0	6	60	88
NOBs	0	4	0	0	0	11	12	16
PAOs	0	4	3	0	0	0	0	7
PHA	0	0	0	0	0	0	0	0
Poly-P	0	1	1	0	0	0	0	2
VSS (lbs/day)	12,625	2,962	722	1,098	1,098	115	1,149	4,832
Biodegradable	1,522	1,803	16	132	132	8	78	1,897
Non-Biodegradable	10,539	780	212	916	916	91	923	1,916
Decay Prod Aer/Anx	0	303	194	0	0	5	31	528
Decay Prod Anaerobic	348	3	0	30	30	3	30	34
Metal Hydroxide	216	21	10	19	19	2	19	50
Heterotrophs	0	32	271	0	0	1	10	313
Methanol Degraders	0	3	1	0	0	0	0	4
AOBs	0	10	15	0	0	5	55	79
NOBs	0	3	0	0	0	0	1	4
PAOs	0	3	3	0	0	0	0	6
PHA	0	0	0	0	0	0	0	0
TKN (lbs/day)	562	156	53	656	656	82	183	392
NH_3-N (lbs-N/day)	63	34	1	596	596	68	120	154
Particulate Bio Org N	118	57	1	10	10	1	6	63
Non-Bio Part Org N	349	26	7	30	30	3	31	64
Decay Prod Aer/Anx	0	26	17	0	0	0	3	45
Decay Prod Anaerobic	30	0	0	3	3	0	3	3
Heterotrophs	0	3	23	0	0	0	1	27
Methanol Degraders	0	0	0	0	0	0	0	0
AOBs	0	1	1	0	0	0	5	7
NOBs	0	0	0	0	0	0	0	0
PAOs	0	0	0	0	0	0	0	1
Non-Bio Soluble Org. N	2	4	3	17	17	9	17	24
Non-Bio Colloidal Org. N	0	0	0	0	0	0	0	0
Soluble Bio Org N	0	2	0	0	0	0	0	2
Colloidal Bio Org N	0	2	0	0	0	0	0	2
NO_3-N (lbs-N/day)	0	0	0	0	0	0	0	0
NO_2-N (lbs-N/day)	0	1	8	0	0	35	62	70
Total Nitrogen (lbs-N/day)	562	157	61	656	656	117	246	463
TP (lbs-P/day)	408	47	27	161	161	75	162	236
Bio Particulate	38	17	0	3	3	0	2	18
Non-Bio Particulate	98	7	2	9	9	1	9	18
Decay Prod Aer/Anx	0	9	6	0	0	0	1	15
Decay Prod Anaerobic	10	0	0	1	1	0	1	1
Metal Absorbed	248	12	11	22	22	2	22	44
Heterotrophs	0	1	8	0	0	0	0	9
Methanol Degraders	0	0	0	0	0	0	0	0
AOBs	0	0	0	0	0	0	2	2
NOBs	0	0	0	0	0	0	0	0
PAOs	0	0	0	0	0	0	0	0
Poly-P	0	0	0	0	0	0	0	1
Ortho-PO4	13	1	0	127	127	72	127	128
Alkalinity (lbs/day as $CaCO_3$)	234	463	243	2,204	2,204	460	811	1,518
H_2S (lbs/day)	3	0	0	30	30	0	0	0
Temperature (°C)	35	14	14	35	35	35	35	17
BOD_5 (mg/L)	24,886	909	228	318	318	50	265	562
COD (mg/L)	279,019	2,442	757	3,216	3,216	972	3,184	1,945
TSS (mg/L)	250,000	1,850	626	2,310	2,310	424	2,406	1,492
VSS (mg/L)	198,524	1,587	514	1,834	1,834	338	1,919	1,249
TKN (mg-N/L)	8,840	83	38	1,096	1,096	241	306	101
NH_3-N (mg-N/L)	995	18	1	995	995	200	200	40
NO_2-N (mg/L)	0	0	0	0	0	0	0	0
NO_3-N (mg-N/L)	0	0	5	0	0	104	104	18
Total Nitrogen (mg/L)	8,840	84	43	1,096	1,096	345	410	120
TP (mg-P/L)	6,408	25	19	269	269	222	271	61
Alkalinity (mg/L as $CaCO_3$)	3,682	248	173	3,682	3,682	1,355	1,355	392
H_2S (mg/L)	50	0	0	50	50	0	0	0

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Appendix B: Non-Economic Scoring Criteria

Appendix B:

Table B.1: Dry Weather Criteria Weighting Validation

Criterion	Original Weighting			Validated Weighting		
	Total Scores	Weighting Percentage	Relative Weights	Total Scores	Weighting Percentage	Relative Weights
Flexibility/Performance Risk	48	15.6%	2.29	48	13.5%	1.60
Adaptability/Phasing	42	13.6%	2.00	42	11.8%	1.40
Proven Experience	31	10.1%	1.48	31	8.7%	1.03
Staffing/Multiple Processes	21	6.8%	1.00	**42**	11.8%	1.40
Land Requirements	51	16.6%	2.43	**30**	8.5%	1.00
Sludge/Solids Impacts	33	10.7%	1.57	33	9.3%	1.10
Social Impacts	47	15.3%	2.24	47	13.2%	1.57
Safety	35	11.4%	1.67	**47**	13.2%	1.57
Environmental	NA	NA	NA	**35**	9.9%	1.17
TOTALS	**308**	**100%**		**355**	**100%**	

Note: Red text represents modified value

Table B.2: Dry Weather Alternative Scoring Modifications

Alternative	Flexibility/ Performance Risk	Adaptability/ Phasing	Proven Experience	Staffing/Multiple Processes	Land Requirements	Sludge/Solids Impacts	Social Impacts	Safety	Environmental	Unweighted Total Score	Unweighted Rank	Weighted Total Score	Weighted Rank
Dry 1 – CAS w/ EBPR	3	4	7	5	**4** (2)	**4** (6)	4	7	**7**	**45** (38)	3	**58.43** (65.10)	3
Dry 2 – IFAS w/ EBPR	7	4	4	4	6	**3** (5)	4	7	**7**	**46** (41)	2	**61.23** (76.95)	**Tie** (2)
Dry 3 – CAS w/ ChemP	5	6	7	6	**5** (7)	**6** (3)	**6** (8)	3	**3**	**47** (45)	1	**61.23** (84.38)	**Tie** (1)

Note: Red text represents modified value. Values contained in parenthesis represent the original score.

Table B.3: Wet Weather Criteria Weighting Validation

Criterion	Total Scores	Weighting Percentage	Relative Weights	Notes
Flexibility/Performance Risk	20	**11.5** (11.3%)	**1** (20.0)	For wet weather alternatives, was considered lower priority than proven experience. Score lowered accordingly.
Adaptability/Phasing	51	**29.3** (28.8%)	**2.6** (51.0)	With unknowns on magnitude and timing of future wet weather flows arriving at WWTF, adaptability and phasing capability is more important for these alternatives
Proven Experience	31	**17.8** (17.5%)	**1.6** (31.0)	
Staffing/Multiple Processes	21	**12.1** (11.9%)	**1.1** (21.0)	
Land Requirements	51	**29.3** (28.8%)	**2.6** (51.0)	
Sludge/Solids Impacts	**0**	**0** (0.6%)	**0** (1.0)	Not considered a decision factor for wet weather facilities that operate only occasionally
Social Impacts	**0**	**0** (0.6%)	**0** (1.0)	Not considered a decision factor for wet weather facilities that operate only occasionally
Safety	**0**	**0** (0.6%)	**0** (1.0)	Not considered a decision factor for wet weather facilities that operate only occasionally
TOTALS	174(177)	**100** (100%)		

Note: Red text represents modified value. Values contained in parenthesis represent the original score.

Table B.4: Wet Weather Alternative Scoring Modifications

Alternative	Flexibility/ Performance Risk	Adaptability/ Phasing	Proven Experience	Staffing/Multiple Processes	Land Requirements	Sludge/Solids Impacts	Social Impacts	Safety	Unweighted Total Score	Unweighted Rank	Weighted Total Score	Weighted Rank
Wet 1 - Disc Filters	8	9	8	8	6	0	0	0	39	1	**67.1** (1341.0)	1
Wet 3 - CEPT	3	2	2	6	4	0	0	0	17	3	**27.7** (554.0)	3
Wet 4 - Ballasted Floc	8	9	8	3	6	0	0	0	34	2	**61.8** (1236.0)	2

Values contained in parenthesis represent the original score.

Appendix C: Detailed Opinion of Costs

Johson County Wastewater Nelscon Complex

		Estimator:	Colin Fitzgerald/DEN
Phase:	4 - Alternatives Evaluation	STC:	Bill Leaf/BOI
Alternative:	Dry 1: CAS + EBPR	Date:	11/9/2018

Construction

Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Screening and Grit	1	7403000	$ 7,403,000	6 mm Screens (3 duty, 1 standby), Vortex Grit (2), appurtenances	CPES
Primary Sludge Pumping	1	956000	$ 956,000	4 Duty (2 standby) @ 15 HP Primary Sludge Pump Station	CPES
Primary Clarifiers	1	5001000	$ 5,001,000	4 @ 85' diameter, 18' deep	CPES
Secondary Clarifiers	1	7062000	$ 7,062,000	4 @ 121' diameter, 16' deep	CPES
Chlorine Contact Basin	1	487000	$ 487,000	2 trains @ combined 30 min CT, 15 min HRT @ 52mgd	CPES
Disinfection Chemical Storage	1	2011000	$ 2,011,000	15 days (average day), 2@6,000 gallons NaOCl, 2@ 4,000 gallons NaHSO3	CPES
Aeration Basin	1	12679000	$ 12,679,000	4 Trains @ 1.875MG/Each, NMLR Pumps, mixers, etc.	CPES
Blower Building	1	4039000	$ 4,039,000	5 PD blowers (4 duty, 1 standby), 420 HP Each	CPES
RAS/WAS PS	1	3540000	$ 3,540,000	6 RAS Pumps (4-duty), 6 WAS Pumps (4-duty)	CPES
Fermenter	1	1512000	$ 1,512,000	1 @ 65' diameter	CPES
WAS Thickening	1	4636000	$ 4,636,000	Gravity Belt Thickeners (2-duty, 1 standby)	CPES
Ferric Chloride Feed/Storage	1	441000	$ 441,000	2 Tanks@ 3,500 gallons each, 6 chemical feed pumps	CPES
Sitework	1	9%	$ 4,479,030	General Sitework Markup	
SCADA	1	9%	$ 4,479,030	Global SCADA, insturments included in unit processes	
Yard Electrical/Wiring	1	10%	$ 4,976,700	Global electrical	
Yard Piping/Utilities	1	17%	$ 8,460,390	Process interconnections	
Other	1	0%	$ -		
Subtotal			$ 72,162,150		
Contractor Overhead	1	10%	$ 7,216,215		
Contractor Profit	1	5%	$ 3,968,918		
Contractor Mob., Bond, Insurance	1	3%	$ 2,500,418		
Project Contingency	1	40%	$ 34,339,081	Contingency	
Subtotal			**$ 120,186,782**		

Adjustments

Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Escalation				None	
Location				Adjustments for Location	
Site Conditions				Dewattering	
Subtotal			**$ -**		

Non-Construction Costs

Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Engineering	1	13%	$ 15,624,282		
Services During Construction	1	7%	$ 8,413,075		
Commissioning & Startup	1	3%	$ 3,605,603		
JCW Project Admin. Fee	1	1.5%	$ 1,802,802		JCW
Permitting	1	0.5%	$ 600,934		
Legal / Admin			$ -		
Other Default Description			$ -		
Subtotal			**$ 30,046,696**		

Total Costs

Component		*Extended Cost*	*Notes*	
Total Const./Non-Const.		**$ 150,240,000**		

Johson County Wastewater Nelscon Complex

		Estimator:	Colin Fitzgerald/DEN
Phase:	4 - Alternatives Evaluation	STC:	Bill Leaf/BOI
Alternative:	Dry 2: IFAS + EBPR	Date:	11/9/2018

Construction

Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Screening and Grit	1	7403000	$ 7,403,000	6 mm Screens (3 duty, 1 standby), Vortex Grit (2), appurtenances	CPES
Primary Sludge Pumping	1	956000	$ 956,000	4 Duty (2 standby) @ 15 HP Primary Sludge Pump Station	CPES
Primary Clarifiers	1	5001000	$ 5,001,000	4 @ 85' diameter, 18' deep	CPES
Secondary Clarifiers	1	7062000	$ 7,062,000	4 @ 121' diameter, 16' deep	CPES
Chlorine Contact Basin	1	487000	$ 487,000	2 trains @ combined 30 min CT, 15 min HRT @ 52mgd	CPES
Disinfection Chemical Storage	1	2011000	$ 2,011,000	15 days (average day), 2@6,000 gallons NaOCl, 2@ 4,000 gallons NaHSO3	CPES
Aeration Basin	1	15048000	$ 15,048,000	4 Trains @ 1.0 MG/Each, NMLR Pumps, IFAS K5 Media, mixers, etc.	CPES/Veolia
Blower Building	1	4342000	$ 4,342,000	5 PD blowers (4 duty, 1 standby), 500 HP Each	CPES
RAS/WAS PS	1	3585000	$ 3,585,000	6 RAS Pumps (4-duty), 6 WAS Pumps (4-duty)	CPES
Fermenter	1	1567000	$ 1,567,000	1 @ 65' diameter	CPES
WAS Thickening	1	4531000	$ 4,531,000	Gravity Belt Thickeners (2-duty, 1 standby)	CPES
Ferric Chloride Feed/Storage	1	441000	$ 441,000		CPES
Sitework	1	9%	$ 4,719,060	General Sitework Markup	
SCADA	1	9%	$ 4,719,060	Global SCADA, insturments included in unit processes	
Yard Electrical/Wiring	1	10%	$ 5,243,400	Global electrical	
Yard Piping/Utilities	1	17%	$ 8,913,780	Process interconnections	
Other	1	0%	$ -		
Subtotal			$ 76,029,300		
Contractor Overhead	1	10%	$ 7,602,930		
Contractor Profit	1	5%	$ 4,181,612		
Contractor Mob., Bond, Insurance	1	3%	$ 2,634,415		
Project Contingency	1	40%	$ 36,179,303	Contingency	
Subtotal			**$ 126,627,559**		

Adjustments

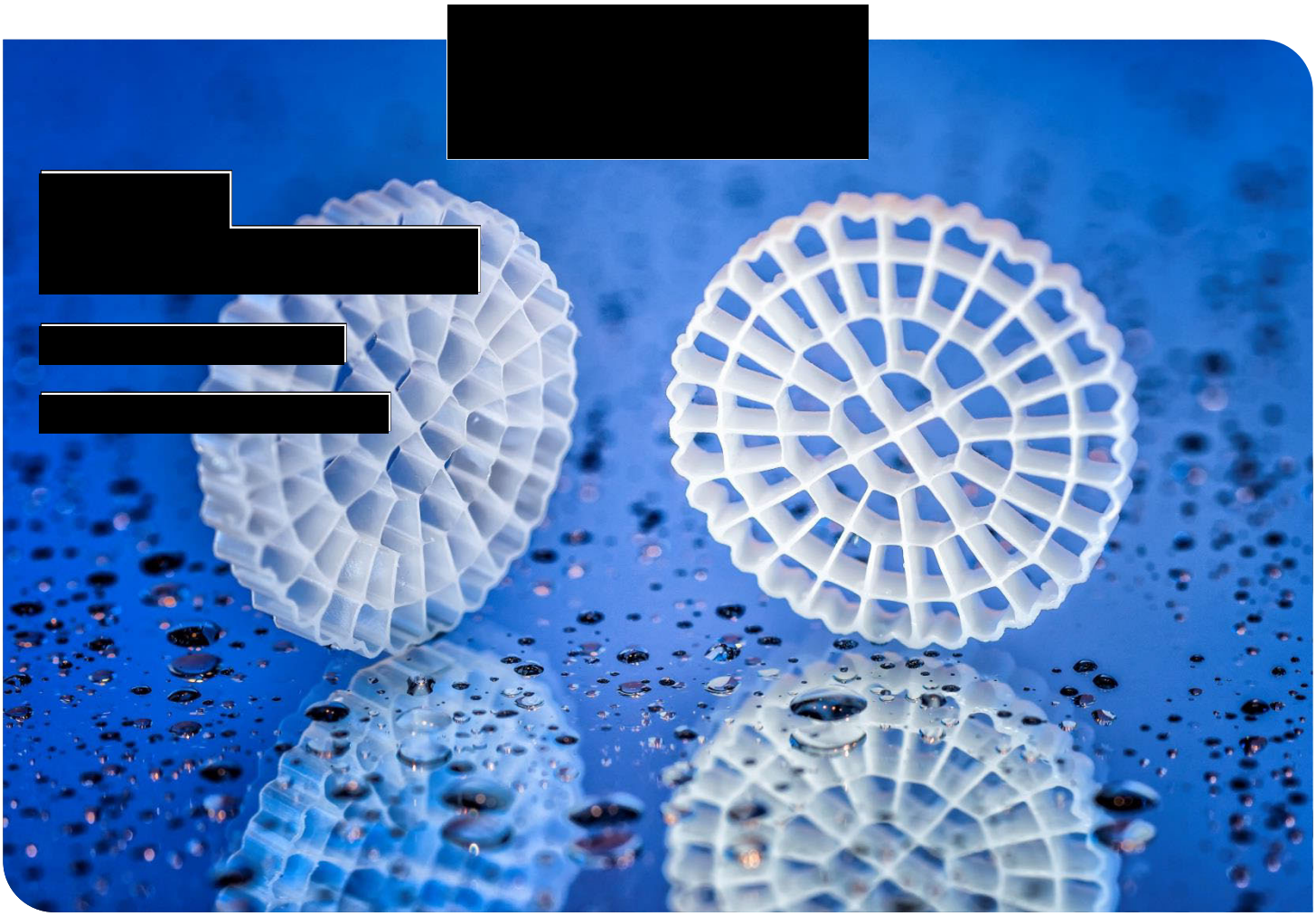
Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Escalation				None	
Location				Adjustments for Location	
Site Conditions				Dewattering	
Subtotal			**$ -**		

Non-Construction Costs

Component	*Units*	*Unit Cost*	*Extended Cost*	*Notes*	*Source*
Engineering	1	13%	$ 16,461,583		
Services During Construction	1	7%	$ 8,863,929		
Commissioning & Startup	1	3%	$ 3,798,827		
JCW Project Admin. Fee	1	1.5%	$ 1,899,413		JCW
Permitting	1	0.5%	$ 633,138		
Legal / Admin			$ -		
Other Default Description			$ -		
Subtotal			**$ 31,656,890**		

Total Costs

Component		*Extended Cost*	*Notes*	
Total Const./Non-Const.		**$ 158,290,000**		



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Appendix D: Auxiliary Treatment Design Conditions – V4

TECHNICAL MEMORANDUM

Appendix D - Auxiliary Treatment Design Conditions

PREPARED FOR: Brandon Coleman/HDR
Mike Kalis/HDR

COPY TO: Dale Gabel/CH2M, John Metzler/CH2M

PREPARED BY: Colin Fitzgerald/CH2M, Estell Johnson/CH2M

DATE: August 8, 2018

This Technical Memorandum proposes design conditions for the auxiliary treatment system at the Nelson Complex. The replacement plant is being sized to handle a peak hour flow (PHF) of 45 mgd. Flows above 45 mgd are to be treated through auxiliary treatment. The design PHF identified in TM#3 for future flows was 140 mgd; 95 mgd of which could be treated through auxiliary treatment at the Nelson Complex.

Turkey Creek and Mission Main Wet Weather Events

Peak Excess Flow Treatment Facility (PEFTF) discharges were analyzed to characterize wet weather events. Between 2014 through 2017 there was a total of 86 PEFTF discharges in the Turkey Creek system and 109 in the Mission Main system. For each PEFTF discharge event, the theoretical combined influent characteristics to the Nelson Complex was calculated assuming the PEFTF discharge volumes were sent to the Nelson Complex rather than being diverted to the PEFTFs. The combined influent characteristics were calculated by flow weighting the individual influents of the Mission Main Wastewater Treatment Facility (WWTF) and Turkey Creek WWTF utilizing the total flow in each collection system, which includes WWTF influent and PEFTF discharge flows. If influent data was not available for both influents, the data reported for the single influent was extended to the total plant flow. The resulting influent characteristics are represented in Table 1. BOD_5, TSS, and NH_3 during PEFTF discharges are further plotted against flow. In the figures, the flow represents the total flow to both the Turkey Creek WWTF and the Mission Main WWTF, as well as any flow sent to their respective PEFTFs.

Table 1: Mission Main and Turkey Creek WWTFs Flow Weighted Wet Weather Characteristics

Metric	pH (Field)	Temp (Field)	Alk	BOD_5	TSS	VSS	TKN	NH_3-N	TP	PO_4-P
	s.u.	*Deg C*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
Average	7.2	19.3	232	112.91	130	106	22.6	10.9	2.5	0.7
St. dev.	0.2	2.8	22	80.16	105	86	12.9	5.4	1.5	0.3
Min	6.7	12.5	196	0.00	0	0	5.8	2.1	0.0	0.0
5%	6.8	14.5	197	37.68	0	0	8.6	2.8	0.7	0.2
25%	7.0	16.7	213	56.00	65	53	12.3	3.8	1.2	0.3
50% (median)	7.2	18.0	232	90.82	110	84	16.9	7.4	1.8	0.4
75%	7.3	21.0	247	126.00	143	120	25.1	11.3	2.9	0.6
95%	7.6	23.1	262	263.60	311	251	49.6	18.1	5.6	1.0
Max	7.6	24.0	267	347.00	470	425	54.5	21.0	6.2	1.4

*Note: Flow weighting did not occur if data was not available for both influents

Figure 1: Flow Weighted Influent BOD_5

Total flow includes Turkey Creek WWTF, Mission main WWTF, and any PEFTF discharge

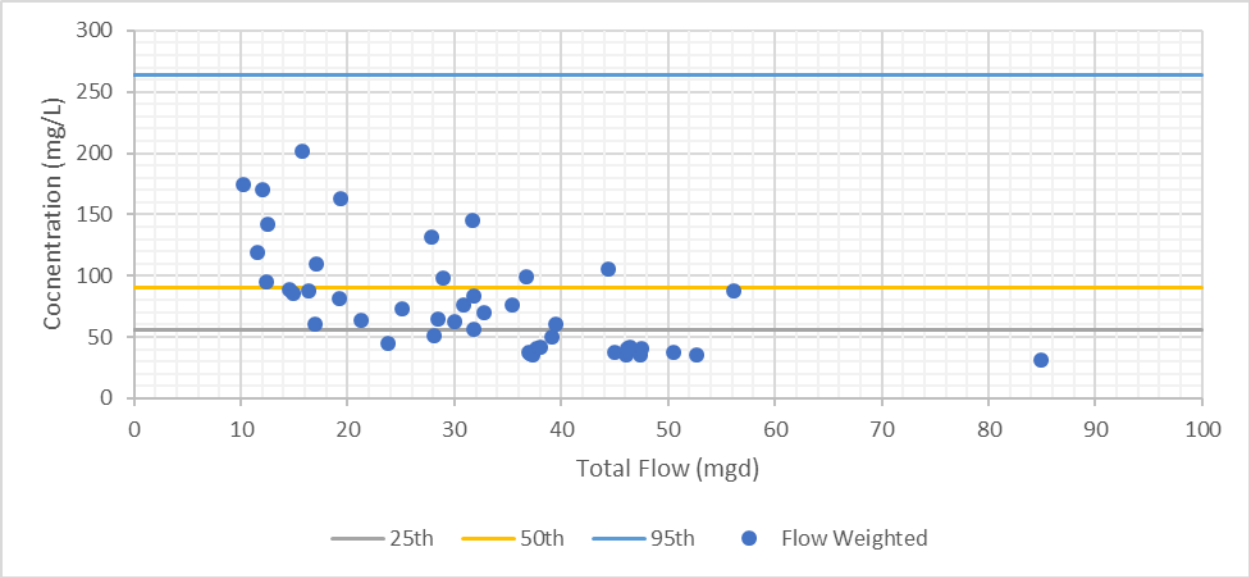


Figure 2: Flow Weighed Influent TSS

Total flow includes Turkey Creek WWTF, Mission main WWTF, and any PEFTF discharge

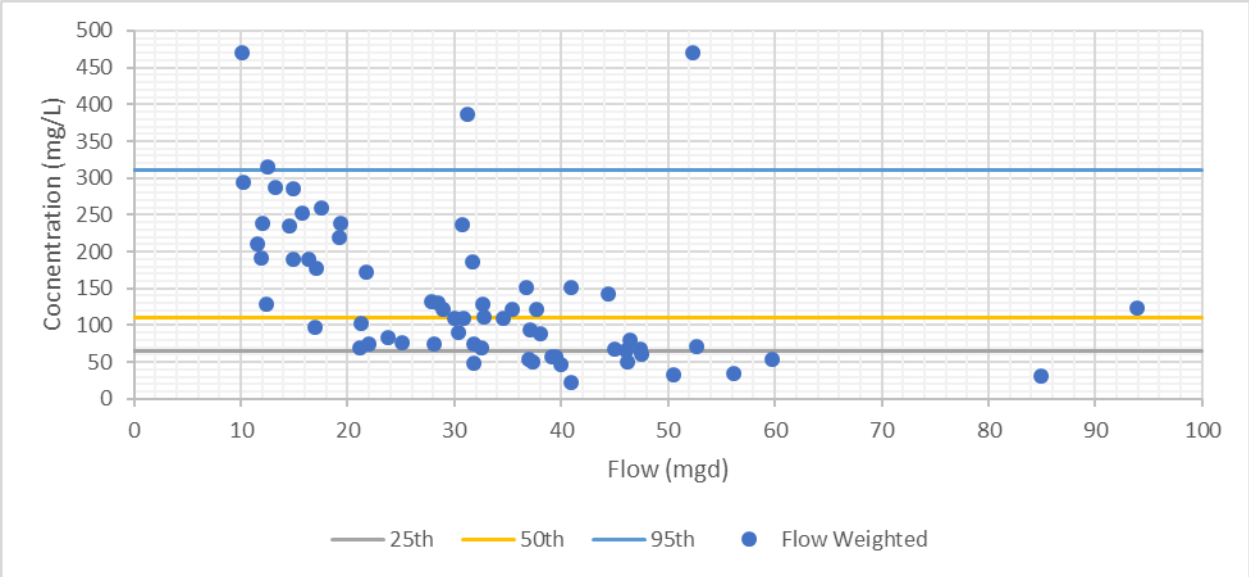
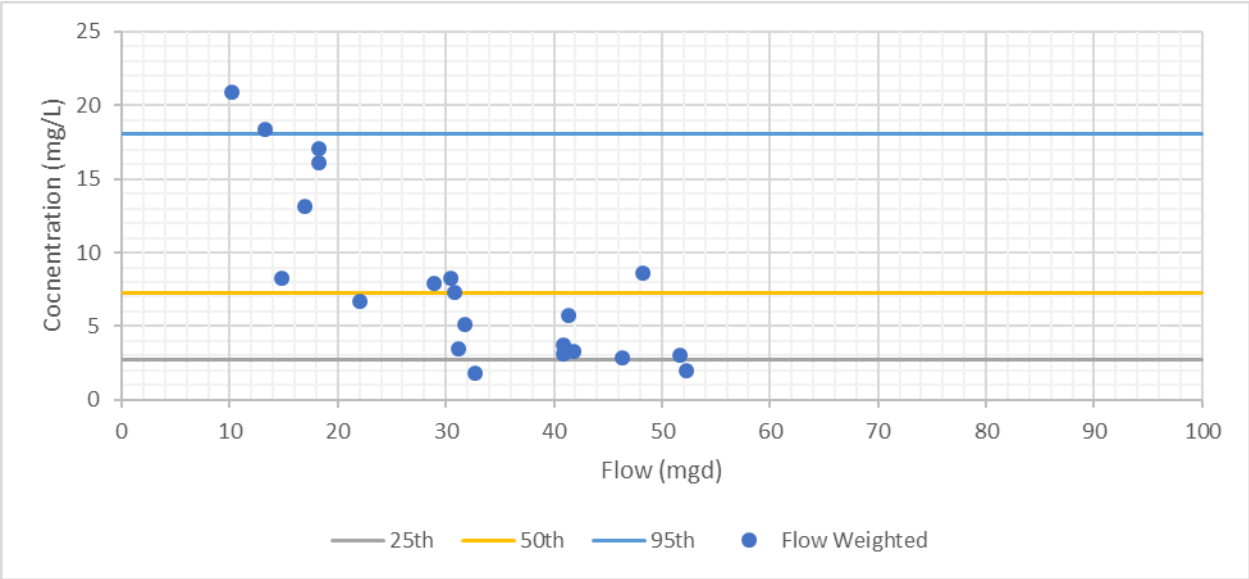


Figure 3: Flow Weighted Influent Ammonia

Total flow includes Turkey Creek WWTF, Mission main WWTF, and any PEFTF discharge



Analysis of the wet weather flow characteristics along with the understanding that the growth in the peak flows is primarily driven by collection system and pumping station modifications, rather than growth within in the service area, was utilized to develop conceptual auxiliary treatment system design conditions. These conditions are represented as follows:

- First Flush Events
  - Based on the graphics in Figures 1, 2 and 3, it is apparent that higher first-flush concentrations normally occur below influent flows of 52 mgd and would therefore not be expected to be routed to auxiliary treatment.
- High Flow Events
  - Flows 52 mgd to 75 mgd
  - Moderate storms and periods following peak wet-weather events.
  - Equivalent to 50th percentile in Table 1
- Peak Flow Events
  - Flows above 75 mgd
  - Equivalent to 25th percentile in Table 1

Future development of peak flow event hydrographs and pollutographs should be used to refine peak flow design criteria from the daily numbers presented in Table 1 to shorter time frames, such as hourly, to more accurately represent wet weather events. This would be helpful particularly in regard to first flush events and the progression of influent loadings.

Comparison to Nelson Complex 308 findings

The 2009 308 response for the Nelson Complex also evaluated influent BOD_5 and TSS during wet weather events. The influent TSS figure is reproduced below.

FIGURE 3-4
NELSON COMPLEX WET-WEATHER INFLUENT TSS

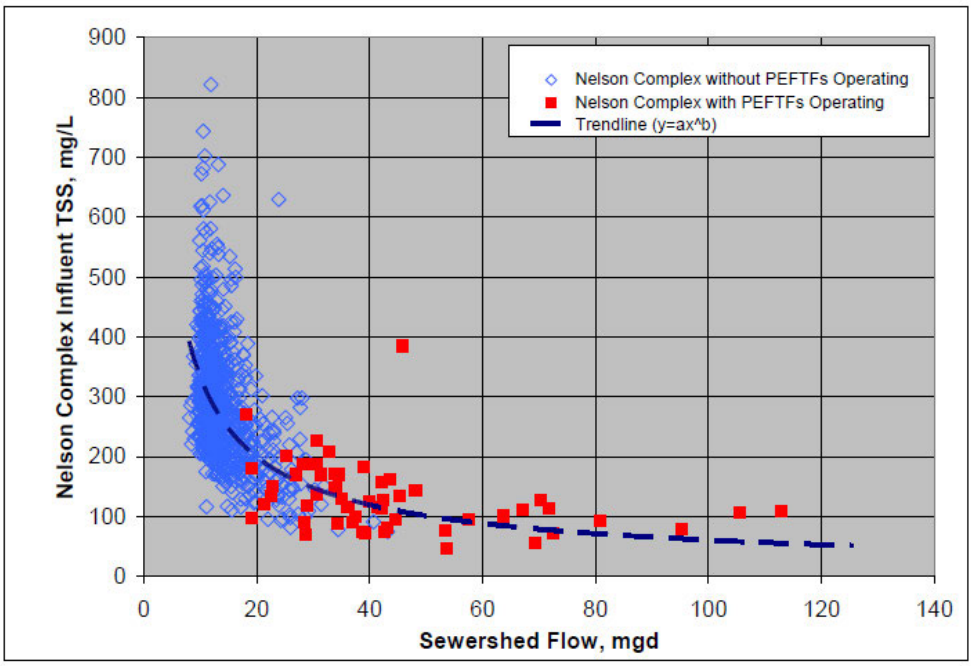


Table 3-2 of that document compared Mission Main influent to Belinder PEFTF influent during times when PEFTF was discharging. The findings of that analysis were that Mission Main influent averaged 75 mg/L TSS and Belinder influent averaged 71 mg/L TSS. However, that analysis was concentration-based only, and not flow-weighted. It was stated in the document that the "typical influent concentration range processed at the PEFTFs" was 43-92 mg/L TSS at that time.

Comparison to Tomahawk Creek Design Conditions

The filter complex planned for the Tomahawk Wastewater Treatment Facility is designed for both a tertiary mode and an auxiliary mode, as reported in section 5.7 Filter Complex of the Basis of Design Report Addendum. Table 5-37 Disc Filtration Equipment Criteria lists influent loading criteria in auxiliary mode as shown in Table 2, but it is noted that the filter complex loading for the auxiliary mode is based on maximum hydraulic loading rate and average solids loading rate (highlighted in Table 2). These values are also compared to the values proposed for the MK Nelson Complex in Table 2.

Table 2: Tomahawk Creek Disc Filtration Criteria for Auxiliary Mode and Comparison to Proposed

Metric	Tomahawk Disc Filtration – Aux Mode	Nelson 308 Response (2009)	MK Nelson Proposed
Peak Flow	115 mgd		95 mgd
Min Inf TSS	25 mg/L 24,000 ppd	43 mg/L	65 mg/L[1] @ 95 mgd (51,500 ppd)
Avg Inf TSS	80 mg/L 77,000 ppd	75 mg/L	
Max Inf TSS	150 mg/L 144,000 ppd	92 mg/L	110 mg/L[2] @ 30 mgd (27,500 ppd)

[1]25th percentile observation

[2]50th percentile observation

The Project Definition Preliminary Design Report for the Tomahawk Wastewater Treatment Facility also provided "Recommended Basis of Design Loads" in Table 2-4, which included peak day. Table 3, below, compares those Tomahawk values to the wet weather concentrations being proposed for the Nelson Complex wet weather alternatives.

Table 3: Tomahawk Peak Day Basis of Design Loads and Comparison to Proposed Nelson Values

Metric	Tomahawk Peak Day	MK Nelson Proposed (50th percentile)	MK Nelson Proposed (25th percentile)
Peak Flow	105.4 mgd	75 mgd (30 mgd to Auxillary treatment)	140 mgd (95 mgd to Auxillary treatment)
TSS	74.4 mg-TSS/L	110 mg-TSS/L	65 mg-TSS/L
BOD	52.2 mg-BOD/L	90.82 mg-BOD/L	56 mg-BOD/L
TKN	9.02 mg-N/L	16.9 mg-N/L	12.3 mg-N/L
Ammonia	5.02 mg-N/L	7.4 mg-N/L	3.8 mg-N/L
Total Phosphorus	1.22 mg-P/L	1.8 mg-P/L	1.2 mg-P/L
Ortho-phosphate	0.50 mg-P/L	0.4 mg-P/L	0.3 mg-P/L

Conclusions

Adopting the criteria proposed in Table 3 appears to provide comparable wet weather concentration ranges to those adopted in the past and will be used for sizing wet weather treatment facilities.

Nelson Complex WWTF and Collection System Technical Memorandum #5 Project Development

May 2019

FINAL

JOHNSON COUNTY KANSAS

Wastewater

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Appendices

Appendix A: Figures-Enlarged Versions

ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
GPD	Gallons per Day
GPM	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
MGAL	Million Gallons
MGD	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/l	Milligrams/liter
MM	Mission Main
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NCAC	New Century Air Center
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NH3-N	Ammonia Nitrogen
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow

PC	Primary Clarifier
Pro2D^2	Professional Process Design and Dynamics Whole Plant Simulator by CH2M
PS	Pump Station
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TC	Turkey Creek
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

1 Introduction

1.1 Background & Purpose

The Facility Plan for the improvements to the Myron K Nelson Wastewater Treatment Complex (Nelson Complex) is one of several study efforts that will collectively determine the best long term improvement plan for the treatment facility and its contributing sewershed. Technical Memorandum Number One (TM #1) established the Basis of Analysis, and TM #2 will document the ongoing development of a regulatory strategy to guide implementation. TM #3 and TM #4 dealt with screening of treatment alternatives and comparative evaluation of the retained alternatives, respectively, to arrive at the preferred dry weather and wet weather treatment processes.

In the first part of this TM #5, the selected treatment alternative will be further developed into a fully-defined capital improvement project. In addition, the pump stations that pump to the treatment facility will be evaluated to determine whether the proposed treatment upgrades will require improvements to these facilities.

The second part of TM #5 addresses the issue of whether to retain and upgrade the Peak Extraneous Flow Treatment Facilities (PEFTF's) or to eliminate them through a combination of system storage, infiltration/inflow (I&I) reduction, and conveyance of the wet weather flows to the treatment facility for centralized auxiliary treatment. In TM #5, conceptual designs and costs for the pump stations and PEFTF's to handle the wet weather flow are developed, but the alternative analysis is performed under the Collection System Wet Weather Plan Development and Optimization (the "Collection System Study") Task 6 – Alternative Development and Evaluation which ties in the collection system to provide a comprehensive service area solution.

1.2 Treatment Alternatives Development Approach

In TM #3 evaluated several dry weather and wet weather treatment alternatives. The alternatives were screened utilizing non-economic criteria to provide a short list of retained alternatives. The retained alternatives were as follows:

Dry Weather
- Conventional Activated Sludge with Enhanced Biological Phosphorus Removal (CAS with EBPR)
- Integrated Fixed Film Activated Sludge (IFAS) with EBPR
- CAS with Chemical Phosphorus Removal (Chem-P)

Wet Weather
- Filtration
- Chemically Enhanced Primary Treatment (CEPT)
- Ballasted Flocculation

In TM #4, these alternatives were further developed to produce comparative conceptual designs, corresponding capital costs and annual operating costs. The alternatives were subjected to a comparative analysis based on Net Present Value (NPV) and Triple Bottom Line (TBL) to produce a Weighted Cost per Benefit Score (NPV per benefit unit). The preferred dry and wet weather alternatives were determined to be:

Dry Weather – CAS with EBPR
Wet Weather – Filtration

1.3 TM #5 Organization

This TM is organized as follows:

Section 2 - Dry Weather Train Development

The primary focus of Section 2 is the evaluation of several possible site layout alternatives and selecting the preferred layout. Several factors were considered, including:

- Cost
- Operational Considerations
- Off Site Pump Station Impacts – different layouts with different hydraulic grade lines have differing impacts on needed improvements at the three WWTF influent pump stations: Turkey Creek, Rock Creek, and Belinder that pump to the plant.
- Construction Phasing/Schedule
- Impact on Interim Operations

Section 3 - Balance of Process Facilities

The liquid process facilities common to all alternatives – e.g. Headworks, Primary Clarifiers, etc. are further developed in Section 3. Also, Wet Weather filtration and disinfection facilities are evaluated to determine optimum unit, or module, sizing from a phasing standpoint, recognizing that increases in wet weather flows may be conveyed incrementally over time to the treatment facility from different sub-basins in the collection system. Finally, biosolids facilities, previously defined in the Nelson and Middle Basin Solids Handling Study, are incorporated into the plan.

Section 4 - WWTF Support Facilities

Part 4 addressed support facilities such as building space to house engineering and operations staff, off site utilities, and construction access/storage/staging provisions.

Section 5 - Whole Plant Cost Estimate

The total project cost to serve as a basis for Capital Improvement planning is developed in Section 5.

Section 6 - Wet Weather Management Alternatives Development and Evaluation

In the concurrent Collection System Study, a detailed optimization process was performed which resulted in two collection system wet weather management alternatives:

Alternative 1 – Eliminate PEFTF's through Wet Weather Management
Alternative 2 – Retain PEFTF's with Enhanced High Rate Treatment

Each of these alternatives involves collection system improvements such as I/I reduction, relief sewers, and storage which are evaluated under the Collection System Study, and facility improvements such as pump stations and/or PEFTF upgrades or use of centralized auxiliary treatment facilities which are evaluated under this study. Section 6 includes conceptual design and cost estimates for the pump stations and PEFTF's. The actual NPV and TBL analysis of the two wet weather management alternatives is provided in the Collection System Study, although a summary of the results is included in Section 6 of this study.

Section 7 - Pump Station, PEFTF, and WWTF Asset Renewal Needs

The dry and wet weather facility improvements are not projected to be completed and in service until 2029 or later. In the interim, asset renewal improvements will need to be made to existing facilities to allow them to function properly until the new facilities are available. Section 7 includes a detailed review of near-term asset renewal needs at these existing facilities.

Section 8 - Summary, Recommendations, and Next Steps

This section discusses prioritization, scheduling, and implementation of the improvements identified in this Facility Plan and the concurrent Collection System Study.

2 WWTF Dry Weather Train Development

2.1 Background

In the November 13th and December 17th, 2018 Task #6 workshops, preliminary site layouts for the retained dry and wet weather treatment processes were presented. A total of three (3) site layout alternatives were reviewed and are discussed in further in Section 2.2. For the various site layout alternatives, the location of the new Headworks Building will dictate the scope of the required off-site conveyance improvements from the Turkey Creek, Rock Creek and Belinder Pump Stations. The impacts to these pump stations based on the location of the new Headworks is discussed in Section 2.3.

2.2 Layout Alternatives

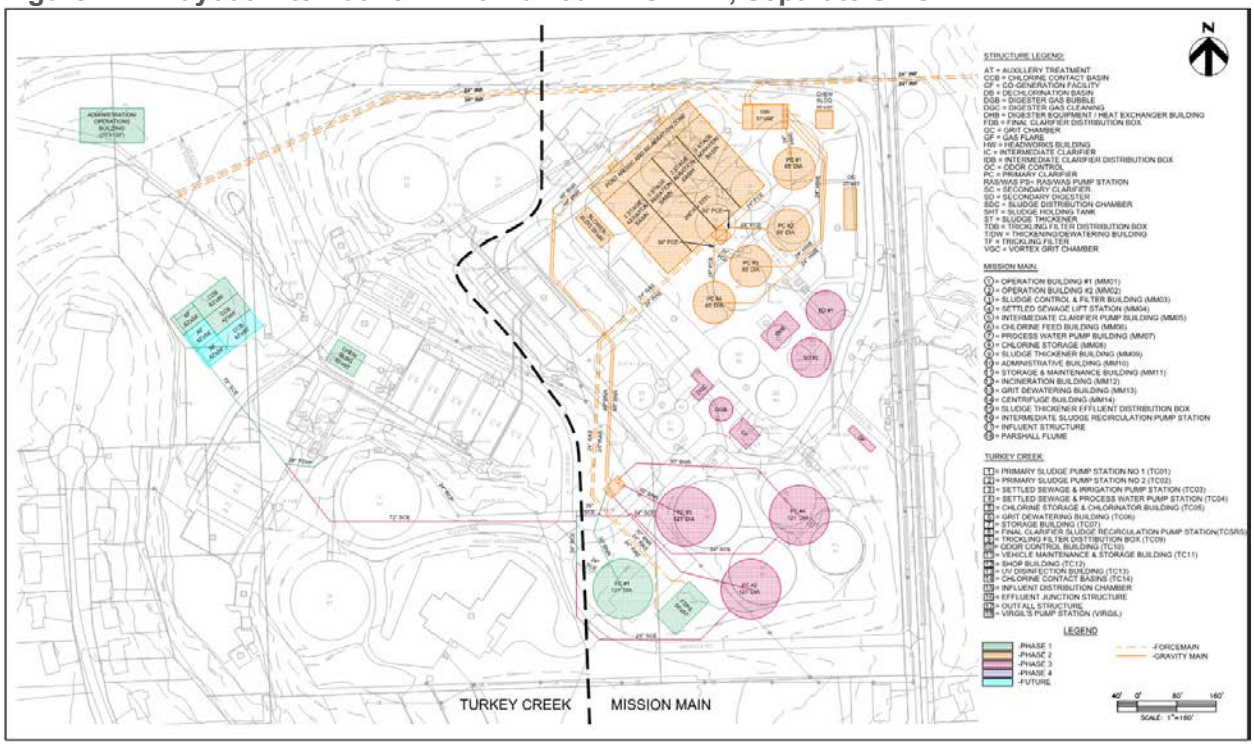
The site layout alternatives are based on the dry weather facilities associated with the five-stage BNR configuration (CAS with EBPR) and wet weather facilities associated with disk filtration and chemical disinfection selected as the preferred approach in TM #4. For each alternative, a summary of the overall construction sequencing, proposed layout as well as advantages and disadvantages is provided. The construction sequencing is separated into general phases and each phase is represented with a color as noted in the applicable exhibit legend. For each alternative, the proposed sequencing results in a phased demolition approach to the existing Mission Main (MM) unit processes. For all alternatives, the existing influent screening, grit removal, primary clarification and 1st stage Trickling Filters (TF's) including Settled Sewage Lift Station 4 (SSLS 4) are preserved throughout the construction period, until sufficient new facilities are in place to replace them. Each alternative also includes the addition of CEPT to reduce the organic loading on the remaining TF units during interim operations. These aspects are discussed in further detail in Section 2.4.

For each site layout alternative, it is assumed the current Administration Building will be demolished and replaced. This and other support facilities are discussed further in Section 4.

2.2.1 Site Layout Alternative 1 - Combined PC's BNR, Separate FC's

Site Layout Alternative 1 consists of constructing the new Headworks Building, primary clarifiers and biological trains on the existing upper Mission Main (MM) site. New secondary clarifiers and a Final Sludge Pump Station would be constructed in the vicinity of the MM first stage Trickling Filters 1 and 2. Figure 2-1 depicts the conceptual layout of the proposed unit processes associated with Site Layout Alternative 1. An enlarged version of this figure is included in Appendix A.

Figure 2-1: Layout Alternative 1 - Combined PC's/BNR, Separate SC's



Below are general construction phasing considerations associated with this alternative:

Phase 1:

- Construct one (1) new secondary clarifier and a new Final Sludge Pump Station (with RAS/WAS pumping facilities) in the vicinity of the first stage TF's 1 and 2.
- Construct temporary ferric chloride facilities and institute chemically enhanced primary treatment (CEPT).
- Construct interconnecting piping / valves to allow effluent from the MTM1 first stage TF's 1 and 2 to be directed to the new secondary clarifier.
- Modify SSLS 4 to pump only the required "wetting rate" flows for first stage TF's 1 and 2.
- Demolish existing upper MTM1 site downstream of SSLS 4 (intermediate clarifiers, 2nd stage TF's and final clarifiers).

Phase 2:

- Construct remainder of liquid train unit processes.
- Construct additional solids facilities.
- Demolish TF's 1 and 2, and existing headworks facilities.

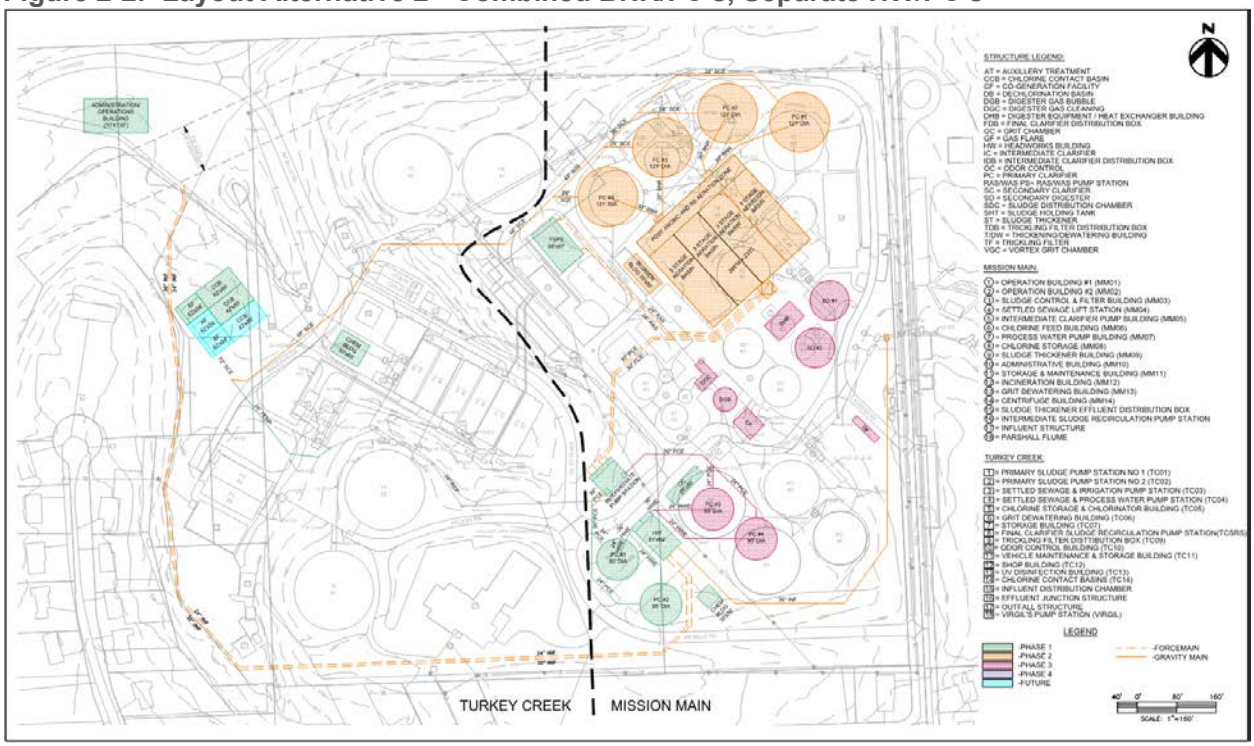
Phase 3:

- Construct remainder of secondary clarifiers.
- Demolish Turkey Creek (TC) WWTF facilities.

2.2.2 Site Layout Alternative 2 - Combined BNR/FC's, Separate HW/PC's

Site Layout Alternative 2 consists of constructing the new biological trains, secondary clarifiers and Final Sludge Pump Station on the existing upper MTM1 site. The new Headworks Building, primary clarifiers and intermediate pumping facilities would be constructed in the vicinity of the first stage TF's 1 and 2. Figure 2-2 (also included in a larger version in Appendix A) depicts the conceptual layout of the proposed unit processes associated with Site Layout Alternative 2.

Figure 2-2: Layout Alternative 2 - Combined BNR/FC's, Separate HW/PC's



Below are general construction phasing considerations associated with this alternative:

Phase 1:

- Construct new Headworks Building (excluding new fine screening and grit removal equipment, since this facility won't be used as a true Headworks until a later phase) and two new primary clarifiers in the vicinity of the first stage TF's 1 and 2. Under this alternative, the two new primary clarifiers would be used in a temporary configuration as new secondary clarifiers, similar to Alternative 1 for the first stage TF's. Primary sludge pumping facilities would be located in the lower level of the new Headworks Building and also used in a temporary configuration for waste activated sludge (WAS) pumping.
- Construct temporary ferric chloride facilities and institute CEPT.
- Construct interconnecting piping / valves to allow effluent from first stage TF's 1 and 2 to be directed to the two new primary clarifiers being used as temporary secondary clarifiers.
- Modify SSLS 4 to pump the required wetting rate flows for first stage TF's 1 and 2.
- Demo existing upper MTM1 site.

Phase 2:

- Populate Headworks Building with fine screening and grit removal equipment and construct Intermediate Pump Station (IPS).
- Construct remainder of liquid train unit processes.
- Construct additional solids facilities.
- Demolish TF's 1 and 2, and existing headworks facilities.
- Demolish TC WWTF facilities.

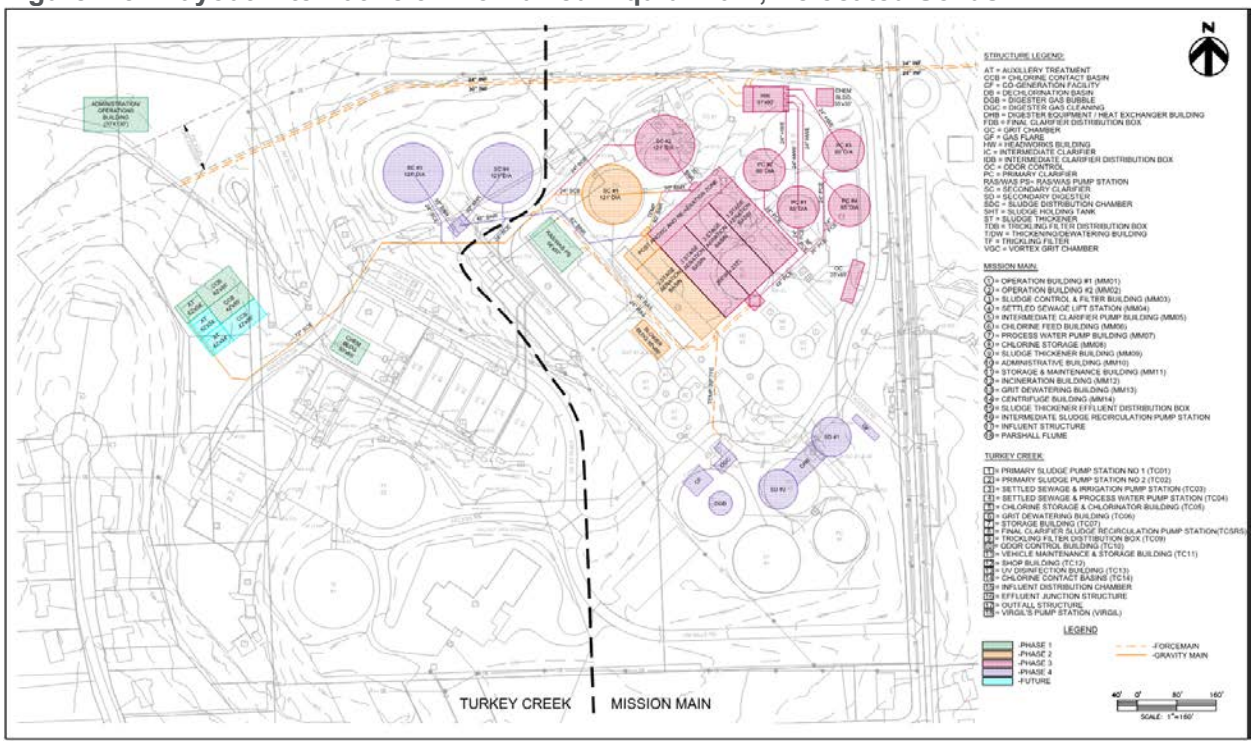
Phase 3:

- Construct remainder of secondary clarifiers.

2.2.3 Site Layout Alternative 3 - Combined Liquid Train, Relocated Solids

Alternative 3 consists of constructing all new liquid train unit processes on the existing upper MTM1 site. To accommodate space for the proposed facilities, the proposed solids digestion facilities would be installed on the lower MTM1 site. Figure 2-3 (also included in enlarged version in Appendix A) depicts the conceptual layout of the proposed unit processes associated with Site Layout Alternative 3.

Figure 2-3: Layout Alternative 3 - Combined Liquid Train, Relocated Solids



Below are general construction phasing considerations associated with this alternative:

Phase 1:

- Construct new solids digestion facilities.
- Construct temporary ferric chloride facilities and institute CEPT.
- Demolish existing MTM1 Intermediate Clarifier (IC) 4.

Phase 2:

- Construct Phase 1 of new liquids train improvements and place into service.
- Demolish remainder of MTM1 WWTF.

Phase 3:

- Construct remainder of new liquids train improvements and place into service.

Phase 4:

- New remainder of secondary clarifiers.
- Demolish TC WWTF facilities.

Based on the description of the different alternatives discussed above, the advantages and disadvantages associated with each alternative are summarized and presented in Table 2-1.

Table 2-1: Site Layout Alternatives - Advantages/Disadvantages

Site Layout Alt. 1 - Combined PC's BNR, Separate FC's	Site Layout Alt. 2 - BNR/FC's, Separate HW/PC's	Site Layout Alt. 3 - Combined HW/PC's/BNR/FC's, Relocated Solids
Advantages		
Allows a new secondary clarifier to be built prior to MM WWTF demolition and therefore simplifies construction sequencing	Reduces forcemain extensions and pumping head improvements for Belinder and Rock Creek lift stations. Reduces the increased pumping head requirements for Turkey Creek Pump Station as compared to Alternative #1.	Allows new liquid train from primary clarifiers through secondary clarifiers to be co-located
Provides increased space between new clarifiers and biological trains	Allows secondary treatment train to be co-located with secondary clarifiers which reduces floc shearing potential as well as required pumping head for the new Final Sludge Pump Station	Does not require intermediate pumping
Does not require intermediate pumping	Preserves existing digester complex	Reduces energy requirements associated with lower pumping head for the Final Sludge Pump Station
Preserves existing digester complex	New Headworks Building is centrally located for grit/screening truck traffic	Odorous facilities (HWs and PCs) not located close to South property line
Disadvantages		
New Headworks Building is located in furthest corner of the site for grit/screenings truck traffic and represents the highest head condition for improvements to the Turkey Creek, Belinder and Rock Creek	Requires intermediate pumping	New digestion facilities located on lower MM site
New secondary clarifiers and Final Sludge Pump Station are separated from biological train. May result in separation of the biological floc prior to secondary clarification.	Reduces space between new biological trains and clarification facilities on existing upper MM WWTF site	Reduces space between new facilities on existing upper MM WWTF site
Increased energy requirements associated with higher pumping head for the Final Sludge Pump Station	Odorous facilities (HWs and PCs) located close to South property line	New Headworks Building is located in furthest corner of the site for grit/screenings truck traffic and represents the highest head condition for improvements to the Turkey Creek, Belinder and Rock Creek pump stations
		Requires phased demolition of MM WWTF

2.3 Off Site Conveyance Improvements

Currently the Turkey Creek Pump Station conveys flows to the TC WWTF headworks through two forcemains of 24-inch and 30-inch diameter. The Rock Creek and Belinder Pump Stations convey flows to the MTM1 WWTF headworks through two 24-inch forcemains, one dedicated to each pump station. A new single Headworks Building will require these offsite forcemains to be redirected to the new facility and therefore its location directly impacts the required offsite conveyance improvements. The major impacts are primarily associated with the required conveyance line extensions as well associated changes to the pump operating head conditions.

As discussed in Section 2.2, site layout Alternatives 1 and 3 would locate the new Headworks Building in the northeast corner of the Nelson Complex site. This would require all offsite forcemains to be extended to this new location. For site layout Alternative 2, the new Headworks Building would be located in the middle of the Nelson Complex site near the southern property line. This location would require the two Turkey Creek Pump Station forcemains to be extended to this location. Similarly, the Rock Creek and Belinder Pump Station forcemains would also need to be extended to the new location. A conceptual layout of the offsite conveyance alternatives is depicted in Figure 2-4, and included in enlarged version in Appendix A.

Figure 2-4: Offsite Conveyance Improvements

Comparative costs associated with the offsite conveyance improvement alternatives are presented in Table 2-2. This table includes the capital cost of the proposed forcemain and gravity line extensions as well as pump replacement costs where applicable to address higher pumping head conditions. These costs represent “above the line” estimates. That is, the costs do not include markups for overhead and profit, contingencies, engineering, or other general markups. All costs are presented in 2018 dollars.

Table 2-2: Comparative Cost Analysis for Offsite Conveyance Improvements

Offsite Improvements	HW Location for Site Layout Alts. 1 and 3		HW Location for Site Layout Alt. 2	
	Linear Feet	Cost (Million)	Linear Feet	Cost (Million)
Turkey Creek PS				
Pump Station Head Imp. (27 MGD)	-	$2.12	-	$1.29
24-Inch FM Extension	1,222	$0.50	2,060	$0.67
30-Inch FM Extension	1,222	$0.50	2,060	$0.83
Sub-Total	**-**	***$3.02***	**-**	***$2.79***
Rock Creek PS				
Pump Station Head Imp. (12 MGD)	-	$0.79	-	-
24-Inch FM Extension	2,920	$0.95	-	-
Sub-Total	**-**	***$1.73***	**-**	**-**
Belinder PS				
Pump Station Head Imp. (10.6 MGD)	-	$0.82	-	-
24-Inch FM Extension	2,920	$0.95	-	-
Sub-Total	**-**	***$1.77***	**-**	**-**
Mission Main Gravity				
36-Inch Gravity Influent Line Extension	-	-	950	$0.51
Sub-Total	**-**	**-**	***950***	***$0.51***
Total (2018 $$$)	***$6.52***		***$3.30***	

Notes:
All costs are direct and exclude markups

As depicted in Table 2-2, the comparative offsite conveyance improvements associated with the new Headworks Building location for site layout Alternatives 1 and 3 versus Alternative 2 is $6.52 million and $3.30 million respectively.

2.4 Interim Operations

Operation of portions of the existing TC and MM WWTF's will need to be maintained during construction of the proposed improvements. Since the majority of the new unit processes will be constructed on the MM site, a plan for modifications to its unit processes and associated interim operations was evaluated. As discussed in Section 2.2, each site layout alternative has varying impacts to the MM unit processes as a result of the general construction phasing. These impacts also include associated durations which will impact the temporary operational costs of the MM WWTF during construction. To quantify these costs, an interim operations plan was developed for the respective alternatives. For each alternative, it is assumed the new auxiliary treatment and disinfection facilities are constructed and placed into operation prior to modification of the MM

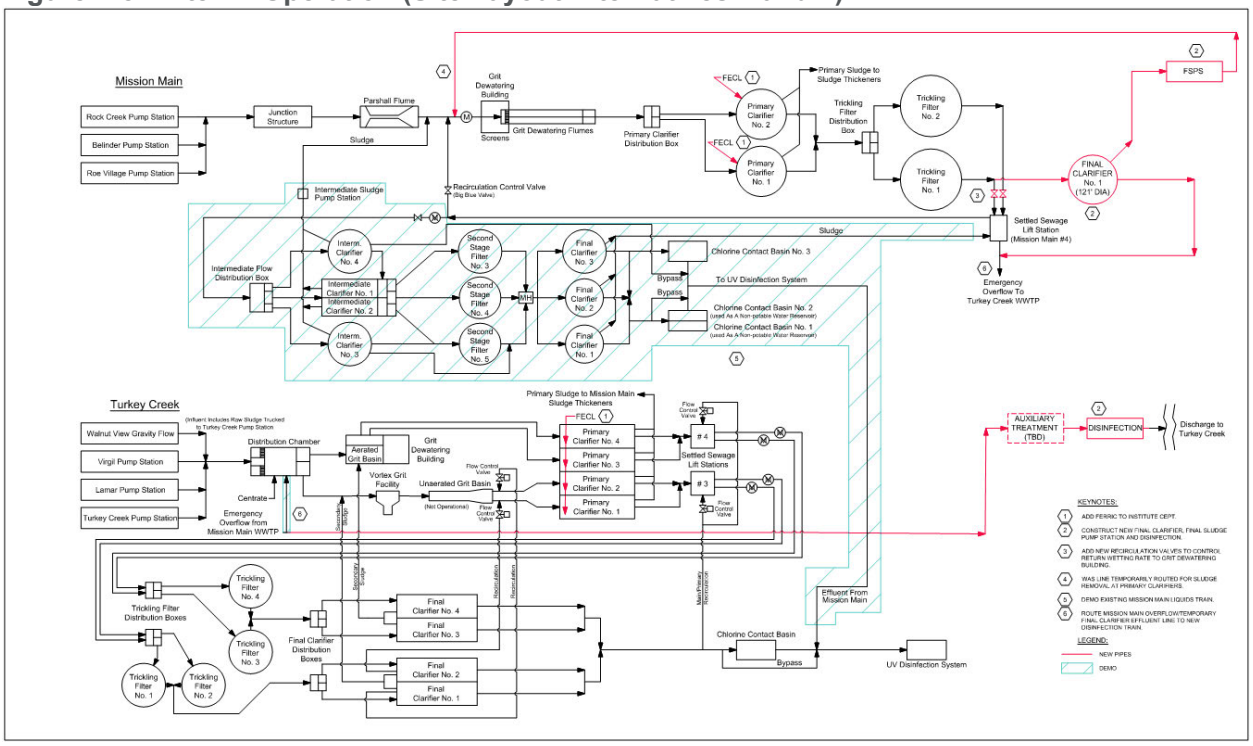
WWTF. This would allow the new filtration facilities to be used for dry weather flows during the interim operational period to aid in polishing of effluent.

For site layout Alternative 1, it is proposed to convert the MM WWTF to a single stage TF process and add CEPT to reduce the organic loading rate to TF's 1 and 2. This temporary configuration includes the following initial construction activities:

- Construct one new secondary clarifier and new Final Sludge Pump Station
- Install temporary ferric feed facilities at MM to institute CEPT
- Modify inlet piping to SSLS #4 to control flows to new secondary clarifier
- Tie new secondary clarifier effluent line to overflow line to TC and extend to new auxiliary treatment and disinfection facilities.

A schematic of these improvements is shown in Figure 2-5 and also included in Appendix A. The improvements to accommodate site layout Alternative 2 would be similar, with the exception of using two new primary clarifiers in a temporary secondary clarification role.

Figure 2-5: Interim Operation (Site Layout Alternatives 1 and 2)



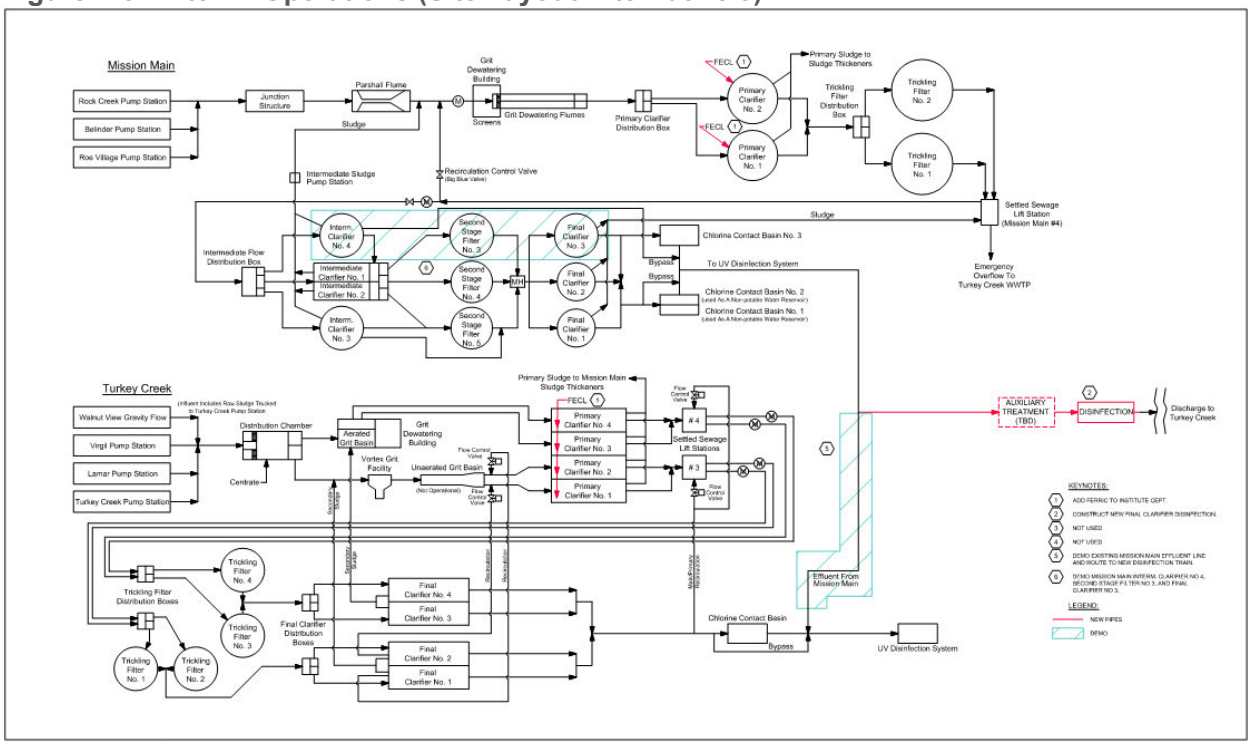
For site layout Alternative 3, it is proposed to demolish one treatment train of the MM WWTF on the upper portion of the MM site to accommodate the construction of the first new BNR train. The addition of CEPT to the MM WWTF would be provided to reduce the organic loading to the remaining treatment trains. This temporary configuration includes the following initial construction activities:

- Install temporary ferric feed facilities at MM to institute CEPT.
- Demolish MM IC #4, TF #3 and FC #3.

- Control SSLS #4 pumped flow to MM IC's and utilize overflow to TC WWTF for flows exceeding MM capacity. Extend overflow line to TC to new auxiliary treatment and disinfection facilities.

A schematic of these improvements is shown in Figure 2-6, and included in Appendix A.

Figure 2-6: Interim Operations (Site Layout Alternative 3)



The primary goal of interim operations for any of the alternatives is to maximize the treatment performance of the remaining unit processes. Compliance with discharge limits under all conditions during interim operations is expected to be a challenge, particularly with ammonia and to a lesser extent with BOD and TSS.

Incorporation of CEPT at both MM and TC would reduce organic loading to the TF's to a level that would allow increased nitrification at both WWTFs. The greatest challenges are expected to occur in the spring and fall periods that are associated with increased flows, lower than average temperatures, and more restrictive effluent ammonia limits. Further evaluation of the trickling filter nitrification response to organic loading rate is recommended during final design and in the years leading up to the interim operations.

2.5 Construction Schedule and Interim Operation Costs

Based on the general phasing steps outlined in Section 2-2 and estimated construction durations per phase, a construction timeline comparison between site layout Alternatives 1 through 3 was prepared. This timeline, as well as the estimated costs associated with the two interim operations alternatives is presented in Table 2-3, also included in Appendix A.

Table 2-3: Construction Timeline and Temporary Cost Comparison

Items	Site Layout Alt. 1 - Combined PC's BNR, Separate FC's	Site Layout Alt. 2 - Combined BNR/FC's, Separate HW/PC's	Site Layout Alt. 3 - Combined HW/PC's/BNR/FC's , Relocated Solids
Notice to Proceed	January 2024		
Estimated Total Construction Duration	4 Years, 11 Months	4 Years, 4 Months	5 Years, 3 Months
Start-Up Liquids Train Improvements	February 2027	July 2027	March 2028
Completion of Construction	November 2028	April 2028	March 2029
Estimated Duration of CEPT	23 Months	23 Months	42 Months
Estimated Cost Per Month for CEPT	$32,000		
Estimated Total Cost for CEPT (Millions)	$730,000	$730,000	$1,330,000

2.6 Site Layout Alternatives Comparative Cost Evaluation

In addition to the comparative costs identified for offsite improvements and temporary operational impacts from construction phasing (CEPT), there are additional capital cost items associated with the variances between the alternative site layouts. These items are summarized below.

- Site Layout Alternative 1:
  - Higher head pumps for the Final Sludge Pump Station due to its location on the lower MM site.
- Site Layout Alternative 2:
  - Need for intermediate pumping to convey primary clarifier effluent to the BNR train located on the upper MM site.

With respect to operations and maintenance (O&M) cost differences between the site layout alternatives, 20-year O&M costs were developed for the differences in pumping head from the offsite pump stations, Final Sludge Pump Station as well as intermediate pumping if required. These comparative capital and O&M costs as well as their 20-year net present value (NPV) cost are summarized Table 2-4. Costs for items such as site piping were developed from preliminary site piping plans with adders included for rock removal and fittings.

Table 2-4: Layout Alternatives - Cost Evaluation Summary

Improvements	Site Layout Alt. 1 - Combined PC's BNR, Separate FC's	Site Layout Alt. 2 - BNR/FC's, Separate HW/PC's	Site Layout Alt. 3 - Combined HW/PC's/BNR/FC's, Relocated Solids Train
	(Millions)	(Millions)	(Millions)
Off-Site Conveyance Improvements	$6.51	$3.30	$6.51
Intermediate PS	-	$3.44	-
RAS Pumping TDH	$0.06	-	-
CEPT	$0.73	$0.73	$1.33
Liquid Train Piping (Incl. Rock at 25% Adder), Fittings, Etc.	$8.05	$4.46	$5.10
Total Capital Cost	$15.11	$11.75	$12.75
Total 20-Year O&M Cost (Incremental)	$2.21	$2.75	$1.70
20-Year NPV	***$17.32***	***$14.50***	***$14.45***

Notes:
1. All costs are above the line and exclude markups
2. O&M costs include cost for additional pumping head for offsite pump stations as well as RAS and intermediate pumping where applicable.

Based on the comparative cost analysis presented in Table 2-4, Alternatives 2 and 3 had the lowest 20-year NPV cost prior to project markups. In addition to the lowest NPV cost, site layout Alternative 3 was identified as the preferred alternative for the following primary reasons:

- Allows liquid train to be combined on upper MM site.
- Eliminates the need for intermediate pumping.
- Locates most odorous facilities away from south property line.

2.7 Site Layout Optimization

Based on feedback received from JCW operations staff, the preferred site layout Alternative 3 was further refined and presented as the “optimized” site layout in the December 17th, 2018 workshop. Modifications to the optimized site layout included the following:

- Reoriented combined liquids train on upper MM site to allow new solids facilities to be built adjacent to the existing solids facilities.
- Relocated Secondary Clarifiers 1 and 2 which eliminated the proposed phased demolition of the MM upper site. The optimized alternative would make use of the temporary treatment scheme as described for site layout Alternatives 1 and 2 which includes conversion of MM to a single stage TF process with CEPT.

The optimized site layout is depicted in Figure 2-7 and included in Appendix A.

Figure 2-7: Optimized Site Layout Alternative

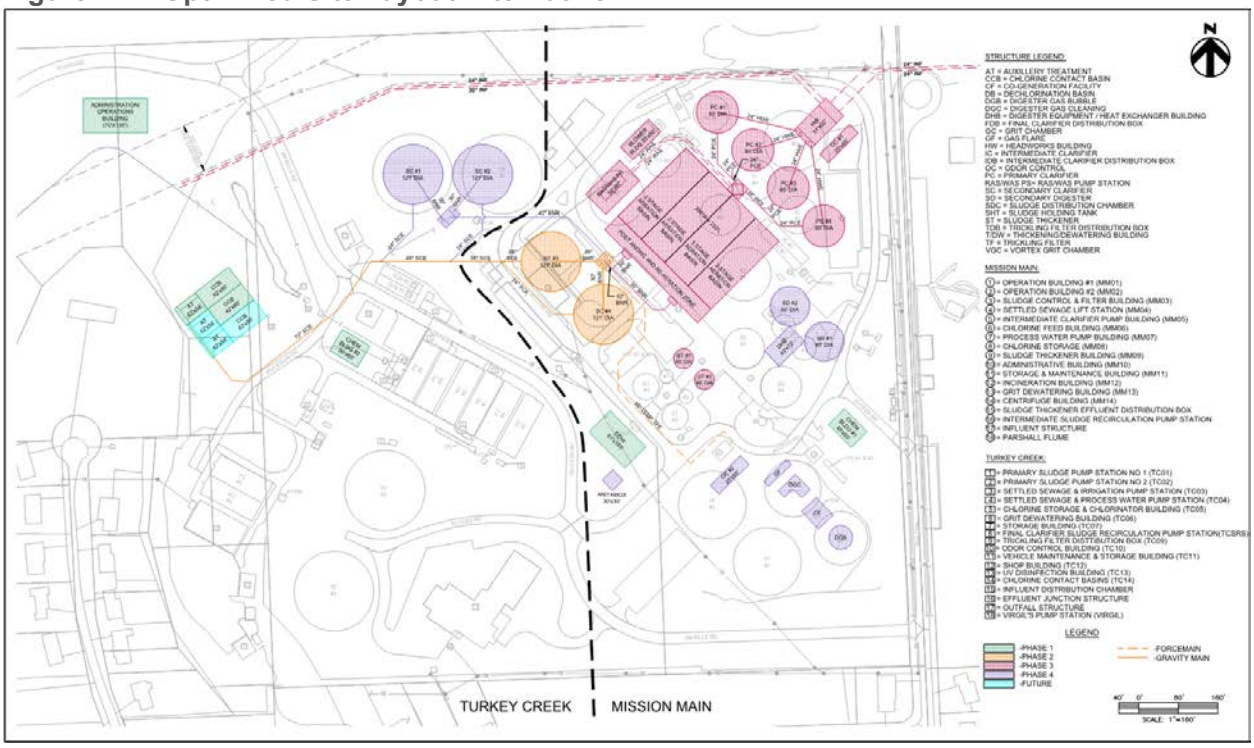


Table 2-5 presents a conceptual schedule for this alternative that was derived through development of the associated phasing considerations. Based on this schedule, the estimated timeline for completion of the project is five years and four months in April of 2029, with a liquids train startup in April of 2028. In addition, the estimated timeline for interim operations which includes the addition of CEPT is three years and three months.

Table 2-5: Optimized Site Layout - Conceptual Schedule

Site Layout Alternative #4 - "Optimized" Combined Liquid Train

Item	Months	2024												2025												2026												2027												2028												2029											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1. Demo Admin/Incinerator Building and SD's #1 and #2	8	1	2	3	4	5	6	7	8																																																																								
2. Construct AT and CCB	8	1	2	3	4	5	6	7	8																																																																			
3. Construct Thickening / Dewatering Building (assumes SD's demo'd 1st)	10				1	2	3	4	5	6	7	8	9	10																																																														
4. Demo Dewatering Building	3														1	2	3																																																								
5. Construct SC's #1 and #2, Modify SSLS #4	9																	1	2	3	4	5	6	7	8	9																																															
6. Institute CEPT (excludes construction)	27																										1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27																							
7. Demo upper MM site	6																										1	2	3	4	5	6																																															
8. Construct HW, PC's, BNR Train, RAS PS	24																													1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24																							
9. Tie-in TC, BE and RC FM's to new HW	18																																			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																							
10. Demo TC and remaining MM facilities	12																																																						1	2	3	4	5	6	7	8	9	10	11	12										
11. Construct SC's #3 - #4 (assumes MM PC's, TF's and TC TF's #1-#2 demo'd 1st	9																																																								1	2	3	4	5	6	7	8	9											
12. Construct additional solids facilities (assumes MM PC's, TF's and TC TF's #	9																																																								1	2	3	4	5	6	7	8	9											

Key: AT = Auxiliary Treatment, BE = Belinder, CCB = Chlorine Contact Basin, CEPT = Chemically Enhanced Primary Treatment, SC = Secondary Clarifier, RAS PS = Return Activated Sludge Pump Station, HW = Headworks, IPS = Intermediate Pump Station, MM = Mission Main, PC = Primary Clarifier, RC = Rock Creek, SSLS = Settled Sewage Lift Station, TC = Turkey Creek, TF = Trickling Filter, WW = Wet Weather

3 Balance of Process Facilities

3.1 Dry Weather Train

Design criteria for the dry weather unit process components was presented in TM #4 – Alternatives Selection. This Section will discuss additions/modifications to provide a complete process system.

3.1.1 Odor Control

Odor control for the headworks, primary clarifiers and primary clarifier splitter structures is proposed. Design criteria are listed in Table 3-1. Odor Control for solids facilities are discussed in a separate Section 3.3 of this TM.

Table 3-1: Odor Control Design Considerations

Component	Units	Value
Headworks		
• Channels / Wetwells	Air Changes/Hour	6
• Screen and Grit Rooms	Air Changes/Hour	12
• Anticipated Total Air Flow Rate	cfm	28,000
Primary Clarifiers Splitter Structures		
• Splitter Structures	Air Changes/Hour	6
• Anticipated Total Air Flow Rate	cfm	500
Primary Clarifier		
• Basins	Air Changes/Hour	12
• Anticipated Total Air Flow Rate	cfm	14,000

3.1.2 Bioreactor

The bioreactor has been further evaluated to consider a wider range of design and operating conditions. The revised conditions include cold month operation, the addition of external hauled sludge from Blue River Main WWTF and the NCAC WWTF, and operation without sidestream nitrogen removal. Table 3-2 represents the cold month loading condition compared to initial design loading conditions originally presented in TM #1.

Table 3-2: Dry Weather Design Loadings

Table	Annual Average		Maximum Month[2]		Cold Month[3]	
	Conc. (mg/L)	Load (ppd)	Conc. (mg/L)	Load (ppd)	Conc. (mg/L)	Load (ppd)
Flow (MGD)[1]	15		19		15	
Temperature (°C)	17		13.5		11	
BOD_5	150	18,765	154	24,395	165	20,642
TSS	183	22,893	188	29,761	201	25,182
VSS	161	20,183	166	26,238	177	22,162
TKN	28	3,502	29	4,554	31	3,852
NH_3 -N	17.1	2,135	18	2,776	18.8	2,349
TP	3.1	393	3.2	512	3.5	432

[1]Peak hour flow treated at facility = 52 MGD. Peak Hour through dry weather treatment = 45 MGD.
[2]Flow at Maximum Month BOD Load, not maximum month flow.
[3]Coldest 30-day temperature with 10% increase in annual average load

The revised operational and loading conditions identified slight modifications to the original configuration to improve process flexibility. The primary modifications include the addition of 0.4 MG of RAS fermentation tankage and a 0.15 MG expansion of the bioreactor for incorporation of an anoxic/aerobic swing zone. Additionally, the evaluation and selection process identified initial construction of the entire 5-stage process rather than initially constructing the 3-stage process was a more cost-effective approach due to decreased constructability related to future construction of the two remaining stages. The revised bioreactor details are included in Table 3-3.

Table 3-3: Revised Bioreactor Details

Component	Revised: Dry 1 – CAS with EBPR
5-stage Bioreactor Volume, MG	9.1
Zone Partitions	
Anaerobic, %	12
Anoxic, %	13
Swing	4
Aerobic, %	57
DeOX/Reaeration,%	14
RAS Fermentation Zone, MG	0.4
No. Aerobic Diffuser Grids Per Basin	4
Nitrified Mixed Liquor Recycle Rate, %	300
RAS Rate, %	100
Supplemental Carbon	Primary Sludge Fermentation, Carbon feed as backup
Metal Salt Addition	Digested Sludge

3.1.3 Dry Weather Train Cost Summary

The resulting dry weather unit process costs are summarized in Table 3-4. These costs represent above the line costs, which does not include site related markups, contractor markups, or non-construction related costs.

Table 3-4: Above the line Dry Weather Costs

Item	Above the line Cost
Headworks Building	$9,048,000
Primary Clarifiers	$7,813,000
Odor Control #1 (HW and PC's)	$2,491,000
Miscellaneous Splitter Boxes	$932,000
BNR Train (including blowers)	$25,988,000
Secondary Clarifiers	$7,085,000
RAS/WAS Pump Station	$4,359,000
Chemical Addition Building #1 (Ferric, Carbon)	$1,136,000
Chlorine Contact Basins	$2,836,000 (1)
Chemical Addition Building #2 (Hypo and Bi-Sulfite)	$1,070,000
Effluent Reaeration	$1,185,000

Notes:
(1) Includes 45 MGD dry and 7 MGD wet weather treatment capacity.

3.2 Auxiliary Treatment and Disinfection

As presented in TM #4 – Alternatives Selection, the cloth disk filters (filters) alternative was the lowest cost per benefit score and thus provides the best value for the Nelson Complex WWTF improvements. The filtration facilities would be used for the treatment of wet weather related flows prior to disinfection. The proposed initial improvements at the Nelson Complex would consist of a dry weather train with a peak treatment capacity of 45 MGD and wet weather train with peak treatment capacity of 7 MGD. The total of these flows matches the current combined peak capacity of the TC and MTM1 WWTF's and influent pump stations of 52 MGD. Per the refined optimization results as presented in TM #4, Refined Optimization Results – January 2019, a future wet weather design peak flow rate of 122 MGD was determined. Based on the proposed design peak dry weather train capacity of 45 MGD, the filtration facility would be expanded to 77 MGD in the future.

In the December 17, 2018 workshop, a total of three modular filter sizing scenarios were presented. Each sizing scenario is based on Aqua-Aerobic Systems "Mega Disk" cloth media filter. The three filter sizing scenarios are summarized below:

- Scenario #1: Provide 1 firm / 1 standby 7 MGD filters for initial project. Expand to future capacity of 77 MGD through the addition of 12.6 MGD filter increments for a total of 7 firm / 1 standby units.
- Scenario #2: Provide 1 firm / 1 standby 15.4 MGD filters for initial project but populate with only 7 MGD of filter capacity. Expand to future capacity of 77 MGD through the addition of 15.4 MGD filter increments for a total of 5 firm / 1 standby units.

- Scenario #3: Provide 1 firm / 1 standby 15.4 MGD filters for initial project. Expand to future capacity of 77 MGD through the addition of 15.4 MGD filter increments for a total of 6 firm / 1 standby units.

The incremental filter sizing for each scenario is presented in more detail in Table 3-5.

Table 3-5: Modular Approach-Optimized Size of Filters

Step	Scenario 1			Scenario 2			Scenario 3		
	Flow Increment	Number of Units	Total Capacity/Firm Capacity	Flow Increment	Number of Units	Total Capacity/Firm Capacity	Flow Increment	Number of Units	Total Capacity/Firm Capacity
	(MGD)	(#)	(MGD)	(MGD)	(#)	(MGD)	(MGD)	(#)	(MGD)
1 (Initial)	7	2	14 / 7	7	2	14 / 7	15.4	2	30.8 / 15.4
2	12.6	3	26.6 / 14	15.4	2	30.8 / 15.4	15.4	3	46.2 / 30.8
3	12.6	4	39.2 / 26.6	15.4	3	46.2 / 30.8	15.4	4	61.6 / 46.2
4	12.6	5	51.8 / 39.2	15.4	4	61.6 / 46.2	15.4	5	77 / 61.6
5	12.6	6	64.4 / 51.8	15.4	5	77 / 61.6	15.4	6	92.4 / 77
6	12.6	7	77 / 64.4	15.4	6	92.4 / 77	-	-	-
7	12.6	8	89.6 / 77	-	-	-	-	-	-

Notes:
Filtration area per disk = 108 sf
Design peak flux rate = 5 gpm/sf

Each filtration alternative is assumed to be constructed in concrete tankage and includes a masonry type building enclosure. Costs for the initial phase of filtration facilities for Scenarios 1 to 3 are presented in Table 3-6.

Table 3-6: Auxiliary Treatment Costs (Above the Line, Prior to 45% Site Adders)

Scenario	Cost (Million)
1	$1.80
2	$3.40
3	$3.94

At the December 17, 2018 workshop, it was decided to proceed with Scenario 3 as it provides an even modular approach (all increments are the same size). Additionally, Scenario 3 was similar in cost to Scenario 2 but provides a total installed filtration capacity of 30.8 MGD versus 14 MGD. As discussed in Section 2, the use of the filters during the construction period to aid in effluent polishing will be reviewed further during detailed design.

Regarding effluent disinfection, due to the influence of wet weather flows, it was recommended to utilize chemical disinfection via liquid sodium hypochlorite for the following reasons:

- Represents largest site footprint and therefore reserves adequate space on-site for disinfection improvements
- Standardizes designs between multiple JCW WWTF's such as the Tomahawk Creek WWTF

For the initial Nelson Complex improvements with a total peak design flow capacity of 52 MGD, a total of two contact basins will provided. When expanding to the future peak design flow capacity, a third contact basin will be added. The applicable disinfection design criteria for each phase is presented below is Table 3-7.

Table 3-7: Disinfection Design Criteria

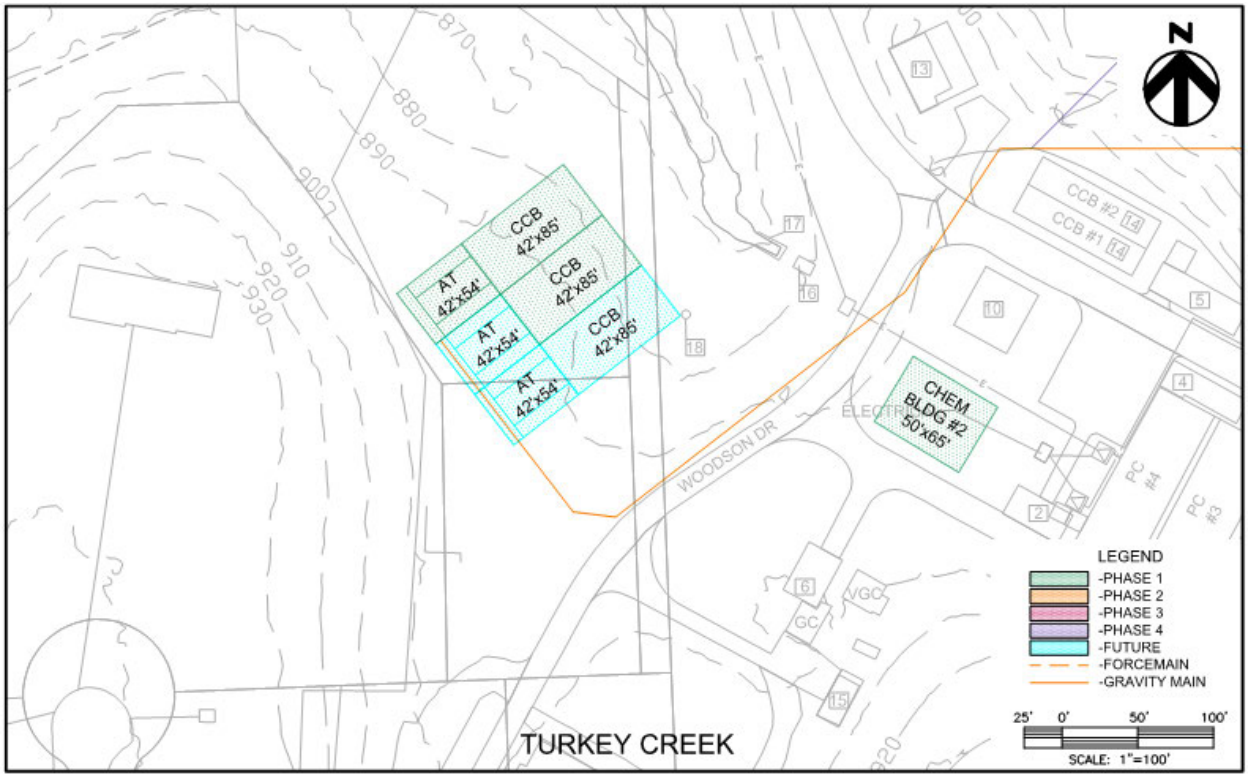
Component	Units	Proposed Value	Future Value
Flow	MGD	52	122
Hydraulic Retention Time (HRT)[1]	Min	15	10
Chlorine Contact Basin Minimum Volume	MG	0.60	0.89
Disinfectant Concentration Time (CT)	$mgCl_2$*min	30	
Primary Disinfectant	-	NaOCl	
Dechlorination Chemical	-	$NaHSO_3$	
Disinfectant Dose[1]	$mgCl_2/L$	6	
Target Residual	$mgCl_2/L$	2	
Chemical Storage[1]	Days	15	

Note:
[1]Average Day Chemical Use

If in the future, it is decided that the PEFTF's are to be removed and the additional peak flows conveyed to the Nelson Complex, the auxiliary treatment system will require expansion. If the timing for removal of the PEFTF's is far enough in the future, potentially beyond 15 years, the option of installing a 52 MGD of UV disinfection facility in lieu of chemical disinfection could be a lower cost alternative. This option would require future disinfection expansions to be served with chemical disinfection and would therefore result in having two disinfection methods on-site. This alterative will be investigated further in detailed design once the schedule for PEFTF removal in the collection system is finalized.

A layout of the filtration and disinfection facilities is depicted in Figure 3-1 below. The layout shows the footprint of the initial facilities as well those required to meet the future design peak flow capacity of 122 MGD.

Figure 3-1: Filtration and Disinfection Facilities Layout


N
CCB 42'x85'
CCB 42'x85'
CCB 42'x85'
AT 42'x54'
AT 42'x54'
AT 42'x54'
CHEM BLDG. #2 50'x65'
CCB #2
CCB #1
WOODSON DR
TURKEY CREEK
LEGEND
-PHASE 1
-PHASE 2
-PHASE 3
-PHASE 4
-FUTURE
-FORCEMAIN
-GRAVITY MAIN
25' 0' 50' 100'
SCALE: 1"=100'

3.3 Solids Processes

The solids process was recently evaluated under the 2018 Nelson-Middle Basin Solids Handling Study (Solids Study). The study focused on evaluation of digestion, sludge storage, biogas utilization, Fat, Oil and Grease (FOG) waste receiving, and receiving of hauled sludge from Blue River Main and New Century Air Center (NCAC) facilities. The costs associated with improvements to these areas are based on the 2018 Solids Study. Dewatering, WAS thickening, and primary sludge thickening were not addressed in the previous study. As such, these processes were further evaluated in this project.

TM #4 – Alternatives Selection identified design criteria for the solids processes. Refinement of the overall site plan identified that demolition and removal of the existing centrifuge dewatering building allowed for a more efficient site layout with reduced phasing complexity. The dewatering process will be relocated into a combined dewatering and WAS thickening building. Design criteria for WAS thickening and dewatering are included in TM #4.

Modifications beyond relocation of the dewatering building include refinement of the centrate treatment process, addition of centrate storage, and the addition of odor control facilities. Design criteria for centrate management are included in Table 3-8. Biosolids odor control design details are summarized in Table 3-9.

Table 3-8: Centrate Storage and Treatment Design Criteria

Component	Units	Value
Centrate Storage		
No. Tanks	-	1
Storage[1]	days	3
Tank Volume Each	Gallons	324,000
Centrate Treatment		
Type	-	Nitrogen Removal (Anitamox)
No. Trains	-	1
Volume	Gallons	15,500
Performance		
Ammonia Removal	%	80-85
Total Inorganic Nitrogen	%	75-80
Centrate Pumping		
No. Pumps	-	2 (1-duty, 1 standby)
Flowrate	GPM	85

[1]Assumes average day production and five days of dewatering

Table 3-9: Solids Odor Control Design Criteria

Component	Units	Value
Thickening / Dewatering Building		
• Channels / Wetwells / Rooms	Air Changes/Hour	6
• Truck Bays / Equipment / Conveyors	Air Changes/Hour	12
• Anticipated Total Air Flow Rate	cfm	29,000
Centrate / Side Stream Treatment		
• Channels / Wetwells	Air Changes/Hour	6
• Anticipated Total Air Flow Rate	cfm	5,000
Gravity Thickeners		
• Basins	Air Changes/Hour	12
• Anticipated Total Air Flow Rate	cfm	3,000

The resulting solids process costs are summarized in Table 17. These costs represent above the line costs, which does not include site related markups, contractor markups, or non-construction related costs.

Table 3-10: Above the line Solids Processing Costs
([1])

Item	Above the line Cost
Gravity Thickening	$3,187,000
Thickening / Dewatering Building	$9,412,000
Centrate Storage and return pumping	$929,000
Sidestream Treatment (AnitaMox)	$2,067,000
Odor Control #2 (Solids)	$2,847,000

[1]Costs based on the 2018 Nelson-Middle Basin Solids Handling Study

In addition, a cost of $24,645,000 for digestion / FOG receiving / gas utilization, was identified in the Solids Study. Unlike the costs above, this estimate already included general markups for site work, piping, electrical, and I&C but not for overhead and profit, contingencies, or engineering.

4 WWTF Support Facilities

4.1 Administration, Operations, and Maintenance Facilities

Four staff groups are currently located at the Nelson Complex; Plant Operation and Maintenance, Line Maintenance and Repair, Operation and Maintenance (O&M) Management, and Existing Infrastructure (EI) Engineering. With the exception of Line Maintenance and Repair, the buildings housing the other three groups will need to be demolished to make room for the new treatment facilities. In addition, the Line Maintenance and Repair groups are currently located in separate areas and a portion of the facilities are inadequate and/or outdated. Due to the efficiencies that would be realized, it would be preferred to have this group located together in a more functional arrangement.

Facilities to house these groups proposed as part of the treatment facility upgrades are discussed in the following paragraphs.

4.1.1 EI Engineering/O&M Management

A new building is proposed for these two groups. A needs assessment was performed, the results of which are presented in Table 4-1. This table lists the types, number, and size of the various spaces, based on the following assumptions:

- Staff size was based on existing (including currently unfilled positions) plus 20% growth. This also includes space for the New Development and Asset Management engineering staff currently located at the Sunset Office Building.
- An emphasis was made on providing ample conference space. Collaboration between EI, O&M, and third parties such as other agencies, consultants, contractors, and vendors is essential to JCW in managing their infrastructure and operational challenges and meeting their level of service objectives.
- This building is proposed to be located near the plant entrance along Foxridge Drive for ease of access by the public and other third parties. The building will include a large meeting room where visiting groups could gather for orientation prior to plant tours, or for presentations and training. It is envisioned that room will contain displays highlighting the Nelson Complex's and JCW's history, and other exhibits of an educational nature for the benefit of visiting students and other groups.

Table 4-1: EI Engineering O/M Management Building Space Needs

Item	Quantity	Length (ft)	Width (ft)	Area (SF)	Subtotal (SF)
Engineering Offices	6	10	15	150	900
Operations Management Offices	6	15	10	150	900
General Cubicles	20	7	7	49	980
Vestibule	1	12	12	144	144
Greeting / Seating Space	1	20	20	400	400
Reception	1	10	8	80	80
Restrooms	2	20	10	200	400
Janitors Closet	1	8	5	40	40
Medium Conference Room	2	24	16	384	768
Small Conference Room	3	20	12	240	720
Library/Future Expansion	1	40	20	800	800
Storage	1	10	10	100	100
Breakroom	1	20	16	320	320
Large Meeting/Training Room	1	40	25	1,000	1,000
				Subtotal	7,552
				Circulation (20%)	1,510
				Total	9,062

4.1.2 Plant O&M

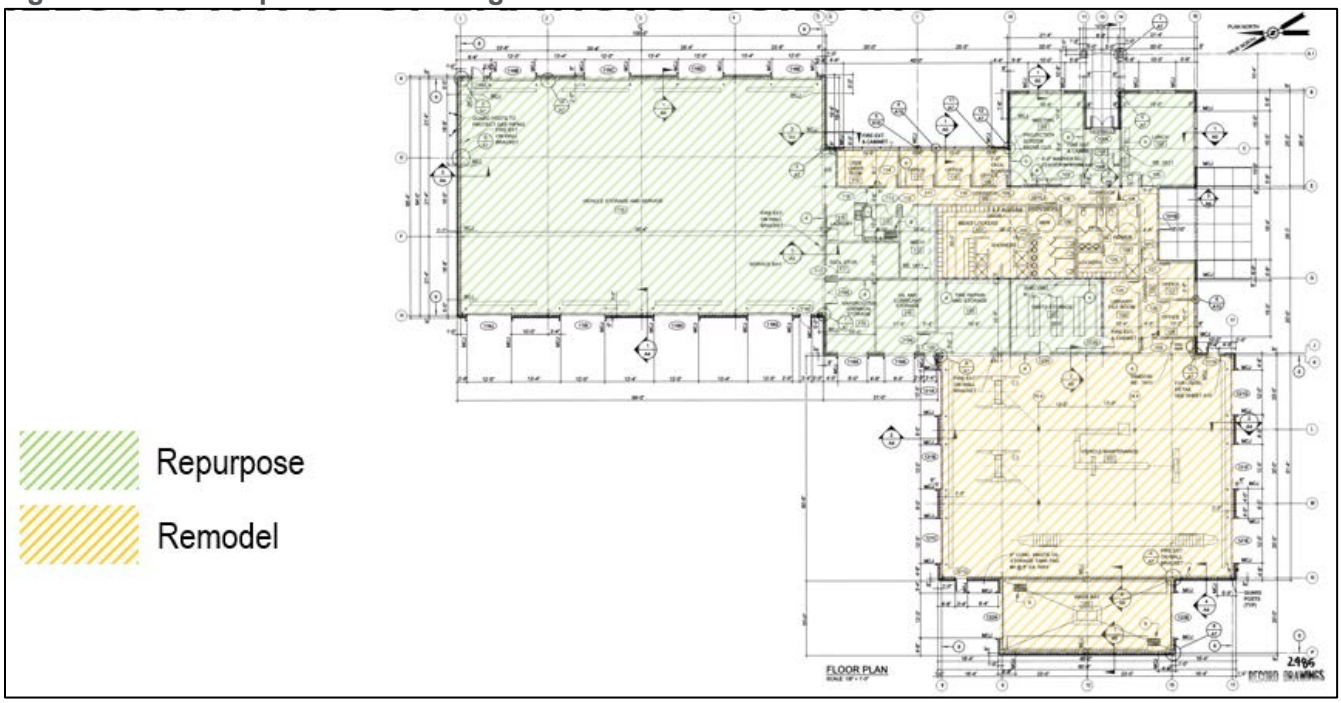
The existing Line Maintenance building is not in the path of the proposed plant upgrades, and can therefore be retained as part of the new facility. It is proposed that this building be repurposed to house the Plant O&M staff. Table 4-2 presents a need assessment for the Plant O&M group, which demonstrates that the existing building size is adequate.

Table 4-2: Conversion of Existing Line Maintenance Building to Plant Operations Building

Retain Current Use	
Office	900 SF
Men's Locker/Restroom	760 SF
Women's Locker/Restroom	340 SF
Garage/Vehicle Parking	4,850 SF
Total	**6,850 SF**
Repurposed	
SCADA/Control Room	1,600 SF
Server Room	250 SF
Break Room	800 SF
Lab	500 SF
Meeting Room	550 SF
Training Room	500 SF
Electrical Room	200 SF
Tech Work Area	400 SF
Mechanical/Fire	300 SF
Misc/Storage/Circulation	3,000 SF
Total	**8,100 SF**
Total Required	**14,950 SF**
Existing Building Size	**17,400 SF**

Figure 4-1 shows a possible plan for repurposing portions of the building. It should also be noted that there is ample space around the building to expand if this is ultimately determined to be warranted.

Figure 4-1: Plant Operations Building Conversion



4.1.3 Line Maintenance and Repair

A space needs assessment for this group is presented in Table 4-3. A key element of this plan is providing sufficient indoor parking space for vehicles and equipment to maximize their reliability and longevity. In addition to this enclosed space, additional yard space will be needed for storage of construction and maintenance materials – pipe, fittings, MH parts, gravel, salt, etc. A specific location on site for this operation has not been designated but there will be ample space in the lower portion of the NC site once the Turkey Creek headworks and clarifiers have been demolished.

Table 4-3: Line Maintenance and Repair Building Space Needs

Office Space	500 SF
Restrooms	1,750 SF
Computer/SCADA	1,750 SF
Training/Brea/Multi-Purpose Room	1,500 SF
Conference Rooms (2)	500 SF
Storage (Tools, Supplies, etc.)	3,000 SF
Miscellaneous	1,000 SF
Circulation	2,000 SF
Subtotal	12,000 SF
Indoor Vehicle/Equipment	18,000 SF
Total	30,000 SF
Note: Include space for up to 64 staff and 22 large vehicles/construction equipment	

4.1.4 Summary

A cost estimate for the three facilities, along with associated site work, parking, and fuel pumps is presented in Table 4-4.

Table 4-4: Facilities Summary
(1)

Eng/O&M Management Building	
Building, Complete	$ 3,625,000
Site work	$ 218,000
Parking	$ 257,000
Total	**$4,100,000 SF**
Nelson Operations Building	
Building, Complete	$ 2,300,000
Parking	$ 160,000
Fuel Island	$ 300,000
Total	**$2,760,000 SF**
Line Maintenance & Repair	
Building, Complete	$ 8,700,000
Site work	$ 522,000
Parking	$ 320,000
Total	**$9,542,000 SF**

(1) Costs exclude markups for OH & P, Contingencies, and Engineering

4.2 Off-Site Utilities

The proposed WWTF improvements will result in significantly increased demands for electricity and natural gas.

4.2.1 Electricity

The Nelson Complex is currently served by three main service entrances, one with redundant feeds serving Mission Main, one with redundant feeds serving Turkey Creek, and one single feed serving the Centrifuge Building. It is envisioned that the proposed facility will have two service entrances, each redundant, as reflected in Table 4-5.

Table 4-5: Electric Service Demand and Service Upgrade

Facility	Service (kVA)	
	Service #1	Service #2
Existing		
Turkey Creek	1,000	1,000
Mission Main	1,000	1,000
Centrifuge Building	500	
Vehicle Maintenance	150	
CNG	25	
Total	2,675	2,000
Proposed		
Nelson BNR	5,300	5,300

This information was provided to KCPL. Their reply, below in Figure 4-2 stated that the increased demand would not exceed the capacity of the existing distribution system, and that any upgrades to the services would be minor.

Figure 4-2: KCPL Communication

From: Gary Price [mailto:Gary.Price@kcpl.com]
Sent: Monday, December 3, 2018 9:09 AM
To: Buechler, Kathy <Kathy.Buechler@hdrinc.com>
Cc: Tristan Cox <Tristan.Cox@kcpl.com>
Subject: RE: JCW Nelson Complex Study

Kathy,

The Planning Engineer has looked at the two circuits feeding into the site and the only work that will be needed at this point is an upgrade to circuit 6823 from the north end of the property to wherever the metering point would be. I would guess less than 1000'. I have put together an order of magnitude estimate for 1000' of underground feeder in 6" conduit, a 600 amp terminal pole, a 600 amp switchgear and 600 amp sectionalizer and it came to about $250,000. Of course the farther to the north the metering point is located will reduce the cost. My understanding is that you will need two primary metering feeds and one of those feeds can have revenue justification for the added load applied, so I would think the worst case cost for them would be the $250,000. Of course this information is valid for today and could change in the future if new load is added to either of these circuits or other factors to the system are changed. I hope this answers your questions.

Thanks,
Gary Price

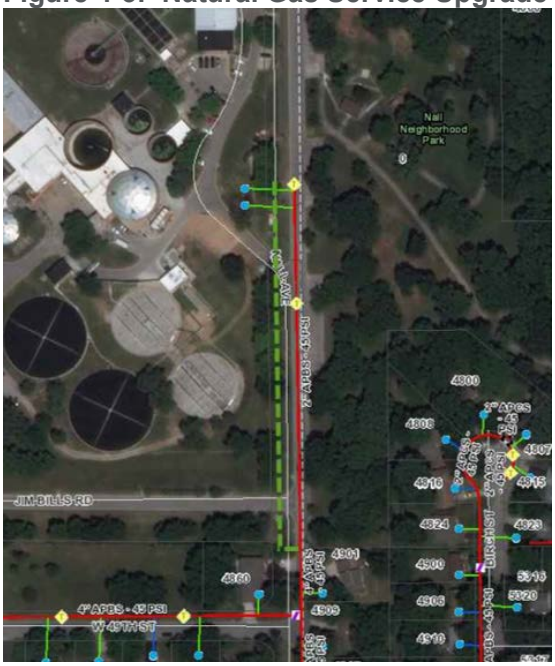
4.2.2 Natural Gas

The following projected load information and a figure was provided to Kansas Gas Service (KGS):

- Max Demand = 22,000 CFH
- Pressure = 5 PSI

KGS confirmed that upgrades to their system would also be minor, and provided the map shown in Figure 4-3 which depicts the 4-inch main extension that would be required.

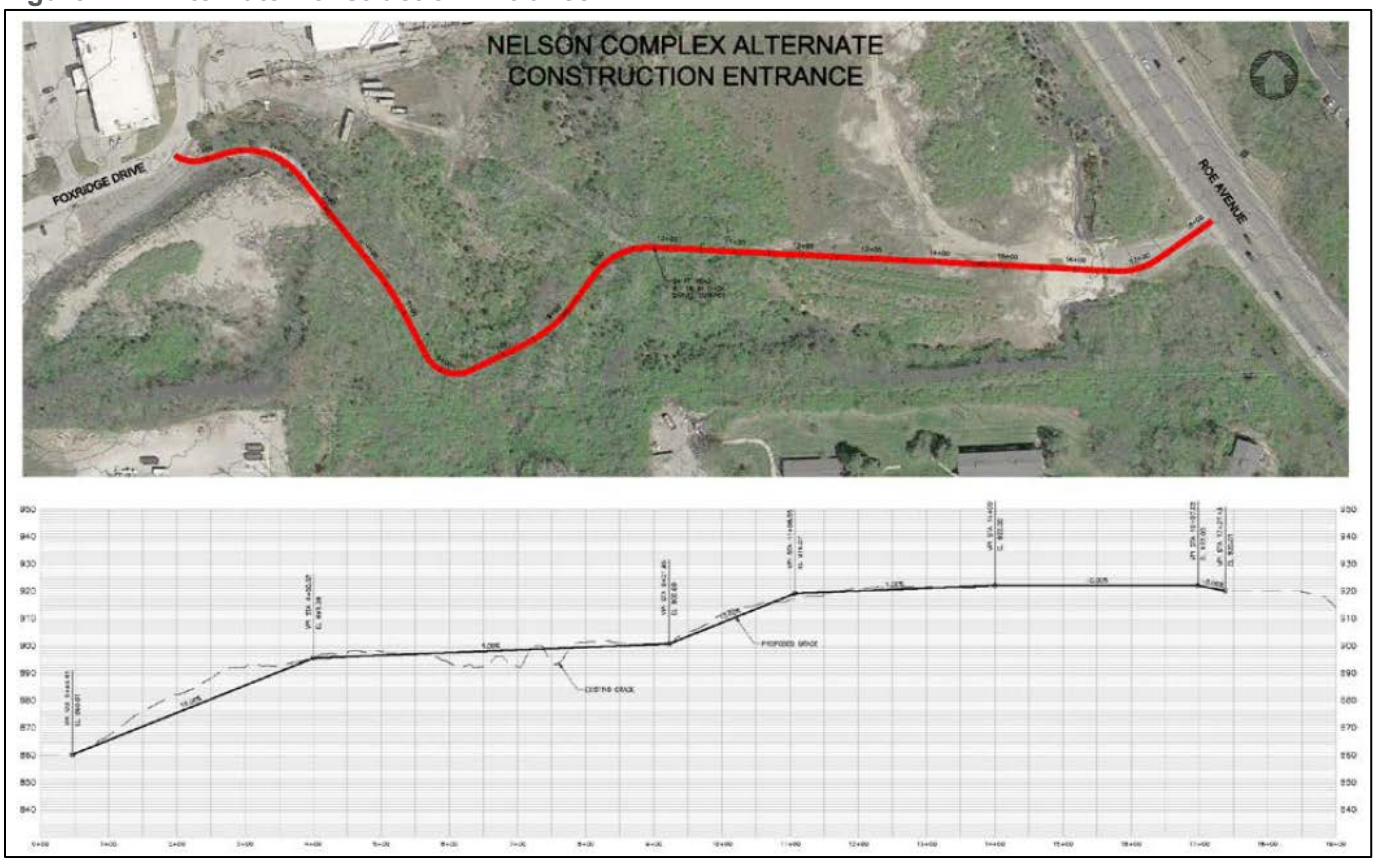
Figure 4-3: Natural Gas Service Upgrade



4.3 Construction Logistics

Site access by construction traffic and space for on-site storage and staging will present significant challenges for the construction contractor. While the site is close to Interstate 35, the Lamar-Foxridge Intersection and the I-35 on/off ramps will present significant bottlenecks. Furthermore, there is limited space on site where construction storage/staging would not adversely impact treatment operations. A cursory review of a secondary construction entrance and off-site storage/staging space has been performed. One such possibility is shown in Figure 4-4 which consists of a temporary road from Roe Avenue to the east with several possible laydown areas along the route. While the details of this concept have not been worked out, a representative cost has been included in the cost estimates in Section 5.

Figure 4-4: Alternate Construction Entrance



5 Whole Facility Cost Estimate

In Sections 2 through 4, individual components of the WWTF have been identified, including the main dry and wet weather treatment processes, the balance of the plant facilities including biosolids processing, and administrative/support facilities. These are consolidated in Table 5-2, along with representative multipliers for costs such as Overhead and Profit, Contingencies, and Engineering, to provide a Whole Facility Project Cost Estimate. The total cost is expressed both in 2018 dollars - $328 million - and in 2026 dollars (mid-point of construction) - $416 million.

Also, as the wet weather conveyance analysis was proceeding simultaneously with the WWTF evaluation, more detailed review was performed of the off-site dry weather conveyance improvements. Refinements in the cost estimates for Turkey Creek, Belinder, and Rock Creek Pump Stations from the comparative figures presented in Table 2-2 resulted. The revised figures are shown in Table 5-1:

Table 5-1: Dry Weather Pumping Cost Refinances

Pump Station	Comparative Analysis (Table 2-2)	Refined Estimate
Turkey Creek	$3.02 M	$5.03 M
Rock Creek	$1.73 M	$3.57 M
Belinder	$1.77 M	$15.44 M

- Turkey Creek – The difference is primarily due to the comparative costs being “above the line” without markups, while the refined costs include all markups, i.e. OH&P, contingencies, engineering, etc., to represent a total project cost.
- Belinder – The difference is due to the same considerations as Turkey Creek.
- Rock Creek – The figures for Rock Creek changed significantly from $1.77 million to $15.44 million. A near term project was already contemplated at Rock Creek to address issues such as equipment reliability and functionality, safety, flooding and other issues. Rather than incur a sizable expenditure at this time, it was decided to proceed now only with replacing the electrical room, and to replace the pump station in its entirety in a later project concurrent with the treatment facility upgrade. The replacement would include provisions for future wet weather pumping associated with the Martway PEFTF abandonment, which is discussed further in Section 6.

In addition, it was determined that the smaller Lamar Pump Station, which currently pumps to the Turkey Creek Headworks should be replaced in its entirety. The resulting pump station costs are presented along with the WWTF cost in Table 5-3.

Table 5-2: "Whole" Facility Project Cost Estimate (2018 Dollars)

Item		Cost
Temporary Facilities		$669,000
Headworks Building		$9,048,000
Primary Clarifiers		$7,813,000
Odor Control #1 (HW and PC's)		$2,491,000
Miscellaneous Splitter Boxes		$932,000
BNR Train		$25,988,000
Secondary Clarifiers		$7,085,000
RAS/WAS Pump Station		$4,359,000
Chemical Addition Building #1 (Ferric, Carbon)		$1,136,000
Auxiliary Treatment (1 Firm / 1 Standby Filter, 15.4 MGD Each)		$3,935,000
Chlorine Contact Basins		$2,836,000
Chemical Addition Building #2 (Hypo and Bi-Sulfite)		$1,070,000
NPW Pump Station		$714,000
Effluent Reaeration		$1,185,000
Gravity Thickening		$3,187,000
Thickening / Dewatering Building		$9,412,000
Centrate Storage		$929,000
Sidestream Treatment (AnitaMox)		$2,067,000
Odor Control #2 (Solids)		$2,847,000
Plant Drain Pump Station		$250,000
Subtotal		***$87,953,000***
Site work	10%	$8,795,000
SCADA	9%	$7,916,000
Site Electrical	10%	$8,795,000
Site Piping	10%	$8,795,000
Subtotal		***$122,254,000***
Demolition		$4,768,893
MOPO's		$1,759,060
Rock Allowance		$2,000,000
Digestion/FOG Receiving/Gas Utilization		$24,645,000
Administration/Operations/Line Maintenance Facilities		$16,402,000
Access Road/Laydown Yard		$1,400,000
Offsite Staging		$500,000
Subtotal		***$173,729,000***
Overhead	10%	$17,373,000
Profit	5%	$9,555,000
Bonds and Insurance	3%	$6,020,000
Contingency	30%	$62,003,000
Subtotal		***$268,680,000***
Engineering, Legal and Administrative (ELA)	22%	$59,110,000
Offsite Electrical Supply Improvements		$375,000
Total (2018 Dollars)		***$328,165,000***
Total (2026 Dollars - Mid-Point of Construction)		***$415,710,000***

Table 5-3: Nelson Complex WWTF and Dry Weather Pumping Cost Estimates, 2018 Dollars

	Estimated Cost
Treatment Facility	$ 328,165,000
Pump Stations / FM Ext.	
• Turkey Creek	$ 5,026,000
• Belinder	$ 3,569,000
• Rock Creek	$ 15,444,000 (1)
• Lamar	$ 730,000
Sub-Total	**$ 24,769,000**
Total	**$ 352,934,000 (2018)**
Total	**$ 447 million (2026** mid-point)

(1) Includes $4 million in provisions for future wet weather conveyance.

6 Wet Weather Facilities Conceptual Design and Cost Estimates

6.1 Preferred Solutions from Refined Optimization

The Collection System Study team carried out an extensive optimization process to narrow down the literally infinite number of possible combinations of improvements to address the wet weather challenges in the Mission Main and Turkey Creek watersheds. Various combinations of system storage, relief/replacement sewers, I/I reduction, pumping and forcemain sizing, PEFTF sizing/upgrades, and centralized enhanced high rate treatment were considered. Throughout this process, representative cost curves for pump station and PEFTF upgrades were provided to the collection team under Task 5 – Collection System Facility Evaluation and Optimization Support of this Facility Plan. The results of this optimization process are documented in the Collection System Study TM #4 – Refined Optimization.

The optimization process yielded two primary Collection System Management strategies:

Alternative 1 - Eliminate PEFTF's through Wet Weather Management
Alternative 2 - Retain PEFTF's with Enhanced High Rate Treatment

Alternative 1 – Eliminate PEFTF's through Wet Weather Management, is depicted in Figure 6-1 (also included in Appendix A).

Figure 6-1: Alternative 1 – Eliminate PEFTF's

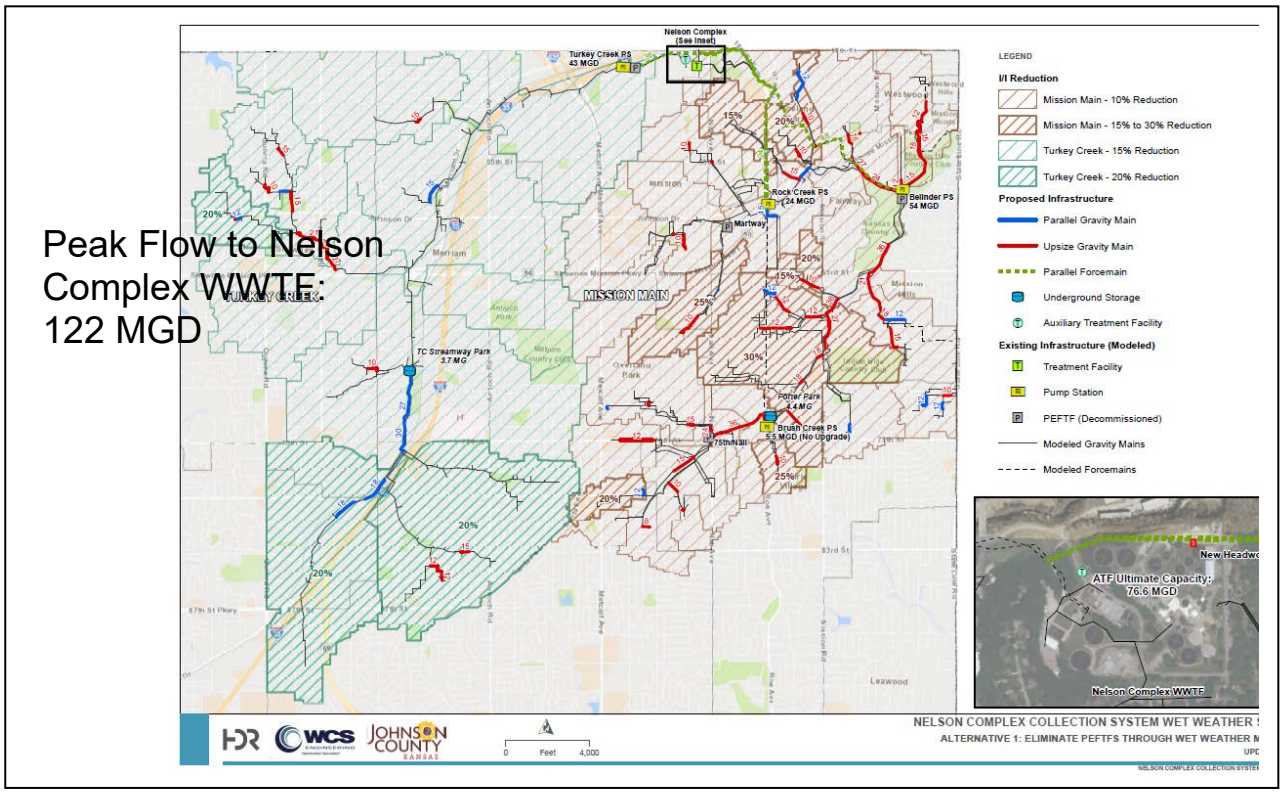


Table 6-1: Major Projects Recommended to Eliminate PEFTFs

- Turkey Creek Basin
  - Upgrade Turkey Creek Pump Station Capacity to 43 MGD and new 36-inch Forcemain to WWTF
  - Two Remote Underground Storage Facilities (2 MG and 1 MG), or One Combined Facility
  - System Wide Public Sector I/I Reduction and Targeted Private I/I (overall reduction of 16.5%)
  - Gravity Conveyance Upgrades (Interceptor and Localized Improvements)
- Mission Main Basin
  - Storage at Brush Creek PS to eliminate 75th and Nall PEFTF (4.5 MG)
  - Upgrade Rock Creek PS to 24 MG and new 24-inch Forcemain to eliminate Martway PEFTF
  - Upgrade Belinder PS to 54 MGD and new 48-inch Forcemain to eliminate Belinder PEFTF
  - System Wide Public Sector I/I Reduction and Targeted Private I/I (overall reduction of 14%)
  - Gravity Conveyance Upgrades (Interceptor and Localized Improvements)
- Auxiliary Treatment Facility (ATF) at Nelson Complex (ultimate size 77 MGD)

The major components included in this alternative are itemized in Table 6-1

Alternative 2 – Retain PEFTF's with Enhanced High Rate Treatment is depicted in Figure 6-2 (also included in Appendix A).

Figure 6-2: Alternative 2 – Retain PEFTF's

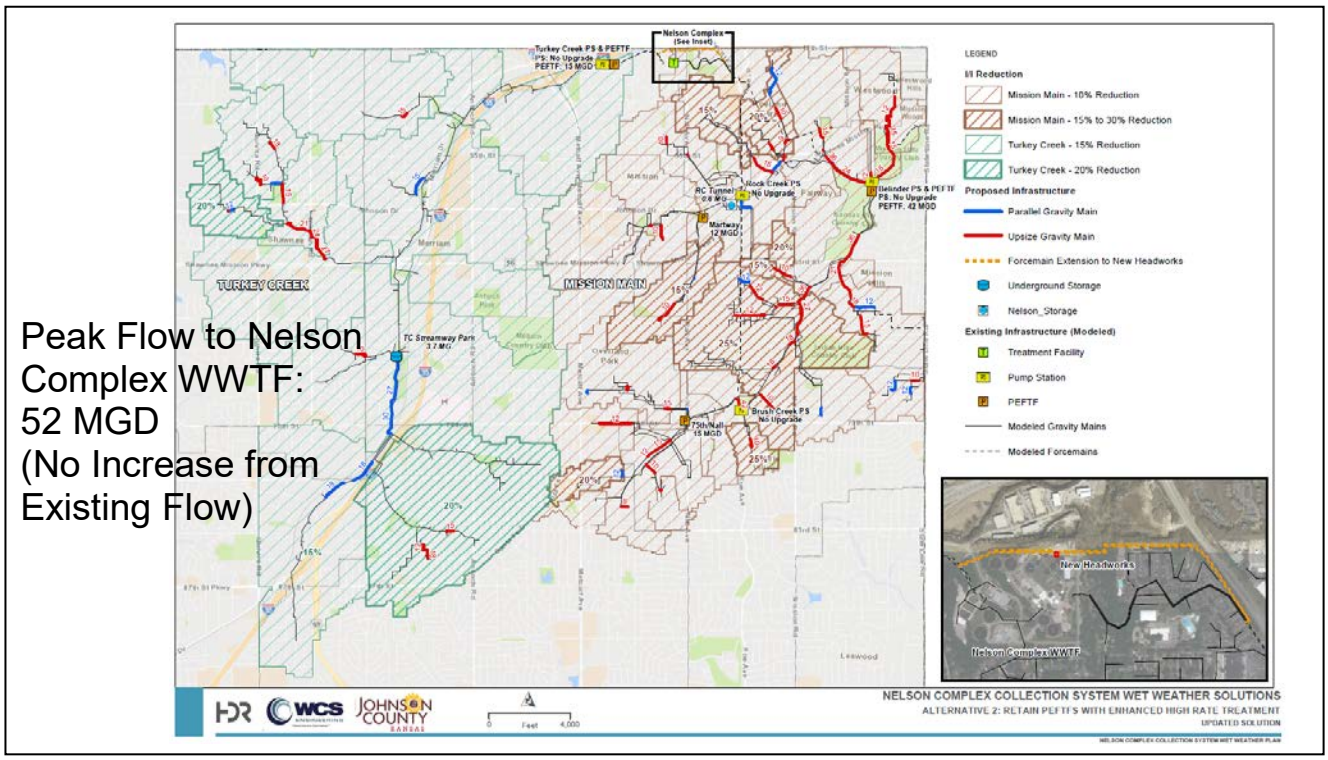


Table 6-2: Major Projects Recommended to Eliminate PEFTFs

- Turkey Creek Basin
  - Upgrades to Turkey Creek PEFTF (15.2 MGD)
  - Remote Underground Storage Facilities (2 MG and 1 MG) or One Combined Facility
  - System Wide Public Sector I/I Reduction and Targeted Private I/I
  - Gravity Conveyance Upgrades (Interceptor and Localized Improvements)
- Mission Main Basin
  - Upgrades to PEFTFs (75th/Nall @ 15 MGD, Martway @ 12 MGD, Belinder @ 42 MGD)
  - System Wide Public Sector I/I Reduction and Targeted Private I/I
  - Gravity Conveyance Upgrades (Interceptor and Localized Improvements)

The major components included in this alternative are itemized in Table 6-2.

These two alternatives were then subjected to a more detailed alternative analysis based on conceptual designs and more detailed, site specific costs. In the following sections of Section 6, conceptual designs and cost estimates are presented for each pump station: Turkey Creek, Rock Creek, and Belinder, and each PEFTF: Turkey Creek, Martway, 75th and Nall, and Belinder.

These costs will then be combined with corresponding costs developed under the Collection System Study for storage, conveyance, and I/I reductions as a basis for the alternative analysis.

6.2 Alternative 1 – Eliminate PEFTFs through Wet Weather Management

6.2.1 Pump Station Parameters

Three major pump stations were identified for upgrade during the refined optimization process, Turkey Creek, Rock Creek, and Belinder Pump Stations (PS's). The Brush Creek PS was not selected for upgrade due to the recommendation to provide storage at that location, which resulted in no increase in flow at the Brush Creek PS. As part of the alternative refinement process, each pump station site was evaluated in detail on a site specific basis to develop more refined upgrade costs. When developing the cost basis for these alternatives, the following conceptual design assumptions were utilized for all locations:

- Screening: New automated mechanical coarse screening was included to provide sufficient levels of debris removal to protect downstream equipment. The scope of these facilities generally include the following items:
    - New screening structure
    - Minimum of one mechanical bar screen (maximum of 20 MGD per screen) with 0.75-inch bar spacing and dedicated washer/compactor
    - One manual bar rack with 2-inch bar spacing
    - Dedicated / separate electrical room
    - Dedicated dumpster room
- Pumping: All wet weather pumping improvements assume the use of submersible type pumps due to the required head conditions as well as to improve the pumping equipment's ability to handle potential debris in the wastewater stream. The scope of these improvements assume that the "initial" modifications to accommodate the higher dry weather pumping head to convey existing flows to the new Nelson Complex Headworks Building location are complete. Additionally, the following conceptual design parameters were utilized for all locations:
    - Wetwell modifications to accommodate conversion from turbine style pumps to submersible pumps
    - Assumed one common standby pump between dry and wet weather stations
    - All pumps on variable frequency drives (VFDs)
    - Design peak force main velocity generally less than 6 ft/s

6.2.2 Turkey Creek

The Turkey Creek pump station dry weather facility currently has a firm pumping capacity of 27 MGD. Information related to the existing dry and wet weather pumping facilities is summarized below. Information related to the existing PEFTF can be found in Section 6.3.

The existing dry weather pump station consists of the following main components:

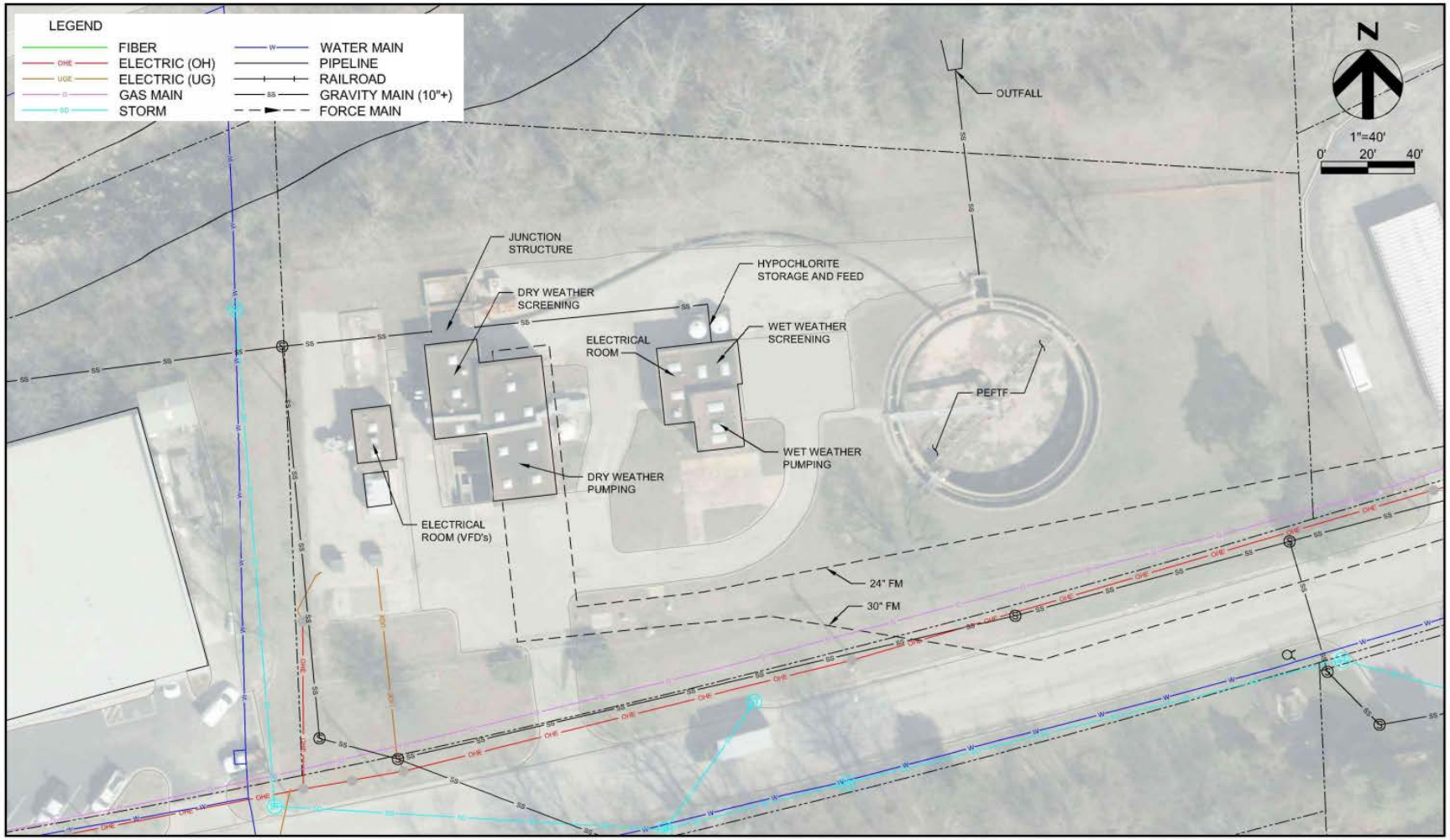
- Screening:
  - Two flexible multi-rake mechanical bar screens with 0.75-inch bar spacing and dedicated washer/compactors (planned through SMTC-CO37 project)
- Pumping:
  - The existing pump station contains four horizontal dry pit type pumps with the following capacity:
    - 9.0 MGD each @ 86-feet TDH (when operating at 27 MGD)
      - 300 HP motors each with VFDs (planned through SMTC-CO37 project)
  - The improved pump station to convey influent flow to the new headworks location will consist of four horizontal dry pit type pumps with the following capacity:
    - 9.0 MGD each @ 155-feet TDH
      - 350 HP motors each with VFDs

The existing wet weather pump station currently serving the PEFTF consists of the following main components:

- Screening:
  - One manual bar rack with 1-inch bar spacing
- Pumping
  - Two firm and no standby turbine style pumps (planned through SMTC-CO37 project)
    - 11.0 MGD each @ 42-feet TDH, 22 MGD total
      - 100 HP motors each with VFDs

Figure 6-3 depicts the arrangement of the existing facilities at the pump station site.

Figure 6-3: Turkey Creek Pump Station Existing Layout



The Turkey Creek Pump Station would be upgraded to a total firm pumping capacity of 43 MGD. In order to meet this increased pumping capacity requirement, it is proposed to repurpose the wet weather pump station currently serving the PEFTF to pump to the new Nelson Complex Headworks Building. No improvements are anticipated at the dry weather pump station beyond the initial improvements to accommodate the higher pumping head to the new Headworks Building location. The scope of the proposed improvements include the following items:

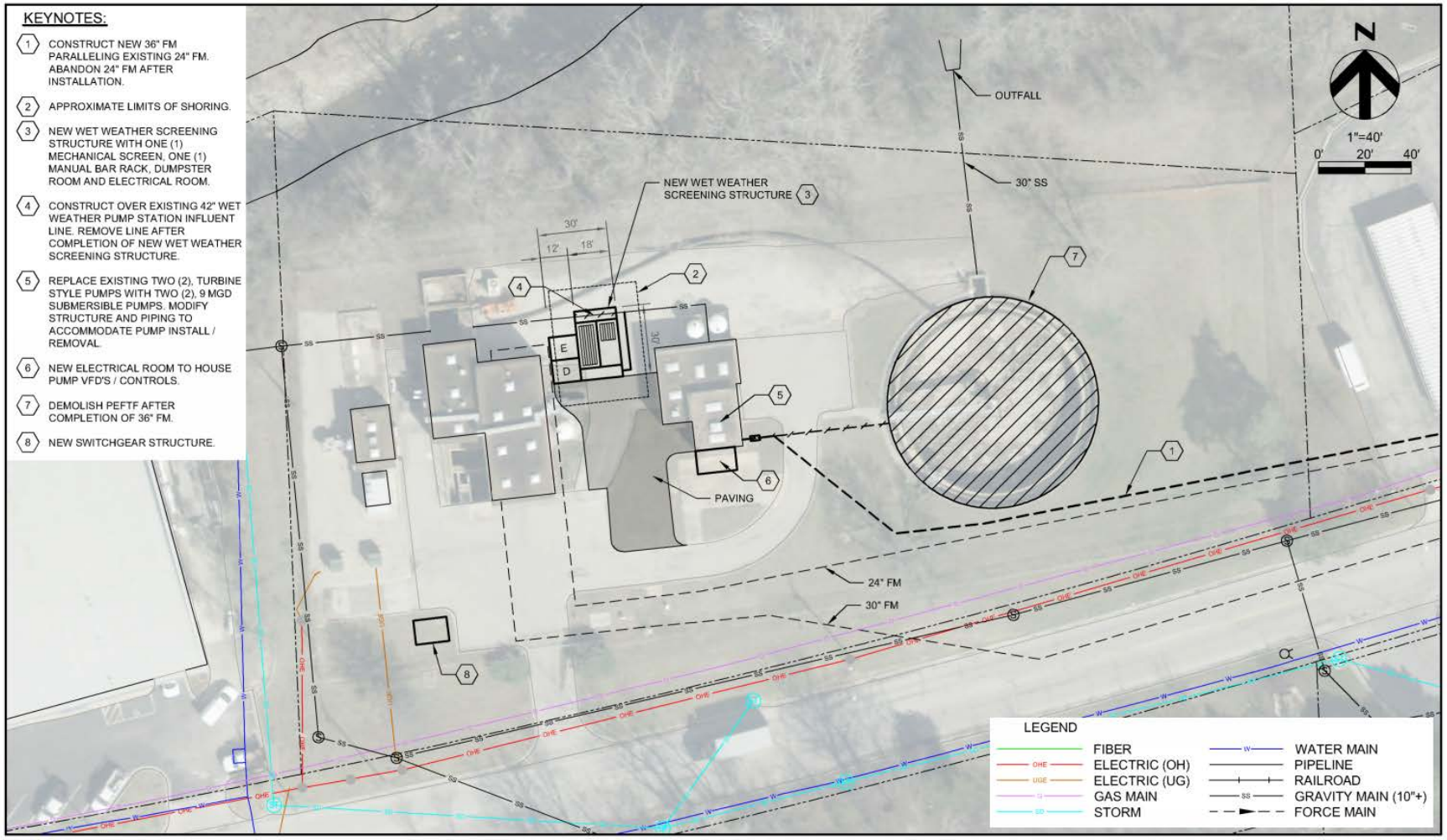
- New wet weather screening facility:
    - Two screening channels with isolation gates
        - One 18 MGD mechanical bar screen with washer/compactor
        - One manual bar rack
    - New superstructure including all electrical, mechanical and other improvements
- Improved wet weather pumping facility
    - Two submersible type pumps
        - 9.0 MGD each @ 155-feet TDH
            - 385 HP motors each with VFDs
    - New electrical room to house VFDs

Additional site related improvements include:

- Demolition of existing PEFTF chemical feed facilities and contact basin
- Upgrade of incoming electrical service entrance from 2,000 amps to 3,000 amps.

Figure 6-4 depicts the arrangement of the proposed improvements at the pump station site.

Figure 6-4: Turkey Creek Pump Station Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-3. Parallel FM costs are included in the Collection System Study.

Table 6-3: Turkey Creek Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Screening Improvements		$2,058,000
Wet Weather Pumping Improvements		$1,278,000
Sub-Total		$3,336,000
MOPOs		$39,000
Site Related Percentage Adders	20%	$664,000
PEFTF Demolition		$107,000
Sub-Total		$4,150,0000
Overhead/Profit/Bonds and Insurance	18%	$787,000
Contingency	30%	$1,481,000
Sub-Total		$6,418,000
ELA	25%	$1,605,000
Total		**$8,023,000**

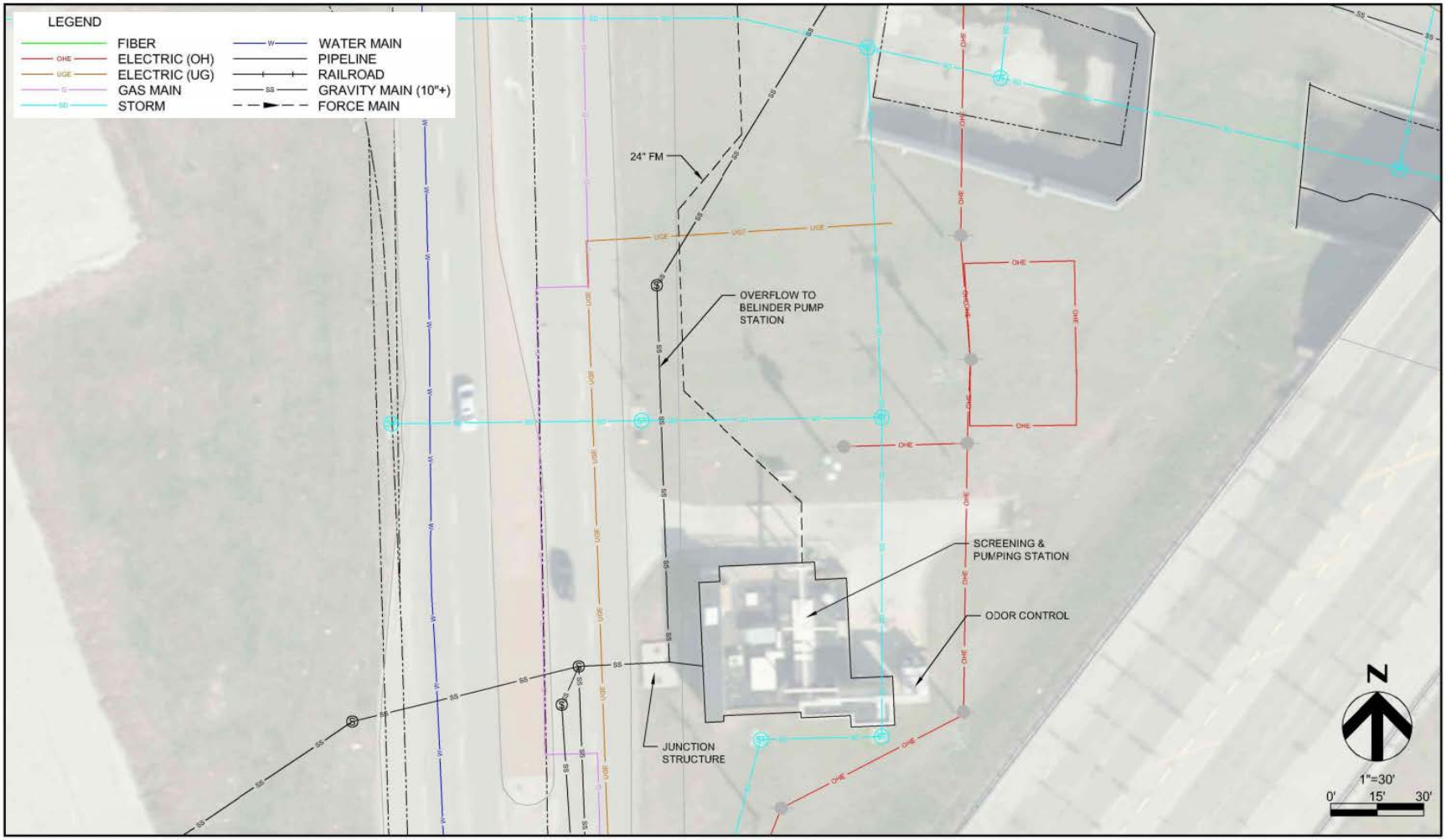
6.2.3 Rock Creek

The Rock Creek Pump Station currently has a firm pumping capacity of 12 MGD. It operates in conjunction with the upstream Martway PEFTF. Information related to the existing pumping facilities are summarized below:

- Screening:
  - Two mechanical bar screens with conveyor and washer/compactor (climber type, 0.75-inch bar spacing)
- Pumping:
  - Four horizontal dry pit type pumps
  - 4.0 MGD each @ 150-feet TDH
    - 200 HP with two on VFDs

Figure 6-5 depicts the arrangement of these existing facilities at the pump station site.

Figure 6-5: Rock Creek Pump Station Existing Layout



The Rock Creek Pump Station would be upgraded to a total firm pumping capacity of 24 MGD. To meet this increased pumping capacity requirement, and due to a number of concerns with the existing station including periodic flooding, it is proposed to construct a new pump station north of the existing station. While the structure will be able to accommodate a total pumping capacity of 24 MGD when the Martway PEFTF is abandoned, it will only be initially provided with equipment to convey 12 MGD. The scope of the proposed improvements include the following items:

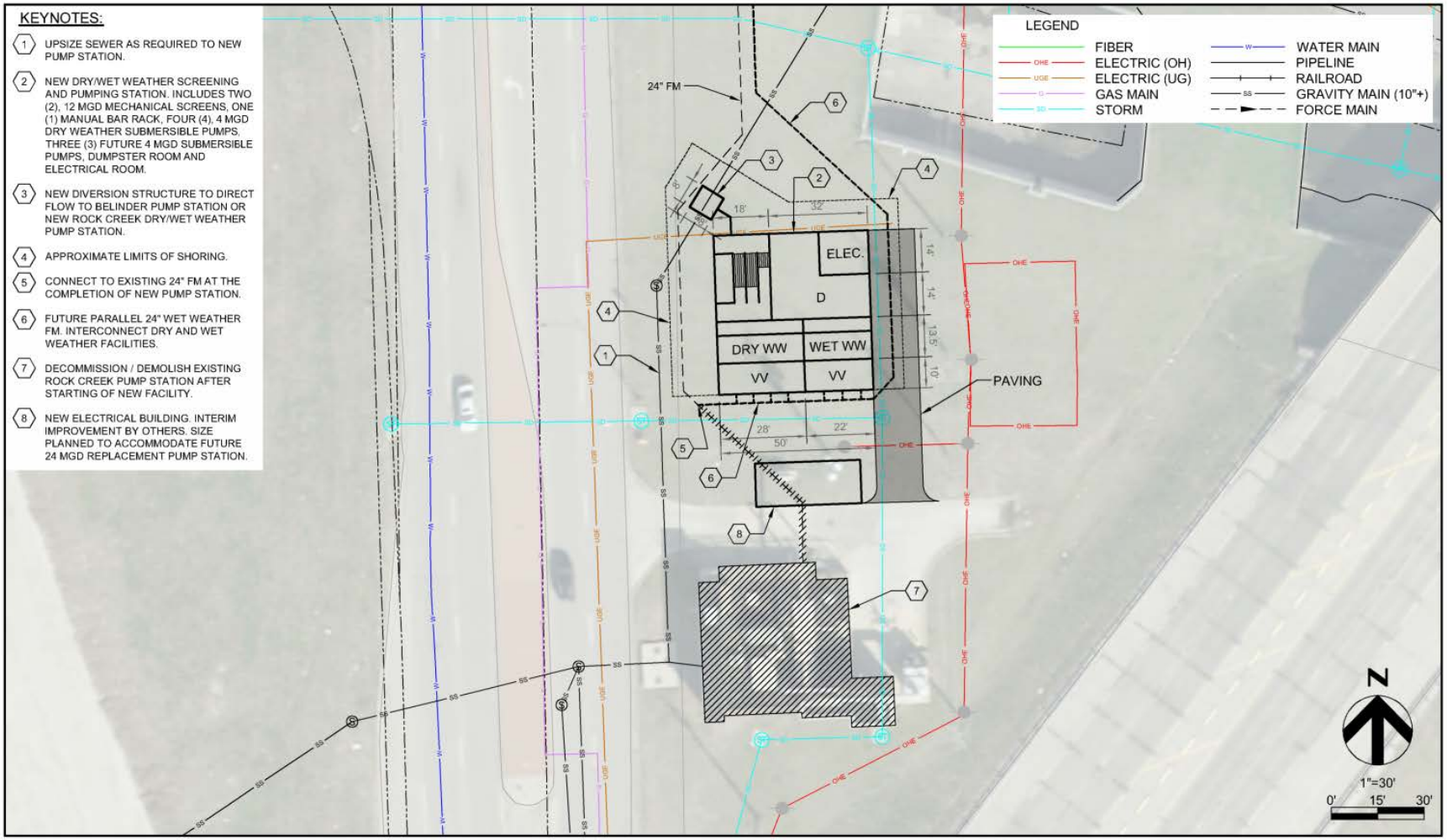
- New screening facility:
    - Three screening channels with isolation gates
        - Two, 12 MGD mechanical bar screens with washer/ compactor, 0.75-inch bar spacing
            - 1 firm/1 standby for 12 MGD pumping condition
            - 2 firm for future 24 MGD pumping condition
        - One manual bar rack
    - New superstructure to house electrical, mechanical and other improvements
- New pumping facility
    - Initial phase consists of:
        - Four submersible type pumps
            - 4.0 MGD each @ 166-feet TDH
                - 200 HP with VFDs
        - Discharge piping and valves
        - Hatches for pump removal with monorail crane
        - Tie to existing 24-inch forcemain
    - Future phase consists of:
        - Three submersible type pumps
            - 4.0 MGD each @ 166-feet TDH
                - 200 HP with VFDs
        - Discharge piping and valves
        - Hatches for pump removal with monorail crane
        - New parallel 24-inch forcemain

Additional site related improvements include:

- Upgrade of incoming electrical service from 1,000 amps to 2,000 amps.

Figure 6-6 depicts the arrangement of the proposed improvements at the pump station site. This layout assumes current planned electrical improvements at the Rock Creek Pump Station to house new switchgear and distribution equipment are complete.

Figure 6-6: Rock Creek Pump Station Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-4 and Table 6-5. Parallel FM costs are included in the Collection System Study.

Table 6-4: Rock Creek Pump Station Replacement Cost Estimate

Item		Extension
Diversion Structure		$180,500
Dry Weather Screening/Pumping Improvements		$5,180,000
Sub-Total		**$5,361,000**
Site Related Percentage Adders	20%	$1,066,000
Forcemain Extension		$947,000
Sub-Total		**$7,562,000**
Overhead/Profit/Bonds and Insurance	18%	$1,434,000
Contingency	30%	$2,699,000
Sub-Total		$11,695,000
ELA	**25%**	**$2,924,000**
Land Acquisition for Forcemain Extension		$148,000
Total		**$14,767,000**

Table 6-5: Rock Creek Future Wet Weather Pumping Cost Estimate

Item		Extension
Wet Weather Pumping Improvements		$662,000
Sub-Total		**$662,000**
Site Related Percentage Adders	20%	$132,000
Sub-Total		**$794,000**
Overhead/Profit/Bonds & Insurance	18%	$151,000
Contingency	30%	$284,000
Sub-Total		**1,229,000**
ELA	25%	$307,000
Total		**$1,536,000**

6.2.4 Belinder

The Belinder Pump Station dry weather facility currently has a firm pumping capacity of 10.6 MGD. Information related to the existing dry and wet weather pumping facilities are summarized below. Information related to the existing PEFTF can be found in Section 6.3.

The existing dry weather pump station consists of the following main components:

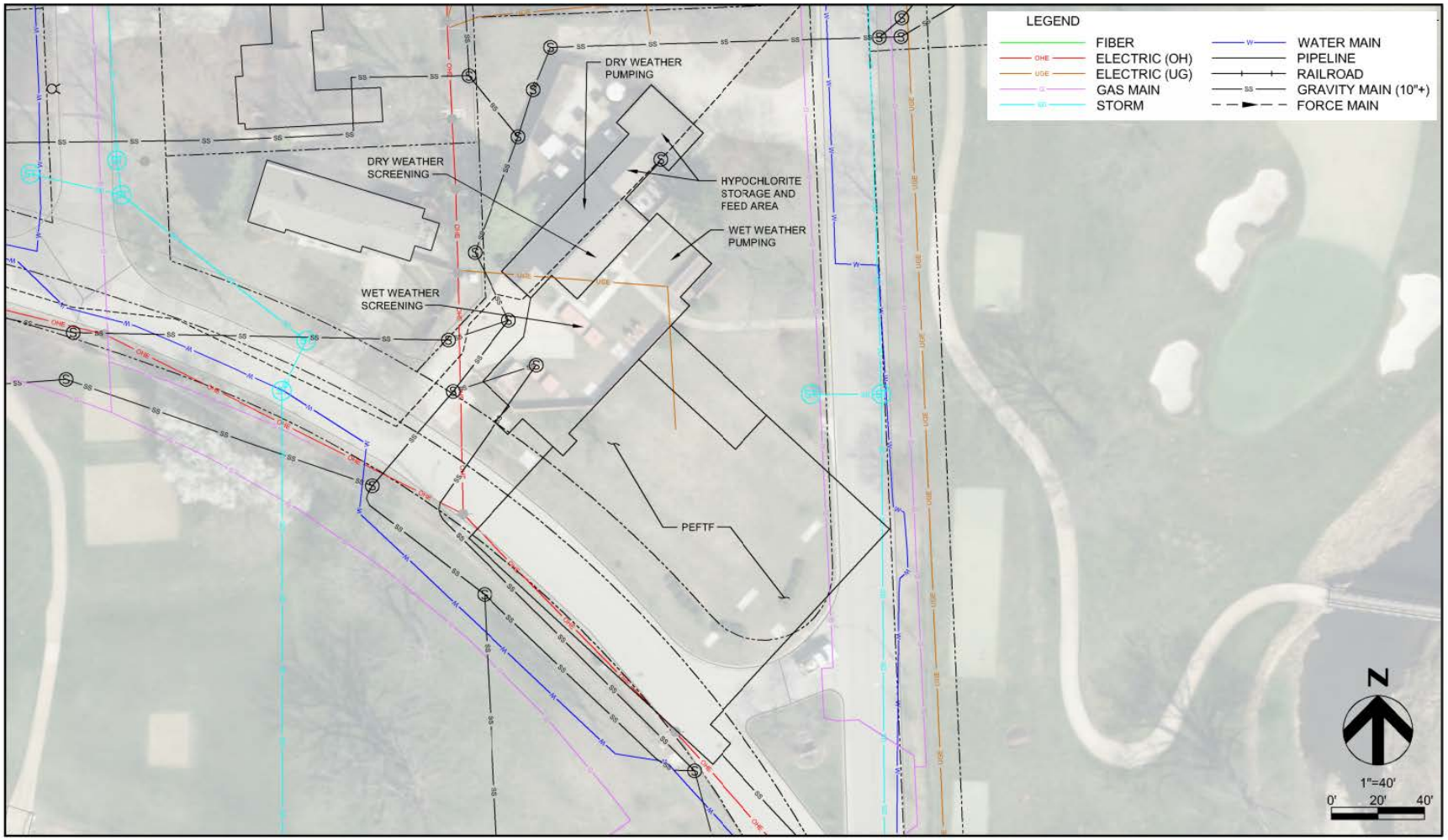
- Screening:
    - Two mechanical bar screens (climber type, 1.5-inch bar spacing) with one screw press
- Pumping:
    - The existing pump station contains the following:
        - 2 – 2.7 MGD each @ 183-feet TDH
            - 200 HP with VFDs
        - 2 – 5.2 MGD each @ 183 TDH
            - 250 HP with VFDs
    - The improved pump station to convey influent flow to the new headworks location will consist of:
        - Four horizontal dry pit type pumps with the following capacity:
        - 4.0 MGD each @ 205-feet TDH
            - 250 HP motors each with VFDs

The existing wet weather pump station serving the PEFTF consists of the following main components:

- Screening:
    - Two manual bar racks (2-inch bar spacing)
- Pumping
    - Two firm and no standby turbine style pumps
        - 20.0 MGD each @ 21-feet TDH
            - 100 HP with VFDs

Figure 6-7 depicts the arrangement of these existing facilities at the pump station site

Figure 6-7: Belinder Pump Station Existing Layout



The Belinder pump station would be upgraded to a total firm pumping capacity of 54 MGD. To meet this increased pumping capacity requirement, it is proposed to repurpose the existing PEFTF to serve as a wet weather pump station that will convey flows to the new Nelson Complex Headworks Building. The scope of the proposed improvements includes the following items:

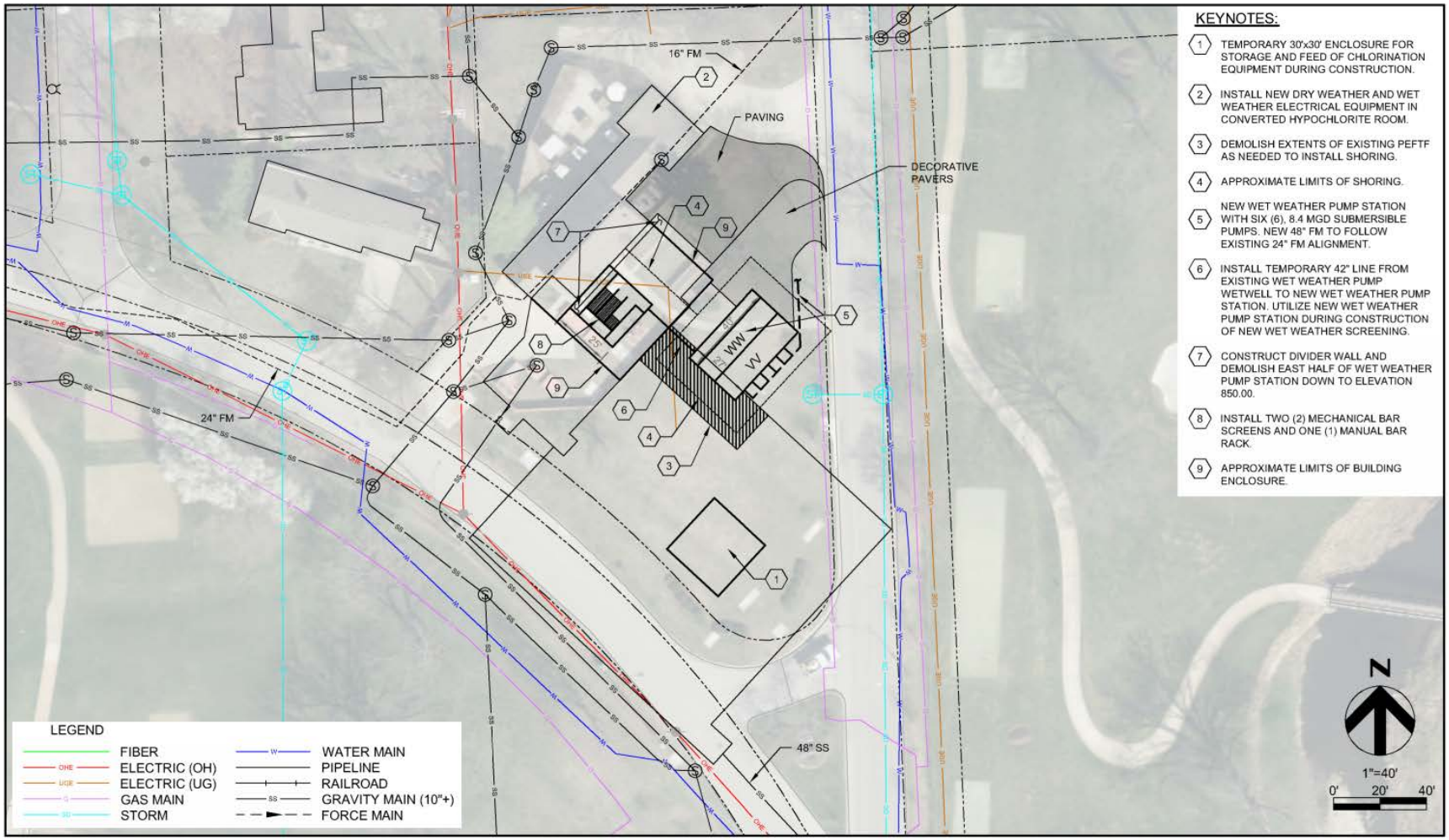
- Existing Structure
    - Replace existing above grade superstructure
    - Convert chemical room to new electrical room to house VFD's
- New wet weather screening facility:
    - Three screening channels with isolation gates
        - Two 18 MGD mechanical bar screen with washer/compactors
        - One manual bar rack
    - New superstructure with restroom
- New wet weather pumping facility
    - Six submersible type pumps
        - 8.4 MGD each @ 154-feet TDH
            - 470 HP with VFDs
        - Discharge piping and valves, hatches for pump/valve removal

Additional site related improvements include:

- Abandonment of existing PEFTF and filling with sand backfill
- Upgrade of two incoming electrical services (1,200 amps and 400 amps) to a consolidated service entrance rated 4,000 amps
- New 48-inch Forcemain

Figure 6-8 depicts the arrangement of the proposed improvements at the pump station site.

Figure 6-8: Belinder Pump Station Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-6.

Table 6-6: Belinder Pump Station Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Pumping Improvements		$4,642,000
Wet Weather Screening Improvements	1,222	$3,997,000
Sub-Total		**$8,639,000**
MOPOs		$225,000
Site Related Percentage Adders	20%	$1,727,800
Demolition/Existing Structure Modifications		$1,388,000
Sub-Total		**$11,980,000**
Overhead/Profit/Bonds and Insurance	18%	$2,272,000
Contingency	30%	$4,276,000
Sub-Total		**$18,528,000**
ELA	25%	$4,632,000
Station Electrical Service		$2,500,000
Total		**$25,660,000**

6.3 Alternative 2 – Retain PEFTFs with Enhanced High Rate Treatment

6.3.1 PEFTF Parameters

Four (4) PEFTFs would be upgraded under this alternative. These facilities consist of the Turkey Creek, Martway, 75th and Nall, and Belinder PEFTFs. As part of the alternative refinement process, the improvements at each PEFTF site were evaluated in detail on a site specific basis to develop more refined upgrade costs. When developing the cost basis for these alternatives, the following conceptual design assumptions were utilized for all locations:

- Screening and Pumping: Same assumptions as provided in Section 6.2.
- All pumps assumed to be submersible.
- Disk Filters: Based on 5 gal/min sizing and use of "Aqua Prime MegaDisk®".
- Chlorination and Dechlorination at all Facilities:
    - Sizing based on seven day peak flow event with first and seventh day at 50% flow and fourth day at 100% flow. Other days ratioed accordingly.
    - All tanks of double wall type
    - Hypochlorite:
        - Minimum tank size = 5,000 gallons
        - Assumed dose = 9 mg/L (based on assumed degraded 7.5% solution)
        - Minimum contact time = 15 min
    - Bisulfite:
        - Minimum tank size = 2,500 gallons (assumes two tanks utilized to accept 5,000 gallon delivery)
        - Assumed dose = 10 mg/L (Based on 38% solution)
        - Minimum contact time = one min

6.3.2 Turkey Creek

The Turkey Creek PEFTF currently has a pumping capacity of 22 MGD with both pumps in service. Information related to the existing PEFTF can be found below.

The existing facility consists of the following main components:

- Screening:
    - One manual bar rack
- Pumping:
    - Two turbine style pumps
        - 11.0 MGD each @ 42-feet TDH
            - 100 HP with VFDs (planned through SMTC-CO37 project)
- PEFTF:
    - 90-feet diameter x 8.5-feet side water depth = 405,000 gallons
    - Contact time at 22 MGD = 26 minutes, or eight minutes assuming a 0.3 baffling factor
    - Hypochlorite facilities
        - Two 5,400 gallon double walled tanks (planned through SMTC-CO37 project)

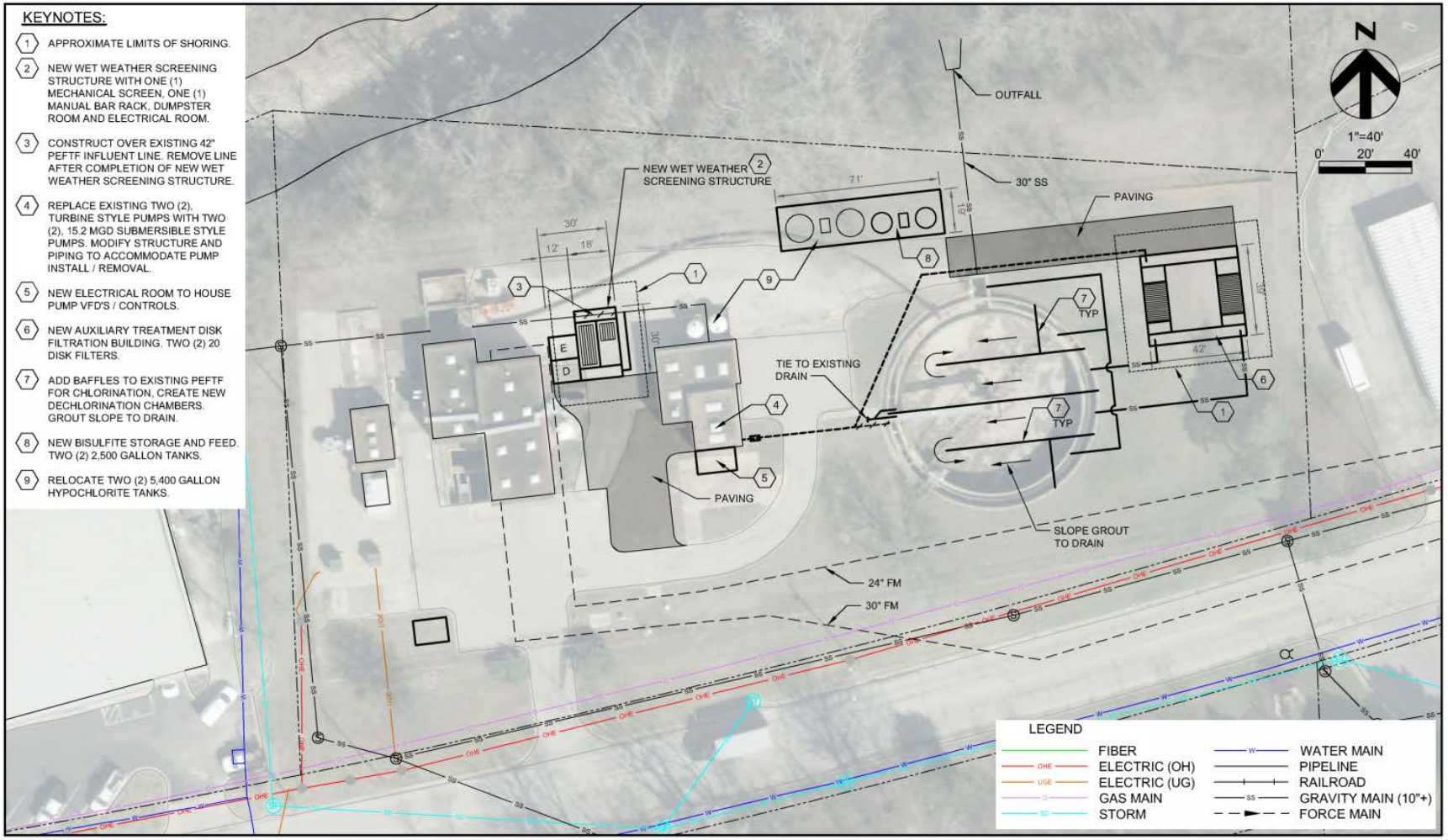
For a layout of the existing Turkey Creek facility, see previously presented Figure 6-3.

The Turkey Creek PEFTF would be upgraded to a total firm pumping capacity of 15.2 MGD. To meet this increased pumping capacity requirement the proposed improvements include the following items:

- New wet weather screening facility:
    - Two screening channels with isolation gates
        - One 15.2 MGD mechanical bar screen with washer/compactor
        - One manual bar rack
    - New superstructure including all electrical, mechanical and other improvements
- Improved pumping facility
    - Two submersible type pumps
        - 15.2 MGD each @ 40-feet TDH
            - 150 HP with VFDs
    - New electrical room to match existing structure facade
- Improved PEFTF
    - New disk filtration building
        - Two disk filters
        - 15.2 MGD each with 20 disks per filter
    - Addition of concrete baffles to existing contact basin (includes dechlorination chamber). The addition of baffles allows for the existing basin to be reused and will be arranged in a manner along with grout sloping to allow for draining the tank after use. Based on a flow rate of 15.2 MGD and a baffling factor of 0.8, the estimated contact time is approximately 38 minutes. A new rectangular contact basin was considered, however there was not enough room on site to construct it without first removing the existing circular basin.
    - New chlorination/dechlorination building
        - Reuse existing hypochlorite feed and storage (two 5,400 gallon double walled tanks)
        - Dechlorination feed and storage (two 2,500 gallons double walled tanks)

Figure 6-9 depicts the arrangement of the proposed improvements at the PEFTF site.

Figure 6-9: Turkey Creek Pump Station and PEFTF Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-7.

Table 6-7: Turkey Creek PEFTF Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Screening Improvements		$1,864,000
Wet Weather Pumping Improvements		$872,000
Disk Filter Facility		$3,685,000
Chlorination/Dechlorination Building		$882,000
Sub-Total		**$7,303,000**
MOPOs		$33,000
Site Related Percentage Adders	20%	$1,460,000
Sub-Total		**$8,796,000**
Overhead/Profit/Bonds and Insurance	18%	$1,669,000
Contingency	30%	$3,140,000
Sub-Total		**$13,605,000**
ELA	25%	$3,401,000
Total		**$17,006,000**

6.3.3 Martway

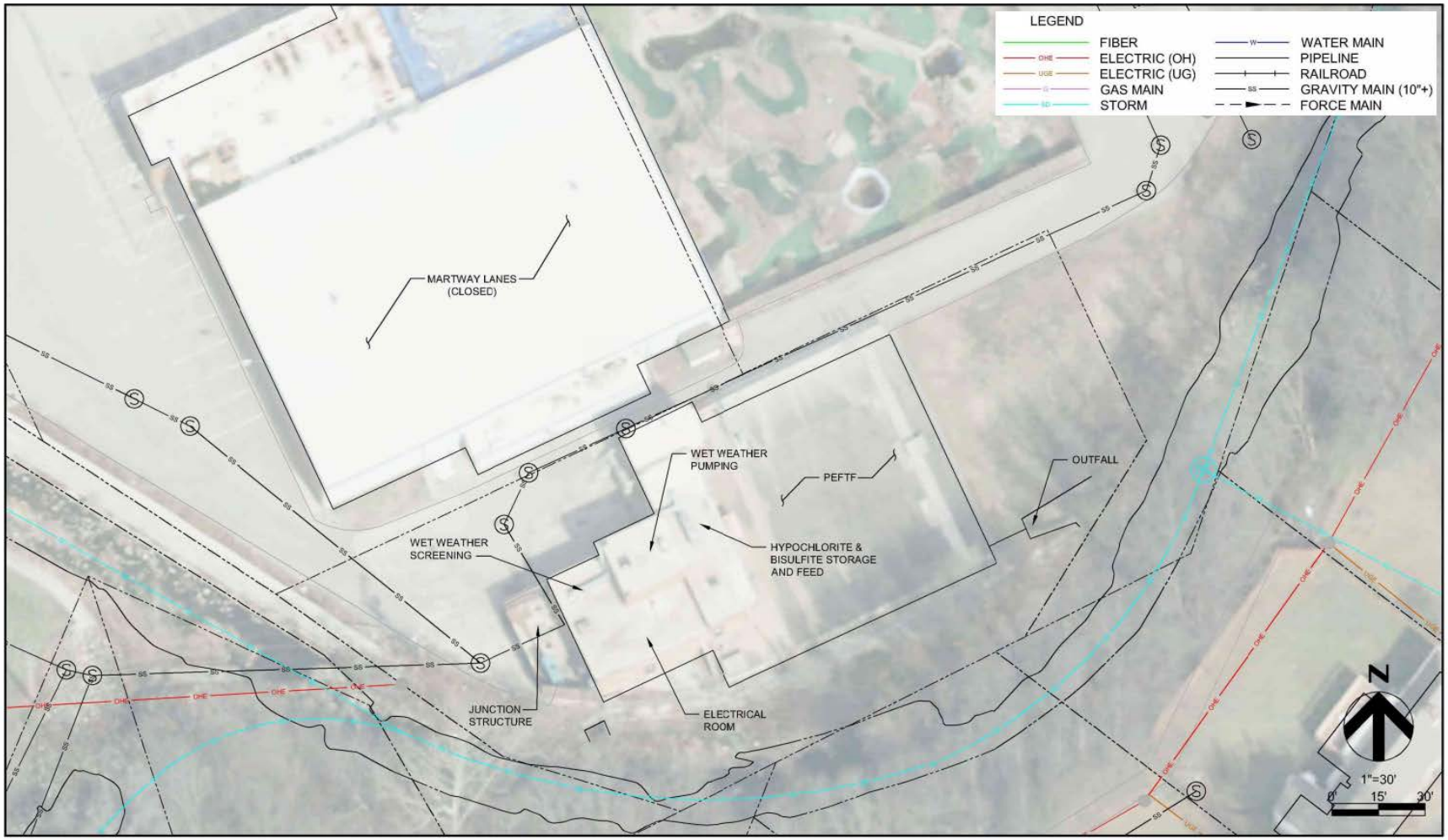
The Martway PEFTF currently has a pumping capacity of 20 MGD with both pumps in service. Information related to the existing PEFTF can be found below.

The existing facility consists of the following main components:

- Screening:
  - Two manual bar racks (2-inch bar spacing)
- Pumping
  - Two turbine style pumps
    - 10.0 MGD each @ 21-feet TDH
      - 50 HP with VFDs
- PEFTF:
  - 116-feet length x 80-feet width x 6.9-feet side water depth = 479,000 gallons
  - Contact time at 20 MGD = 35 minutes
    - Excluded baffling factor due to plug flow arrangement of existing basin
  - Hypochlorite facilities
    - Four 2,450 gallon single walled tanks in a concrete containment area
  - Bisulfite facilities
    - Two 550 gallon single walled tanks in a concrete containment area
  - Bioxide facilities
    - Two single walled tanks

Figure 6-10 depicts the existing layout at the PEFTF site.

Figure 6-10: Martway PEFTF Existing Layout



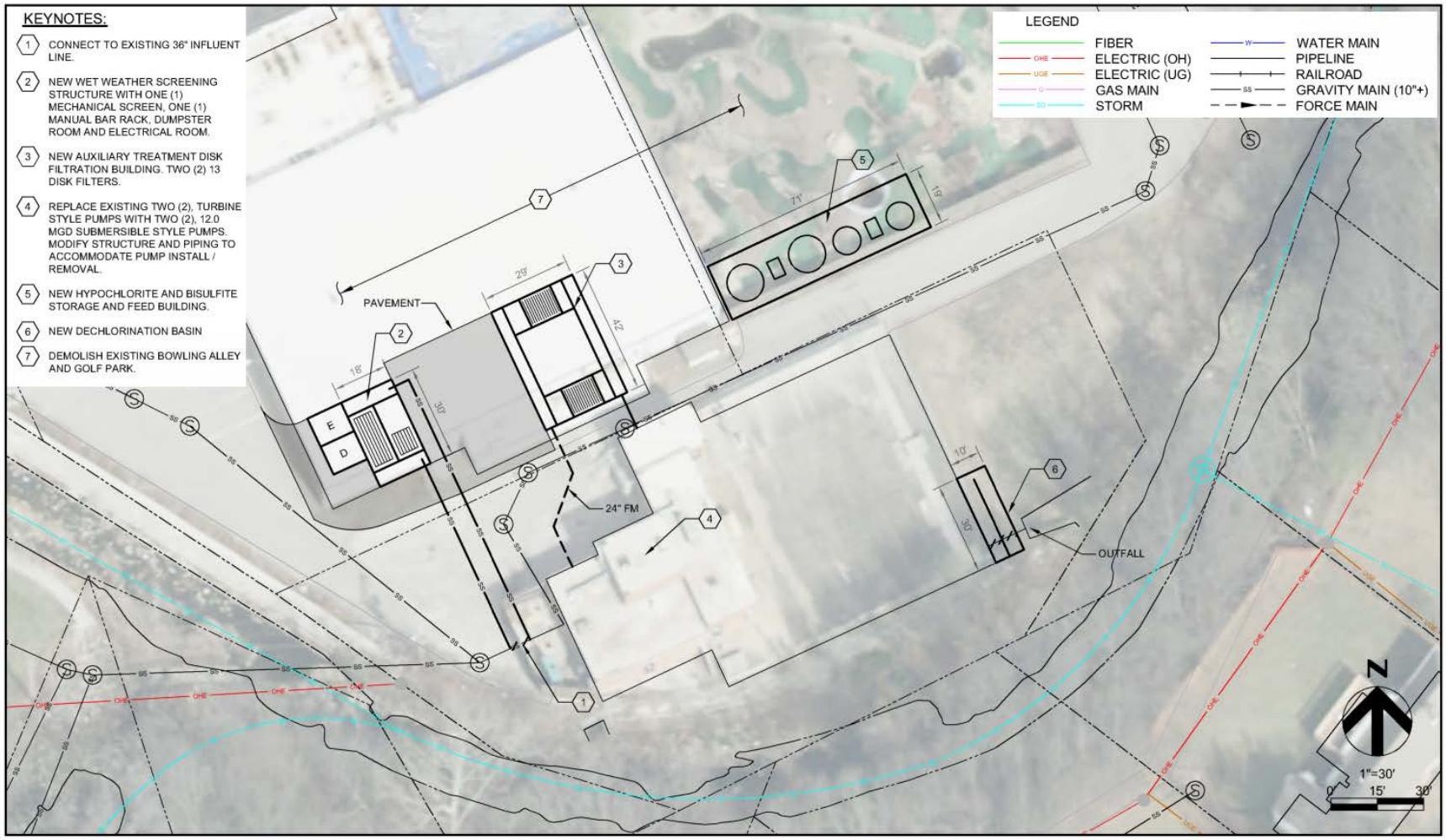
The Martway PEFTF would be upgraded to a total firm pumping capacity of 12 MGD. In order to meet this increased pumping capacity requirement, the proposed improvements include the following items:

- New wet weather screening facility:
  - Two screening channels with isolation gates
    - One 12 MGD mechanical bar screen with washer/compactor
    - One manual bar rack
  - New superstructure including all electrical, mechanical and other improvements
- Improved pumping facility
  - Two submersible type pumps
    - 12 MGD each @ 35' TDH
      - 100 HP with VFDs
  - New discharge piping and valves, structural floor improvements
- Improved PEFTF
  - New disk filtration building
    - 2 disk filters
    - 12 MGD each with 16 disks per filter
  - New dechlorination basin: 4,000 gallons
  - New chlorination/dechlorination building
    - Chlorination feed and storage (two 5,000 gallon double walled tanks)
    - Dechlorination feed and storage (two 2,500 gallons double walled tanks)

In addition to the above outlined improvements, the existing Mission Main Bowl facility would require purchase and demolition to make room for the improvements.

Figure 6-11 depicts the arrangement of the proposed improvements at the PEFTF site.

Figure 6-11: Martway PEFTF Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-8.

Table 6-8: Martway PEFTF Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Screening Improvements		$1,341,000
Wet Weather Pumping Improvements		$684,000
Disk Filter Facility		$2,785,000
Chlorination/Dechlorination Building		$979,000
Dechlorination Basin		$71,000
Sub-Total		**$5,860,000**
MOPOs		$53,000
Site Related Percentage Adders	20%	$1,172,000
Mission Bowl Demolition		$403,000
Sub-Total		**$7,488,000**
Overhead/Profit/Bonds and Insurance	18%	$1,420,000
Contingency	30%	$2,672,000
Sub-Total		**$11,580,000**
ELA	25%	$2,895,000
Property Acquisition		$550,000
Total		***$15,025,000***

6.3.4 75th St and Nall

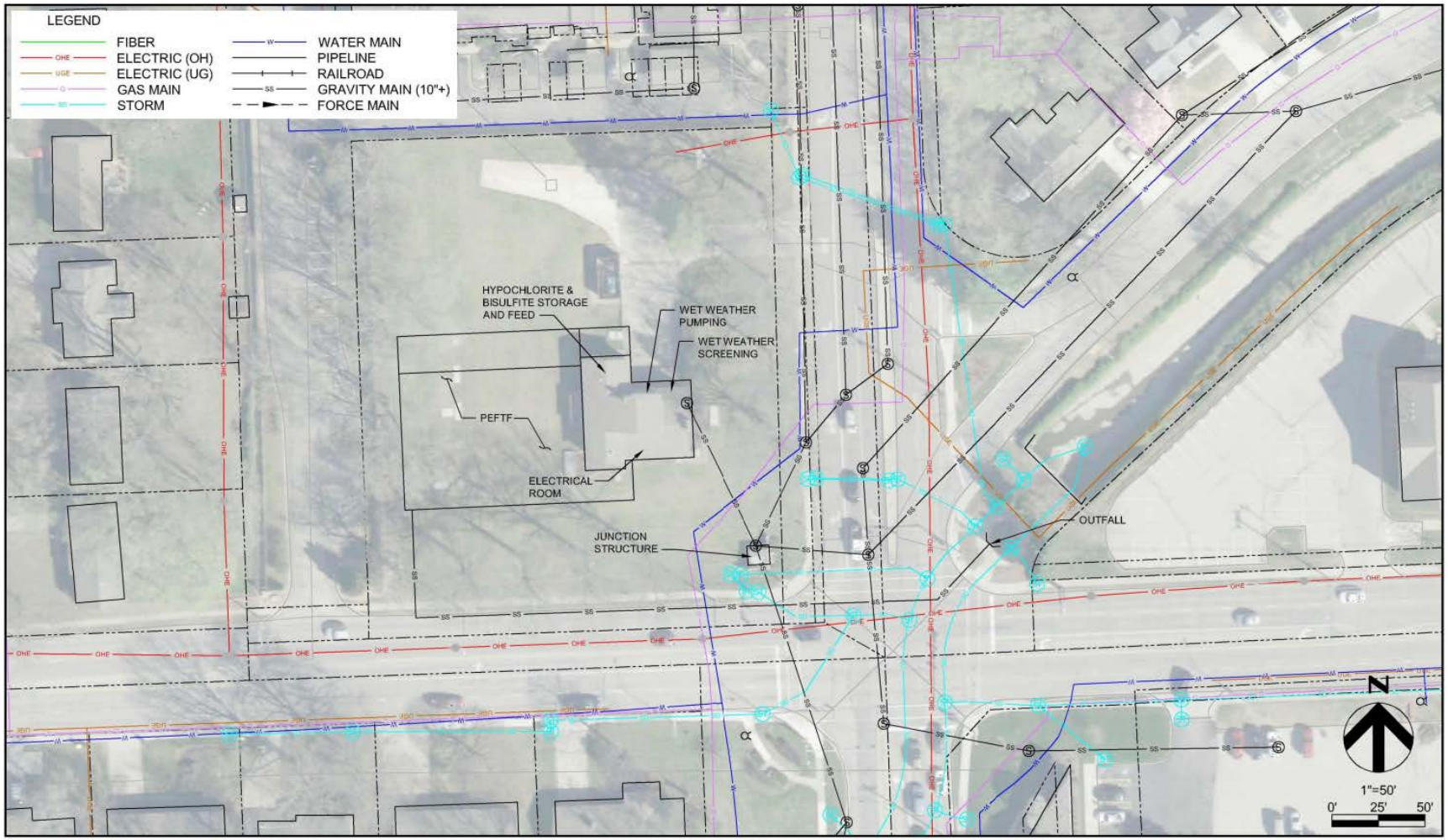
The 75th and Nall PEFTF currently has a pumping capacity of 20 MGD with both pumps in service. Information related to the existing PEFTF can be found below.

The existing facility consists of the following main components:

- Screening:
  - Two manual bar racks (2-inch bar spacing)
- Pumping
  - Two turbine style pumps
    - 10.0 MGD each @ 20-feet TDH
      - 40 HP with VFDs
- PEFTF:
  - 124-feet length x 80-feet width x 6.9-feet side water depth = 512,000 gallons
    - Excluded baffling factor due to plug flow arrangement of existing basin
  - Contact time at 20 MGD = 37 minutes
  - Hypochlorite facilities
    - Four 2,450 gallon single walled tanks in a concrete containment area
  - Bisulfite facilities
    - Two 550 gallon single walled tanks in a concrete containment area
  - Bioxide facilities
    - Two 3,150 gallon single walled tanks

Figure 6-12 depicts the existing layout at the PEFTF site.

Figure 6-12: 75th and Nall PEFTF Existing Layout

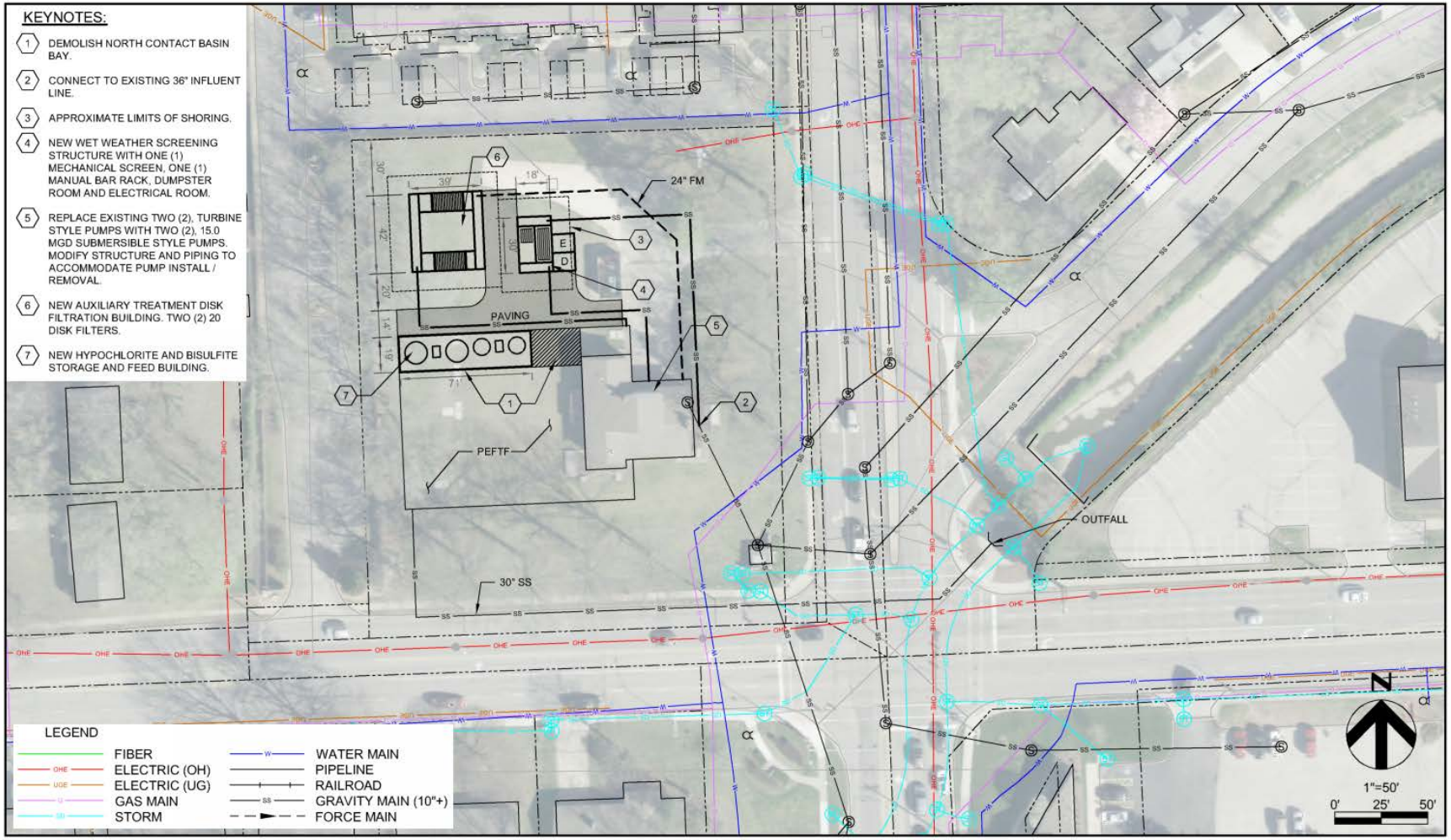


The 75th and Nall PEFTF would be upgraded to a total firm pumping capacity of 15 MGD. To meet this increased pumping capacity requirement, the proposed improvements include the following items:

- New wet weather screening facility:
  - Two screening channels with isolation gates
    - One 15 MGD mechanical bar screen with washer/compactor
    - One manual bar rack
  - New superstructure including all electrical, mechanical and other improvements
- Improved pumping facility
  - Two submersible type pumps
    - 15 MGD each @ 30-feet TDH
      - 100 HP with VFDs
  - New discharge piping and valves, structural floor improvements
- Improved PEFTF
  - New disk filtration building
    - Two disk filters
    - 15 MGD each with 20 disks per filter
  - New chlorination/dechlorination building
    - Chlorination feed and storage (two 5,000 gallon double walled tanks)
    - Dechlorination feed and storage (two 2,500 gallons double walled tanks)

Figure 6-13 depicts the arrangement of the proposed improvements at the PEFTF site.

Figure 6-13: 75th and Nall PEFTF Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-9.

Table 6-9: 75th and Nall PEFTF Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Screening Improvements		$1,946,000
Wet Weather Pumping Improvements		$773,000
Disk Filter Facility		$3,750,000
Chlorination/Dechlorination Building		$936,000
Sub-Total		**$7,405,000**
MOPOs		$53,000
Site Related Percentage Adders	20%	$1,172,000
PEFTF Demolition (Basin and Chemical Facilities)		$108,000
Sub-Total		**$9,093,00**
Overhead/Profit/Bonds Insurance	18%	$1,724,000
Contingency	30%	$3,245,000
Sub-Total		**$14,062,000**
ELA	25%	$2,895,000
Total		**$17,578,000**

6.3.5 Belinder

The Belinder PEFTF currently has a pumping capacity of 40 MGD. Information related to the existing PEFTF can be found below.

The existing facility consists of the following main components:

- Screening:
  - Two manual bar racks (2-inch bar spacing)
- Pumping
  - Two turbine style pumps
    - 20.0 MGD each @ 21-feet TDH
      - 100 HP with VFDs
- PEFTF:
  - 140-feet length x 122-feet width x 7-feet side water depth = 894,000 gallons
  - Contact time at 40 MGD = 32 minutes
    - Excluded baffling factor due to plug flow arrangement of existing basin
  - Hypochlorite facilities
    - One 4,100 gallon single walled tank with containment

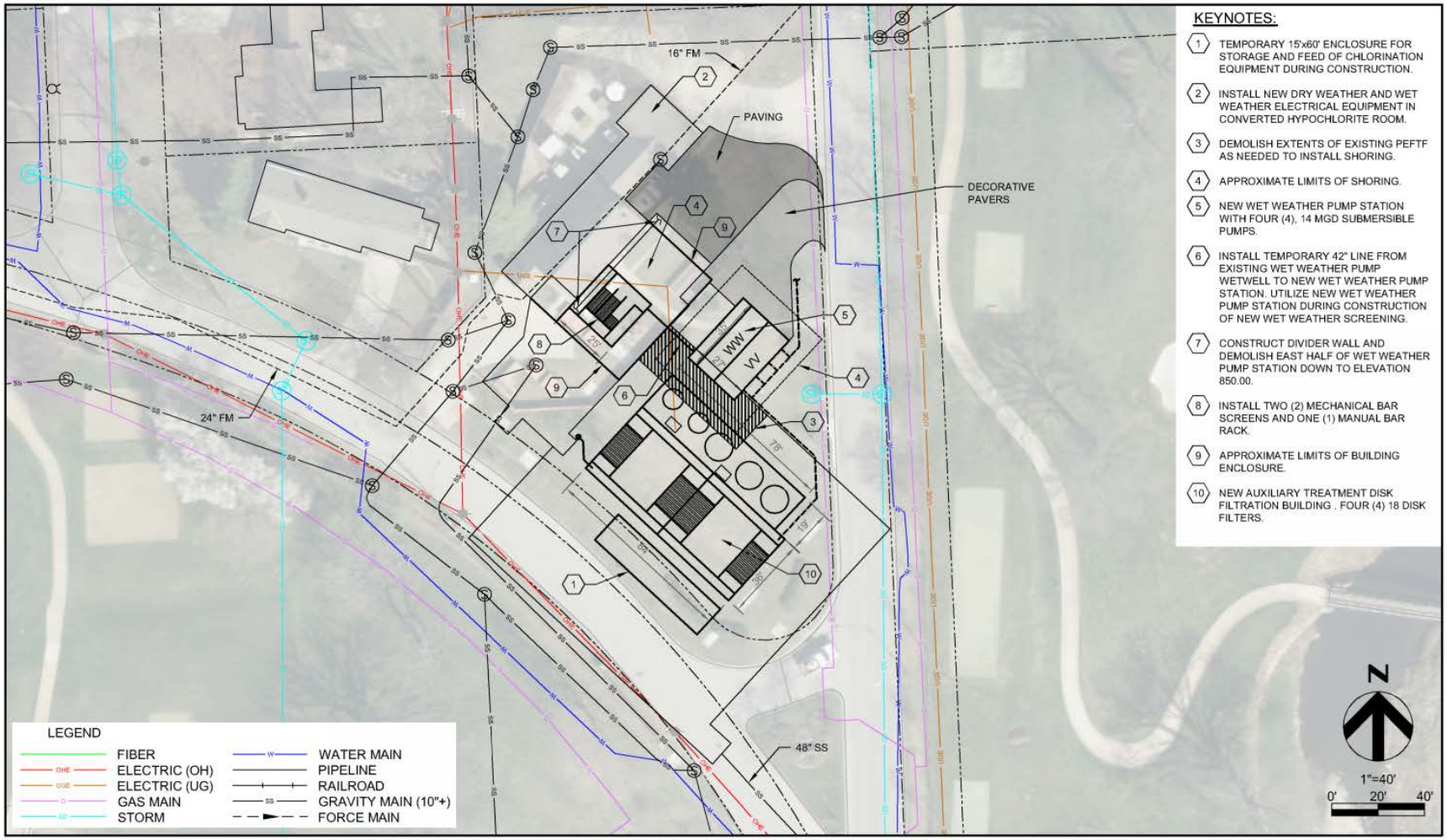
See previously presented Figure 6-7 for the existing Belinder facility.

The Belinder PEFTF would be upgraded to a total firm capacity of 42 MGD. To meet this increased capacity requirement, the proposed improvements include the following items:

- New wet weather screening and pumping facility:
  - Same as Belinder screening option but with two, 21 MGD capacity screens
  - Same as Belinder pumping option but with four, 14 MGD at 40-feet TDH pumps
    - 150 HP with VFDs
- Improved PEFTF
  - New disk filtration building
    - Four disk filters
    - 14 MGD each with 18 disks per filter
  - New chlorination/dechlorination building
    - Chlorination feed and storage (three 8,700 gallon double walled tanks)
    - Dechlorination feed and storage (two 5,000 gallons double walled tanks)
- Replace superstructure and add restroom

Figure 6-14 depicts the arrangement of the proposed improvements at the PEFTF site.

Figure 6-14: Belinder PEFTF Proposed Layout



Costs for the proposed improvements are summarized below in Table 6-10.

Table 6-10: Belinder PEFTF Proposed Improvements Cost Estimate

Item		Extension
Wet Weather Pumping Improvements		$3,225,000
Wet Weather Screening Improvements		$3,997,000
Disk Filter Facility		$5,956,000
Chlorination/Dechlorination Building		$1,190,000
Sub-Total		**$14,398,000**
MOPOs		$401,000
Site Related Percentage Adders	20%	$2,885,000
Demolition/Existing Structure Modification		$1,683,000
Sub-Total		**$19,367,000**
Overhead/Profit/Bonds Insurance	18%	$3,673,000
Contingency	30%	$6,912,000
Sub-Total		**$29,952,000**
ELA	25%	$7,488,000
Total		**$37,440,000**

6.4 Summary of Collection System Wet Weather Alternative Evaluation

The pump stations and PEFTF costs developed in the prior sections were combined with similar work on storage conveyance, and I/I reduction performed under the Collection System Study to provide updated cost estimates for the two collection system wet weather alternatives, shown in Table 6-11

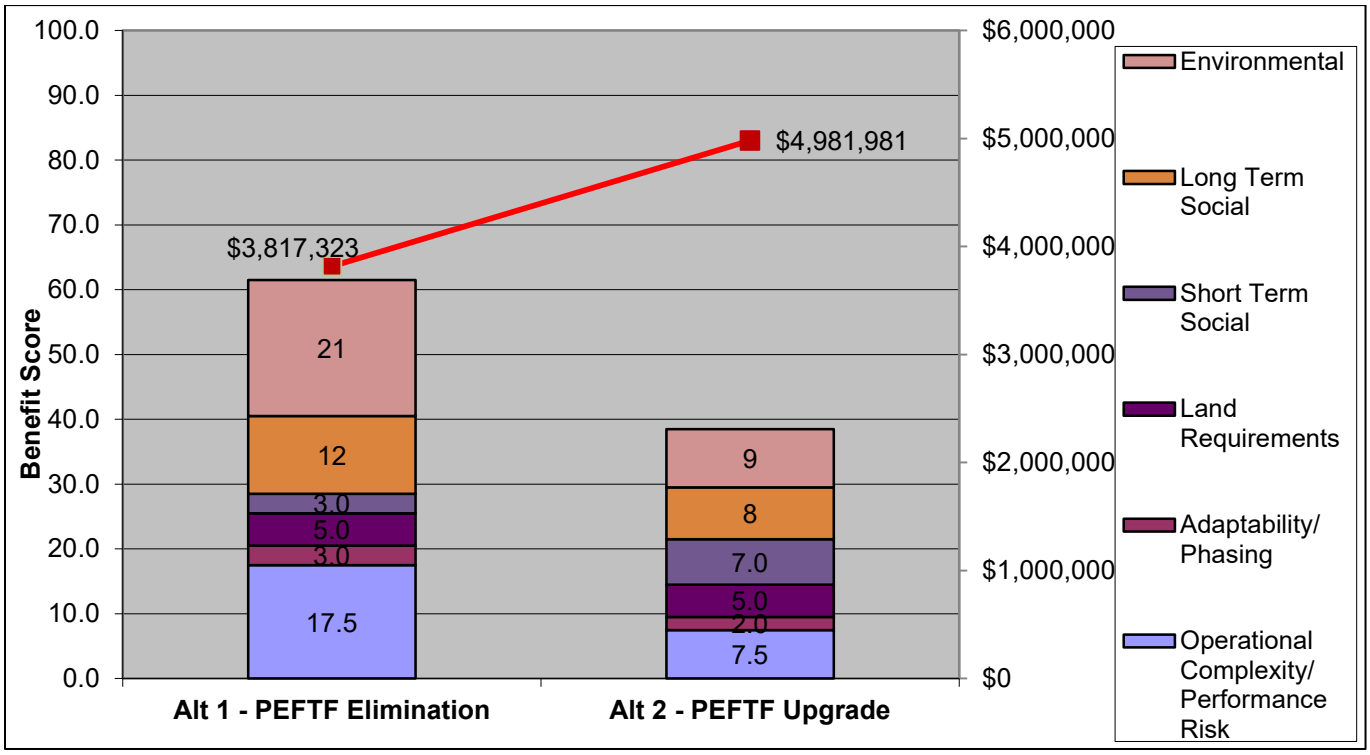
Table 6-11: Collection System Alternative Evaluation

Cost Item	Alt 1 – No PEFTFs ($M)	Alt 2 –PEFTFs Remain ($M)
Gravity Sewers	$31.87	$29.76
Pumping Station Upgrades	$39.21	$ -
Force Mains	$26.26	$ -
Underground Storage Facilities	$48.69	$31.19
Linear Storages	$ -	$ -
PEFTF Upgrades	$ -	$ 87.05
Baseline I/I Reduction	$30.00	$30.00
Additional I/I Reduction	$13.89	$9.49
ATF Phases 1-3	$37.52	$ -
Total, Capital Costs	**$227.44**	**$187.49**
Comparative O&M Increase	$11.32	$6.67
Total , 20 Year NPV	**$238.76**	**$194.16**

The cost analysis was then combined with a Triple Bottom Line non-economic analysis to produce an overall Cost per Benefit score, shown graphically in Figure 6-15. The details of the NPV and TBL analyses are presented in the Collection System Study TM6 – Alternatives Development and Refinement. While Alternative 2 had a $40 million lower capital cost ($187M vs $227M) and a $45 million lower NPV ($194M vs $239M), all expressed in 2018 dollars, the Cost Benefit analysis showed Alternative 1 to be clearly preferable to Alternative 2.

Figure 6-15: Collection System Wet Weather Alternative Evaluation

COST PER BENEFIT



7 Pump Station, PEFTF, and WWTF Asset Renewal Needs

The schedule for the projected WWTF upgrade, and its attendant pump stations, identified 2029 as the first full year of operation for the new facilities. The age of the existing WWTF and pump station facilities is such that near term renewal of some assets is warranted so they will continue to operate reliably until they are replaced or upgraded. This is also true of the PEFTF's, which will also not be upgraded until at least 2029 or later.

To identify near term asset renewal needs, representative of JCW and the HDR/CH2M team met the week of February 11, 2019, to review a list of known needs and to tour all of the facilities. Some of the needs have already been packaged into projects and are in various stages of planning, design, or construction, while others are still in the identification stage.

Table 7-1 presents the identified renewal needs by facility, along with a description of the need, an estimated cost, and the probable timing of the improvement.

Table 7-1: Facility Renewal Needs by Facility

Facility		Description	Schedule	Cost in 2018 $'s	Notes
A	***Mission Main WWTF***				
	1	CMSD-C028 Digester Conversion	2019-2021	$7,600,000	(1)
	2	MTM-CO75 Clarifiers (IC 3 & 4, FC 1, 2 & 3)	2019-2020	$250,000	(1)
	3	Term & Supply Project	2020	$420,000	-
		Disinfection Chemical Flow Control			
		FC 1 Influent Valve Replacement			
		Lift Station 5 Plugging			
		Instrumentation/timers on pumps/valves for IC 3 & IC 4			
		Bldg 14 MAU replacement			
		Bldg 4 Air/Oil Actuator Rework			
	4	Ferric Tank Replacement	2019	O&M	(2)
B	***Turkey Creek WWTF***				
	1	Clarifier Rehab	2019	$400,000	(1)
	2	TF 2, 3, 4 Bearing Repair	-	O&M	(2)
	3	Grit Systems Controls	-	O&M	(2)
	4	Kitchen Sink Bid Project	2020	$1,180,000	-
		Splitter Tower Safety/Structural			
		Rotating Scum Weirs on Contact Basins			

Facility		Description	Schedule	Cost in 2018 $'s	Notes
		Second Bisulfite Tank			
		Bldg's 3 & 4 MAU Replacement			
		FC 1 and 2 Sludge Pumps Instrumentation			
		Bldg's 1 & 2 Sludge Pump Instrumentation			
		Virgil PS Move Controls Above Ground			
		Grit Structural Repairs			
		PC Scum Beaches			
C	***Turkey Creek PS and PEFTF***				
	1	SMTC – CO37 Pump Station & PEFTF R&R	2019-2021	$7,015,000	(1)
	2	Regulatory Negotiations (if required)	2024	-	
		Mechanical WW bar screens		$1,505,000	
		Bisulfite		$195,000	
		Chemical dosing		$60,000	
D	***Martway PEFTF***				
	1	MTM – CO74 PEFTF R&R	2019-2021	$2,103,000	(1)
	2	Regulatory Negotiations (if required)	2024	-	
		Mechanical bar screens		$1,450,000	
		Chemical dosing		$60,000	
E	***75th Street PEFTF***				
	1	MTM – CO74 PEFTF R&R	2019-2021	$842,000	(1)
	2	Regulatory Negotiations (if required)	2024	-	
		Mechanical bar screens		$1,440,000	
		Chemical dosing		$60,000	
F	***Brush Creek PS***				
	1	Term & Supply Project	2020	$390,000	
		Soft starts, all 4 pumps			
		New pump control valves on 2 large pumps			
		Replace all valves			
	2	Pump Station R&R Project	TBD	$3,621,000	
		New pumps			
		Valve vault east of dry well			
		Replace grinder w/bar screen			
		Washer compactors (2)			

Facility		Description	Schedule	Cost in 2018 $'s	Notes
		Dumpster room to west			
		Electrical room to north (replace MCC?)			
		New HVAC			
	3	Future New Station (with Brush Creek Storage)	TBD	$3,300,000	
G	***Rock Creek PS***				
	1	Term & Supply Projects	2020	$340,000	
		New discharge plug valves (4)			
		Floor hatch west of screens			
		Forcemain air release valves			
		Roof replacement			
	2	Electrical Room Project	2019-2021	$1,572,000	(1)
H	***Belinder PS & PEFTF***				
	1	CMSD – CO27 Electrical Improvements	2020-2021	$5,800,000	(1)
	2	MTM1 – CO73 Safety/Chemical Feed	2019	$275,000	(1)
	3	Pump Station R&R Bid Project	2020	$2,800,000	
		Size for future TDH			
		4 – 4 mgd pumps, new VFD's			
		4 check valves, 8 plug valves			
	4	Pumping/PEFTF R&R Bid Project	TBD	$3,605,000	
		Replace DW screens/add washer compactors			
		Add dumpster room			
		Electrical code upgrades fix in Nelson CMAR			
		HVAC upgrades			
		Replace WW pumps and VFD'S			
		Better way to pump down PEFTF			
	5	Regulatory Negotiations		-	
		Bisulfite (2024 if required)		$195,000	
		Chemical dosing (2024 if required)		$60,000	

Notes:
(1) Already included in current CIP
(2) To be funded out of O&M Budget

Table 7-2 presents the same information of Table 7-1, but is sorted by timing and delivery method rather than facility.

Table 7-2: Facility Renewal Needs by Timing and Delivery Method

Delivery Mechanism	Schedule	Facility	Description	Cost in 2018 $'s
Already Planned/In 2020 – 2024 CIP	2019-2021	Mission Main WWTF	(A.1) CMSD-C028 Digester Conversion	$7,600,000
	2019-2021	Mission Main WWTF	(A.2) MTM-CO75 Clarifiers (IC 3 & 4, FC 1, 2 & 3)	$250,000
	2019	Turkey Creek WWTF	(B.1) Clarifier Rehab	$400,000
	2019-2021	Turkey Creek PS and PEFTF	(C.1) SMTC – CO37 Pump Station & PEFTF R&R	$7,015,000
	2019-2021	Martway PEFTF	(D.1) MTM – CO74 PEFTF R&R	$2,103,000
	2019-2021	75th Street PEFTF	(E.1) MTM – CO74 PEFTF R&R	$842,000
	2019-2021	Rock Creek PS	(G.2) Electrical Room Project	$1,572,000
	2020-2021	Belinder PS & PEFTF	(H.1) CMSD – CO27 Electrical Improvements	$5,800,000
	2019	Belinder PS & PEFTF	(H.2) MTM1 – CO73 Safety/Chemical Feed	$275,000
Sub-Total				**$25,857,000**
2020 Term & Supply Projects	2020	Mission Main WWTF	(A.3) Term & Supply	$420,000
	2020	Brush Creek PS	(F.1) Term & Supply	$390,000
	2020	Rock Creek PS	(G.1) Term & Supply	$340,000
Sub-Total				**$1,150,000**
2020 – 2021 Bid Projects	2020-2021	Turkey Creek WWTF	(B.4) Kitchen Sink Project	$1,180,000
	2020-2021	Belinder PS & PEFTF	(H.3) Pump Station R&R Bid Project	$2,800,000

Delivery Mechanism	Schedule	Facility	Description	Cost in 2018 $'s
Sub-Total				**$3,980,000**
Timing Unspecified	TBD	Brush Creek PS	(F.2) Pump Station R&R Project	$3,621,000
	TBD	Belinder PS & PEFTF	(H.4) R&R Project	$3,605,000
Sub-Total				**$7,226,000**
Concurrent with Wet Weather Project	TBD	Brush Creek PS	(F.3) Future (with Brush Creek Storage)	$3,300,000
Sub-Total				**$3,300,000**
Subject to Regulatory Negotiation (2024 if required)	2024	Turkey Creek PS and PEFTF	(C.3) Mechanical WW bar screens	$1,505,000
	2024		(C.3) Bisulfite	$195,000
	2024		(C.3) Chemical dosing	$60,000
	2024	Martway PEFTF	(D.2) Mechanical bar screens	$1,450,000
	2024		(D.2) Chemical dosing	$60,000
	2024	75th Street PEFTF	(E.2) Mechanical WW bar screens	$1,440,000
	2024		(E.2) Chemical dosing	$60,000
	2024	Belinder PS & PEFTF	(H.5) Bisulfite (2024 if required)	$195,000
	2024		(H.5) Chemical dosing (2024 if required)	$60,000
Sub-Total				**$5,025,000**
Grand Total				**$46,538,000**

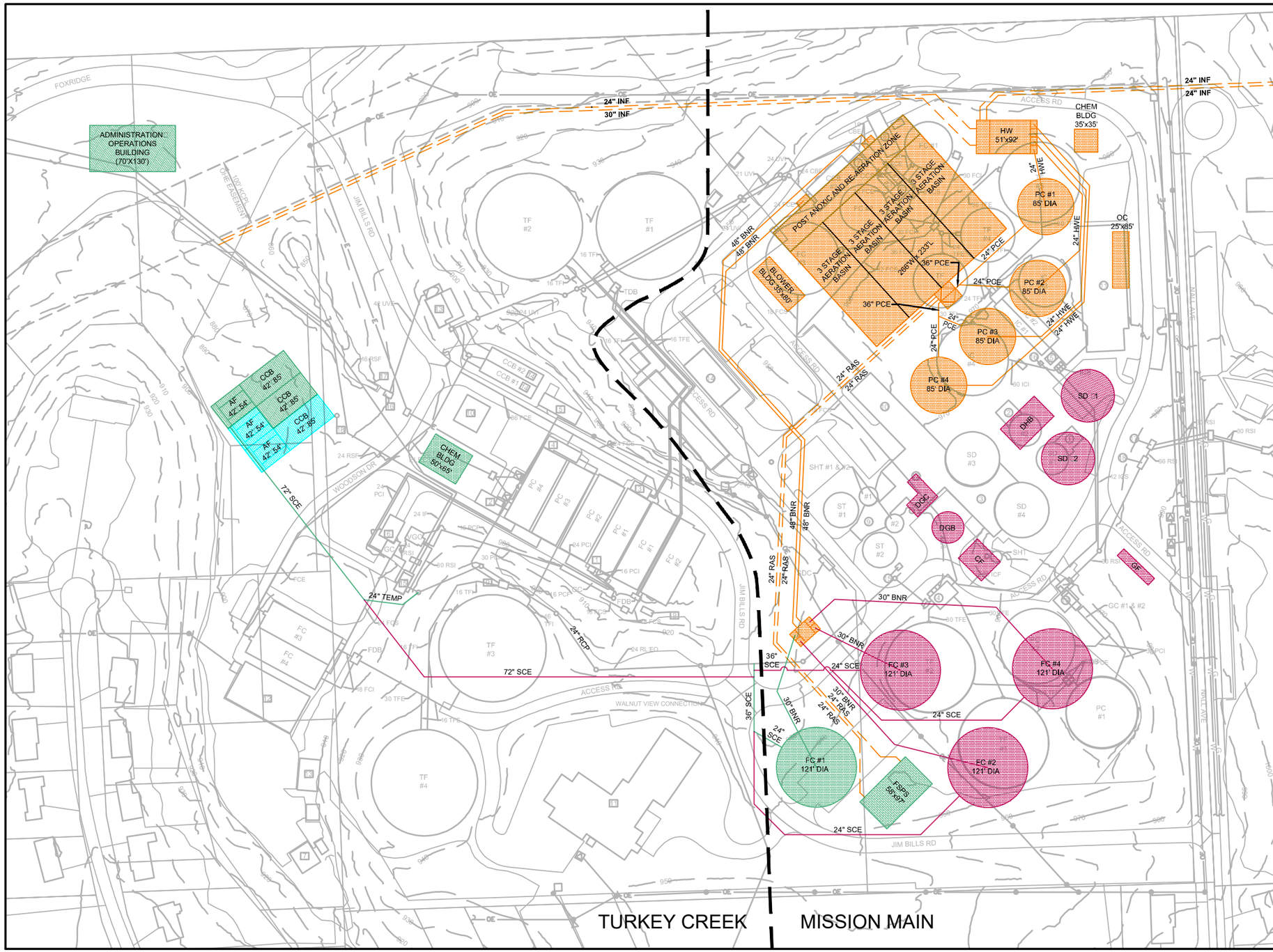
8 Summary and Next Steps

The key findings of TM #5 include the following:

- A preferred layout was determined for the Nelson Complex WWTF BNR upgrade. A schedule, sequencing plan, and interim operations plan were developed. The project is tentatively scheduled for construction in 2024-2028, with mid-point in year 2026.
- The treatment facility total project cost is estimated to be $328 million in 2018 dollars ($416 million in 2026 dollars). With the necessary improvements to the pump stations that pump to the plant the total cost is estimated to be $353 million in 2018 dollars ($447 million in 2026 dollars).
- A detailed optimization process and comparative analysis concluded that removal of the PEFTF's and conveyance of wet weather flows to the WWTF for auxiliary treatment is the preferred long-term plan for the Nelson Watershed.
- In support of the wet weather analysis, wet weather pumping upgrades were estimated to cost $39 million, while PEFTF upgrades, should the PEFTF's be retained, were estimated at $87 million (both figures in 2018 dollars). The overall watershed cost, including collection system improvements, was less for the "retain the PEFTF's" alternative - $187 million vs $227 million capital, $194 million vs $239 million Net Present Value (all in 2018 dollars). However, the triple Bottom Line analysis strongly favored upgraded conveyance and centralized auxiliary treatment.
- Over $42 million (2018 dollars) in near term asset renewal projects were identified. Of these $26 million are already in the five-year CIP. However, up to $16 million in assorted projects are needed at the WWTF, pump stations, and PEFTF's that are not currently scheduled, but are needed to keep these facilities operating reliably until they can be upgraded or replaced beginning in 2024 or later.
- The total sewershed cost included the WWTF, dry and wet weather conveyance, and near term asset renewal, expressed in 2018 dollars, is $620 Million.

Although the timing of the major upgrades to the WWTF and its tributary pump stations has been defined, that is not the case with the wet weather upgrades associated with PEFTF removal or the near term asset renewal needs. JCW has identified over $2 billion in system wide capital needs that must be addressed over the next 25-30 years. Thus, the Nelson Watershed improvement, other than the WWTF project must be incorporated into a comprehensive system wide prioritization process so they, along with other system needs, are scheduled in order of priority based on the benefits afforded to water quality and JCW's customers.

Therefore, the next step for the improvements identified in this WWTF Facility Plan and the Collection System Study is to incorporate them, along with other known needs, into a system-wide Integrated Plan.



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LEGEND

-PHASE 1
-PHASE 2
-PHASE 3
-PHASE 4
-FUTURE
-FORCEMAIN
-GRAVITY MAIN

40' 0' 80' 160'
SCALE: 1"=160'

LAYOUT ALTERNATIVE 1
COMBINED PC's/BNR,
SEPARATE SC's

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FIGURE
FIG. 2-1

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LEGEND

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-PHASE 3
-PHASE 4
-FUTURE
-FORCEMAIN
-GRAVITY MAIN

40' 0' 80' 160'
SCALE: 1"=160'

LAYOUT ALTERNATIVE 2
COMBINED BNR/FC's,
SEPARATE HW/PC's

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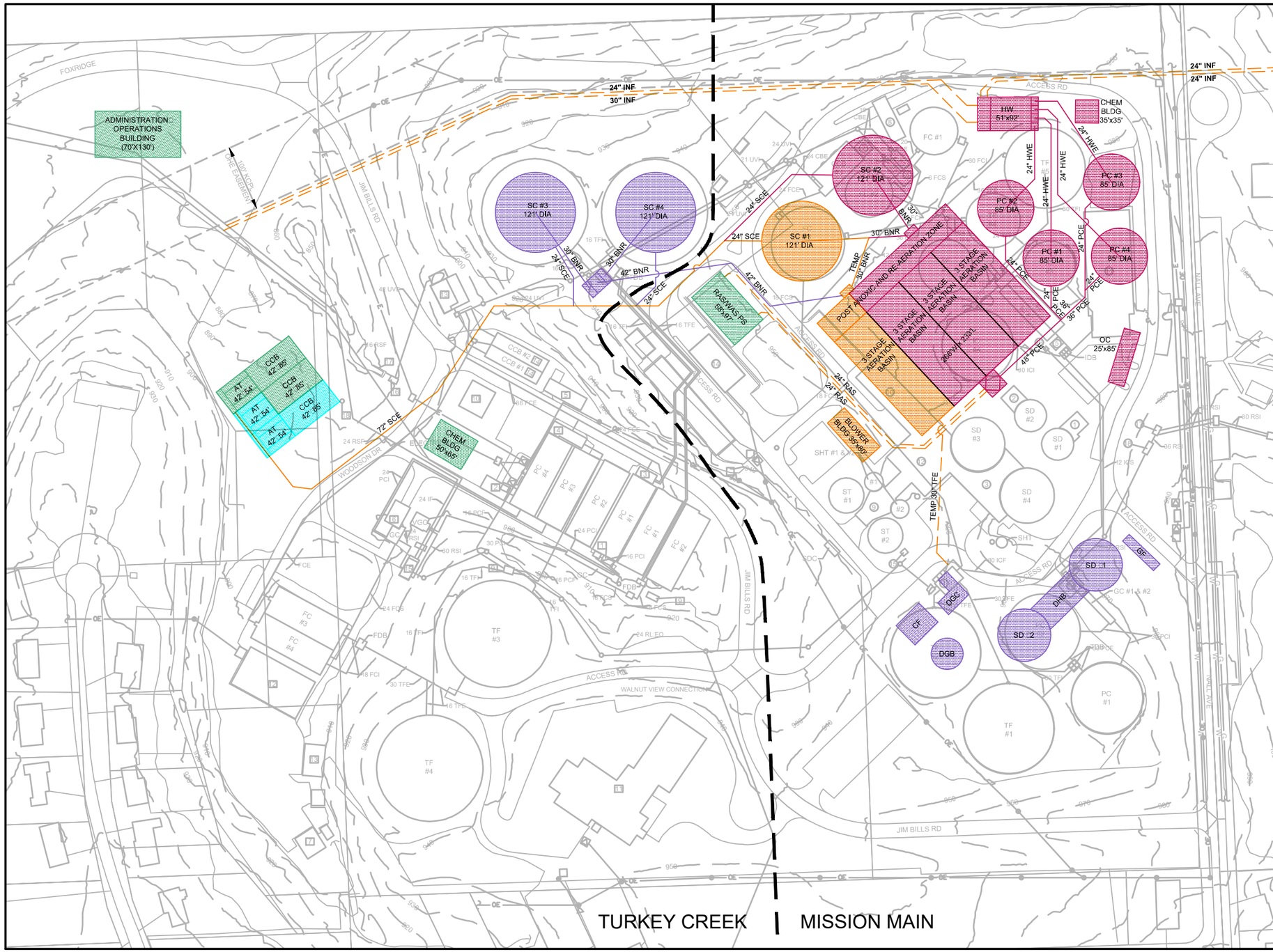
FIGURE
FIG. 2-2



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-PHASE 1
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-PHASE 3
-PHASE 4
-FUTURE
-FORCEMAIN
-GRAVITY MAIN

40' 0' 80' 160'
SCALE: 1"=160'

LAYOUT ALTERNATIVE 3
COMBINED LIQUID TRAIN,
RELOCATED SOLIDS

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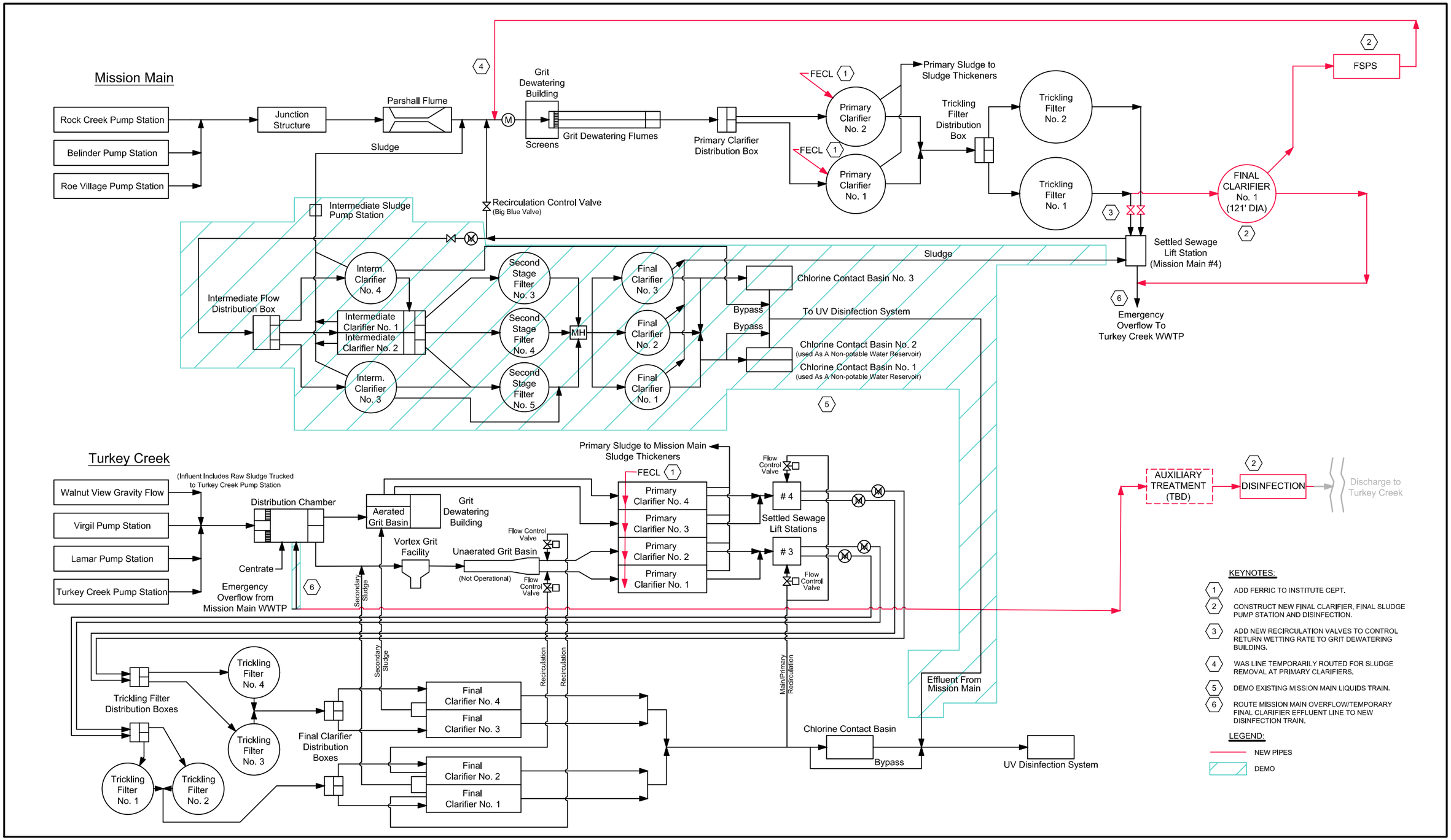
FIGURE
FIG. 2-3



INTERIM OPERATION
(SITE LAYOUT ALTERNATIVES 1 AND 2)

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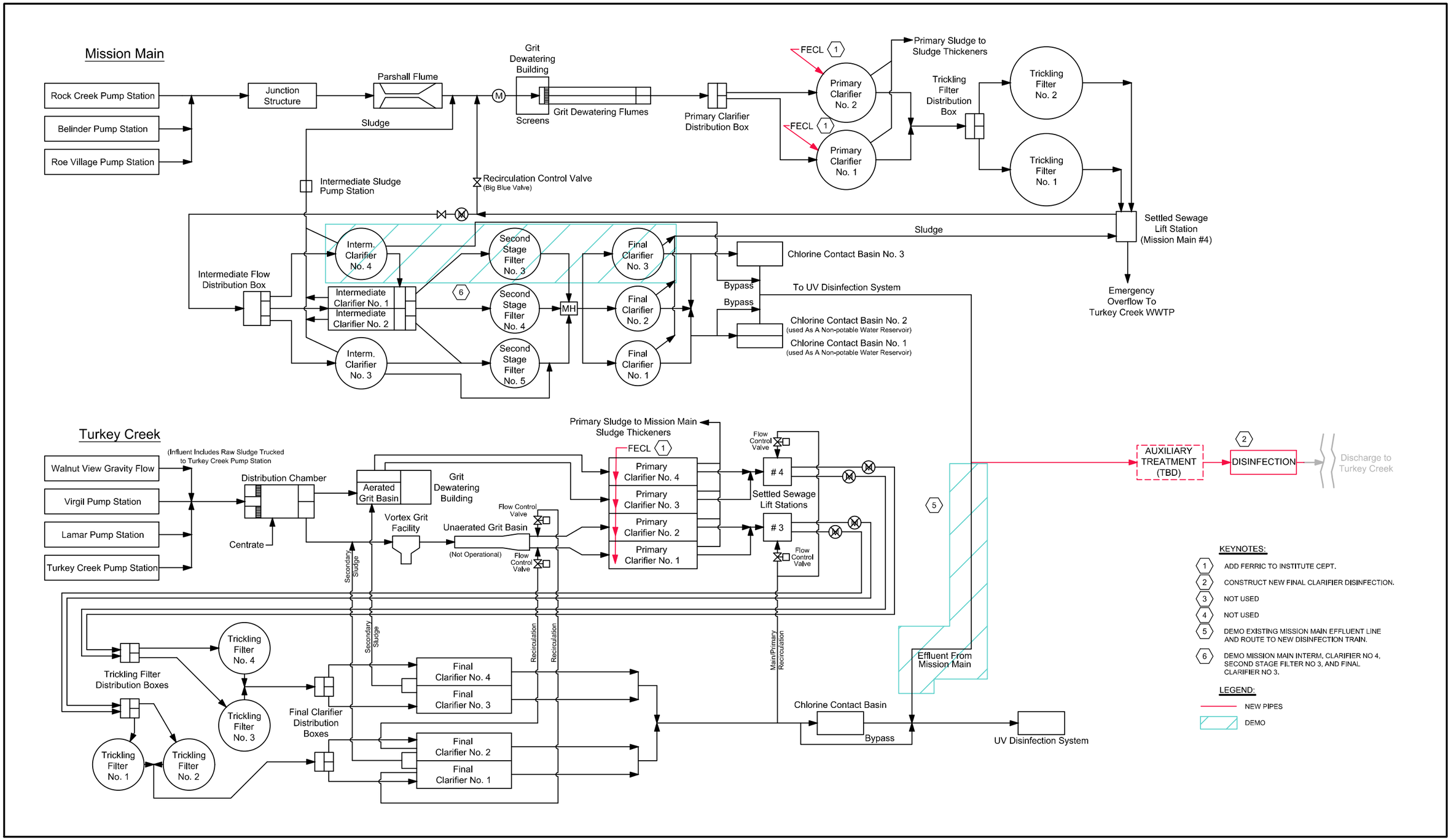
FIGURE
FIG. 2-5



INTERIM OPERATION
(SITE LAYOUT ALTERNATIVE 3)

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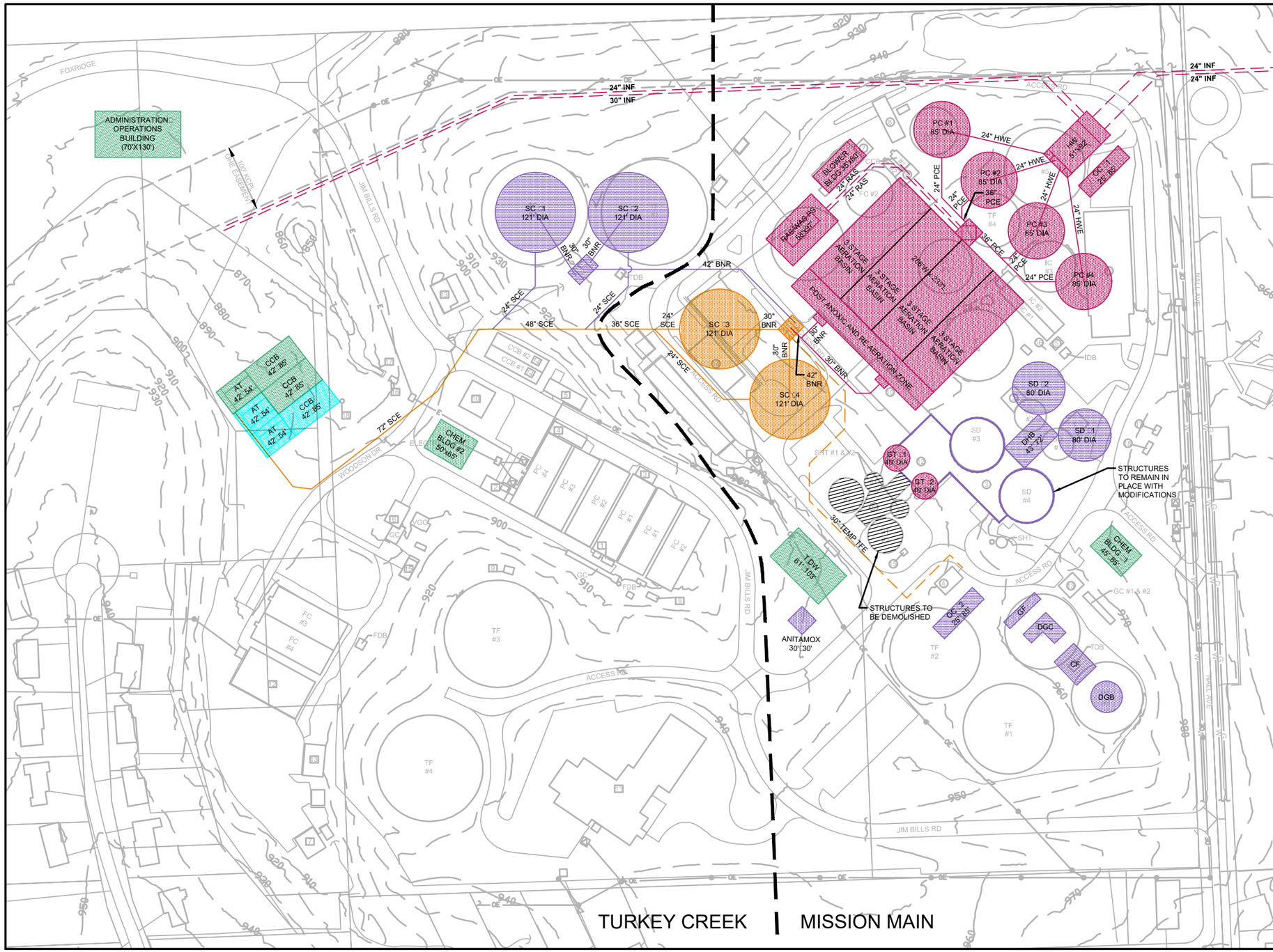
FIGURE
FIG. 2-6



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LEGEND

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-PHASE 4
-FUTURE
-FORCEMAIN
-GRAVITY MAIN

40' 0' 80' 160'
SCALE: 1"=160'

OPTIMIZED SITE LAYOUT ALTERNATIVE

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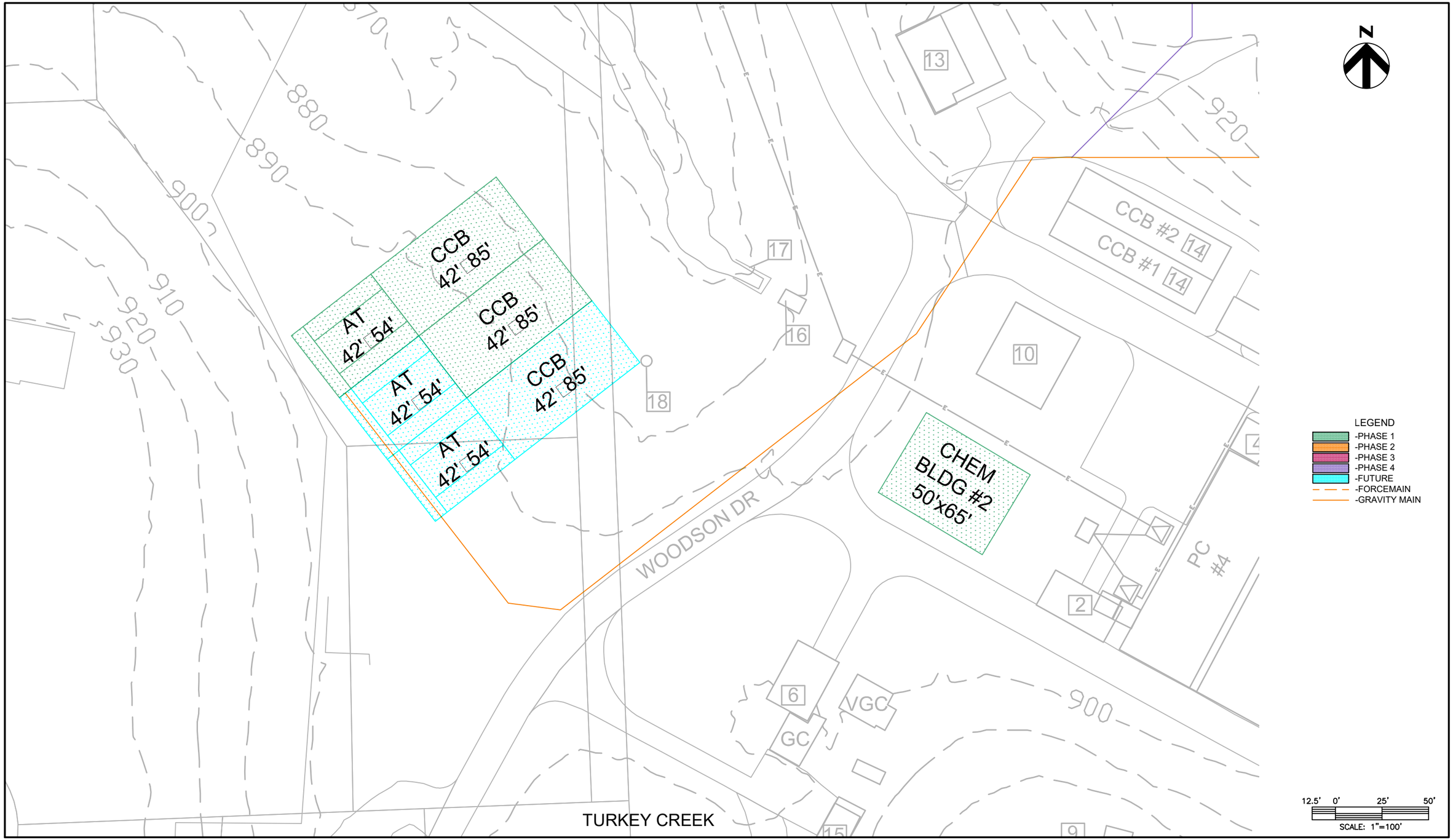
FIGURE
FIG. 2-7



FILTRATION AND DISINFECTION FACILITIES LAYOUT

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FIGURE
FIG. 3-1

Nelson Complex Collection System Wet Weather Plan Technical Memorandum #1 Basis of Analysis

May 2018

JOHNSON COUNTY KANSAS
Wastewater

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Appendices

Appendix A Relevant Past Studies & Documents
Appendix B Nelson Complex Treatment Facility and Collection System Study Schedule

ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
GPD	Gallons per Day
GPM	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
MGAL	Million Gallons
MGD	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/l	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NH3-N	Ammonia Nitrogen
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
$Pro2D^2$	Professional Process Design and Dynamics Whole Plant Simulator by CH2M

PS	Pump Station
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

Note: Portions of the project approach and information presented in this technical memorandum (TM) were subsequently updated and new alternative naming conventions were adopted as the project progressed. Changes are noted in italics, where practicable. In general, information presented in TM 6 or the Phase 1 Integrated Management Plan supersedes conflicting information presented in this TM.

1 Introduction

1.1 Program Background

The Nelson Wastewater Treatment Facility (WWTF) Complex is comprised of two separate treatment trains, referred to as Mission Main (originally Mission Township Main Sewer District 1) and Turkey Creek (originally Shawnee Mission Turkey Creek). These were originally two separate WWTFs sharing a common site. They have since been consolidated into a single facility, the Nelson Complex (NC), with two distinct process trains that share a common disinfection and biosolids facilities and a single permitted outfall.

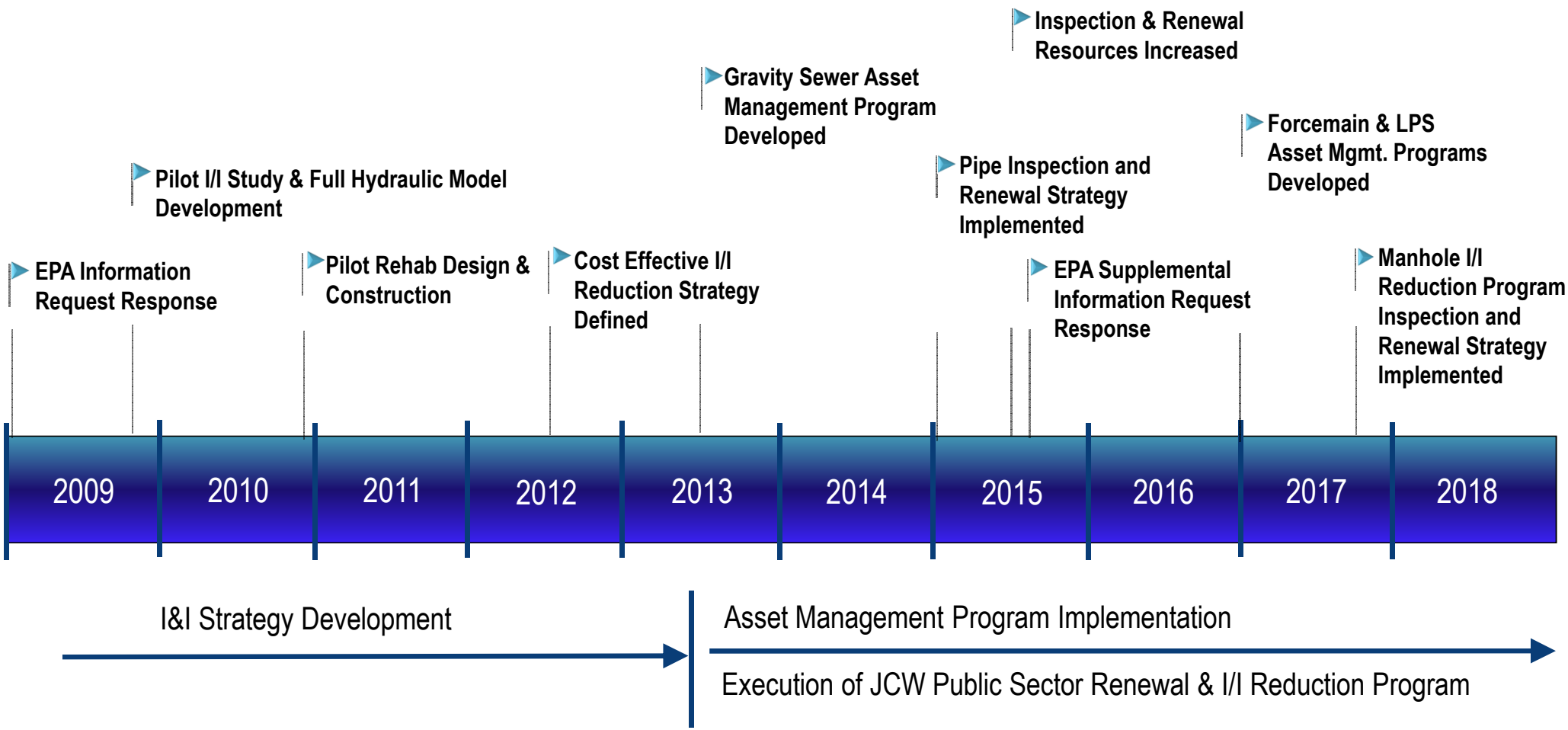
The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two WWTF trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or which discharge directly from the collection system to the creek after providing primary treatment and disinfection. In the Mission Main watershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flows to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow to the WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the WWTF. On the Turkey Creek side, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the WWTF.

Johnson County Wastewater (JCW) received a request for information, pursuant to Section 308(a) of the Clean Water Act on December 17, 2007, regarding management of peak wet weather flows within the Nelson Complex. JCW submitted a response to EPA Region VII in January 2009 (2009 Response). EPA identified several uncertainties in the 2009 response and requested additional information and data be collected. JCW submitted a supplemental response in December 2014 (2014 Response) to address the uncertainties in the 2009 Response. An Executive Plan, dated March 2015, was also developed as a supplement to provide additional detail for the 2014 Response. A list of these documents and other relevant studies is located in Appendix A.

Within the Response documents are five (5) improvement options for managing wet weather flows. Detailed information about the options can be found in various documents, including the 2015 Executive Plan. Each alternative was presented as a stand-alone option and was not studied in parallel with other alternatives to find the most cost-effective solution. Therefore, the options as presented are not implementable, however, ideas and information from past studies will be considered where relevant.

Since the most recent response, JCW has continued to increase system renewal investments within the Turkey Creek and Mission Main basins. A timeline of programmatic collection system improvements is presented in Figure 1.

FIGURE 1: TIMELINE OF PROGRAMMATIC COLLECTION SYSTEM IMPROVEMENTS



Concurrent with these improvements, JCW has continued to invest in asset renewal and technology upgrade projects at the WWTF, pump stations and PEFTFs. Refer to the WWTF Study TM No. 1 Basis of Analysis for a detailed list of recent and ongoing facilities projects within the Nelson Complex.

These ongoing systemwide investments in renewal and continued improvements have enabled JCW to become an industry leading utility that serves as a model to emulate for other regional utilities. JCW has achieved a position where the utility can proactively develop a long term plan to address wet weather flow management within the Nelson Complex. This study was initiated in order to develop the long term phased improvements program within the Nelson Complex. This study will be completed concurrently with the Nelson Complex WWTF Facility Plan.

1.2 Purpose and Approach

The primary objectives of this study are:

- Develop the optimized long-term, phased improvement plan for wet weather improvements in the collection system tributary to the Nelson Complex (the Mission Main and Turkey Creek basins).
- Establish regulatory strategy to develop and implement the long-term wet weather management plan for the Nelson Complex watersheds.
- Determine, in conjunction with the wastewater treatment facility (WWTF) planning effort (WWTF study), the technical feasibility of auxiliary wet weather treatment at the Nelson Complex.
- Evaluate water quality impacts of major capacity-driven sanitary sewer overflows (SSOs), peak excess flow treatment facilities (PEFTFs), and urban stormwater on local receiving streams.
- Work with JCW's financial team and WWTF Improvements study team to develop a schedule of plant and collection system improvements compatible with JCW's user rate objectives.
- Discuss the schedule of improvements with the Kansas Department of Health and the Environment (KDHE) and the United States Environmental Protection Agency (USEPA) and determine the best strategy for obtaining regulatory acceptance.
- The findings of this study will serve as input into the long-term Nelson watershed plan to be developed in conjunction with the WWTF study.

This study will occur simultaneously with the MK Nelson WWTF Improvements Facility Plan and the two plans will be highly interdependent. The Facility Plan scope includes evaluating improvements and associated costs for upgrading the WWTF itself, as well as each of the major pump stations and PEFTFs. This information will be used to aid in developing the optimum plan for the collection system. This in turn may impact the WWTF if auxiliary treatment is found to be part of the optimum plan. These two studies will also be complementary in supporting development of a regulatory and permitting strategy that addresses the entire Nelson watershed. Together, these studies will holistically address existing capacity constraints and support JCW in achieving their desired level of service for both the collection system and facilities. Improvements identified in these studies will be incorporated into JCW's Integrated Management Plan (IMP).

The Collection System Wet Weather Plan will consist of six (6) technical memoranda (TMs) along with a final report including an executive summary:

- TM 1 – Basis of Analysis
- TM 2 – Hydraulic Model Update and Conversion
- TM 3 – Preliminary Optimization Findings and Alternatives Screening
- TM 4 – Refined Optimization Analysis
- TM 5 – Water Quality Modeling
- TM 6 – Alternatives Evaluation

The Plan will also include a Wet Weather Operations Standard Operating Procedures document, which will provide near-term recommendations for optimal wet weather operations until such time that long term collection system improvements have been made.

This technical memorandum (TM 1) serves to document the basis of analysis that will be used to guide the subsequent work on the Collection System Wet Weather Plan, including collection system hydraulic modeling, water quality modeling, and the optimization process. The objectives of TM 1 – Basis of Analysis are to:

- Describe the existing service area and confirm attributes of major facilities
- Define the basis of preliminary alternatives analysis and optimization
- Establish the collection system study approach for preliminary optimization.

2 Existing Service Area and Facilities

The Nelson Complex service area consists of two main tributary watersheds - Turkey Creek (SMTC) and Mission Main (MTM1). The service area is approximately bounded by 47th Street to the north, 95th Street to the south, Pflumm Road to the west, and State Line Road to the east. Metcalf Avenue roughly divides the two watersheds, Turkey Creek to the west and Mission Main to the east. Turkey Creek encompasses approximately 10,367 acres and Mission Main encompasses approximately 7,635 acres, for a total service area of approximately 18,002 acres. The service area is nearly built-out with a primary land use of suburban residential development.

The watersheds contain several major pump stations and Peak Excess Flow Treatment Facilities (PEFTFs). At the PEFTFs, flow can be stored and released back to the system after a storm event or can undergo primary treatment and disinfection before being released to the creek.

An overall map of the Turkey Creek and Mission Main basins tributary to the Nelson Complex, with facility capacities and the sizes of gravity lines 10” in diameter and larger is presented in Figure 2.

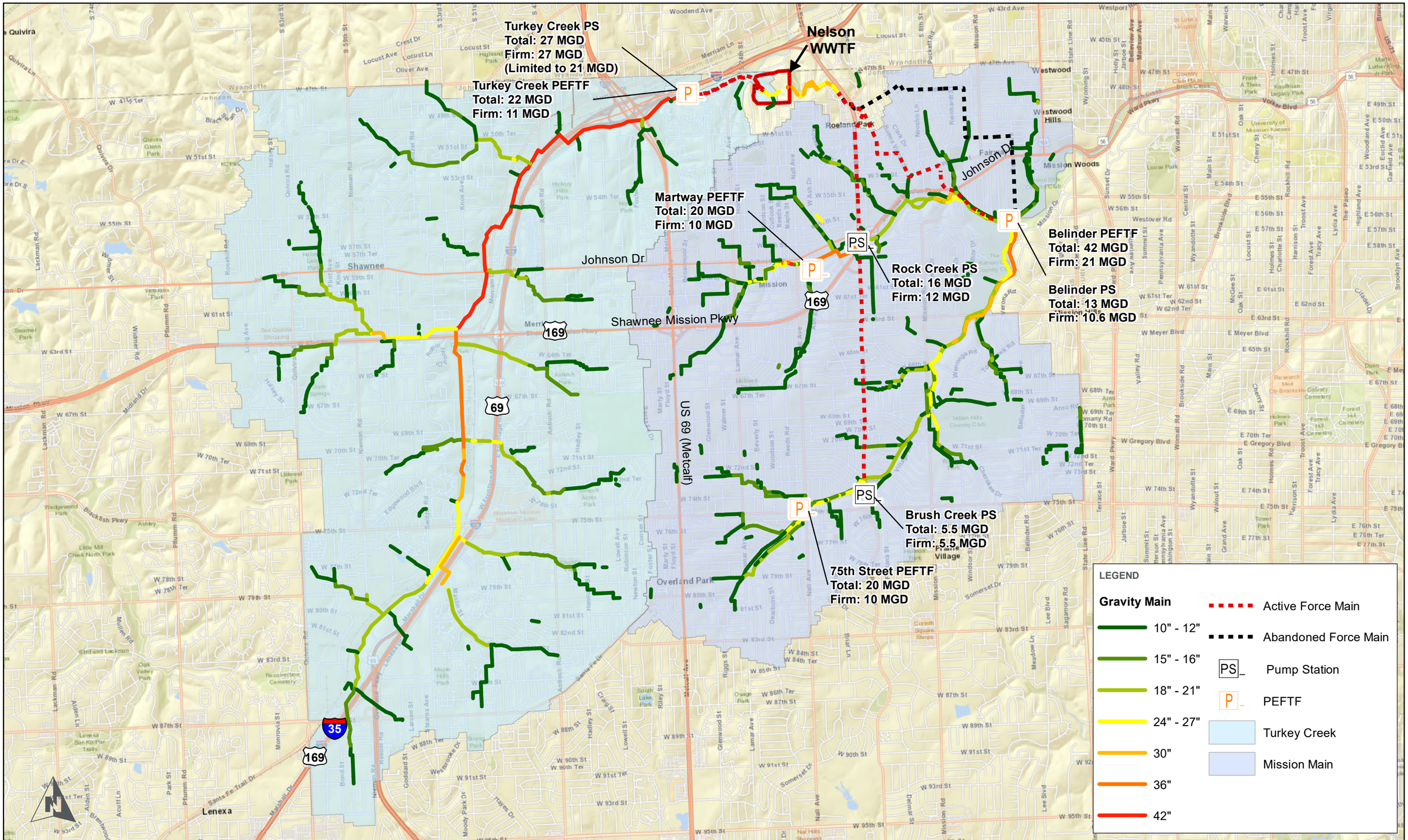


FIGURE 2: TURKEY CREEK AND MISSION MAIN WATERSHEDS

2.1 Turkey Creek (SMTC)

2.1.1 Service Area Description

The Turkey Creek watershed contains approximately 245 miles of active gravity mains, ranging from 8” to 48”, and 2 miles of active forcemains. The sewers within this watershed generally flow from southwest to northeast to one (1) major interceptor, the Turkey Creek Interceptor. This interceptor flows to the Turkey Creek Pump Station and PEFTF, where flow can either be pumped to the Nelson Complex for treatment or be diverted to the PEFTF.

2.1.2 Key Facilities and Existing Constraints

The Turkey Creek watershed contains one (1) major pump station, Turkey Creek PS, and three (3) smaller pump stations, County Line, Lamar Foxridge and Virgil’s. Nearly the entire watershed flows to the Turkey Creek Pump Station and PEFTF. Facilities within the Turkey Creek Watershed are presented in Figure 3.

The Turkey Creek Pump Station has a rated capacity of 27 MGD. However, due to capacity restrictions at the Nelson Complex, pumping is currently limited to 21 MGD. Gravity system capacity constraints present in the basin will be detailed in TM 2 - Hydraulic Model Update and Conversion.

A detailed description of the facility operation and equipment present at each major facility is included in the WWTF Study TM No. 1, Basis of Analysis.

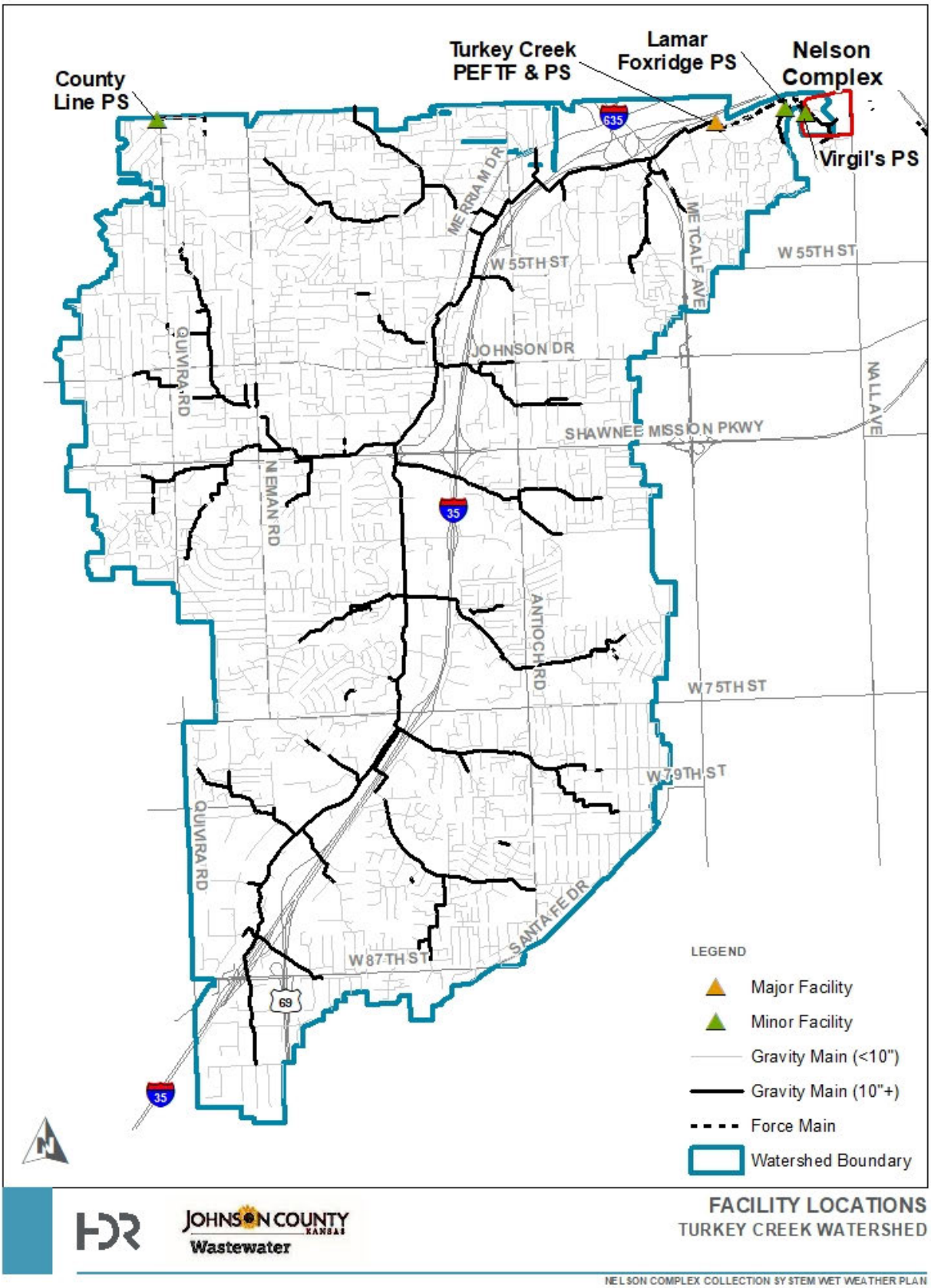


Figure 3: Turkey Creek Facility Locations

2.2 Mission Main (MTM1)

2.2.1 Service Area Description

The Mission Main watershed contains approximately 242 miles of active gravity mains, ranging from 8” to 48”, and 9 miles of active forcemains. The sewers within this watershed generally flow from southwest to northeast to two (2) major interceptors, Rock Creek and Brush Creek. Both interceptors contain sections of parallel sewer.

2.2.2 Key Facilities and Existing Constraints

There are several inter-connected facilities within the Mission Main Watershed. The key facilities include three (3) pump stations (Rock Creek, Brush Creek, and Belinder) and three (3) PEFTFs (Martway, 75th Street/Nall, and Belinder). The watershed also includes four (4) smaller pump stations – Granthurst, Mission Woods, Swatzell View, and Roe Village. Facilities within the Mission Main Watershed are presented in Figure 4.

Facilities on the Rock Creek interceptor are the Martway PEFTF and Rock Creek Pump Station. Martway is located upstream of Rock Creek PS. During dry weather, flow bypasses Martway and continues by gravity to Rock Creek PS. During wet weather, flow can be diverted to the Martway PEFTF. Flow reaching Rock Creek PS can either be pumped to the Nelson Complex for treatment or be diverted and continue by gravity to Belinder PS.

Facilities on the Brush Creek interceptor are the 75th Street/Nall PEFTF, Brush Creek Pump Station, and the Belinder PEFTF and Pump Station. During dry weather, flow bypasses the 75th Street/Nall PEFTF and flows by gravity to Brush Creek PS. During wet weather, flow can be diverted to the 75th Street/Nall PEFTF. Flow reaching Brush Creek PS can either be pumped to Rock Creek PS or be diverted and continue by gravity to Belinder PS. During dry weather, flow reaching Belinder PS is pumped to the Nelson Complex for treatment. During wet weather, peak flows are diverted to the Belinder PEFTF.

A detailed description of the facility operation and equipment present at each major facility is included in the WWTF Study TM No. 1, Basis of Analysis.

This complex configuration of facilities presents operational challenges and constraints, particularly during wet weather events. These constraints, as well as gravity system capacity constraints will be detailed in TM 2 - Hydraulic Model Update and Conversion.

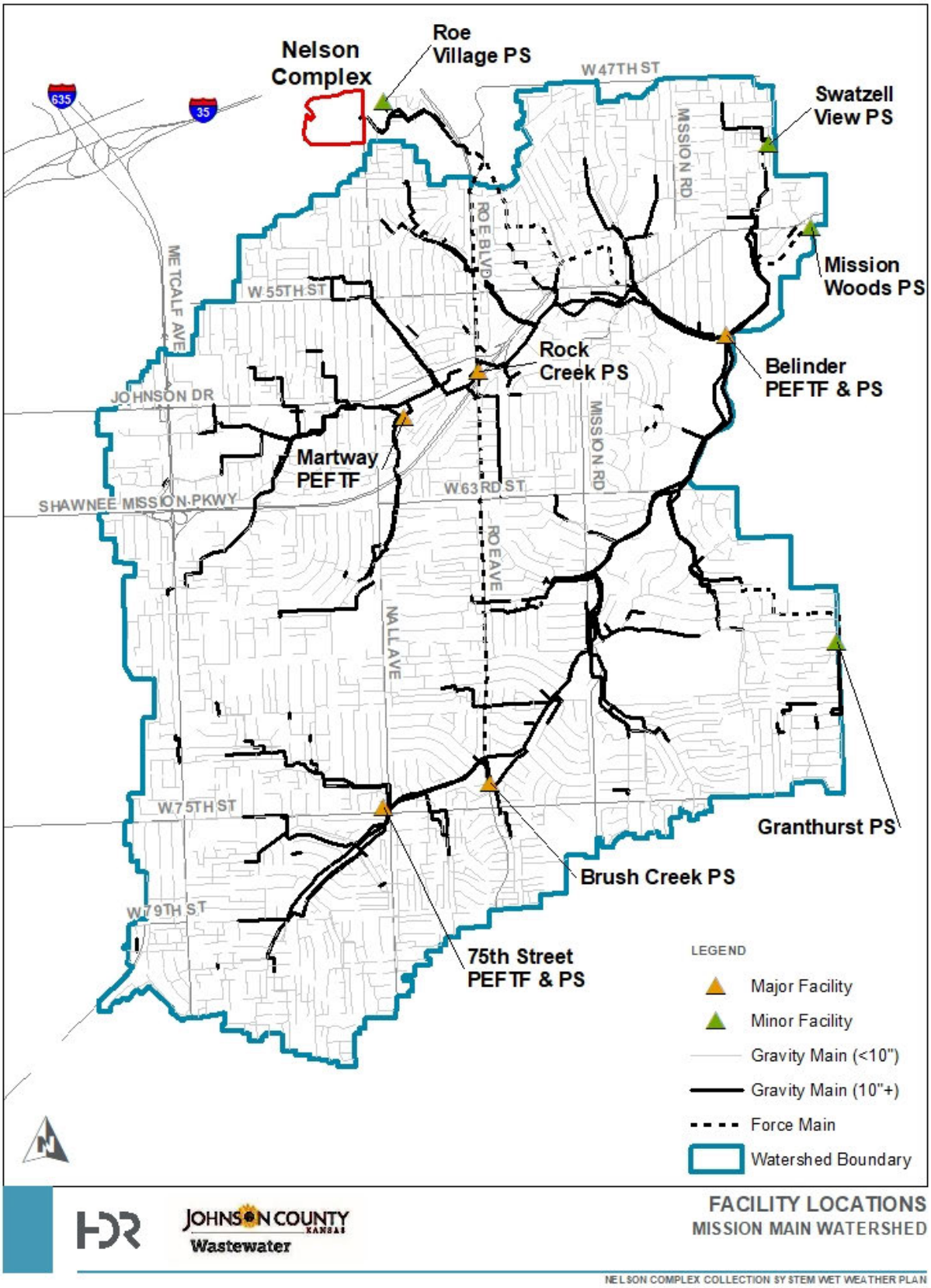


Figure 4: Mission Main Facility Locations

2.3 System Flow Summary

The permitted average day capacity of Mission Main is 7.0 MGD. Flows are pumped to the Mission Main WWTF primarily by the Belinder Pump Station, with a firm capacity of 10.6 MGD, and the Rock Creek Pump Station, with a capacity of firm 12.0 MGD. The total combined pumping rate exceeds the hydraulic capacity of the facility which is currently limited to approximately 25 MGD.

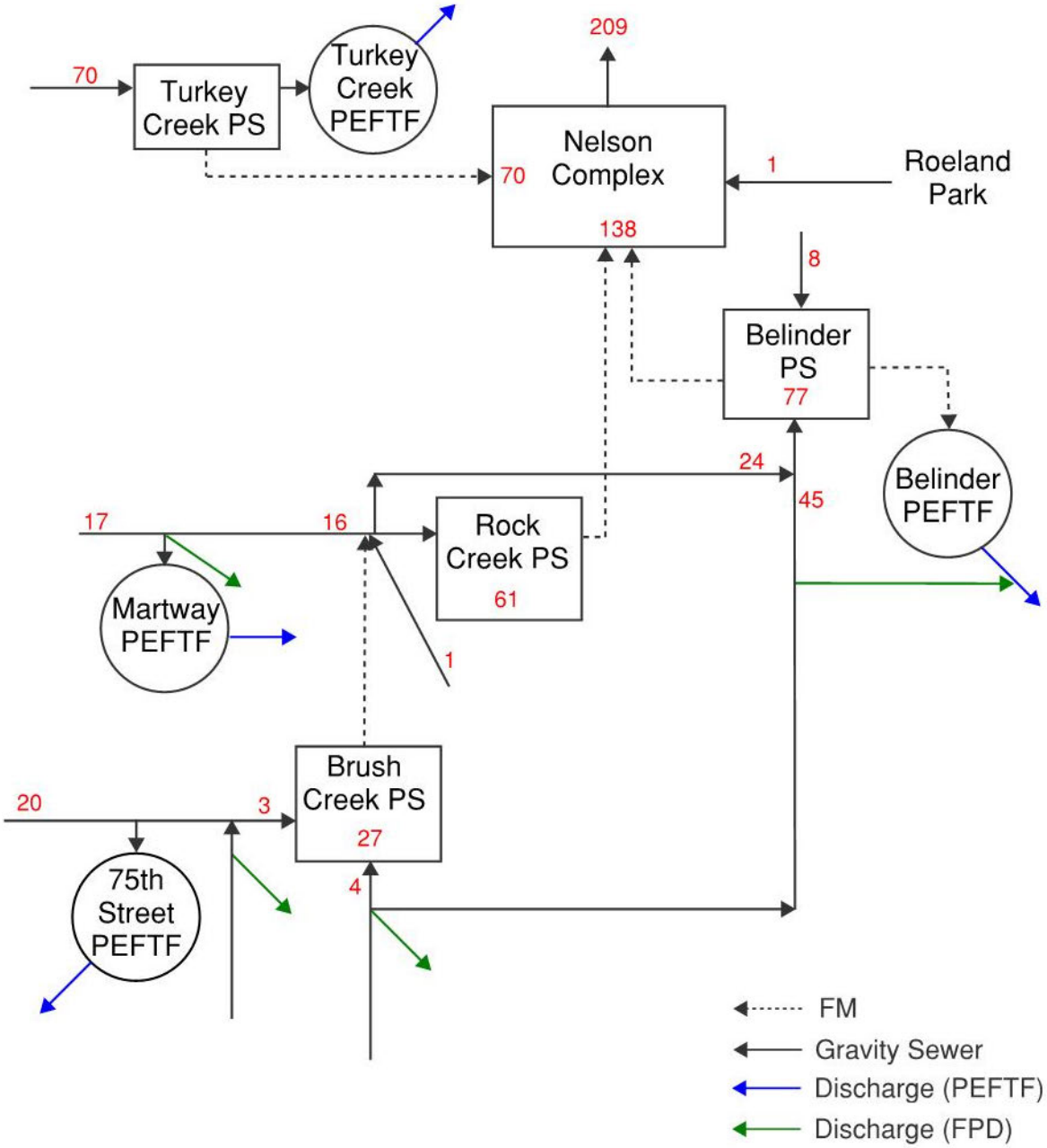
The permitted average day capacity of Turkey Creek is 8.0 MGD. Turkey Creek flows are pumped to the facility primarily by the Turkey Creek Pump Station (also referred to as Foxridge Pump Station), with a firm capacity of 27 MGD. The maximum capacity of the pump station exceeds the hydraulic capacity of the facility, which is currently limited to approximately 21 MGD.

Existing wet weather flows and capacity constraints throughout the collection system will be documented in detail in TM No. 2, Hydraulic Model Update. An approximation of the “existing unrestricted flow” from the collection system tributary to each satellite facility is included below. “Existing unrestricted” is the flow that would occur if there was no upstream flow reduction (storage or I/I removal), and the pipes were of sufficient size that all flows would be conveyed to the facility with any upstream surcharging or overflows. These flows are presented in Table 1 and shown schematically in Figure 5:

Table 1: Unrestricted Flows (10 YR, 24 HR Storm Event)

Reach/Item	Description	Flow (MGD)
Brush Creek Pump Station Service Area		
1	US of 75th & Nall	20
2	DS of 75th & Nall and US of Brush Creek	7
3	Total, Brush Creek Pump Station Service Area	27
Rock Creek Pump Station Service Area		
4	US of Martway	17
5	DS of Martway and US of Rock Creek	16
6	To Rock Creek from South	1
7	Total, Rock Creek Pump Station Service Area	34
8	Total, Rock Creek and Brush Creek PS Service Areas	61
Belinder Pump Station Service Area		
9	DS of Brush Creek and US of Belinder	45
10	DS of Rock Creek and US of Belinder	24
11	To Belinder from North	8
12	Total, Belinder Pump Station Service Area	77
13	**Total, Mission Main Service Area**	**138**
14	**Total, Turkey Creek Service Area**	**70**
15	Total, Roeland Park Service Area	1
15	**Nelson Complex Total**	**209**

Figure 5: Unrestricted Flows (10 YR, 24 HR Storm Event)



3 Basis of Preliminary Alternatives Analysis and Optimization

This study will take a holistic basin-wide approach to determine the most cost-effective combination of alternatives by utilizing the optimization process. This process will be completed through an iterative process that begins with a preliminary optimization and alternatives analysis. During preliminary optimization, all feasible alternatives are included in the analysis in order to complete a thorough evaluation of alternatives and complete the following objectives:

- Investigate a wide range of scenarios and sensitivities to identify consistent trends
- Evaluate potential level of service scenarios to establish incremental costs to achieve varying levels of service and identify common/divergent improvements required between scenarios
- Identify key assumptions/alternatives that require further refinement and screening prior to the final optimization
- Identify and screen likely sites for major improvement projects (e.g. storage facilities)
- Identify which cost assumptions are most sensitive, so they can be further refined in the final optimization analysis.

The assumptions and approach that form the basis of the preliminary optimization analysis are described below. These items were reviewed and confirmed with JCW during the Basis of Analysis workshop on March 22, 2018.

3.1 Level of Service

Two (2) distinct level of service (LOS) scenarios will be included in the initial stages of preliminary optimization – Scenario 1 and Scenario 1B.

Scenario 1 ("base case") requires a minimum LOS of 10 years for the collection system and a minimum LOS of 5 years for facilities. In the base case, it is assumed that the PEFTFs will eventually be eliminated and not available for use during any wet weather event. In place of the PEFTFs, it is assumed that a Facility Protection Device would be constructed upstream of each major facility and may activate above a 5 year event. *This alternative was ultimately referred to as Alternative 1: Eliminate PEFTFs through Wet Weather Management, or PEFTF Elimination.*

Scenario 1B ("PEFTFs remain in service"), like Scenario 1, requires a 10 year minimum LOS for the collection system and a 5 year minimum LOS for facilities. In this scenario, it is assumed that the PEFTFs will be upgraded and remain in service indefinitely. The PEFTFs would provide a 5 year LOS, above which the Facility Protection Devices may activate. *This alternative was ultimately referred to as Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment, or PEFTF Retention.*

The optimization process will be used to determine the most economical combination of improvements necessary to meet the LOS requirements set forth in each scenario. The

improvements identified for each scenario will then be compared in order to establish the incremental cost difference and evaluate the timing of improvement.

The findings from these scenarios will be used to inform the remainder of the preliminary optimization analyses. These may include evaluating additional level of service and/or PEFTF activation scenarios (e.g. PEFTFs remain in service but only discharge during greater than a 1-year storm event). The scope of the additional level of service scenarios and sensitivity analyses will be developed based on the findings of Scenario 1 and Scenario 1B.

3.2 Improvement Alternatives

Improvement alternatives considered during optimization will include capacity improvements, I/I reduction, storage, auxiliary treatment, and PEFTF upgrades. The results from the hydraulic modeling and optimization analysis will help determine which combination of alternatives is most cost effective. Each of the alternatives will be described in more detail in the following sections.

3.2.1 Capacity Improvements

The first alternative is to improve conveyance by upgrading capacity throughout the collection system. Capacity improvements may include upsizing pipes, relief sewers (parallel pipes), force main upgrades, and pump station upgrades.

3.2.2 I/I Reduction

I/I reduction will be considered within specific sub-basins in Mission Main and Turkey Creek. Utilizing the information developed through JCW's Pilot I/I Reduction Strategy project (Pilot I/I Study), unit cost curves for I/I reduction have been developed and are shown in Figure 6 (Turkey Creek) and Figure 7 (Mission Main). The curves are based on a cost for percentage reduction per linear foot of sewer upstream of the point in the system to be evaluated. This method enables the evaluation of varying levels of I/I reduction on a sub-basin level – i.e., levels of I/I reduction can be evaluated for each sub-basin in order to identify the optimum level of I/I reduction at different locations within the system in conjunction with other combinations of improvement alternatives.

During the Pilot I/I Study, JCW determined that the "typical comprehensive" rehabilitation strategy was the most cost effective and preferred I/I reduction and system rehabilitation strategy. The typical comprehensive approach includes cost effective rehabilitation of pipes and manholes as well as disconnecting direct building connections. JCW's pipe and manhole rehabilitation programs (executed through the Collection System Asset Management Program) and private I/I source disconnection program utilize decision models aligned with this approach. This strategy is projected to provide a reduction of up to 30%. The unit cost of I/I reduction increases rapidly and becomes cost-prohibitive as the desired percentage of I/I reduction increases beyond this point. Therefore, to align with JCW's programmatic approach to I/I reduction, a maximum of 30% I/I reduction will be considered as the base case during optimization.

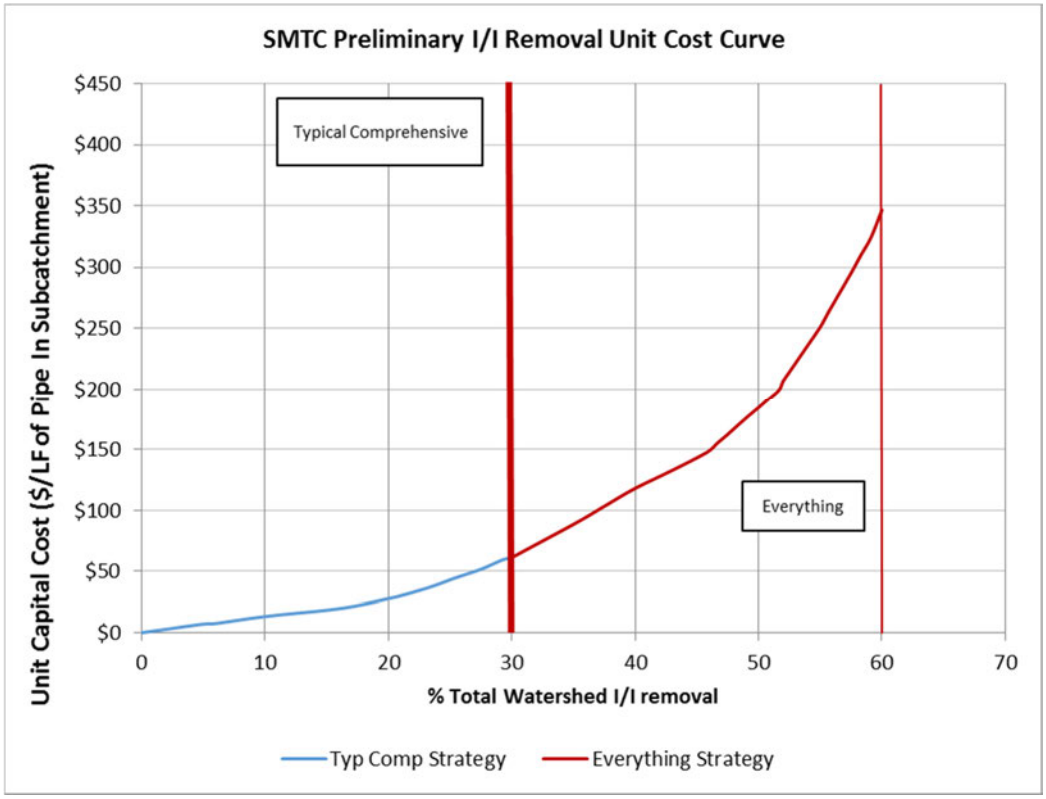


Figure 6: Turkey Creek Watershed Unit Cost Curve

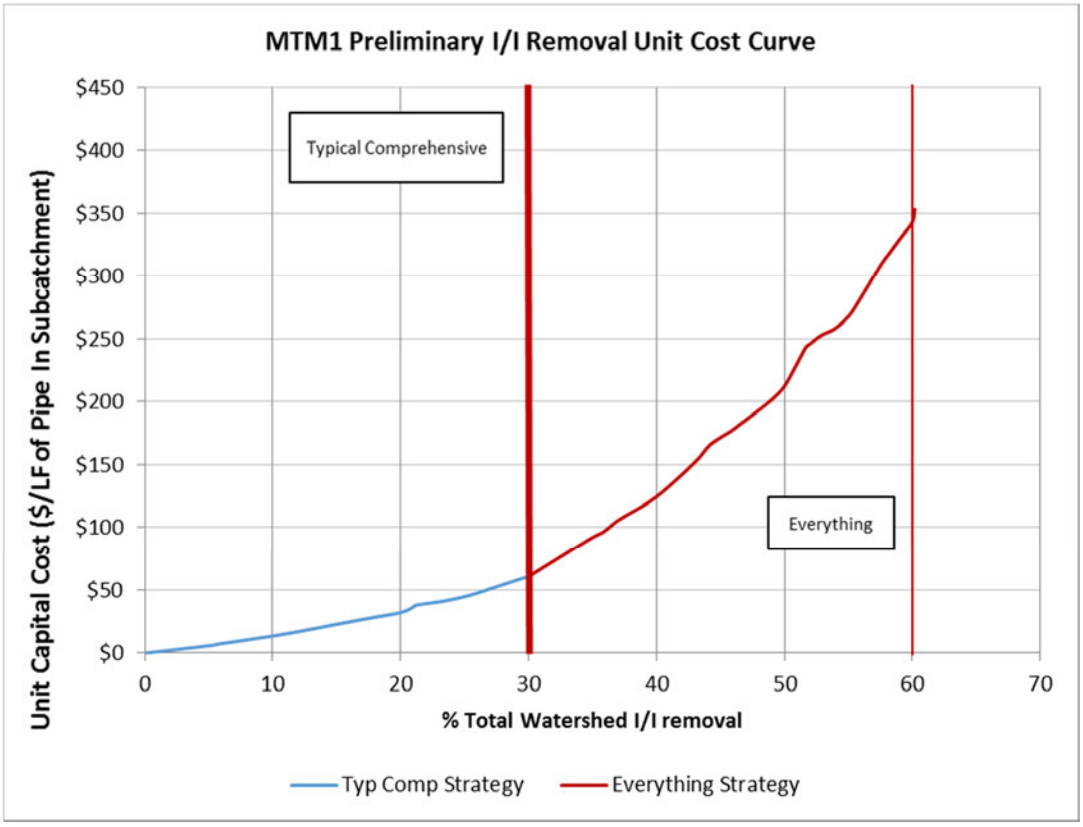


Figure 7: Mission Main Watershed Unit Cost Curve

JCW has completed extensive collection system rehabilitation since the last calibration of the Turkey Creek and Mission Main hydraulic models using flow data collected from 2009 - 2011. This includes both public sector rehabilitation of pipes and manholes, and ongoing private I/I source disconnections. These efforts may have resulted in I/I reduction within these basins that is not accounted for in the hydraulic models. This study will assume the current model calibration as the baseline level of I/I within the system for the purposes of the alternatives analysis. As recent and ongoing efforts to reduce I/I are completed and reduction levels are quantified, these efforts will be taken into account during the development of the implementation plan. *Quantification of ongoing public I/I reduction is discussed in Section 4.1.3 of TM 3. Ongoing pipe and manhole rehabilitation efforts are projected to reduce peak I/I by 10% in Mission Main and 15% in Turkey Creek; this data was incorporated after preliminary optimization.*

3.2.3 Storage

Storage can be used to collect and temporarily store excess flow during wet weather events, to dampen peak flows in the system. Utilizing storage to dampen peak flows could reduce the need to upsize gravity mains and/or pump stations and forcemains. Stored flows would instead be released back to the system at such time when there is sufficient capacity in the system. Storage options that will be evaluated during optimization include:

- Remote storage facilities (assumed to be shallow below ground storage for cost estimating purposes during preliminary optimization) and linear storage within the collection system
- Facility storage at major pump station and PEFTF locations
- Centralized storage at the Nelson Complex
- Linear storage (large diameter pipe storage) at key locations to reduce peak flows and limit surcharging within the system.

The preliminary optimization approach is to include the option of storage at all major facilities and at any reasonable remote location within the collection system. Potential locations for storage that will be considered during preliminary optimization are presented for the Turkey Creek Watershed and Mission Main Watershed in Figures 8 and 9, respectively.

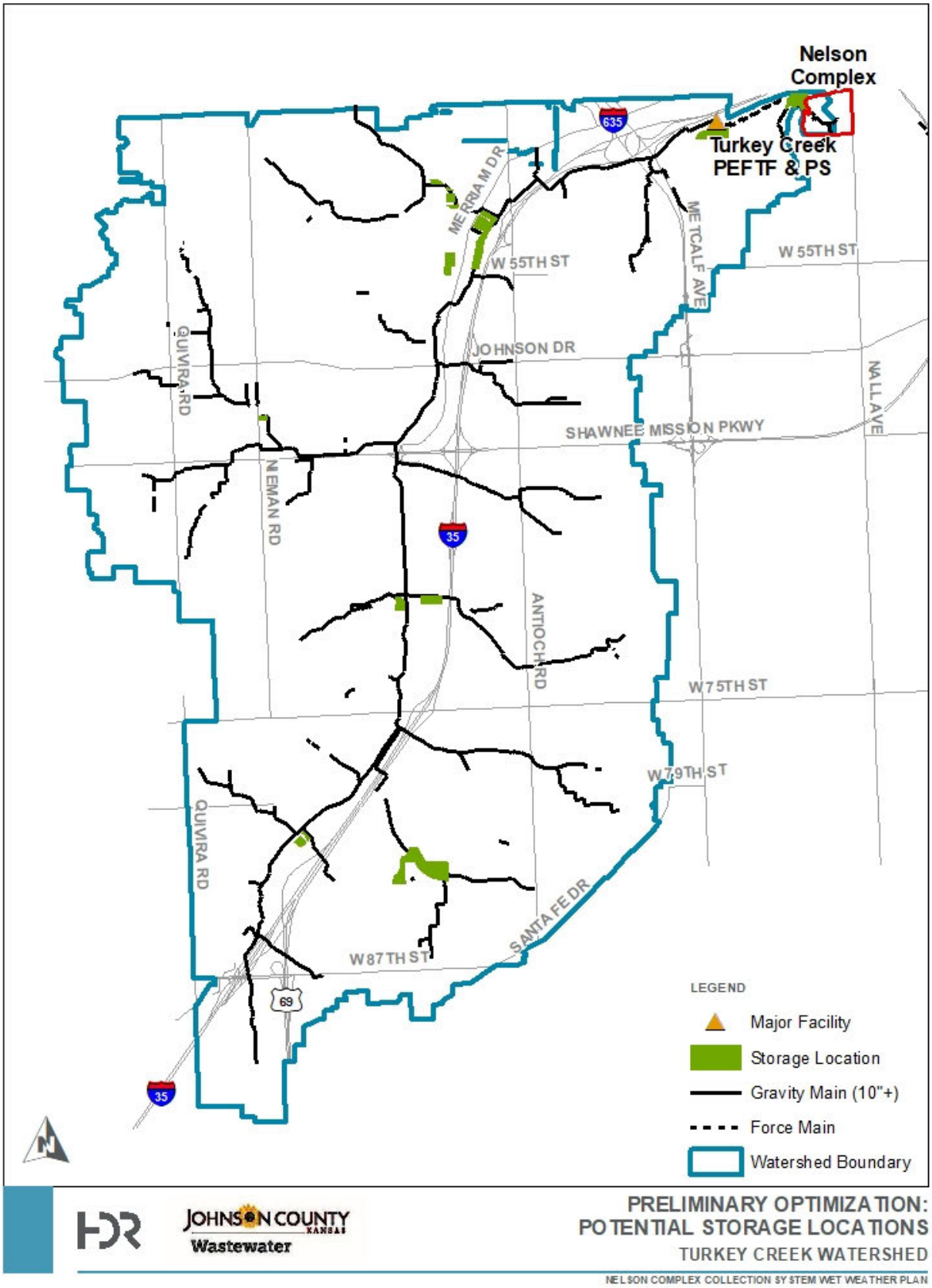


Figure 8: Turkey Creek Potential Storage Locations

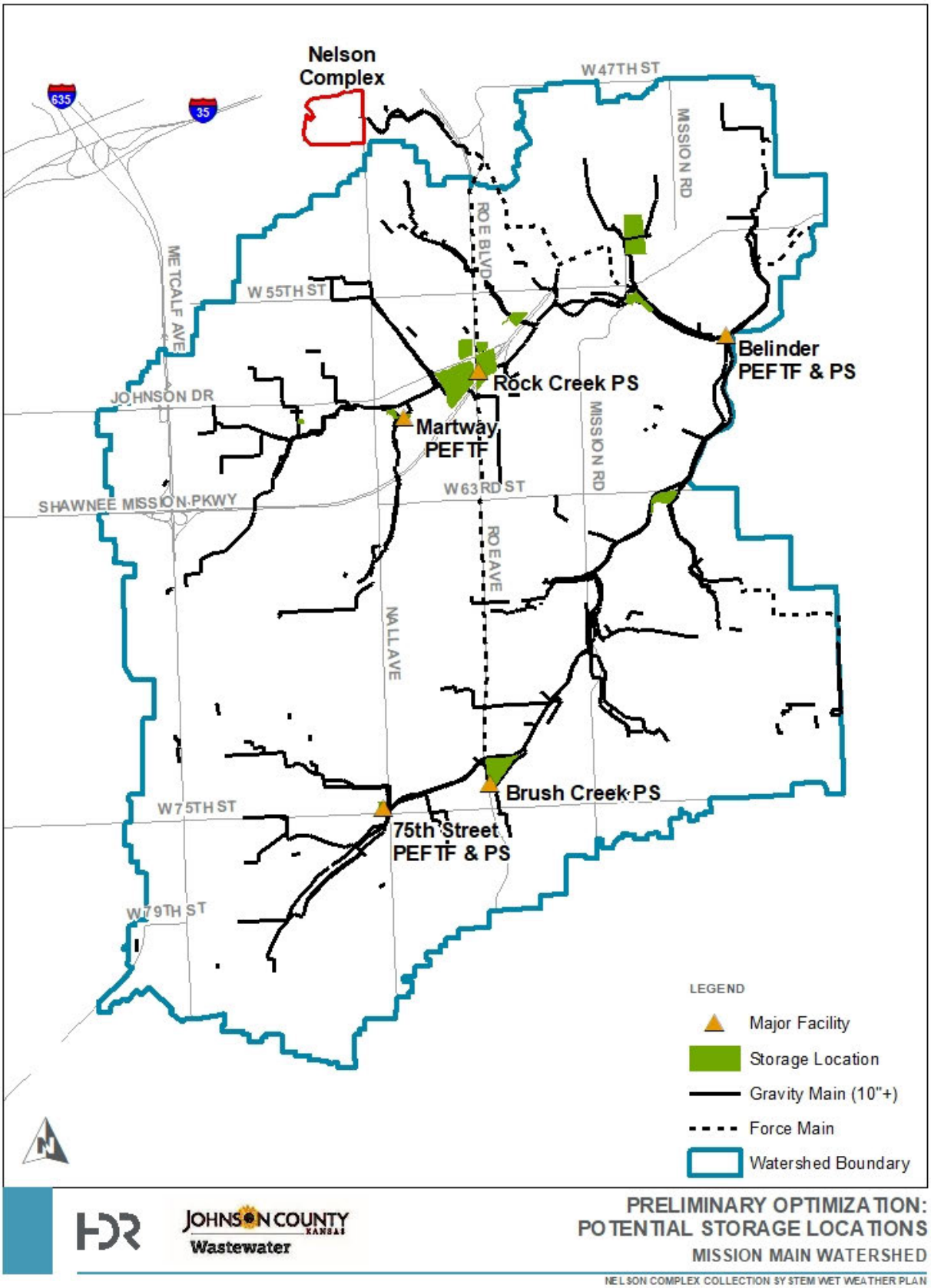


Figure 9: Mission Main Potential Storage Locations

3.2.4 Auxiliary Treatment

An auxiliary treatment facility (ATF) will be considered at the Nelson Complex. During preliminary optimization, the technology used in the ATF will be assumed to be the same technology that will be constructed at Tomahawk Creek (THC) WWTF for unit cost estimating purposes. The study will consider the disc filters used at the THC WWTF for primary treatment as well as other technologies, and disinfection using chlorination/dechlorination.

3.2.5 PEFTF Upgrades

At this time, it is unknown whether the PEFTFs will continue to be permitted indefinitely. The optimization and modeling will provide insight as to the costs and benefits of continuing to utilize and upgrade the PEFTFs. During preliminary optimization, it will be assumed that PEFTFs could be upgraded both with additional capacity and more advanced treatment technology, similar in nature to the ATF.

3.3 Preliminary Optimization Performance Criteria

Performance criteria have been established for the improvement alternatives that will be considered during preliminary optimization. The criteria are listed in Table 2.

Table 2: Preliminary Optimization Design Criteria

Category	Design Criteria & Assumptions
Parallel Pipe Options	Pipe diameter alternatives ranging from 1' to 6'. Capital costing based on gravity sewer cost tables with increased costs included for trenchless crossings.
Storage Facilities	All preliminary options considered will be assumed as below ground storage.
Linear Storage	Pipe diameter alternatives ranging from 3' to 12' with same cost methodology used for gravity sewers.
Pump Station Upgrades	Pump Station upgrades will utilize a cost curve during Preliminary Optimization. During Refined Optimization, the analysis will be refined to determine what the maximum output of the existing facility is and define the “break point” where a new facility will be required and costs will jump substantially.
Force Main	A maximum velocity of no more than 6 fps will be assumed, beyond that a new or parallel force main will be required.
I/I Reduction Option	Typical Comprehensive Rehab Strategy assumed (rehab pipes, manholes, and remove building direct connections) – maximum I/I reduction of 30% assumed. Costs curves specific for Mission Main and Turkey Creek basins were developed during Pilot Study.
WWTF	Auxiliary Treatment Facility Cost Curves – Based on recent similar projects
Surcharge	Surcharge limited to 10 feet below the ground surface. Localized variances will be identified near facilities and shallow lines (e.g. creek crossings) and will be addressed on a case-by-case basis.
Present Value Costing	20-yr cost analysis period – Based on most recent OMB Circular A-94 Appendix C.

3.4 Water Quality Modeling

The Storm Water Management Model (SWMM) version 5 watershed model will be used to evaluate water quality impacts on receiving waters from various wet weather management alternatives. SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The SWMM model will predict the effects of different alternatives on *Escherichia coli* (*E. coli*), total residual chlorine (TRC), ammonia, nitrate, total nitrogen, and total phosphorus in Turkey, Rock, and Brush Creeks. Model results will help inform cost/benefit analyses and the regulatory assessment of the alternatives.

Wet and dry weather inputs from the Nelson Complex WWTF and collection system will be simulated using models previously developed for the Mission Main and Turkey Creek sewersheds using the InfoWorks ICM hydraulic modeling platform by Innovyze. The models were subsequently updated in 2011 and 2016, and most recently again in 2018 for use in long-term simulations. Output from the updated InfoWorks hydraulic models will be directly input into the SWMM model to simulate point source discharges.

The SWMM model will be calibrated based on existing flow and water quality data. The hydrologic calibration will rely on flow data from the U.S. Geological Survey (USGS) gage station 06893557 (Brush Creek at Ward Parkway). The water quality component of model setup and calibration will principally rely on a 2012-2013 wet weather water quality study sponsored by JCW and routine water quality data collection activities by both JCW and USGS. The calibrated water quality model will be used to model various alternatives plus baseline conditions during select years representative of typical and worst case conditions. The model will be run in continuous simulation mode to assess long-term variability within the watersheds. Additional model runs will be made to help finalize the optimization plan and to provide regulatory justification.

4 Collection System Study Approach

The Collection System Wet Weather Plan will take place in conjunction with the Nelson Complex Facility Plan. This shared approach will ensure that the proposed collection system improvements and the phasing of improvements align with the solutions proposed at the Nelson Complex.

4.1 Schedule

The schedule for the collection system study will generally follow the order of the TMs listed previously. The existing hydraulic model network will be updated to include recent improvements and near-future improvements. The model will then be converted to SWMM for optimization, and preliminary optimization efforts will begin. Following preliminary optimization, an alternatives screening analysis will be completed, which will then facilitate the refined optimization process. The improvements alternatives identified during refined optimization will then be further developed and evaluated. Ultimately, the selected optimization scenario will be used to develop the detailed long-term prioritized improvements plan.

Water quality modeling will be performed throughout the project in conjunction with the optimization to provide an indication of water quality results for different optimization scenarios. Regulatory engagement began at the early stages (and prior to the beginning) of the study, and will continue intermittently throughout both studies. The prioritization process will be finalized in conjunction with financial impact evaluations and regulatory negotiations.

Concurrent with development of the long term plan, near term improvements to wet weather operations within the Mission Main system will be developed. The performance of the system during recent major wet weather events will be modeled and evaluated. The results of the model will be used to develop a wet weather standard operating procedure that can be followed until long-term collection system improvements are constructed.

The schedule for the completion of this study is presented in Appendix B.

4.2 Economic Analysis Assumptions

The economic analysis of alternatives considered in this study will be based on the following assumptions:

- Planning horizon for O&M costs will be 20 years
- Economic analysis criteria used for the net present value analysis will be derived from the Office of Management and Budget (OMB) Circular A-94 App. C, November 2017:
    - Annual Inflation = 2.00%
    - Net Discount Rate = 0.20%
    - Nominal Discount Rate = 2.20%

Capital costs used in preliminary optimization will be described in *TM 3 - Preliminary Optimization Findings and Alternatives Screening*.

Appendix A - Relevant Past Studies & Documents

Following is a list of relevant past studies and documents, from most current to least current.

HDR. *Johnson County Wastewater Facilities Asset Management Program Implementation Plan.* April 2018

HDR. *Johnson County Wastewater Collection System Asset Management Program. Implementation Plan and other Program Documents.* January 2014 to Date.

Black and Veatch/HDR. *Johnson County Wastewater Tomahawk Creek WWTF Project Definition Study.* June 2016.

CH2M HILL. *Nelson Wastewater Treatment Complex Sanitary Sewer Service Area, EPA 308(a) Response Document: Executive Plan*. March 2015.

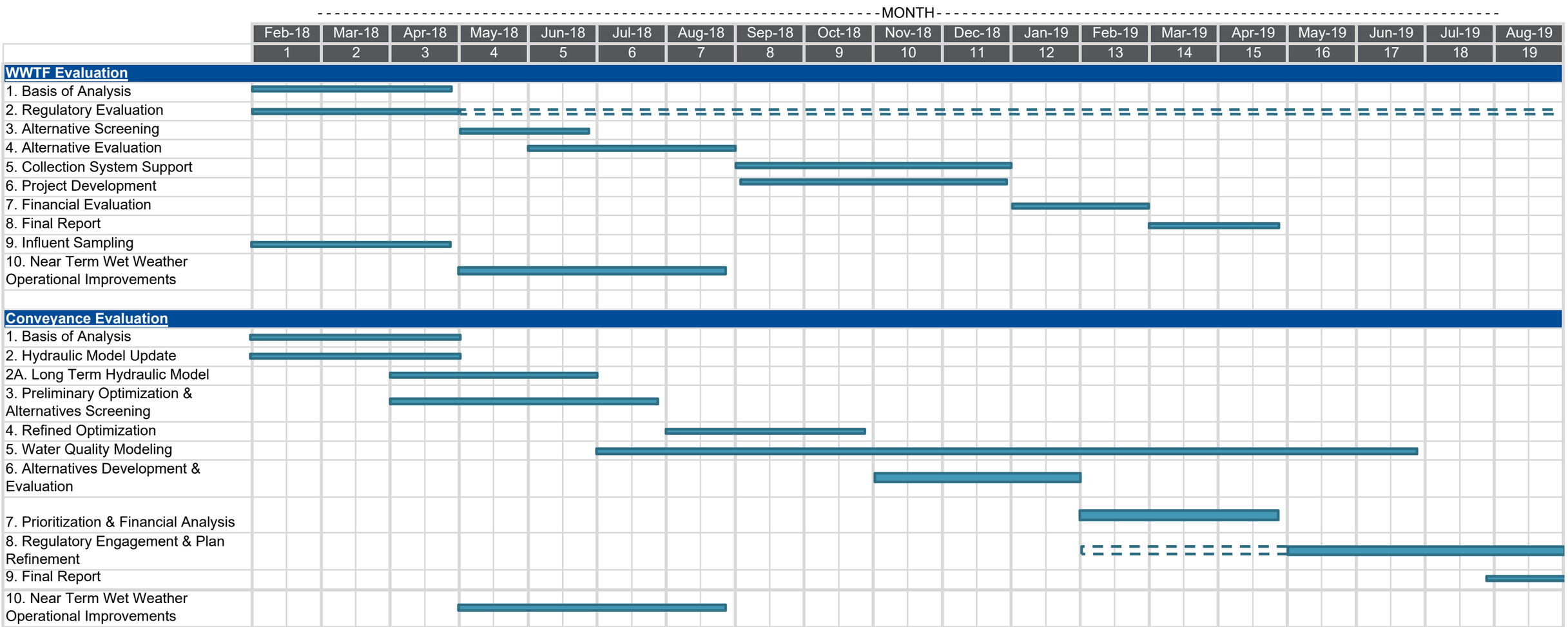
CH2M HILL. *Collection System Analysis for Peak Excess Flow Treatment Facilities: Mission Township Main Sewer District No. 1 and Shawnee Mission Turkey Creek Watersheds, Supplement to January 2009 Technical Response to EPA 308(a) Request*. December 2014.

CH2M HILL. *Draft Technical Memorandum #2 and #3: Data Characterization, Quantification, and Costing I/I Curve Development, Repair Prioritization, and Application of Results to other Basins*. June 2011.

CH2M HILL. *Draft Technical Memorandum #2: Inventory Verification, Hydraulic Model Development and Model Calibration*. March 2010.

Johnson County Wastewater. *Response to: EPA Request for Information Pursuant to Section 308(a) of the Clean Water Act Items A.2, A.4, A.5 and A.6*. January 2009.

Appendix B - Nelson Complex Treatment Facility and Collection System Study Schedule



Nelson Complex Collection System Wet Weather Plan Technical Memorandum #2 Hydraulic Model Updates

June 2018

JOHNSON COUNTY KANSAS

Wastewater

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Note: Portions of the project approach and information presented in this technical memorandum (TM) were subsequently updated and new alternative naming conventions were adopted as the project progressed. Changes are noted in italics, where practicable. In general, information presented in TM 6 or the Phase 1 Integrated Management Plan supersedes conflicting information presented in this TM.

1 Introduction

1.1 Background

The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two Wastewater Treatment Facility (WWTF) trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or discharge directly from the collection system to the creek after providing primary treatment and disinfection. In the Mission Main watershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flows to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow to the WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the WWTF. On the Turkey Creek side, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the WWTF.

Hydraulic models have previously been developed for the Mission Main and Turkey Creek watersheds using InfoWorks hydraulic modeling platform by Innovyze. The models were updated by CH2M HILL in 2011, documented in a previous technical memorandum (*Technical Memorandum #2: Inventory Verification, Hydraulic Model Development, and Model Calibration,* August 2011). The models were updated again by CH2M HILL in 2016, at which time the hydrology methodology was updated from the Wallingford method to the RTK method (*RTK Flow Analysis and Hydraulic Model Update: DRAFT TM Kp Selection Methodology Follow-up*, August 2016). The 2016 RTK model networks include most pipes 8-inch and larger and all major facilities.

1.2 Purpose

Prior to use for capacity analysis in this study, the parameters used to describe hydraulic model network elements (gravity system, force mains, pump stations, and PEFTFs) were reviewed and updated. Since the model networks were last updated in 2011, JCW has continued to update their sewer records correcting discrepancies and incorporating new data pertaining to the many assets that have been constructed, realigned, rehabilitated, or abandoned. These changes had been captured in the GIS database but had not yet been incorporated into the hydraulic models. This updated model will be referred to as the Capacity Assessment/Optimization model. The model will be used for peak flow/capacity analysis and will form the basis for the converted SWMM model to be used for optimization.

In addition to the Capacity Assessment/Optimization model, HDR will develop a closely related Long-Term model. The current calibration parameters are adequately estimating peak inflows, but may be under-estimating infiltration during long-term simulations. The calibration will be reviewed and modified as necessary to more accurately estimate flows for long-term simulations.

This technical memorandum (TM 2) serves to document the hydraulic model review and update, existing conditions analysis, and the model conversion from InfoWorks to SWMM for use in optimization.

1.3 Existing Hydraulic Model Review

The existing hydraulic models were most recently updated in November 2016 utilizing RTK hydrographs. HDR used the following model networks as the starting point for the Capacity Assessment/Optimization model updates:

- Mission Main:
  - Archive Database: MTM1_2016RTKUpdate_FinalDeliverable.icmt
  - Network: *MTM1_ES_Calibrated_W/RTCControl_Nov2016*
- Turkey Creek:
  - Archive Database: SMTC_2016RTKUpdate_FinalDeliverable.icmt
  - Network: *SMTC_ExistingSystem_CalibratedNov2016_2016RTKUpdate_TCUpdate*

The results from these model networks were reviewed and compared to the model results presented in prior reports.

The Mission Main model network includes the three (3) major pump stations (Belinder, Brush Creek, and Rock Creek), as well as four (4) minor pump stations (Granthurst, Mission Woods, Roe Village, and Swatzell View). The model network also includes three (3) PEFTFs – 75th/Nall, Martway, and Belinder.

The Turkey Creek model network includes the Turkey Creek pump station and PEFTF as well as a minor pump station (County Line). It does not include the two (2) minor pump stations near the Nelson Complex (Lamar Foxridge and Virgil's).

Both model networks include nearly all pipes 8-inch and larger.

2 Hydraulic Model Network Updates

While the Mission Main and Turkey Creek hydraulic models are kept in two separate networks, the models will be referred to as a singular hydraulic model for the remainder of this TM for clarity.

The existing hydraulic model network was converging without any major issues and producing reasonable results. However, because the network had not been updated for several years, the entire gravity system was reviewed and updated in order to incorporate data for assets that have been constructed, realigned, rehabilitated, or abandoned. Pump station and PEFTF configuration and operations were also verified and updated as necessary. Updates to the model were made based on several data sources including GIS data, as-builts and record drawings, previous reports, site visits, and interviews with JCW staff. This section pertains to the model update performed for the Capacity Assessment/Optimization model; any updates specific to the Long-Term Model are documented in Section 5.

2.1 Gravity Network Updates

2.1.1 Current Gravity Network Updates

Modeled assets (pipes and manholes) were reconciled with a January 2018 export of the GIS database to determine where new development had occurred, where existing assets had been abandoned, and where there were other discrepancies in network connectivity/routing. The GIS database is continually updated by JCW staff as existing assets are rehabilitated or abandoned and new assets are constructed. Therefore, it was assumed that GIS generally contains the most current and correct asset information. In cases where connectivity was unclear, as-builts from AIMS were used to supplement GIS data. Where as-builts were unavailable, assumptions were made and documented as such using the appropriate data flag within the model.

The most common updates represent adding new assets (new developments and flow re-routing), deleting abandoned assets, and updating diameter and material of existing pipe assets. Where new assets were added and abandoned assets were deleted, the associated subcatchments were updated to correspond with the network updates. A map showing areas of gravity network updates is provided in Appendix B.

Additional gravity network updates were made as needed throughout the project, including recent improvements at Nieman Road between 60th Street and Shawnee Mission Parkway, as noted in Section 3.2.2 of TM 6.

2.1.2 Near-term Gravity Improvements

Turkey Creek interceptor improvements, designed by HDR, have been scheduled for construction beginning in 2018. The improvements include upgrading a portion of the interceptor from 42-inches to 54-inches. Since the improvements will be in place in the near future, they were included in the updated model. The drawing used to update the model is provided in Appendix C.

2.1.3 Bypass Closures

JCW has had an ongoing annual bypass monitoring program since 2007 in order to actively monitor the bypass sites and determine which, if any, can be closed. As a part of the program, GBA submits annual

reports summarizing the data collected for that year and documenting when bypass sites are removed or plugged. The most recent report is the *2017 Annual Bypass Manhole Depth Monitoring Draft Report*.

The most recent Mission Main model network, *MTM1_ES_Calibrated_W/RTCControl_Nov2016*, contained seven (7) active bypass sites. As indicated in Appendix B of the *2017 Annual Bypass Manhole Depth Monitoring Draft Report*, bypass sites 3, 4, and 8 were plugged in 2013. As of 2018, there are only four (4) remaining active bypass sites. Table 1 indicates which bypass sites are still active and have been included in the model.

Table 1: Bypass Site Status

Bypass Site ID	Associated Facility	Status of Bypass Model as Received by HDR (2016)	Status of Bypass HDR Model Update (2018)
3	-	Active	Plugged (2013)
4	Between Martway Holding Station and Rock Creek Pump Station	Active	Plugged (2013)
8	-	Active	Plugged (2013)
12	Brush Creek Pump Station	Active	Active
13	-	Active	Active
22	Belinder Holding Station	Active	Active
23B	Martway Holding Station	Active	Active

2.1.4 Roughness Coefficients

Manning's roughness coefficients (n values) typically correspond with the pipe material type. The original models had multiple n values for different pipes of the same material. These variations were applied in the past in order to calibrate to flow depth data. A global update of n values was performed according to material type for purpose of uniformity. The plastic materials, HDPE and PVC, were assigned an n value of 0.011, while all other materials were assigned an n value of 0.013. The original and updated n values are shown in Table 2. A verification run was performed which confirmed that the updated values did not change the flow calibration.

Table 2: Manning's Roughness Coefficients

Pipe Material	Original SMTC Manning's n	Original MTM1 Manning's n	Updated Manning's n
CIP	0.013 / 0.015	0.013	0.013
CIPP	--	0.012	0.013
DIP	0.013 / 0.015	0.013	0.013
HDPE	--	0.014	0.011
PVC	0.013 / 0.015	0.012 / 0.013	0.011
RCP	0.013	0.013	0.013
VCP	0.013 / 0.015	0.013	0.013
UNKN	0.013 / 0.015	0.013	0.013

2.2 Pump Station and PEFTF Updates

The modeled configuration of each major pump station and PEFTF was reviewed and revised as necessary. Pump curves for each facility were updated based on information provided by JCW, presented in Appendix E of the *Nelson Complex WWTF Improvement Facility Plan Technical Memorandum #1 Basis of Analysis,* April 2018. Typical pump operating schemes and pump set points were confirmed during facility site visits performed on March 28-29, 2018.

From recent capacity testing and discussion with JCW staff, it was determined that Turkey Creek PS, Rock Creek PS, and the Belinder PEFTF can all pump greater than their stated capacities. The stated and tested capacities for all major facilities is provided in Table 3. In the optimization process, pump upgrades will only become required after exceeding the tested capacities during the selected design storm. At the point where upgrades are necessary, the pump station will be sized adequately for the required firm capacity.

Table 3: Stated and Tested Facility Capacities

PEFTFs				
	Stated Firm Capacity (MGD)	**Tested Firm Capacity (MGD)**	**Stated Total Capacity (MGD)**	**Tested Total Capacity (MGD)**
75th/Nall PEFTF	10	-	20	-
Martway PEFTF	10	-	20	-
Belinder PEFTF	21	-	42	50
Turkey Creek PEFTF	11	-	22	-
Pump Stations				
	Stated Firm Capacity (MGD)	**Tested Firm Capacity (MGD)**	**Stated Total Capacity (MGD)**	**Tested Total Capacity (MGD)**
Brush Creek PS	5.5	-	5.5	-
Rock Creek PS	12	14.4	16	-
Belinder PS	10.6	-	13	-
Turkey Creek PS	27[1]	-	27	33

[1] Currently limited to approximately 21 MGD due to hydraulic restrictions at the Nelson Complex

Specific facility configurations, capacities, operations, and controls are described in more detail in the following sub-sections. The existing (2016) and updated model configuration for each facility is provided in Appendix D.

2.2.1 75th/Nall PEFTF and Brush Creek Pump Station

During normal operation, flow is routed to Brush Creek Pump Station where it is pumped to Rock Creek Pump Station and pumped again to the Nelson Complex. During wet weather, flow can be diverted to the PEFTF at 75th/Nall to relieve the pump station. The diversion of flow into the PEFTF is controlled by sluice gates and a weir.

The sluice gate controls at 75th/Nall were confirmed with the control logic programmer, R.E. Pedrotti. The gate to the PEFTF is manually operated and is left open by default; a weir prevents flow going to the PEFTF during normal operation. During dry weather conditions, the gate to Brush Creek is open. Flow

bypasses the PEFTF and continues to Brush Creek. During wet weather, the gate to Brush Creek will close to direct flow to the PEFTF. When the Brush Creek wet well level reaches 9.75', the gate to Brush Creek is forced to close without the delay timing positioning time cycle. The gate closes within 5 minutes. The gate remains fully closed until the Brush Creek wet well level falls below 9.25', at which point the gate opens at a rate of 1% every 3 seconds. The gate continues to open until either the Brush Creek wet well level rises above 9.25' or the gate is fully opened.

The existing conditions model results show that the current gate controls allow the sluice gate to Brush Creek to cycle open and closed frequently during wet weather events. The gate controls will be studied in more detail for near-term operational improvements. Recommended improvements may include changes to the gate control scheme.

The 75th/Nall PEFTF pumps have a stated total capacity of 20 MGD but are currently only able to convey approximately 13 MGD. It is anticipated that replacement pumps (specified in MTM Contract 74) will restore the total capacity to 20 MGD. Optimization scenarios including the PEFTFs will assume that the 75th/Nall PEFTF can pump up to the total capacity of 20 MGD.

2.2.2 Martway PEFTF and Rock Creek Pump Station

During normal operation, flow is routed to Rock Creek Pump Station where it is pumped to the Nelson Complex. During wet weather, flow can be diverted to the PEFTF at Martway to relieve the pump station. The diversion of flow into the PEFTF is controlled by sluice gates and a weir.

The sluice gate controls at Martway were confirmed with the control logic programmer, R.E. Pedrotti. The gate to the PEFTF is manually operated and is left open by default. During dry weather conditions, the gate to Rock Creek is open. Flow bypasses the PEFTF and continues to Rock Creek. During wet weather, the gate to Rock Creek will close to direct flow to the PEFTF. When the Rock Creek wet well level reaches 9.75', the gate to Rock Creek is forced to close without the delay timing positioning time cycle. The gate closes within 5 minutes. The gate remains fully closed until the Rock Creek wet well level falls below 9.25', at which point the gate opens at a rate of 1% every 3 seconds. The gate continues to open until either the Rock Creek wet well level rises above 9.25' or the gate is fully opened.

The existing conditions model results show that the current gate controls allow the sluice gate to Rock Creek to cycle open and closed frequently during wet weather events. The gate controls will be studied in more detail for near-term operational improvements. Recommended improvements may include changes to the gate control scheme.

The Martway PEFTF pumps have a stated total capacity of 20 MGD but are currently only able to convey approximately 16 MGD. It is anticipated that pump repairs (specified in MTM Contract 74) will restore the PEFTF capacity to 20 MGD. Optimization scenarios including the PEFTFs will assume that the Martway PEFTF can pump up to the total capacity of 20 MGD.

The Rock Creek Pump Station has a stated firm capacity of 12 MGD with three (3) pumps running. Recent testing has shown a higher firm capacity of 14.4 MGD with three (3) pumps running. During optimization, the pump station will be allowed to pump up to the tested firm capacity of 14.4 MGD before an upgrade is required.

2.2.3 Belinder PEFTF and Pump Station

During normal operation, flow is routed to Belinder Pump Station where it is pumped to the Nelson Complex. During wet weather, flow can be diverted to the Belinder PEFTF to relieve the pump station. The diversion of flow into the wet weather PEFTF pump station is controlled by a weir.

JCW staff has noted that while the Belinder PEFTF has a stated capacity of 42 MGD, it has at times pumped 50 MGD or more. Optimization scenarios including the PEFTFs will assume that the Belinder PEFTF can pump up to a total capacity of approximately 50 MGD.

2.2.4 Turkey Creek PEFTF and Pump Station

During normal operation, flow is routed to Turkey Creek Pump Station where it is pumped to the Nelson Complex. During wet weather, flow can be diverted to the Turkey Creek PEFTF to relieve the pump station. The diversion of flow into the wet weather PEFTF pump station is controlled by a weir.

The Turkey Creek Pump Station has a stated total capacity of 27 MGD, however recent testing has shown that the station can pump up to 33 MGD. Currently, the pump station is limited to approximately 21 MGD due to hydraulic restrictions at the Nelson Complex. During optimization, the pump station will be allowed to pump up to the tested total capacity of 33 MGD before an upgrade is required.

3 Modeled System Performance

3.1 Existing Conditions

The updated Capacity Assessment/Optimization models were used to evaluate existing system capacity during the 1-year, 5-year, and 10-year design storms. The model results identified areas of overcapacity pipes and areas of manhole flooding. Manholes were typically designated as Stored for the purpose of this analysis. Results are presented in Table 4 as a percentage of the total system. Results are also shown graphically in Figure 1 (1 Year), Figure 2 (5 Year), and Figure 3 (10 Year).

Table 4: Existing Conditions Gravity Network Modeled Results

Category	1-Year Event	5-Year Event	10-Year Event
% of Manholes Flooded	0.04%	0.7%	1.8%
% of Overcapacity Pipes	2.2%	5.7%	7.3%
% of Pipes Surcharged Due to Conditions Downstream	3.5%	10.3%	13.4%

An indicator of system capacity is whether the PEFTFs activate during a storm event. The model indicates that all of the PEFTFs activate during the 1-year event as presented in Table 5.

Table 5: Existing Conditions PEFTF Activation Results

Facility	1-Year Event		5-Year Event		10-Year Event	
	Max Overflow (MGD)	Overflow Volume (MG)	Max Overflow (MGD)	Overflow Volume (MG)	Max Overflow (MGD)	Overflow Volume (MG)
Turkey Creek PEFTF	22.0	6.9	22.0	15.0	22.0	19.9
75th / Nall PEFTF	17.9	2.0	20.0	4.7	20.0	6.4
Martway PEFTF	10.0	1.6	17.2	3.8	17.5	4.9
Belinder PEFTF	33.2	10.6	48.0	18.6	53.4	23.4

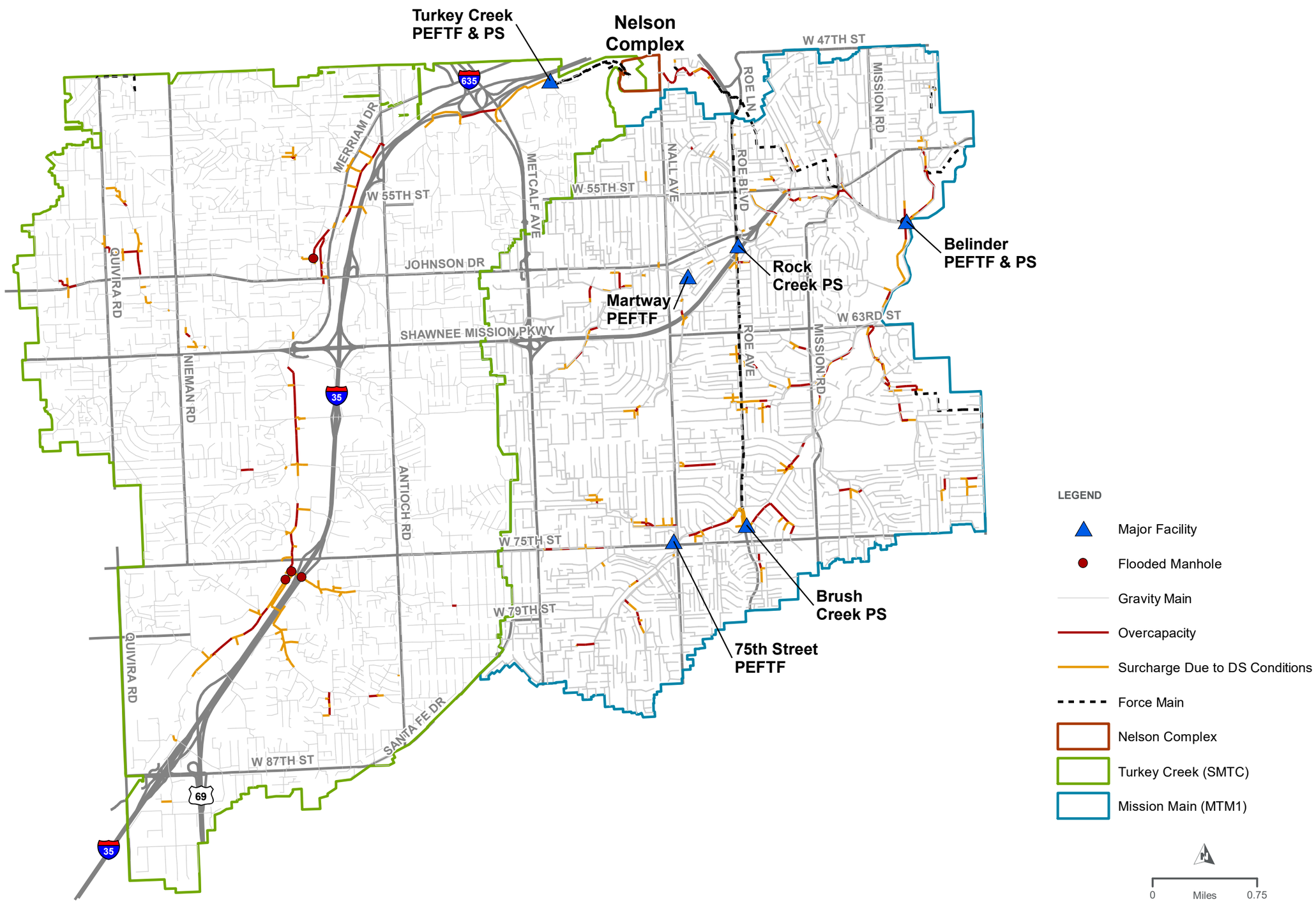

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FIGURE 1
MODELED EXISTING CONDITIONS
DESIGN STORM RESULTS: 1 YR, 24 HR

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN

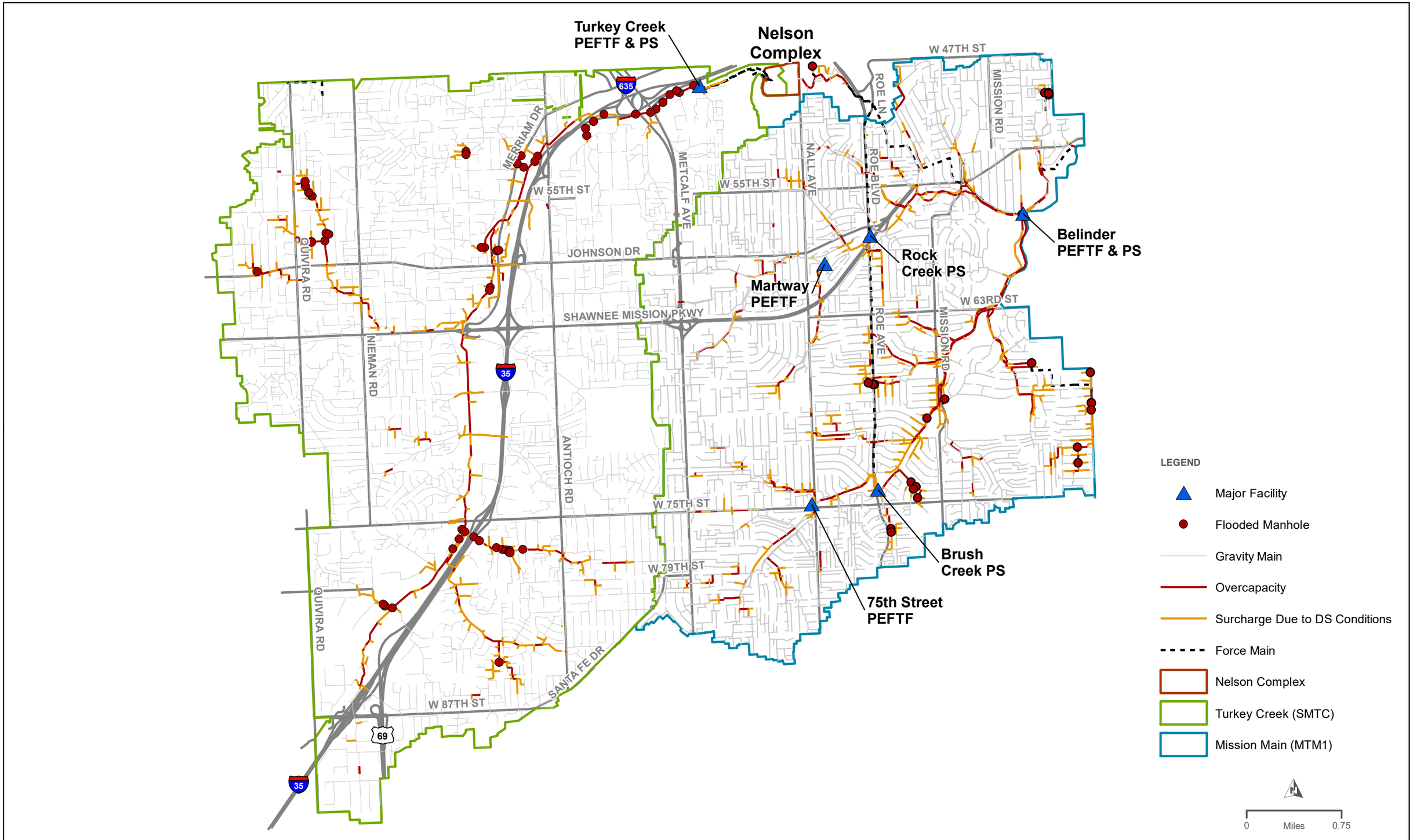

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FIGURE 2
MODELED EXISTING CONDITIONS
DESIGN STORM RESULTS: 5 YR, 24 HR

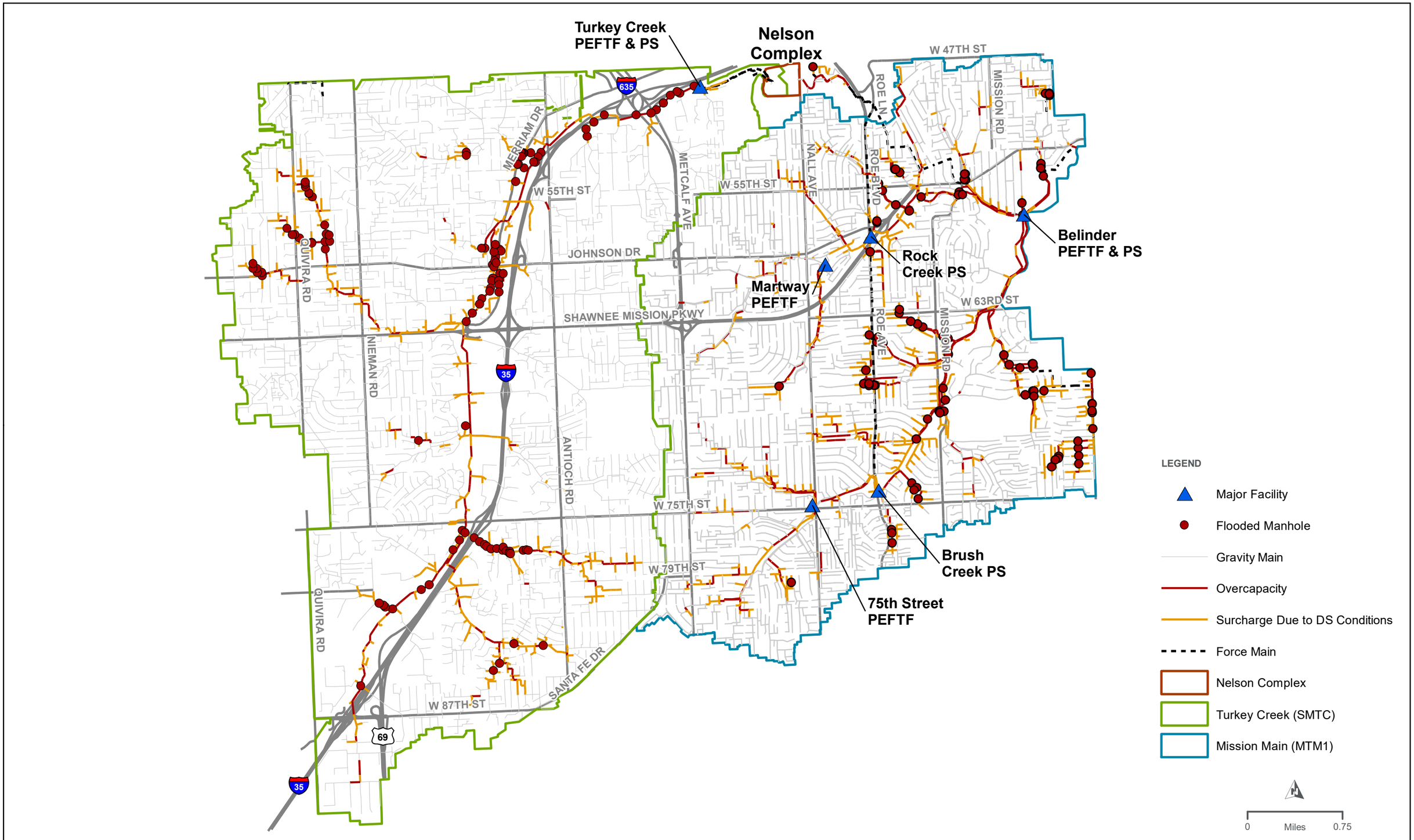

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FIGURE 3
MODELED EXISTING CONDITIONS
DESIGN STORM RESULTS: 10 YR, 24 HR

3.2 Unrestricted Conditions

An approximation of the existing unrestricted flow from the collection system tributary to each satellite facility was modeled. Existing unrestricted flow is the flow that would occur if there was no upstream flow reduction (storage or I/I removal) and the pipes were of sufficient size to convey all flows to the facility without any surcharging or overflows. Resulting instantaneous unrestricted peak flows for the 10-year, 24-hour event are presented in Table 6 and shown schematically in Figure 4.

Table 6: Instantaneous Peak Unrestricted Flows (10 YR, 24 HR Storm Event)

Reach/Item	Description	Flow (MGD)
Brush Creek Pump Station Service Area		
1	US of 75th & Nall	20
2	DS of 75th & Nall and US of Brush Creek	7
3	Total, Brush Creek Pump Station Service Area	27
Rock Creek Pump Station Service Area		
4	US of Martway	17
5	DS of Martway and US of Rock Creek	16
6	To Rock Creek from South	1
7	Total, Rock Creek Pump Station Service Area	34
8	Total, Rock Creek and Brush Creek PS Service Areas	61
Belinder Pump Station Service Area		
9	DS of Brush Creek and US of Belinder	45
10	DS of Rock Creek and US of Belinder	24
11	To Belinder from North	8
12	Total, Belinder Pump Station Service Area	77
13	**Total, Mission Main Service Area**	**138**
14	**Total, Turkey Creek Service Area**	**70**
15	Total, Roeland Park Service Area	1
15	**Nelson Complex Total**	**209**

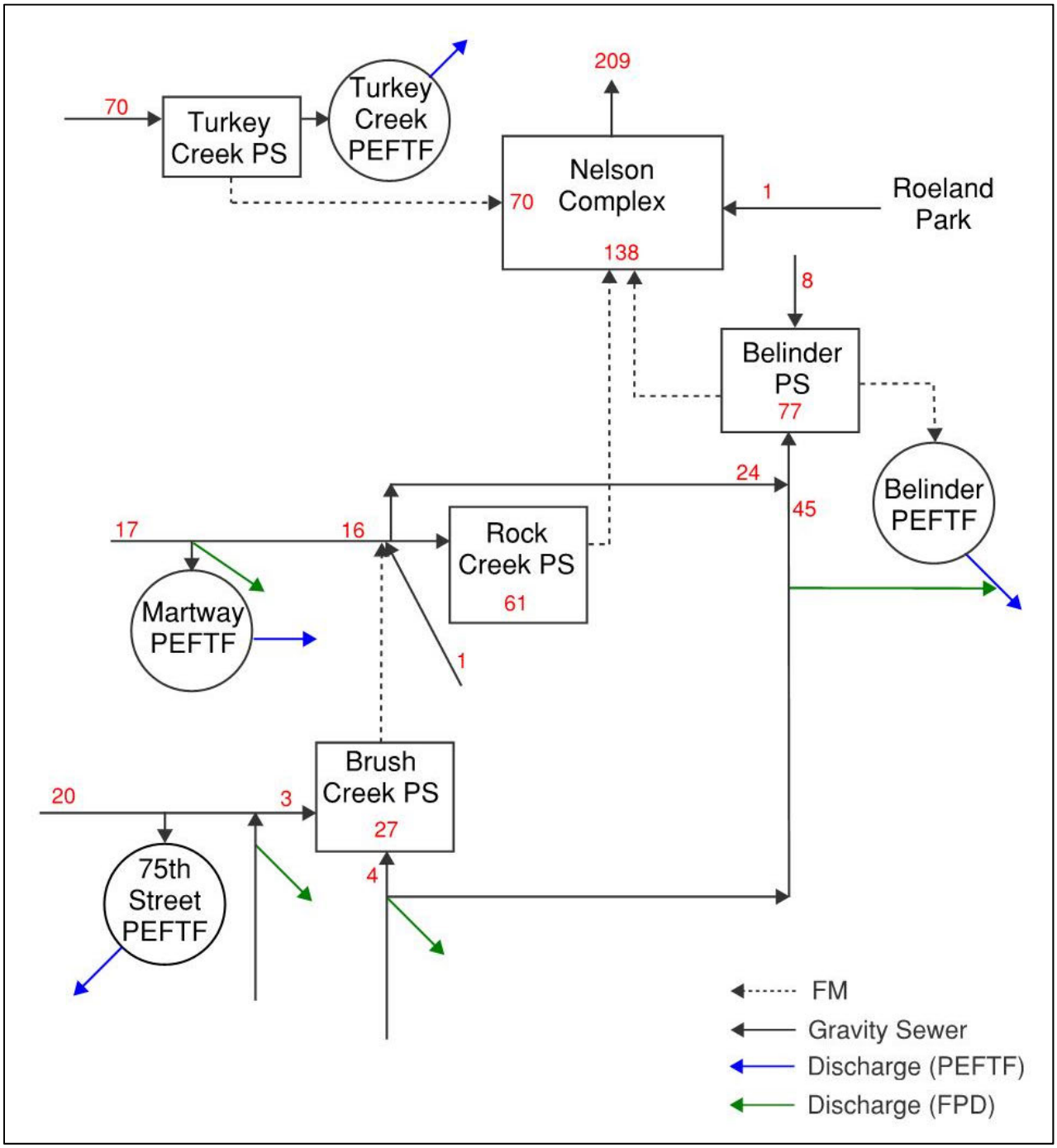

Figure 4: Instantaneous Peak Unrestricted Flows (10 YR, 24 HR Storm Event)

The unrestricted flow model, which was prepared for the 10-year unrestricted flows, was then used to approximate unrestricted peak flows for the 5-year and 1-year events. The unrestricted peak flows were compared to the current capacity of each major pump station to gain an understanding of the magnitude of unrestricted flows. This flow comparison is presented in Table 7.

Table 7: Instantaneous Peak Unrestricted Flows to Major Pump Stations

Description	Peak Flow (MGD)				
	1 YR, Unrestricted	5 YR, Unrestricted	10 YR, Unrestricted	Current Total Capacity	Current Firm Capacity
Total to Brush Creek Pump Station	16	23	27	5.5	5.5
US of Rock Creek Pump Station	22	31	34	-	-
Total to Rock Creek Pump Station	38	54	61	16	12
Total to Belinder Pump Station	46	68	77	13	10.6
Total to Turkey Creek Pump Station	47	65	70	27	27

4 Model Conversion for Optimization

The Nelson Complex has been divided into two calibrated network models (Turkey Creek and Mission Main) modelled in InfoWorks ICM. The optimization is run using EPA SWMM Version 5.1 which required both InfoWorks models to be converted to SWMM, trimmed and combined to create one Nelson Complex SWMM model.

4.1 Model Conversion Process

The two calibrated InfoWorks ICM models provided by HDR were exported to SWMM 5.1 format and the hydrologic components (e.g. DWF, infiltration, hydrographs, sub catchments, etc.) were removed. Inflows were exported from ICM as time series and imported into the converted SWMM models to replicate network flows.

The EPA SWMM hydraulic models were then trimmed to only include elements downstream of capacity deficiencies based on the 10-yr design storm flows (i.e. the trimmed model includes all sewer mains that require improvements in the worst-case design scenario irrespective of pipe size). Upstream sections of the model were removed and replaced with time series boundary conditions created from the detailed model link discharge hydrographs immediately upstream of the point of truncation.

4.2 Validation of SWMM Results

Upon completion of the conversion and trimming process, network inflows and outflows were compared for both models to validate total flow volume in the models. Conveyance improvements and unconstrained pumps were included to address network deficiencies under the 10-yr design storm and ensure the comparison between the InfoWorks ICM and EPA SWMM models was not impacted by loss of flows due to flooding in the network. The InfoWorks model results are compared to the EPA SWMM trimmed model results in Table 8. The validation results are shown graphically at several key points in the system in Figure 5 through Figure 8.

Table 8: InfoWorks ICM to EPA SWMM Model Conversion Results

Network Model	Flow Type	Total Volume (MG)		Difference (%)
		EPA SWMM	InfoWorks ICM	
Turkey Creek	Inflow	71.21	71.20	-0.02%
	Outflow	70.99	69.97	-1.44%
Mission Main	Inflow	79.93	79.82	-0.13%
	Outflow	79.83	79.32	-0.64%

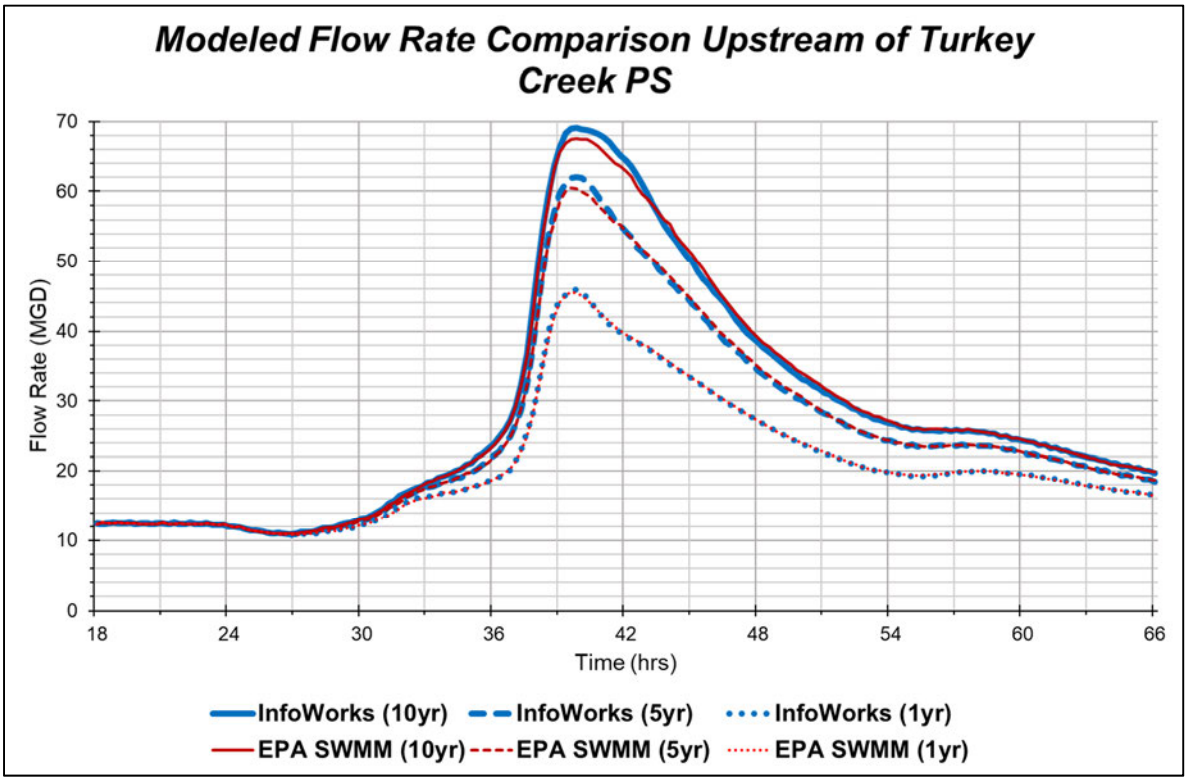

Figure 5: Comparison of Discharge Hydrographs at Turkey Creek Pump Station

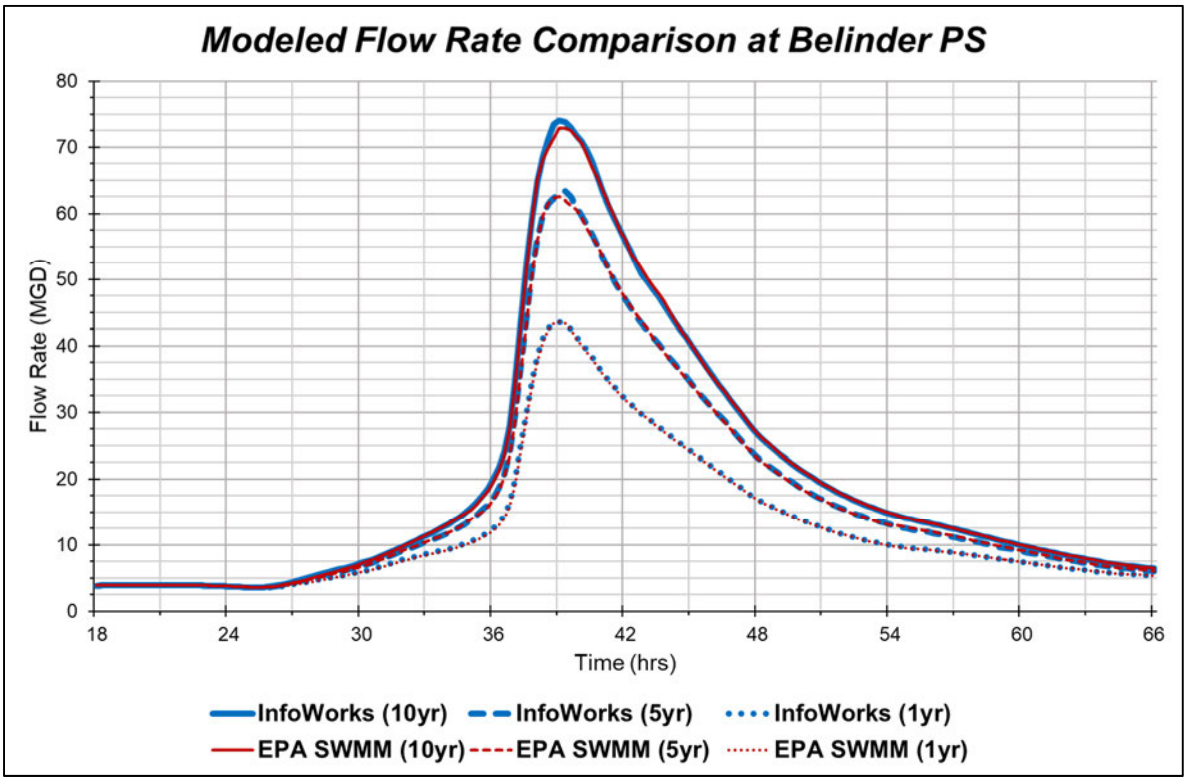

Figure 6: Comparison of Discharge Hydrographs at Belinder Pump Station

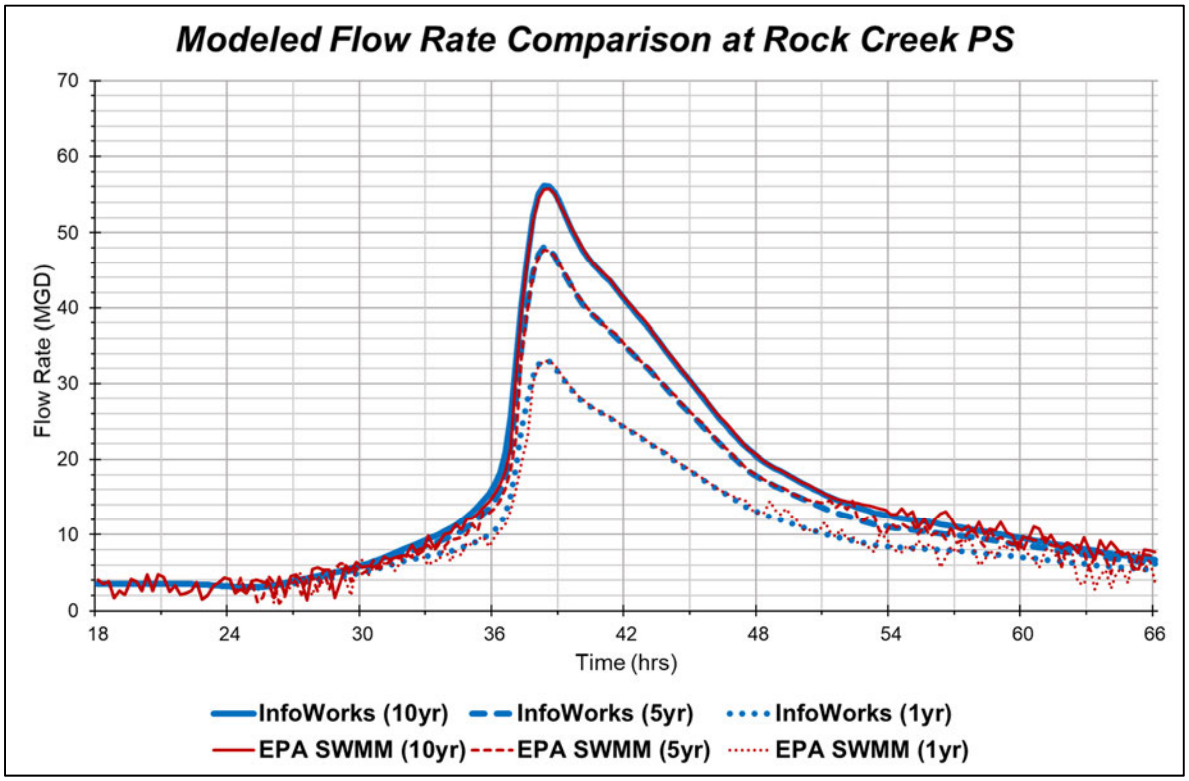

Figure 7: Comparison of Discharge Hydrographs at Rock Creek Pump Station

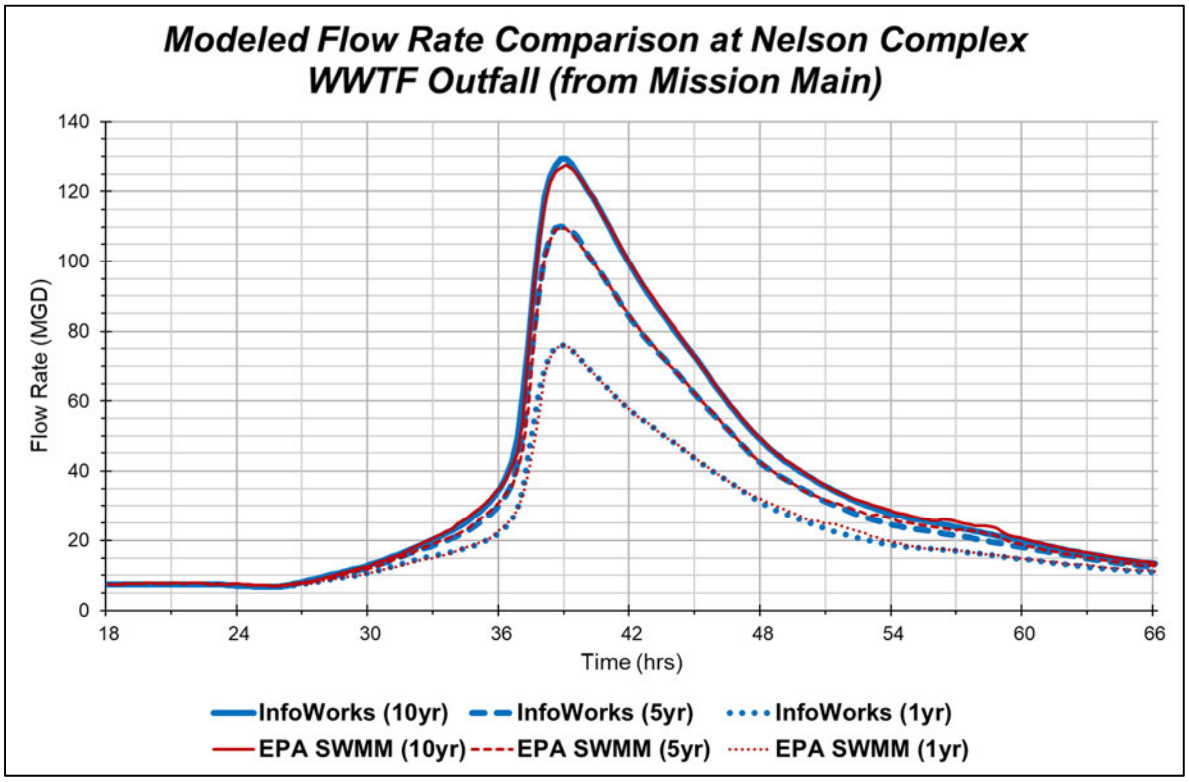

Figure 8: Comparison of Discharge Hydrographs at Nelson WWTP (Mission Main)

4.3 Summary of SWMM Modifications

Several modifications were required in the EPA SWMM models due to differences in the capabilities of the software modeling engines as well as for optimization purposes. The following is a summary of these amendments:

- EPA SWMM is sensitive to short length pipes which can result in model continuity errors. For this reason, a minimum length of 20 ft has been adopted for all conduits modelled;
- There were several instances where manhole invert levels were below the upstream conduit outlet elevation and the downstream conduit inlet elevation. This can result in continuity errors and at a minimum excess storage so in these instances, node invert levels have been raised to match the downstream pipe inlet elevation;
- Real time controls for pump operation were removed and all pumps were modelled as variable speed in-line pumps where flow varies continuously with inlet node depth up to a specified maximum capacity; and
- Force mains were removed from the models and the upgrade design criteria and associated costs have been built directly into the formulation of pump and PEFTF upgrade costs.

The modifications should not significantly impact the capacity of the hydraulic models and were primarily adopted to reduce continuity errors and improve the optimization formulation. Proposed improvement alternatives were remodeled in the original calibrated InfoWorks ICM model to ensure that hydraulic deficiencies were resolved in both models.

5 Long-Term Model Calibration

In addition to the Capacity Assessment/Optimization model, HDR developed a closely related Long-Term Simulation model. The calibration parameters of the Capacity Assessment/Optimization model were adequately estimating peak inflows, but may under-estimate infiltration during long-term simulations. The calibration was reviewed and modified as necessary to more accurately estimate flows for long-term simulations.

5.1 Hydraulic Model Context

The Turkey Creek and Mission Main InfoWorks hydraulic models were updated by CH2M HILL in 2011, documented in a previous technical memorandum (*Technical Memorandum #2: Inventory Verification, Hydraulic Model Development, and Model Calibration,* August 2011). At this time, the model was calibrated using flow monitoring data collected in 2009 and 2010.

The models were updated again by CH2M HILL in 2016, at which time the hydrology methodology was updated from the Wallingford method to the RTK method (*RTK Flow Analysis and Hydraulic Model Update: DRAFT TM Kp Selection Methodology Follow-up*, August 2016).

HDR received the 2016 models for use in this study. The model networks used are documented in Section 1.3 of this TM.

5.2 Long-Term Hydraulic Model Calibration Update

HDR reviewed the 2016 model calibration and compared the long-term simulation results to the available flow monitoring data from 2009 and 2010. Generally, the RTK method calibration was adequately predicting inflows for discrete rainfall events. However, this method was not accurately predicting the long periods of infiltration following rainfall that occur in these basins. It was particularly under-predicting flows during wet antecedent conditions and for back-to-back rainfall events. The long infiltration tails observed in the flow data are indicative of saturated soils and/or groundwater influence, likely due to a raised groundwater table.

ICM includes a groundwater infiltration (GWI) module to complement some of the hydrology methods included in the software. However, GWI cannot be implemented with the RTK method in the current version of ICM, so to implement GWI, the hydrology method was changed from RTK to Wallingford. The Wallingford method, in conjunction with the GWI module, was found to better account for seasonal variation and elongated tails during periods of saturated soils and/or groundwater influence. These calibration updates resulted in a better representation of conditions throughout the year, and therefore the model more accurately predicted flows in the system during long-term, year-long simulations.

The results of these long-term simulations were used as input to the water quality model, described in TM 5.

Appendix A References

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Appendix B Gravity Network Updates

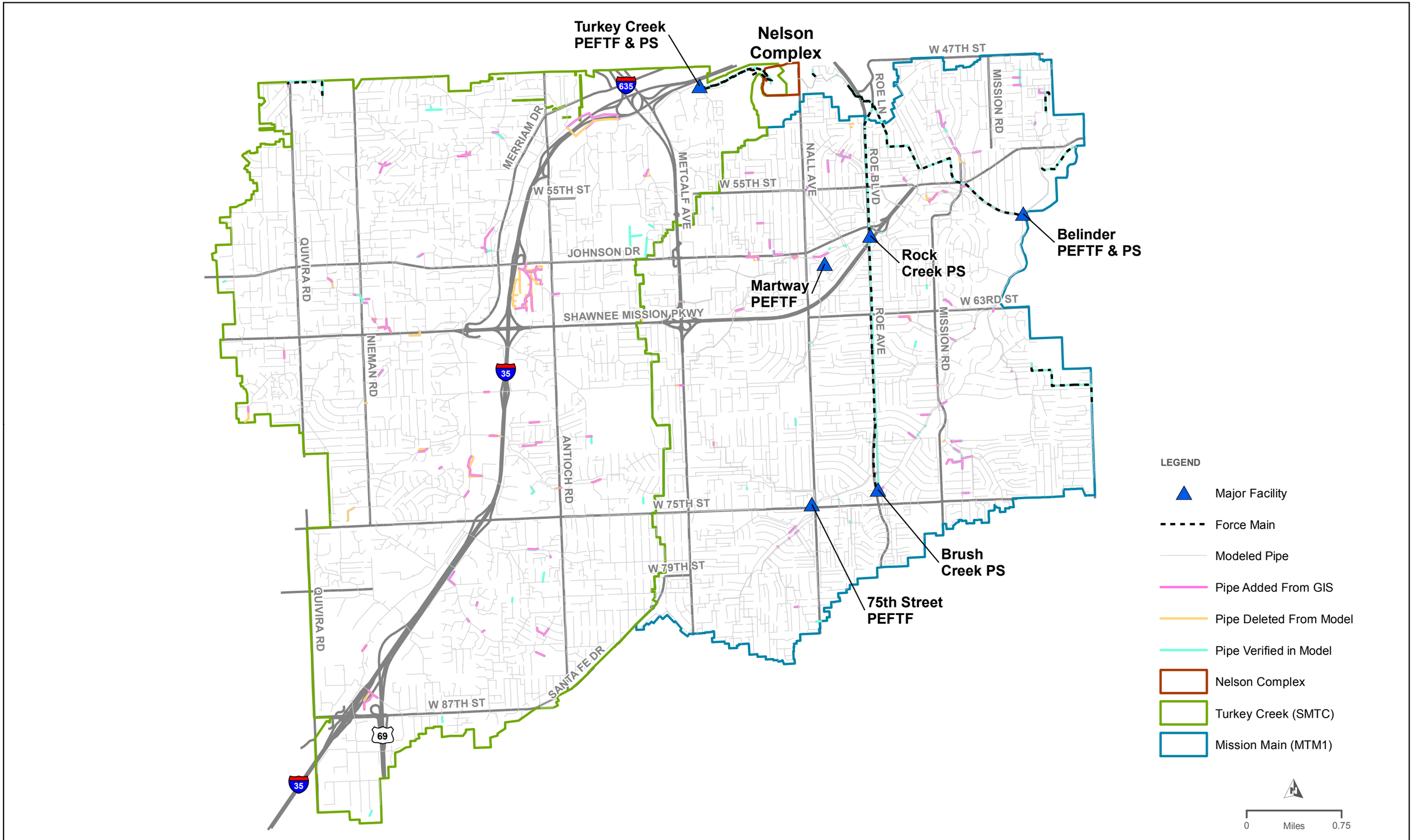

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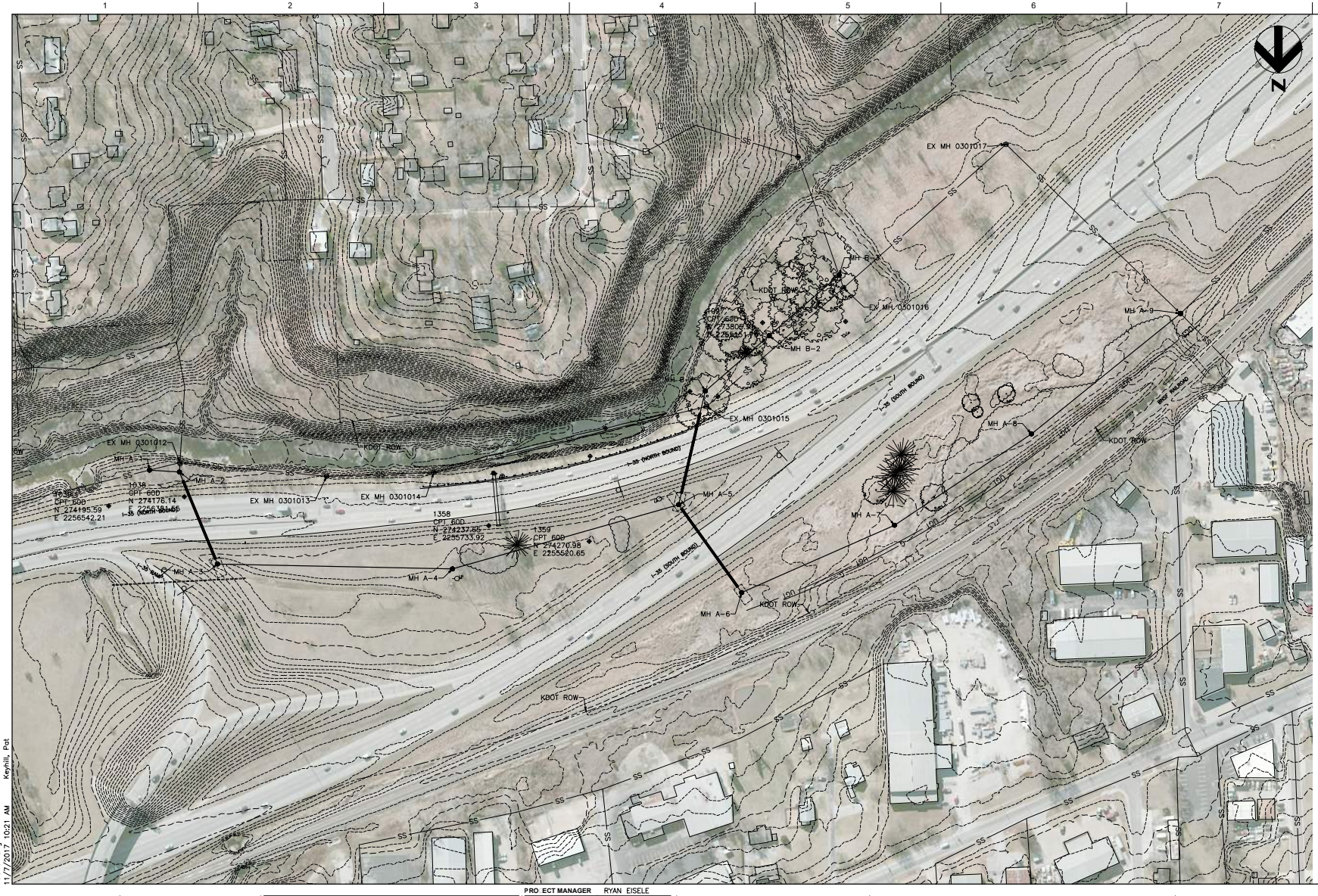
FIGURE A-1
GRAVITY NETWORK UPDATE AND VERIFICATION LOCATIONS

Appendix C Turkey Creek Interceptor Improvements



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11/7/2017 10:21 AM Keyhill, Pat

HDR

HDR
MISSOURI CERTIFICATE OF
AUTHORITY □ 000856

3741 NE TROON DRIVE
LEE'S SUMMIT, MO 64064
816-347-1100

ISSUE	DATE	DESCRIPTION
1	11-07-17	PRELIMINARY JCW/KDOT REVIEW PLANS

PRO ECT MANAGER	RYAN EISELE
PRO ECT NUMBER	10075062

PRELIMINARY
NOT FOR CONSTRUCTION

ELECTRONIC SEAL □ SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT

11/07/2017

JOHNSON COUNTY KANSAS
Wastewater

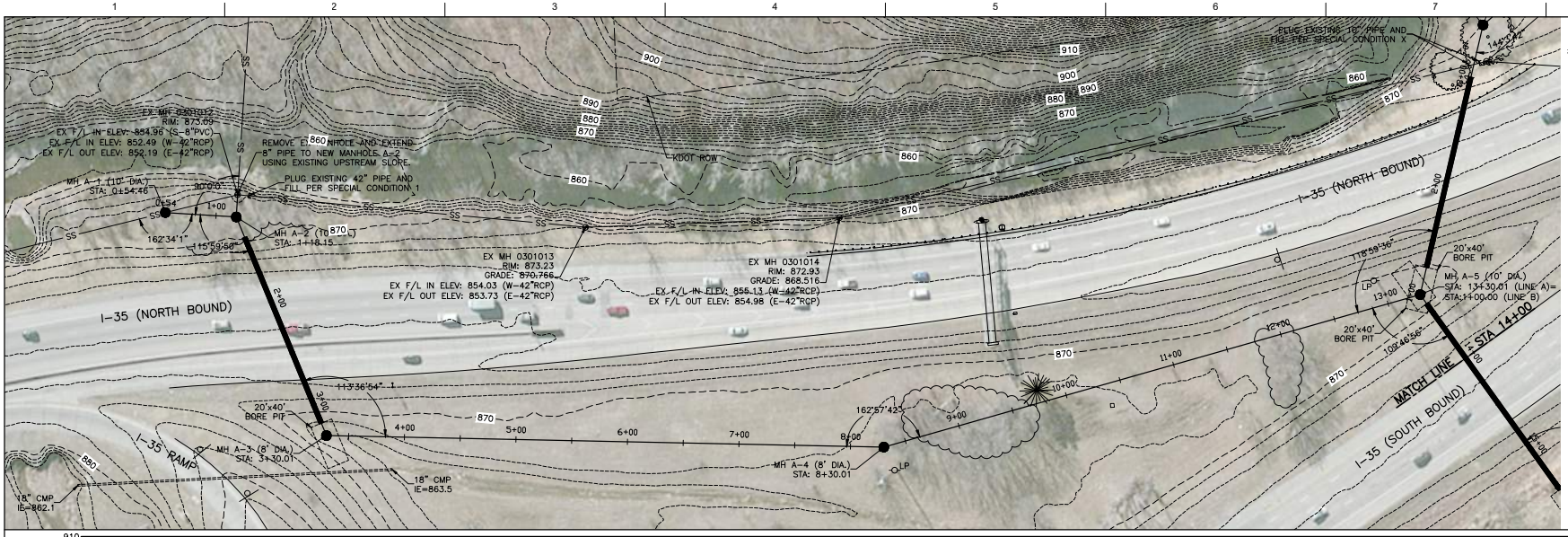
OHNSON COUNTY WASTEWATER
TURKEY CREEK INTERCEPTOR
IMPROVEMENTS CONTRACT NO. 38

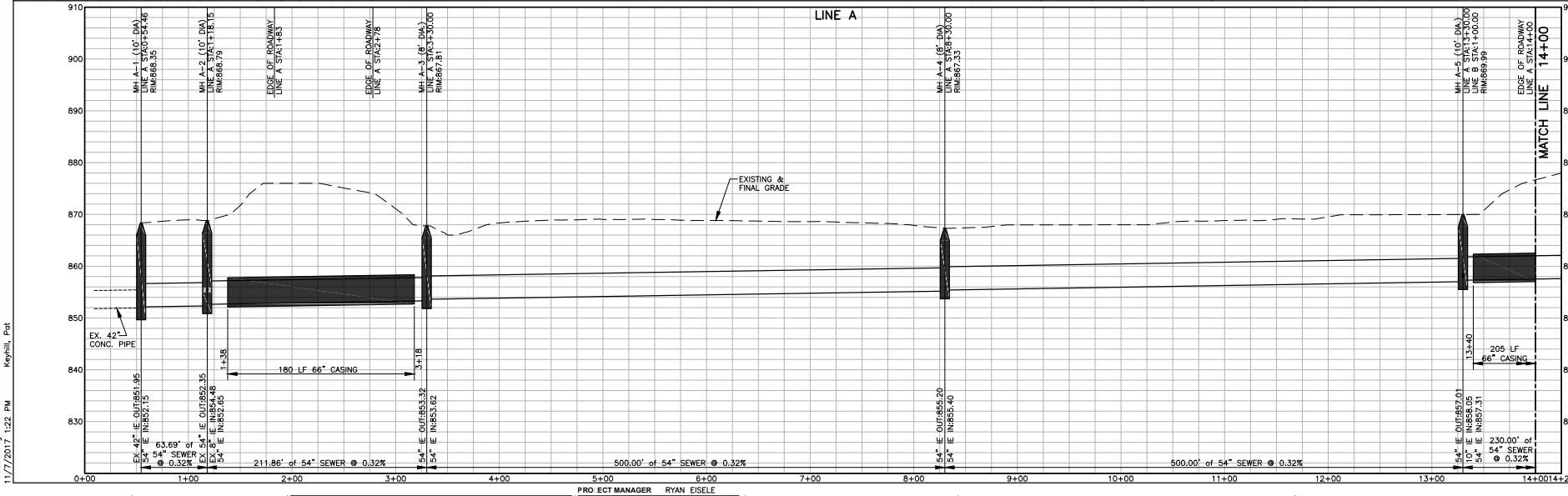
OVERALL SITE PLAN

0 1" 2"

FILENAME 10C101.dwg
SCALE 1" = 80'

SHEET
10C101





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HDR

HDR
MISSOURI CERTIFICATE OF AUTHORITY 000856

3741 NE TROON DRIVE
LEE'S SUMMIT, MO 64064
816-347-1100

ISSUE	DATE	DESCRIPTION
1	11-07-17	PRELIMINARY JCW/KDOT REVIEW PLANS

PROJECT MANAGER	RYAN EISELE
PROJECT NUMBER	10075062

PRELIMINARY
NOT FOR CONSTRUCTION

ELECTRONIC SEAL SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT
11/07/2017

JOHNSON COUNTY KANSAS Wastewater

JOHNSON COUNTY WASTEWATER
TURKEY CREEK INTERCEPTOR
IMPROVEMENTS CONTRACT NO. 38

PLAN AND PROFILE
LINE A
STA 0+54.46 TO STA 14+00.00

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SCALE 1" = 50'

SHEET
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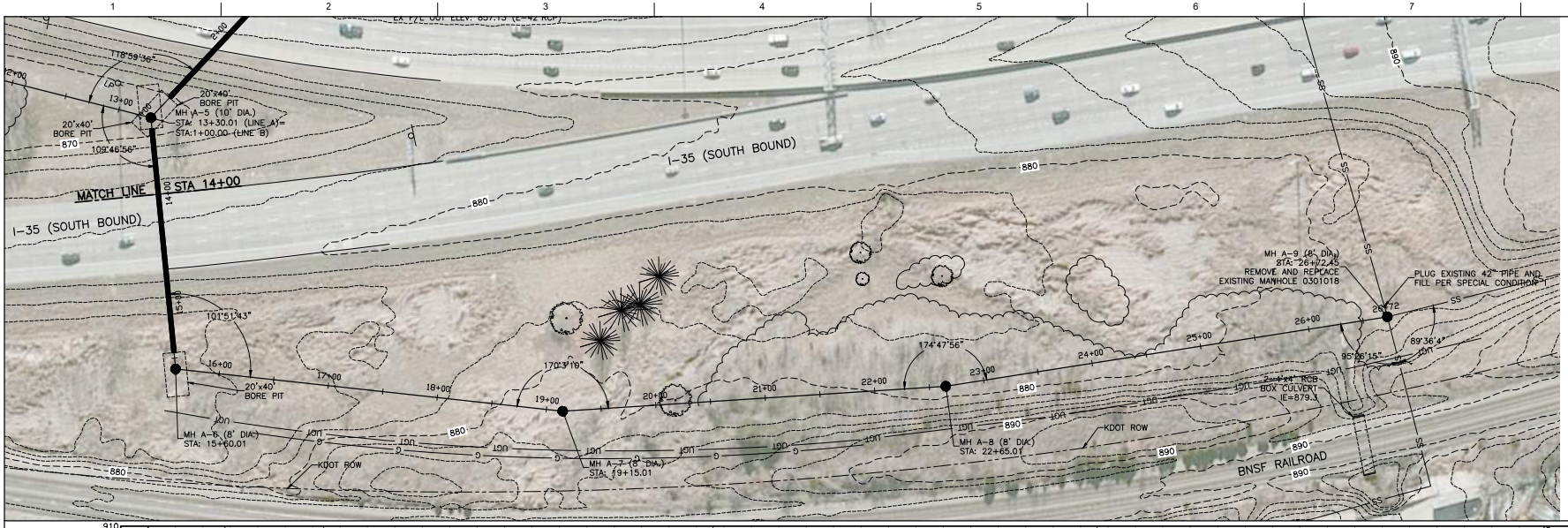

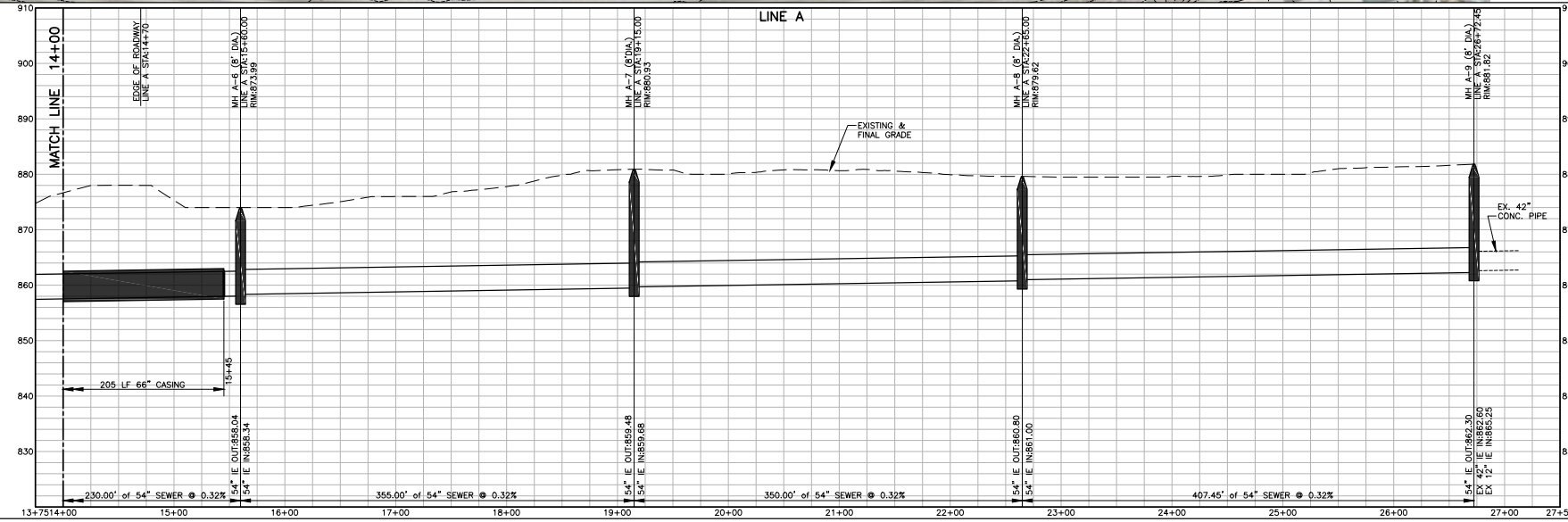

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HDR
MISSOURI CERTIFICATE OF AUTHORITY 000856

3741 NE TROON DRIVE
LEE'S SUMMIT, MO 64064
816-347-1100

ISSUE	DATE	DESCRIPTION
1	11-07-17	PRELIMINARY JCW/KDOT REVIEW PLANS

PROJECT MANAGER	RYAN EISELE
PROJECT NUMBER	10075062

PRELIMINARY
NOT FOR CONSTRUCTION

ELECTRONIC SEAL SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT
11/07/2017

JOHNSON COUNTY KANSAS Wastewater

JOHNSON COUNTY WASTEWATER
TURKEY CREEK INTERCEPTOR
IMPROVEMENTS CONTRACT NO. 38

PLAN AND PROFILE
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SCALE 1" = 50'

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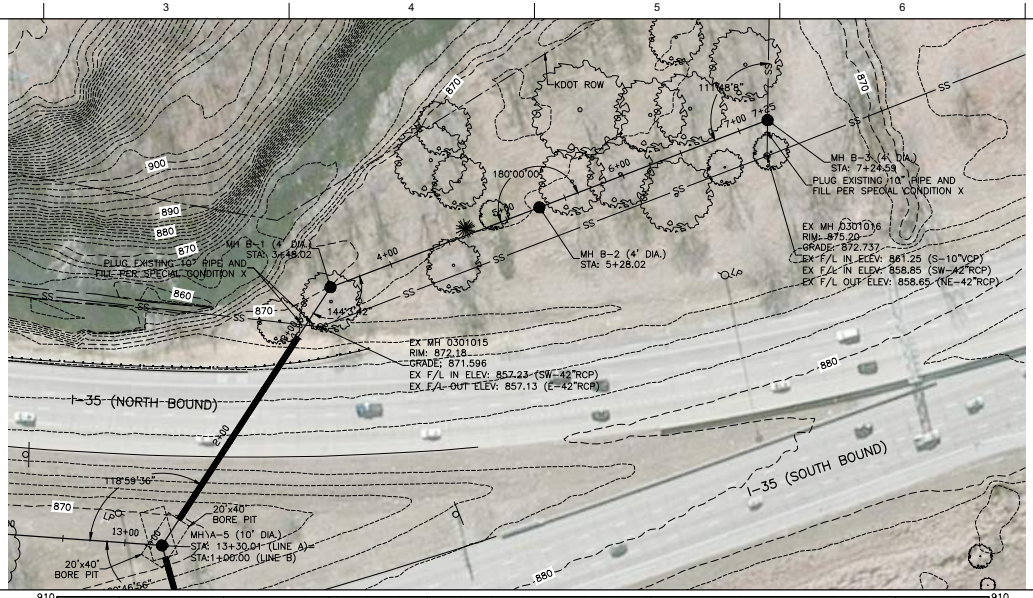

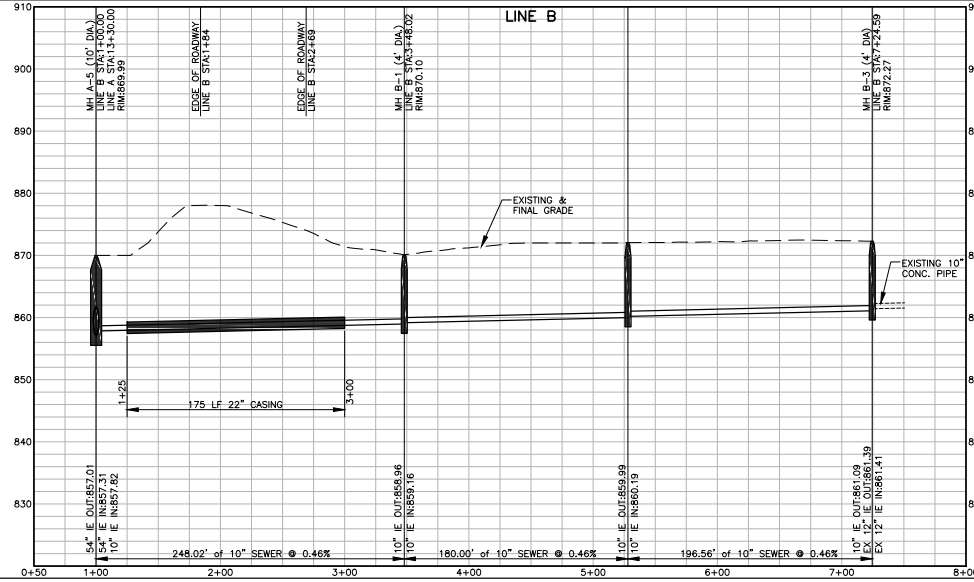

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MISSOURI CERTIFICATE OF AUTHORITY 000856

3741 NE TROON DRIVE
LEE'S SUMMIT, MO 64064
816-347-1100

ISSUE	DATE	DESCRIPTION
1	11-07-17	PRELIMINARY JCW/KDOT REVIEW PLANS

PROJECT MANAGER	RYAN EISELE
PROJECT NUMBER	10075062

PRELIMINARY
NOT FOR CONSTRUCTION

ELECTRONIC SEAL SIGNATURE HAVE BEEN REMOVED. THIS SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT
11/07/2017

JOHNSON COUNTY KANSAS Wastewater

JOHNSON COUNTY WASTEWATER
TURKEY CREEK INTERCEPTOR
IMPROVEMENTS CONTRACT NO. 38

PLAN AND PROFILE
LINE B
STA 1+00.00 TO STA 7+24.59

0 1" 2"

FILENAME 10C803.dwg
SCALE 1" = 50'

SHEET
10C803

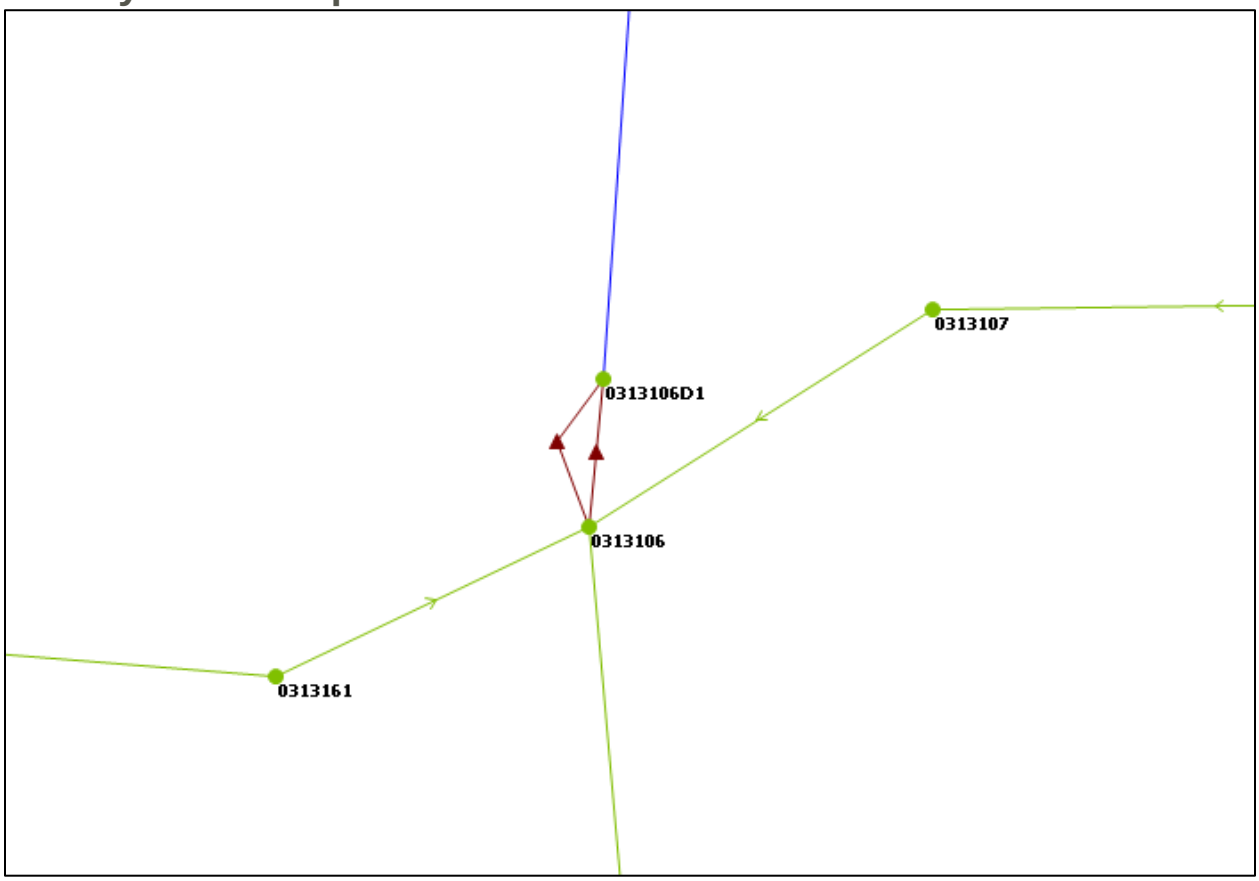
Appendix D Modeled Facility Configurations

Model Received by HDR

Modeled Pump Stations – SMTC

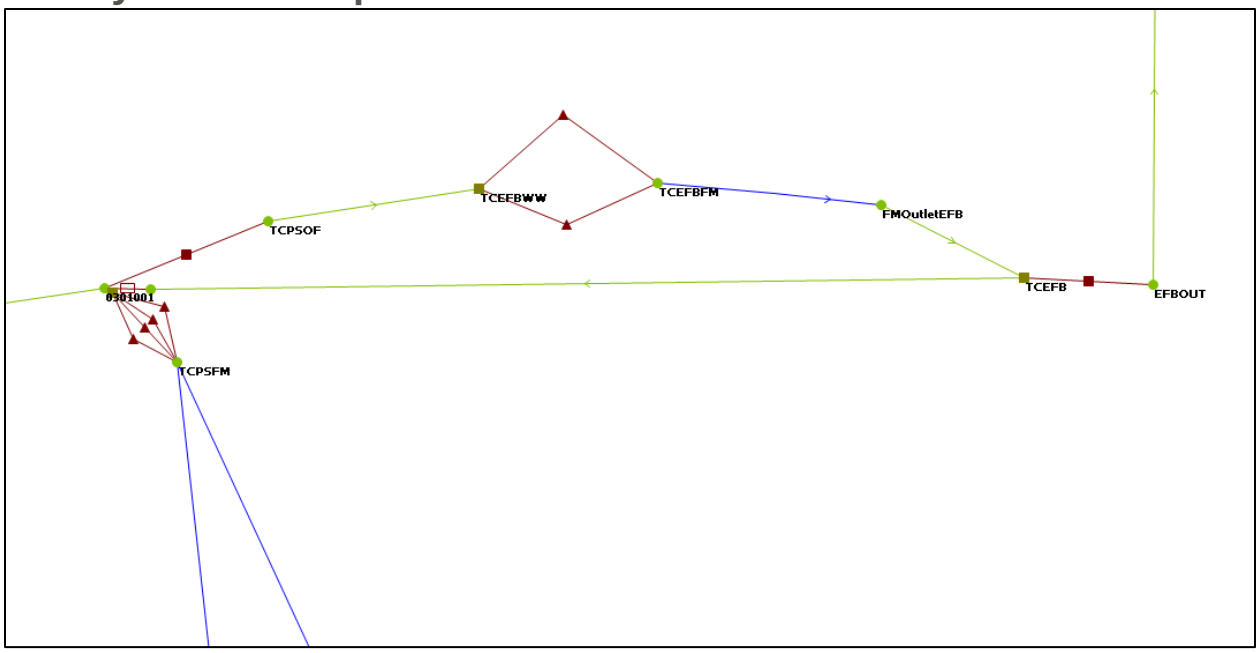
Model Network: *SMTC_ExistingSystem_CalibratedNov2016_2016RTKUpdate_TCUpdate*

County Line Pump Station



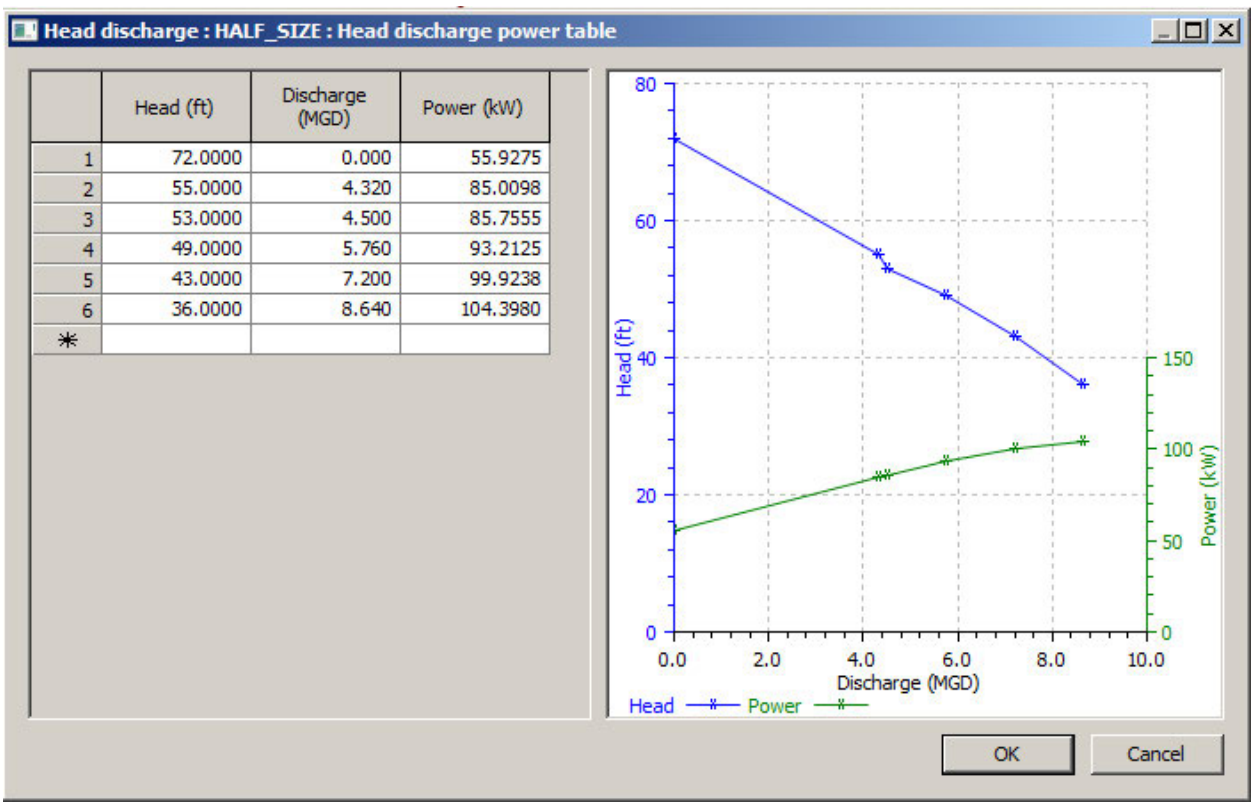
Parameter	Quantity	Notes
Wet Well Volume (gal)	7,500	Approx. volume to lowest invert of connecting pipe
Wet Well Floor Elevation (ft)	961.552	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 0.43 mgd P2: 0.43 mgd	
Pump Controls (on/off)	P1: 965.33 / 961.88 P2: 965.58 / 961.88	

Turkey Creek Pump Station & PEFTF



Parameter	Quantity	Notes
Turkey Creek Pump Station		
Wet Well Volume (gal) (TCPSWW)	97,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	826.00	
# of Pumps	4	All modeled as constant speed
Pump Capacity	P1: HALF_SIZE P2: PUMP 2&3 P3: PUMP 2&3 P4: SMALLER	See curves
Pump Controls (on/off)	P1: 834.5 / 832.5 P2: 836.5 / 834.5 P3: 845.0 / 844.5 P4: 835.5 / 833.0	Pump #1 -- NOT USED, Not Operable since Jan. 1994) Pump #2 -- Constant Speed Pump, 300hp, 10500gpm, centrifugal pumps Pump #3 -- Variable Speed Pump, 10300gpm (not set up in model this way) Pump #4 -- Variable Speed, 10500 gpm (not set up in model this way) Pump #3 & #4 alternate pumping cycles during dry weather conditions
Weir Elevation to PEFTF (0301001.3)	839.00	Width = 15.5 ft; Coefficient = 0.85
Turkey Creek PEFTF		
Wet Well Volume (gal) (TCEFBWW)	34,700	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	828.75	
# of Pumps	2	Both modeled as FIXED

Pump Capacity	P1: 11.0 mgd P2: 11.0 mgd	
Pump Controls (on/off)	P1: 836.75 / 831.75 P2: 837.25 / 832.25	
PEFTF Storage Volume (gal) (TCEFB)	456,000	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	842.77	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (TCEFB.1)	854.5	Width = 15.0 ft; One notch, Height = 0.208 ft @ 90 degrees
PEFTF Drain Pipe Diameter	8 in	IE Out = 838.46



Head discharge : PUMP 2&3 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	144.0000	0.000	111.8550
2	110.0000	8.640	170.0196
3	106.0000	9.000	171.5110
4	98.0000	10.520	186.4250
5	86.0000	12.800	199.8476
6	72.0000	15.280	208.7960
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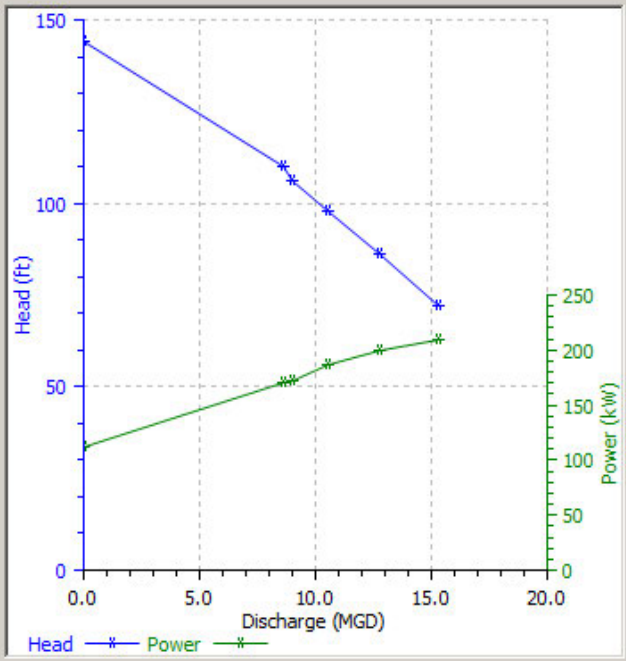
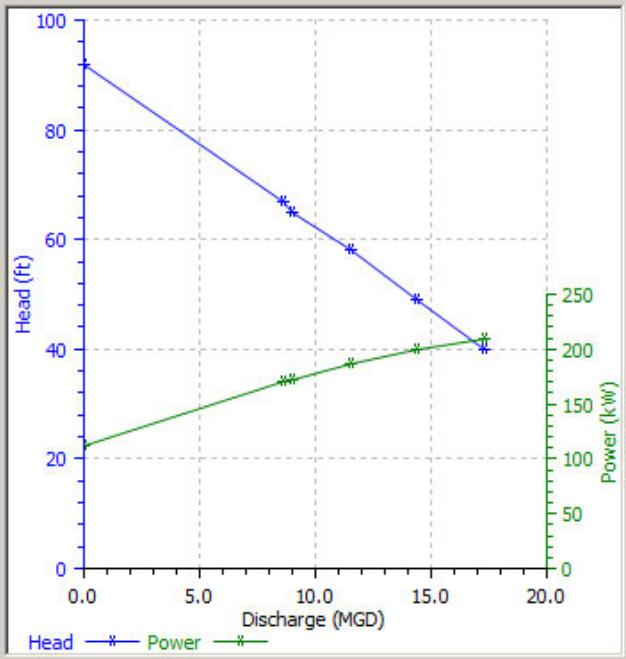


OK Cancel

Head discharge : SMALLER : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	92.0000	0.000	111.8550
2	67.0000	8.640	170.0196
3	65.0000	9.000	171.5110
4	58.0000	11.520	186.4250
5	49.0000	14.400	199.8476
6	40.0000	17.280	208.7960
*			



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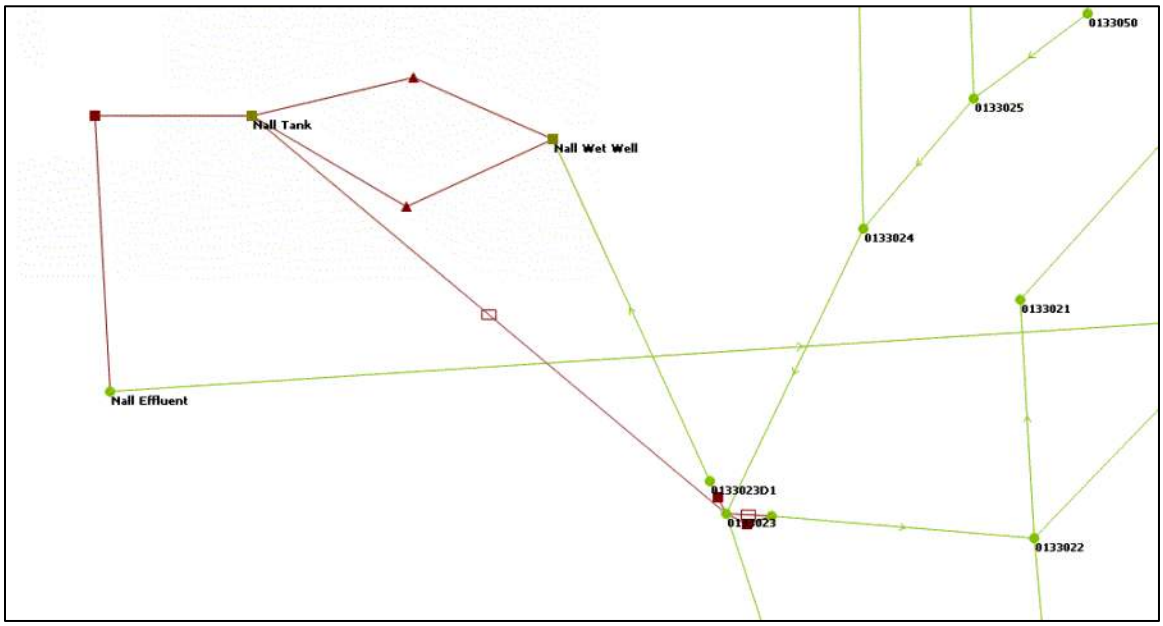
Modeled Pump Stations – MTM1

Model Network: *MTM1_ES_Calibrated_W/RTCControl_Nov2016*

Nall PEFTF

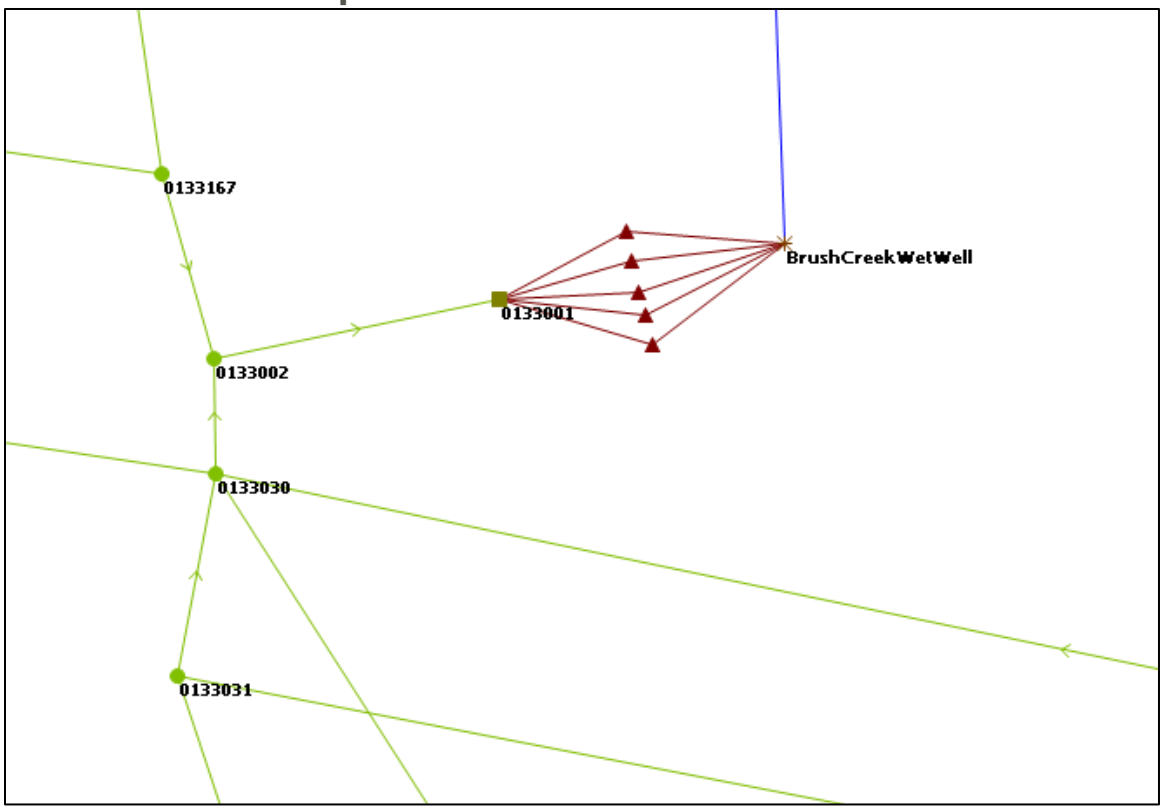


Parameter	Quantity	Notes
Sluice to Brush Creek (0133023.2)	24 in x 24 in	IE = 938.00
Weir to Brush Creek (0133023.3)	943.5	Width = 2.0 ft; Coefficient = 0.85
Weir to Nall PEFTF (0133023.4)	940.0	Width = 5.0 ft; Coefficient + 0.85
Wet Well Volume (gal) (Nall Wet Well)	40,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	932.00	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 10.0 mgd P2: 10.0 mgd	
Pump Controls (on/off)	P1: 938.5 / 936.5 P2: 940.0 / 937.5	
PEFTF Storage Volume (gal) (Nall Tank)	456,000	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	842.77	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (Nall Tank.1)	951.75	Width = 19.5 ft; Coefficient = 3.33
PEFTF Drain Sluice (Nall Tank.2)	10 in x 10 in	IE = 943.75

RTC

- If Nall P1 (Nall Wet Well.1) idle > 86400 seconds then Nall PEFTF drain sluice (Nall Tank.2) open
- If Nall P1(Nall Wet Well.1) running for > 60 seconds then Nall PEFTF drain sluice (Nall Tank.2) open

Brush Creek Pump Station



Parameter	Quantity	Notes
Wet Well Volume (gal) (0133001)	33,300	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	916.5	
# of Pumps	4 +1 dummy	All modeled as constant speed Dummy pump modeled as FIXED (5th pump is dummy pump used for RTC)
Pump Capacity	P1: BRUSH CREEK 1 P2: BRUSH CREEK 2&4 P3: BRUSH CREEK 1 P4: BRUSH CREEK 2&4 P5: 0.0 mgd	See curves
Pump Controls (on/off)	P1: 924.5 / 922.5 P2: 925.5 / 922.0 P3: 925.0 / 923.0 P4: 936.5 / 936.0 P5: 926.5 / 923.5	Pumps 2 & 4 do not operate together. Pump #5 used for RTC settings

RTC

- If elevation in Brush Creek WW (0133001) >= 926.5 then sluice to Brush Creek (0133023.2) closed
- If Brush Creek dummy pump (0133001.5) idle for > 900 seconds then sluice to Brush Creek (0133023.2) open

Head discharge : BRUSH CREEK 1 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	125.2000	0.000	14.0900
2	112.2000	0.580	17.9000
3	100.9000	1.200	22.3700
4	89.6000	1.770	26.5500
5	75.2000	2.190	28.0400
6	65.1000	2.430	29.2300
7	45.2000	2.880	29.6800
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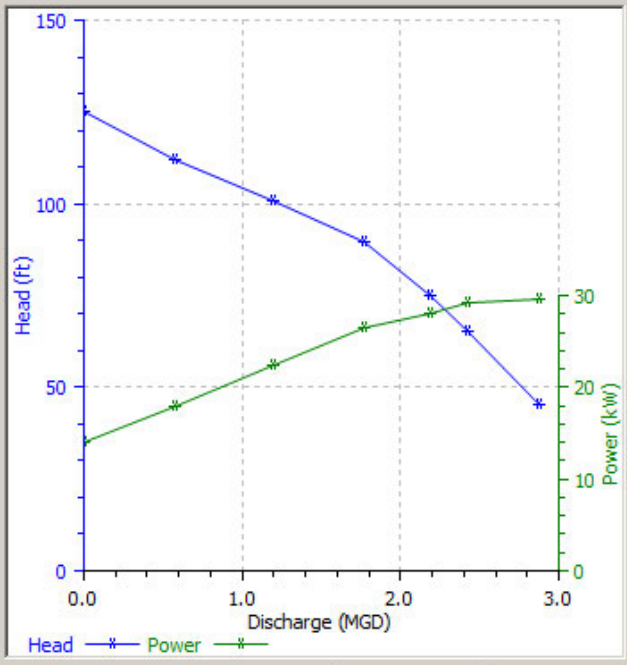

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Head discharge : BRUSH CREEK 2&4 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	208.0000	0.000	74.6000
2	187.5000	1.870	87.9900
3	175.0000	3.000	111.8500
4	150.0000	5.470	128.2600
5	145.8000	5.620	130.5000
6	104.0000	7.490	137.2100
7	83.4000	8.060	145.4100
8	66.6000	8.580	149.1400
9	54.0000	8.930	145.4100
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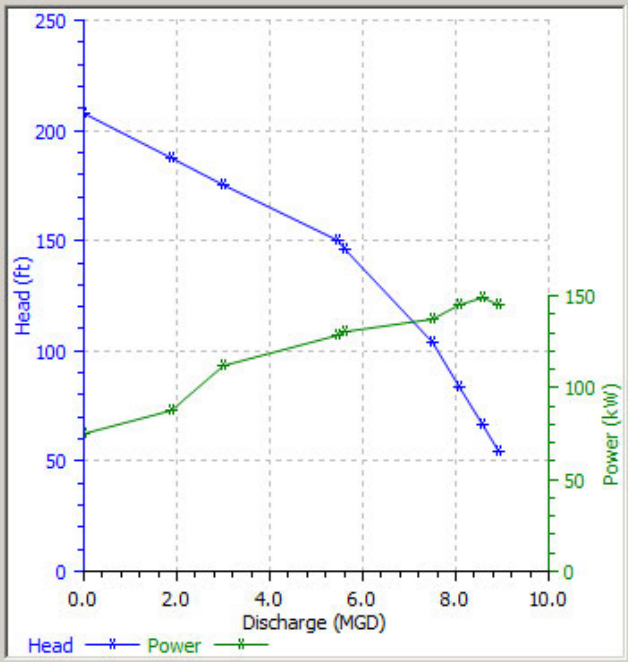

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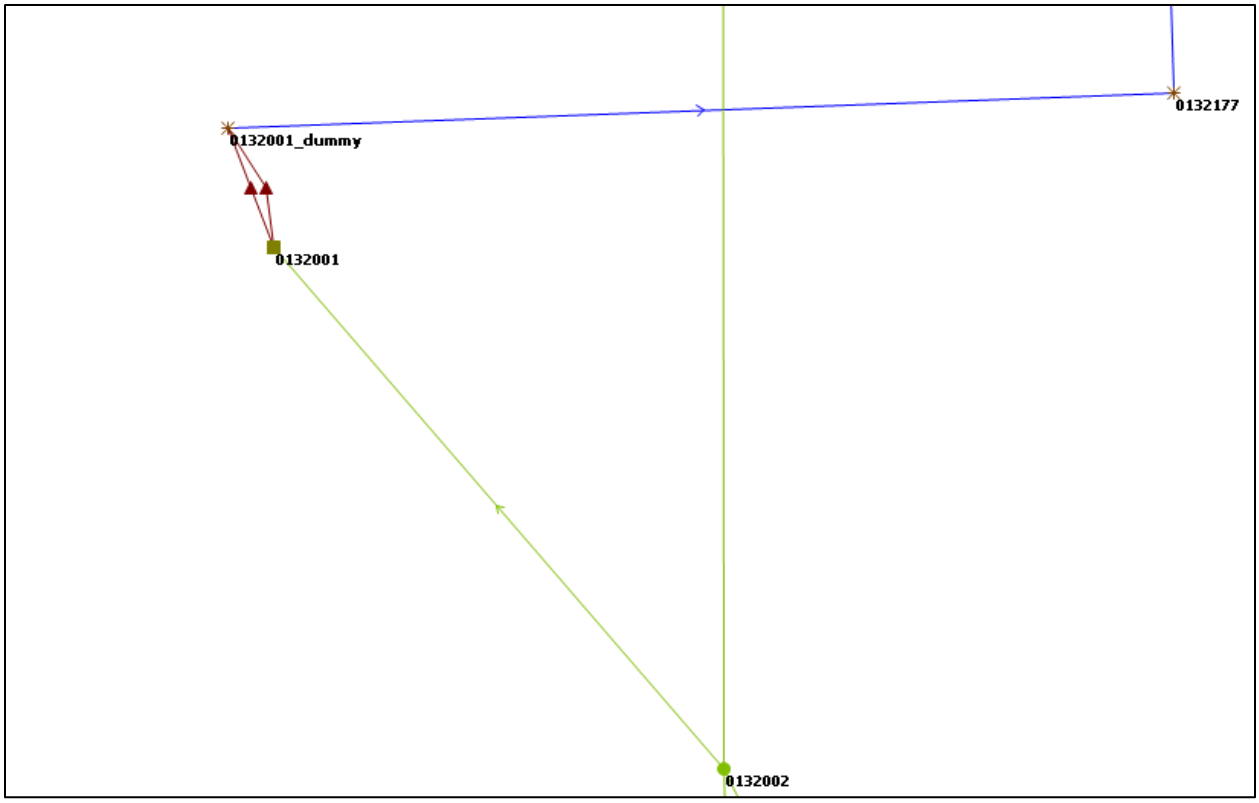
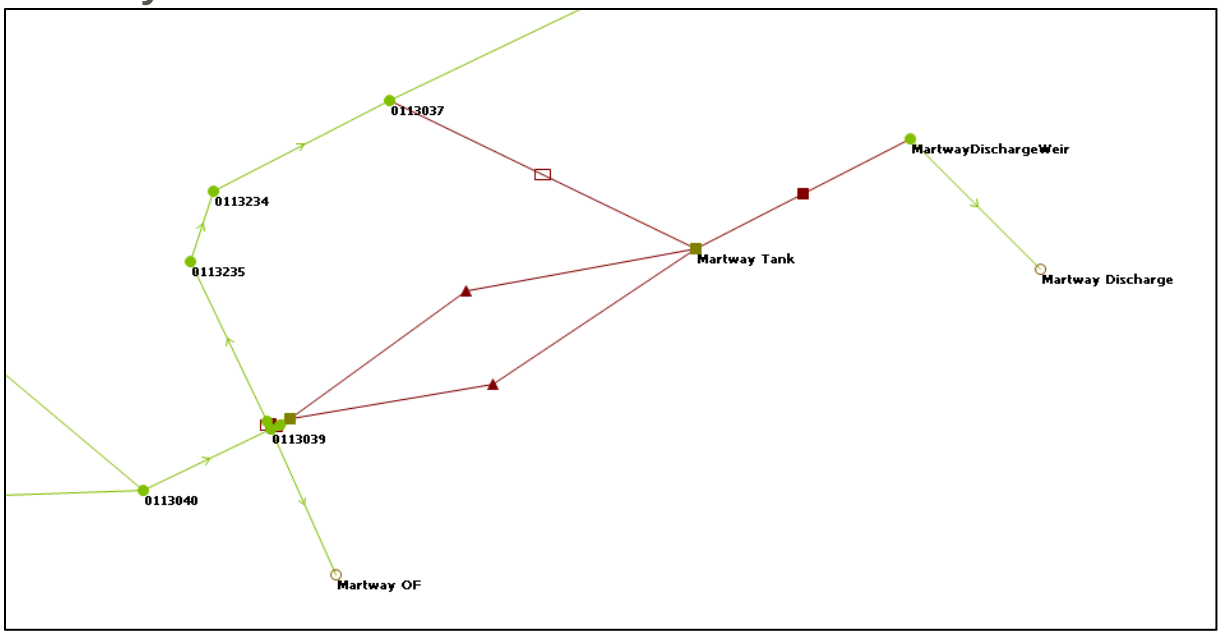
Granthurst Lift Station



Parameter	Quantity	Notes
Wet Well Volume (gal) (0132001)	4,900	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	931.0	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 2.74 mgd P2: 2.74 mgd	
Pump Controls (on/off)	P1: 936.42 / 935.17 P2: 950.0 / 949.0	

Martway PEFTF



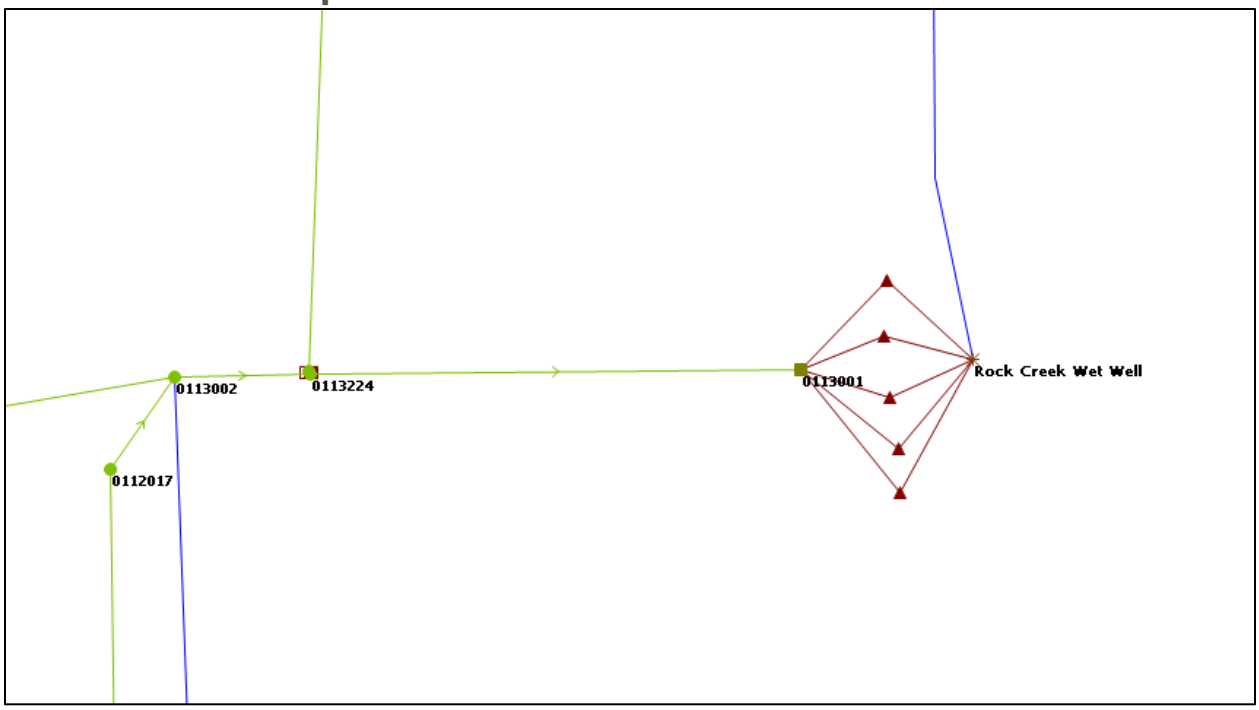
Parameter	Quantity	Notes
Sluice to Rock Creek (0113039.2)	36 in x 36 in	IE = 920.54
Weir to Rock Creek (0113039.4)	924.0	Width = 9.0 ft; Coefficient = 0.85
Sluice to PEFTF (0113039.3)	48 in x 36 in	IE = 922.0
Wet Well Volume (gal) (Martway HS Wet Well)	46,400	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	915.0	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 10.0 mgd P2: 10.0 mgd	
Pump Controls (on/off)	P1: 916.0 / 915.5 P2: 917.0 916.5	
PEFTF Storage Volume (gal) (Martway Tank)	559,000	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	927.26	
PEFTF Overflow Weir Elevation (Martway Tank.1)	936.75	Width = 19.5 ft; Coefficient = 3.33
PEFTF Drain Sluice (Martway Tank.2)	10 in x 10 in	IE = 927.26

RTC

- If elevation in Rock Creek WW (0113001) >= 906.5 then sluice to Rock Creek (0113039.2) closed
- If Rock Creek dummy pump (0113001.5) idle for > 900 seconds then sluice to Rock Creek (0113039.2) open

- If elevation in Rock Creek WW (0113001) >= 906.5 then sluice to Martway PEFTF (0113039.3) open
- If Rock Creek dummy pump (0113001.5) idle > 900 seconds then sluice to Martway PEFTF (0113039.3) closed
- If Martway P1 idle for > 86400 seconds then Martway PEFTF Drain Sluice (Martway Tank.2) open.
- If Martway P1 running for > 60 seconds then Martway PEFTF Drain Sluice (Martway Tank.2) closed.

Rock Creek Pump Station



Parameter	Quantity	Notes
Sluice to Belinder Pump Station (0113224.2)	42 in x 42 in	IE = 907.57
Weir to Belinder PS (0113224.3)	917.5	Width = 3.5 ft; Coefficient = 0.85
Wet Well Volume (gal) (0113001)	43,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	896.5	
# of Pumps	4 +1 dummy	All modeled as constant speed Dummy pump modeled as FIXED (5th pump is dummy pump used for RTC)
Pump Capacity	P1: ROCK CREEK 2&4 P2: ROCK CREEK 2&4 P3: ROCK CREEK 2&4 P4: ROCK CREEK 2&4 P5: 0.0 mgd	See curves
Pump Controls (on/off)	P1: 903.5 / 901.5 P2: 906.0 / 904.5 P3: 917.5 / 917.5 P4: 908.5 / 906.0 P5: 906.5 / 903.5	Pump #3: This pump alternates with Pump-1 so it is not necessary in the model. The on level was set very high so that it never starts. Pump #5 used for RTC settings

Head discharge : ROCK CREEK 2&4 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	140.0000	0.000	44.7420
2	135.0000	1.440	55.9275
3	127.0000	2.880	70.8415
4	108.0000	4.320	78.2985
5	81.0000	5.760	80.5356
6	50.0000	7.200	74.5700
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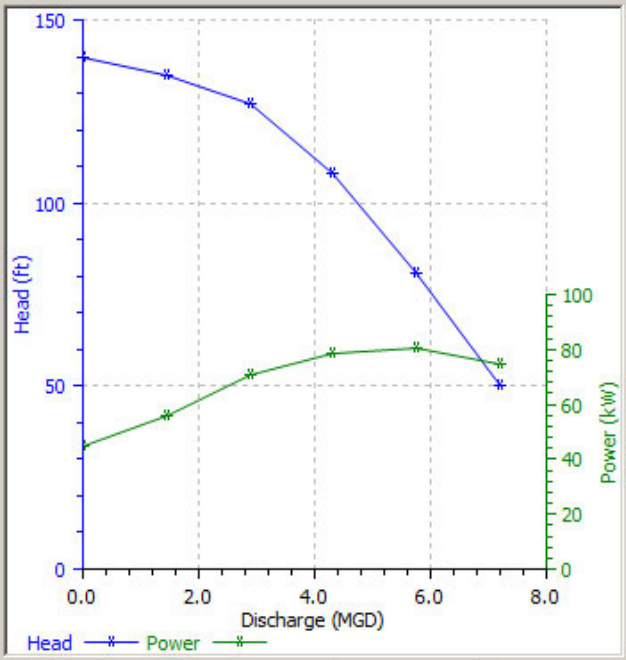

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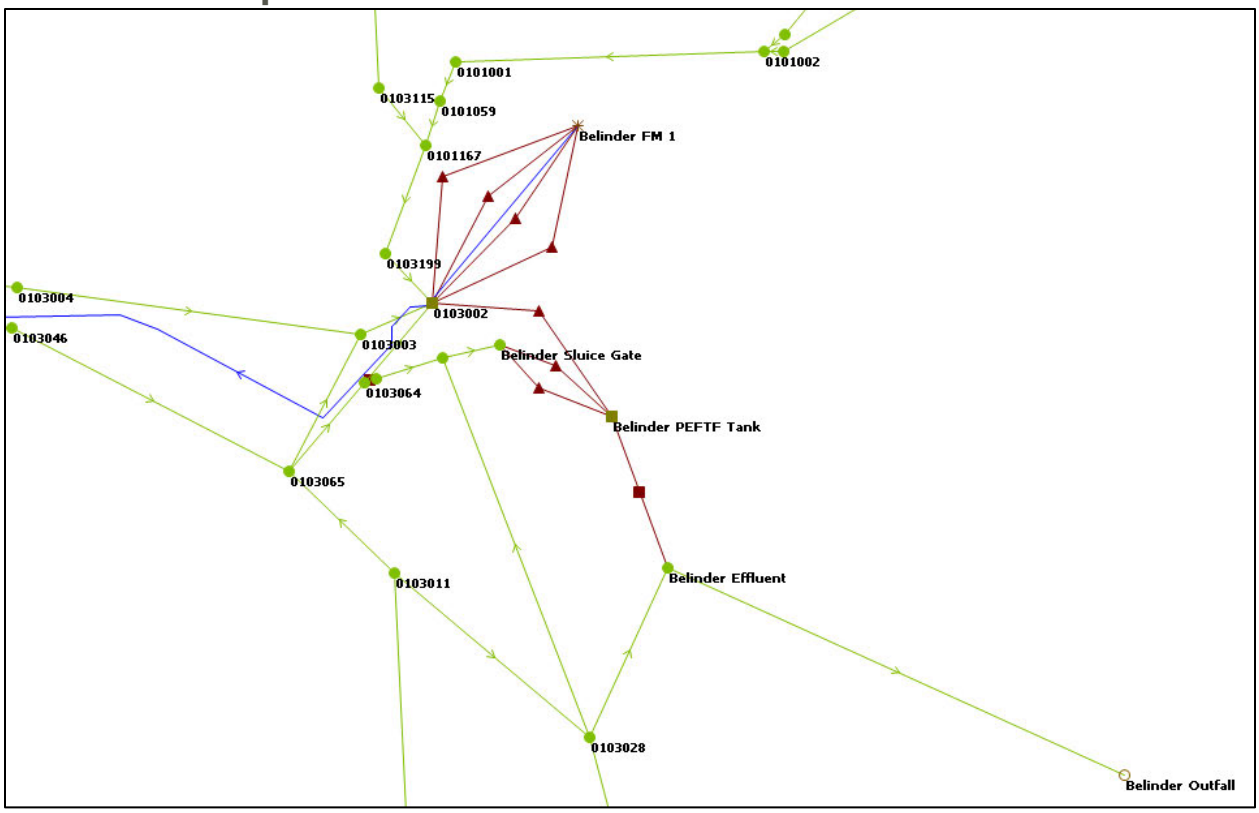
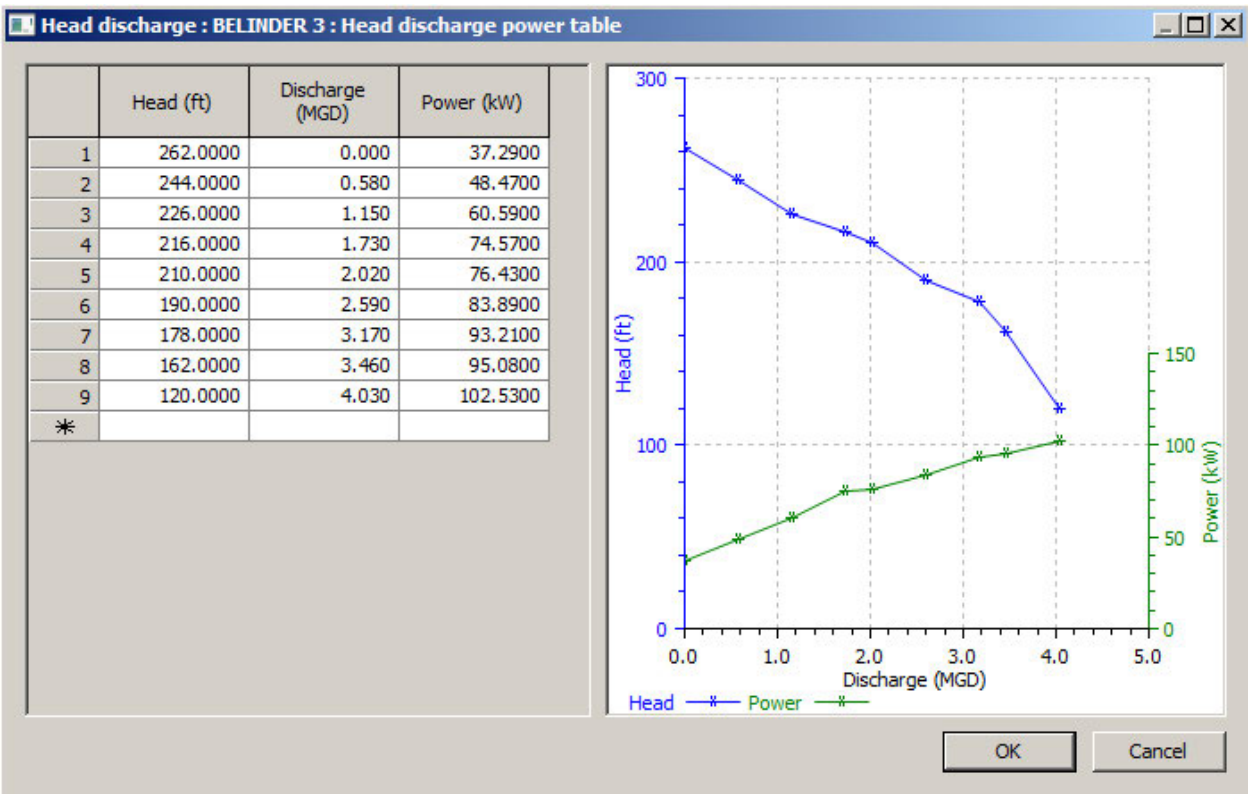
Belinder Pump Station & PEFTF



Parameter	Quantity	Notes
Belinder Pump Station		
Wet Well Volume (gal) (0103002)	29,500	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	847.0	
# of Pumps	4	All modeled as VFD
Pump Capacity	P1: BELINDER 3 P2: BELINDER 4 & 5 P3: BELINDER 3 P4: BELINDER 4 & 5	See curves
Pump Controls (on/off)	P1: 852.5 / 852.0 P2: 853.43 / 852.5 P3: 867.0 / 866.0 P4: 854.5 / 853.0	P1: Min / Max Speed = 1200 rpm / 1780 rpm P2: Min / Max Speed = 1187 rpm / 1781 rpm P3: Min / Max Speed = 1200 rpm / 1780 rpm (This pump is set to only come on when the met well is going to overflow.) P4: Min / Max Speed = 1187 rpm / 1781 rpm
Weir Elevation to PEFTF (0103064.1)	856.97	Width = 4.0 ft; Coefficient = 0.85
Belinder PEFTF		
Wet Well Volume (gal) (Belinder Sluice Gate)	29,300	Approx. volume to chamber roof
Wet Well Floor Elevation (ft)	834.5	
# of Pumps	2	Both modeled as FIXED

Pump Capacity	P1: 20.0 mgd P2: 20.0 mgd	
Pump Controls (on/off)	P1: 842.5 / 839.5 P2: 842.0 / 839.0	
PEFTF Storage Volume (gal) (Belinder PEFTF Tank)	843,300	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	846.8	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (Belinder PEFTF Tank.1)	859.0	Width = 19.2 ft; Coefficient = 0.85
PEFTF Drain Pump (Belinder PEFTF Tank.2)	Fixed @ 1 mgd	On / Off = 848.0 / 847.0



Head discharge : BELINDER 4 & 5 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	258.0000	0.000	76.4300
2	252.0000	0.700	88.5500
3	246.0000	1.400	95.4500
4	240.0000	2.200	111.8600
5	234.0000	2.900	121.1800
6	218.0000	3.600	135.1600
7	198.0000	4.300	139.8200
8	186.0000	5.000	149.1400
9	167.0000	5.800	158.4600
10	136.0000	6.400	167.7800
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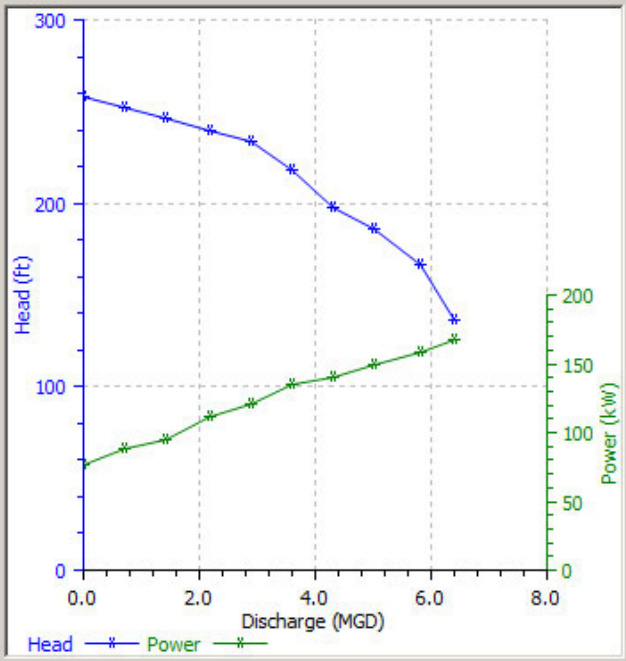

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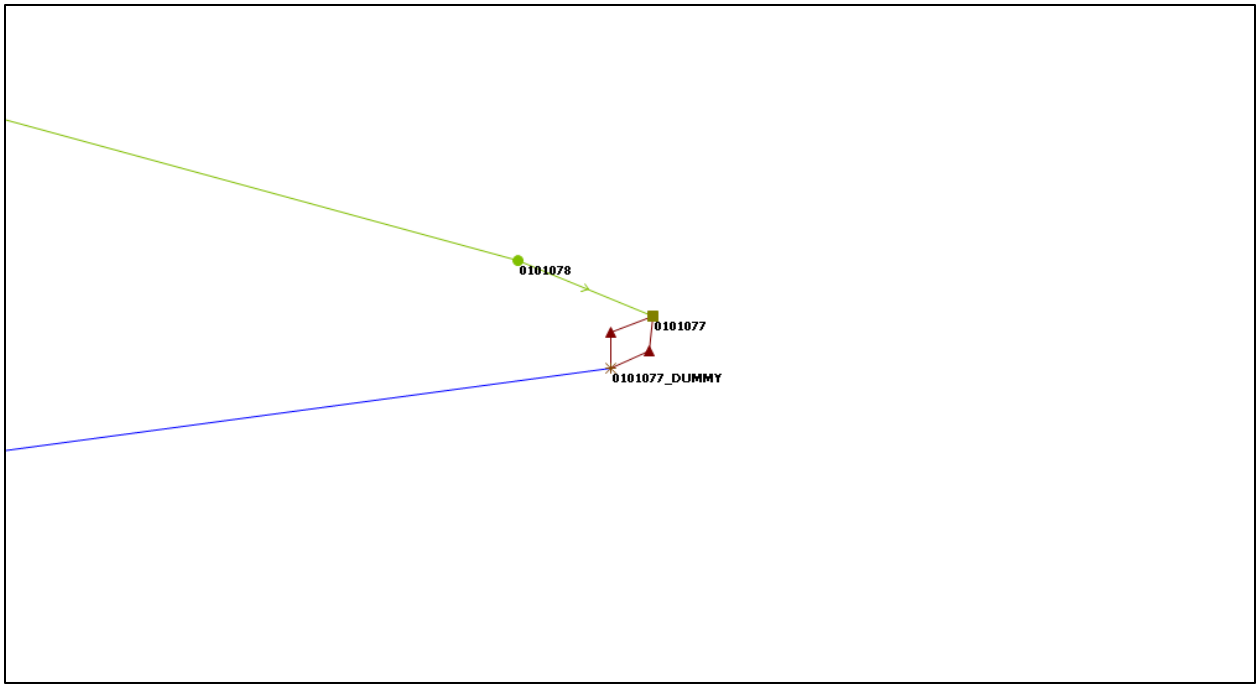
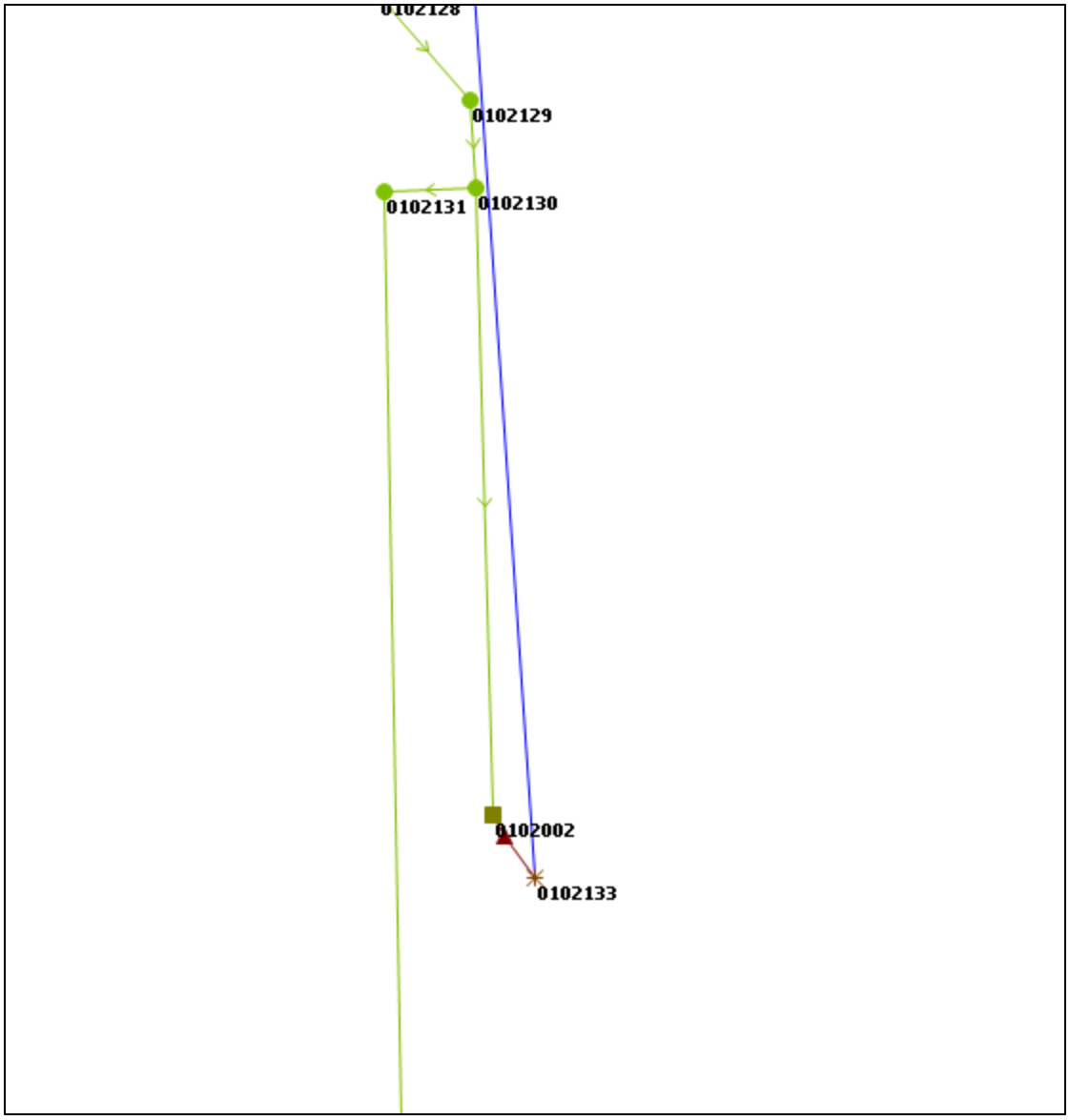
Mission Woods Lift Station



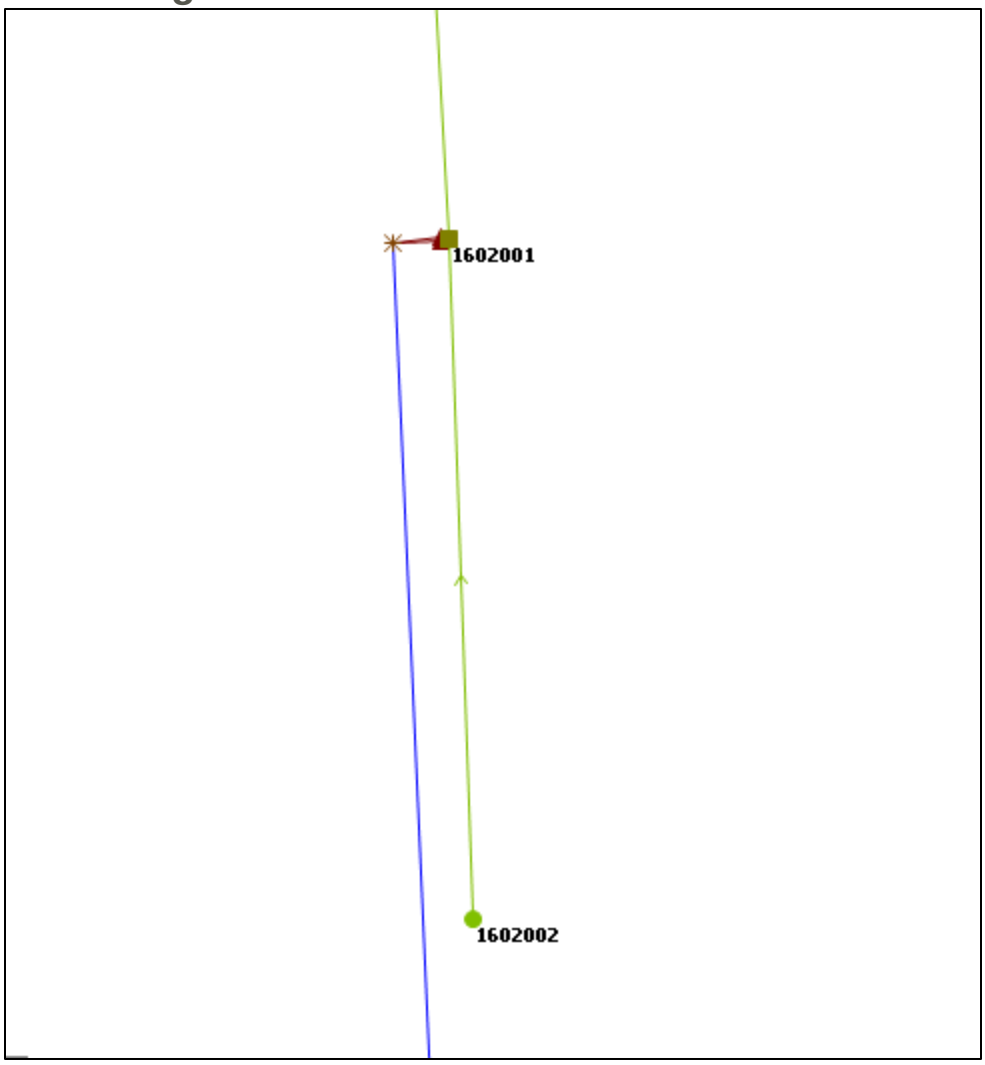
Parameter	Quantity	Notes
Wet Well Volume (gal)	2,600	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	843.17	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 0.58 mgd P2: 0.58 mgd	
Pump Controls (on/off)	P1: 847.34 / 846.50 P2: 846.17 / 846.09	

Swatzell View



Parameter	Quantity	Notes
Wet Well Volume (gal)	20,100	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	903.75	
# of Pumps	1	Modeled as FIXED
Pump Capacity	P1: 1.63 mgd	
Pump Controls (on/off)	P1: 906.75 / 905.75	

Roe Village

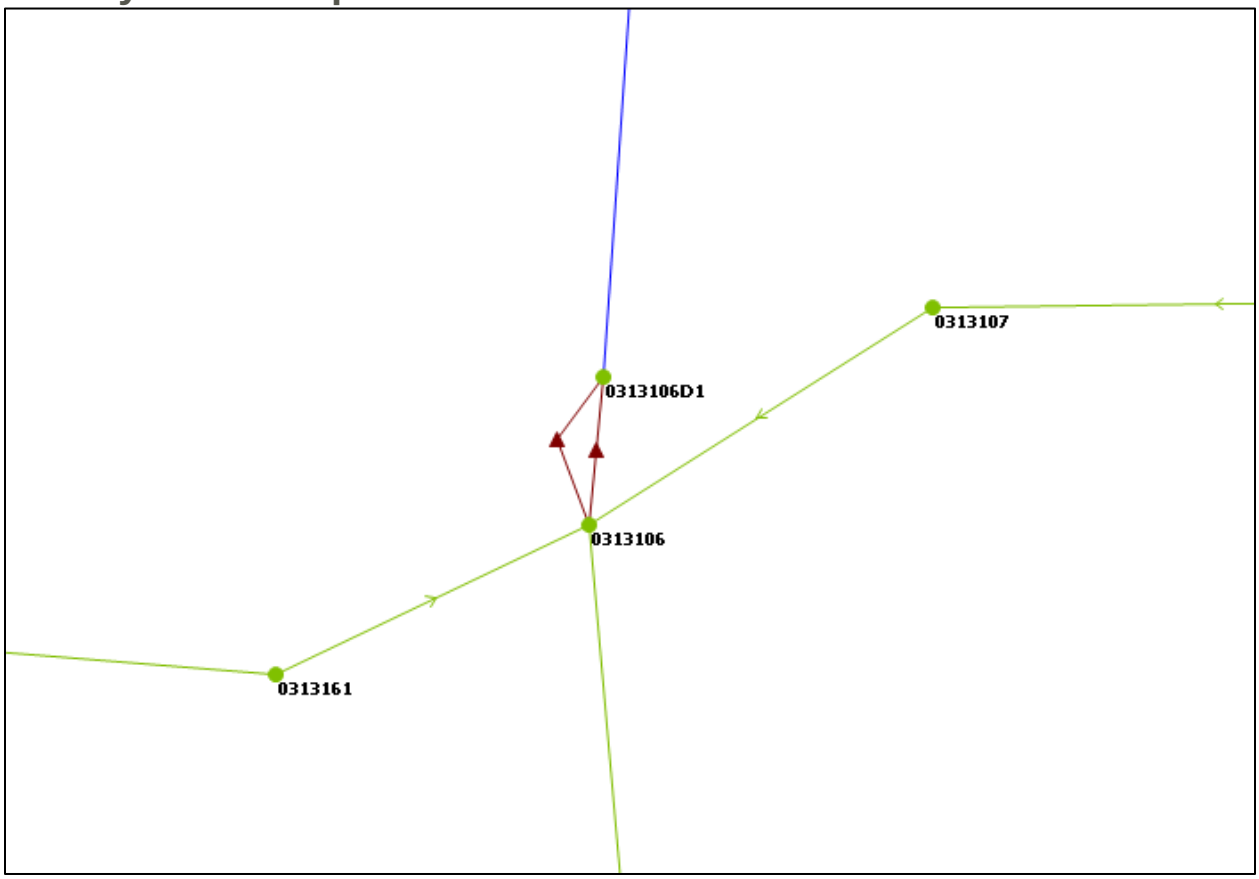


Parameter	Quantity	Notes
Wet Well Volume (gal)	2,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	947.10	
# of Pumps	2	Modeled as FIXED
Pump Capacity	P1: 0.22 mgd P2: 0.22 mgd	
Pump Controls (on/off)	P1: 952.10 / 949.60 P2: 951.27 / 948.77	

Capacity Assessment/Optimization Model

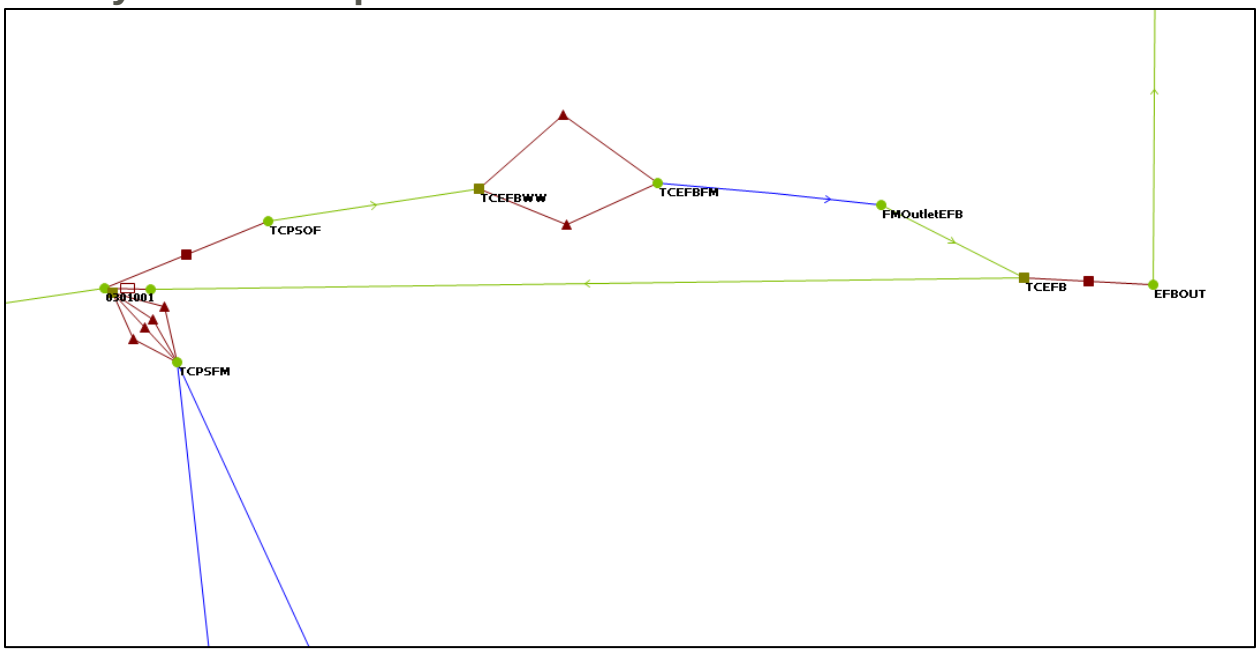
Modeled Pump Stations - SMTC

County Line Pump Station



Parameter	Quantity	Notes
Wet Well Volume (gal)	7,500	Approx. volume to lowest invert of connecting pipe
Wet Well Floor Elevation (ft)	961.552	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 0.43 mgd P2: 0.43 mgd	
Pump Controls (on/off)	P1: 965.33 / 961.88 P2: 965.58 / 961.88	

Turkey Creek Pump Station & PEFTF

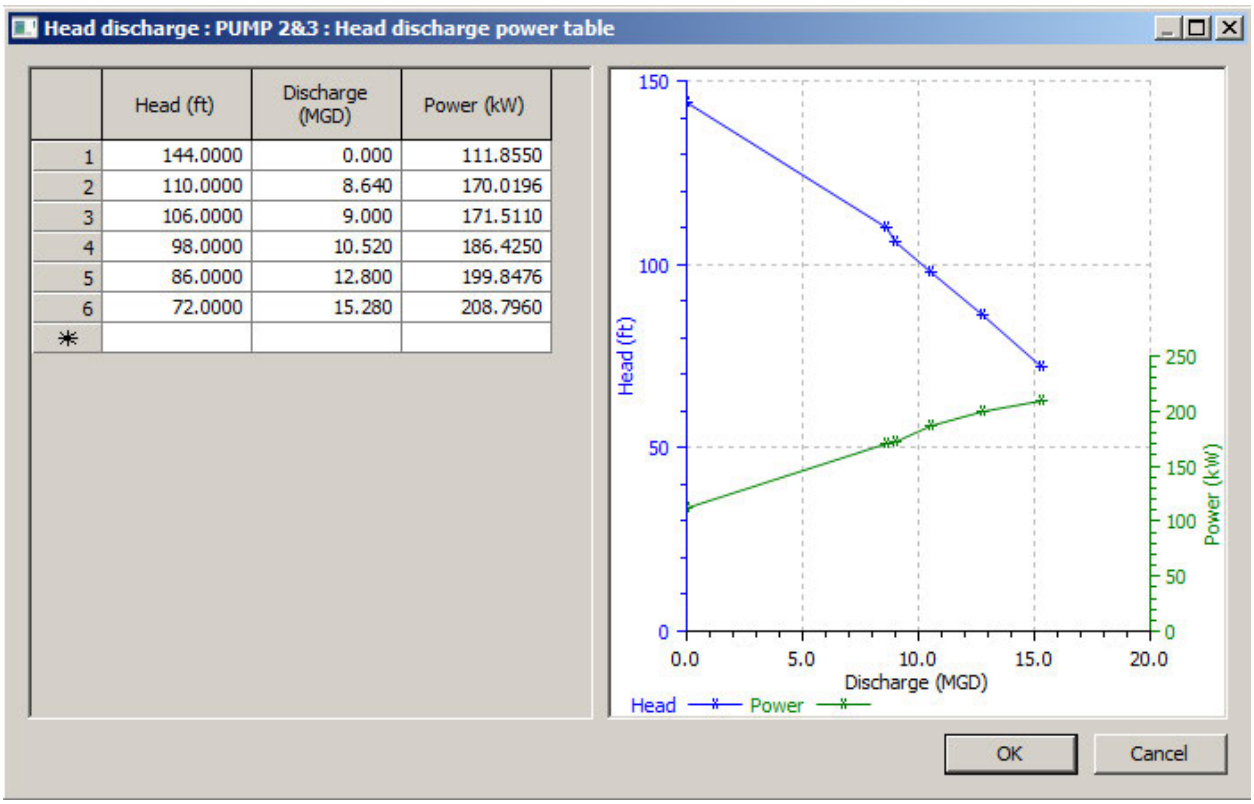


Parameter	Quantity	Notes
Turkey Creek Pump Station		
Wet Well Volume (gal) (TCPSWW)	97,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	826.00	
# of Pumps Modeled	3	All modeled w/ VFD
Pump Capacity	P1: PUMP 2&3 P2: PUMP 2&3 P4: PUMP 2&3	See curves P1 represents Pump 1 and Pump 3; These pumps do not operate simultaneously.
Pump Controls (on/off)	P1: 834.5 / 833.5 P2: 836.0 / 834.0 P4: 836.5 / 834.5	Wet Well Set Point = 8.5 ft Speed range (all same): Min Speed: 560 rpm Max Speed: 710 rpm
Weir Elevation to PEFTF (0301001.3)	839.00	Width = 15.5 ft; Coefficient = 0.85
Turkey Creek PEFTF		
Wet Well Volume (gal) (TCEFBWW)	34,700	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	828.75	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 11.0 mgd P2: 11.0 mgd	
Pump Controls (on/off)	P1: 836.75 / 831.75 P2: 837.25 / 832.25	
PEFTF Storage Volume (gal) (TCEFB)	456,000	Approx. volume to weir elevation

PEFTF Floor Elevation (ft)	842.77	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (TCEFB.1)	854.5	Width = 15.0 ft; One notch, Height = 0.208 ft @ 90 degrees
PEFTF Drain Pipe Diameter	8 in	IE Out = 838.46

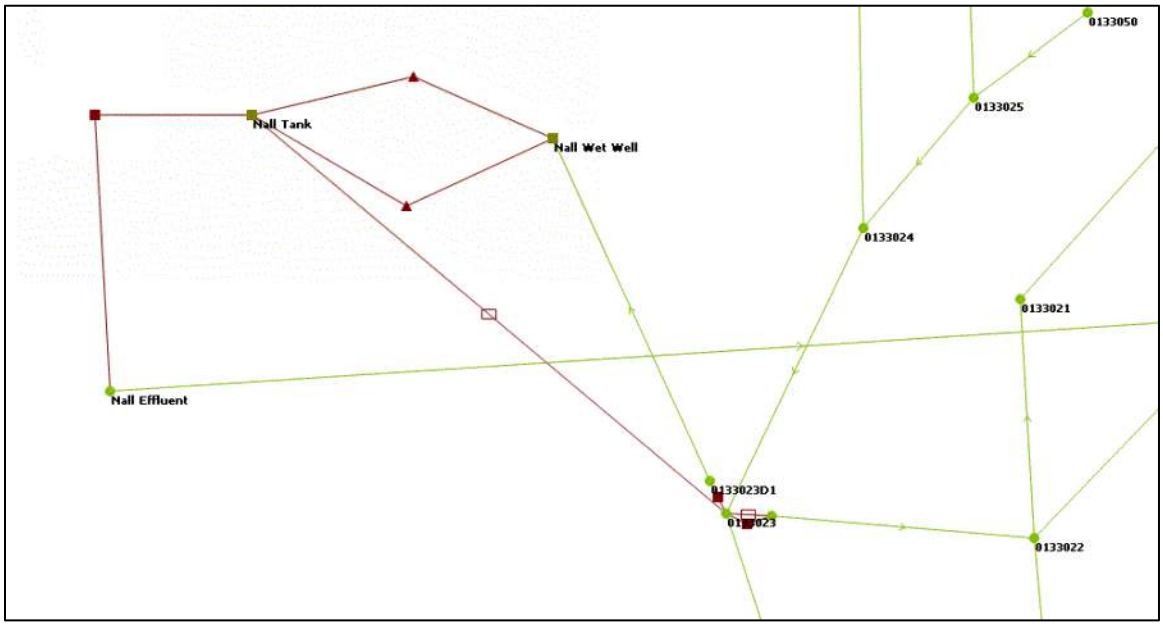
RTC

- If elevation in Turkey Creek WW (TCPSWW) >= 834.5 (depth > 8.5 ft) then Turkey Creek P1 , P2 or P3 speed increased by 5 rpm
- If elevation in Turkey Creek WW (TCPWW) < 834.5 (depth < 8.5 ft) then Turkey Creek P1, P2 or P3 speed decreased by 5 rpm



Modeled Pump Stations – MTM1

Nall PEFTF

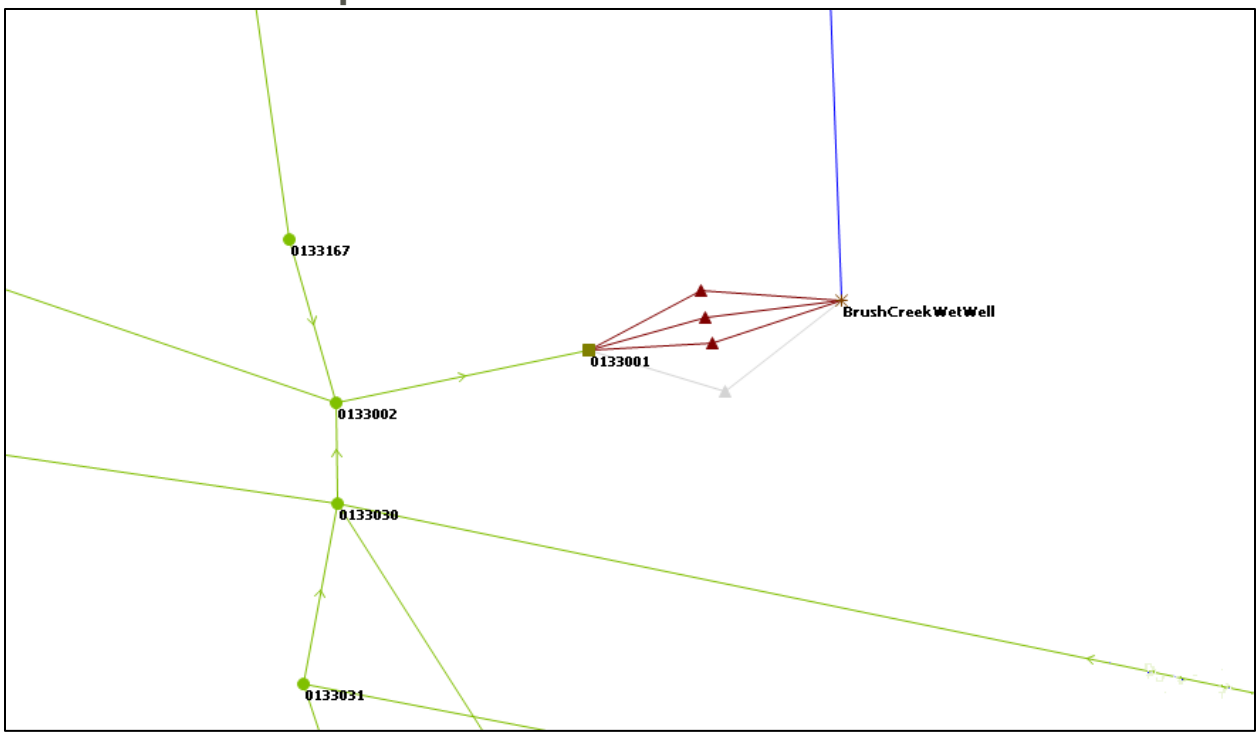


Parameter	Quantity	Notes
Sluice to Brush Creek (0133023.2)	24 in x 24 in	IE = 938.00 Open speed: 0.00667 ft/s Close speed: 0.00667 ft/s
Weir to Brush Creek (0133023.3)	943.5	Width = 2.0 ft; Coefficient = 0.85
Weir to Nall PEFTF (0133023.4)	940.0	Width = 5.0 ft; Coefficient + 0.85
Wet Well Volume (gal) (Nall Wet Well)	40,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	932.00	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 10.0 mgd P2: 10.0 mgd	
Pump Controls (on/off)	P1: 938.5 / 936.5 P2: 940.0 / 937.5	
PEFTF Storage Volume (gal) (Nall Tank)	456,000	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	842.77	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (Nall Tank.1)	951.75	Width = 19.5 ft; Coefficient = 3.33
PEFTF Drain Sluice (Nall Tank.2)	10 in x 10 in	IE = 943.75

RTC

- If Nall P1 (Nall Wet Well.1) idle > 86400 seconds (24 hrs) then Nall PEFTF drain sluice (Nall Tank.2) open
- If Nall P1(Nall Wet Well.1) running for > 60 seconds then Nall PEFTF drain sluice (Nall Tank.2) closed
- If elevation in Brush Creek WW (0133001) >= 926.25 then sluice to Brush Creek (0133023.2) closed
- If elevation in Brush Creek WW (0133011 < 925.75 then sluice to Brush Creek (0133023.2) open (2 ft)

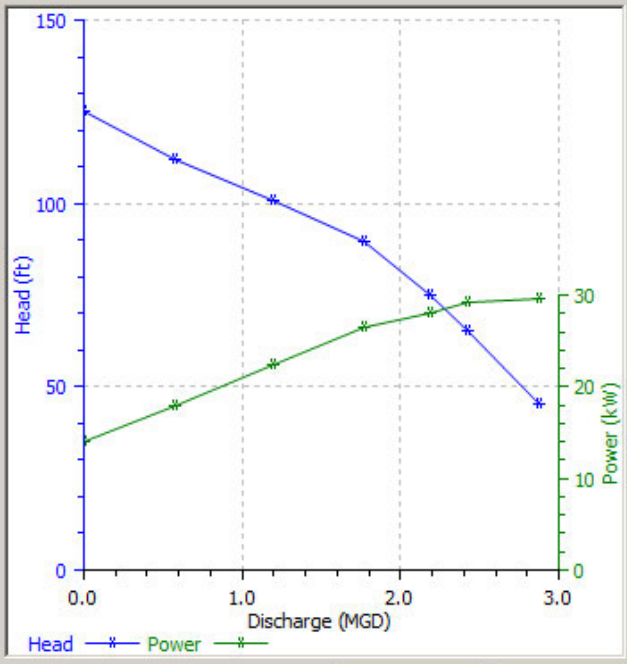
Brush Creek Pump Station



Parameter	Quantity	Notes
Wet Well Volume (gal) (0133001)	33,300	Approx. volume as defined by storage array Wet well dimensions 9' x 24.5'
Wet Well Floor Elevation (ft)	916.5	
# of Pumps	3	All modeled as constant speed
Pump Capacity	P1: BRUSH CREEK 1 P2: BRUSH CREEK 2&4 P3: BRUSH CREEK 1	See curves P1 & P3 small pumps rated for 1,500 gpm @ 74 ft P2 represents pumps 2 & 4. These high flow pumps do not operate simultaneously. Rated at 3,800 gpm @ 150 ft
Pump Controls (on/off)	P1: 922.5 / 921.5 P2: 925.5 / 923.5 P3: 923.5 / 922.5	Pumps 2 & 4 do not operate together so only one represented in model.

Head discharge : BRUSH CREEK 1 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	125.2000	0.000	14.0900
2	112.2000	0.580	17.9000
3	100.9000	1.200	22.3700
4	89.6000	1.770	26.5500
5	75.2000	2.190	28.0400
6	65.1000	2.430	29.2300
7	45.2000	2.880	29.6800
*			



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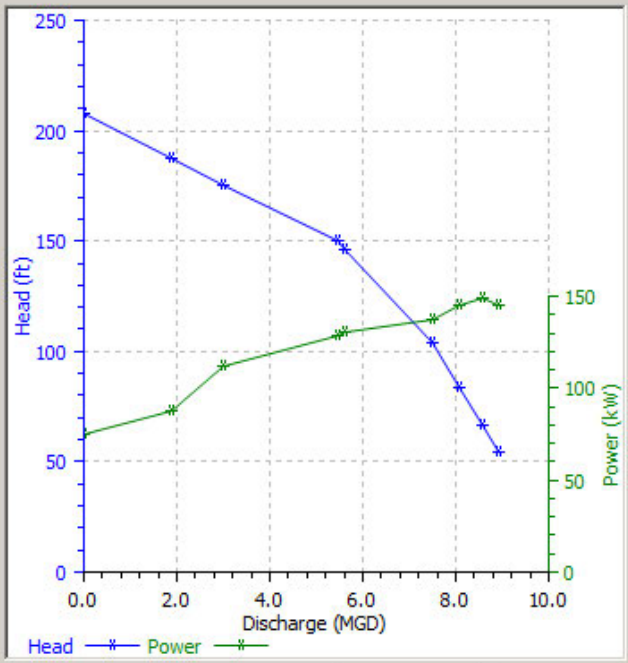
Head discharge : BRUSH CREEK 2&4 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	208.0000	0.000	74.6000
2	187.5000	1.870	87.9900
3	175.0000	3.000	111.8500
4	150.0000	5.470	128.2600
5	145.8000	5.620	130.5000
6	104.0000	7.490	137.2100
7	83.4000	8.060	145.4100
8	66.6000	8.580	149.1400
9	54.0000	8.930	145.4100
*			



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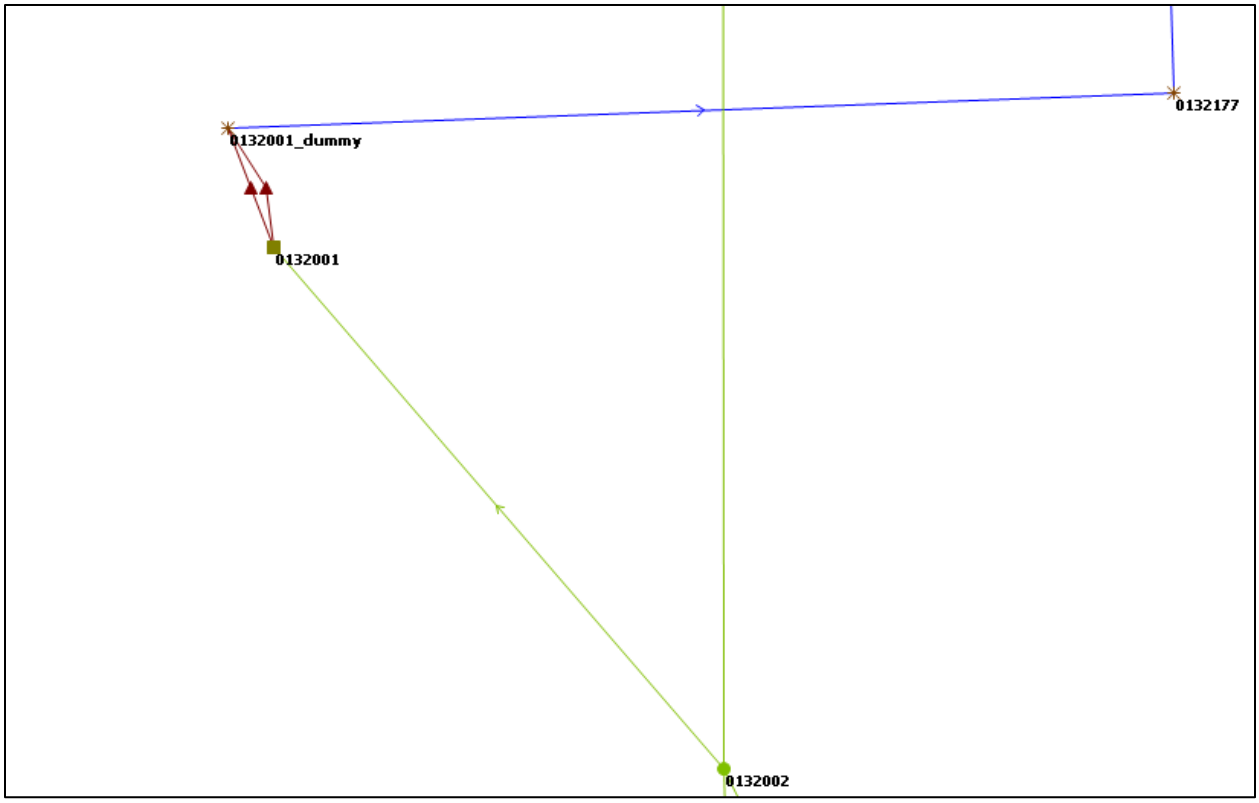
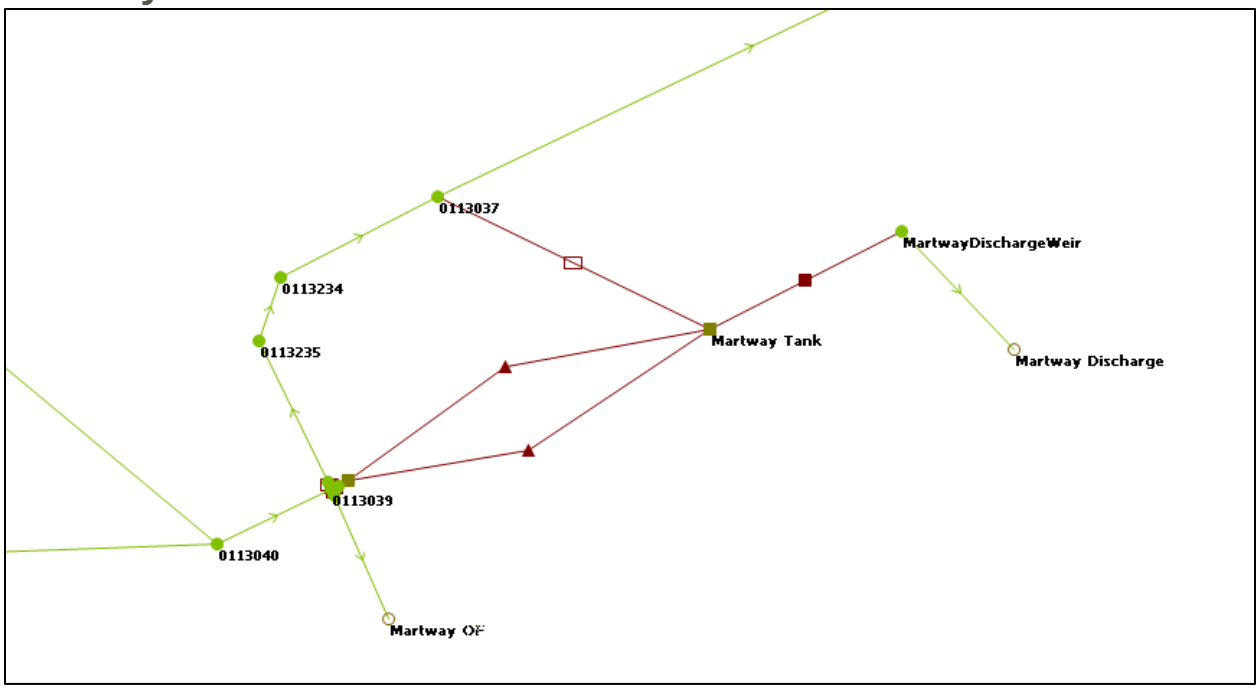
Granthurst Lift Station



Parameter	Quantity	Notes
Wet Well Volume (gal) (0132001)	4,900	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	931.0	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 2.74 mgd P2: 2.74 mgd	
Pump Controls (on/off)	P1: 936.42 / 935.17 P2: 950.0 / 949.0	

Martway PEFTF

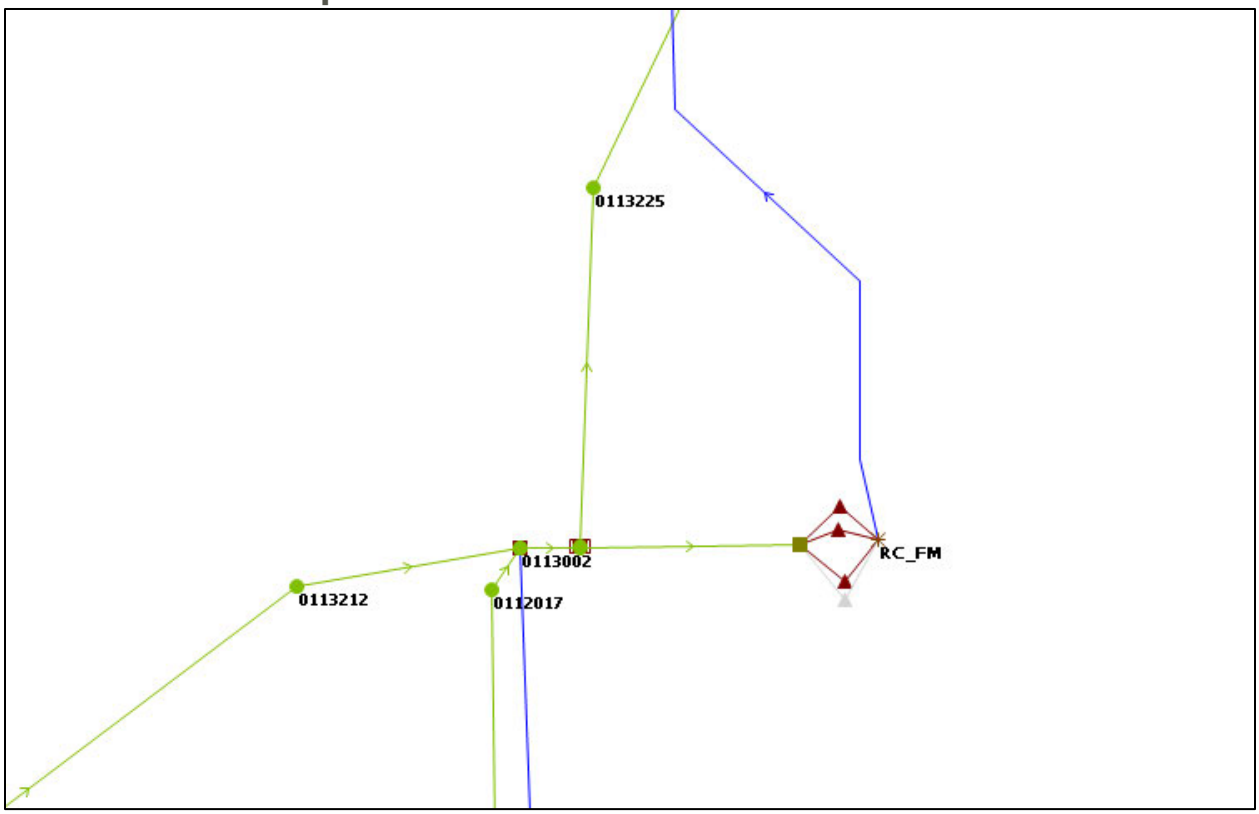


Parameter	Quantity	Notes
Sluice to Rock Creek (0113039.2)	36 in x 36 in	IE = 920.54 Open speed: 0.0100 Close speed: 0.0100
Weir to Rock Creek (0113039.4)	924.0	Width = 9.0 ft; Coefficient = 0.85
Sluice to PEFTF (0113039.3)	48 in x 36 in	IE = 922.0 Always open
Weir to Martway Outfall	926.67	Width = 8.0 ft; Coefficient = 0.85
Wet Well Volume (gal) (Martway HS Wet Well)	46,400	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	915.0	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 10.0 mgd P2: 10.0 mgd	
Pump Controls (on/off)	P1: 921.0 / 919.5 P2: 923.0 / 921.0	
PEFTF Storage Volume (gal) (Martway Tank)	559,000	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	927.26	
PEFTF Overflow Weir Elevation (Martway Tank.1)	936.75	Width = 19.5 ft; Coefficient = 3.33
PEFTF Drain Sluice (Martway Tank.2)	10 in x 10 in	IE = 927.26

RTC

- If elevation in Rock Creek WW (0113001) >= 906.25 then sluice to Rock Creek (0113039.2) closed
- If elevation in Rock Creek WW (0113001) < 905.75 then sluice to Rock Creek (0113039.2) open (3 ft)
- If Martway P1 (Martway HS Wet Well.1) idle for > 86400 seconds (24 hrs) then Martway PEFTF Drain Sluice (Martway Tank.2) open (10 in).
- If Martway P1 (Martway HS Wet Well.1) running for > 60 seconds then Martway PEFTF Drain Sluice (Martway Tank.2) closed.

Rock Creek Pump Station

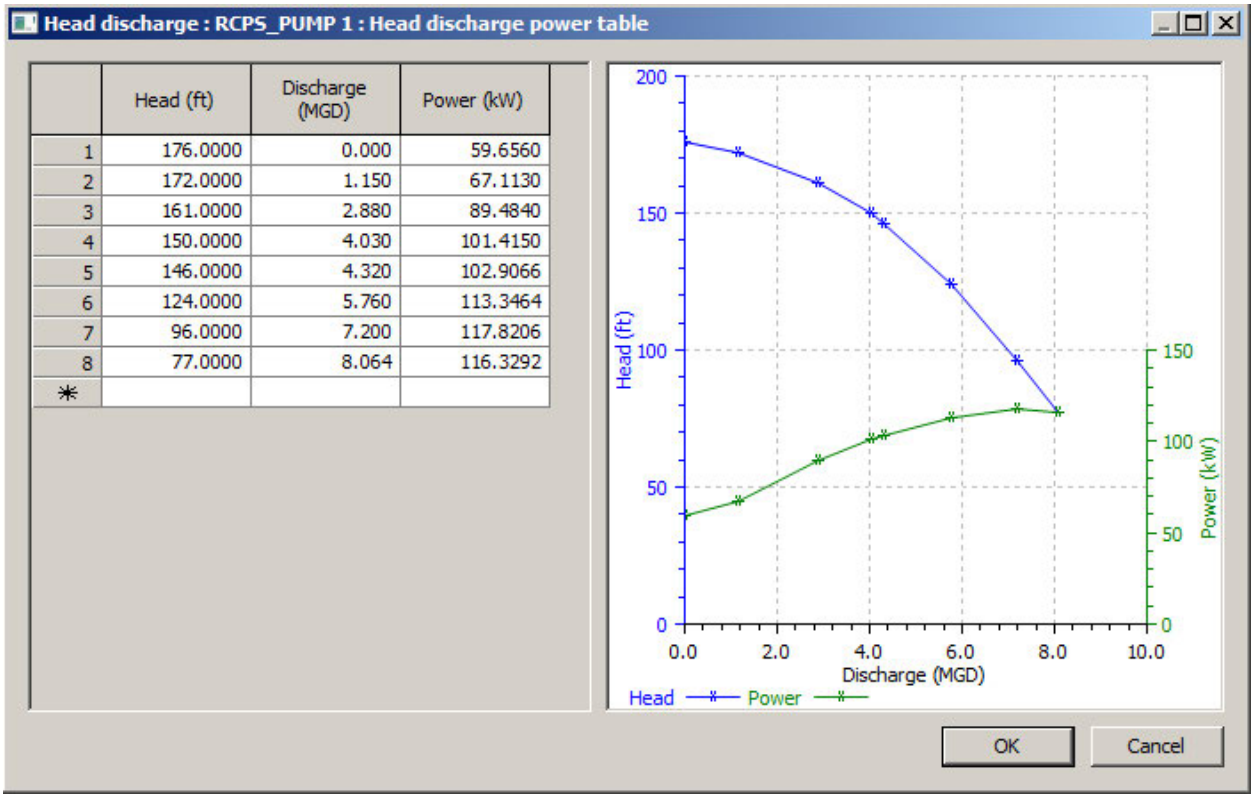


Parameter	Quantity	Notes
Sluice to Belinder Pump Station (0113224.2)	42 in x 42 in	IE = 907.57 Always closed
Weir to Belinder PS (0113224.3)	917.5	Width = 3.5 ft; Coefficient = 0.85
Wet Well Volume (gal) (0113001)	43,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	896.5	
# of Modeled Pumps	3	All modeled w/ VFD Dummy pump modeled as FIXED
Pump Capacity	P1: RCPS_PUMP1 P2: RCPS_PUMP1 P4: RCPS_PUMP1	See curve P1 represents Pumps 1 & 3. These pumps do not operate simultaneously.
Pump Controls (on/off)	P1: 904.5 / 902.5 P2: 905.5 / 903.5 P4: 906.0 / 905.5	Wet Well Set Point (for VFD) = 6.0 ft Speed range (all same): Min Speed: 700 Max Speed: 1160

RTC

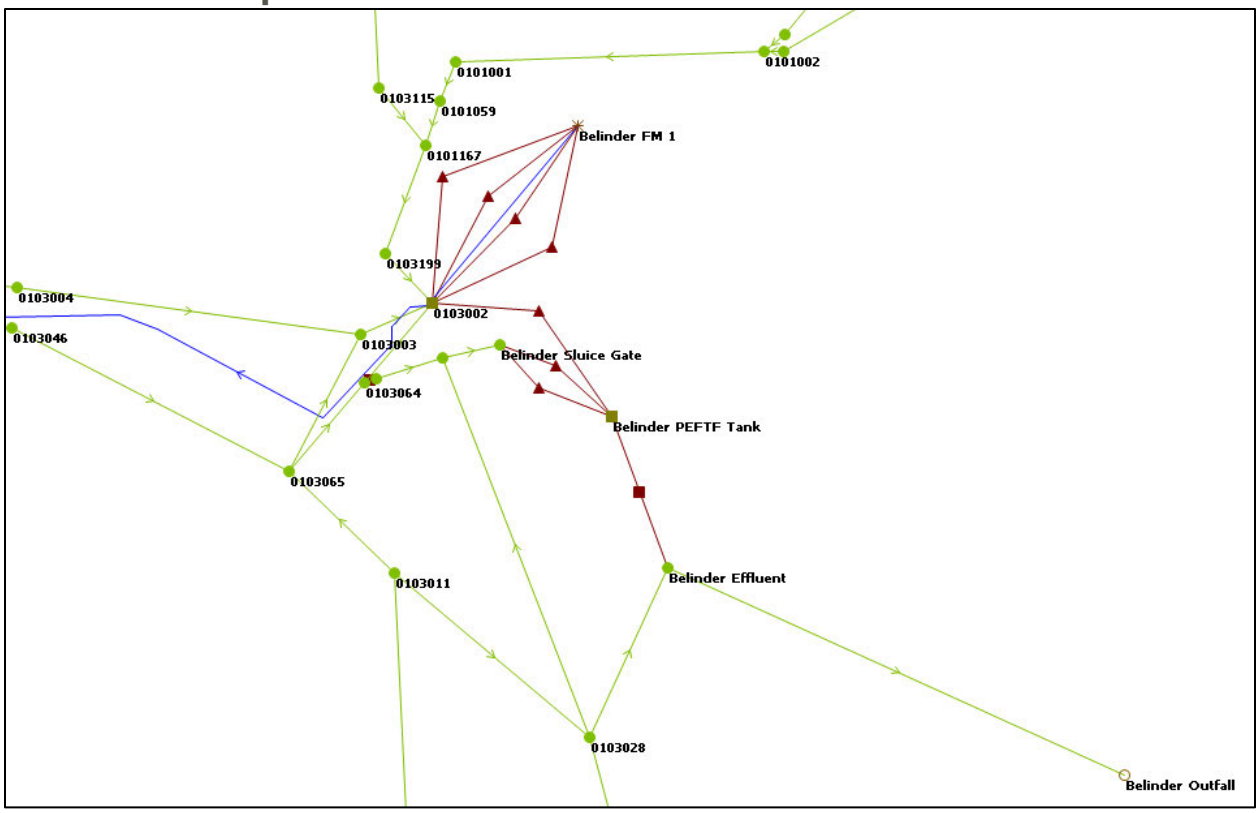
- If elevation in Rock Creek WW (Rock_Creek_WW) >= 902.5 (depth >6.0 ft) then Rock Creek P1 , P2 or P4 speed increased by 5 rpm

- If elevation in Rock Creek WW (Rock_Creek_WW) < 902.5 (depth < 6.0 ft) then Rock Creek P1, P2 or P4 speed decreased by 5 rpm



	Head (ft)	Discharge (MGD)	Power (kW)
1	176.0000	0.000	59.6560
2	172.0000	1.150	67.1130
3	161.0000	2.880	89.4840
4	150.0000	4.030	101.4150
5	146.0000	4.320	102.9066
6	124.0000	5.760	113.3464
7	96.0000	7.200	117.8206
8	77.0000	8.064	116.3292
*			

Belinder Pump Station & PEFTF



Parameter	Quantity	Notes
Belinder Pump Station		
Wet Well Volume (gal) (0103002)	29,500	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	847.0	
# of Pumps	4	All modeled as VFD
Pump Capacity	P1: BELINDER 1 & 3 P2: BELINDER 2 & 4 P3: BELINDER 1 & 3 P4: BELINDER 2 & 4	See curves
Pump Controls (on/off)	P1: 853.0 / 852.0 P2: 854.0 / 853.0 P3: 853.5 / 852.5 P4: 867.0 / 866.0	Wet Well Set Point = 6.0 ft (same as P1 ON) All min speed set to 80% of max speed (Operation Mode A) Speed Range (all same): Min Speed: 1425 rpm Max Speed: 1780 rpm P4 is set to only come on when the wet well is going to overflow.
Weir Elevation to PEFTF (0103064.1)	856.97	Width = 4.0 ft; Coefficient = 0.85
Belinder PEFTF		
Wet Well Volume (gal) (Belinder Sluice Gate)	29,300	Approx. volume to chamber roof
Wet Well Floor Elevation (ft)	834.5	

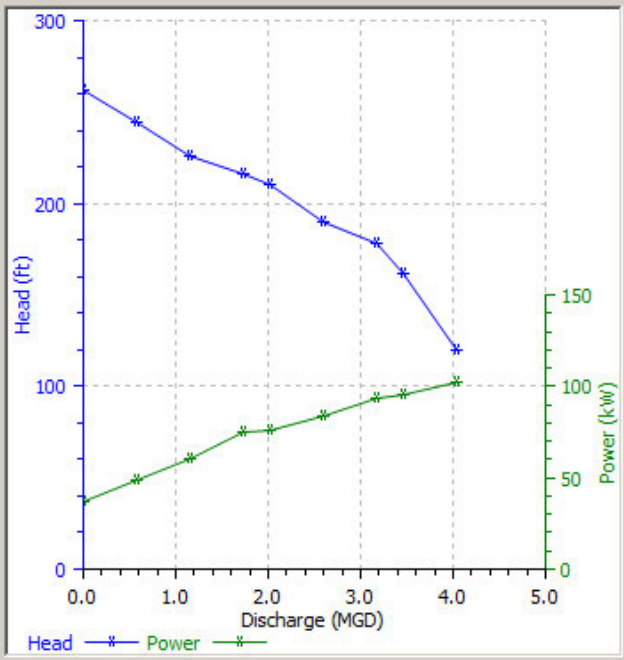
# of Pumps	2	Both modeled as VFD
Pump Capacity	PEFTF P1: BELINDER PEFTF PUMP 1 PEFTF P2: BELINDER PEFTF PUMP 1	See curve
Pump Controls (on/off)	PEFTF P1: 841.44 / 838.67 PEFTF P2: 841.91 / 839.13	Wet Well Set Point = 6.94 ft (same as P1 ON) Speed range (all same): Min Speed: 700 rpm Max Speed: 885 rpm
PEFTF Storage Volume (gal) (Belinder PEFTF Tank)	843,300	Approx. volume to weir elevation
PEFTF Floor Elevation (ft)	846.8	Not including bottom channel (bottom channel has IE = 838.0)
PEFTF Overflow Weir Elevation (Belinder PEFTF Tank.1)	859.0	Width = 19.2 ft; Coefficient = 0.85
PEFTF Drain Pump (Belinder PEFTF Tank.2)	Fixed @ 1 mgd	On / Off = 848.0 / 847.0

RTC

- If elevation in Belinder WW (0103002) >= 853.0 (depth > 6.0 ft) then Belinder Wastewater P1 , P2 or P3 speed increased by 5 rpm
- If elevation in Belinder WW (0103002) < 853.0 (depth < 6.0 ft) then Belinder Wastewater P1, P2 or P3 speed decreased by 5 rpm
- If elevation in Belinder PEFTF WW (Belinder Sluice Gate) >= 841.44 (depth > 6.94 ft) then Belinder PEFTF P1 or P2 speed increased by 5 rpm
- If elevation in Belinder PEFTF WW (Belinder Sluice Gate) < 841.44 (depth < 6.94 ft) then Belinder PEFTF P1 or P2 speed decreased by 5 rpm
- If elevation in PEFTF Storage (Belinder PEFTF Tank) > 846.8 (has water in it) AND elevation at the dry weather PS WW (0103002) < 853.0 then PEFTF Drain Pump ON
- If elevation in dry weather PS WW (0103002) > 855.0 then PEFTF Drain Pump OFF

Head discharge : BELINDER 1 & 3 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	262.0000	0.000	37.2900
2	244.0000	0.580	48.4700
3	226.0000	1.150	60.5900
4	216.0000	1.730	74.5700
5	210.0000	2.020	76.4300
6	190.0000	2.590	83.8900
7	178.0000	3.170	93.2100
8	162.0000	3.460	95.0800
9	120.0000	4.030	102.5300
*			



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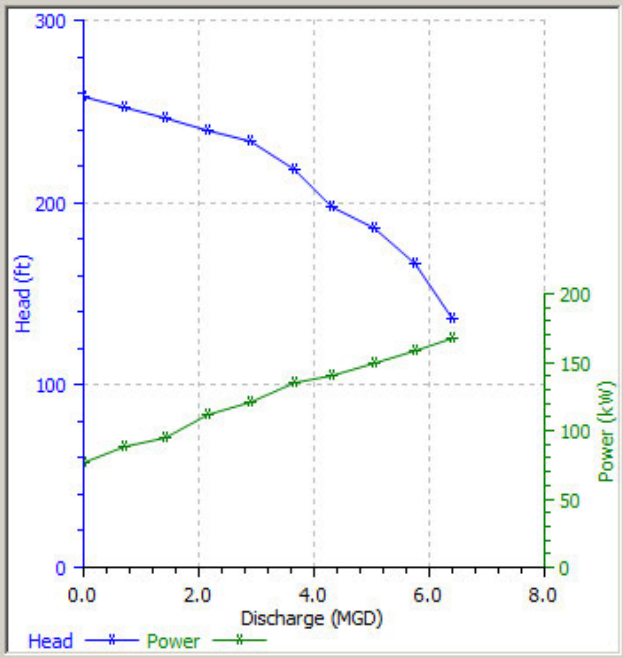
Head discharge : BELINDER 2 & 4 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	258.0000	0.000	76.4300
2	252.0000	0.700	88.5500
3	246.0000	1.400	95.4500
4	240.0000	2.160	111.8600
5	234.0000	2.880	121.1800
6	218.0000	3.670	135.1600
7	198.0000	4.320	139.8200
8	186.0000	5.040	149.1400
9	167.0000	5.760	158.4600
10	136.0000	6.410	167.7800
*			



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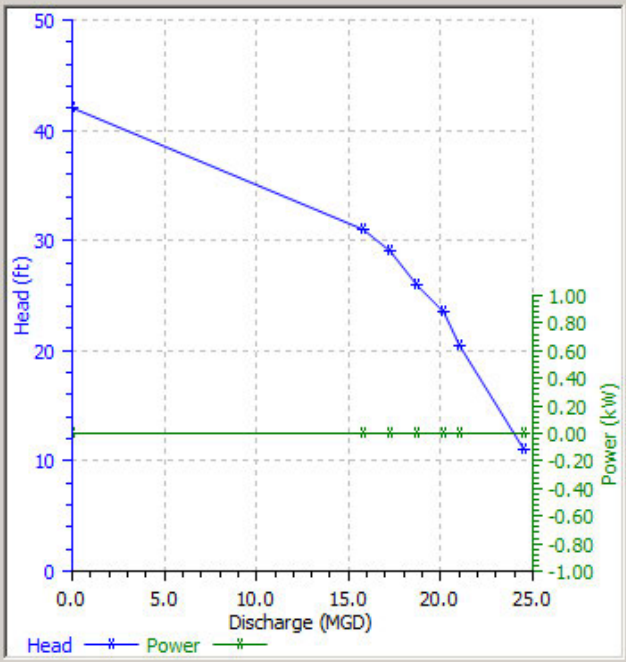
Head discharge : BELINDER PEFTF PUMP 1 : Head discharge power table

	Head (ft)	Discharge (MGD)	Power (kW)
1	42.0000	0.000	0.0000
2	31.0000	15.840	0.0000
3	29.0000	17.280	0.0000
4	26.0000	18.720	0.0000
5	23.5000	20.160	0.0000
6	20.5000	21.020	0.0000
7	11.0000	24.480	0.0000
*			



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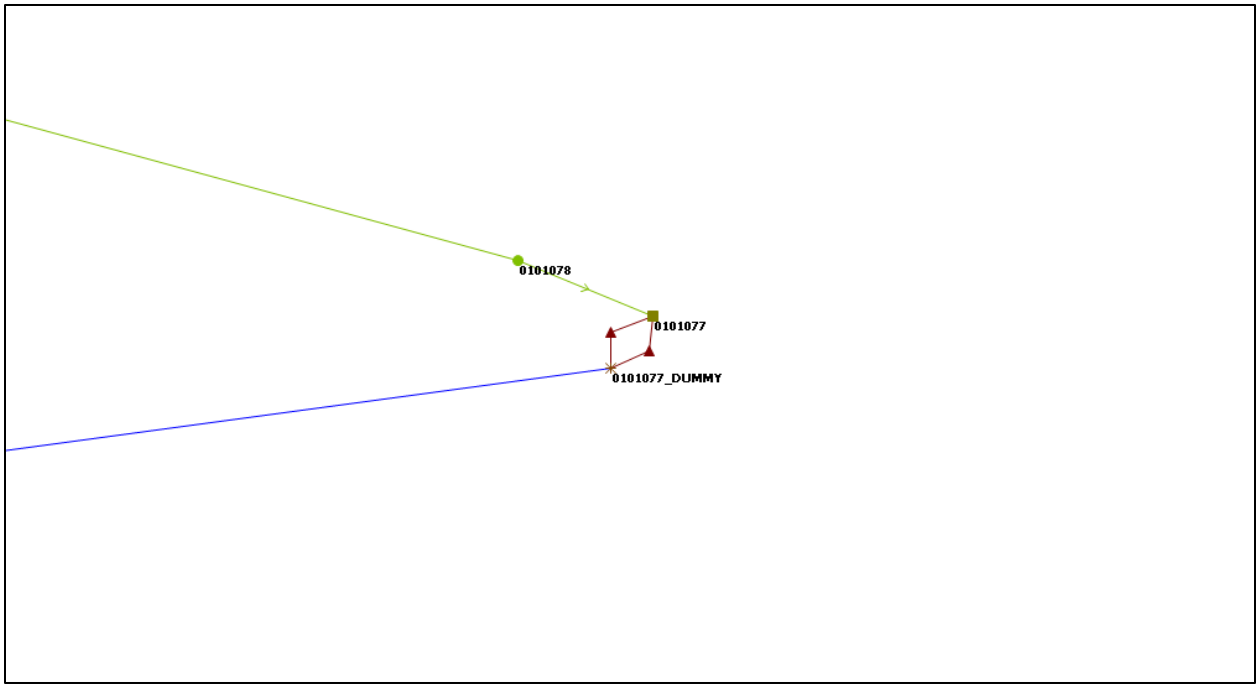
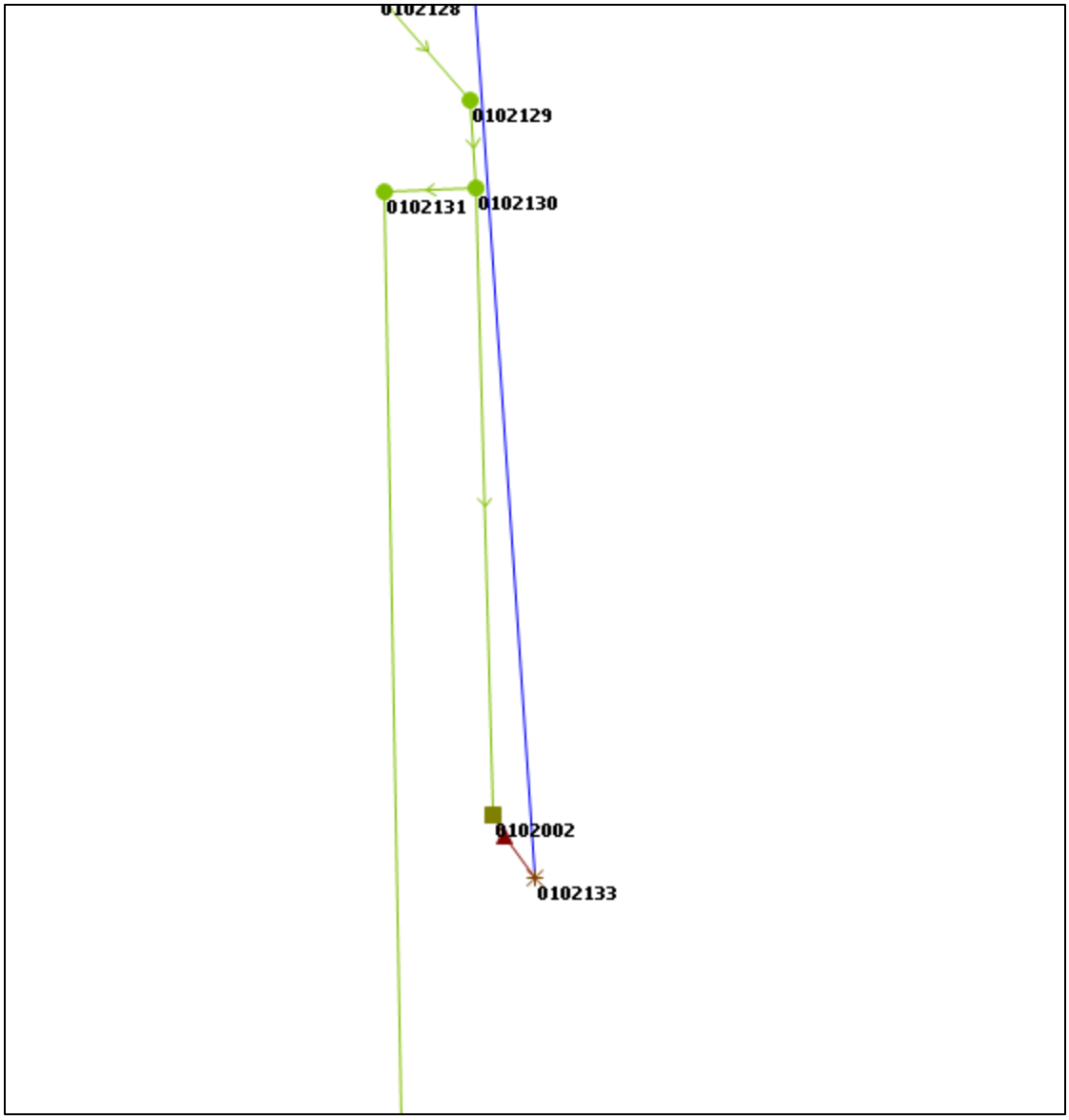
Mission Woods Lift Station



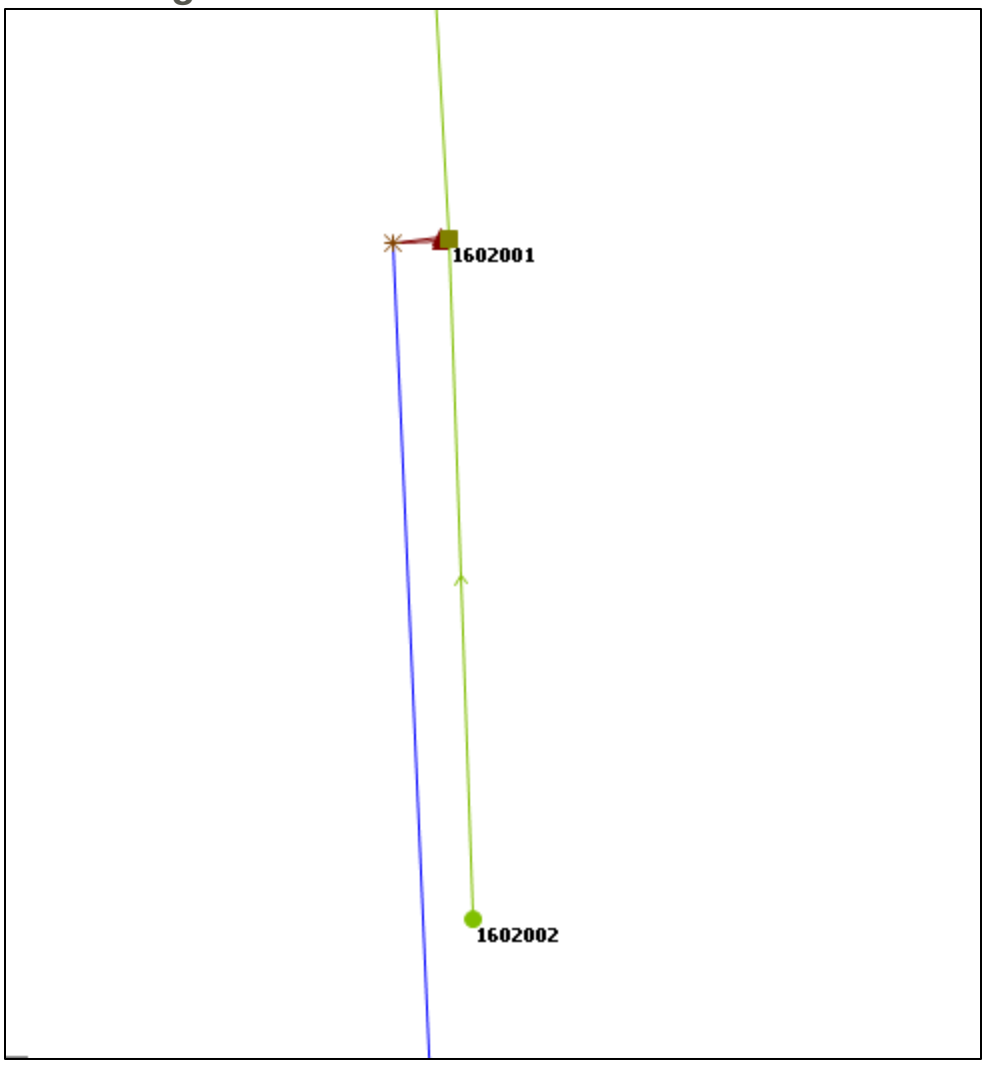
Parameter	Quantity	Notes
Wet Well Volume (gal)	2,600	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	843.17	
# of Pumps	2	Both modeled as FIXED
Pump Capacity	P1: 0.58 mgd P2: 0.58 mgd	
Pump Controls (on/off)	P1: 847.34 / 846.50 P2: 846.17 / 846.09	

Swatzell View



Parameter	Quantity	Notes
Wet Well Volume (gal)	20,100	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	903.75	
# of Pumps	1	Modeled as FIXED
Pump Capacity	P1: 1.63 mgd	
Pump Controls (on/off)	P1: 906.75 / 905.75	

Roe Village



Parameter	Quantity	Notes
Wet Well Volume (gal)	2,000	Approx. volume as defined by storage array
Wet Well Floor Elevation (ft)	947.10	
# of Pumps	2	Modeled as FIXED
Pump Capacity	P1: 0.22 mgd P2: 0.22 mgd	
Pump Controls (on/off)	P1: 952.10 / 949.60 P2: 951.27 / 948.77	

Nelson Complex Collection System Wet Weather Plan Technical Memorandum #3 Preliminary Optimization Findings and Alternatives Screening

September 2018

JOHNSON COUNTY KANSAS
Wastewater

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Appendix E PEFTF Refined Cost Curve Development

ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
GPD	Gallons per Day
GPM	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
MGAL	Million Gallons
MGD	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/l	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NH3-N	Ammonia Nitrogen
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
$Pro2D^2$	Professional Process Design and Dynamics Whole Plant Simulator by CH2M

PS	Pump Station
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

Note: Portions of the project approach and information presented in this technical memorandum (TM) were subsequently updated and new alternative naming conventions were adopted as the project progressed. Changes are noted in italics, where practicable. In general, information presented in TM 6 or the Phase 1 Integrated Management Plan supersedes conflicting information presented in this TM.

1 Introduction

1.1 Background & Purpose

The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two Wastewater Treatment Facility (WWTF) trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or discharge directly from the collection system to the creek after providing primary treatment and disinfection. In the Mission Main watershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flows to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow to the WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the WWTF. On the Turkey Creek side, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the WWTF.

JCW is developing a long term plan to address wet weather flows within the Turkey Creek and Mission Main watersheds. Several upgrade alternatives are being considered for both watersheds including:

- Conveyance Upgrades
  - Gravity
  - Pump Station/Forcemain
- Storage
  - Shallow Underground
  - Linear/Tunnel
- I/I Reduction
- PEFTF Upgrades
- Auxiliary Treatment at the Nelson Complex.

Optimization is being used as a tool in the planning process to identify the most cost-effective combination of these alternatives that will meet JCW's desired level of service (LOS). This technical memorandum (TM 3) serves to document the preliminary optimization approach (design criteria and preliminary unit costs), results from the preliminary optimization, alternatives screening, and cost refinements to be used in the refined optimization.

1.2 Optimization Approach

Optimization is an iterative process that begins with preliminary optimization and alternatives analysis. During preliminary optimization, all feasible alternatives were included in the analysis in order to complete a thorough evaluation of alternatives and complete the following objectives:

- Investigate a wide range of scenarios and sensitivities to identify consistent trends

- Evaluate potential level of service scenarios to establish incremental costs to achieve varying levels of service and identify common/divergent improvements required among scenarios
- Identify key assumptions/alternatives that require further refinement and screening prior to the final optimization
- Identify and screen likely sites for major improvements projects (e.g. storage facilities)
- Identify which cost assumptions are most sensitive, so they can be further refined in the final optimization analysis.

Three (3) level of service (LOS) scenarios were evaluated during preliminary optimization – Scenario 1A, Scenario 1B, and Scenario 2.

- Scenario 1A ("Base Case") requires a minimum LOS of 10 years for the collection system and a minimum LOS of 5 years for major facilities. In the base case, it is assumed that the PEFTFs will eventually be eliminated and not available for use during any wet weather event. In place of the PEFTFs, it is assumed that a Facility Protection Device (FPD) would be in place at each major remaining facility and may activate to protect the public and JCW facilities for events greater than 5-year storm. It is assumed that an FPD would be constructed at Rock Creek PS in lieu of the Martway PEFTF, and an FPD would be constructed at Turkey Creek PS in lieu of the Turkey Creek PEFTF. Scenario 1A has been termed "All Options, No PEFTFs" in this TM. *This alternative was ultimately referred to as Alternative 1: Eliminate PEFTFs through Wet Weather Management, or PEFTF Elimination.*

- Scenario 1B ("PEFTFs Remain"), like Scenario 1A, requires a 10 year minimum LOS for the collection system and a 5 year minimum LOS for facilities. In this scenario, it is assumed that the PEFTFs will be upgraded and remain in service indefinitely. The PEFTFs would provide a 5 year LOS, above which the Facility Protection Devices may activate. Scenario 1B has been termed "All Options, PEFTFs Remain" in this TM. *This alternative was ultimately referred to as Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment, or PEFTF Retention.*

- Scenario 2 requires a 10 year minimum LOS for the collection system and a 1 year minimum LOS for facilities. In this scenario, like the Base Case, it is assumed that the PEFTFs will be eliminated. Scenario 2 has been termed "All Options, No PEFTFs– 10/1" in this TM. *This alternative was not carried forward as a viable option after preliminary optimization.*

The optimization process was used to determine the most economical combination of improvements necessary to meet the LOS requirements set forth in each scenario. The results of the preliminary optimization were used to identify which alternatives and costs needed further evaluation and refinement. These updated alternatives and refined costs will be used for refined optimization.

1.3 TM Organization

This contents of this TM are organized into three sections. Section 2 and Section 3 describe the preliminary optimization analysis approach and findings. Section 2 includes design and performance criteria and preliminary unit costs for alternatives used in the preliminary optimization, while Section 3 includes the results from the preliminary optimization scenarios.

Section 4 describes the alternatives screening process and cost refinement for selected alternatives. This evaluation was presented to JCW during two workshops in August 2018. At these workshops,

several decisions were made and specific site alternatives were removed from further consideration. These decisions are documented in Section 4.

The refined alternatives and costs presented in Section 4 will be used in the refined optimization analysis.

2 Preliminary Optimization Design Data

This section describes the approaches followed during the preliminary optimization analysis, including the following:

- Design criteria
- Performance criteria and system constraints
- Alternatives evaluated
- Unit cost information and approach

2.1 Design & Performance Criteria

2.1.1 Conveyance Alternatives

Gravity sewer improvement alternatives were included for all existing gravity mains that had a 10 year-storm design flow exceeding the full pipe conveyance capacity. Sections of gravity sewer with relatively consistent design requirements were grouped to form a single parallel improvement option spanning several existing segments. For preliminary optimization, all gravity capacity improvements were assumed to be parallel lines.

Forcemain upgrade alternatives were integrated with pump station upgrade options. The forcemains were not included in the model and the cost of forcemain upgrades are calculated implicitly based on pump rate, the maximum allowable velocity of 6 fps and cost equations developed specifically for each forcemain.

Parallel pipe upgrades were assumed along existing alignments with most conveyance improvements assumed as 'open cut' construction. Trenchless costs were applied to alternatives that crossed arterial roads, streams, highway or railroads. The crossing lengths were determined through a GIS analysis and are documented in the detailed optimization solution summary spreadsheets (Appendix A).

Pump upgrade options were considered in increments up to the maximum possible 5-year design flow at facilities with an FPD (or up to the 1-year design flow in scenarios where that event is considered). New FPDs were included at Turkey Creek Pump Station and Rock Creek Pump Station. Pump station downgrade options were included to allow the optimization to avoid exceeding the assumed WWTF capacity (45 MGD for preliminary optimization, or 3:1 throughput). Pump capacity increments corresponded to the maximum capacity before a force main upgrade is triggered (based on consideration of existing force main size, parallel force main options and a maximum allowable velocity of 6 fps) up to a maximum capacity option corresponding to the 5-year design flow. The pump capacity options considered in the preliminary optimization at each facility are shown in Table 1. Note that the optimization can also control flow to the pump stations by selecting alternative combinations of storage and I/I reduction in the upstream catchment. The pumps are modelled as upper limiting capacity, variable speed pumps such that the maximum pump rate evaluated does not exceed the maximum inflow. Finer pump increments will be included in the refined optimization to allow for additional flow control alternatives.

Table 1: Pump Station Firm Capacity Options Considered (Preliminary Optimization)

Facility	Modelled Existing Capacity (MGD)	Pump Capacity Options Considered(1) (MGD)									
Belinder	11.6	6.6	15	17	20	34	54	**63.5**	66	81	**86.6**(2)
Brush Creek	6	9	11	15	21	**23.1**	-	-	-	-	-
Turkey Creek	27	22	33	38	45	**60.5**	-	-	-	-	-
Rock Creek	15.5	10.5	20	26	34	**48.5**	-	-	-	-	-
Swatzell	1.6	2.1	**2.8**	-	-	-	-	-	-	-	-
Roe Village	0.4	**0.7**	-	-	-	-	-	-	-	-	-

Notes: 1) Pump capacity options in **BOLD** represent maximum 5-year design flow
2) Belinder pump upgrade considered maximum 5-year design flow with and without Brush Creek complete diversion

2.1.2 Storage Facilities and Linear Storage

Two storage alternatives were considered within the optimization:

- Underground storage facilities; and
- Linear transport/storage options where suitable.

During preliminary optimization, underground storage was considered at all major facilities and at reasonable remote locations within the collection system. Locations considered for storage during preliminary optimization are presented for the Mission Main Watershed and Turkey Creek Watershed in Figure 1 and Figure 2, respectively.

Inflow to storage facilities was controlled by weir height options ranging from top of pipe up to 1 foot below the maximum allowable surcharge (considered in 1-foot increments). Storage facilities were modelled with effectively unlimited capacity and the cost of the storage calculated based on volume received. Small storage facilities with volumes less than 0.5 MG were costed as inline pipe storage but modelled as storage tanks.

Offline linear transport/storage alternatives were included at locations with suitable pipe grade and surface elevation. Inline linear transport/storage alternatives were also considered at all gravity improvement locations to allow the optimization to select large diameter options. They were modeled as offline, parallel large diameter gravity sewers, an example of which is presented in Figure 3. These facilities only operate in wet weather once the existing interceptor capacity is exceeded and have capacity to attenuate peak wet weather flows to reduce or eliminate downstream improvements. The linear storage sizes evaluated include 4, 6 and 8-foot diameter pipes, and twin barrel 6 and 8-foot diameter options.

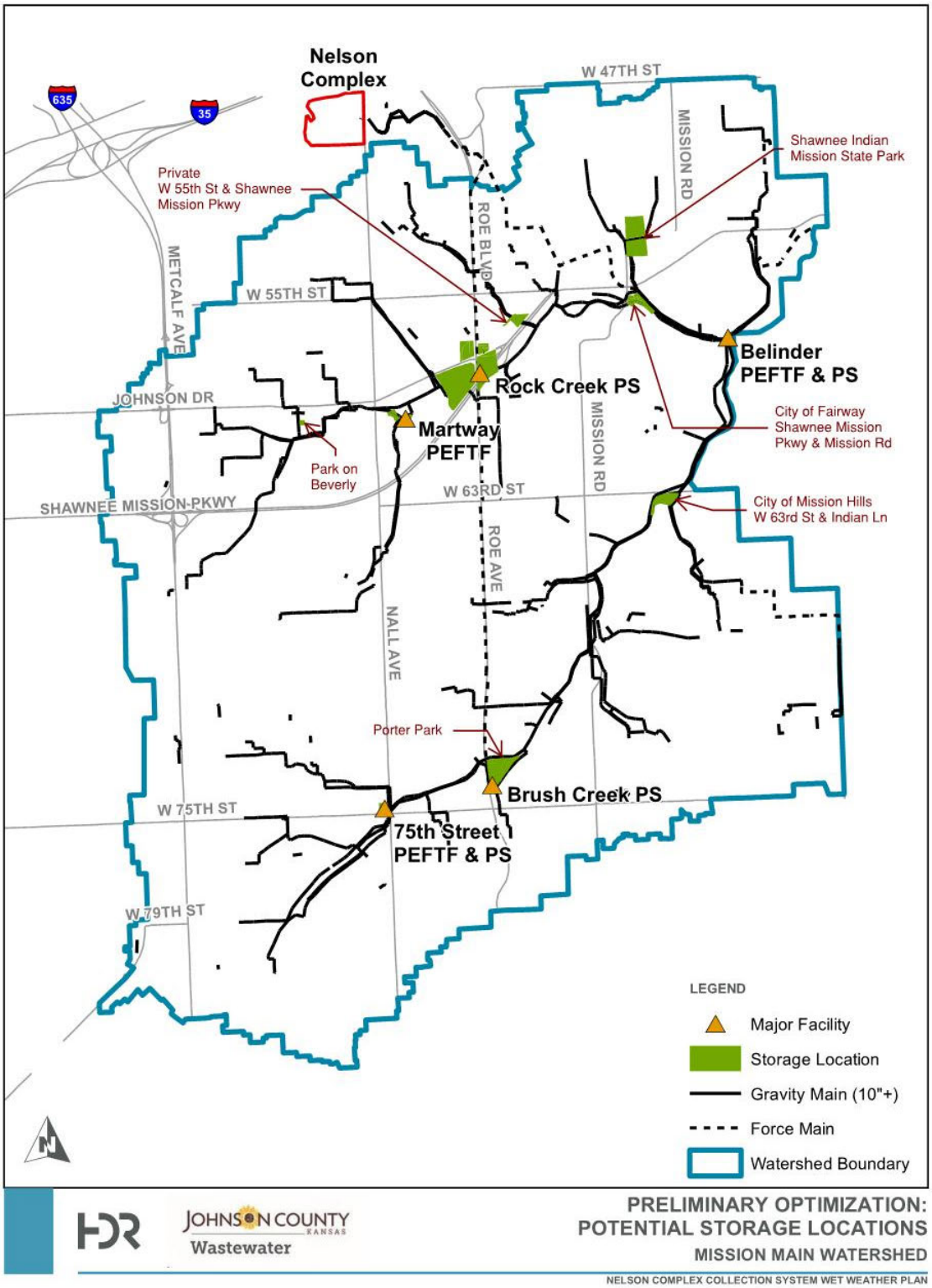


Figure 1: Mission Main Potential Storage Locations

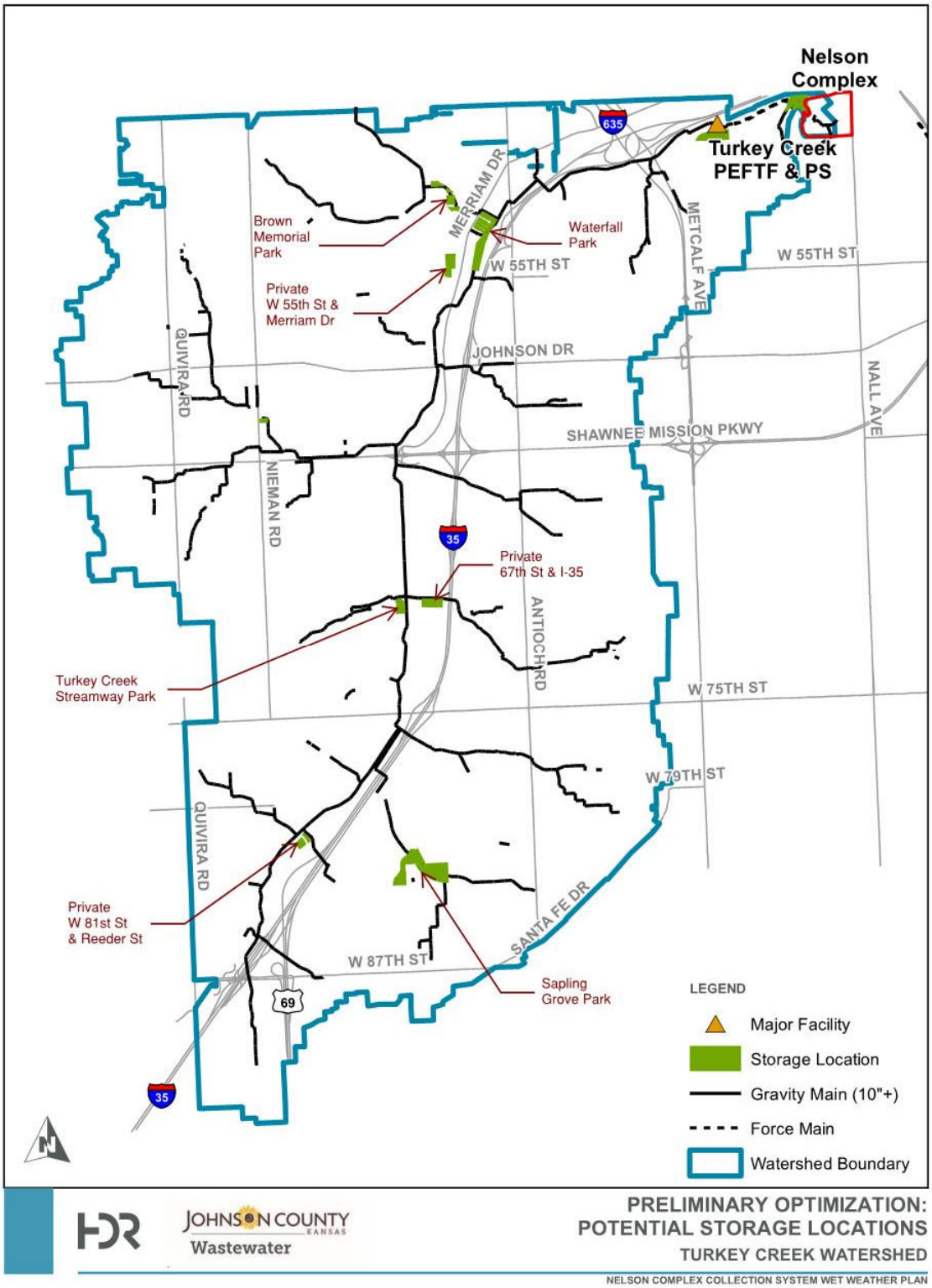


Figure 2: Turkey Creek Potential Storage Locations

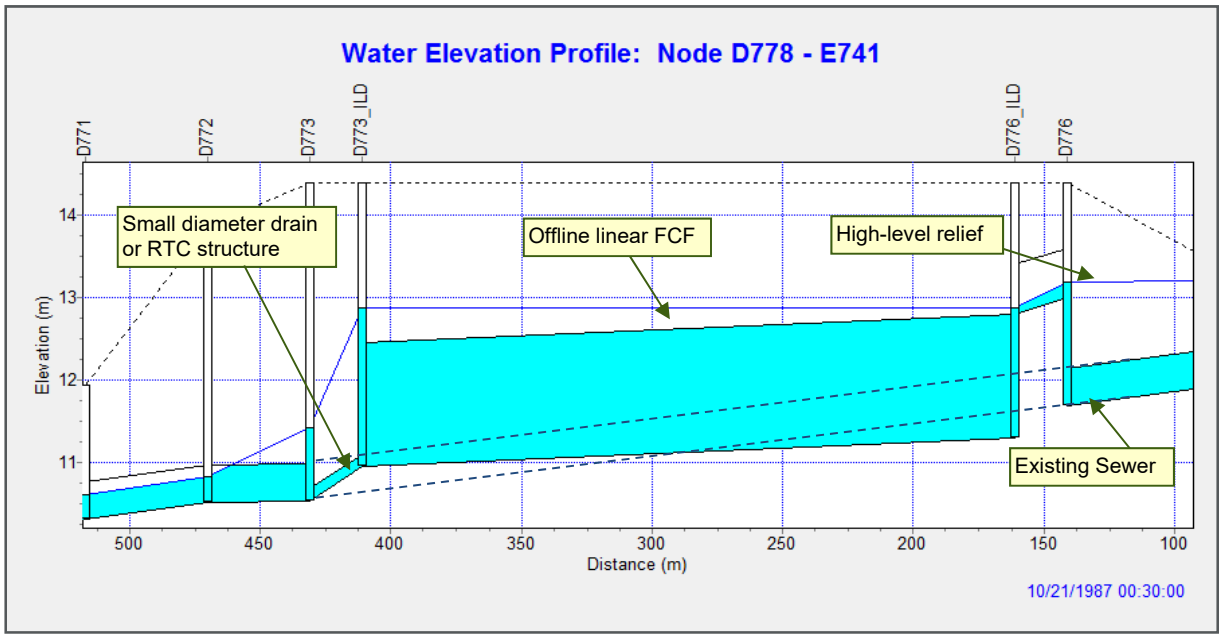


Figure 3: Example Profile of an Offline Linear Transport/Storage Facility

2.1.3 Inflow and Infiltration (I/I) Reduction

The optimization evaluated potential I/I reduction that could be achieved from the cost effective rehabilitation of public sector assets and the disconnection of private sector sources. There were 40 flow meter basins considered for I/I reduction, 29 in Mission Main and 11 in Turkey Creek. The optimization evaluated various I/I reduction percentages to determine the optimal balance between I/I reduction costs and downstream capacity upgrade costs.

Estimating the effectiveness of rehabilitation and the ability to implement both public and private rehabilitation carries a significant degree of uncertainty. As such, optimization of the Nelson Complex I/I reduction alternatives included a broad range of sensitivity analyses ranging from excluding I/I alternatives (to demonstrate maximum conveyance and storage requirements) to reducing the cost of I/I alternatives significantly (to demonstrate upper I/I reduction targets and minimum conveyance and storage requirements).

I/I reduction options are defined as a percentage reduction in wet weather inflow/infiltration within a flow meter basin. For example, a basin may be assigned I/I reduction options of 10%, 20%, and 30%. If the 10% reduction option is being trialed, then all wet weather inflow/infiltration hydrographs within the basin will be reduced by 10%. The percentage reduction applies to the entire hydrograph, thus reducing both peak and volume.

The maximum I/I reduction option considered for each basin was 30% based on the typical comprehensive strategy adopted by JCW, described in more detail in Section 2.2.5. I/I reduction options were considered in 5% increments up to the maximum allowable option.

2.1.4 Peak Excess Flow Treatment Facilities (PEFTFs)

Existing PEFTFs were considered for upgrade or decommissioning. No new PEFTFs were considered. The existing capacity of PEFTFs was neglected in the optimization and all PEFTF capacity alternatives were costed assuming an entirely new PEFTF structure. The range of PEFTF capacity options evaluated in the optimization are shown in Table 2**.** The maximum PEFTF capacity option considered was equal to the difference between the 5-year design flow (or the 1-year design flow in that scenario) and the minimum pump capacity option considered. The cost of PEFTFs is applied to the outfall from the existing storage tanks that part of the existing PEFTFs and therefore if the optimization selected to remove a PEFTF (by not allowing discharge at the outfall) then the existing storage tank capacity may still be utilized. Scenarios were run with and without PEFTF alternatives included.

Table 2: PEFTF Capacity Options Considered (Preliminary Optimization)

Facility	Modeled Existing Capacity (MGD)	PEFTF Capacity Options Considered (MGD)									
Belinder	42	5	10	15	20	30	40	60	65	70	75
Turkey Creek	22	5	10	15	25	28	31	35.5	-	-	-
75th/Nall	20	5	10	15	20	-	-	-	-	-	-
Martway	20	5	10	15	20	-	-	-	-	-	-

2.1.5 Auxiliary Treatment Facility

A new auxiliary treatment facility (ATF) was considered at the Nelson Complex for all wet weather flows exceeding the proposed peak secondary treatment capacity of the Nelson WWTF. For the preliminary optimization analysis described in Section 2 and Section 3, it was assumed that all flows beyond 45 MGD will be treated through auxiliary treatment; this corresponds with 3:1 throughput of the average day flow for the dry weather treatment processes at the WWTF.

2.1.6 20-Year Present Value Cost Approach

Improvement alternatives were compared in the optimization using a 20-year net present value (NPV) economic analysis. The NPV formula and respective parameters used to calculate the life-cycle cost of improvement projects for comparison of alternatives is shown below:

$$Present\ Value\ (PV) = \frac{1 - (1 + net\ discount\ rate)^{-asset\ life}}{net\ discount\ rate}$$

Economic analysis criteria used for the NPV analysis were derived from the Office of Management and Budget (OMB) Circular A-94 App. C, November 2017:

- Annual Inflation = 2.00%
- Net Discount Rate = 0.20%
- Nominal Discount Rate = 2.20%

2.1.7 Design Criteria Summary

A summary of the design criteria used in preliminary optimization is shown in Table 3. It describes the ranges and constraints assigned to each optimization alternative. The costs mentioned in the table are described in detail in Section 2.2.

Table 3: Preliminary Optimization Design Criteria

Category	Design Criteria & Assumptions
Parallel Pipe Options	Pipe diameter alternatives ranging from 1' to 6'. Capital costing based on gravity sewer cost tables with increased costs included for trenchless crossings.
Storage Facilities	All preliminary options considered will be assumed as below ground storage.
Linear/Tunnel Storage	Pipe diameter alternatives ranging from 3' to 12' with same cost methodology used for gravity sewers.
Pump Station Upgrades	Pump Station upgrades will utilize a cost curve during Preliminary Optimization. During Refined Optimization, the analysis will be refined to determine what the maximum output of the existing facility is and define the “break point” where a new facility will be required and costs will jump substantially.
Force Main	A maximum velocity of no more than 6 fps will be assumed, beyond that a new or parallel force main will be required.
I/I Reduction Option	Typical Comprehensive Rehab Strategy assumed (rehab pipes, manholes, and remove building direct connections) – maximum I/I reduction of 30% assumed. Costs curves specific for Mission Main and Turkey Creek basins were developed from the Pilot Study findings.
WWTF	Auxiliary Treatment Facility Cost Curves – Based on recent similar projects
Surcharge	Surcharge limited to 10 feet below the ground surface. Localized variances will be identified near facilities and shallow lines (e.g. creek crossing) and will be addressed on a case-by-case basis.
Present Value Costing	20-yr cost analysis period – Based on most recent OMB Circular A-94 Appendix C.

2.2 Preliminary Optimization Unit Cost Rates

Unit cost rates were developed for each alternative, as presented in the following sub-sections. All costs presented herein are shown in 2018 dollars.

2.2.1 Gravity Mains

Preliminary gravity sewer unit costs are detailed in Table 4. The base cost assumes residential, open cut construction. Costs include complete installation of pipes, manholes, ancillary structures, and surface restoration. Capital costs include 25% engineering, admin, and legal and 30% contingency.

Table 4: Gravity Sewer Costs

	Trench Depths < 10 Feet					
	Base - Residential		Crossing Adjustments (Applied to Individual Line Segments)			
Size (IN)	Construction Cost (2018$/LF)	Capital Cost (2018$/LF, SCF = 1.625)	Capital Cost - Arterial Crossing (1.15)	Capital Cost - Stream Crossing (3)	Capital Cost - Highway Crossing (5)	Capital Cost - Railroad Crossing (7)
6	$95	$154	$178	$463	$772	$1,081
8	$127	$203	$237	$618	$1,029	$1,441
10	$158	$253	$296	$772	$1,287	$1,801
12	$171	$274	$320	$834	$1,389	$1,945
15	$184	$294	$343	$895	$1,492	$2,089
18	$196	$314	$367	$957	$1,595	$2,233
21	$228	$365	$426	$1,112	$1,853	$2,594
24	$260	$415	$485	$1,266	$2,110	$2,954
27	$310	$497	$580	$1,513	$2,522	$3,530
30	$361	$578	$675	$1,760	$2,933	$4,107
36	$431	$689	$805	$2,100	$3,499	$4,899
42	$507	$811	$947	$2,470	$4,117	$5,764
48	$576	$922	$1,077	$2,810	$4,683	$6,556
54	$646	$1,034	$1,207	$3,149	$5,249	$7,349
60	$716	$1,145	$1,337	$3,489	$5,815	$8,141
72	$1,146	$1,834	$2,142	$5,589	$9,315	$13,040
78	$1,311	$2,098	$2,450	$6,392	$10,653	$14,914
84	$1,488	$2,381	$2,782	$7,256	$12,094	$16,931
90	$1,653	$2,645	$3,089	$8,059	$13,432	$18,804

Notes:
1. Includes complete installation of pipes, MHs, and other ancillary structure and surface restoration
2. Service and Contingency Factor (SCF) of 1.625 used to cover EAI (25%) and contingency (30%)
3. See below for Trench Depth and Crossing Factor Cost Factor Tables. Factors are applied to Construction Costs, Prior to applying SCF

Trench depth cost factors were applied to account for depth of construction. Trench depth cost factors are presented in Table 5.

Table 5: Sewer Trench Depth Cost Factors

Depth (ft)	Cost Factor
<10 ft	1
10 ft - 15 ft	1.25
15 ft - 20 ft	1.5

Crossing factors were applied to account for increased cost of construction when sewer mains are constructed across or in arterial roads, streams, highways, or railroads. A spatial analysis was conducted to identify all potential locations of conveyance improvement where crossing factors should be applied. Crossing type cost factors are presented in Table 6.

Table 6: Sewer Crossing Type Cost Factor

Crossing Type	Cost Factor
Residential	1
Arterial	1.15
Stream	3
Highway	5
Railroad	7

2.2.2 Forcemains

Preliminary forcemain unit costs are detailed in Table 7. The base costs assume residential, open cut construction. Costs include complete installation of pipes, manholes, ancillary structures, and surface restoration. Capital costs include 25% engineering, admin, and legal and 30% contingency. Sewer trench depth and crossing type cost factors were applied where appropriate, as described in the previous section.

Table 7: Forcemain Costs

	Trench Depths < 10 Feet					
Size (ID, IN)	Base - Residential		Crossing Adjustments (Applied to Individual Line Segments)			
	Construction Cost (2018$/LF)	Capital Cost (2018$/LF, SCF = 1.625)	Capital Cost - Arterial Crossing (1.15)	Capital Cost - Stream Crossing (3)	Capital Cost - Highway Crossing (5)	Capital Cost - Railroad Crossing (7)
8	$108	$176	$202	$527	$878	$1,229
10	$135	$219	$252	$658	$1,097	$1,536
12	$162	$263	$303	$790	$1,317	$1,844
14	$189	$307	$353	$922	$1,536	$2,151
16	$216	$351	$404	$1,053	$1,756	$2,458
20	$270	$439	$505	$1,317	$2,195	$3,073
24	$324	$527	$606	$1,580	$2,634	$3,687
30	$405	$658	$757	$1,975	$3,292	$4,609
36	$486	$790	$909	$2,370	$3,951	$5,531
48	$648	$1,053	$1,211	$3,160	$5,267	$7,374
54	$729	$1,185	$1,363	$3,555	$5,926	$8,296
60	$810	$1,317	$1,514	$3,951	$6,584	$9,218

Notes:
1. Includes complete installation of pipes, MHs, and other ancillary structure and surface restoration
2. Service and Contingency Factor (SCF) of 1.625 used to cover EAI (25%) and contingency (30%)
3. See below for Trench Depth and Crossing Factor Cost Factor Tables. Factors are applied to Construction Costs, Prior to applying SCF

2.2.3 Pump Stations

Preliminary pump station replacement costs were based on several recent local HDR projects, including the Tomahawk Creek WWTF peak flow pump station and influent pump station upgrade. The pump station replacement cost curve is presented in Figure 4. The following cost formula was developed for pump station replacements:

$$20yr\ PV\ \$ = \left(-0.0028 * {Q_{max}}^2 + 0.5457 * Q_{max} + 0.7327\right) * 10^6$$

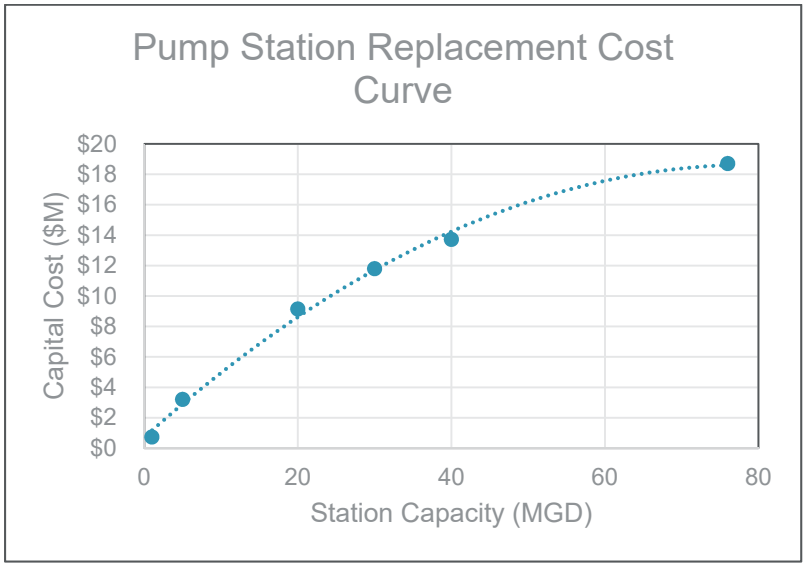


Figure 4: Pump Station Replacement Capital Cost Curve

Pump station expansion costs were assumed to be about 15% less than replacement. The pump station expansion cost curve is presented in Figure 5. For preliminary optimization, all pump station upgrades were assumed to be expansion. The following cost formula was developed for pump station expansions:

$$20yr\ PV\ \$ = \left(-0.0024 * {Q_{max}}^2 + 0.4779 * Q_{max} + 0.6228\right) * 10^6$$

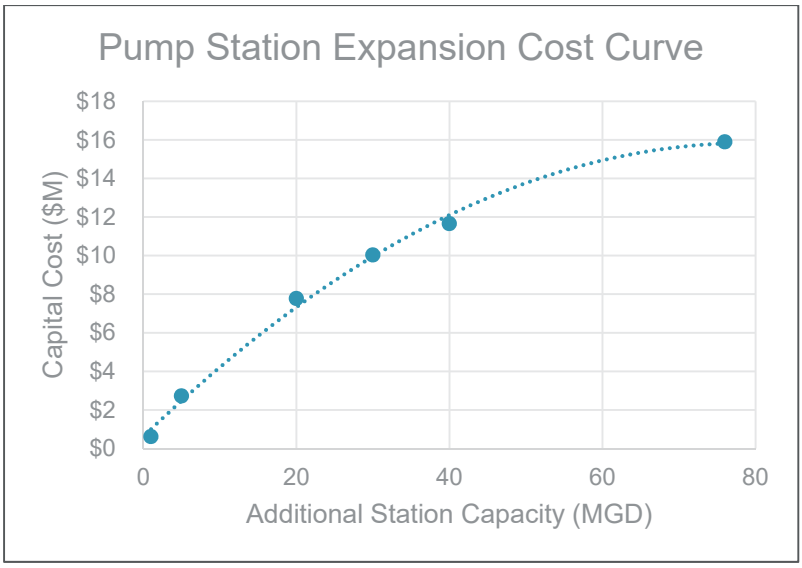


Figure 5: Pump Station Expansion Capital Cost Curve

2.2.4 Storage

Shallow underground storage unit costs are detailed in Table 8. Capital costs include 25% engineering, admin, and legal and 30% contingency. The following cost formula was developed for underground storage:

$$20yr\ PV\ (incl.\ pump\ \&\ storage)\ \$ = \frac{3.8215}{133680.6} * V + 4.1926 * 10^6$$

Table 8: Storage Facility Costs

Storage Facility Costs				
Volume (MG)	**Construction Cost - Underground Storage (Millions 2018$)**	**Capital Cost - Underground Storage (Millions 2018$,1.625 SCF)**	**Pump Station Construction Cost (Millions 2018$)**	**Pump Station Capital Cost (Millions 2018$,1.625 SCF)**
1	$3.4	$5.5	$1.2	$2.0
5	$12.4	$20.1	$1.7	$2.7
10	$23.6	$38.4	$2.3	$3.7
15	$34.9	$56.7	$2.8	$4.6
20	$46.1	$75.0	$3.4	$5.5
25	$57.4	$93.3	$4.1	$6.6
30	$68.7	$111.6	$4.6	$7.5
100	$224.0	$364.0	$12.6	$20.5

Notes:
1. Service and Contingency Factor (SCF) of 1.625 used to cover EAI (25%) and contingency (30%)

For preliminary optimization, linear/tunnel storage utilized gravity sewer costs presented in Section 2.2.1.

2.2.5 I/I Reduction

I/I reduction was considered within specific sub-basins in Mission Main and Turkey Creek. Utilizing the information developed through JCW's Pilot I/I Reduction Strategy project (Pilot I/I Study), unit cost curves for I/I reduction were developed and are shown in Figure 6 (Mission Main) and Figure 7 (Turkey Creek). The curves are based on a cost for percentage reduction per linear foot of sewer upstream of the point in the system to be evaluated. This method enables the evaluation of varying levels of I/I reduction on a sub-basin level – i.e., levels of I/I reduction can be evaluated for each sub-basin in order to identify the optimum level of I/I reduction at different locations within the system in conjunction with other combinations of improvement alternatives.

During the Pilot I/I Study, JCW determined that the "typical comprehensive" rehabilitation strategy was the most cost effective and preferred I/I reduction and system rehabilitation strategy. The typical comprehensive approach includes cost effective rehabilitation of pipes and manholes as well as disconnecting direct building connections. JCW's pipe and manhole rehabilitation programs (executed through the Collection System Asset Management Program) and private I/I source disconnection program utilize decision models aligned with this approach. This strategy is projected to provide a reduction of up to 30%. The unit cost of I/I reduction increases rapidly and becomes cost-prohibitive as the desired percentage of I/I reduction increases beyond this point. Therefore, to align with JCW's

programmatic approach to I/I reduction, a maximum of 30% I/I reduction was considered as the base case during preliminary optimization.

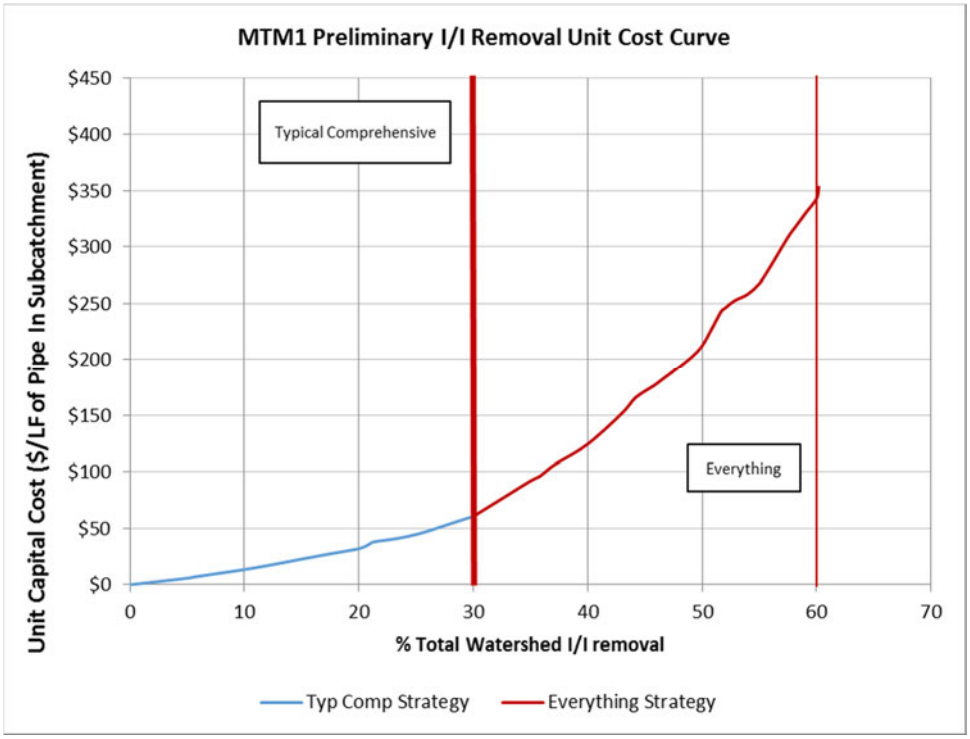


Figure 6: MTM1 Preliminary I/I Removal Unit Cost Curve

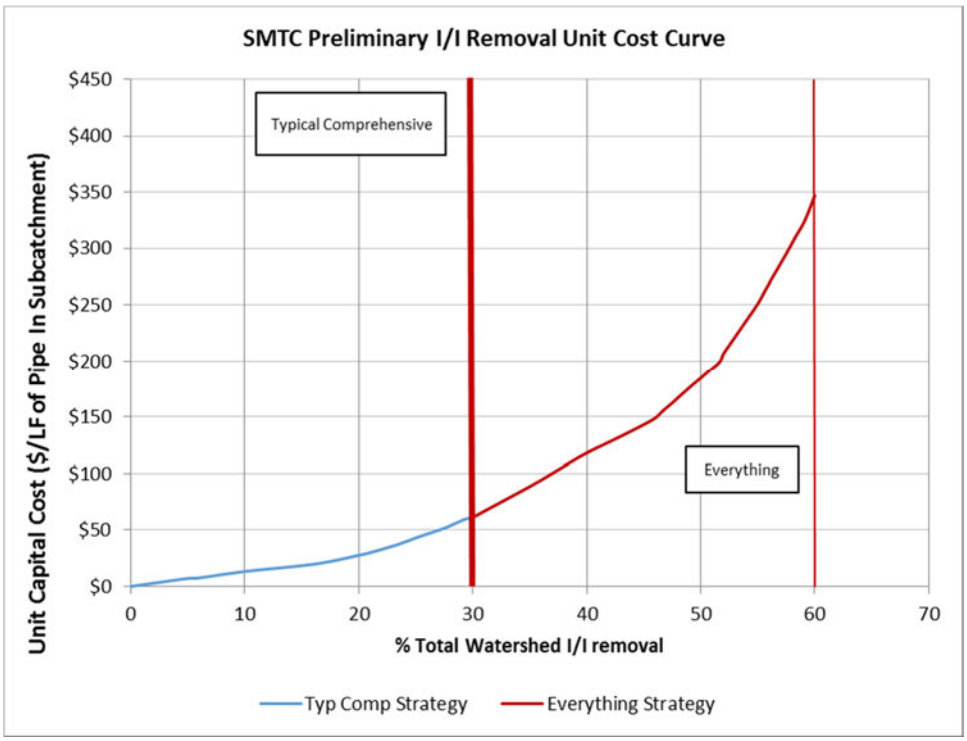


Figure 7: SMTC Preliminary I/I Removal Unit Cost Curve

JCW has completed extensive collection system rehabilitation since the last calibration of the Turkey Creek and Mission Main hydraulic models, which used flow data collected from 2009 - 2011. This includes both public sector rehabilitation of pipes and manholes, and ongoing private I/I source disconnections. These efforts may have resulted in I/I reduction within these basins that is not accounted for in the hydraulic models. This study will assume the current model calibration as the baseline level of I/I within the system for the purposes of the alternatives analysis. As recent and ongoing efforts to reduce I/I are completed and reduction levels are quantified, these efforts will be taken into account during the development of the implementation plan. *Quantification of ongoing public I/I reduction is discussed in Section 4.1.3 of this TM.*

2.2.6 PEFTFs

During preliminary optimization, it was assumed that, if selected, PEFTFs would be upgraded with more advanced treatment technology and design capacity may be modified. During preliminary optimization, the technology used for PEFTF upgrades was assumed to be the same technology (disc filters) that will be constructed at Tomahawk Creek (THC) WWTF for unit cost estimating purposes.

The preliminary capital cost curve for PEFTF upgrades is presented in Figure 8. The following cost formula was developed for PEFTF upgrades:

$$20yr\ PV\ \$ = \left(-0.0016 * {Q_{max}}^2 + 0.8267 * Q_{max} + 12.416\right) * 10^6$$

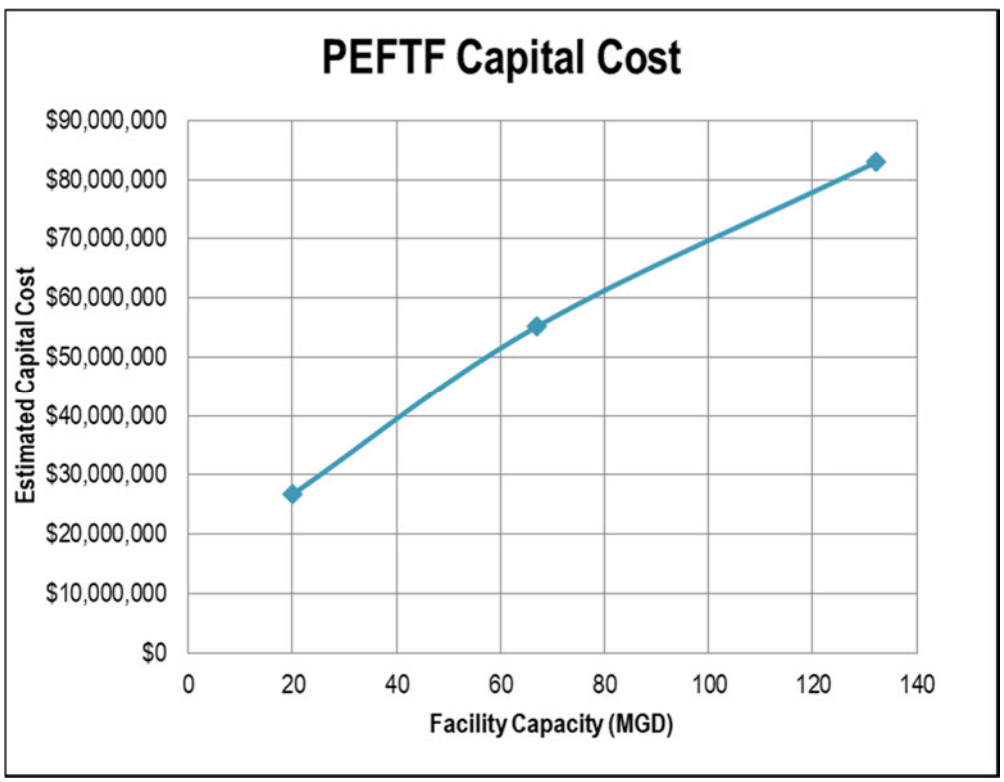


Figure 8: PEFTF Upgrade Capital Cost

2.2.7 Auxiliary Treatment Facility

An auxiliary treatment facility (ATF) was considered at the Nelson Complex. During preliminary optimization, the technology used in the ATF was assumed to be the same technology that will be

constructed at Tomahawk Creek (THC) WWTF for unit cost estimating purposes. The study will consider the disc filters used at the THC WWTF for primary treatment as well as other technologies, and disinfection using chlorination/dechlorination.

The preliminary capital cost curve for ATF is presented in Figure 9. The following cost formula was developed for ATF:

$$20yr\ PV\ \$ = \left(-0.0005 * {Q_{max}}^2 + 0.4916 * Q_{max} + 13.448\right) * 10^6$$

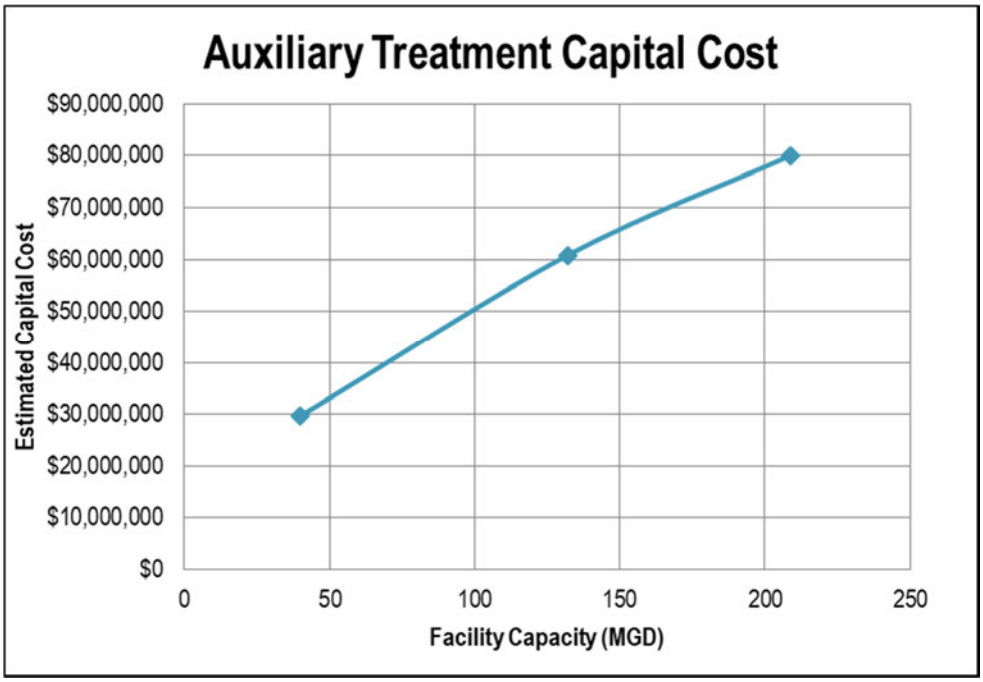


Figure 9: Auxiliary Treatment Capital Cost

2.2.8 Operations & Maintenance

In addition to capital costs, operations & maintenance (O&M) costs associated with each alternative were considered during preliminary optimization. The O&M components considered were electricity requirements, equipment requirements, and filter replacement. Routine maintenance (CCTV, cleaning, etc.) of gravity mains, forcemains, and storage tanks was not included as part of the optimization. O&M costs that were considered to be relatively even between alternatives (e.g. the chemical costs for treating wet weather flows through an ATF or PEFTF) were not included in the comparative analysis.

O&M costs used in the analysis are presented below in Table 9.

Table 9: Preliminary Annual O&M Costs

	Annual Cost ($/MGD)			
O&M Component	**Pump Station (Stand-Alone)**	**Pump Station (Storage Facility)**	**PEFTF**	**ATF**
Electricity Requirements	1,200	200	200	-
Equipment Replacement	3,600	600	600	-
Filter Replacement	-	-	3,300	3,300
All O&M	4,800	800	4,100	3,300

Notes:
1. O&M costs are only applied to additional capacity (not existing capacity)
2. Electrical costs are based on:
   a. 150' total dynamic head (TDH)
   b. Facility operating 5% of year (438 hours)
   c. $0.09/kWh electricity costs
3. PEFTF O&M costs are inclusive of pumping into PEFTF
4. JCW labor costs are assumed to be equal for all alternatives, for the purposes of preliminary optimization.
5. Chemical treatment costs are assumed to be equal for all alternatives (PEFTF, ATF, storage and treat at WWTF) for the purposes of preliminary optimization

3 Preliminary Optimization Results

Preliminary optimization runs were completed for the following scenarios:

- Conveyance Only – Optimization scenario without storage, PEFTF, or I/I reduction alternatives
- Conveyance and Storage - Optimization scenario without PEFTF or I/I reduction alternatives
- All Options, No PEFTFs – Optimization scenario without PEFTF alternatives
- All Options, PEFTFs Remain – Optimization scenario including all alternatives

The above optimization scenarios were completed for the 10-year/5-year design storm combination. That is, facility protection devices must contain the 5-year design storm but can discharge in the 10-year design storm and all other network improvements must be designed for the 10-year design storm. The All Options scenario (with and without PEFTF) was also evaluated for the 10-year/1-year design storm combination.

The optimization was initially formulated just for Turkey Creek. Rigorous testing and solution review was completed based on this formulation prior to formulating Turkey Creek and Mission Main in a combined optimization analysis. Optimization runs were completed with alternatives progressively included to enable a more comprehensive quality check of the results. By first evaluating the conveyance-only scenario, and then performing separate runs with storage, I/I reduction and PEFTF alternatives progressively included, it was possible to observe key trends and to verify the alternatives were being evaluated effectively.

3.1 Scenario 1A – 10-Year/5-Year, No PEFTFs (Base Case)

3.1.1 Conveyance Only

The Conveyance Only scenario was analyzed during the early stages of preliminary optimization in order to develop a baseline "convey and treat" scenario used to inform future analyses. This scenario restricted the optimization to allow only gravity, pump station, and forcemain upgrades. Storage and I/I reduction were not allowed in this scenario. The Conveyance Only scenario solution is presented in Figure 10. Costs for this scenario are provided in Table 10.

As shown on the figure, the FPDs at Turkey Creek PS, Belinder PS, and Rock Creek PS activate in this scenario. The volume discharged is approximately the volume difference between the 5-year and 10-year event. A 101 MGD ATF at the Nelson Complex WWTF is necessary to treat wet weather flows above 45 MGD.

Table 10: 10-Year/5-Year Conveyance Only Scenario Costs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost [1] ($M)	20-yr PV Total Cost [1] ($M)
Gravity Sewers	$ 65.69	$ -	$ 65.69
Pumping Station Upgrades	$ 35.33	$ 9.59	$ 44.91
Force Mains	$ 29.29	$ -	$ 29.29
Underground Storage Facilities	$ -	$ -	$ -
Linear Storages	$ -	$ -	$ -
PEFTF Upgrades	$ -	$ -	$ -
Inflow / Infiltration Reduction	$ -	$ -	$ -
Auxiliary Treatment Facility	$ 51.37	$ 6.51	$ 57.87
TOTAL	**$ 181.68**	**$ 16.09**	**$ 197.77**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

LEGEND

PROPOSED INFRASTRUCTURE

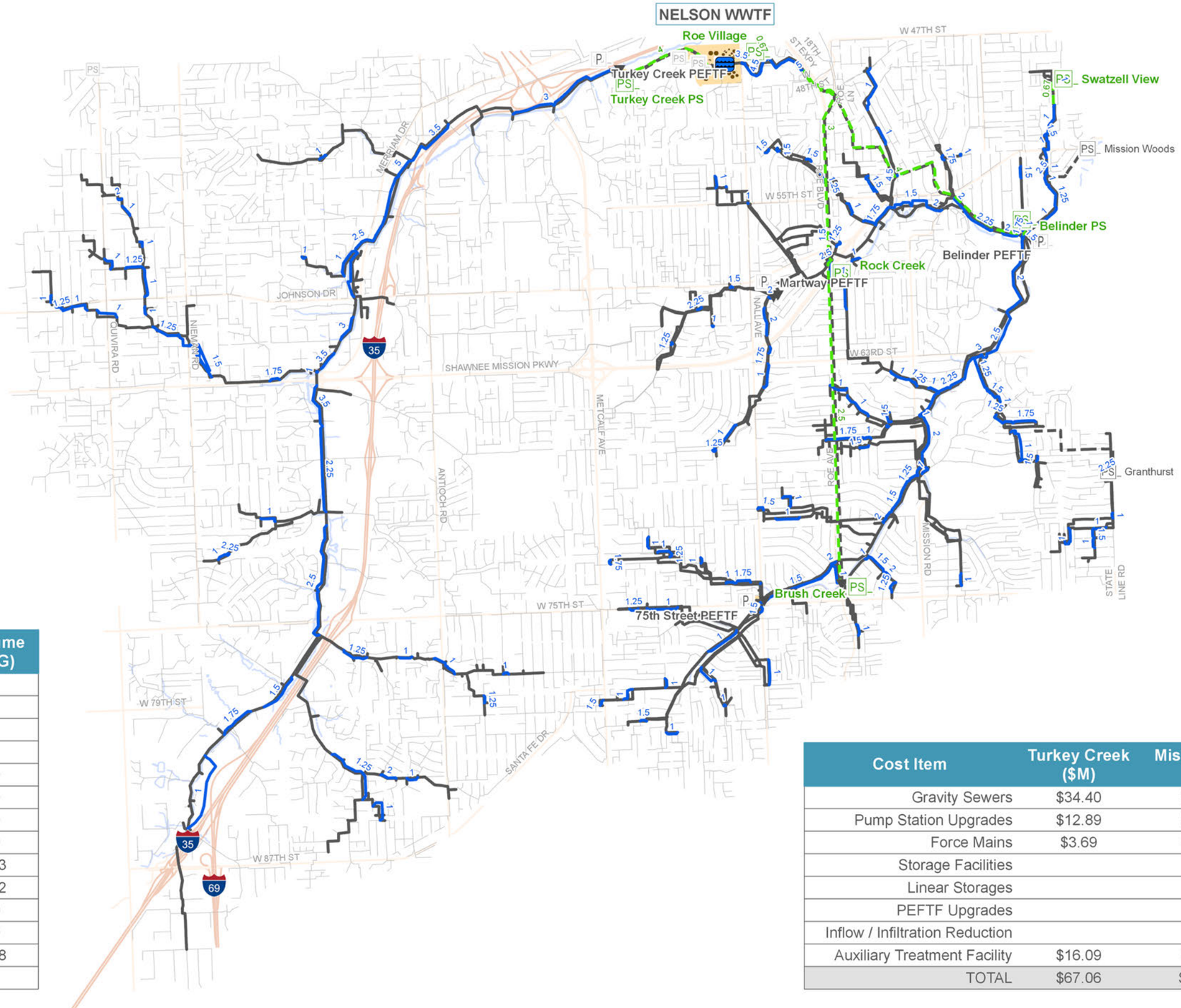
- Auxiliary Treatment Facility
- PS_ Pump Station Upgrade
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (MODELLED)

- PS_ Sewage Pumping Station
- P_ PEFTF
- Controlled Outfall
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (NOT MODELLED)

- PS_ Sewage Pumping Station
- Gravity Main
- Force Main



Infrastructure ID	Flow Rate (MGD)	Volume (MG)
Turkey Creek PS	57.3	
Belinder PS	54	
Brush Creek PS	15.5	
Rock Creek PS	34	
Turkey Creek PEFTF	0	0
Belinder PEFTF	0	0
Martway PEFTF	0	0
Nall & 75th PEFTF	0	0
Turkey Creek FPD	5.6	0.3
Belinder FPD	8	0.2
Brush Creek FPD	0	0
Martway FPD	0	0
Rock Creek FPD	6.5	0.8
Nelson Complex ATF	100.7	

Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$34.40	$31.29	$65.69
Pump Station Upgrades	$12.89	$32.03	$44.91
Force Mains	$3.69	$25.60	$29.29
Storage Facilities			
Linear Storages			
PEFTF Upgrades			
Inflow / Infiltration Reduction			
Auxiliary Treatment Facility	$16.09	$41.79	$57.87
TOTAL	$67.06	$130.71	$197.77

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NOTES:
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TURKEY CREEK PRELIMINARY OPTIMIZATION

5Y / 10Y CONVEYANCE ONLY

JCW-NC_GIS03

3.1.2 Conveyance and Storage Only

The Conveyance and Storage Only scenario restricted the optimization to allow gravity, pump station, and forcemain upgrades, with the addition of storage alternatives. I/I reduction was not included in this scenario. The Conveyance and Storage Only scenario solution is presented in Figure 11. Costs for this scenario are provided in Table 11.

As shown on the figure, storage was selected at two locations, at Turkey Creek PS and Belinder PS. The optimization selected these locations in order to avoid more costly conveyance upgrades. The FPDs at Turkey Creek PS, Belinder PS, and Rock Creek PS activated in this scenario. A 69 MGD ATF at the Nelson Complex WWTF is necessary to treat wet weather flows above 45 MGD.

Table 11: 10-Year/5-Year Conveyance and Storage Only Scenario Costs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost [1] ($M)	20-yr PV Total Cost [1] ($M)
Gravity Sewers	$ 65.10	$ -	$ 65.10
Pumping Station Upgrades	$ 27.82	$ 6.65	$ 34.47
Force Mains	$ 25.56	$ -	$ 25.56
Underground Storage Facilities	$ 24.94	$ 0.07	$ 25.01
Linear Storages	$ -	$ -	$ -
PEFTF Upgrades	$ -	$ -	$ -
Inflow / Infiltration Reduction	$ -	$ -	$ -
Auxiliary Treatment Facility	$ 40.55	$ 4.46	$ 45.02
TOTAL	**$ 183.98**	**$ 11.18**	**$ 195.16**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

LEGEND

PROPOSED INFRASTRUCTURE

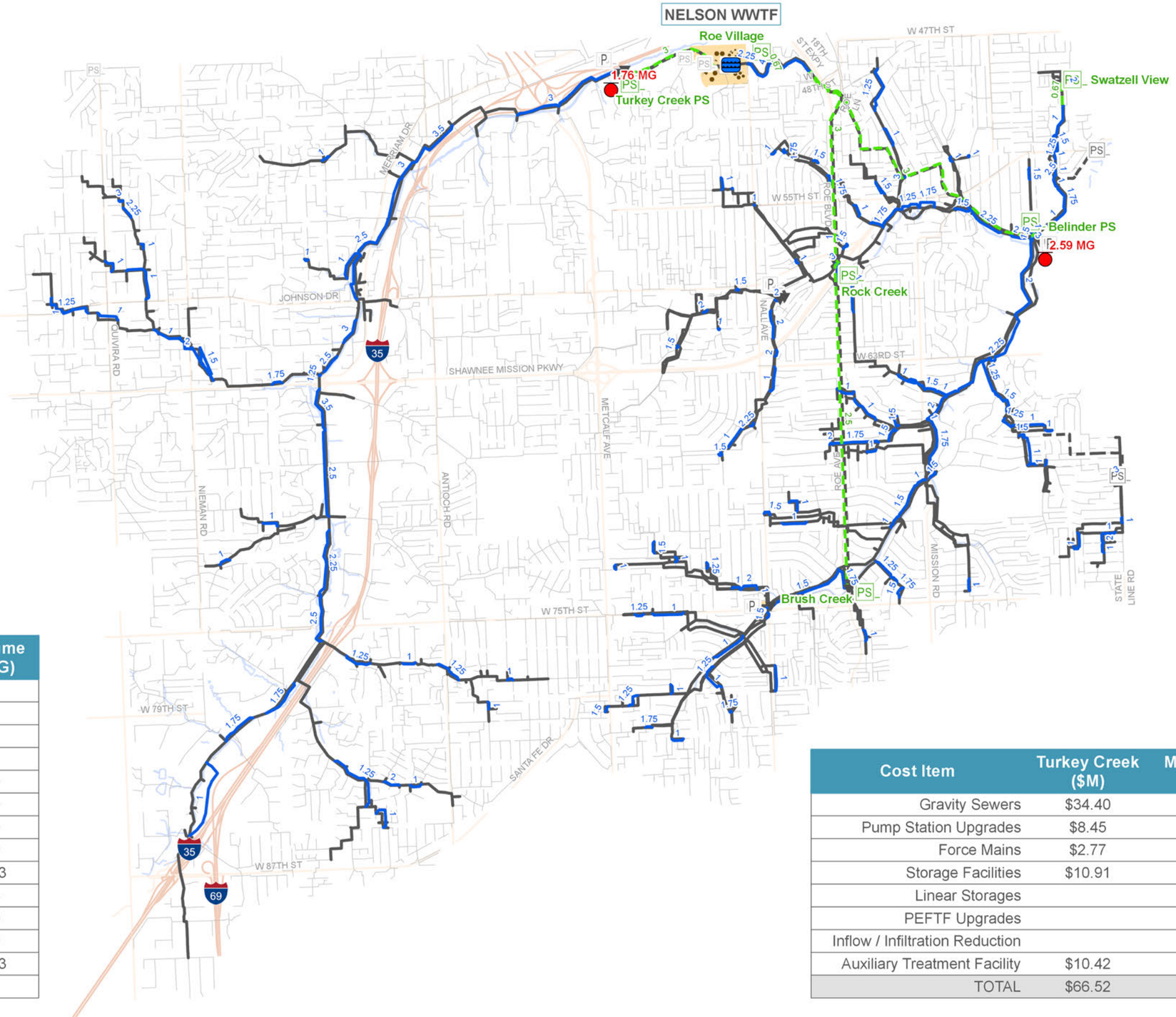
- Auxiliary Treatment Facility
- PS Pump Station Upgrade
- Underground Storage Facility
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (MODELLED)

- PS Sewage Pumping Station
- P PEFTF
- Controlled Outfall
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (NOT MODELLED)

- PS Sewage Pumping Station
- Gravity Main
- Force Main



Infrastructure ID	Flow Rate (MGD)	Volume (MG)
Turkey Creek PS	45	
Belinder PS	34	
Brush Creek PS	16.5	
Rock Creek PS	34	
Turkey Creek PEFTF	0	0
Belinder PEFTF	0	0
Martway PEFTF	0	0
Nall & 75th PEFTF	0	0
Turkey Creek FPD	6.5	2.3
Belinder FPD	13	3
Brush Creek FPD	0	0
Martway FPD	0	0
Rock Creek FPD	8.5	1.3
Nelson Complex ATF	69.1	

Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$34.40	$31.12	$65.10
Pump Station Upgrades	$8.45	$26.02	$34.47
Force Mains	$2.77	$22.80	$25.56
Storage Facilities	$10.91	$14.10	$25.01
Linear Storages			
PEFTF Upgrades			
Inflow / Infiltration Reduction			
Auxiliary Treatment Facility	$10.42	$34.60	$45.02
TOTAL	$66.52	$128.64	$195.16

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TURKEY CREEK PRELIMINARY OPTIMIZATION

5Y / 10Y CONVEYANCE AND STORAGE

JCW-NC_GIS05

3.1.3 All Options

The All Options scenario allowed the optimization to choose among all alternatives except PEFTFs. The All Options scenario solution is presented in Figure 12. Costs for this scenario are provided in Table 12.

In Turkey Creek, I/I reduction was selected between 15% and 20% reduction in four (4) meter basins near the top of the watershed. The selection of these particular basins for I/I reduction makes sense because wet weather flow from these basins impact relatively long sections of the trunk and interceptor sewer. Storage was selected at two (2) locations, a private site at 81st Street and Reeder Street and Shawnee Mission Streamway Park.

In Mission Main, I/I reduction was more widely selected throughout the watershed, between 5% and 30% reduction. Storage was selected at three (3) locations – 75th/Nall PEFTF, Brush Creek PS, and Rock Creek PS ("Mission Mall" site). Widespread I/I reduction, in conjunction with storage, was selected in order to avoid upgrading Brush Creek PS, Rock Creek PS, and their associated forcemains. Upgrades are still required at Belinder PS and the associated forcemain in this scenario.

The FPDs at all major facilities (Turkey Creek PS, Brush Creek PS, Rock Creek PS, and Belinder PS) activate in this scenario. A 51 MGD ATF at the Nelson Complex WWTF is necessary to treat wet weather flows above 45 MGD.

Table 12: 10-Year/5-Year All Options (No PEFTFs) Scenario Costs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost (1) ($M)	20-yr PV Total Cost (1) ($M)
Gravity Sewers	$ 30.01	$ -	$ 30.01
Pumping Station Upgrades	$ 15.45	$ 3.81	$ 19.26
Force Mains	$ 11.26	$ -	$ 11.26
Underground Storage Facilities	$ 53.85	$ 0.15	$ 53.99
Linear Storages	$ -	$ -	$ -
PEFTF Upgrades	$ -	$ -	$ -
Inflow / Infiltration Reduction	$ 30.33	$ -	$ 30.33
Auxiliary Treatment Facility	$ 33.76	$ 3.27	$ 37.03
TOTAL	**$ 174.65**	**$ 7.23**	**$ 181.88**

(1) Costs do not include operation and maintenance costs that are common among alternatives.

LEGEND

PROPOSED INFRASTRUCTURE

- Auxiliary Treatment Facility
- PS Pump Station Upgrade
- Underground Storage Facility
- Gravity Main
- Force Main

I/I Reduction

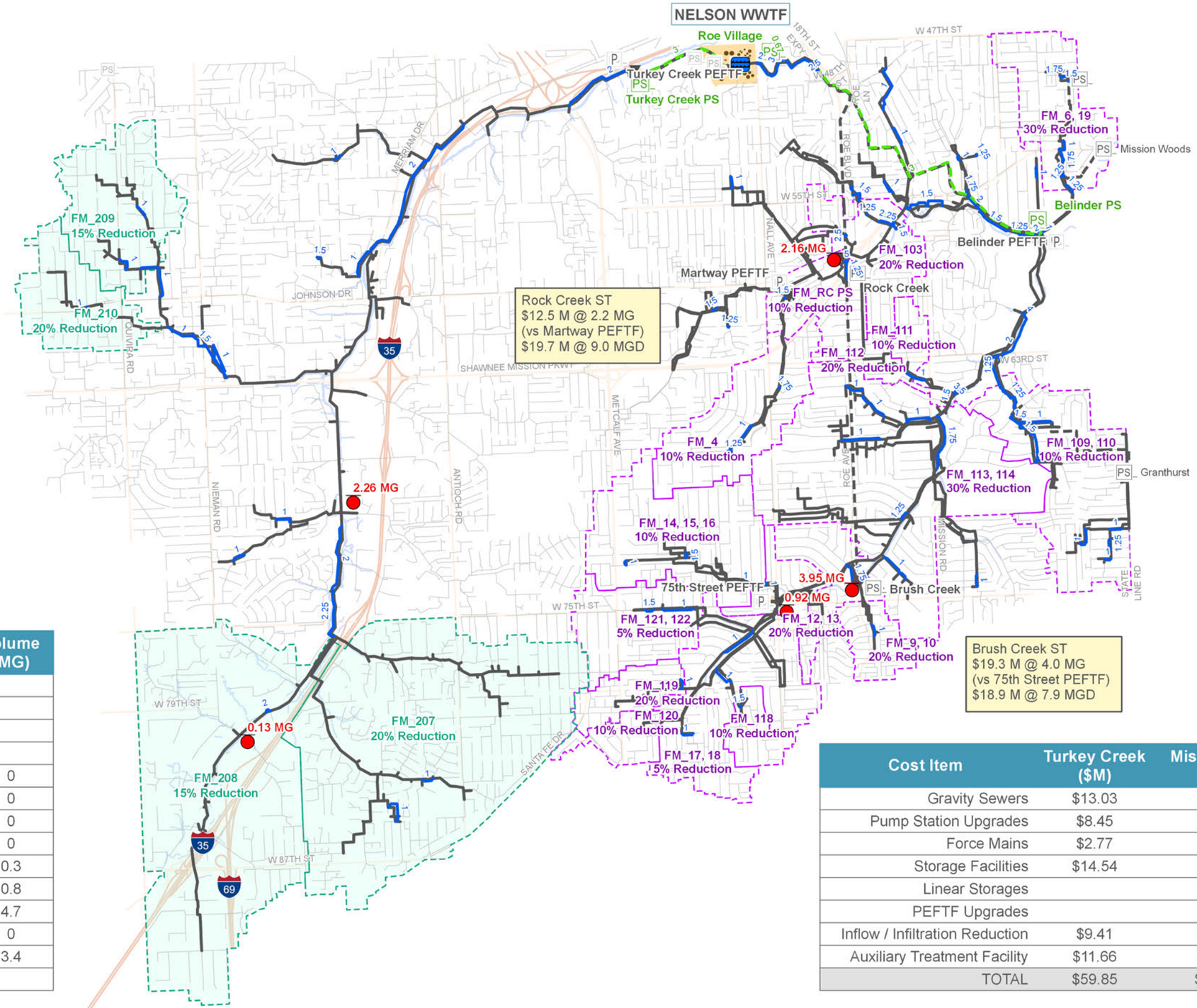
- Turkey Creek
- Mission Main

EXISTING INFRASTRUCTURE (MODELLED)

- PS Sewage Pumping Station
- P PEFTF
- Controlled Outfall
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (NOT MODELLED)

- PS Sewage Pumping Station
- Gravity Main
- Force Main



Infrastructure ID	Flow Rate (MGD)	Volume (MG)
Turkey Creek PS	45	
Belinder PS	34	
Brush Creek PS	6	
Rock Creek PS	15.5	
Turkey Creek PEFTF	0	0
Belinder PEFTF	0	0
Martway PEFTF	0	0
Nall & 75th PEFTF	0	0
Turkey Creek FPD	3.1	0.3
Belinder FPD	11	0.8
Brush Creek FPD	8.8	4.7
Martway FPD	0	0
Rock Creek FPD	12.8	3.4
Nelson Complex ATF	50.6	

Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$13.03	$16.98	$30.01
Pump Station Upgrades	$8.45	$10.82	$19.26
Force Mains	$2.77	$8.49	$11.26
Storage Facilities	$14.54	$39.45	$53.99
Linear Storages			
PEFTF Upgrades			
Inflow / Infiltration Reduction	$9.41	$20.92	$30.33
Auxiliary Treatment Facility	$11.66	$25.37	$37.03
TOTAL	$59.85	$122.03	$181.88

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NOTES:
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TURKEY CREEK PRELIMINARY OPTIMIZATION

5Y / 10Y ALL OPTIONS CONSIDERED

JCW-NC_GIS05

3.2 Scenario 1B – 10-Year/5-Year, PEFTFs Remain

The All Options with PEFTF scenario did not select PEFTFs and therefore produced the same solution as the scenario without PEFTFs. To produce a solution with PEFTFs included for comparison with the least-cost solution, an additional scenario was performed with storage alternatives at PEFTFs excluded.

An additional optimization scenario was also performed with the maximum discharge to Nelson Complex limited to 45 MGD to produce a solution that did not include the ATF. This scenario allowed a cost-effective analysis curve to be produced showing the relationship among the costs of the optimized scenario and the conveyance-only scenario.

PEFTF upgrades are cost-prohibitive in the optimized solution and only become feasible if ATF is not included as an alternative in the solution. In this scenario, Turkey Creek PEFTF and Belinder PEFTF were selected for improvements. A 13 MGD facility is required at Turkey Creek and a 47 MGD facility is required at Belinder. 75th/Nall PEFTF and Martway PEFTF were selected for decommission in favor of storage near Brush Creek PS and Rock Creek PS, however PEFTF upgrades were only slightly more expensive than storage. Costs for this scenario are provided in Table 13 and the solution figure is presented in Figure 13.

Table 13: 10-Year/5-Year All Options (PEFTFs Remain) Scenario Costs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost [1] ($M)	20-yr PV Total Cost [1] ($M)
Gravity Sewers	$ 32.16	$ -	$ 32.16
Pumping Station Upgrades	$ 0.68	$ 0.01	$ 0.69
Force Mains	$ 0.06	$ -	$ 0.06
Underground Storage Facilities	$ 70.30	$ 0.22	$ 70.51
Linear Storages	$ 2.00	$ -	$ 2.00
PEFTF Upgrades	$ 66.12	$ 4.86	$ 70.97
Inflow / Infiltration Reduction	$ 28.58	$ -	$ 28.58
Auxiliary Treatment Facility	$ -	$ -	$ -
TOTAL	**$ 199.89**	**$ 5.09**	**$ 204.98**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

LEGEND

PROPOSED INFRASTRUCTURE

- PS Pump Station Upgrade
- P PEFTF
- Underground Storage Facility
- Gravity Main
- Force Main
- Linear Storage

I/I Reduction

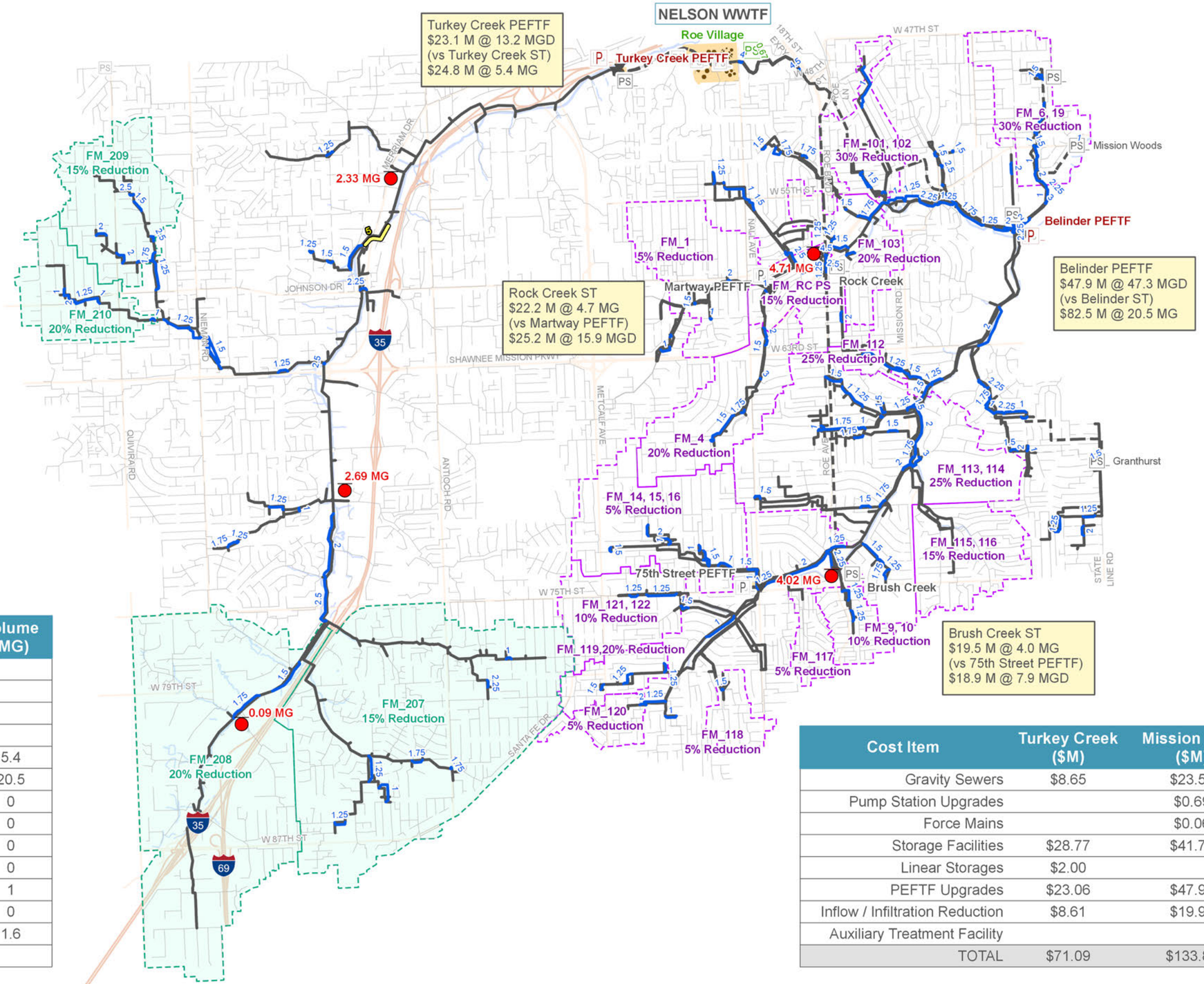
- Turkey Creek
- Mission Main

EXISTING INFRASTRUCTURE (MODELLED)

- PS Sewage Pumping Station
- P PEFTF
- Controlled Outfall
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (NOT MODELLED)

- PS Sewage Pumping Station
- Gravity Main
- Force Main



Infrastructure ID	Flow Rate (MGD)	Volume (MG)
Turkey Creek PS	27	
Belinder PS	6.6	
Brush Creek PS	6	
Rock Creek PS	10.5	
Turkey Creek PEFTF	13.2	5.4
Belinder PEFTF	47.3	20.5
Martway PEFTF	0	0
Nall & 75th PEFTF	0	0
Turkey Creek FPD	0	0
Belinder FPD	0	0
Brush Creek FPD	0.8	1
Martway FPD	0	0
Rock Creek FPD	4.6	1.6
Nelson Complex ATF	0	

Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$8.65	$23.51	$32.16
Pump Station Upgrades		$0.69	$0.69
Force Mains		$0.06	$0.06
Storage Facilities	$28.77	$41.74	$70.51
Linear Storages	$2.00		$2.00
PEFTF Upgrades	$23.06	$47.91	$70.97
Inflow / Infiltration Reduction	$8.61	$19.96	$28.58
Auxiliary Treatment Facility			
TOTAL	$71.09	$133.89	$204.98

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TURKEY CREEK PRELIMINARY OPTIMIZATION

5Y / 10Y ALL OPTIONS CONSIDERED (NO ATF UPGRADE)

JCW-NC_GIS05

3.3 Scenario 2 – 10-Year/1-Year, No PEFTFs

Scenario 2 was a 10-Year/1-Year All Options scenario in which the optimization was allowed to choose among all alternatives except PEFTFs. Gravity sewers were sized to convey the 10-year storm. Facilities were sized to convey the 1-year storm, with excess flows discharging through an FPD. The 10-Year/1-Year All Options scenario solution is presented in Figure 14. Costs for this scenario are provided in Table 14.

In Turkey Creek, the 10-Year/1-Year scenario solution is characterized mainly by conveyance upgrades. I/I reduction was selected in only one (1) meter basin at 5% reduction. Storage was not selected at any locations. Because the Turkey Creek PS is only required to convey the 1-year storm in this scenario, considerably more flow is discharged from the Turkey Creek FPD when compared to Scenario 1A – 10-Year/5-Year, No PEFTFs.

In Mission Main, the 10-Year/1-Year scenario solution is characterized by conveyance upgrades, storage, and I/I reduction. Storage was selected at Brush Creek PS, Rock Creek PS ("Mission Mall" site), and Belinder PS. Because the Belinder PS is only required to convey the 1-year storm in this scenario, considerably more flow is discharged from the Belinder FPD when compared to Scenario 1A – 10-Year/5-Year, No PEFTFs.

Table 14: 10-Year/1-Year All Options (No PEFTFs) Scenario Costs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost [1] ($M)	20-yr PV Total Cost [1] ($M)
Gravity Sewers	$ 57.23	$ -	$ 57.23
Pumping Station Upgrades	$ 9.30	$ 1.93	$ 11.24
Force Mains	$ 8.12	$ -	$ 8.12
Underground Storage Facilities	$ 28.59	$ 0.07	$ 28.65
Linear Storages	$ -	$ -	$ -
PEFTF Upgrades	$ -	$ -	$ -
Inflow / Infiltration Reduction	$ 12.92	$ -	$ 12.92
Auxiliary Treatment Facility	$ 25.43	$ 1.88	$ 27.30
TOTAL	**$ 141.59**	**$ 3.88**	**$ 145.46**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

LEGEND

PROPOSED INFRASTRUCTURE

- Auxiliary Treatment Facility
- PS Pump Station Upgrade
- Underground Storage Facility
- Gravity Main
- Force Main

I/I Reduction

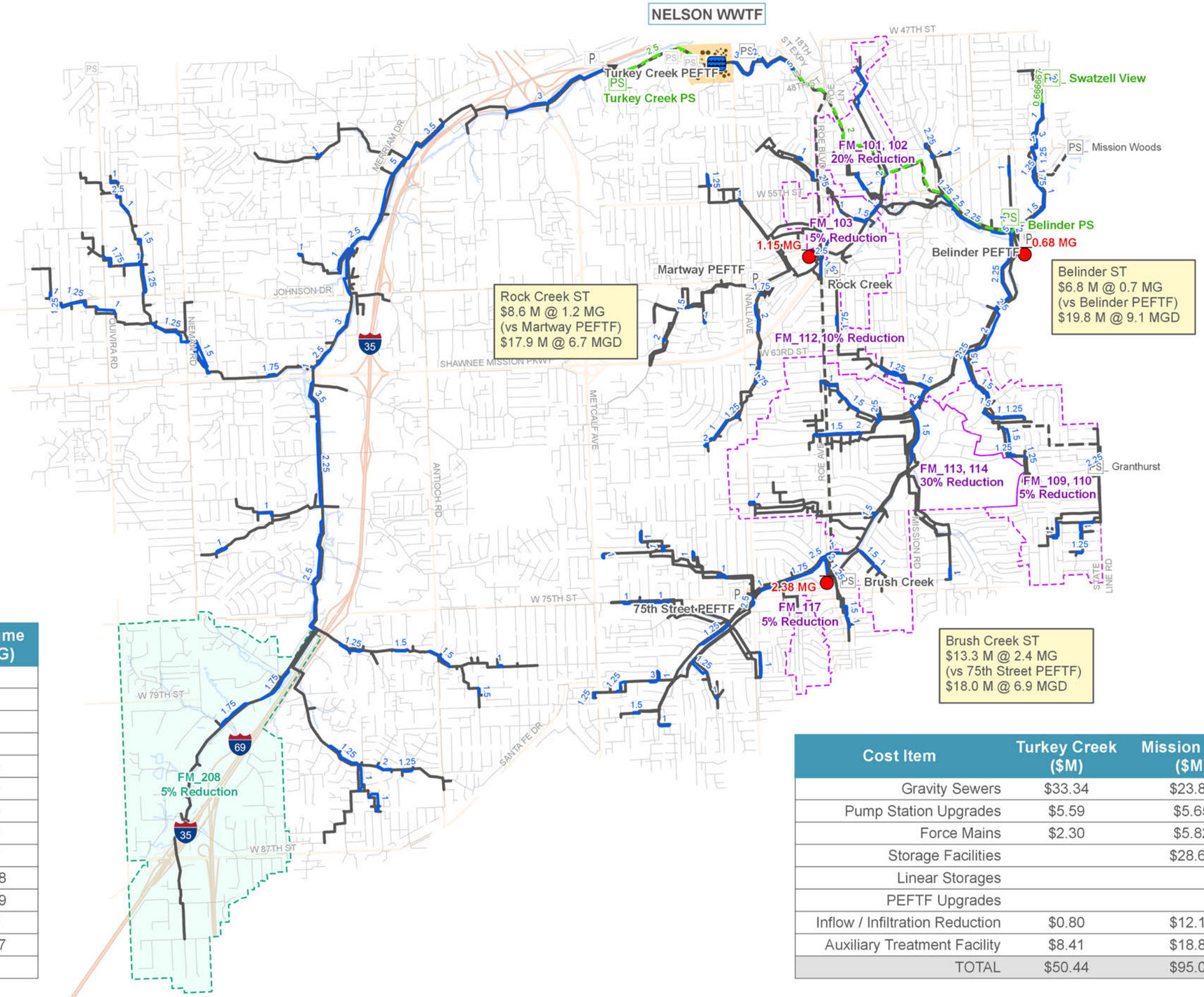
- Turkey Creek
- Mission Main

EXISTING INFRASTRUCTURE (MODELLED)

- PS Sewage Pumping Station
- P PEFTF
- Controlled Outfall
- Gravity Main
- Force Main

EXISTING INFRASTRUCTURE (NOT MODELLED)

- PS Sewage Pumping Station
- Gravity Main
- Force Main



Infrastructure ID	Flow Rate (MGD)	Volume (MG)
Turkey Creek PS	38	
Belinder PS	20	
Brush Creek PS	6	
Rock Creek PS	15.5	
Turkey Creek PEFTF	0	0
Belinder PEFTF	0	0
Martway PEFTF	0	0
Nall & 75th PEFTF	0	0
Turkey Creek FPD	29	7
Belinder FPD	36.1	8.8
Brush Creek FPD	5.3	3.9
Martway FPD	0	0
Rock Creek FPD	12.6	3.7
Nelson Complex ATF	29	

Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$33.34	$23.89	$57.23
Pump Station Upgrades	$5.59	$5.65	$11.24
Force Mains	$2.30	$5.82	$8.12
Storage Facilities		$28.65	$28.65
Linear Storages			
PEFTF Upgrades			
Inflow / Infiltration Reduction	$0.80	$12.12	$12.92
Auxiliary Treatment Facility	$8.41	$18.89	$27.30
TOTAL	$50.44	$95.02	$145.46

HDR WCS ENGINEERING JOHNSON COUNTY KANSAS Wastewater

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NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.

TURKEY CREEK PRELIMINARY OPTIMIZATION

1Y / 10Y ALL OPTIONS CONSIDERED

JCW-NC_GIS07

3.4 Summary of Results

Solution layout figures for each scenario were presented in Figure 10 through Figure 14. Detailed solution summaries for each scenario are provided in Appendix B. The 20-yr PV total costs for each preliminary optimization scenario are summarized in Table 15.

Table 15: Preliminary Optimization Scenario Costs

Optimization Scenario	20-yr PV Total Cost ($M) [1]
Scenario 1A - Conveyance Only (10/5 Year Design Storms)	$ 197.8
Scenario 1A - Conveyance and Storage Only (10/5 Year Design Storms)	$ 195.2
Scenario 1A - All Options (10/5 Year Design Storms)	$ 181.9
Scenario 1B - PEFTFs Remain (No ATF Allowed)	$ 205.0
Scenario 2 - All Options (10/1 Year Design Storms)	$ 145.5

[1] Costs do not include operation and maintenance costs that are common among alternatives.

The total project costs associated with each scenario, itemized by capital cost, I/I reduction cost, and O&M cost, are presented in Figure 15.

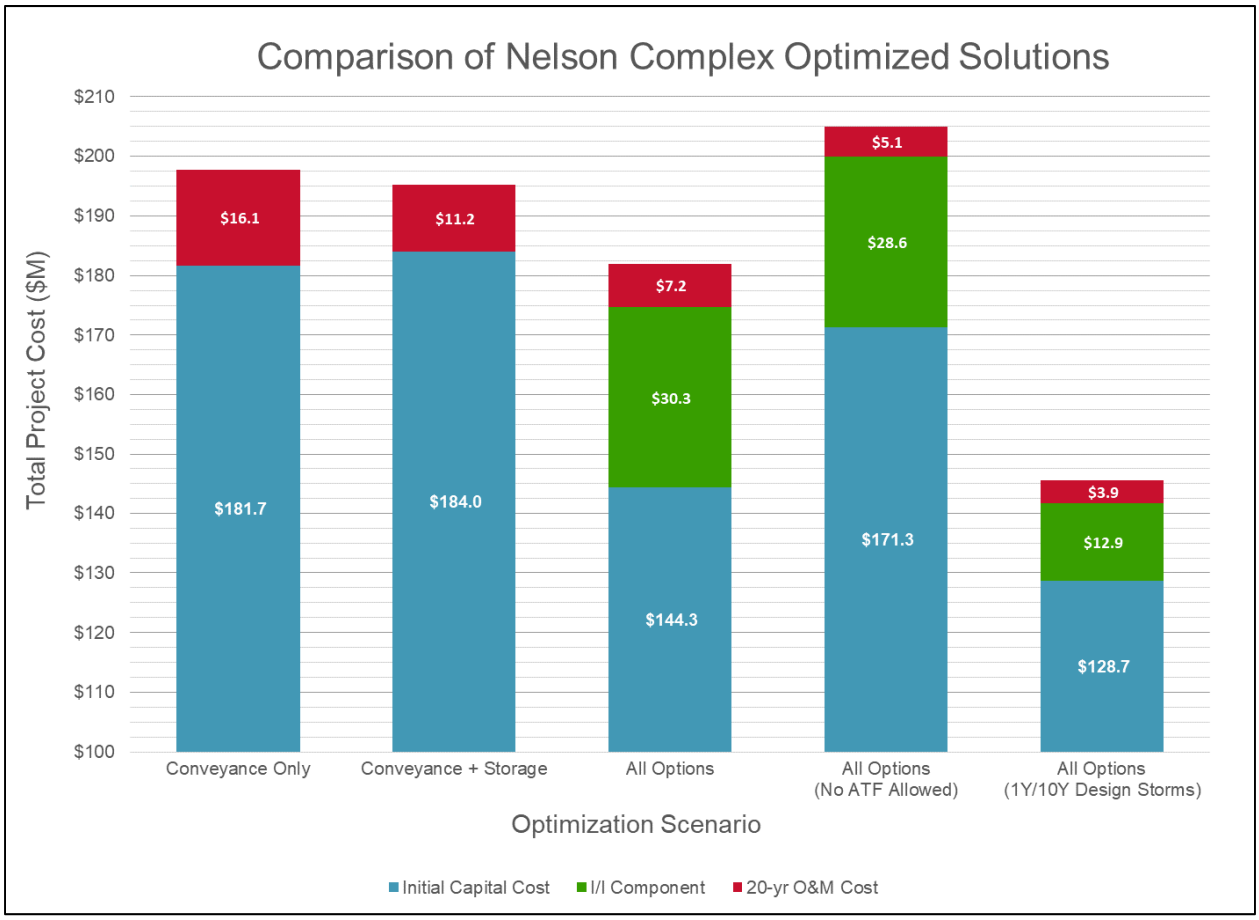


Figure 15: Comparison of Nelson Complex Optimized Solutions

Figure 16 is a cost effective analysis curve, which shows the costs incurred for each alternative within each scenario and the 20-yr PV total cost of each scenario.

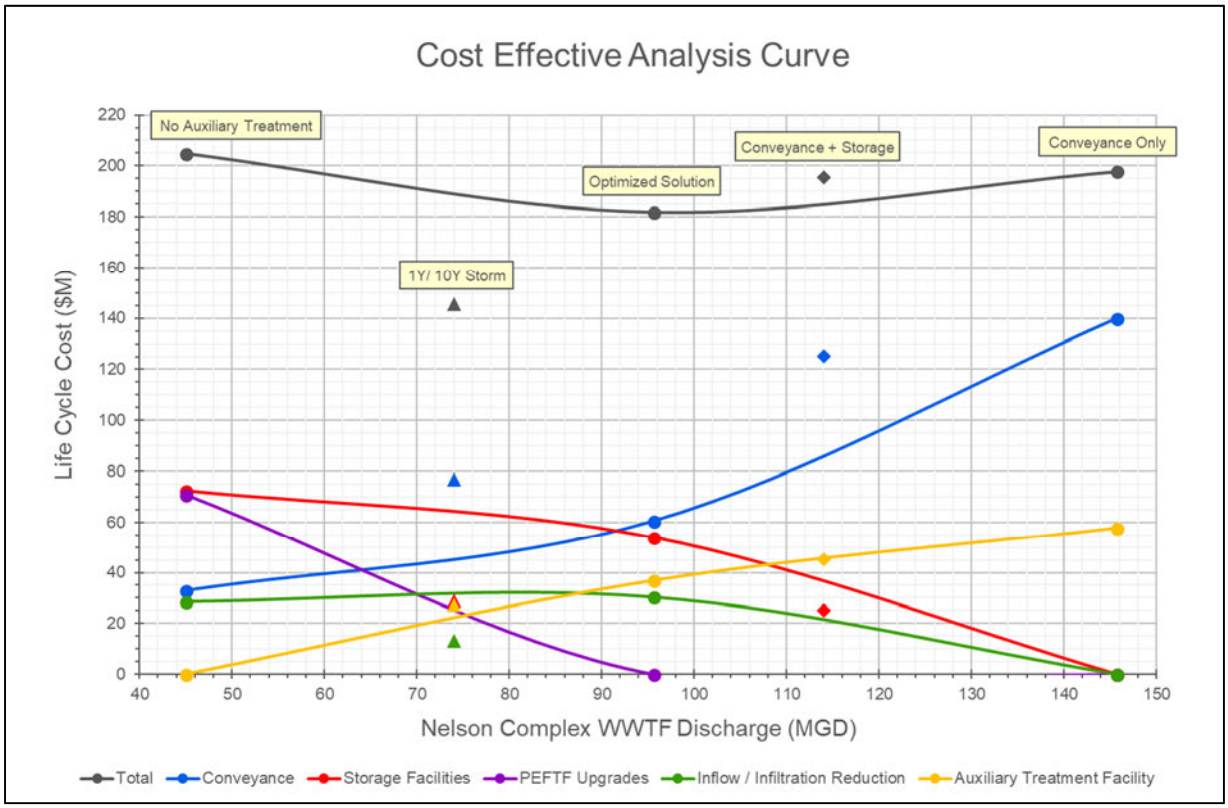


Figure 16: Cost Effective Analysis Curve from Preliminary Optimization

3.5 Key Trends and Sensitivities

The intent of preliminary optimization was to identify key trends among improvement alternatives, identify alternatives that should be screened for further evaluation, and to identify sensitivities that require additional input prior to refined optimization. The preliminary optimization demonstrated several key trends. It helped identify aspects of the optimization that are sensitive to assumptions and cost estimates to be reviewed prior to the refined optimization. By comparing the preliminary optimization solutions, the following trends were observed.

1. The total costs for the various combinations of alternatives evaluated in preliminary optimization were relatively close. The differential among the various combinations of conveyance, storage, and I/I reduction alternatives was approximately 10%.
2. Preliminary optimization identified similar sets of improvements alternatives in Turkey Creek characterized by a remote storage facility along the interceptor, I/I reduction in the upper reaches, and an expansion to the Turkey Creek Pump Station to convey wet weather flows to an Auxiliary Treatment Facility along with gravity conveyance improvements.
3. Preliminary optimization of Mission Main identified storage near Rock Creek and Brush Creek pump stations in lieu of pump station expansion, along with an expansion to Belinder Pump Station to convey wet weather flows to an Auxiliary Treatment Facility along with gravity conveyance improvements as the most cost-effective set of alternatives. Extensive I/I reduction was selected. However, it was noted that the costs of expanding Rock Creek and Brush Creek in lieu of storage were comparable.
4. The All Options scenario selected cost-effective targets for I/I reduction in each flow metered basin. More extensive I/I reduction was selected throughout Mission Main in comparison to Turkey Creek. In Turkey Creek, the optimization focused I/I reduction primarily in the upstream reaches of the basin.
5. In general, the existing Turkey Creek and Mission Main trunk conveyance network is significantly under capacity. The All Options scenarios were therefore characterized by extensive I/I reduction, particularly in Mission Main. By reducing extraneous volumes in the conveyance network, storage became a cost-effective alternative throughout both watersheds.
6. An alternative where the PEFTFs remained in service was evaluated (by removing the ATF option from the optimization). This scenario assumes full upgrade of the PEFTFs with enhanced treatment technology. Construction of storage at the facilities and PEFTF upgrade options were similar in overall cost.
7. ATF was key to reducing total costs; Scenario 1A (All Options, No PEFTFs) was approximately $23M cheaper than Scenario 1B (PEFTFs Remain, No ATF).

4 Alternatives Screening and Cost Refinement

For preliminary optimization, simplifying assumptions were made for each alternative in order to formulate the optimization and gain initial insights into how the system was performing. The analysis utilized the same unit costs curves for each type of facility (e.g. storage, pump station expansion, etc.) and did not limit the volume of storage or extent of capacity upgrades allowable at each facility. The refined optimization will utilize site and facility specific improvements costs. Any limitations to the magnitude of improvements based on feasibility will be included.

The following sub-sections describe the alternatives screening and cost refinement process. This evaluation was presented to JCW during two workshops in August 2018. At these workshops, several decisions were made and specific site alternatives were removed from further consideration. These decisions are documented in this section.

4.1 Alternatives Screening

4.1.1 Gravity Main Upgrade Considerations

For preliminary optimization, it was assumed that all selected gravity main improvements would be parallel relief sewers. Relief sewers are generally preferred to main replacement due to reduced construction sequencing requirements and the smaller pipe diameter of the relief sewer relative to a larger, equivalent diameter single main. However, the Turkey Creek and Mission Main watersheds are nearly built-out and are densely populated; relief sewers may not be feasible in all cases. During the alternatives screening, each length of improvements was evaluated considering utility conflicts, space constraints, current SRS scores (as available), and existing routing considerations. If the parallel option was not feasible, the length was recommended to be upsized in place.

Figure 17 shows an example of an area that is recommended for a parallel relief sewer if chosen by the optimization for upgrade. This portion of the Turkey Creek interceptor is not built-out and appears to have adequate space to construct a parallel sewer.

Many interceptors already consist of multiple parallel mains, particularly in Mission Main. In locations where parallel mains currently exist, one of the parallel mains will be recommended for replacement/upsize-in-place. Figure 18 is an example of an area that is recommended for upsize in place if chosen by the optimization for upgrade. This portion of the interceptor from Brush Creek PS to Belinder PS is built-out and runs along the Mission Hills Country Club golf course. The interceptor is already paralleled; it is recommended that one of the parallel pipes be upsized in place.

Basin-wide recommendations have been included as figures in Appendix C.

Figure 17: Gravity Main Example – Recommended to be Parallelled

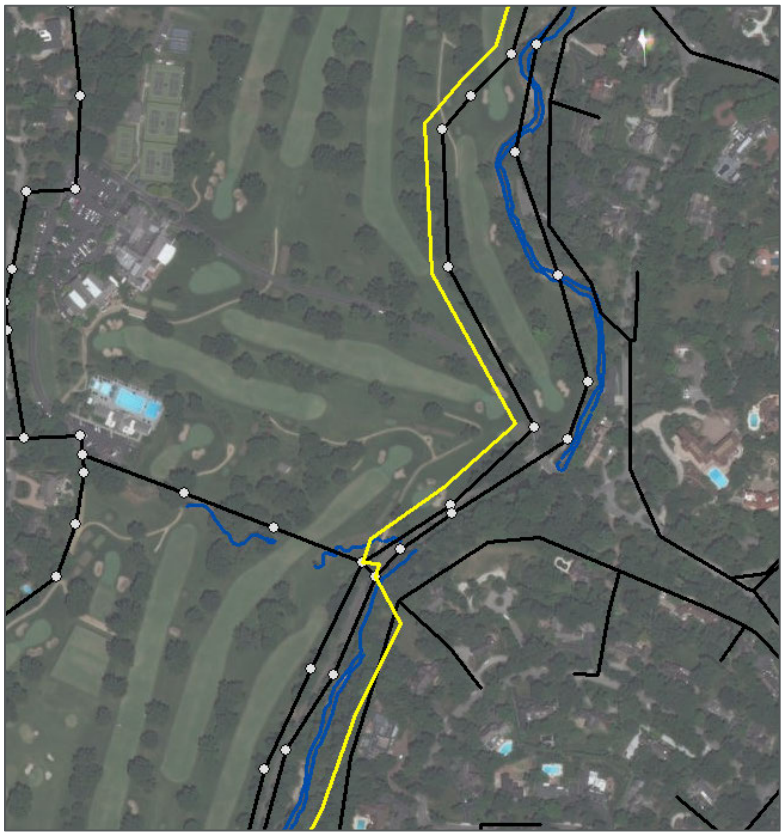


Figure 18: Gravity Main Example – Recommended to be Upsized-in-Place

4.1.2 Storage Location Refinement

Note that the storage locations named in this section may not be the final parcels selected when site acquisition begins. JCW will communicate and collaborate with stakeholders to determine suitable parcels for storage.

4.1.2.1 EVALUATION & SCREENING

Preliminary optimization provided initial guidance as to which storage locations are cost-effective. Those storage locations selected in the preliminary optimization scenarios were further vetted considering feasibility of land acquisition and construction, public impacts, utility conflicts, floodplain permitting, and possible depth of rock excavation.

The locations selected for further evaluation in the Turkey Creek Watershed include:

- Turkey Creek Streamway Park (City of Merriam)
- Waterfall Park (City of Merriam)
- Turkey Creek Pump Station and PEFTF site
- Private parcel near W 81st Street and Reeder Street (LIT Industrial Limited)
- Parking lots and green spaces near I-35 and Shawnee Mission Parkway.

The locations selected for further evaluation in the Mission Main Watershed include:

- Porter Park (City of Prairie Village)
- Parcel near Rock Creek Pump Station ("Mission Mall")
- 75th & Nall PEFTF (JCW)
- Martway PEFTF (JCW) and Mission Bowl (Mission Mart Shopping Center)
- Belinder Pump Station and PEFTF site.

4.1.2.1.1 Turkey Creek Streamway Park

Turkey Creek Streamway Park, owned by the City of Merriam, was selected during preliminary optimization as a key location to reduce peak flows and avoid conveyance improvements along a portion of the Turkey Creek interceptor. This area is presented in Figure 19. As shown on the figure, the park has a large open green space with a natural gas transmission pipeline running through the site. There is opportunity to build a storage facility north or south of the pipeline.

The north site is within the floodway and would require permitting. Improvements would likely result in a no-rise scenario, since existing grade would be re-established. There is also an overhead transmission line over the proposed location, which would require an access agreement with Kansas City Power & Light Company (KCPL).

The south site is not within the floodplain and would not require permitting. It is on a hillside, which would require a deeper excavation than the north site. The south site is less accessible for construction and maintenance.

Storage at this park will continue to be included for consideration during the refined optimization.

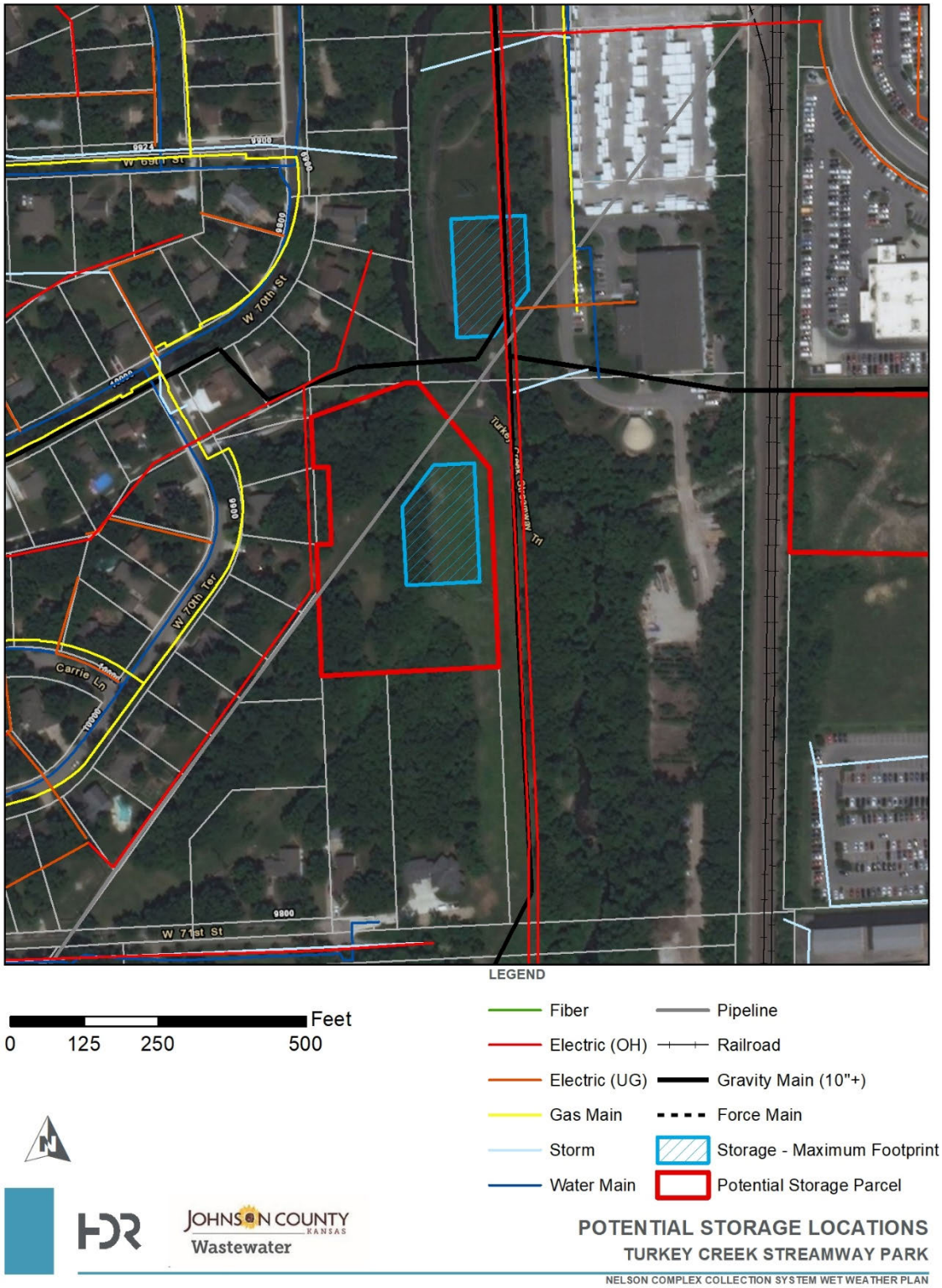


Figure 19: Storage - Turkey Creek Streamway Park

4.1.2.1.2 Waterfall Park

Waterfall Park, owned by the City of Merriam, was selected during preliminary optimization as an alternative to the Turkey Creek Streamway Park location. This area is presented in Figure 20. The park has green space/soccer fields, under which storage could be constructed. Existing grade and function could be re-established after construction. The area is within the floodplain fringe and would require a floodplain development permit. There is a water main on the property that, if active, would require relocation. There are no other known utility conflicts.

Storage at this park will continue to be included for consideration during the refined optimization.

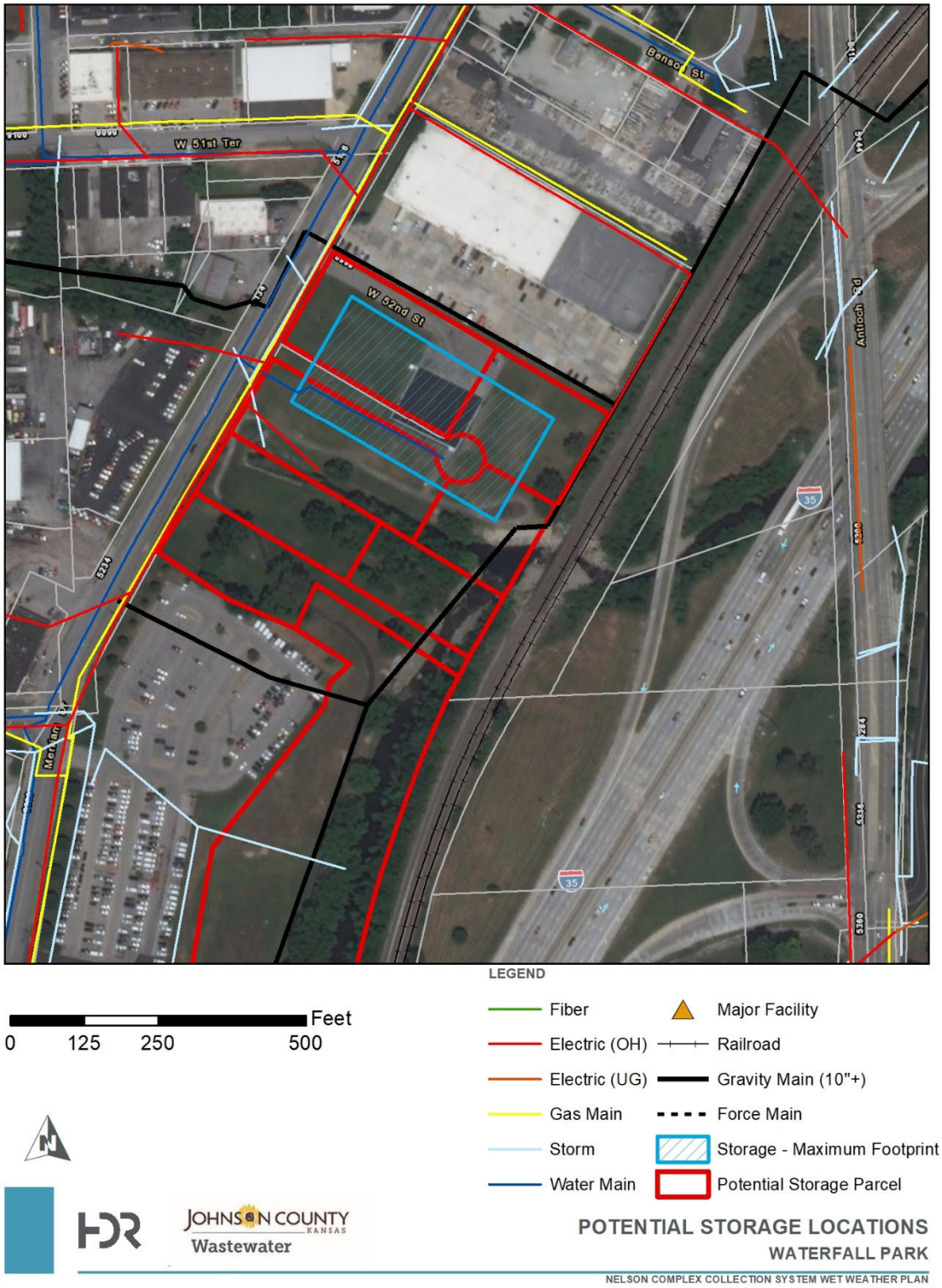


Figure 20: Storage - Waterfall Park

4.1.2.1.3 Turkey Creek Pump Station & PEFTF

The parcel south of Foxridge Drive, owned by the City of Mission, was not selected for storage during preliminary optimization. It was still important to evaluate the site, as it would provide an alternative to major pump station upgrades and a larger ATF at the WWTF. This area is presented in Figure 21.

The parcel is on a hillside. There are two valleys that could potentially be utilized to construct storage. Even in the valleys, pump in/gravity out is the only feasible option due to the difference in elevations between the interceptor inverts and storage location. There is also an overhead transmission line, which would require an access agreement with KCPL or relocation of the line.

Along with these considerations, it was noted by the project team that this storage site location at the downstream end of the basin does not provide any additional benefits in reducing capacity improvement needs in the upstream collection system. Additionally, it appears that increasing pumping capacity at the Turkey Creek Pump Station and utilizing an ATF at the WWTF will be more cost effective than storage at this site.

Storage at this site will not be included for consideration during the refined optimization.

Figure 21: Storage - Turkey Creek PS & PEFTF

4.1.2.1.4 LIT Industrial Limited (Private Parcel)

This parcel at W 81st Street and Reeder Street was identified during preliminary optimization as an opportunity for a small storage facility to reduce peak flows in the Turkey Creek interceptor. This area is presented in Figure 22. During the site review, it was noted that this site appears to be developable and will likely be utilized in the near future.

Storage at this site will not be included for consideration during the refined optimization.

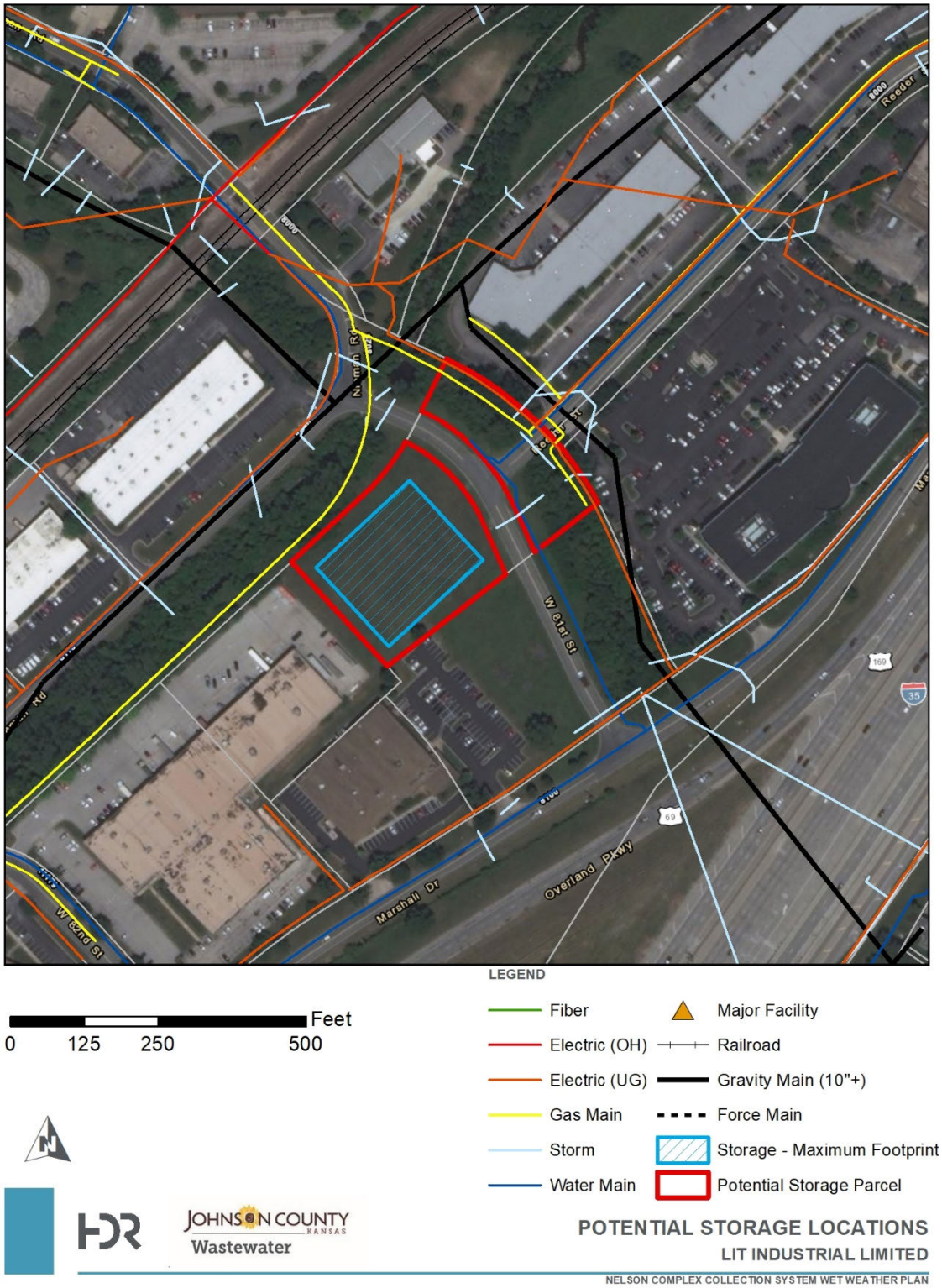


Figure 22: Storage - LIT Industrial Limited

4.1.2.1.5 Shawnee Mission Parkway (Private Parcels)

Parcels near I-35 and Shawnee Mission Parkway were identified for evaluation during the Alternatives Screening Workshop, held on August 15, 2018. This area is the confluence of multiple trunk lines to the Turkey Creek Interceptor, and is presented in Figure 23.

There are green spaces and parking lots that could be utilized for storage. Any parking lots or other features disturbed could be re-established after construction. There are various utility conflicts depending on the site selected. Portions of the area are also within the floodway and/or floodplain.

Storage in this vicinity will be included for consideration during the refined optimization. If selected, the area would be evaluated to select a specific parcel for inclusion in the long-term plan.

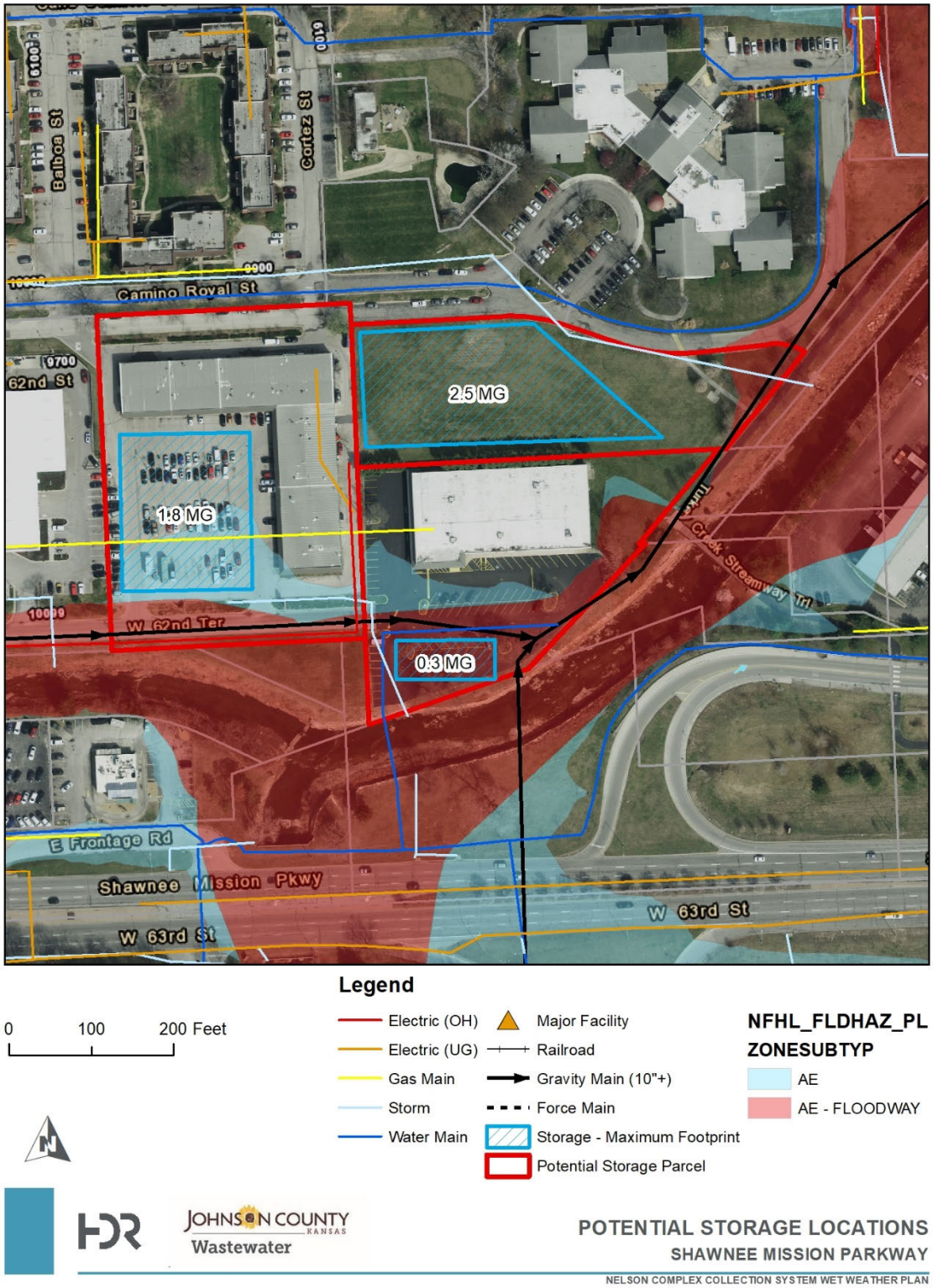


Figure 23: Storage - Shawnee Mission Parkway

4.1.2.1.6 Porter Park

Porter Park, owned by the City of Prairie Village, was identified during the preliminary optimization as a key location for a large storage facility. Storage at this location would be instrumental in reducing or eliminating the need for an upgrade of the Brush Creek Pump Station and force main. This area is presented in Figure 24.

The park offers ample green space and the opportunity to construct storage under existing baseball practice fields. Any disturbed park features, including the baseball fields, could be re-established after construction. A local floodplain permit may be needed as portions of the park have been noted for a future floodplain. Depending on the selected size and location of the storage facility, a storm sewer relocation may be necessary. There are no other known utility conflicts.

Storage at this park will continue to be included for consideration during the refined optimization. The park may either be utilized for storage or a wet weather pump station. It will not be considered for both alternatives.

Figure 24: Storage - Porter Park

4.1.2.1.7 Rock Creek Pump Station ("Mission Mall" Site)

Storage near Rock Creek Pump Station was identified during the preliminary optimization as a key location for a large storage facility. Storage at this location would be instrumental in reducing or eliminating the need for an upgrade of the Rock Creek Pump Station and forcemain. The pump station site and surrounding area is shown in Figure 25.

The parcel on the west side of Roe Ave was previously known as Mission Mall. The site is currently under construction for a mixed-use development called Mission Gateway. Because of this development, JCW does not want to pursue storage at this site.

Storage at this site will not be included for consideration during the refined optimization.

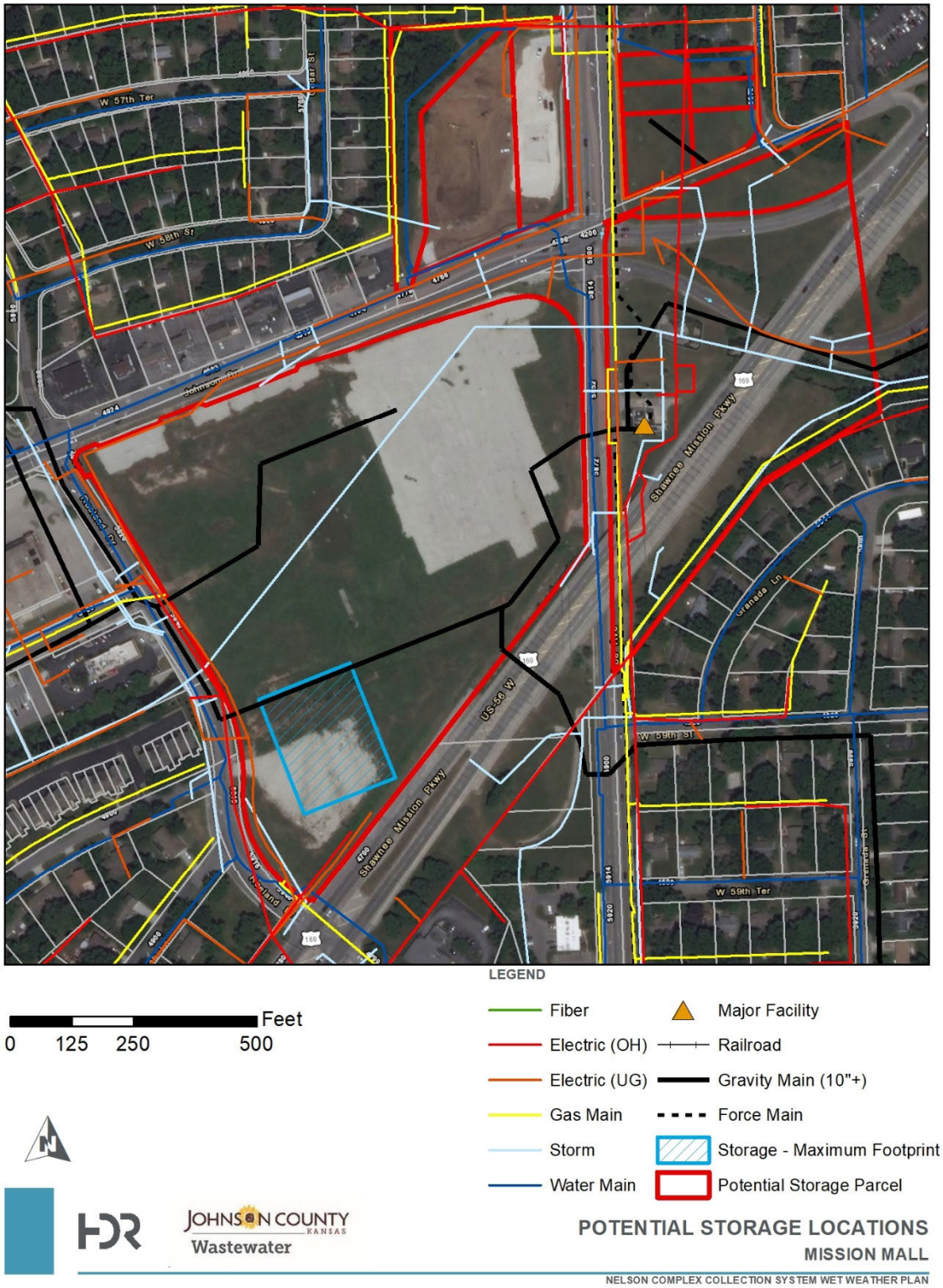


Figure 25: Storage - "Mission Mall"

4.1.2.1.8 75th & Nall PEFTF

Storage at 75th/Nall PEFTF was identified during preliminary optimization as an opportunity to reduce peak flows to Brush Creek Pump Station. This area is presented in Figure 26. A gas main on the site limits the available footprint. There are no other known utility conflicts.

Storage at this site will continue to be included for consideration during the refined optimization. The site may either be utilized for storage or continue to operate as a PEFTF. Storage will only be selected if the PEFTF is selected for decommissioning.

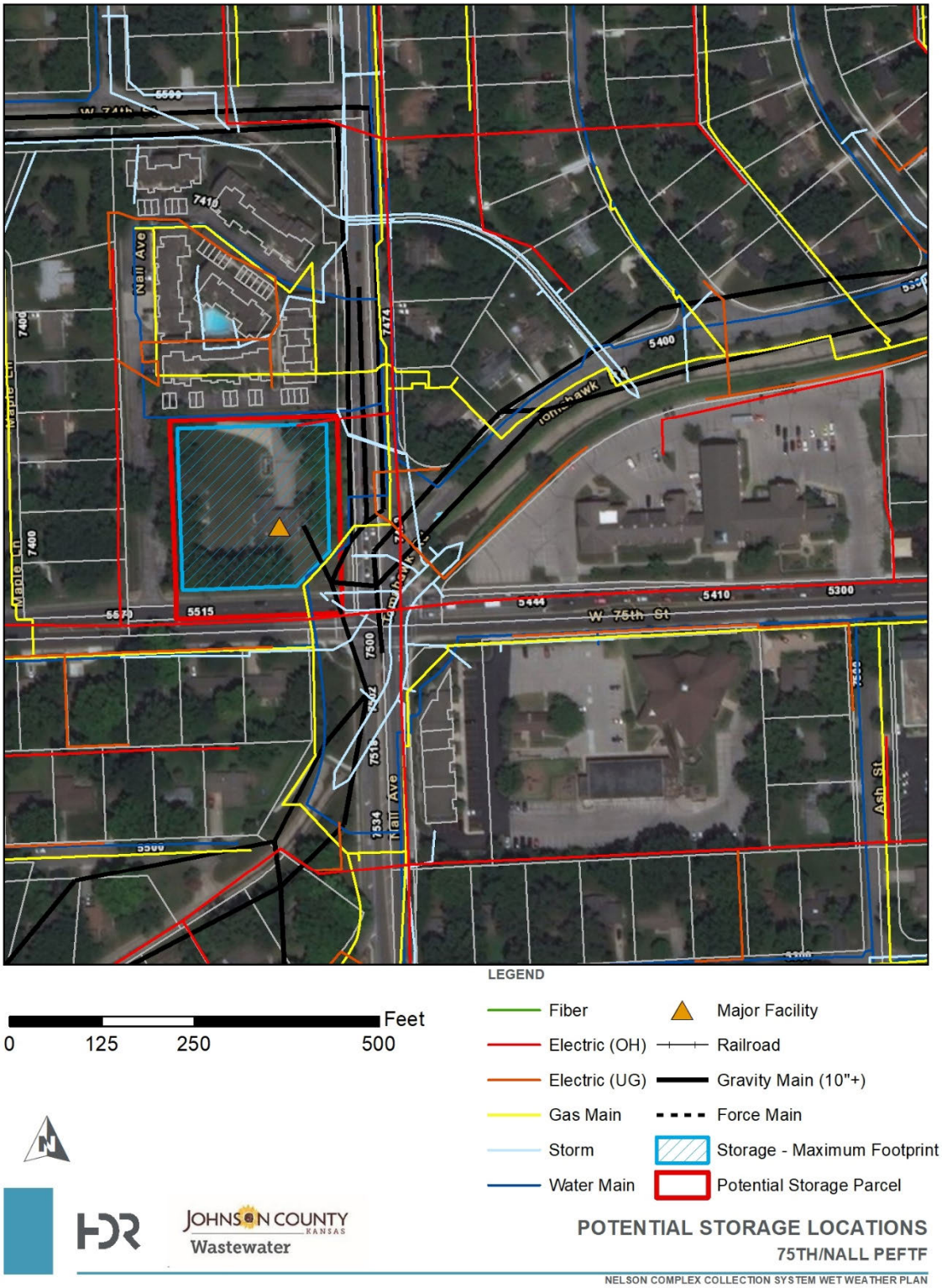


Figure 26: Storage - 75th/Nall PEFTF

4.1.2.1.9 Martway PEFTF and Mission Bowl

Storage at Martway PEFTF was identified during preliminary optimization as an opportunity to reduce peak flows to Rock Creek Pump Station. This area is presented in Figure 27.

The parcel to the north of the PEFTF is owned by Mission Mart Shopping Center, according to AIMS, and currently contains an abandoned bowling alley and a miniature golf course. This parcel has been identified as the primary site for a storage facility, however there are other opportunities for storage along Martway Street. Depending on the selected size and location of the storage facility, underground and overhead electric utility relocation may be necessary. There are no other known utility conflicts.

Storage at this location will continue to be included for consideration during the refined optimization. The location may either be utilized for storage or a disc filter facility for an upgraded PEFTF. It will not be considered for both alternatives.

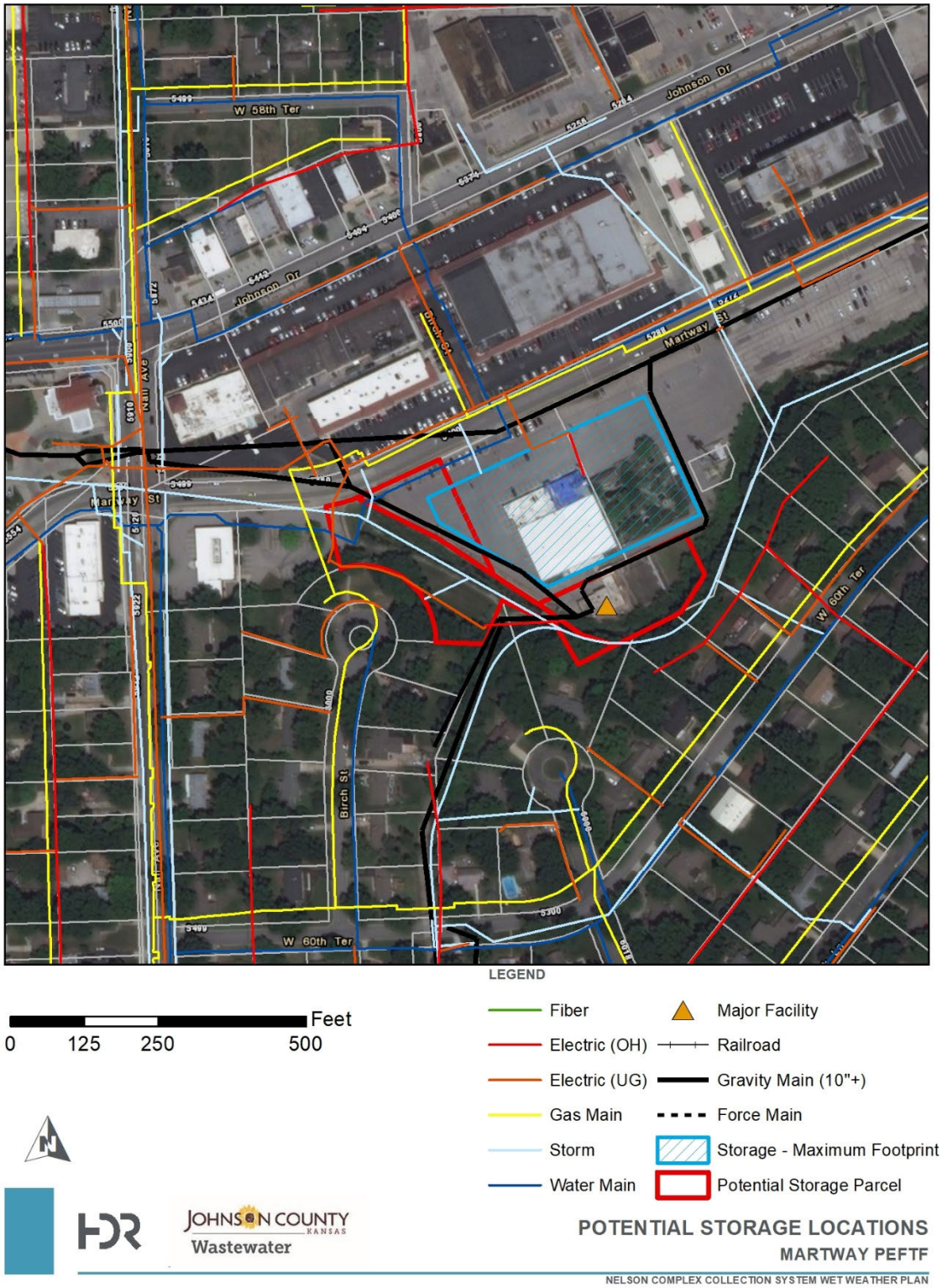


Figure 27: Storage - Martway PEFTF & Mission Bowl

4.1.2.1.10 Belinder Pump Station and PEFTF site

The Belinder Pump Station and PEFTF site was selected for storage during preliminary optimization in the Conveyance and Storage scenario. It was not selected in scenarios allowing I/I reduction. There is minimal space available, as shown in Figure 28. The site is located directly beside the Mission Hills Country Club, and is not an ideal site for a storage facility.

Shallow storage at this site will not be included for consideration during the refined optimization. Tunnel storage will be considered in lieu of shallow storage upstream of Belinder Pump Station.

Figure 28: Storage - Belinder PS & PEFTF

4.1.2.2 SELECTED STORAGE LOCATIONS

The locations to be considered for shallow storage during refined optimization in Turkey Creek are:

- Turkey Creek Streamway Park (City of Merriam)
- Waterfall Park (City of Merriam)
- Parking lots and green spaces near I-35 and Shawnee Mission Parkway

The locations to be considered for shallow storage during refined optimization in Mission Main are:

- Porter Park (City of Prairie Village)
- 75th & Nall PEFTF (JCW)
- Martway PEFTF (JCW) and Mission Bowl (Mission Mart Shopping Center)

Storage at the 75th & Nall PEFTF and Martway PEFTF sites would be an either/or alternative with retaining and upgrading the PEFTFs; the optimization will only be able to select storage or the PEFTF, not both. If either the 75th/Nall PEFTF or Martway PEFTF is selected for decommissioning, the existing PEFTF storage volume may be considered for reuse.

For preliminary optimization, each storage location was allowed unlimited volume. During alternatives screening, a reasonable maximum volume was determined for each specific location as presented in Table 16. The maximum footprint of each potential shallow storage location is shown in blue hatching on the previous storage figures (Figure 19 to Figure 28).

Table 16: Storage - Maximum Volume to Consider for Refined Optimization

Storage Site	Maximum Volume (MG)
Turkey Creek Streamway Park	2.1
Waterfall Park	4.8
Shawnee Mission Parkway	2.0
Brush Creek/Porter Park	8.4
75th/Nall PEFTF	2.5
Martway PEFTF	4.8

4.1.3 I/I Reduction Approach Refinement

The preliminary optimization analysis included evaluation of a range of allowable I/I reduction for each individual flow meter basin, ranging from no reduction up to a maximum of 30%. This approach provided a comparison of conveyance/storage alternatives for a range of I/I reduction scenarios, and a preliminary identification of where I/I reduction efforts are likely to be most cost effective.

The hydraulic model was primarily calibrated to flow meter data collected in 2010 and 2011. Since that time, JCW has greatly expanded investments in inspection and rehabilitation of the collection system. These ongoing inspection and renewal efforts are executed through the Collection System Asset Management Program (CSAMP). Many of these efforts have been focused within the Nelson Complex service area. These investments are anticipated to results in a reduction of I/I from public sector sources within Mission Main and Turkey Creek. Additionally, JCW's ongoing private I/I program has continued to identify and disconnect private sources of I/I within the service area.

A preliminary rehabilitation strategy for public sector assets (pipes and manholes) was developed during JCW's Pilot I/I Study. The strategies were then refined and implemented on an ongoing, system wide basis through the CSAMP. To date, many of the public sector assets within the Nelson Complex service area have already been inspected and renewed. The program will ultimately encompass all of the older pipes and manholes within the service area.

The refined optimization analysis will capture these improvements and factor their impacts on I/I reduction into the alternatives analysis. The goal for approach refinement was to establish realistic baseline I/I reduction assumptions to account for the reduction JCW will realize through public sector asset management efforts. This includes both establishing the assumed percentage reduction achieved, and the programmatic costs associated with these efforts. This baseline I/I reduction will be applied throughout the Nelson Complex service area to align with programmatic renewal efforts.

To develop these projections at a high level of confidence, data developed through both the CSAMP and pilot I/I study was utilized. The projections were developed by leveraging JCW's CCTV and manhole inspection program data and programmatic yield rates (i.e. the percentage of inspection assets that met the threshold for renewal). Utilizing this data enabled the use of individual defect flow rates developed during the pilot I/I study. The previous CSAMP projections for gravity mains and manhole rehab yield was utilized to project the total amount of public sector I/I and the expected amount of I/I that would be reduced through past renewal efforts and future efforts in the remaining uninspected portions of the Nelson Complex service area.

4.1.3.1 MANHOLE RENEWAL PROGRAM

The CSAMP programmatic projections were developed and reviewed with JCW during CSAMP workshops in February 2018. These projections were developed by utilizing approximately 3,500 Tier 2 manhole inspections that were completed in two phases during 2016 and 2017 (these included manholes of similar ages and materials outside the Nelson basins). Approximately 40 percent of the manholes with Mission Main have been inspected to date. Only one full Turkey Creek sub-basin has been inspected, along with inspection of a portion of the manholes in low lying areas along the Turkey Creek Interceptor.

Tier 2 manhole inspections and corresponding yield rates within the Nelson basins are presented in Table 17. Based on findings to date, a 25% projected yield rate was estimated for uninspected areas

within these basins. The inspections findings and projections are documented in detail in the CSAMP Manhole Renewal Program Implementation, Development, and Renewal Forecast TM.

Table 17: Manhole Inspection and Yield Rate Summary (as of February 2018)

Basin	Basin Total No.	Inspected Total	Individual Rehab Yield to Date	Projected Rehab Yield %
Mission Main	6,046	2,344	18%	25%
Turkey Creek	6,311	222	40%	
Roeland Park	261	45	69%	

Defect specific I/I 10-year storm inflow rates were applied to all manholes inspected to date. Figure 29 shows the total I/I identified and the total projected I/I reduction. The total I/I identified and percentage reduction is shown both for all inspected manholes, and for only those recommended for renewal.

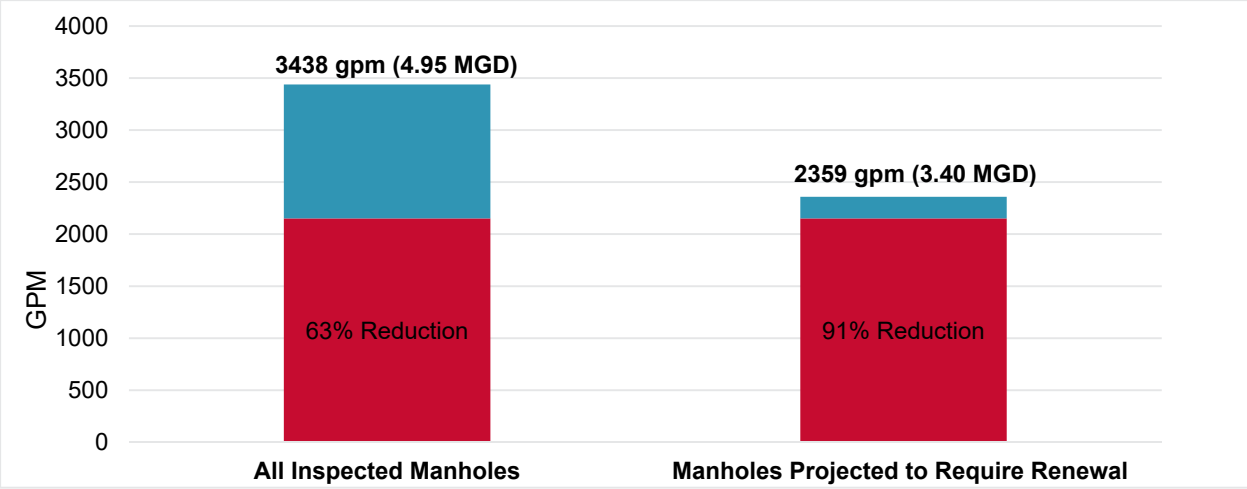


Figure 29: Inspected Manhole I/I Estimates

Utilizing all the manhole inspection data, the I/I identified within these manholes was used as the basis for projecting the I/I within the remaining uninspected manholes. Similarly, the overall yield of 25 percent was used to project future renewal rates. The manhole projection summary is shown in Table 18 and in Figure 30 and Figure 31.

Table 18: Nelson Basins Manhole I/I Program Projections

Basin	Total Basin I/I (MGD)[2]	Identified I/I (MGD)[2]	Identified I/I Removed (MGD)[2]	Projected Total I/I (MGD)[2]	Projected Total I/I Removed (MGD)[2]
Mission Main[1]	5.81	2.74	1.48	8.55 (6.6%)	5.12 (4.0%)
Turkey Creek	9.04	0.78	0.67	9.82 (16.9%)	6.33 (10.9%)
Nelson Total	14.85	3.52	2.15	18.37 (9.8%)	11.45 (6.1%)

[1] Includes Roeland Park

[2] All I/I totals shown for the 10-year storm

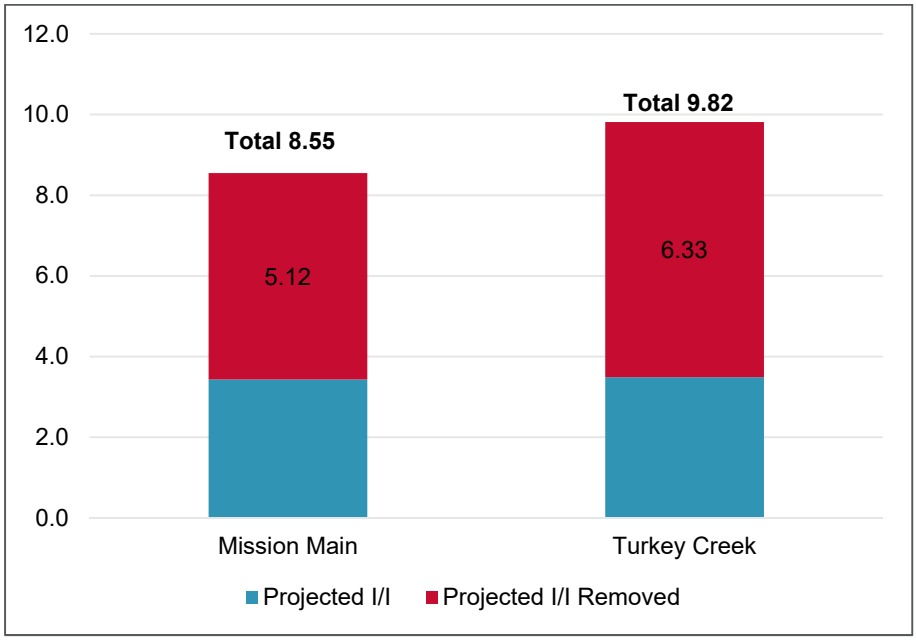


Figure 30: Projected I/I per Basin

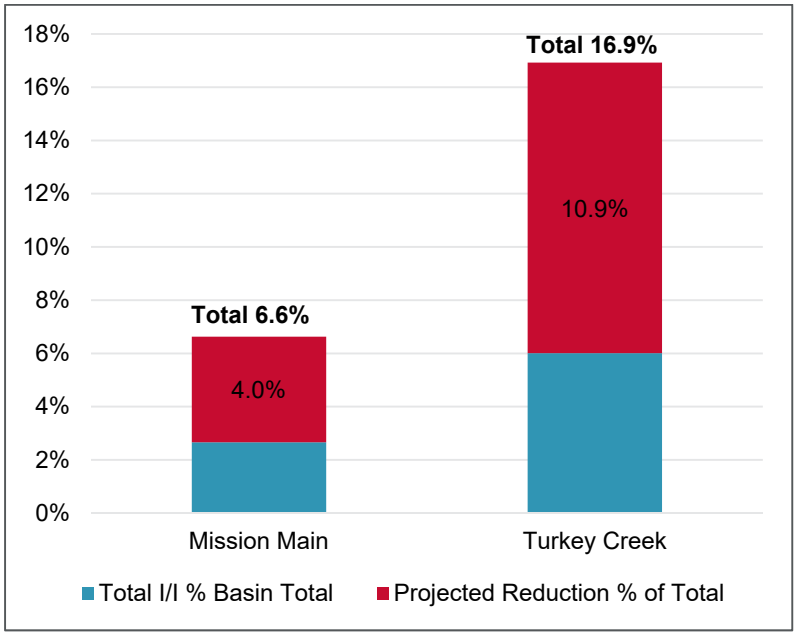


Figure 31: Projected I/I Percent of Basin Total Summary

Programmatic cost projections were reviewed with JCW during the CSAMP workshops in February 2018. These costs were used as the basis for developing programmatic costs specific to the Nelson area, presented below in Table 19. These projections include cast past and ongoing program development investments and the projected costs for future program efforts.

Table 19: Nelson Area Manhole Program Cost Projections Summary

Total Manholes in Nelson Area (MTM1, SMTC, RPM)	12,618
Inspected to Date	2,611
Remaining to Be Inspected	10,007
Total Manholes Projected to Require Renewal, to Date	548
Total Projected to Require Renewal	2,787
Total I/I Projected in Nelson (10-Year Storm Event)	18.37 MGD
Total I/I Projected to be Removed in Nelson (10-Year Storm Event)	11.45 MGD
Cost per GPM reduced (10-Year Storm Event)	$1,258
Program Costs to Date – Inspection & Program Development	$1,000,000
Total Inspection Costs Remaining	$1,745,000
Total Projected Renewal Costs	$7,254,000
Subtotal, Manhole Program Costs	$10,000,000
Contingency (10%)	$1,000,1000
Total Projected Nelson Manhole Program Costs	**$11,000,000**

It is projected that it will require a $10 Million investment to inspect all manholes within the service area and complete system renewal targeted to mitigate I/I sources that are cost effective to address, along with structural deficiencies. This is projected to reduce the total I/I within the Turkey Creek service area by 10.9% and Mission Main by 4.0%.

4.1.3.2 PIPE RENEWAL PROGRAM

The Nelson public sector main line pipe I/I projections were developed utilizing the CCTV inspection data collected by JCW's CCTV crews. JCW's CCTV crews began collecting CCTV data in PACP format in 2009. Initial program efforts were focused on completing sub-basin wide inspections in the basins with the highest Business Risk Exposure (BRE) score, many of which were located within the Nelson service area. After the CSAMP program implementation, JCW dedicated additional resources to CCTV and significantly increased the amount of inspection data collected system-wide, with many of the efforts focused in the Nelson service area.

The extensive data collection efforts completed through the CSAMP program were utilized to develop public sector I/I projections for the Nelson Service Area. Defect specific I/I flow rates were developed in the Pilot I/I study conducted within Mission Main and Turkey Creek sub-basins. Pipe specific defect flow adjustments were made based on pipe diameter, a basin leakiness factor assumption, and adjustments for continuous defects. This process is documented in Appendix C of the *Public Sector I/I Reduction Strategy Implementation, TM 2* (CH2M, 2016). An I/I quantification tool was developed through CSAMP to run with the easy button in order to automatically estimate I/I for each PACP coded individual defect, and quantify the total projected I/I within each pipe. These defect specific flow rates were used to identify the amount of I/I in pipes that were inspected and project these rates to uninspected areas. Note that PACP coded data is required to estimate defect level I/I flow rates; CCTV data collected prior to JCW implementing PACP coding standards was not included in this analysis.

During that same timeframe, JCW made major investments in system rehabilitation, primarily focused on CIPP lining of pipes with structural and I/I source defects. As the CSAMP program was implemented, JCW increased investments in pipe renewal, with many of the efforts focused within the Nelson service

area. The renewal program efforts were utilized along with the CCTV inspection data collected to develop the public sector main line pipe I/I projections presented herein.

Approximately two-thirds of the pipes in the Nelson service area have been inspected through CCTV, with observation coding included in JCW's Lucity CCTV database (coding from some older CCTV data and some data collected by contractors is not available). Of these inspections, approximately 50 percent of the pipes with the Nelson service area were inspected with PACP coded data. For the purpose of I/I estimations at the defect and pipe level, defect flow rates were only applied to PACP coded inspections which were collected 2009 or later. However, the historical CIPP yield rates including those from older inspection data were used to estimate basin wide yields that could be projected to uninspected areas.

Table 20 displays the basin specific yields used for future I/I projections.

Table 20: Gravity Main Inspection and Yield Rate Summary

Basin	Total Pipes	Inspected Total (1)	Basin CIPP Rehab Yield % (1)
Mission Main	6,140	4.374	24%
Turkey Creek	6,181	3,340	12%
Roeland Park	241	138	16%
Nelson Total	**12,562**	**7,852**	**17%**

(1) Total includes all pipes inspected to-date, including those without PACP coding. Yield rates do not include point repairs.

The estimated identified I/I and projected removal amounts from the PACP coded inspections were used to develop an estimated I/I reduction average for each pipe that was CCTV lined. These I/I reduction averages and historical yield rates were used to determine the estimated I/I reduction in the Pre-PACP coded pipes that were lined. The basin wide yield rates were then used to estimate projected I/I reduction in the pipes that are yet to be inspected.

The gravity main I/I reduction projections are shown in Table 21.

Table 21: Gravity Main I/I Reduction Projections by Basin

CCTV Status	Mission Main/Roeland Park				Turkey Creek			
	# of Pipes	Yield (%)(1)	I/I Identified (MGD)	Projected I/I Reduction (MGD)	# of Pipes	Yield (%)(1)	I/I Identified (MGD)	Projected I/I Reduction (MGD)
CCTV'd with PACP Coding	3003	27%	10.54	4.90	3169	10%	3.94	1.61
CCTV'd Pre-PACP Coding	1509	18%	N/A	1.71	171	51%	N/A	0.46
No CCTV Record Available	1869	24%	N/A	2.68	2841	12%	N/A	1.77
Total	**6381**	**24%**	**-**	**9.29**	**6181**	**12%**	**-**	**3.85**

(1) Historical CIPP yield rates were used for all inspected pipes. Total basin yield rates were used to project yield rates in uninspected pipes.

The projected I/I and percentage of basin total I/I are displayed in Figure 32 and Figure 33, respectively.

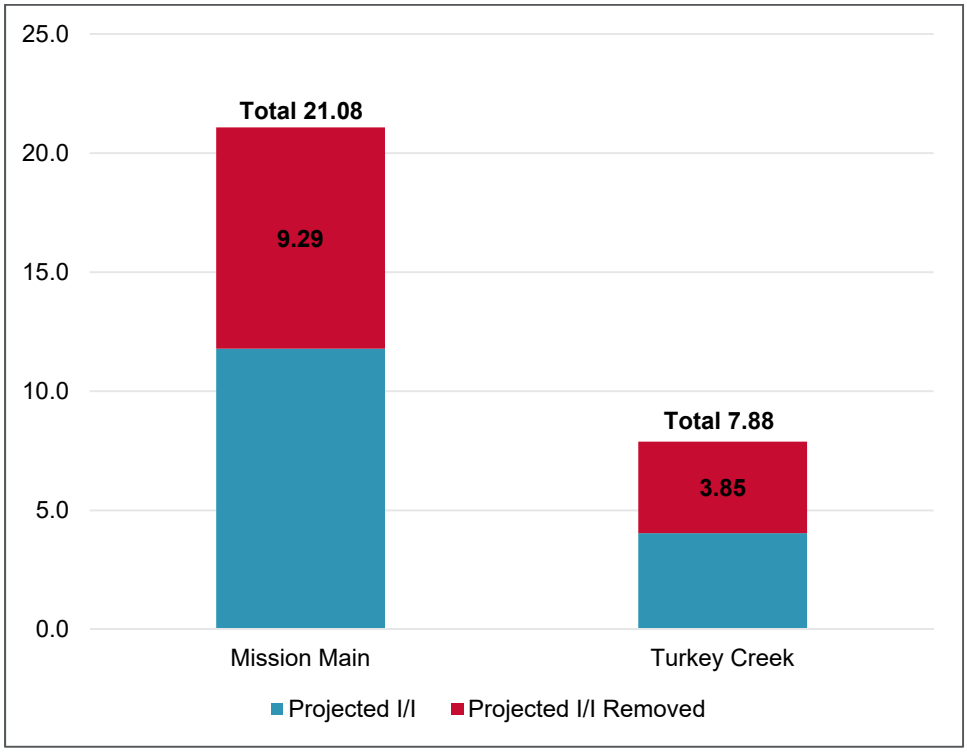


Figure 32: Gravity Mains Projected I/I (MGD) per Basin

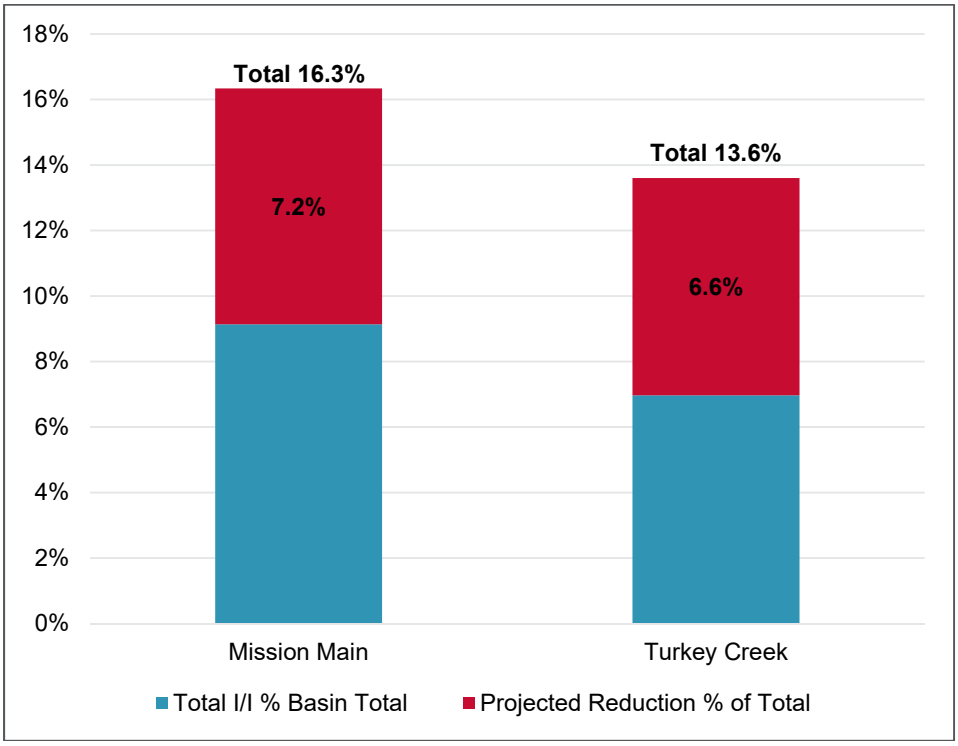


Figure 33: Gravity Mains Projected I/I Percent of Basin Total Summary

The current unit costs in JCW's term and supply contract for CIPP lining were used to define the total costs for past renewal work in 2018 dollars. The renewal costs for these 1,459 pipes were used to determine an average renewal cost per foot to use for projecting costs to uninspected areas. An average costs of $23.45 per linear foot was established.

Table 22 displays the historical pipe renewal summary for the Nelson service area.

Table 22: Nelson Historical Pipe Renewal Summary

Basin	Basin Total No.
Diameter (in) Range	8-30"
Total Length (LF)	364,521
Count CIPP Pipes	1,459
Unit Costs Range	$22.50 - $63
Total CIPP Costs	$8,549,572
Average Cost per Pipe	**$5,859.89**
Average Cost per Foot	**$23.45**

Similar to the MH I/I projections the gravity main I/I projection reduction assumptions were monetized, including previous investment within the Nelson basin, in order to capture past and future program efforts. Renewal cost projections were based on the historical rehabilitation data for the Nelson basins as described above. JCW's in-house CCTV crews are completing the vast majority of CCTV work within the Nelson service area; a representative contractor CCTV unit cost of $1.05 per foot of pipes was used to quantify the inspection costs incurred by JCW.

These costs were used as the basis for developing programmatic costs specific to the Nelson area, presented below in Table 23. These projections include cast past and ongoing program development investments and the projected costs for future program efforts.

Table 23: MH Cost Projections and Summary

Total No. Pipes (MTM1, SMTC, RPM)	12,562
Inspected to Date	7,852
Remaining to Be Inspected	4,710
Projected to Require Renewal	2,268
Total I/I Projected in Nelson	28.97 MGD
Total I/I Projected to be Removed in Nelson	13.5 MGD
Cost per GPM reduced (10-year storm)	$1,830.06
Average Per Pipe Cost for CIPP	$5,859.89
Total Projected Costs for I/I Reduction	$13,300,00
CCTV Cost	$3,000,000
CIPP Program Development and Execution	$850,000
Subtotal, Pipe Program Costs	$17,100,000
Contingency (10%)	$1,710,000
Total Projected Nelson Pipe Program Costs	**$19,000,000**

4.1.3.3 PUBLIC SECTOR I/I REDUCTION PROJECTIONS SUMMARY

The total projected I/I reduction to be achieved through public sector renewal for the entire Nelson service area is presented by asset type in Figure 34, and summarized in Table 24. The Nelson service area as a whole is estimated to see a total I/I reduction 13.3%, with reductions of 6.1% and 7.2% through the manhole and pipe programs, respectively.

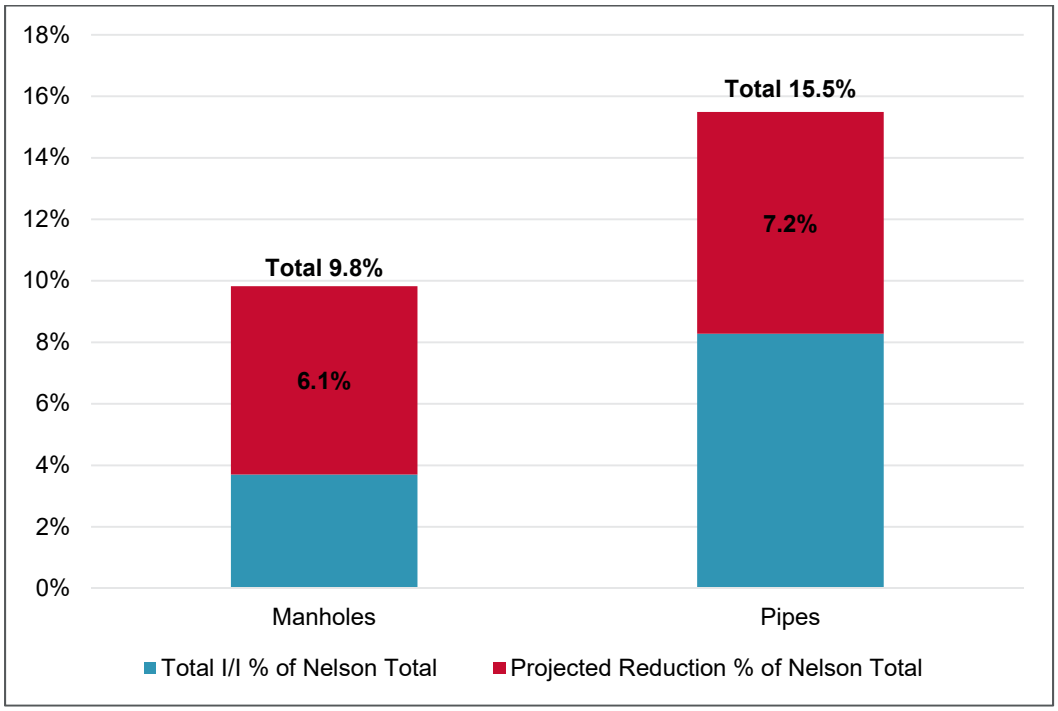


Figure 34: Nelson Service Area Public Sector Program I/I Reduction Projection by Asset Type

Table 24: Nelson Service Area Public Sector I/I Program Projections Summary by Asset Type

	Identified I/I through CCTV and MH Inspections (MGD)		Basin Wide Projections (MGD)				
Asset Type	**Total I/I** (1)	**Projected Reduction** (1)	**Total I/I**	**Total I/I % of Nelson Total**	**Projected Reduction**	**Projected Reduction % of Nelson Total**	**Total Projected Costs** (2)
Manholes	3.5	2.2	18.37	9.8%	11.45	6.1%	$11,000,000
Pipes	14.49	6.51	28.97	15.5%	13.49	7.2%	$19,000,000
Public Sector Total	**18.01**	**8.67**	**47.34**	**25.3%**	**24.94**	**13.3%**	**$30,000,000**

(1) Includes only pipes with PACP coded inspections and manholes with Tier 2 inspections.

(2) Includes Renewal Program Cost, Inspection, and Engineering Support for Program Development and Authorization Packages.

The total projected I/I reduction to be achieved through public sector renewal for each basin is presented by asset type in Figure 35, and summarized in Table 25 and Table 26 for Mission Main and Turkey Creek, respectively. The following I/I reduction is projected:

- Mission Main - Total I/I reduction of 11.2%, with reductions of 4.0% and 7.2% through the manhole and pipe programs, respectively
- Turkey Creek - Total I/I reduction of 17.5%, with reductions of 10.9% and 6.6% through the manhole and pipe programs, respectively

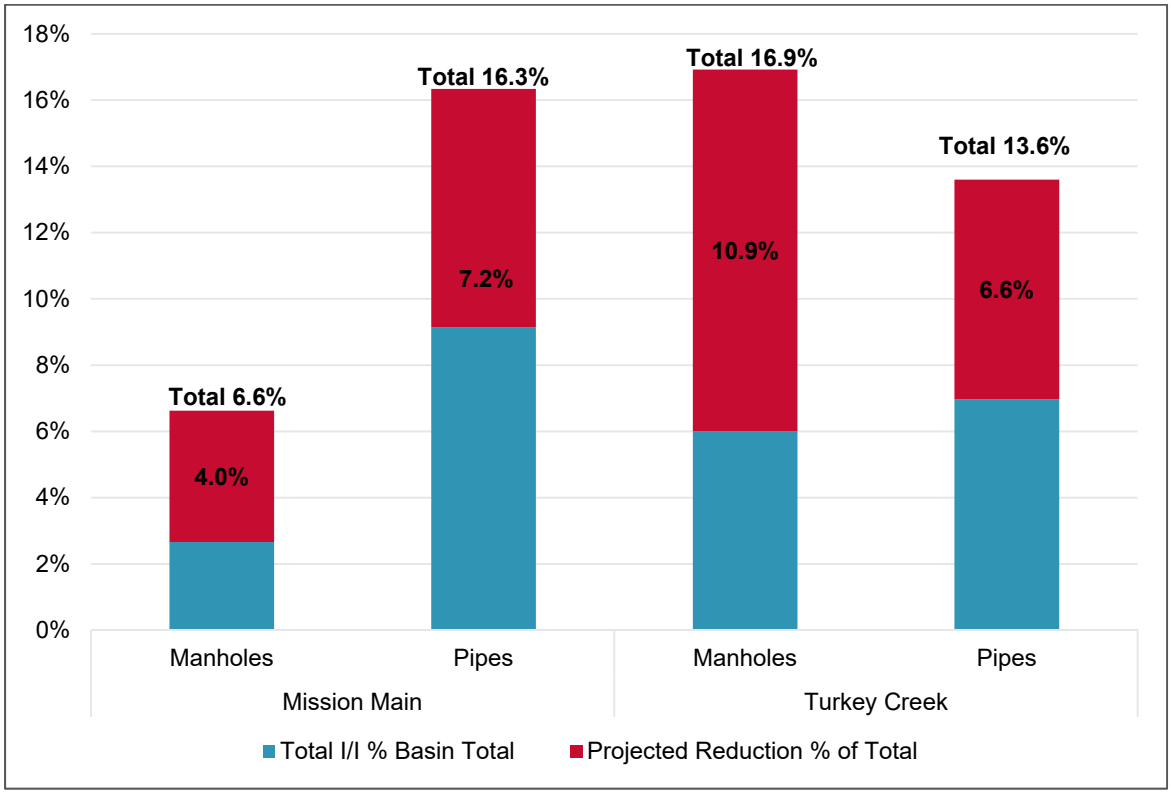


Figure 35: Nelson Individual Basin Breakdown

Table 25: Mission Main Public Sector I/I Program Projections

Asset Type	Identified I/I through CCTV and MH Inspections (MGD)		Basin Wide Projections (MGD)				Total Projected Costs [2]
	Total I/I [1]	Projected Reduction [1]	Total I/I	% of MM Total	Projected Reduction	% of Mission Main Total	
Manholes	2.74	1.48	8.55	6.6%	5.12%	4.0%	$5,500,000
Pipes	10.54	4.90	21.08	16.3%	9.29%	7.2%	$9,600,000
Public Sector Total	**13.28**	**6.38**	**29.63**	**23.0%**	**14.41%**	**11.2%**	**$15,100,000**

[1] All Pipes with PACP coded inspections and manholes with Tier 2 Inspections
[2] Includes Renewal Program Cost, Inspection, and Engineering Support for Program Development and Authorization Packages.

Table 26: Turkey Creek Public Sector I/I Program Projections

Asset Type	Identified I/I through CCTV and MH Inspections (MGD)		Basin Wide Projections (MGD)				Total Projected Costs [2]
	Total I/I [1]	Projected Reduction [1]	Total I/I	% of SMTC Total	Projected Reduction	% of Turkey Creek Total	
Manholes	0.78	0.67	9.82	16.9%	6.33	10.9%	$5,500,000
Pipes	3.94	1.61	7.89	13.6%	3.85	6.6%	$9,300,000
Public Sector Total	**4.72**	**2.29**	**17.70**	**30.5%**	**10.18**	**17.5%**	**$14,800,000**

[1] All Pipes with PACP coded inspections and manholes with Tier 2 Inspections
[2] Includes Renewal Program Cost, Inspection, and Engineering Support for Program Development and Authorization Packages.

These projections were reviewed with JCW during the workshops held in August of 2018. In order to be conservative, it was decided that the following assumed levels of I/I reduction will be assumed to be achieved through JCW's public sector renewal program executed through the CSAMP:

- Mission Main – 10% I/I reduction
- Turkey Creek – 15% I/I reduction

These I/I reduction projections represent the assumed baseline I/I reduction that will be achieved throughout the Nelson service area. For the refined optimization analysis, this I/I reduction will be applied to all individual sub-basins. I/I reduction beyond these baseline values is assumed to likely be achieved through private sector source disconnection efforts. Recommended values will be evaluated for each individual sub-basin through the refined optimization analysis.

4.1.4 PEFTF Flow Range Refinements

For preliminary optimization, the PEFTFs were allowed to perform at a large range of peak flows, both below and above current capacities. These capacity ranges were refined based on flow analysis, the results of the preliminary optimization, and regulatory considerations.

For refined optimization, the PEFTFs will be restricted to the capacities defined in Table 27. Belinder PEFTF is the only facility that will be considered for an upgraded capacity due to the option of diverting wet weather flows to the facility from Brush Creek PS and/or Rock Creek PS. 75th/Nall, Martway, and Turkey Creek all include options to downsize the facilities to half their current capacities. Each PEFTF alternative assumes disc filters are arranged in groups of 2 and include a standby unit.

Table 27: PEFTF Refined Flow Ranges

Facility	Minimum Capacity to be Evaluated (MGD)	Maximum Capacity to be Evaluated (MGD)
75th/Nall	10	20
Martway	10	20
Belinder	42	90
Turkey Creek	12	22

4.1.5 Auxiliary Treatment Facility

For refined optimization, the dry weather plant throughput was increased to 52 MGD to align with the updated WWTF study process approach. Wet weather flows above 52 MGD will be treated by ATF.

4.2 Cost Refinement

4.2.1 Gravity Mains

Gravity main upgrade costs remain unchanged from preliminary optimization. The cost tables presented in Section 2.2.1 will be used for refined optimization.

4.2.2 Forcemains

Forcemain upgrade costs remain unchanged from preliminary optimization. The cost tables presented in Section 2.2.2 will be used for refined optimization.

4.2.3 Pump Stations

For the refined optimization, site specific cost curves were developed for each pump station based on several recent local HDR projects. From these projects, unit cost metrics were developed for projecting costs associated with new and improved pumping stations. The unit costs used in developing the costs curves is as follows:

- Pumping improvements = $1,100 per HP
- Electrical improvements = $1,000 per HP
- Existing pump station concrete and structural improvements = $2,400 per MGD
- New pump station concrete and structural improvements = $28,300 per MGD
- Existing pump station process piping improvements = $15,100 per MGD
- New pump station process piping improvements = $9,000 per MGD
- Screening equipment improvements = $13,700 per MGD
- Building improvements = $350 per square foot

In addition to the above costs, improvements were also included for each pump station that pumps directly to the Nelson Complex in order to account for the proposed new Headworks Building location in the northeast corner of the existing WWTF site. For the Turkey Creek treatment train, these improvements include costs for additional pumping head and required forcemain extensions for the Turkey Creek PS. For the Mission Main treatment train, this includes forcemain extensions for the Belinder PS and Rock Creek PS since the new pumping head condition will be similar to the existing condition. The proposed location and potential force main alignments are shown in Figure 36.

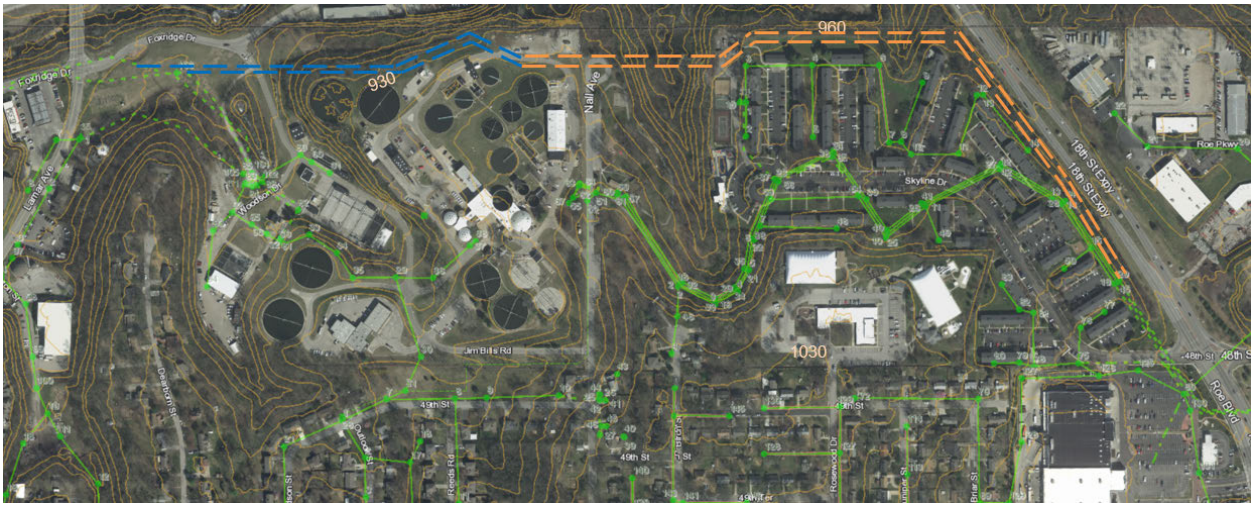


Figure 36: Proposed Headworks Building Location

The initial upgrades to Turkey Creek PS and forcemain extensions are baseline improvements, required in any scenario. Therefore, the initial upgrade costs will be excluded from the optimization. If pump station and forcemain improvements beyond the baseline are selected, the incremental upgrade costs will be included in the optimization. Incremental costs, exclusive of baseline improvements, are reflected in the refined cost curves presented herein.

The refined cost curves do not include land acquisition, odor control, and electrical distribution upgrades within KCPL's system. Anticipated maximum electrical load demands associated with the pump station and PEFTF improvements have been furnished to KCPL and will be included in updated project cost estimates at a later date. At the time this Draft TM was written, KCPL had responded and indicated there were no issues with the increased loads at Brush Creek, Rock Creek, or Turkey Creek. KCPL was still investigating if it could handle the load required for major upgrades to Belinder PS; final determination will likely be dependent on pump station capacity as well as other future load growths in this area, independent of JCW facilities.

In order to determine if pump station improvements in the form of a new pump station are required, the estimated maximum capacity of the existing pump station was determined. Several Hydraulic Institute (HI) standards were selected as criteria to determine the reasonable maximum size of each existing pump station. The criteria used were as follows:

- Maximum pump suction velocity = 8.0 fps
- Maximum pump bay velocity = 1.5 fps
- Maximum approach channel/conduit velocity, dry pit pumps = 3 fps
- Maximum approach channel/conduit velocity, vertical turbine/submersible pumps = 4 fps
- Maximum TDH = 180 ft

Itemized costs used to produce the following cost curves are provided in Appendix D.

4.2.3.1 BRUSH CREEK PUMP STATION

For refined optimization, Brush Creek PS was evaluated for peak flows between the current firm capacity of 5.5 MGD and a theoretical maximum firm capacity of 20 MGD. The existing dry weather pump station capacity build-out is limited to approximately 12 MGD, beyond which a new wet weather facility would become necessary. The wet weather facility would likely be constructed at a site in the vicinity of the pump station. All flow scenarios include a $50,000 cost for local electrical service upgrades.

At the maximum evaluated capacity (20 MGD), it is assumed there will be 5 pumps in service with 1 standby pump (total of 6 pumps) between both facilities. Costs include new VFD buildings for both facilities.

The refined cost curve for Brush Creek PS is provided in Figure 37.

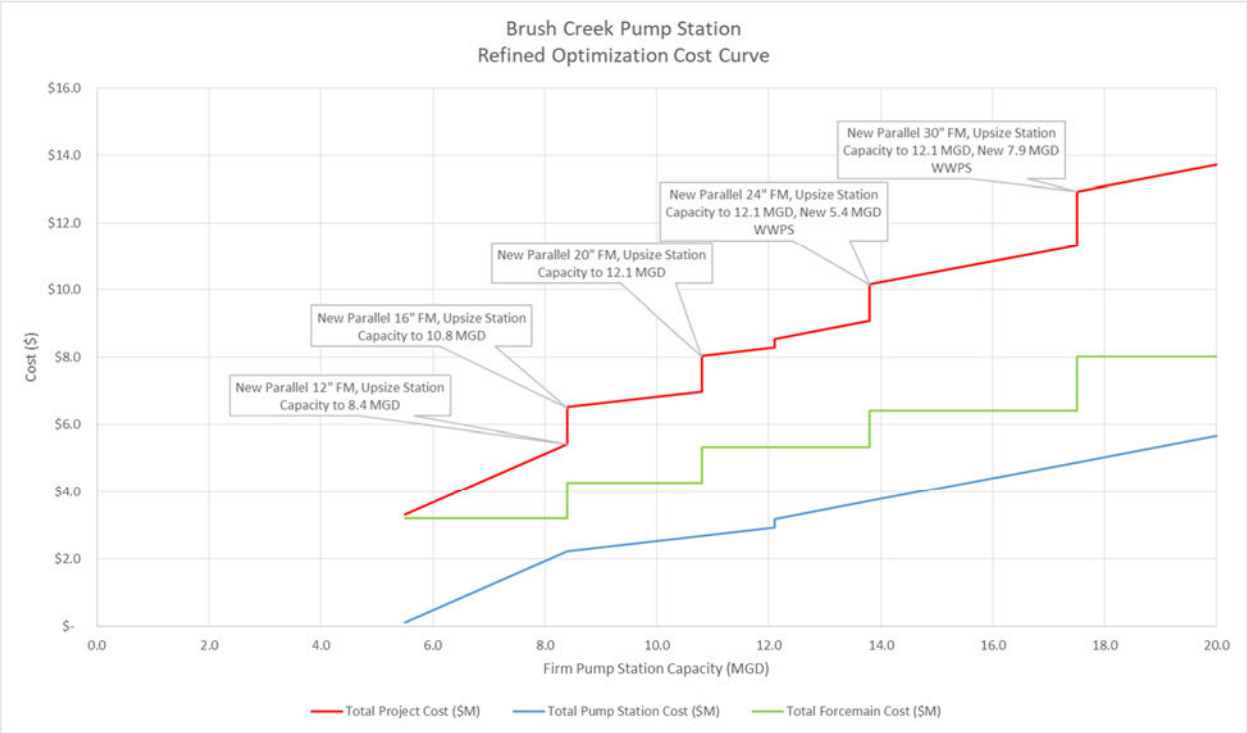


Figure 37: Brush Creek Pump Station Refined Optimization Cost Curve

4.2.3.2 ROCK CREEK PUMP STATION

For refined optimization, Rock Creek PS was evaluated for peak flows between the current firm capacity of 12 MGD and a theoretical maximum firm capacity of 50 MGD. The existing dry weather pump station capacity build-out is limited to approximately 22 MGD, beyond which a new wet weather facility would become necessary. The wet weather facility would likely be constructed just north of the existing facility.

At the maximum evaluated capacity (50 MGD), it is assumed there will be 5 pumps in service with 2 standby pumps (total of 7 pumps) between both facilities. Costs include new VFD buildings for both facilities.

The refined cost curve for Rock Creek PS is provided in Figure 38.

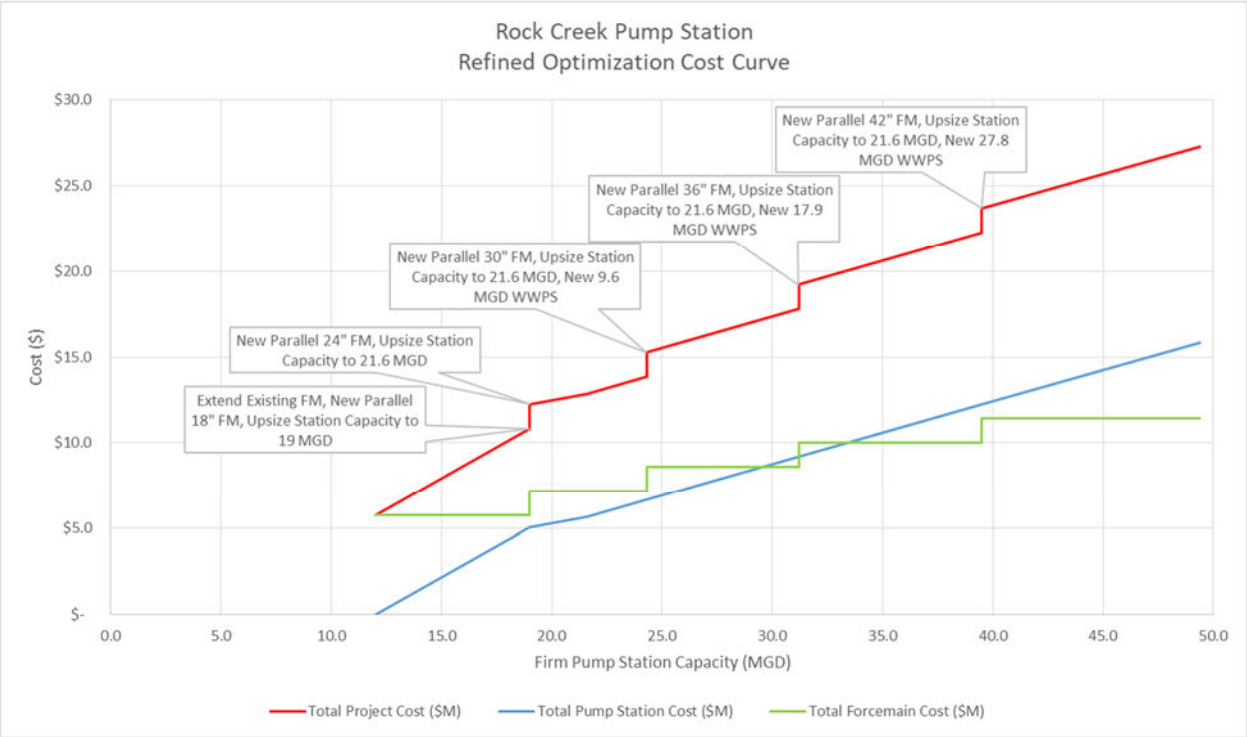


Figure 38: Rock Creek Pump Station Refined Optimization Cost Curve

4.2.3.3 BELINDER PUMP STATION

For refined optimization, Belinder PS was evaluated for peak flows between the current firm capacity of 10.6 MGD and a theoretical maximum firm capacity of 65 MGD. The existing dry weather pump station capacity build-out is limited to approximately 27 MGD, beyond which the Belinder PEFTF facility would be re-purposed as a wet weather pump station.

At the maximum evaluated capacity (65 MGD), it is assumed there will be 5 pumps in service with 2 standby pumps (total of 7 pumps) between both facilities. Costs include new VFD buildings for both facilities.

The refined cost curve for Belinder PS is provided in Figure 39.

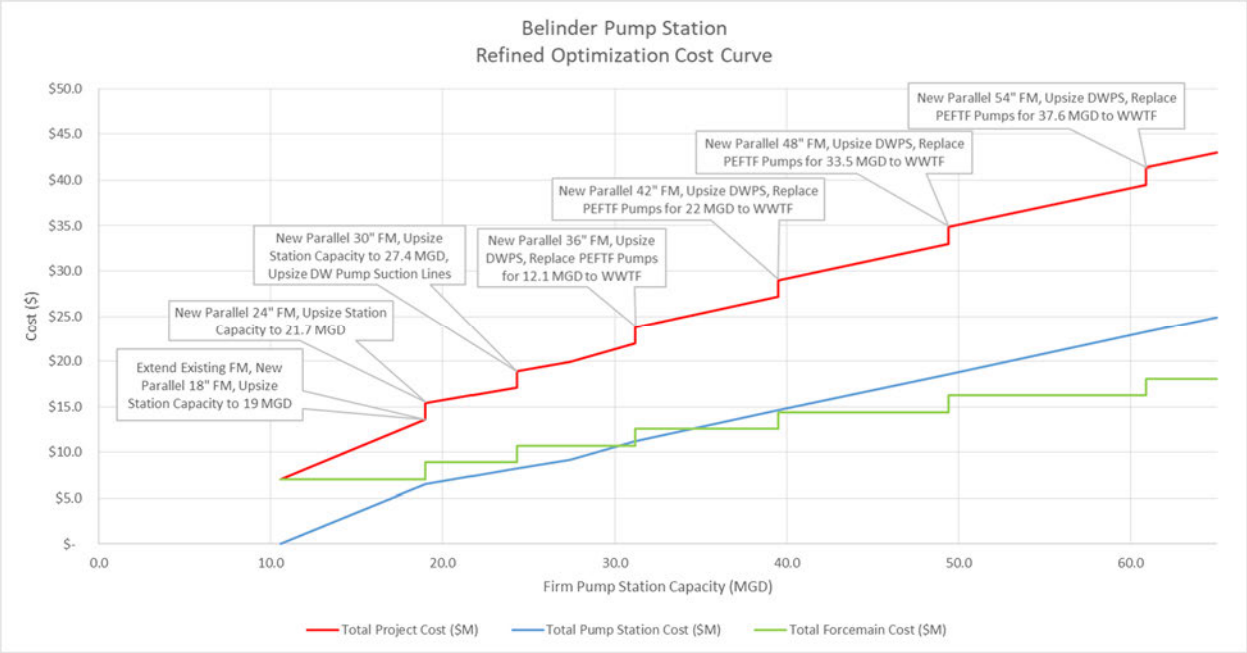


Figure 39: Belinder Pump Station Refined Optimization Cost Curve

4.2.3.4 TURKEY CREEK PUMP STATION

For refined optimization, Turkey Creek PS was evaluated for peak flows between the current firm capacity of 27 MGD and a theoretical maximum firm capacity of 60 MGD. The existing dry weather pump station capacity build-out is limited to approximately 36 MGD, beyond which the Turkey Creek PEFTF facility would be re-purposed as a wet weather pump station.

At the maximum evaluated capacity (60 MGD), it is assumed there will be 5 pumps in service with 1 standby pump (total of 6 pumps) between both facilities. Costs include new VFD buildings for both facilities.

The refined cost curve for Turkey Creek PS is provided in Figure 40.

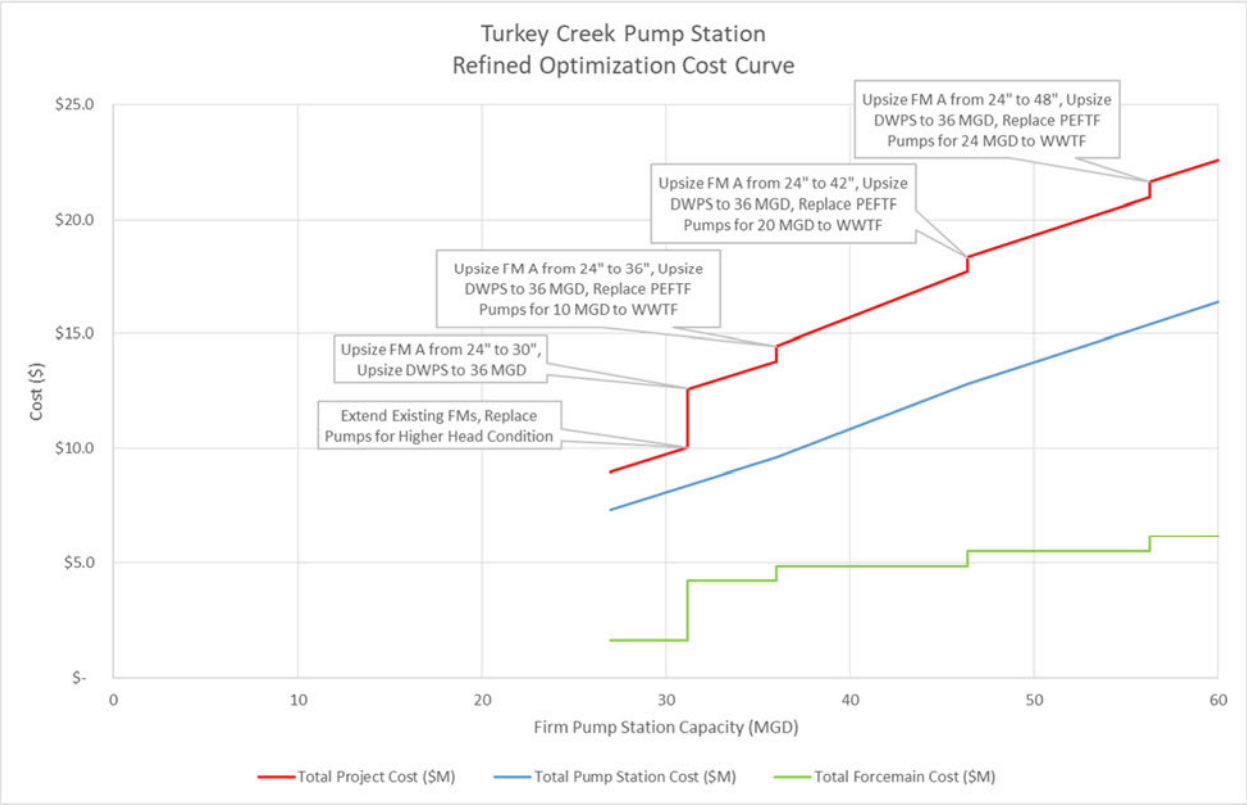


Figure 40: Turkey Creek Pump Station Refined Optimization Cost Curve

Shown in Figure 41 is a comparison of each facility-specific cost curve with the cost curves utilized during preliminary optimization.

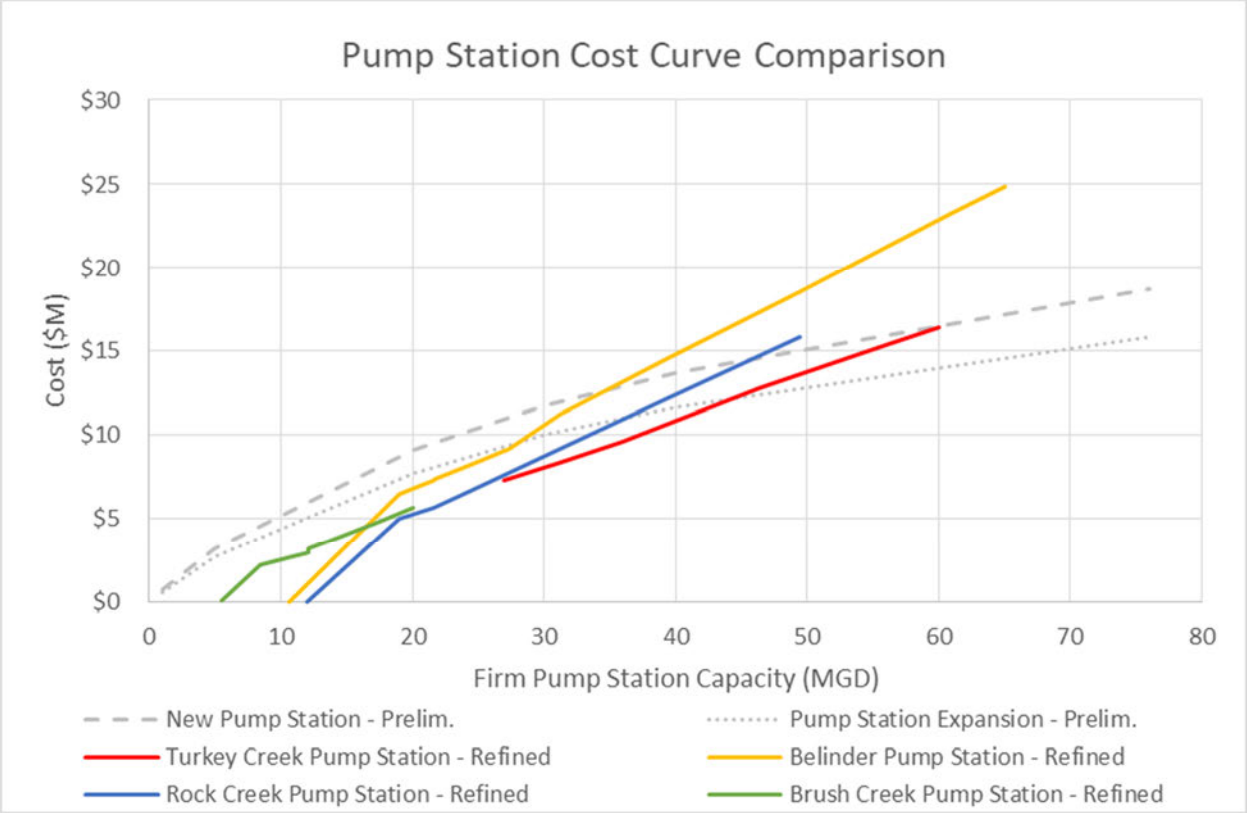


Figure 41: Pump Station Cost Curve Comparison

4.2.4 Storage

Shallow underground storage costs remain unchanged from preliminary optimization. The cost table presented in Section 2.2.4 will be used for refined optimization.

Several tunnel projects in the area were evaluated to determine a representative cost per gallon for tunnel storage. Recent HDR projects in Omaha, Nebraska and St. Louis, Missouri, have indicated that tunnel storage on average costs approximately $8 per gallon. Tunnel storage will considered at this unit cost during refined optimization.

4.2.5 I/I Reduction

I/I reduction costs curves remain unchanged from preliminary optimization. The cost curves presented in Section 2.2.5 will be used for refined optimization.

Based on projections presented in Section 4.1.3, Mission Main will start with a base level of 10% I/I reduction in each sub-basin with the option to go up to a maximum of 30% I/I reduction. Turkey Creek will start with a base level of 15% I/I reduction in each sub-basin with the option to go up to a maximum of 30% I/I reduction. The baseline costs will be excluded from the optimization, while any incremental costs above the baseline will be included.

4.2.6 PEFTFs

The refined optimization will continue with the assumption that improved treatment (filtration and disinfection at facilities that do not currently have it) will be required if a PEFTF is retained. For refined optimization, site specific cost curves have been developed for each PEFTF.

PEFTF improvements of varying capacity were developed for each existing PEFTF location. Assumed improvements generally consist of the following:

- Expansion of chlorination volume if needed to provide a minimum 15 minute contact time as well as associated chemical pumping improvements.
- Addition or expansion of dechlorination volume to provide a minimum of 30 seconds contact time as well as associated chemical pumping improvements.
- Addition of disc filters to provide improved suspended solids removal prior to disinfection.

Costs for the outlined improvements were developed from applicable prior project cost information. For the disc filters, cost information from the Tomahawk Creek (THC) dual purpose filters was utilized. Applicable unit costs from the THC estimate were modified to reflect improvements at a remote facility versus at a WWTF site. Costs for screening, chemical pumping and storage improvements were developed from the Turkey Creek Pump Station (TCPS) project and include costs for locating equipment within a building.

Itemized costs used to produce the following cost curves are provided in Appendix E.

4.2.6.1 75TH/NALL PEFTF

75th/Nall PEFTF relieves peak flow for both Brush Creek PS and Rock Creek PS. Site-specific costs were developed for peak flows between 10 MGD and the existing capacity of 20 MGD, considering disinfection and filtration needs:

- Disinfection
    - Chlorination (sodium hypochlorite) – Existing basin volume provides sufficient contact time for 20 MGD scenario.
    - Dechlorination (sodium bisulfite) – Existing facility provides dechlorination for 20 MGD scenario.
- Filtration
    - At 20 MGD scenario, a 40’x95’ structure must be constructed to house disc filters. A smaller structure would be required for a lower capacity scenario.

The suggested site layout is provided in Figure 42. The refined cost curve for the 75th/Nall PEFTF is presented in Figure 43.

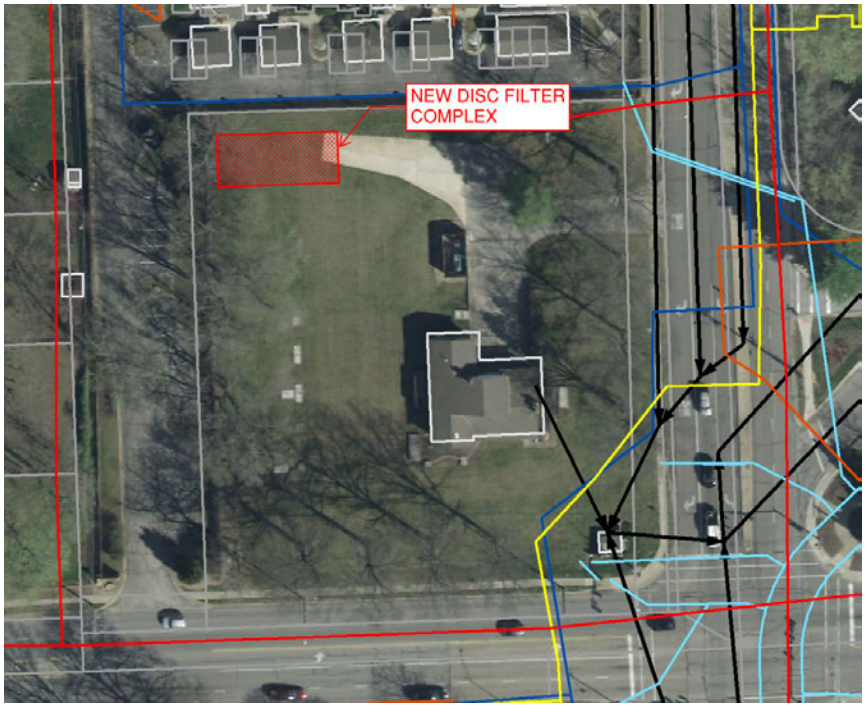


Figure 42: 75th/Nall PEFTF Refined Site Layout

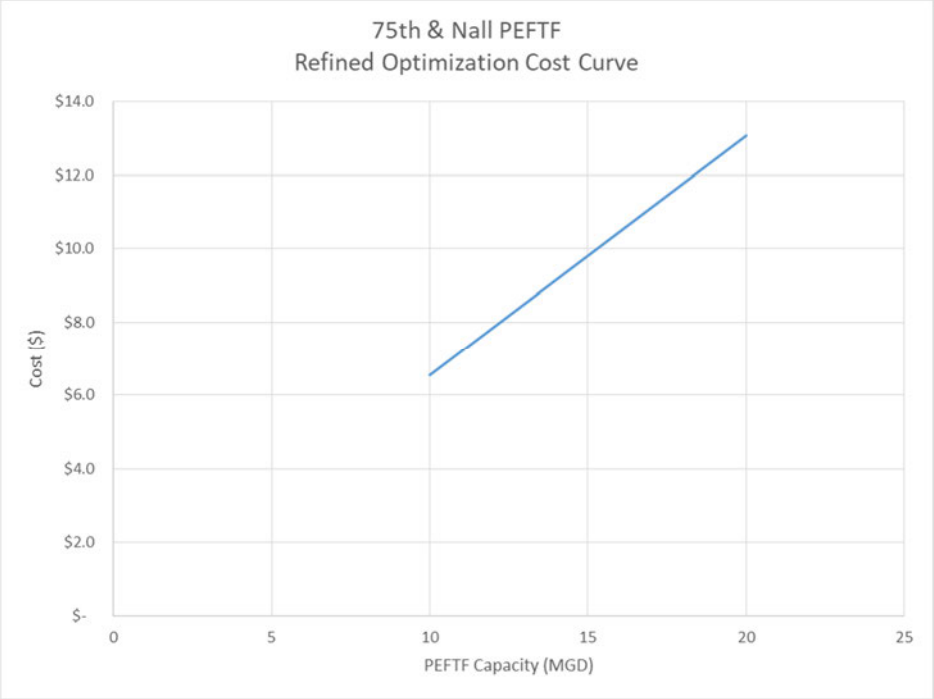


Figure 43: 75th/Nall PEFTF Refined Cost Curve

4.2.6.2 MARTWAY PEFTF

Martway PEFTF relieves peak flow for Rock Creek PS. Site-specific costs were developed for peak flows between 10 MGD and the existing capacity of 20 MGD, considering disinfection and filtration needs:

- Disinfection
  - Chlorination (sodium hypochlorite) – Existing basin volume provides sufficient contact time for 20 MGD scenario.
  - Dechlorination (sodium bisulfite) – Existing facility provides dechlorination, but requires modifications to expand contact zone for 20 MGD scenario.
- Filtration
  - At 20 MGD scenario, a 40'x95' structure must be constructed to house disc filters. A smaller structure would be required for a lower capacity scenario. Land acquisition is required for disc filter building.

The suggested site layout is provided in Figure 44. The refined cost curve for Martway PEFTF is presented in Figure 45.

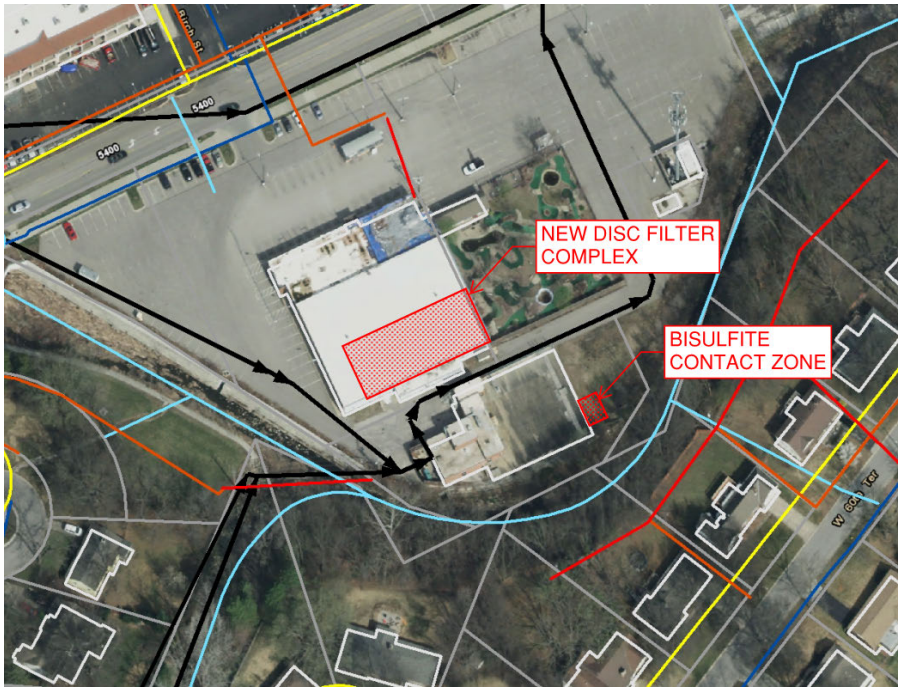


Figure 44: Martway PEFTF Refined Site Layout

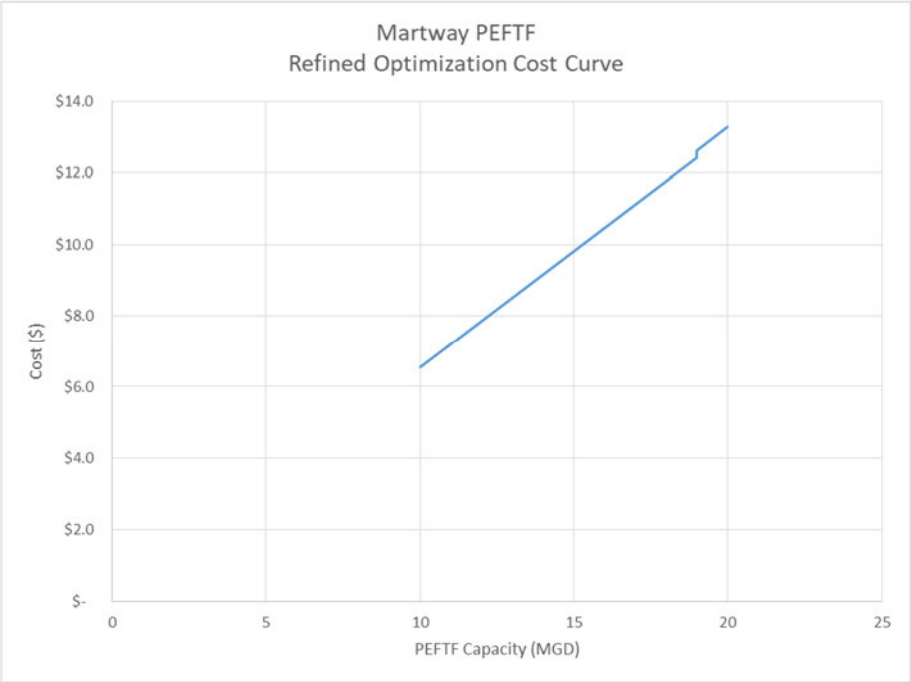


Figure 45: Martway PEFTF Refined Cost Curve

4.2.6.3 BELINDER PEFTF

Site-specific costs were developed for peak flows between the existing capacity of 42 MGD and 90 MGD, considering disinfection and filtration needs:

- Disinfection
  - Chlorination (sodium hypochlorite) – Existing basin volume provides sufficient contact time up to 85 MGD scenario.
  - Dechlorination (sodium bisulfite) – Existing facility does not provide dechlorination. Cost curve includes addition of a bisulfite contact basin for all flow scenarios.
- Filtration
  - At 90 MGD scenario, a 60'x140' structure must be constructed to house disc filters. A smaller structure would be required for a lower capacity scenario.

The suggested site layout is provided in Figure 46. The refined cost curve for Belinder PEFTF is presented in Figure 47.

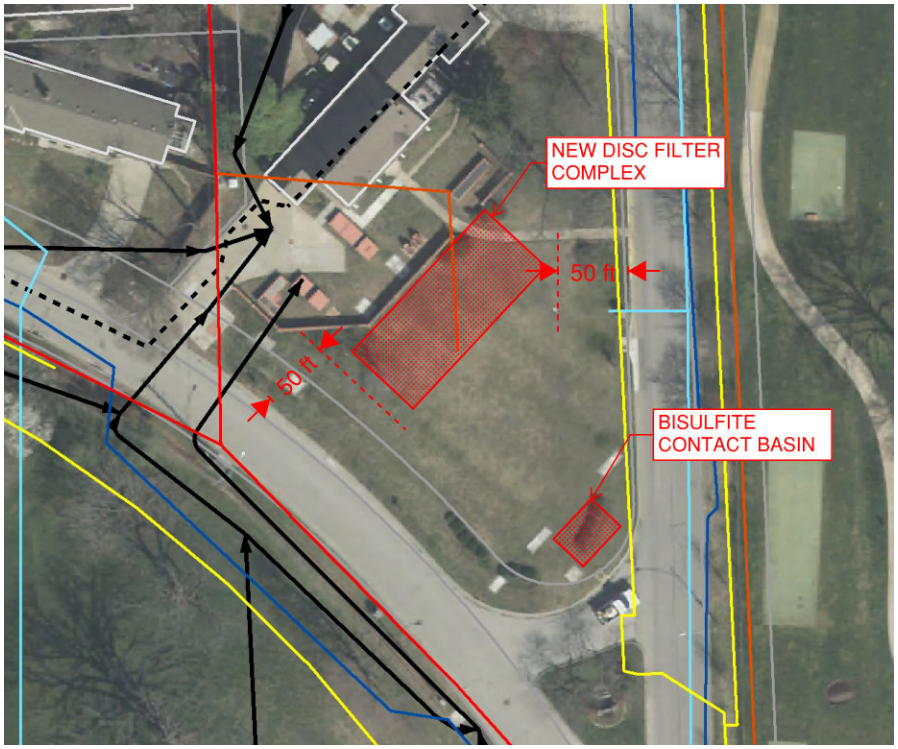


Figure 46: Belinder PEFTF Refined Site Layout

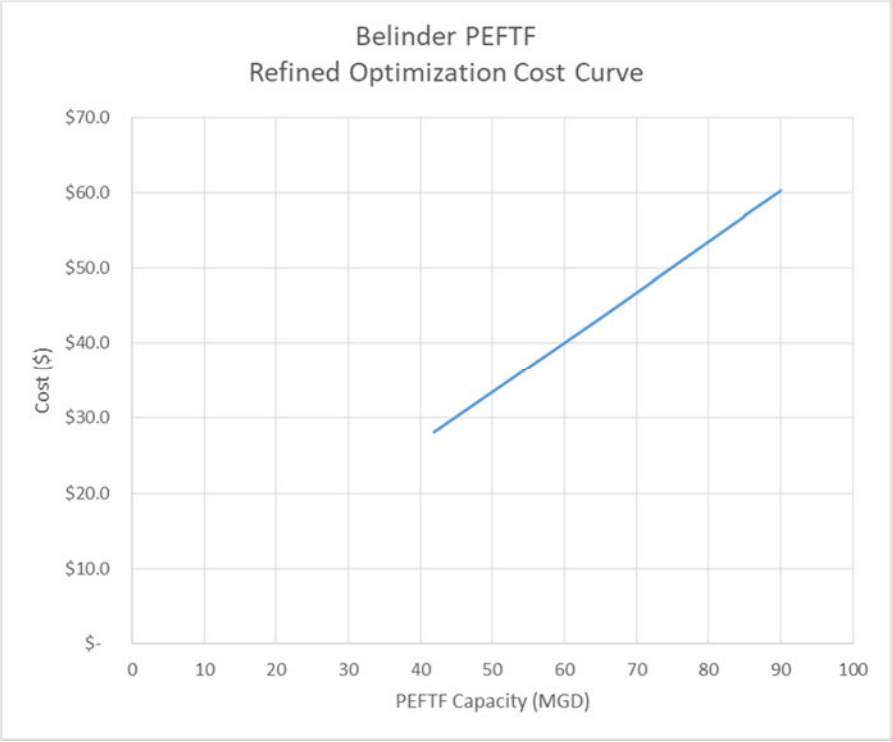


Figure 47: Belinder PEFTF Refined Cost Curve

4.2.6.4 TURKEY CREEK PEFTF

Site-specific costs were developed for peak flows between 11 MGD and the existing capacity of 22 MGD, considering disinfection and filtration needs:

- Disinfection
  - Chlorination (sodium hypochlorite) – Existing basin volume provides sufficient contact time for 22 MGD scenario. Costs include contact basin improvements, including construction of five (5) baffles.
  - Dechlorination (sodium bisulfite) – Existing facility does not provide dechlorination. Cost curve includes addition of a bisulfite contact basin for all flow scenarios.
- Filtration
  - At 22 MGD scenario, a 40'x95' structure must be constructed to house disc filters. A smaller structure would be required for a lower capacity scenario.

The suggested site layout is provided in Figure 48. The refined cost curve for Turkey Creek PEFTF is presented in Figure 49.

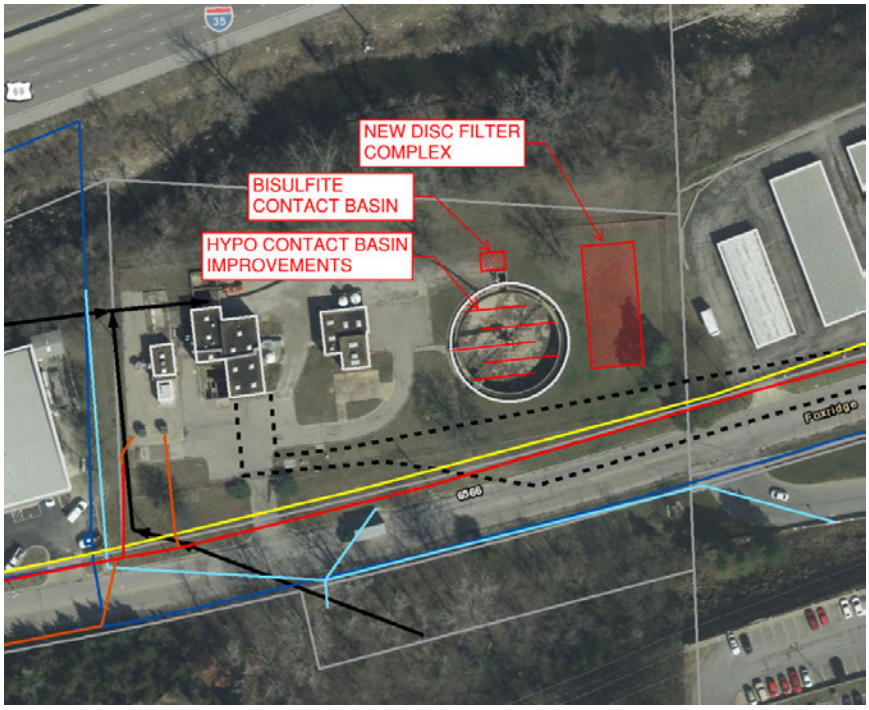


Figure 48: Turkey Creek PEFTF Refined Site Layout

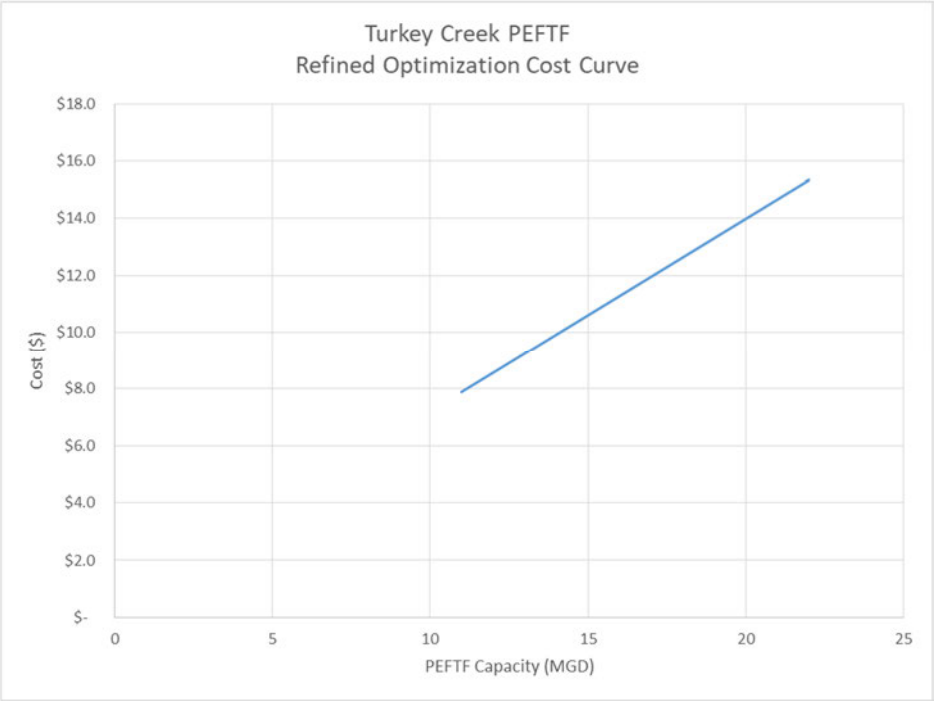


Figure 49: Turkey Creek PEFTF Refined Cost Curve

4.2.7 Auxiliary Treatment Facility

ATF costs remain unchanged from preliminary optimization. The cost curve presented in Section 2.2.7 will be used for refined optimization.

5 Summary and Next Steps

5.1 Preliminary Optimization Summary

Optimization is an iterative process that begins with preliminary optimization and alternatives analysis. The intent of preliminary optimization was to identify key trends among improvement alternatives, identify alternatives that should be screened for further evaluation, and to identify sensitivities that require additional input prior to refined optimization. During preliminary optimization, all feasible alternatives were included in the analysis in order to complete a thorough evaluation of alternatives.

Three (3) level of service (LOS) scenarios were evaluated during preliminary optimization – Scenario 1A, Scenario 1B, and Scenario 2.

- Scenario 1A ("Base Case") requires a minimum LOS of 10 years for the collection system and a minimum LOS of 5 years for major facilities. In the base case, it is assumed that the PEFTFs will eventually be eliminated and not available for use during any wet weather event. In place of the PEFTFs, it is assumed that a Facility Protection Device (FPD) would be in place at each major remaining facility and may activate to protect the public and JCW facilities for events greater than 5-year storm. It is assumed that an FPD would be constructed at Rock Creek PS in lieu of the Martway PEFTF, and an FPD would be constructed at Turkey Creek PS in lieu of the Turkey Creek PEFTF. Scenario 1A was termed "All Options, No PEFTFs" in this TM. *This alternative was ultimately referred to as Alternative 1: Eliminate PEFTFs through Wet Weather Management, or PEFTF Elimination.*

- Scenario 1B ("PEFTFs Remain"), like Scenario 1A, requires a 10 year minimum LOS for the collection system and a 5 year minimum LOS for facilities. In this scenario, it is assumed that the PEFTFs will be upgraded and remain in service indefinitely. The PEFTFs would provide a 5 year LOS, above which the Facility Protection Devices may activate. Scenario 1B was termed "All Options, PEFTFs Remain" in this TM. *This alternative was ultimately referred to as Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment, or PEFTF Retention.*

- Scenario 2 requires a 10 year minimum LOS for the collection system and a 1 year minimum LOS for facilities. In this scenario, like the Base Case, it is assumed that the PEFTFs will be eliminated. Scenario 2 was termed "All Options, PEFTFs Remain – 10/1" in this TM. *This alternative was not carried forward as a viable option after preliminary optimization.*

The total 20-yr PV cost for each preliminary optimization scenario is presented in Table 28 and Figure 50. The presented costs do not include operation and maintenance costs that are common among alternatives.

Table 28: Preliminary Optimization Scenario Costs

Optimization Scenario	20-yr PV Total Cost ($M) [1]
Scenario 1A - Conveyance Only (10/5 Year Design Storms)	$ 197.8
Scenario 1A - Conveyance and Storage Only (10/5 Year Design Storms)	$ 195.2
Scenario 1A - All Options (10/5 Year Design Storms)	$ 181.9
Scenario 1B - PEFTFs Remain (No ATF Allowed)	$ 205.0
Scenario 2 - All Options (10/1 Year Design Storms)	$ 145.5

[1] Costs do not include operation and maintenance costs that are common among alternatives.

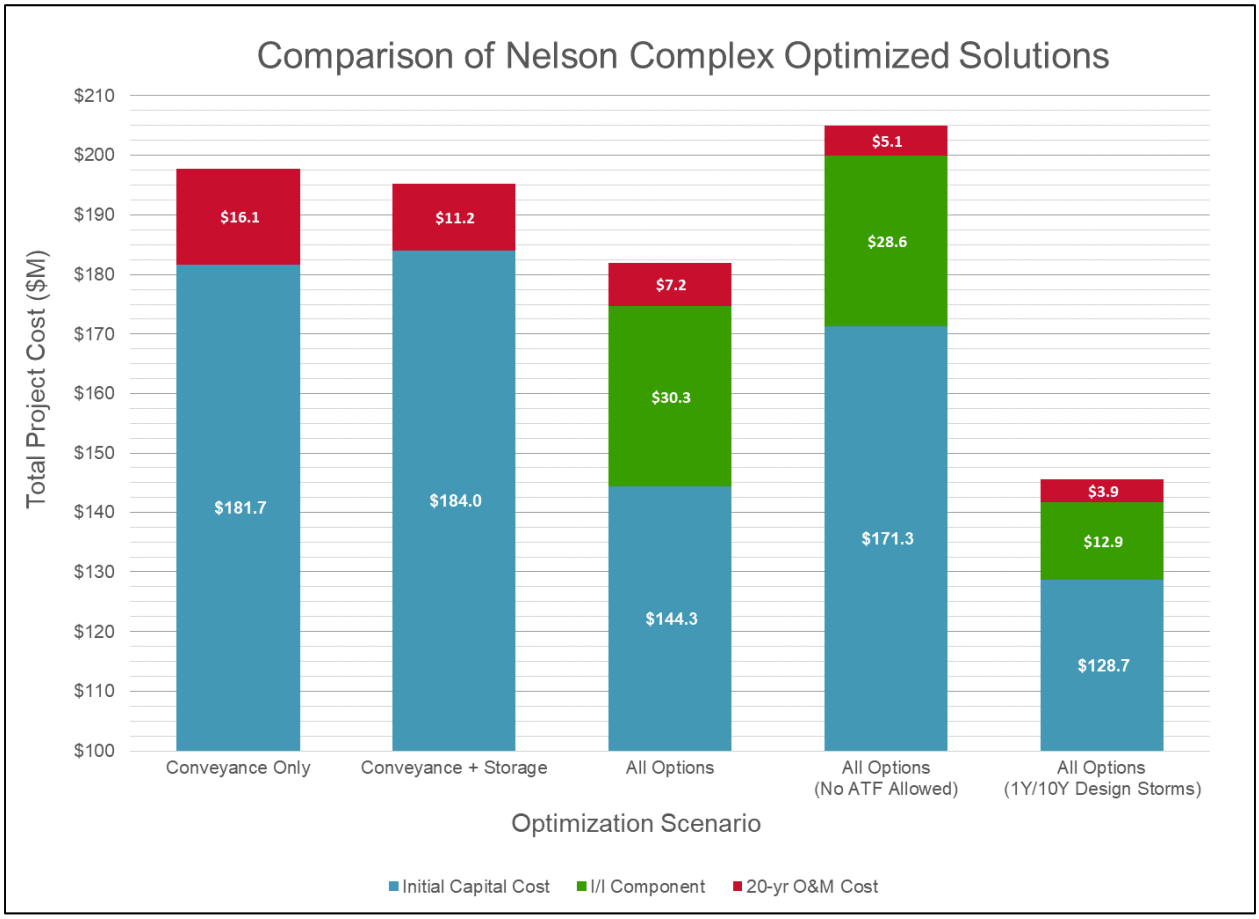


Figure 50: Comparison of Nelson Complex Optimized Solutions

As presented in Table 28 and Figure 50, total costs were similar among preliminary optimization scenarios. The preliminary optimization demonstrated several key trends. It helped identify aspects of the optimization that are sensitive to assumptions and cost estimates to be reviewed prior to the refined optimization.

By comparing the preliminary optimization solutions, the following trends were observed:

1. The total costs for the various combinations of alternatives evaluated in preliminary optimization were relatively close. The differential among the various combinations of conveyance, storage, and I/I reduction alternatives was approximately 10%.

2. Preliminary optimization identified similar sets of improvements alternatives in Turkey Creek characterized by a remote storage facility along the interceptor, I/I reduction in the upper reaches, and an expansion to the Turkey Creek Pump Station to convey wet weather flows to an Auxiliary Treatment Facility along with gravity conveyance improvements.
3. Preliminary optimization of Mission Main identified storage near Rock Creek and Brush Creek pump stations in lieu of pump station expansion, along with an expansion to Belinder Pump Station to convey wet weather flows to an Auxiliary Treatment Facility along with gravity conveyance improvements as the most cost-effective set of alternatives. Extensive I/I reduction was selected. However, it was noted that the costs of expanding Rock Creek and Brush Creek in lieu of storage were comparable.
4. The All Options scenario selected cost-effective targets for I/I reduction in each flow metered basin. More extensive I/I reduction was selected throughout Mission Main in comparison to Turkey Creek. In Turkey Creek, the optimization focused I/I reduction primarily in the upstream reaches of the basin.
5. In general, the existing Turkey Creek and Mission Main trunk conveyance network is significantly under capacity. The All Options scenarios were therefore characterized by extensive I/I reduction, particularly in Mission Main. By reducing extraneous volumes in the conveyance network, storage became a cost-effective alternative throughout both watersheds.
6. An alternative where the PEFTFs remained in service was evaluated (by removing the ATF option from the optimization). This scenario assumes full upgrade of the PEFTFs with enhanced treatment technology. Construction of storage at the facilities and PEFTF upgrade options were similar in overall cost.
7. ATF was key to reducing total costs; Scenario 1A (All Options, No PEFTFs) was approximately $23M cheaper than Scenario 1B (PEFTFs Remain, No ATF).

5.2 Alternatives Screening Summary

For preliminary optimization, simplifying assumptions were made for each alternative in order to formulate the optimization and gain initial insights into how the system was performing. The analysis utilized the same unit costs curves for each type of facility (e.g. storage, pump station expansion, etc.) and did not limit the volume of storage or extent of capacity upgrades allowable at each facility. The refined optimization will utilize site and facility specific improvements costs. Any limitations to the magnitude of improvements based on feasibility will be included.

5.2.1 Gravity Improvements

For preliminary optimization, it was assumed that all selected gravity main improvements would be parallel relief sewers. During alternatives screening, each length of improvements was evaluated; if the parallel option was determined to be infeasible, the length was recommended to be upsized in place.

Due to this refinement, it is anticipated costs will rise for selected gravity upgrades, potentially steering the optimization toward larger storage facilities and more extensive I/I reduction.

5.2.2 Pump Station & Forcemain Improvements

For preliminary optimization, pump station upgrades utilized the same cost curve for each facility. All pump station upgrades were assumed to be expansions of the existing facilities. During alternatives screening and cost refinement, a separate cost curve was developed for each of the major pump stations. Forcemain upgrades were considered in conjunction with each pump station curve. Each

refined facility curve has a flow breakpoint, beyond which a new wet weather facility must be constructed, as well as several other breakpoints where additional costs are incurred.

At lower flow rates, the refined cost curves are cheaper than the expansion cost curve developed for preliminary optimization. At higher flow rates, the refined cost curves are more expense than the expansion cost curve. If more expensive than preliminary optimization, the refined cost curve may steer the optimization toward larger storage facilities or more I/I reduction to avoid the construction of dedicated wet weather pump stations. If cheaper than preliminary optimization, this refinement may steer the optimization toward conveyance and pumping.

5.2.3 Storage

For preliminary optimization, underground storage was considered at all major facilities and at reasonable remote locations within the collection system. Each site was assumed to have unlimited capacity and storage volumes were unconstrained. Several locations were selected for storage during preliminary optimization. During alternatives screening, these locations, and others, were evaluated for acquisition and construction feasibility and maximum storage capacity available.

For refined optimization, six (6) locations were selected and approved by JCW to be considered in the optimization. A reasonable maximum storage volume was assigned to each site. Constraining the storage volume may steer the optimization toward more conveyance and I/I reduction. *Note that the storage locations named in this TM may not be the final parcels selected when site acquisition begins. JCW will communicate and collaborate with stakeholders to determine suitable parcels for storage.*

In addition to underground storage, tunnel storage will be considered near Belinder. It is anticipated that this option will be cost-prohibitive and will not be selected in refined optimization.

5.2.4 I/I Reduction

The optimization evaluated potential I/I reduction that could be achieved from the cost effective rehabilitation of public sector assets and the disconnection of private sector sources. For preliminary optimization, the maximum I/I reduction option considered for each basin was 30% based on the typical comprehensive strategy adopted by JCW. During the alternatives screening, the results of JCW's ongoing asset renewal efforts were used to project a basin-wide baseline I/I reduction for each watershed, Mission Main and Turkey Creek. It was determined that 10% reduction in Mission Main and 15% reduction in Turkey Creek would be representative of the baseline I/I reduction JCW can expect to achieve through their public sector asset management program.

For refined optimization, the appropriate baseline I/I reduction (10% or 15%) will be applied to each meter basin. Up to 30% reduction will still be considered for each meter basin. This refinement will likely reduce conveyance improvements and required storage volumes.

5.2.5 PEFTFs

Due to the cost of significant treatment upgrades, the PEFTFs were not selected in the preliminary optimization unless ATF was disallowed from the scenario. Due to the many decisions and limitations placed on alternatives during the alternatives screening, it is possible that PEFTFs may become a more cost-effective option during refined optimization. For example, storage was removed from consideration at Rock Creek PS, which may steer the optimization to select Martway PEFTF for upgrade.

5.2.6 Auxiliary Treatment Facility

The ATF cost curve remains unchanged from preliminary optimization. It is unknown how the refinements to alternatives and costs will impact the likelihood of ATF being selected. It is still anticipated that the optimization will, when given the option, select ATF in some capacity.

5.3 Next Steps

The refined optimization will use the refinements, limitations, and other design criteria documented in this TM to find an optimized solution that meets JCW's preferred LOS. Sensitivity analyses will be performed throughout the refined optimization, providing flexibility to choose among alternatives if similar in cost. For example, storage may be preferred to constructing a dedicated wet weather pump station, even if slightly higher in cost.

Ultimately, selected alternatives will be incorporated into a prioritized long-term collection system plan. Individual improvement projects will be phased based on financial impacts to JCW and its ratepayers, as well as water quality benefits that will be realized as improvements are completed.

Appendix A References

HDR. *CSAMP Manhole Renewal Program Implementation, Development, and Renewal Forecast TM*. Ongoing.

HDR. *Johnson County Wastewater Facilities Asset Management Program Implementation Plan.* April 2018.

HDR. *Johnson County Wastewater Collection System Asset Management Program. Implementation Plan and other Program Documents.* January 2014 to Date.

Black and Veatch/HDR. *Johnson County Wastewater Tomahawk Creek WWTF Project Definition Study.* June 2016.

CH2M. *Public Manhole Sewer I/I Reduction Implementation: Public Sector I/I Strategy Implementation, Technical Memorandum 2 – Public Manhole I/I Reduction Strategy*. January 2016.

CH2M HILL. *Nelson Wastewater Treatment Complex Sanitary Sewer Service Area, EPA 308(a) Response Document: Executive Plan*. March 2015.

CH2M HILL. *Technical Memorandum No. 5: Alternatives Analysis*. January 2015.

CH2M HILL. *Collection System Analysis for Peak Excess Flow Treatment Facilities: Mission Township Main Sewer District No. 1 and Shawnee Mission Turkey Creek Watersheds, Supplement to January 2009 Technical Response to EPA 308(a) Request*. December 2014.

CH2M HILL. *Technical Memorandum #3: Updated System Performance Information*. June 2013.

CH2M HILL. *Draft Technical Memorandum #2 and #3: Data Characterization, Quantification, and Costing I/I Curve Development, Repair Prioritization, and Application of Results to other Basins*. June 2011.

Johnson County Wastewater. *Response to: EPA Request for Information Pursuant to Section 308(a) of the Clean Water Act Items A.2, A.4, A.5 and A.6*. January 2009.

Appendix B – Preliminary Optimization Solution Summary Spreadsheets

Preliminary Optimization Results

10-Year/5-Year, PEFTFs Decommissioned
Conveyance Only

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
GRAVITY SEWER (NELSON COMPLEX)																								**$ 65,694,412**	**$ -**	**$ 65,694,412**
GRAVITY SEWER (TUKEY CREEK)																								**$ 34,404,105**	**$ -**	**$ 34,404,105**
F_GS_006		184			YES	0341025	0341015	1	1.00	2,852	991.00	973.18	0.6%	12.31	19.36	15.84	4	1.6	3.57	3.57	$ 417	$ -	$ 1,251	$ 1,342,782	$ -	$ 1,342,782
F_GS_010		138			YES	0341012	0341009	1	1.75	1,224	969.93	966.78	0.3%	16.49	19.19	17.84	4	4.4	0.85	0.49	$ 557	$ -	$ 1,671	$ 835,233	$ -	$ 835,233
F_GS_011					NO																					
F_GS_012		829			YES	0341008	0341004	1	1.50	1,416	965.05	960.51	0.3%	12.50	17.88	15.19	4	3.9	1	0.67	$ 479	$ -	$ 1,437	$ 1,472,298	$ -	$ 1,472,298
F_GS_015					NO																					
F_GS_017					YES	0340003	0338019	1	1.25	948	988.18	977.03	1.2%	13.10	11.46	12.28	3	2.0	0.47	0.38	$ 373	$ -	$ -	$ 353,597	$ -	$ 353,597
F_GS_018					YES	0340106	0340091	1	1.00	980	1013.43	1007.03	0.7%	13.84	10.12	11.98	3	0.5	0.68	0.68	$ 348	$ -	$ -	$ 341,012	$ -	$ 341,012
F_GS_019					NO																					
F_GS_021	85				NO																					
F_GS_022					YES	0339003	0338027	1	1.00	423	1009.67	999.23	2.5%	8.73	8.85	8.79	2	1.3	0.56	0.56	$ 278	$ -	$ -	$ 117,486	$ -	$ 117,486
F_GS_023					YES	0338026	0338024	1	2.00	548	994.13	988.39	1.0%	15.47	11.66	13.57	3	1.7	0.61	0.31	$ 528	$ -	$ -	$ 289,471	$ -	$ 289,471
F_GS_024					NO																					
F_GS_025					YES	0338019	0338015	1	1.25	1,260	977.03	967.68	0.7%	11.95	12.19	12.07	3	3.3	0.91	0.73	$ 373	$ -	$ -	$ 469,797	$ -	$ 469,797
F_GS_026					NO																					
F_GS_031					YES	0337139	0337131	1	1.25	261	1014.81	1012.51	0.9%	9.52	13.75	11.64	3	1.1	0.53	0.42	$ 373	$ -	$ -	$ 97,338	$ -	$ 97,338
F_GS_034					YES	0337079	0337074	1	1.00	220	1022.09	1020.65	0.7%	12.36	12.84	12.60	3	0.6	0.53	0.53	$ 348	$ -	$ -	$ 76,630	$ -	$ 76,630
F_GS_038	56				YES	0337046	0336176	1	1.00	933	995.71	987.40	0.9%	11.53	15.43	13.48	3	2.0	0.88	0.88	$ 348	$ -	$ 400	$ 327,756	$ -	$ 327,756
F_GS_039					NO																					
F_GS_040					YES	0336141	0336139	1	1.00	448	975.07	970.17	1.1%	18.79	9.73	14.26	3	2.4	0.91	0.91	$ 348	$ -	$ -	$ 155,810	$ -	$ 155,810
F_GS_043					YES	0336028	0336002	1	1.25	890	961.12	954.12	0.8%	10.11	13.39	11.75	3	3.2	0.86	0.69	$ 373	$ -	$ -	$ 332,101	$ -	$ 332,101
F_GS_045	104			169	YES	0335012	0335005	1	2.50	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	17.1	0.87	0.35	$ 734	$ -	$ 3,501	$ 1,987,462	$ -	$ 1,987,462
F_GS_056					YES	0332011	0332002	1	1.00	576	969.79	958.55	2.0%	5.06	3.48	4.27	2	0.6	0.4	0.40	$ 278	$ -	$ -	$ 160,159	$ -	$ 160,159
F_GS_060					NO																					
F_GS_062		95			YES	0331010	0331003	1	2.25	2,882	927.49	920.78	0.2%	16.86	12.18	14.52	3	13.0	0.93	0.41	$ 630	$ -	$ 1,890	$ 1,934,847	$ -	$ 1,934,847
F_GS_064		283			YES	0331003	0320005	1	3.50	1,491	920.78	917.38	0.2%	13.18	11.99	12.59	3	25.2	0.92	0.26	$ 1,029	$ -	$ 3,087	$ 2,117,139	$ -	$ 2,117,139
F_GS_065					YES	0320004	0320185	1	1.00	80	913.63	913.24	0.5%	18.78	17.24	18.01	4	3.2	1	1.00	$ 417	$ -	$ -	$ 33,264	$ -	$ 33,264
F_GS_067	50				YES	0327094	0327053	1	1.00	836	1013.73	1007.08	0.8%	9.58	9.27	9.43	2	0.5	0.37	0.37	$ 278	$ -	$ 320	$ 234,486	$ -	$ 234,486
F_GS_068	57				YES	0327053	0327044	1	1.25	360	1007.08	1000.05	2.0%	9.27	12.76	11.02	3	1.2	0.32	0.26	$ 373	$ -	$ 429	$ 137,435	$ -	$ 137,435
F_GS_069	68				YES	0327044	0327032	1	1.00	637	1000.05	995.11	0.8%	13.67	11.57	12.62	3	1.1	0.77	0.77	$ 348	$ -	$ 400	$ 225,327	$ -	$ 225,327
F_GS_070	43				YES	0327031	0327007	1	1.00	793	991.66	982.57	1.1%	14.81	7.90	11.36	3	1.5	0.69	0.69	$ 348	$ -	$ 400	$ 278,123	$ -	$ 278,123
F_GS_071					NO																					
F_GS_072					NO																					
F_GS_074					YES	0326024	0326003	1	1.00	578	999.24	996.91	0.4%	13.12	11.76	12.44	3	0.9	0.56	0.56	$ 348	$ -	$ -	$ 201,228	$ -	$ 201,228
F_GS_075					YES	0326001	0323131	1	1.25	592	987.50	980.41	1.2%	9.50	7.95	8.72	2	1.0	0.41	0.33	$ 298	$ -	$ -	$ 176,342	$ -	$ 176,342
F_GS_076					NO																					
F_GS_078					NO																					
F_GS_079					YES	0325048	0325047	1	2.00	176	1015.23	1014.99	0.1%	9.00	11.56	10.28	3	1.6	0.66	0.33	$ 528	$ -	$ -	$ 92,680	$ -	$ 92,680
F_GS_080					NO																					
F_GS_081					YES	0325044	0325036	1	1.00	418	1011.90	1008.16	0.9%	8.62	5.76	7.19	2	1.2	0.77	0.77	$ 278	$ -	$ -	$ 116,204	$ -	$ 116,204
F_GS_082					NO																					
F_GS_084					YES	0325006	0325003	1	1.00	220	991.19	988.62	1.2%	12.32	11.51	11.92	3	1.5	0.9	0.90	$ 348	$ -	$ -	$ 76,626	$ -	$ 76,626
F_GS_085					NO																					
F_GS_086					YES	0323131	0323127	1	1.00	1,057	980.41	969.24	1.1%	12.02	16.79	14.41	3	2.2	0.88	0.88	$ 348	$ -	$ -	$ 367,913	$ -	$ 367,913
F_GS_087					YES	0323122	0323113	1	1.00	282	966.44	964.34	0.7%	18.82	19.88	19.35	4	2.0	0.91	0.91	$ 417	$ -	$ -	$ 117,615	$ -	$ 117,615
F_GS_089					YES	0323019	0323013	1	1.25	953	961.12	953.50	0.8%	10.12	12.15	11.14	3	3.9	0.84	0.67	$ 373	$ -	$ -	$ 355,491	$ -	$ 355,491
F_GS_093		98			YES	0323008	0320200	1	1.50	1,548	949.07	941.29	0.5%	12.15	19.91	16.03	4	4.6	0.89	0.59	$ 479	$ -	$ 1,437	$ 835,232	$ -	$ 835,232
F_GS_095					NO																					
F_GS_096					YES	0320014	0320013	1	1.75	377	930.00	928.91	0.3%	10.91	11.17	11.04	3	5.2	0.93	0.53	$ 464	$ -	$ -	$ 174,775	$ -	$ 174,775
F_GS_097		25			YES	0320003	0320001	1	3.50	677	911.54	909.98	0.2%	10.15	10.50	10.33	3	28.5	0.72	0.21	$ 1,029	$ -	$ 3,087	$ 748,381	$ -	$ 748,381
F_GS_098					YES	0310025	0310022	1	3.00	895	902.40	899.77	0.3%	14.10	13.51	13.81	3	23.7	1	0.33	$ 875	$ -	$ -	$ 783,204	$ -	$ 783,204

F_GS_106					NO																					
F_GS_107		204			YES	0310018	0310012	1	2.50	1,757	891.29	886.38	0.3%	18.63	23.10	20.87	4	17.0	1	0.40	$ 881	$ -	$ 2,643	$ 1,907,427	$ -	$ 1,907,427
F_GS_110					YES	0315011	0315010	1	1.00	163	933.22	932.20	0.6%	6.31	9.84	8.08	2	0.7	0.54	0.54	$ 278	$ -	$ -	$ 45,436	$ -	$ 45,436
F_GS_111					NO																					
F_GS_112					YES	0310205	0310012	1	1.00	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.4	0.78	0.78	$ 417	$ -	$ -	$ 434,981	$ -	$ 434,981
F_GS_113	47				YES	0310012	0310002	1	2.50	3,131	886.38	871.09	0.5%	23.10	27.08	25.09	4	21.1	0.94	0.38	$ 881	$ -	$ 1,013	$ 2,764,545	$ -	$ 2,764,545
F_GS_116					NO																					
F_GS_118					YES	0309231	0309022	1	1.00	268	922.91	916.69	2.3%	9.09	12.01	10.55	3	1.6	0.53	0.53	$ 348	$ -	$ -	$ 93,368	$ -	$ 93,368
F_GS_120		36			YES	0310002	0301024	1	5.00	708	871.09	868.77	0.3%	27.08	17.08	22.08	4	38.2	0.46	0.09	$ 1,745	$ -	$ 5,235	$ 1,360,716	$ -	$ 1,360,716
F_GS_121				128	YES	0301024	0301018	1	3.50	1,885	868.77	861.39	0.4%	17.08	18.43	17.76	4	33.8	0.85	0.24	$ 1,235	$ -	$ 8,645	$ 3,276,554	$ -	$ 3,276,554
F_GS_124	62				YES	0301012	0301009	1	3.00	1,435	852.01	846.64	0.4%	18.84	19.14	18.99	4	26.2	0.86	0.29	$ 1,050	$ -	$ 1,208	$ 1,516,368	$ -	$ 1,516,368
F_GS_126	47	95	41		YES	0301009	0301001	1	3.00	2,504	846.64	834.00	0.5%	19.14	19.92	19.53	4	31.8	0.96	0.32	$ 1,050	$ -	$ 3,117	$ 3,007,284	$ -	$ 3,007,284
F_GS_127	48				YES	0323013	0323008	1	1.50	629	953.50	949.07	0.7%	12.15	12.15	12.15	3	4.2	0.71	0.47	$ 399	$ -	$ 459	$ 253,678	$ -	$ 253,678
F_GS_129					YES	0332120	0332119	1	1.00	400	992.79	987.80	1.2%	10.59	9.46	10.03	3	0.7	0.38	0.38	$ 348	$ -	$ -	$ 139,210	$ -	$ 139,210
F_GS_130					YES	0332119	0332118	1	2.25	117	987.80	987.32	0.4%	9.46	9.95	9.71	2	0.8	0.2	0.09	$ 504	$ -	$ -	$ 59,180	$ -	$ 59,180
F_GS_131		62			YES	0335005	0331011	1	2.50	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	16.6	0.94	0.38	$ 881	$ -	$ 2,643	$ 2,157,358	$ -	$ 2,157,358
F_GS_133	34				YES	0327054	0327053	1	1.00	77	1008.25	1007.08	1.5%	8.91	8.40	8.66	2	0.4	0.36	0.36	$ 278	$ -	$ 320	$ 22,762	$ -	$ 22,762
GRAVITY SEWER (MISSION MAIN)																								**$ 31,290,307**	**$ -**	**$ 31,290,307**
F_GS_502					YES	0141096	0141021	1	1.50	232	1006.50	1000.80	2.5%	8.69	10.19	9.44	2	1.0	0.51	0.34	$ 319	$ -	$ -	$ 74,145	$ -	$ 74,145
F_GS_503					NO																					
F_GS_505					YES	0141046	0141010	1	1.00	424	1003.78	1001.90	0.4%	6.08	11.21	8.65	2	0.4	0.46	0.46	$ 278	$ -	$ -	$ 117,739	$ -	$ 117,739
F_GS_506					NO																					
F_GS_507					NO																					
F_GS_509					YES	0140079	0140024	1	1.50	227	1041.55	1039.73	0.8%	10.21	9.83	10.02	3	0.5	0.26	0.17	$ 399	$ -	$ -	$ 90,753	$ -	$ 90,753
F_GS_510					YES	0140021	0140017	1	1.00	575	1019.42	1009.89	1.7%	10.86	12.08	11.47	3	0.7	0.44	0.44	$ 348	$ -	$ -	$ 200,166	$ -	$ 200,166
F_GS_511					NO																					
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.4	0.52	0.52	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_513					YES	0142016	0142001	1	1.00	95	997.15	996.11	1.1%	6.85	10.50	8.68	2	0.8	0.98	0.98	$ 278	$ -	$ -	$ 26,357	$ -	$ 26,357
F_GS_514					NO																					
F_GS_515		19			YES	0136046	0136042	1	1.00	777	979.01	962.60	2.1%	9.33	10.64	9.99	2	0.8	0.67	0.67	$ 278	$ -	$ 834	$ 226,650	$ -	$ 226,650
F_GS_519		180			YES	0140006	0136006	1	1.00	1,204	955.06	944.71	0.9%	15.52	5.99	10.75	3	1.2	0.76	0.76	$ 348	$ -	$ 1,044	$ 544,275	$ -	$ 544,275
F_GS_520					YES	0136028	0136089	1	1.00	851	978.57	974.64	0.5%	18.63	1.76	10.20	3	0.4	0.38	0.38	$ 348	$ -	$ -	$ 296,294	$ -	$ 296,294
F_GS_522	89				YES	0139015	0139014	1	1.25	318	1000.68	998.96	0.5%	11.61	12.58	12.10	3	1.0	0.69	0.55	$ 373	$ -	$ 429	$ 123,451	$ -	$ 123,451
F_GS_523	100				YES	0139013	0139010	1	1.00	1,049	991.40	975.42	1.5%	12.49	10.46	11.48	3	0.8	0.44	0.44	$ 348	$ -	$ 400	$ 370,152	$ -	$ 370,152
F_GS_524					NO																					
F_GS_525					NO																					
F_GS_526					YES	0138020	0138019	1	1.75	197	1024.13	1020.87	1.7%	7.82	9.14	8.48	2	0.8	0.22	0.13	$ 371	$ -	$ -	$ 72,927	$ -	$ 72,927
F_GS_532					YES	0137017	0137016	1	1.00	406	991.83	987.13	1.2%	9.57	11.13	10.35	3	0.5	0.55	0.55	$ 348	$ -	$ -	$ 141,267	$ -	$ 141,267
F_GS_533					NO																					
F_GS_534					NO																					
F_GS_535					YES	0137004	0137001	1	1.25	225	976.90	975.97	0.4%	9.43	9.47	9.45	2	1.3	0.61	0.49	$ 298	$ -	$ -	$ 66,904	$ -	$ 66,904
F_GS_538					YES	0135040	0135039	1	1.00	222	968.20	965.84	1.1%	8.28	7.88	8.08	2	0.5	0.65	0.65	$ 278	$ -	$ -	$ 61,627	$ -	$ 61,627
F_GS_539					NO																					
F_GS_540					NO																					
F_GS_541					NO																					
F_GS_542		172			NO																					
F_GS_543					NO																					
F_GS_545		50			NO																					
F_GS_546	189				YES	0136007	0133054	1	1.50	226	939.66	939.24	0.2%	12.42	12.94	12.68	3	3.4	1	0.67	$ 399	$ -	$ 459	$ 101,519	$ -	$ 101,519
F_GS_547	66	109			YES	Nall_Sluice	0133043	1	1.50	890	938.00	933.10	0.6%	14.62	10.77	12.70	3	5.1	1	0.67	$ 399	$ -	$ 917	$ 445,933	$ -	$ 445,933
F_GS_548	40				YES	0133043	0133034	1	1.50	1,930	933.10	926.33	0.4%	11.42	13.51	12.47	3	4.8	0.92	0.61	$ 399	$ -	$ 459	$ 772,251	$ -	$ 772,251
F_GS_549					YES	0133034	0133002	1	1.00	806	926.33	923.05	0.4%	14.04	13.58	13.81	3	1.5	1	1.00	$ 348	$ -	$ -	$ 280,561	$ -	$ 280,561
F_GS_551					YES	0134174	0134230	1	1.00	414	967.89	955.54	3.0%	8.02	7.15	7.59	2	1.0	0.36	0.36	$ 278	$ -	$ -	$ 115,173	$ -	$ 115,173
F_GS_553					NO																					
F_GS_554					NO																					
F_GS_555					NO																					
F_GS_556		125			NO																					
F_GS_557		15			YES	0130002	0130001	1	1.00	173	919.33	918.28	0.6%	10.10	11.28	10.69	3	0.2	0.64	0.64	$ 348	$ -	$ 1,044	$ 70,672	$ -	$ 70,672
F_GS_558					YES	0130043	0130039	1	1.25	449	949.36	947.38	0.4%	12.65	13.54	13.10	3	1.0	0.7	0.56	$ 373	$ -	$ -	$ 167,574	$ -	$ 167,574
F_GS_559					YES	0130029	0130024	1	2.00	305	939.48	933.49	2.0%	10.46	8.23	9.35	2	1.3	0.18	0.09	$ 422	$ -	$ -	$ 128,558	$ -	$ 128,558
F_GS_560					YES	0130024	0130001	1	1.50	740	933.49	918.28	2.1%	9.73	9.77	9.75	2	1.4	0.27	0.18	$ 319	$ -	$ -	$ 235,958	$ -	$ 235,958
F_GS_562	46				YES	0129126	0129121	1	1.50	286	981.31	978.22	1.1%	11.67	12.95	12.31	3	0.6	0.52	0.35	$ 399	$ -	$ 459	$ 116,859	$ -	$ 116,859
F_GS_563					NO																					

F_GS_564					NO																					
F_GS_565					YES	0129103	0129098	1	1.00	683	978.89	976.19	0.4%	7.39	10.90	9.15	2	0.5	0.42	0.42	$ 278	$ -	$ -	$ 189,893	$ -	$ 189,893
F_GS_566					YES	0129043	0129041	1	1.00	839	971.00	968.20	0.3%	11.03	10.88	10.96	3	0.4	0.37	0.37	$ 348	$ -	$ -	$ 292,132	$ -	$ 292,132
F_GS_567					NO																					
F_GS_568					NO																					
F_GS_569					NO																					
F_GS_570	42				NO																					
F_GS_575					YES	0129008	0126009	1	1.50	301	909.27	907.87	0.5%	11.94	11.83	11.89	3	4.9	0.8	0.53	$ 399	$ -	$ -	$ 120,231	$ -	$ 120,231
F_GS_576					YES	0126009	0126005	1	1.50	1,223	907.87	902.66	0.4%	11.83	8.60	10.22	3	3.6	0.64	0.43	$ 399	$ -	$ -	$ 487,965	$ -	$ 487,965
F_GS_577					YES	0126005	0126044	1	1.25	359	902.66	893.65	2.5%	8.60	11.48	10.04	3	4.3	0.67	0.54	$ 373	$ -	$ -	$ 133,844	$ -	$ 133,844
F_GS_579	63	109			YES	0126044	0126004	1	1.25	366	893.65	891.51	0.6%	14.38	9.63	12.01	3	4.1	1	0.80	$ 373	$ -	$ 867	$ 221,408	$ -	$ 221,408
F_GS_580		83			YES	0126004	0122033	1	2.00	1,863	891.51	884.63	0.4%	9.63	12.67	11.15	3	7.9	0.81	0.41	$ 528	$ -	$ 1,584	$ 1,071,557	$ -	$ 1,071,557
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.37	0.37	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_585					NO																					
F_GS_586					NO																					
F_GS_588					NO																					
F_GS_589					NO																					
F_GS_590	39				YES	0125007	0125003	1	1.75	1,317	940.00	924.35	1.2%	16.44	7.08	11.76	3	1.9	0.27	0.15	$ 464	$ -	$ 534	$ 614,034	$ -	$ 614,034
F_GS_592					YES	0125003	0125002	1	1.00	243	924.35	915.18	3.8%	7.08	7.54	7.31	2	1.6	0.46	0.46	$ 278	$ -	$ -	$ 67,426	$ -	$ 67,426
F_GS_593					NO																					
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	948.48	1.0%	11.09	10.36	10.73	3	1.0	0.54	0.54	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_598					YES	0124007	0124006	1	1.00	337	937.00	936.21	0.2%	12.15	6.82	9.49	2	1.0	0.57	0.57	$ 278	$ -	$ -	$ 93,717	$ -	$ 93,717
F_GS_599					YES	0124006	0122058	1	1.00	698	936.21	916.48	2.8%	6.82	7.02	6.92	2	0.9	0.68	0.68	$ 278	$ -	$ -	$ 193,913	$ -	$ 193,913
F_GS_600					NO																					
F_GS_601					YES	0122137	0122053	1	1.50	479	907.50	902.80	1.0%	11.08	7.67	9.38	2	0.6	0.6	0.40	$ 319	$ -	$ -	$ 152,642	$ -	$ 152,642
F_GS_603					NO																					
F_GS_604	36				NO																					
F_GS_608		23			YES	0122033	0122019	1	2.25	980	884.63	880.74	0.4%	12.67	14.42	13.55	3	12.0	0.81	0.36	$ 630	$ -	$ 1,890	$ 646,761	$ -	$ 646,761
F_GS_612					NO																					
F_GS_613					NO																					
F_GS_614					YES	0122061	0122024	1	1.00	707	908.97	901.26	1.1%	9.98	8.32	9.15	2	0.7	0.38	0.38	$ 278	$ -	$ -	$ 196,654	$ -	$ 196,654
F_GS_615	32				YES	0122024	0122120	1	1.25	357	901.26	894.00	2.0%	8.32	9.75	9.04	2	1.2	0.31	0.25	$ 298	$ -	$ 343	$ 107,683	$ -	$ 107,683
F_GS_616					NO																					
F_GS_617					YES	0122118	0122019	1	1.00	412	886.89	880.74	1.5%	10.08	14.42	12.25	3	1.3	0.74	0.74	$ 348	$ -	$ -	$ 143,477	$ -	$ 143,477
F_GS_619					YES	0122019	0122018	1	2.25	457	880.74	878.77	0.4%	14.42	13.28	13.85	3	13.4	0.89	0.40	$ 630	$ -	$ -	$ 287,645	$ -	$ 287,645
F_GS_620		742			YES	0122018	0103042	1	2.25	1,656	878.77	873.73	0.3%	13.28	9.57	11.43	3	11.8	0.96	0.43	$ 630	$ -	$ 1,890	$ 1,978,013	$ -	$ 1,978,013
F_GS_621					NO																					
F_GS_623					NO																					
F_GS_624					YES	0132002	GTPSWW	1	2.25	35	938.37	931.00	21.1%	10.84	4.00	7.42	2	3.1	0.19	0.08	$ 504	$ -	$ -	$ 17,640	$ -	$ 17,640
F_GS_625					YES	0132017	0132174	1	1.00	188	950.20	949.08	0.6%	10.24	12.16	11.20	3	0.4	0.7	0.70	$ 348	$ -	$ -	$ 65,400	$ -	$ 65,400
F_GS_626					NO																					
F_GS_627					YES	0132028	0132012	1	1.00	424	965.35	959.29	1.4%	11.00	9.23	10.12	3	1.3	0.5	0.50	$ 348	$ -	$ -	$ 147,608	$ -	$ 147,608
F_GS_628					YES	0132029	0132028	1	1.50	363	967.26	965.35	0.5%	13.04	11.00	12.02	3	0.8	0.3	0.20	$ 399	$ -	$ -	$ 144,705	$ -	$ 144,705
F_GS_629					YES	0132172	0132029	1	1.00	376	973.25	967.26	1.6%	10.68	10.36	10.52	3	0.7	0.38	0.38	$ 348	$ -	$ -	$ 130,695	$ -	$ 130,695
F_GS_630					NO																					
F_GS_632					NO																					
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	980.63	0.6%	11.15	11.05	11.10	3	0.7	0.46	0.46	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_635					NO																					
F_GS_636					NO																					
F_GS_640					YES	0123018	0123015	1	1.00	1,071	933.50	922.91	1.0%	10.50	8.23	9.37	2	1.7	0.6	0.60	$ 278	$ -	$ -	$ 297,774	$ -	$ 297,774
F_GS_641					YES	0123015	0123035	1	1.00	264	922.91	919.54	1.3%	8.23	10.18	9.21	2	1.0	0.58	0.58	$ 278	$ -	$ -	$ 73,489	$ -	$ 73,489
F_GS_642					YES	0123091	0123089	1	1.75	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	3.4	0.29	0.17	$ 371	$ -	$ -	$ 290,957	$ -	$ 290,957
F_GS_643					NO																					
F_GS_644					NO																					
F_GS_645					NO																					
F_GS_646					NO																					
F_GS_647					YES	0123086	0123028	1	1.25	517	914.76	911.00	0.7%	8.97	8.60	8.79	2	3.8	0.92	0.74	$ 298	$ -	$ -	$ 154,123	$ -	$ 154,123
F_GS_649		31			NO																					
F_GS_650					YES	0123046	0123025	1	1.25	169	906.92	901.90	3.0%	9.32	7.08	8.20	2	4.0	0.78	0.62	$ 298	$ -	$ -	$ 50,413	$ -	$ 50,413
F_GS_651					YES	0123025	0123005	1	1.00	335	901.90	898.80	0.9%	10.38	7.52	8.95	2	2.8	0.94	0.94	$ 278	$ -	$ -	$ 93,033	$ -	$ 93,033
F_GS_652		66			YES	0123005	0123004	1	1.50	396	898.80	891.28	1.9%	8.04	10.83	9.44	2	7.8	0.72	0.48	$ 319	$ -	$ 957	$ 168,335	$ -	$ 168,335
F_GS_653					YES	0123004	0123021	1	2.00	144	891.28	888.99	1.6%	10.83	10.48	10.66	3	8.0	0.56	0.28	$ 528	$ -	$ -	$ 76,280	$ -	$ 76,280
F_GS_654		148			YES	0123021	0103042	1	1.25	1,374	888.99	873.73	1.1%	11.58	8.58	10.08	3	4.0	0.87	0.70	$ 373	$ -	$ 1,119	$ 622,556	$ -	$ 622,556

F_GS_655		71			YES	0103042	0103026	1	3.00	385	873.73	873.02	0.2%	9.57	11.58	10.58	3	17.4	0.69	0.23	$ 875	$ -	$ 2,625	$ 460,154	$ -	$ 460,154
F_GS_656	135	46			YES	0103026	0103038	1	2.50	1,642	873.02	863.64	0.6%	11.58	8.07	9.83	2	17.8	0.64	0.26	$ 587	$ -	$ 952	$ 1,029,775	$ -	$ 1,029,775
F_GS_659		189			YES	0103018	0103011	1	2.00	2,885	862.48	854.67	0.3%	8.57	9.92	9.25	2	7.7	0.89	0.45	$ 422	$ -	$ 1,266	$ 1,376,796	$ -	$ 1,376,796
F_GS_662					YES	0103011	0103065	1	1.50	80	853.87	853.81	0.1%	9.92	12.91	11.42	3	4.3	1	0.67	$ 399	$ -	$ -	$ 31,920	$ -	$ 31,920
F_GS_663					YES	0103065	0103064	1	2.50	70	853.81	853.75	0.1%	12.91	13.25	13.08	3	12.4	1	0.40	$ 734	$ -	$ -	$ 51,380	$ -	$ 51,380
F_GS_664					YES	0103064	BLPSWW	1	3.50	70	853.75	847.00	9.6%	13.25	13.55	13.40	3	16.5	1	0.29	$ 1,029	$ -	$ -	$ 72,030	$ -	$ 72,030
F_GS_670					NO																					
F_GS_671					YES	0119033	0119032	1	1.25	112	957.68	957.67	0.0%	11.86	14.65	13.26	3	1.0	0.67	0.54	$ 373	$ -	$ -	$ 41,746	$ -	$ 41,746
F_GS_672					NO																					
F_GS_675					NO																					
F_GS_676					NO																					
F_GS_677					YES	0115176	0115016	1	2.25	197	942.95	942.08	0.4%	11.49	12.80	12.15	3	1.5	0.72	0.32	$ 630	$ -	$ -	$ 123,997	$ -	$ 123,997
F_GS_678					YES	0115139	0115137	1	1.00	70	959.90	956.90	4.3%	7.48	5.98	6.73	2	0.6	0.61	0.61	$ 278	$ -	$ -	$ 19,460	$ -	$ 19,460
F_GS_679					NO																					
F_GS_681		43			NO																					
F_GS_682					YES	0115183	0115010	1	1.50	121	930.58	929.98	0.5%	13.29	9.83	11.56	3	2.8	0.67	0.45	$ 399	$ -	$ -	$ 48,147	$ -	$ 48,147
F_GS_683	59				NO																					
F_GS_684					YES	0120023	0120016	1	1.00	1,206	1005.79	987.46	1.5%	8.00	7.61	7.81	2	0.8	0.51	0.51	$ 278	$ -	$ -	$ 335,221	$ -	$ 335,221
F_GS_685					NO																					
F_GS_686	38				NO																					
F_GS_687	11				YES	0120004	0120002	1	1.00	841	963.50	955.19	1.0%	13.05	11.83	12.44	3	1.3	0.58	0.58	$ 348	$ -	$ 400	$ 293,155	$ -	$ 293,155
F_GS_689					YES	0120001	0113054	1	1.75	254	945.50	943.00	1.0%	14.00	12.40	13.20	3	1.6	0.61	0.35	$ 464	$ -	$ -	$ 117,745	$ -	$ 117,745
F_GS_691	111				NO																					
F_GS_692					YES	0113050	0113044	1	2.00	934	937.87	926.49	1.2%	14.71	10.40	12.56	3	3.3	0.65	0.33	$ 528	$ -	$ -	$ 492,994	$ -	$ 492,994
F_GS_694					YES	0113043	0113040	1	2.00	163	922.82	920.89	1.2%	8.88	12.20	10.54	3	4.5	0.97	0.49	$ 528	$ -	$ -	$ 86,238	$ -	$ 86,238
F_GS_696					YES	1601045	1601056	1	4.50	2,937	977.00	971.00	0.2%	7.87	11.44	9.65	2	63.3	0.81	0.18	$ 1,050	$ -	$ -	$ 3,084,050	$ -	$ 3,084,050
F_GS_698					YES	0114083	0114015	1	1.00	427	972.90	969.77	0.7%	9.73	8.84	9.29	2	0.5	0.39	0.39	$ 278	$ -	$ -	$ 118,581	$ -	$ 118,581
F_GS_699					YES	0114012	0114011	1	1.50	53	963.25	962.62	1.2%	6.46	8.55	7.51	2	2.5	0.89	0.59	$ 319	$ -	$ -	$ 17,015	$ -	$ 17,015
F_GS_700	36				NO																					
F_GS_701	65				NO																					
F_GS_702					NO																					
F_GS_703					NO																					
F_GS_705					NO																					
F_GS_706					NO																					
F_GS_707					YES	0112031	0112022	1	1.00	995	942.50	927.88	1.5%	9.49	4.84	7.17	2	1.0	0.49	0.49	$ 278	$ -	$ -	$ 276,696	$ -	$ 276,696
F_GS_708					NO																					
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.3	0.46	0.46	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.00	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.1	0.68	0.68	$ 348	$ -	$ 400	$ 195,763	$ -	$ 195,763
F_GS_711	149				YES	0112016	0113002	1	1.00	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.4	1	1.00	$ 348	$ -	$ 400	$ 120,529	$ -	$ 120,529
F_GS_712	18				NO																					
F_GS_714	40				YES	0113002	0113224	1	2.50	40	906.40	905.26	2.8%	14.63	17.33	15.98	4	17.3	1	0.40	$ 881	$ -	$ 1,013	$ 40,520	$ -	$ 40,520
F_GS_716					YES	0111018	0111002	1	1.00	331	905.06	903.00	0.6%	7.83	9.60	8.72	2	0.1	0.15	0.15	$ 278	$ -	$ -	$ 91,999	$ -	$ 91,999
F_GS_717					YES	0110009	0110008	1	1.50	70	924.08	923.25	1.2%	11.08	10.33	10.71	3	0.7	0.27	0.18	$ 399	$ -	$ -	$ 27,930	$ -	$ 27,930
F_GS_718					YES	0110004	0108071	1	1.25	253	913.77	911.89	0.7%	8.83	14.04	11.43	3	0.2	0.31	0.25	$ 373	$ -	$ -	$ 94,197	$ -	$ 94,197
F_GS_719					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	1.75	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	6.0	0.84	0.48	$ 464	$ -	$ 1,392	$ 416,583	$ -	$ 416,583
F_GS_724					YES	0109195	0109155	1	1.50	202	969.95	968.01	1.0%	3.23	7.98	5.61	2	0.6	0.34	0.23	$ 319	$ -	$ -	$ 64,457	$ -	$ 64,457
F_GS_726					YES	0109147	0109084	1	1.50	146	959.99	958.47	1.0%	4.46	6.90	5.68	2	0.8	0.46	0.31	$ 319	$ -	$ -	$ 46,708	$ -	$ 46,708
F_GS_727					NO																					
F_GS_728					NO																					
F_GS_729					YES	0109040	0109036	1	1.50	211	950.60	950.21	0.2%	7.50	8.86	8.18	2	0.3	0.24	0.16	$ 319	$ -	$ -	$ 67,360	$ -	$ 67,360
F_GS_730	63				NO																					
F_GS_731		35			YES	0109198	0109019	1	1.25	325	936.21	933.20	0.9%	10.83	7.83	9.33	2	2.2	0.6	0.48	$ 298	$ -	$ 894	$ 117,919	$ -	$ 117,919
F_GS_732	34	21			NO																					
F_GS_733	126				YES	0108016	0108005	1	1.00	484	897.11	888.14	1.9%	8.92	10.10	9.51	2	1.8	0.77	0.77	$ 278	$ -	$ 320	$ 139,808	$ -	$ 139,808
F_GS_736					NO																					
F_GS_737		34			NO																					
F_GS_738					NO																					
F_GS_739					NO																					
F_GS_740					NO																					
F_GS_741					YES	0107030	0107027	1	1.50	531	922.83	910.13	2.4%	6.48	7.26	6.87	2	1.3	0.3	0.20	$ 319	$ -	$ -	$ 169,446	$ -	$ 169,446
F_GS_742					YES	0107031	0107030	1	1.50	245	926.20	922.83	1.4%	10.91	6.48	8.70	2	1.3	0.26	0.17	$ 319	$ -	$ -	$ 78,053	$ -	$ 78,053

F_GS_743	50				NO																				
F_GS_744	50				NO																				
F_GS_745					YES	0107097	0107019	1	1.00	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.3	0.34	0.34	$ 278	$ -	$ -	$ 449,128	$ -	$ 449,128
F_GS_748					YES	0107017	0107015	1	1.00	652	946.93	936.29	1.6%	7.75	7.65	7.70	2	0.7	0.55	0.55	$ 278	$ -	$ -	$ 181,209	$ -	$ 181,209
F_GS_750					NO																				
F_GS_751					YES	0107010	0107021	1	4.50	35	913.88	913.30	1.7%	10.90	10.49	10.70	3	1.6	0.18	0.04	$ 1,313	$ -	$ -	$ 45,955	$ -	$ 45,955
F_GS_752					NO																				
F_GS_753					NO																				
F_GS_754		43			YES	0107001	0106009	1	1.50	863	883.98	879.29	0.5%	12.67	8.84	10.76	3	4.5	0.84	0.56	$ 399	$ -	$ 1,197	$ 379,114	$ -	$ 379,114
F_GS_755		53			YES	0106009	0106006	1	1.50	784	879.29	874.69	0.6%	10.92	11.25	11.09	3	4.9	0.88	0.59	$ 399	$ -	$ 1,197	$ 354,883	$ -	$ 354,883
F_GS_757					YES	0106006	0106004	1	2.00	580	874.69	875.08	-0.1%	11.25	11.63	11.44	3	3.8	0.74	0.37	$ 528	$ -	$ -	$ 306,324	$ -	$ 306,324
F_GS_758	35				NO																				
F_GS_759		44			NO																				
F_GS_766					NO																				
F_GS_767					YES	0103104	0103103	1	1.00	50	911.61	907.37	8.5%	3.22	4.81	4.02	2	0.9	0.54	0.54	$ 278	$ -	$ -	$ 13,900	$ -	$ 13,900
F_GS_770					NO																				
F_GS_771					YES	0103226	0103089	1	1.75	203	899.84	896.71	1.5%	8.16	8.90	8.53	2	1.2	0.3	0.17	$ 371	$ -	$ -	$ 75,358	$ -	$ 75,358
F_GS_772					NO																				
F_GS_773	74				NO																				
F_GS_774		49			YES	0103053	0103069	1	2.25	1,236	869.59	865.44	0.3%	11.37	9.18	10.27	3	9.3	0.95	0.42	$ 630	$ -	$ 1,890	$ 840,106	$ -	$ 840,106
F_GS_775					YES	0103049	0103046	1	2.00	576	861.42	859.50	0.3%	12.32	10.37	11.34	3	7.7	0.61	0.31	$ 528	$ -	$ -	$ 304,038	$ -	$ 304,038
F_GS_776					YES	0103121	0103120	1	1.50	399	925.07	922.73	0.6%	10.63	16.71	13.67	3	0.4	0.25	0.17	$ 399	$ -	$ -	$ 159,125	$ -	$ 159,125
F_GS_777					YES	0103116	0103115	1	1.00	437	867.80	856.30	2.6%	12.92	2.82	7.87	2	1.0	0.57	0.57	$ 278	$ -	$ -	$ 121,597	$ -	$ 121,597
F_GS_778					NO																				
F_GS_779					YES	0101167	BLPSWW	1	1.75	83	855.24	847.00	9.9%	13.09	12.46	12.78	3	5.0	1	0.57	$ 464	$ -	$ -	$ 38,577	$ -	$ 38,577
F_GS_782					NO																				
F_GS_783					NO																				
F_GS_784					NO																				
F_GS_785					NO																				
F_GS_786					YES	0102001	0102130	1	1.00	53	912.90	911.98	1.7%	10.10	10.87	10.48	3	1.4	0.49	0.49	$ 348	$ -	$ -	$ 18,430	$ -	$ 18,430
F_GS_789					NO																				
F_GS_790	83				YES	0101018	0101016	1	1.00	323	902.31	895.77	2.0%	15.63	9.36	12.50	3	2.8	0.68	0.68	$ 348	$ -	$ 400	$ 116,586	$ -	$ 116,586
F_GS_791					YES	0101014	0101012	1	1.50	167	883.39	882.29	0.7%	8.43	9.21	8.82	2	3.0	0.55	0.37	$ 319	$ -	$ -	$ 53,404	$ -	$ 53,404
F_GS_794					YES	0101039	0101038	1	1.00	354	881.54	877.06	1.3%	8.61	12.67	10.64	3	2.4	0.8	0.80	$ 348	$ -	$ -	$ 123,140	$ -	$ 123,140
F_GS_795					YES	0101038	0101036	1	1.25	857	877.06	871.17	0.7%	13.17	5.38	9.28	2	2.5	0.69	0.55	$ 298	$ -	$ -	$ 255,499	$ -	$ 255,499
F_GS_796					YES	0123089	0123086	1	1.50	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	3.2	0.56	0.37	$ 319	$ -	$ -	$ 95,183	$ -	$ 95,183
F_GS_797					YES	0101168	0101050	1	1.00	1,150	946.69	923.22	2.0%	8.01	4.94	6.48	2	1.5	0.43	0.43	$ 278	$ -	$ -	$ 319,647	$ -	$ 319,647
F_GS_798					NO																				
F_GS_799					YES	0127005	0127003	1	1.00	123	913.46	911.75	1.4%	2.48	0.81	1.64	2	0.0	0.15	0.15	$ 278	$ -	$ -	$ 34,286	$ -	$ 34,286
F_GS_801	38				NO																				
F_GS_803					YES	0101050	0101047	1	1.50	234	923.22	910.72	5.3%	4.94	10.23	7.59	2	1.9	0.24	0.16	$ 319	$ -	$ -	$ 74,614	$ -	$ 74,614
F_GS_805					NO																				
F_GS_806					YES	0101015	0101014	1	1.00	267	889.35	883.39	2.2%	9.58	8.43	9.01	2	2.4	0.7	0.70	$ 278	$ -	$ -	$ 74,112	$ -	$ 74,112
F_GS_807					YES	1601056	1601051	1	3.50	135	971.00	970.50	0.4%	11.44	11.50	11.47	3	37.1	0.8	0.23	$ 1,029	$ -	$ -	$ 138,966	$ -	$ 138,966
F_GS_808					YES	1601016	1601045	1	5.00	50	979.38	977.00	4.8%	6.55	7.87	7.21	2	50.4	0.67	0.13	$ 1,163	$ -	$ -	$ 58,150	$ -	$ 58,150
F_GS_809					NO																				
F_GS_810					NO																				
F_GS_812					NO																				
F_GS_813		20			NO																				
F_GS_815					YES	0137095	0137004	1	1.00	430	983.16	976.90	1.5%	10.17	9.43	9.80	2	0.7	0.48	0.48	$ 278	$ -	$ -	$ 119,504	$ -	$ 119,504
F_GS_816					YES	0135004	0135001	1	1.75	557	950.06	945.79	0.8%	8.67	9.67	9.17	2	1.0	0.61	0.35	$ 371	$ -	$ -	$ 206,510	$ -	$ 206,510
F_GS_817	38				NO																				
F_GS_818		148			NO																				
F_GS_819					YES	0120137	0120023	1	1.25	144	1006.44	1005.79	0.5%	11.46	8.00	9.73	2	0.6	0.31	0.25	$ 298	$ -	$ -	$ 43,010	$ -	$ 43,010
F_GS_820					NO																				
F_GS_821					YES	0125054	0125046	1	1.50	332	920.68	917.53	0.9%	9.88	9.78	9.83	2	1.0	0.31	0.21	$ 319	$ -	$ -	$ 105,854	$ -	$ 105,854
F_GS_822					NO																				
F_GS_823					NO																				
F_GS_824					NO																				
F_GS_825		95			YES	0127003	0127001	1	1.00	240	911.75	905.51	2.6%	3.90	1.33	2.61	2	0.9	0.49	0.49	$ 278	$ -	$ 834	$ 119,374	$ -	$ 119,374
F_GS_826					YES	0128005	0128003	1	1.50	181	943.64	941.19	1.4%	10.61	10.96	10.79	3	0.6	0.59	0.39	$ 399	$ -	$ -	$ 72,055	$ -	$ 72,055
F_GS_827					YES	0128021	0123018	1	1.00	270	937.29	933.50	1.4%	9.67	10.50	10.09	3	1.2	0.55	0.55	$ 348	$ -	$ -	$ 94,012	$ -	$ 94,012
F_GS_828					NO																				

F_GS_829					NO																					
F_GS_830	222				YES	0101020	0101018	1	1.00	496	907.11	902.31	1.0%	15.73	15.63	15.68	4	2.2	0.77	0.77	$ 417	$ -	$ 480	$ 220,612	$ -	$ 220,612
F_GS_831					YES	0101012	0101039	1	2.50	138	882.29	881.54	0.5%	9.21	8.61	8.91	2	4.9	0.33	0.13	$ 587	$ -	$ -	$ 81,206	$ -	$ 81,206
F_GS_832					NO																					
F_GS_833					NO																					
F_GS_834					NO																					
F_GS_835					YES	0135025	0135023	1	1.00	305	952.69	950.09	0.9%	10.71	8.63	9.67	2	1.2	0.77	0.77	$ 278	$ -	$ -	$ 84,857	$ -	$ 84,857
F_GS_836	57				NO																					
F_GS_837					YES	0108018	0108017	1	1.00	454	915.39	906.42	2.0%	13.25	20.98	17.12	4	1.5	0.85	0.85	$ 417	$ -	$ -	$ 189,310	$ -	$ 189,310
F_GS_838					NO																					
F_GS_839					YES	0103054	0103196	1	2.00	473	872.53	869.97	0.5%	11.17	10.10	10.64	3	9.0	0.82	0.41	$ 528	$ -	$ -	$ 249,601	$ -	$ 249,601
F_GS_840					NO																					
F_GS_841					YES	0103003	BLPSWW	1	1.75	51	854.00	847.00	13.8%	13.44	14.25	13.85	3	11.3	1	0.57	$ 464	$ -	$ -	$ 23,488	$ -	$ 23,488
F_GS_842		335			NO																					
F_GS_843	67				YES	0113212	0113002	1	2.50	67	906.48	906.40	0.1%	15.10	14.63	14.87	3	9.8	1	0.40	$ 734	$ -	$ 844	$ 56,565	$ -	$ 56,565
F_GS_844					NO																					
F_GS_845					YES	0101036	0101034	1	1.00	793	871.17	865.17	0.8%	5.38	7.61	6.50	2	2.1	0.94	0.94	$ 278	$ -	$ -	$ 220,473	$ -	$ 220,473
F_GS_846					NO																					
F_GS_847					NO																					
F_GS_848					NO																					
F_GS_849					NO																					
F_GS_850					NO																					
F_CC_51					YES	0129001	0129008	1	2.00	190	909.32	909.27	0.0%	12.78	11.94	12.36	3	2.9	0.68	0.34	$ 528	$ -	$ -	$ 100,230	$ -	$ 100,230
F_CC_52					NO																					
F_CC_53					YES	0122044	0122040	1	1.25	70	905.87	903.92	2.8%	7.93	9.37	8.65	2	2.2	0.69	0.55	$ 298	$ -	$ -	$ 20,860	$ -	$ 20,860
F_CC_54					NO																					
F_CC_55					YES	0122239	0122033	1	1.00	40	887.30	884.63	6.7%	10.10	12.67	11.39	3	5.8	1	1.00	$ 348	$ -	$ -	$ 13,920	$ -	$ 13,920
F_CC_56					NO																					
F_CC_57					NO																					
F_CC_58					NO																					
F_CC_59					YES	0120032	0120004	1	1.00	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.6	0.77	0.77	$ 348	$ -	$ -	$ 13,920	$ -	$ 13,920
F_CC_60					NO																					
F_CC_61		20			NO																					
F_CC_62	22				YES	0133049	0133056	1	1.00	31	942.64	942.77	-0.4%	9.73	9.69	9.71	2	0.8	1	1.00	$ 278	$ -	$ 320	$ 9,541	$ -	$ 9,541
F_CC_63	32				YES	0114022	0114005	1	1.00	40	950.00	950.03	-0.1%	8.25	8.16	8.21	2	0.2	0.68	0.68	$ 278	$ -	$ 320	$ 12,478	$ -	$ 12,478
F_CC_64					YES	0103196	0103053	1	1.25	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	4.4	1	0.80	$ 373	$ -	$ -	$ 13,055	$ -	$ 13,055
F_CC_65					YES	0133034	0133005	1	2.00	171	926.33	925.83	0.3%	14.04	13.83	13.94	3	4.3	0.95	0.48	$ 528	$ -	$ -	$ 90,262	$ -	$ 90,262
F_CC_66					NO																					
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																					
F_LS_02	47				NO																					
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					
F_LS_52					NO																					
F_LS_53		180			NO																					
F_LS_54					NO																					
F_LS_55		435			NO																					
FORCE MAIN (NELSON COMPLEX)																								**$ 29,289,697**	**$ -**	**$ 29,289,697**
FORCE MAIN (TUKEY CREEK)																								**$ 3,685,500**	**$ -**	**$ 3,685,500**
PS_TurkeyCreek					YES	TCPSWW	0345082	1	4.00	3,500	-	-	-	-	-	-	2	60.5	-	-	$ 1,053	$ -	$ -	$ 3,685,500	$ -	$ 3,685,500
FORCE MAIN (MISSION MAIN)																								**$ 25,604,197**	**$ -**	**$ 25,604,197**
PS_Belinder	439				YES	BLPSWW	1601029	1	4.00	10,604	-	-	-	-	-	-	2	54.0	-	-	$ 1,053	$ -	$ 1,211	$ 11,235,384	$ -	$ 11,235,384
PS_BrushCreek	9,673				YES	BCPSWW	0113002	1	2.50	10,623	-	-	-	-	-	-	2	17.0	-	-	$ 658	$ -	$ 757	$ 7,947,561	$ -	$ 7,947,561
PS_RockCreek	5,030				YES	RCPSWW	1601016	1	3.00	7,047	-	-	-	-	-	-	2	34.0	-	-	$ 790	$ -	$ 909	$ 6,165,700	$ -	$ 6,165,700
PS_RoeVillage					YES	RVPSWW	1601037	1	0.67	351	-	-	-	-	-	-	2	0.6	-	-	$ 176	$ -	$ -	$ 61,776	$ -	$ 61,776
PS_Swatzell					YES	SZPSWW	0101168	1	0.67	1,101	-	-	-	-	-	-	2	2.8	-	-	$ 176	$ -	$ -	$ 193,776	$ -	$ 193,776

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

*SPS Expansion Cost Curve used for Prelim Runs

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 35,328,152**	**$ 9,585,965**	**$ 44,914,118**
TURKEY CREEK							**$ 10,041,296**	**$ 2,844,558**	**$ 12,885,854**
PS_TurkeyCreek	27.0	YES	TCPSWW	0345082	57.3	30.3	$ 10,041,296	$ 2,844,558	$ 12,885,854
MISSION MAIN							**$ 25,286,857**	**$ 6,741,407**	**$ 32,028,263**
PS_Belinder	11.6	YES	BLPSWW	1601029	54.0	42.4	$ 12,585,536	$ 3,986,161	$ 16,571,697
PS_BrushCreek	6.0	YES	BCPSWW	0113002	15.5	9.5	$ 4,049,528	$ 892,092	$ 4,941,620
PS_Granthurst	5.5	NO	GTPSWW	0123091	5.5		$ -	$ -	$ -
PS_MissionWoods	1.2	NO	MWPSWW	0101011	1.2		$ -	$ -	$ -
PS_RockCreek	15.5	YES	RCPSWW	1601016	34.0	18.5	$ 6,903,550	$ 1,739,245	$ 8,642,795
PS_RoeVillage	0.4	YES	RVPSWW	1601037	0.6	0.1	$ 679,565	$ 13,914	$ 693,479
PS_Swatzell	1.6	YES	SZPSWW	0101168	2.8	1.2	$ 1,068,678	$ 109,995	$ 1,178,673

OPTIMISATION SOLUTION SUMMARY:
STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
STORAGE FACILITY TOTAL						**$ -**	**$ -**	**$ -**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ -**	**$ -**	**$ -**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST_01	F_ST_01_IN	NO						
F_ST_02	F_ST_02_IN	NO						
F_ST_03	F_ST_03_IN	NO						
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	NO						
F_ST_06	F_ST_06_IN	NO						
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST_51	F_ST_51_IN	NO						
F_ST_52	F_ST_52_IN	NO						
F_ST_53	F_ST_53_IN	NO						
F_ST_54	F_ST_54_IN	NO						
F_ST_55	F_ST_55_IN	NO						
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TOTAL)						**$ -**	**$ -**	**$ -**
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	YES	5.5	5.6	0.00	$ -	$ -	$ -
STORAGE FACILITY - FACILITY PROTECTION DEVICE (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST-FPD_BC	F_ST-FPD_BC_IN	NO						
F_ST-FPD_BL	F_ST-FPD_BL_IN	YES	3.0	8.0	0.00	$ -	$ -	$ -
F_ST-FPD_MW	F_ST-FPD_MW_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	4.5	6.5	0.00	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX								**$ -**	**$ -**	**$ -**
TURKEY CREEK								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek_PEFTF	TC_PEFTF_OUTFALL	22.0	NO	TC_PEFTF_WW	FMOutletEFB	0.0	0.0	$ -	$ -	$ -
MISSION MAIN								**$ -**	**$ -**	**$ -**
PS_Belinder_PEFTF	Belinder_Outfall	53.1	NO	BLPEFTFWW	Belinder_PEFTF_Tank	0.0	0.0	$ -	$ -	$ -
PS_Martway_PEFTF	Martway_Discharge	20.0	NO	Martway_HS_Wet_Well	Martway_Tank	0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	Nall_Outfall	20.0	NO	Nall_Wet_Well	Nall_Tank	0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
I/I REDUCTION

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	Scaling Factor	% Reduction	I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL						**$ -**	**$ -**	**$ -**
TURKEY CREEK TOTAL						**$ -**	**$ -**	**$ -**
FM_202	0309015	24	NO	1.00		$ -	$ -	$ -
FM_203	0310001	82	NO	1.00		$ -	$ -	$ -
FM_204	0320011	22	NO	1.00		$ -	$ -	$ -
FM_205	0323001	42	NO	1.00		$ -	$ -	$ -
FM_206	0331001	78	NO	1.00		$ -	$ -	$ -
FM_207	0336001	130	NO	1.00		$ -	$ -	$ -
FM_208	0341001	54	NO	1.00		$ -	$ -	$ -
FM_209	0323131	56	NO	1.00		$ -	$ -	$ -
FM_210	0327001	31	NO	1.00		$ -	$ -	$ -
FM_211	0321001	3	NO	1.00		$ -	$ -	$ -
FM_TC PS	0301003	41	NO	1.00		$ -	$ -	$ -
MISSION MAIN TOTAL						**$ -**	**$ -**	**$ -**
FM_1	0115001	53	NO	1.00		$ -	$ -	$ -
FM_101, 102	0107004	63	NO	1.00		$ -	$ -	$ -
FM_103	0108002	54	NO	1.00		$ -	$ -	$ -
FM_104, 105	0108020	53	NO	1.00		$ -	$ -	$ -
FM_106, 107	0110018	45	NO	1.00		$ -	$ -	$ -
FM_108	0115043	24	NO	1.00		$ -	$ -	$ -
FM_109, 110	0123002	126	NO	1.00		$ -	$ -	$ -
FM_111	0122027	2	NO	1.00		$ -	$ -	$ -
FM_112	0112058	14	NO	1.00		$ -	$ -	$ -
FM_113, 114	0122010	213	NO	1.00		$ -	$ -	$ -
FM_115, 116	0126030	28	NO	1.00		$ -	$ -	$ -
FM_117	0133060	5	NO	1.00		$ -	$ -	$ -
FM_118	0142001	7	NO	1.00		$ -	$ -	$ -
FM_119	0140014	17	NO	1.00		$ -	$ -	$ -
FM_12, 13	0133010	48	NO	1.00		$ -	$ -	$ -
FM_120	0141096	3	NO	1.00		$ -	$ -	$ -
FM_121, 122	0139008	21	NO	1.00		$ -	$ -	$ -
FM_123, 124	0115022	9	NO	1.00		$ -	$ -	$ -
FM_14, 15, 16	0135002	71	NO	1.00		$ -	$ -	$ -
FM_17, 18	0136001	110	NO	1.00		$ -	$ -	$ -
FM_2, 3	0103004	93	NO	1.00		$ -	$ -	$ -
FM_4	0113050	51	NO	1.00		$ -	$ -	$ -
FM_5, 7	0103012	66	NO	1.00		$ -	$ -	$ -
FM_6, 19	0101010	53	NO	1.00		$ -	$ -	$ -

FM_9, 10	0134015	17	NO	1.00		$ -	$ -	$ -
FM_BC PS	0129005	30	NO	1.00		$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	1.00		$ -	$ -	$ -
FM_RC PS	0112006	66	NO	1.00		$ -	$ -	$ -
FM_ WWTF	1601002	5	NO	1.00		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL COST				**$ 51,367,845**	**$ 6,506,908**	**$ 57,874,753**
Nelson_ATF	45	145.7	100.7	$ 51,367,845	$ 6,506,908	$ 57,874,753
0345082.1	29.1	57.3	28.0	$ 14,276,619	$ 1,808,459	$ 16,085,078
1601051.1	15.9	89.1	72.7	$ 37,091,226	$ 4,698,449	$ 41,789,675

Preliminary Optimization Results

10-Year/5-Year, PEFTFs Decommissioned
Conveyance and Storage Only

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
GRAVITY SEWER (NELSON COMPLEX)																								**$ 65,101,572**	**$ -**	**$ 65,101,572**
GRAVITY SEWER (TUKEY CREEK)																								**$ 33,978,085**	**$ -**	**$ 33,978,085**
F_GS_006		184			YES	0341025	0341015	1	1.00	2,852	991.00	973.18	0.6%	12.31	19.36	15.84	4	1.6	3.57	3.57	$ 417	$ -	$ 1,251	$ 1,342,782	$ -	$ 1,342,782
F_GS_010		138			YES	0341012	0341009	1	1.75	1,224	969.93	966.78	0.3%	16.49	19.19	17.84	4	4.3	0.85	0.49	$ 557	$ -	$ 1,671	$ 835,233	$ -	$ 835,233
F_GS_011					NO																					
F_GS_012		829			YES	0341008	0341004	1	1.75	1,416	965.05	960.51	0.3%	12.50	17.88	15.19	4	5.0	0.86	0.49	$ 557	$ -	$ 1,671	$ 1,712,045	$ -	$ 1,712,045
F_GS_015					NO																					
F_GS_017					YES	0340003	0338019	1	1.25	948	988.18	977.03	1.2%	13.10	11.46	12.28	3	2.0	0.47	0.38	$ 373	$ -	$ -	$ 353,597	$ -	$ 353,597
F_GS_018					YES	0340106	0340091	1	1.00	980	1013.43	1007.03	0.7%	13.84	10.12	11.98	3	0.5	0.68	0.68	$ 348	$ -	$ -	$ 341,012	$ -	$ 341,012
F_GS_019					NO																					
F_GS_021	85				NO																					
F_GS_022					YES	0339003	0338027	1	1.00	423	1009.67	999.23	2.5%	8.73	8.85	8.79	2	1.3	0.56	0.56	$ 278	$ -	$ -	$ 117,486	$ -	$ 117,486
F_GS_023					YES	0338026	0338024	1	2.00	548	994.13	988.39	1.0%	15.47	11.66	13.57	3	1.7	0.61	0.31	$ 528	$ -	$ -	$ 289,471	$ -	$ 289,471
F_GS_024					NO																					
F_GS_025					YES	0338019	0338015	1	1.25	1,260	977.03	967.68	0.7%	11.95	12.19	12.07	3	3.3	0.91	0.73	$ 373	$ -	$ -	$ 469,797	$ -	$ 469,797
F_GS_026					NO																					
F_GS_031					YES	0337139	0337131	1	1.00	261	1014.81	1012.51	0.9%	9.52	13.75	11.64	3	1.0	0.68	0.68	$ 348	$ -	$ -	$ 90,814	$ -	$ 90,814
F_GS_034					YES	0337079	0337074	1	1.00	220	1022.09	1020.65	0.7%	12.36	12.84	12.60	3	0.6	0.53	0.53	$ 348	$ -	$ -	$ 76,630	$ -	$ 76,630
F_GS_038	56				YES	0337046	0336176	1	1.25	933	995.71	987.40	0.9%	11.53	15.43	13.48	3	2.3	0.77	0.62	$ 373	$ -	$ 429	$ 351,317	$ -	$ 351,317
F_GS_039					NO																					
F_GS_040					YES	0336141	0336139	1	1.00	448	975.07	970.17	1.1%	18.79	9.73	14.26	3	2.4	0.91	0.91	$ 348	$ -	$ -	$ 155,810	$ -	$ 155,810
F_GS_043					YES	0336028	0336002	1	1.25	890	961.12	954.12	0.8%	10.11	13.39	11.75	3	3.2	0.86	0.69	$ 373	$ -	$ -	$ 332,101	$ -	$ 332,101
F_GS_045	104			169	YES	0335012	0335005	1	2.50	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	16.6	1	0.40	$ 734	$ -	$ 3,501	$ 1,987,462	$ -	$ 1,987,462
F_GS_056					YES	0332011	0332002	1	1.00	576	969.79	958.55	2.0%	5.06	3.48	4.27	2	0.6	0.4	0.40	$ 278	$ -	$ -	$ 160,159	$ -	$ 160,159
F_GS_060					NO																					
F_GS_062		95			YES	0331010	0331003	1	2.50	2,882	927.49	920.78	0.2%	16.86	12.18	14.52	3	15.0	0.86	0.34	$ 734	$ -	$ 2,202	$ 2,254,251	$ -	$ 2,254,251
F_GS_064		283			YES	0331003	0320005	1	3.50	1,491	920.78	917.38	0.2%	13.18	11.99	12.59	3	25.1	0.9	0.26	$ 1,029	$ -	$ 3,087	$ 2,117,139	$ -	$ 2,117,139
F_GS_065					YES	0320004	0320185	1	1.25	80	913.63	913.24	0.5%	18.78	17.24	18.01	4	5.1	1	0.80	$ 447	$ -	$ -	$ 35,657	$ -	$ 35,657
F_GS_067	50				YES	0327094	0327053	1	1.25	836	1013.73	1007.08	0.8%	9.58	9.27	9.43	2	0.5	0.29	0.23	$ 298	$ -	$ 343	$ 251,354	$ -	$ 251,354
F_GS_068	57				YES	0327053	0327044	1	1.25	360	1007.08	1000.05	2.0%	9.27	12.76	11.02	3	1.2	0.32	0.26	$ 373	$ -	$ 429	$ 137,435	$ -	$ 137,435
F_GS_069	68				YES	0327044	0327032	1	1.25	637	1000.05	995.11	0.8%	13.67	11.57	12.62	3	1.2	0.7	0.56	$ 373	$ -	$ 429	$ 241,532	$ -	$ 241,532
F_GS_070	43				YES	0327031	0327007	1	1.00	793	991.66	982.57	1.1%	14.81	7.90	11.36	3	1.5	0.69	0.69	$ 348	$ -	$ 400	$ 278,123	$ -	$ 278,123
F_GS_071					NO																					
F_GS_072					NO																					
F_GS_074					YES	0326024	0326003	1	1.00	578	999.24	996.91	0.4%	13.12	11.76	12.44	3	0.9	0.56	0.56	$ 348	$ -	$ -	$ 201,228	$ -	$ 201,228
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	980.41	1.2%	9.50	7.95	8.72	2	1.0	0.54	0.54	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_076					NO																					
F_GS_078					NO																					
F_GS_079					YES	0325048	0325047	1	3.00	176	1015.23	1014.99	0.1%	9.00	11.56	10.28	3	1.6	0.42	0.14	$ 875	$ -	$ -	$ 153,589	$ -	$ 153,589
F_GS_080					NO																					
F_GS_081					YES	0325044	0325036	1	2.25	418	1011.90	1008.16	0.9%	8.62	5.76	7.19	2	1.3	0.59	0.26	$ 504	$ -	$ -	$ 210,672	$ -	$ 210,672
F_GS_082					NO																					
F_GS_084					YES	0325006	0325003	1	1.00	220	991.19	988.62	1.2%	12.32	11.51	11.92	3	1.4	0.79	0.79	$ 348	$ -	$ -	$ 76,626	$ -	$ 76,626
F_GS_085					NO																					
F_GS_086					YES	0323131	0323127	1	1.00	1,057	980.41	969.24	1.1%	12.02	16.79	14.41	3	2.2	0.92	0.92	$ 348	$ -	$ -	$ 367,913	$ -	$ 367,913
F_GS_087					NO																					
F_GS_089					YES	0323019	0323013	1	1.00	953	961.12	953.50	0.8%	10.12	12.15	11.14	3	2.3	0.93	0.93	$ 348	$ -	$ -	$ 331,665	$ -	$ 331,665
F_GS_093		98			YES	0323008	0320200	1	1.50	1,548	949.07	941.29	0.5%	12.15	19.91	16.03	4	4.5	0.88	0.59	$ 479	$ -	$ 1,437	$ 835,232	$ -	$ 835,232
F_GS_095					NO																					
F_GS_096					YES	0320014	0320013	1	1.75	377	930.00	928.91	0.3%	10.91	11.17	11.04	3	5.2	0.92	0.53	$ 464	$ -	$ -	$ 174,775	$ -	$ 174,775
F_GS_097		25			YES	0320003	0320001	1	2.50	677	911.54	909.98	0.2%	10.15	10.50	10.33	3	17.7	0.98	0.39	$ 734	$ -	$ 2,202	$ 533,831	$ -	$ 533,831
F_GS_098					YES	0310025	0310022	1	3.00	895	902.40	899.77	0.3%	14.10	13.51	13.81	3	23.1	1	0.33	$ 875	$ -	$ -	$ 783,204	$ -	$ 783,204

F_GS_106					NO																						
F_GS_107		204			YES	0310018	0310012	1	2.50	1,757	891.29	886.38	0.3%	18.63	23.10	20.87	4	16.9	1	0.40	$ 881	$ -	$ 2,643	$ 1,907,427	$ -	$ 1,907,427
F_GS_110					YES	0315011	0315010	1	1.00	163	933.22	932.20	0.6%	6.31	9.84	8.08	2	0.7	0.54	0.54	$ 278	$ -	$ -	$ 45,436	$ -	$ 45,436
F_GS_111					NO																						
F_GS_112					YES	0310205	0310012	1	1.00	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.4	0.78	0.78	$ 417	$ -	$ -	$ 434,981	$ -	$ 434,981
F_GS_113	47				YES	0310012	0310002	1	2.50	3,131	886.38	871.09	0.5%	23.10	27.08	25.09	4	20.2	1	0.40	$ 881	$ -	$ 1,013	$ 2,764,545	$ -	$ 2,764,545
F_GS_116					NO																						
F_GS_118					YES	0309231	0309022	1	1.00	268	922.91	916.69	2.3%	9.09	12.01	10.55	3	1.6	0.53	0.53	$ 348	$ -	$ -	$ 93,368	$ -	$ 93,368
F_GS_120		36			YES	0310002	0301024	1	3.00	708	871.09	868.77	0.3%	27.08	17.08	22.08	4	28.3	0.9	0.30	$ 1,050	$ -	$ 3,150	$ 818,769	$ -	$ 818,769
F_GS_121				128	YES	0301024	0301018	1	3.50	1,885	868.77	861.39	0.4%	17.08	18.43	17.76	4	33.5	0.85	0.24	$ 1,235	$ -	$ 8,645	$ 3,276,554	$ -	$ 3,276,554
F_GS_124	62				YES	0301012	0301009	1	3.00	1,435	852.01	846.64	0.4%	18.84	19.14	18.99	4	26.0	0.84	0.28	$ 1,050	$ -	$ 1,208	$ 1,516,368	$ -	$ 1,516,368
F_GS_126	47	95	41		YES	0301009	0301001	1	3.00	2,504	846.64	834.00	0.5%	19.14	19.92	19.53	4	31.2	0.94	0.31	$ 1,050	$ -	$ 3,117	$ 3,007,284	$ -	$ 3,007,284
F_GS_127	48				YES	0323013	0323008	1	2.00	629	953.50	949.07	0.7%	12.15	12.15	12.15	3	4.7	0.5	0.25	$ 528	$ -	$ 607	$ 335,676	$ -	$ 335,676
F_GS_129					YES	0332120	0332119	1	1.00	400	992.79	987.80	1.2%	10.59	9.46	10.03	3	0.7	0.62	0.62	$ 348	$ -	$ -	$ 139,210	$ -	$ 139,210
F_GS_130					NO																						
F_GS_131		62			YES	0335005	0331011	1	2.25	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	14.3	0.94	0.42	$ 756	$ -	$ 2,268	$ 1,851,263	$ -	$ 1,851,263
F_GS_133	34				YES	0327054	0327053	1	1.00	77	1008.25	1007.08	1.5%	8.91	8.40	8.66	2	0.4	0.36	0.36	$ 278	$ -	$ 320	$ 22,762	$ -	$ 22,762
GRAVITY SEWER (MISSION MAIN)																								**$ 31,123,487**	**$ -**	**$ 31,123,487**
F_GS_502					YES	0141096	0141021	1	1.75	232	1006.50	1000.80	2.5%	8.69	10.19	9.44	2	1.0	0.42	0.24	$ 371	$ -	$ -	$ 86,232	$ -	$ 86,232
F_GS_503					NO																						
F_GS_505					YES	0141046	0141010	1	1.00	424	1003.78	1001.90	0.4%	6.08	11.21	8.65	2	0.4	0.46	0.46	$ 278	$ -	$ -	$ 117,739	$ -	$ 117,739
F_GS_506					NO																						
F_GS_507					NO																						
F_GS_509					YES	0140079	0140024	1	1.50	227	1041.55	1039.73	0.8%	10.21	9.83	10.02	3	0.5	0.26	0.17	$ 399	$ -	$ -	$ 90,753	$ -	$ 90,753
F_GS_510					YES	0140021	0140017	1	1.25	575	1019.42	1009.89	1.7%	10.86	12.08	11.47	3	0.7	0.34	0.27	$ 373	$ -	$ -	$ 214,546	$ -	$ 214,546
F_GS_511					NO																						
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.4	0.52	0.52	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_513					YES	0142016	0142001	1	1.75	95	997.15	996.11	1.1%	6.85	10.50	8.68	2	1.8	0.61	0.35	$ 371	$ -	$ -	$ 35,175	$ -	$ 35,175
F_GS_514					NO																						
F_GS_515		19			YES	0136046	0136042	1	1.00	777	979.01	962.60	2.1%	9.33	10.64	9.99	2	0.8	0.34	0.34	$ 278	$ -	$ 834	$ 226,650	$ -	$ 226,650
F_GS_519		180			YES	0140006	0136006	1	1.00	1,204	955.06	944.71	0.9%	15.52	5.99	10.75	3	1.2	0.76	0.76	$ 348	$ -	$ 1,044	$ 544,275	$ -	$ 544,275
F_GS_520					YES	0136028	0136089	1	1.00	851	978.57	974.64	0.5%	18.63	1.76	10.20	3	0.4	0.38	0.38	$ 348	$ -	$ -	$ 296,294	$ -	$ 296,294
F_GS_522	89				YES	0139015	0139014	1	1.25	318	1000.68	998.96	0.5%	11.61	12.58	12.10	3	1.0	0.69	0.55	$ 373	$ -	$ 429	$ 123,451	$ -	$ 123,451
F_GS_523	100				YES	0139013	0139010	1	1.00	1,049	991.40	975.42	1.5%	12.49	10.46	11.48	3	0.8	0.44	0.44	$ 348	$ -	$ 400	$ 370,152	$ -	$ 370,152
F_GS_524					NO																						
F_GS_525					NO																						
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1020.87	1.7%	7.82	9.14	8.48	2	0.7	0.44	0.44	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_532					YES	0137017	0137016	1	1.50	406	991.83	987.13	1.2%	9.57	11.13	10.35	3	0.6	0.36	0.24	$ 399	$ -	$ -	$ 161,970	$ -	$ 161,970
F_GS_533					NO																						
F_GS_534					NO																						
F_GS_535					YES	0137004	0137001	1	1.00	225	976.90	975.97	0.4%	9.43	9.47	9.45	2	1.1	0.78	0.78	$ 278	$ -	$ -	$ 62,414	$ -	$ 62,414
F_GS_538					YES	0135040	0135039	1	1.25	222	968.20	965.84	1.1%	8.28	7.88	8.08	2	0.5	0.62	0.50	$ 298	$ -	$ -	$ 66,061	$ -	$ 66,061
F_GS_539					NO																						
F_GS_540					NO																						
F_GS_541					NO																						
F_GS_542		172			NO																						
F_GS_543					YES	0135023	0135022	1	1.00	82	950.09	949.53	0.7%	8.63	9.37	9.00	2	1.9	1	1.00	$ 278	$ -	$ -	$ 22,916	$ -	$ 22,916
F_GS_545		50			NO																						
F_GS_546	189				YES	0136007	0133054	1	1.50	226	939.66	939.24	0.2%	12.42	12.94	12.68	3	3.4	1	0.67	$ 399	$ -	$ 459	$ 101,519	$ -	$ 101,519
F_GS_547	66	109			YES	Nall_Sluice	0133043	1	1.50	890	938.00	933.10	0.6%	14.62	10.77	12.70	3	5.1	1	0.67	$ 399	$ -	$ 917	$ 445,933	$ -	$ 445,933
F_GS_548	40				YES	0133043	0133034	1	1.50	1,930	933.10	926.33	0.4%	11.42	13.51	12.47	3	4.6	0.84	0.56	$ 399	$ -	$ 459	$ 772,251	$ -	$ 772,251
F_GS_549					YES	0133034	0133002	1	1.75	806	926.33	923.05	0.4%	14.04	13.58	13.81	3	6.2	0.94	0.54	$ 464	$ -	$ -	$ 374,081	$ -	$ 374,081
F_GS_551					YES	0134174	0134230	1	1.00	414	967.89	955.54	3.0%	8.02	7.15	7.59	2	1.0	0.36	0.36	$ 278	$ -	$ -	$ 115,173	$ -	$ 115,173
F_GS_553					NO																						
F_GS_554					NO																						
F_GS_555					NO																						
F_GS_556		125			NO																						
F_GS_557		15			NO																						
F_GS_558					YES	0130043	0130039	1	1.50	449	949.36	947.38	0.4%	12.65	13.54	13.10	3	0.9	0.65	0.43	$ 399	$ -	$ -	$ 179,255	$ -	$ 179,255
F_GS_559					YES	0130029	0130024	1	1.75	305	939.48	933.49	2.0%	10.46	8.23	9.35	2	1.3	0.21	0.12	$ 371	$ -	$ -	$ 113,021	$ -	$ 113,021
F_GS_560					YES	0130024	0130001	1	1.25	740	933.49	918.28	2.1%	9.73	9.77	9.75	2	1.4	0.33	0.26	$ 298	$ -	$ -	$ 220,425	$ -	$ 220,425
F_GS_562	46				YES	0129126	0129121	1	1.50	286	981.31	978.22	1.1%	11.67	12.95	12.31	3	0.6	0.52	0.35	$ 399	$ -	$ 459	$ 116,859	$ -	$ 116,859
F_GS_563					NO																						

F_GS_564					NO																					
F_GS_565					YES	0129103	0129098	1	1.00	683	978.89	976.19	0.4%	7.39	10.90	9.15	2	0.5	0.42	0.42	$ 278	$ -	$ -	$ 189,893	$ -	$ 189,893
F_GS_566					YES	0129043	0129041	1	1.00	839	971.00	968.20	0.3%	11.03	10.88	10.96	3	0.4	0.37	0.37	$ 348	$ -	$ -	$ 292,132	$ -	$ 292,132
F_GS_567					NO																					
F_GS_568					NO																					
F_GS_569					NO																					
F_GS_570	42				NO																					
F_GS_575					YES	0129008	0126009	1	1.50	301	909.27	907.87	0.5%	11.94	11.83	11.89	3	3.5	0.62	0.41	$ 399	$ -	$ -	$ 120,231	$ -	$ 120,231
F_GS_576					YES	0126009	0126005	1	1.50	1,223	907.87	902.66	0.4%	11.83	8.60	10.22	3	2.9	0.58	0.39	$ 399	$ -	$ -	$ 487,965	$ -	$ 487,965
F_GS_577					YES	0126005	0126044	1	1.00	359	902.66	893.65	2.5%	8.60	11.48	10.04	3	3.0	0.93	0.93	$ 348	$ -	$ -	$ 124,873	$ -	$ 124,873
F_GS_579	63	109			NO																					
F_GS_580		83			YES	0126004	0122033	1	1.75	1,863	891.51	884.63	0.4%	9.63	12.67	11.15	3	6.3	0.91	0.52	$ 464	$ -	$ 1,392	$ 941,671	$ -	$ 941,671
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.37	0.37	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_585					NO																					
F_GS_586					NO																					
F_GS_588					NO																					
F_GS_589					YES	0125009	0125007	1	2.00	142	942.88	940.00	2.0%	15.46	15.34	15.40	4	0.7	0.14	0.07	$ 633	$ -	$ -	$ 90,076	$ -	$ 90,076
F_GS_590	39				YES	0125007	0125003	1	1.75	1,317	940.00	924.35	1.2%	16.44	7.08	11.76	3	1.9	0.27	0.15	$ 464	$ -	$ 534	$ 614,034	$ -	$ 614,034
F_GS_592					YES	0125003	0125002	1	1.00	243	924.35	915.18	3.8%	7.08	7.54	7.31	2	1.6	0.46	0.46	$ 278	$ -	$ -	$ 67,426	$ -	$ 67,426
F_GS_593					NO																					
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	948.48	1.0%	11.09	10.36	10.73	3	1.0	0.54	0.54	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_598					YES	0124007	0124006	1	1.00	337	937.00	936.21	0.2%	12.15	6.82	9.49	2	1.0	0.57	0.57	$ 278	$ -	$ -	$ 93,717	$ -	$ 93,717
F_GS_599					YES	0124006	0122058	1	1.00	698	936.21	916.48	2.8%	6.82	7.02	6.92	2	0.9	0.68	0.68	$ 278	$ -	$ -	$ 193,913	$ -	$ 193,913
F_GS_600					NO																					
F_GS_601					YES	0122137	0122053	1	1.50	479	907.50	902.80	1.0%	11.08	7.67	9.38	2	0.6	0.6	0.40	$ 319	$ -	$ -	$ 152,642	$ -	$ 152,642
F_GS_603					NO																					
F_GS_604	36				NO																					
F_GS_608		23			YES	0122033	0122019	1	2.00	980	884.63	880.74	0.4%	12.67	14.42	13.55	3	9.9	0.91	0.46	$ 528	$ -	$ 1,584	$ 542,047	$ -	$ 542,047
F_GS_612					NO																					
F_GS_613					NO																					
F_GS_614					YES	0122061	0122024	1	1.00	707	908.97	901.26	1.1%	9.98	8.32	9.15	2	0.7	0.37	0.37	$ 278	$ -	$ -	$ 196,654	$ -	$ 196,654
F_GS_615	32				YES	0122024	0122120	1	1.50	357	901.26	894.00	2.0%	8.32	9.75	9.04	2	1.3	0.25	0.17	$ 319	$ -	$ 367	$ 115,265	$ -	$ 115,265
F_GS_616					YES	0122120	0122118	1	1.50	433	894.00	886.89	1.6%	10.25	8.46	9.36	2	1.1	0.25	0.17	$ 319	$ -	$ -	$ 137,983	$ -	$ 137,983
F_GS_617					YES	0122118	0122019	1	1.00	412	886.89	880.74	1.5%	10.08	14.42	12.25	3	1.3	0.74	0.74	$ 348	$ -	$ -	$ 143,477	$ -	$ 143,477
F_GS_619					YES	0122019	0122018	1	2.25	457	880.74	878.77	0.4%	14.42	13.28	13.85	3	12.7	0.84	0.37	$ 630	$ -	$ -	$ 287,645	$ -	$ 287,645
F_GS_620		742			YES	0122018	0103042	1	2.25	1,656	878.77	873.73	0.3%	13.28	9.57	11.43	3	11.1	0.94	0.42	$ 630	$ -	$ 1,890	$ 1,978,013	$ -	$ 1,978,013
F_GS_621					NO																					
F_GS_623					NO																					
F_GS_624					YES	0132002	GTPSWW	1	3.00	35	938.37	931.00	21.1%	10.84	4.00	7.42	2	3.3	0.13	0.04	$ 700	$ -	$ -	$ 24,500	$ -	$ 24,500
F_GS_625					YES	0132017	0132174	1	1.00	188	950.20	949.08	0.6%	10.24	12.16	11.20	3	0.4	0.7	0.70	$ 348	$ -	$ -	$ 65,400	$ -	$ 65,400
F_GS_626					NO																					
F_GS_627					YES	0132028	0132012	1	1.00	424	965.35	959.29	1.4%	11.00	9.23	10.12	3	1.3	0.5	0.50	$ 348	$ -	$ -	$ 147,608	$ -	$ 147,608
F_GS_628					YES	0132029	0132028	1	2.00	363	967.26	965.35	0.5%	13.04	11.00	12.02	3	0.8	0.22	0.11	$ 528	$ -	$ -	$ 191,490	$ -	$ 191,490
F_GS_629					YES	0132172	0132029	1	1.00	376	973.25	967.26	1.6%	10.68	10.36	10.52	3	0.7	0.38	0.38	$ 348	$ -	$ -	$ 130,695	$ -	$ 130,695
F_GS_630					NO																					
F_GS_632					NO																					
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	980.63	0.6%	11.15	11.05	11.10	3	0.7	0.46	0.46	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_635					NO																					
F_GS_636					NO																					
F_GS_640					YES	0123018	0123015	1	1.00	1,071	933.50	922.91	1.0%	10.50	8.23	9.37	2	1.7	0.58	0.58	$ 278	$ -	$ -	$ 297,774	$ -	$ 297,774
F_GS_641					YES	0123015	0123035	1	1.50	264	922.91	919.54	1.3%	8.23	10.18	9.21	2	1.2	0.38	0.25	$ 319	$ -	$ -	$ 84,328	$ -	$ 84,328
F_GS_642					YES	0123091	0123089	1	1.00	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	2.7	0.57	0.57	$ 278	$ -	$ -	$ 218,022	$ -	$ 218,022
F_GS_643					YES	0123117	0123116	1	1.00	241	957.50	951.00	2.7%	10.69	6.75	8.72	2	0.0	0.27	0.27	$ 278	$ -	$ -	$ 67,040	$ -	$ 67,040
F_GS_644					NO																					
F_GS_645					NO																					
F_GS_646					NO																					
F_GS_647					YES	0123086	0123028	1	1.25	517	914.76	911.00	0.7%	8.97	8.60	8.79	2	3.8	0.88	0.70	$ 298	$ -	$ -	$ 154,123	$ -	$ 154,123
F_GS_649		31			NO																					
F_GS_650					YES	0123046	0123025	1	1.25	169	906.92	901.90	3.0%	9.32	7.08	8.20	2	4.0	0.78	0.62	$ 298	$ -	$ -	$ 50,413	$ -	$ 50,413
F_GS_651					YES	0123025	0123005	1	1.00	335	901.90	898.80	0.9%	10.38	7.52	8.95	2	2.8	0.94	0.94	$ 278	$ -	$ -	$ 93,033	$ -	$ 93,033
F_GS_652		66			YES	0123005	0123004	1	1.50	396	898.80	891.28	1.9%	8.04	10.83	9.44	2	7.8	0.76	0.51	$ 319	$ -	$ 957	$ 168,335	$ -	$ 168,335
F_GS_653					YES	0123004	0123021	1	1.75	144	891.28	888.99	1.6%	10.83	10.48	10.66	3	7.9	0.71	0.41	$ 464	$ -	$ -	$ 67,034	$ -	$ 67,034
F_GS_654		148			YES	0123021	0103042	1	1.25	1,374	888.99	873.73	1.1%	11.58	8.58	10.08	3	4.0	0.89	0.71	$ 373	$ -	$ 1,119	$ 622,556	$ -	$ 622,556

F_GS_655		71			YES	0103042	0103026	1	2.25	385	873.73	873.02	0.2%	9.57	11.58	10.58	3	12.5	0.96	0.43	$ 630	$ -	$ 1,890	$ 331,311	$ -	$ 331,311
F_GS_656	135	46			YES	0103026	0103038	1	2.25	1,642	873.02	863.64	0.6%	11.58	8.07	9.83	2	15.3	0.73	0.32	$ 504	$ -	$ 817	$ 884,228	$ -	$ 884,228
F_GS_659		189			YES	0103018	0103011	1	2.00	2,885	862.48	854.67	0.3%	8.57	9.92	9.25	2	7.2	0.94	0.47	$ 422	$ -	$ 1,266	$ 1,376,796	$ -	$ 1,376,796
F_GS_662					YES	0103011	0103065	1	3.00	80	853.87	853.81	0.1%	9.92	12.91	11.42	3	7.9	1	0.33	$ 875	$ -	$ -	$ 70,000	$ -	$ 70,000
F_GS_663					YES	0103065	0103064	1	5.00	70	853.81	853.75	0.1%	12.91	13.25	13.08	3	22.3	1	0.20	$ 1,454	$ -	$ -	$ 101,780	$ -	$ 101,780
F_GS_664					YES	0103064	BLPSWW	1	4.00	70	853.75	847.00	9.6%	13.25	13.55	13.40	3	22.7	1	0.25	$ 1,171	$ -	$ -	$ 81,970	$ -	$ 81,970
F_GS_670					NO																					
F_GS_671					YES	0119033	0119032	1	1.50	112	957.68	957.67	0.0%	11.86	14.65	13.26	3	1.1	0.55	0.37	$ 399	$ -	$ -	$ 44,656	$ -	$ 44,656
F_GS_672					NO																					
F_GS_675					NO																					
F_GS_676					NO																					
F_GS_677					YES	0115176	0115016	1	2.00	197	942.95	942.08	0.4%	11.49	12.80	12.15	3	1.5	0.81	0.41	$ 528	$ -	$ -	$ 103,921	$ -	$ 103,921
F_GS_678					YES	0115139	0115137	1	1.00	70	959.90	956.90	4.3%	7.48	5.98	6.73	2	0.6	0.61	0.61	$ 278	$ -	$ -	$ 19,460	$ -	$ 19,460
F_GS_679					NO																					
F_GS_681		43			NO																					
F_GS_682					YES	0115183	0115010	1	1.50	121	930.58	929.98	0.5%	13.29	9.83	11.56	3	2.8	0.67	0.45	$ 399	$ -	$ -	$ 48,147	$ -	$ 48,147
F_GS_683	59				NO																					
F_GS_684					YES	0120023	0120016	1	1.00	1,206	1005.79	987.46	1.5%	8.00	7.61	7.81	2	0.8	0.51	0.51	$ 278	$ -	$ -	$ 335,221	$ -	$ 335,221
F_GS_685					YES	0120014	0120013	1	2.25	180	983.77	981.77	1.1%	5.65	8.92	7.29	2	0.6	0.17	0.08	$ 504	$ -	$ -	$ 90,695	$ -	$ 90,695
F_GS_686	38				NO																					
F_GS_687	11				YES	0120004	0120002	1	1.00	841	963.50	955.19	1.0%	13.05	11.83	12.44	3	1.3	0.58	0.58	$ 348	$ -	$ 400	$ 293,155	$ -	$ 293,155
F_GS_689					YES	0120001	0113054	1	2.00	254	945.50	943.00	1.0%	14.00	12.40	13.20	3	1.7	0.53	0.27	$ 528	$ -	$ -	$ 133,985	$ -	$ 133,985
F_GS_691	111				NO																					
F_GS_692					YES	0113050	0113044	1	2.00	934	937.87	926.49	1.2%	14.71	10.40	12.56	3	3.3	0.65	0.33	$ 528	$ -	$ -	$ 492,994	$ -	$ 492,994
F_GS_694					YES	0113043	0113040	1	2.00	163	922.82	920.89	1.2%	8.88	12.20	10.54	3	4.4	0.97	0.49	$ 528	$ -	$ -	$ 86,238	$ -	$ 86,238
F_GS_696					YES	1601045	1601056	1	4.00	2,937	977.00	971.00	0.2%	7.87	11.44	9.65	2	46.7	0.85	0.21	$ 937	$ -	$ -	$ 2,752,147	$ -	$ 2,752,147
F_GS_698					YES	0114083	0114015	1	1.00	427	972.90	969.77	0.7%	9.73	8.84	9.29	2	0.5	0.39	0.39	$ 278	$ -	$ -	$ 118,581	$ -	$ 118,581
F_GS_699					YES	0114012	0114011	1	1.75	53	963.25	962.62	1.2%	6.46	8.55	7.51	2	2.6	0.73	0.42	$ 371	$ -	$ -	$ 19,789	$ -	$ 19,789
F_GS_700	36				NO																					
F_GS_701	65				NO																					
F_GS_702					NO																					
F_GS_703					YES	0113021	0113020	1	1.00	155	923.80	923.09	0.5%	8.62	8.31	8.47	2	1.6	0.9	0.90	$ 278	$ -	$ -	$ 43,071	$ -	$ 43,071
F_GS_705					NO																					
F_GS_706					NO																					
F_GS_707					YES	0112031	0112022	1	1.00	995	942.50	927.88	1.5%	9.49	4.84	7.17	2	1.0	0.49	0.49	$ 278	$ -	$ -	$ 276,696	$ -	$ 276,696
F_GS_708					YES	0113224	RCPSWW	1	2.00	35	905.26	896.50	25.0%	17.64	12.00	14.82	3	21.5	1	0.50	$ 528	$ -	$ -	$ 18,480	$ -	$ 18,480
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.3	0.46	0.46	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.00	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.1	0.52	0.52	$ 348	$ -	$ 400	$ 195,763	$ -	$ 195,763
F_GS_711	149				YES	0112016	0113002	1	1.00	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.4	0.84	0.84	$ 348	$ -	$ 400	$ 120,529	$ -	$ 120,529
F_GS_712	18				NO																					
F_GS_714	40				YES	0113002	0113224	1	3.00	40	906.40	905.26	2.8%	14.63	17.33	15.98	4	19.3	1	0.33	$ 1,050	$ -	$ 1,208	$ 48,320	$ -	$ 48,320
F_GS_716					NO																					
F_GS_717					YES	0110009	0110008	1	1.00	70	924.08	923.25	1.2%	11.08	10.33	10.71	3	0.6	0.42	0.42	$ 348	$ -	$ -	$ 24,360	$ -	$ 24,360
F_GS_718					YES	0110004	0108071	1	1.50	253	913.77	911.89	0.7%	8.83	14.04	11.43	3	0.2	0.26	0.17	$ 399	$ -	$ -	$ 100,763	$ -	$ 100,763
F_GS_719					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	1.75	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	6.0	0.84	0.48	$ 464	$ -	$ 1,392	$ 416,583	$ -	$ 416,583
F_GS_724					YES	0109195	0109155	1	1.00	202	969.95	968.01	1.0%	3.23	7.98	5.61	2	0.6	0.52	0.52	$ 278	$ -	$ -	$ 56,173	$ -	$ 56,173
F_GS_726					YES	0109147	0109084	1	1.75	146	959.99	958.47	1.0%	4.46	6.90	5.68	2	0.9	0.39	0.22	$ 371	$ -	$ -	$ 54,322	$ -	$ 54,322
F_GS_727					NO																					
F_GS_728					NO																					
F_GS_729					YES	0109040	0109036	1	1.50	211	950.60	950.21	0.2%	7.50	8.86	8.18	2	0.3	0.24	0.16	$ 319	$ -	$ -	$ 67,360	$ -	$ 67,360
F_GS_730	63				NO																					
F_GS_731		35			YES	0109198	0109019	1	1.75	325	936.21	933.20	0.9%	10.83	7.83	9.33	2	2.5	0.39	0.22	$ 371	$ -	$ 1,113	$ 146,806	$ -	$ 146,806
F_GS_732	34	21			NO																					
F_GS_733	126				YES	0108016	0108005	1	1.00	484	897.11	888.14	1.9%	8.92	10.10	9.51	2	1.8	0.77	0.77	$ 278	$ -	$ 320	$ 139,808	$ -	$ 139,808
F_GS_736					NO																					
F_GS_737		34			NO																					
F_GS_738					NO																					
F_GS_739					NO																					
F_GS_740					NO																					
F_GS_741					YES	0107030	0107027	1	1.50	531	922.83	910.13	2.4%	6.48	7.26	6.87	2	1.3	0.3	0.20	$ 319	$ -	$ -	$ 169,446	$ -	$ 169,446
F_GS_742					NO																					

F_GS_743	50				NO																					
F_GS_744	50				NO																					
F_GS_745					YES	0107097	0107019	1	1.25	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.4	0.27	0.22	$ 298	$ -	$ -	$ 481,440	$ -	$ 481,440
F_GS_748					YES	0107017	0107015	1	1.00	652	946.93	936.29	1.6%	7.75	7.65	7.70	2	0.7	0.55	0.55	$ 278	$ -	$ -	$ 181,209	$ -	$ 181,209
F_GS_750					NO																					
F_GS_751					YES	0107010	0107021	1	3.00	35	913.88	913.30	1.7%	10.90	10.49	10.70	3	1.7	0.3	0.10	$ 875	$ -	$ -	$ 30,625	$ -	$ 30,625
F_GS_752					NO																					
F_GS_753					NO																					
F_GS_754		43			YES	0107001	0106009	1	1.25	863	883.98	879.29	0.5%	12.67	8.84	10.76	3	3.0	0.85	0.68	$ 373	$ -	$ 1,119	$ 354,410	$ -	$ 354,410
F_GS_755		53			YES	0106009	0106006	1	1.75	784	879.29	874.69	0.6%	10.92	11.25	11.09	3	4.6	0.78	0.45	$ 464	$ -	$ 1,392	$ 412,696	$ -	$ 412,696
F_GS_757					NO																					
F_GS_758	35				NO																					
F_GS_759		44			YES	0106003	0103053	1	1.50	598	871.30	869.59	0.3%	14.63	11.37	13.00	3	3.0	0.87	0.58	$ 399	$ -	$ 1,197	$ 273,790	$ -	$ 273,790
F_GS_766					NO																					
F_GS_767					YES	0103104	0103103	1	1.00	50	911.61	907.37	8.5%	3.22	4.81	4.02	2	0.9	0.54	0.54	$ 278	$ -	$ -	$ 13,900	$ -	$ 13,900
F_GS_770					NO																					
F_GS_771					YES	0103226	0103089	1	1.00	203	899.84	896.71	1.5%	8.16	8.90	8.53	2	1.1	0.55	0.55	$ 278	$ -	$ -	$ 56,467	$ -	$ 56,467
F_GS_772					NO																					
F_GS_773	74				NO																					
F_GS_774		49			YES	0103053	0103069	1	2.25	1,236	869.59	865.44	0.3%	11.37	9.18	10.27	3	9.3	0.94	0.42	$ 630	$ -	$ 1,890	$ 840,106	$ -	$ 840,106
F_GS_775					YES	0103049	0103046	1	2.00	576	861.42	859.50	0.3%	12.32	10.37	11.34	3	7.7	0.7	0.35	$ 528	$ -	$ -	$ 304,038	$ -	$ 304,038
F_GS_776					YES	0103121	0103120	1	1.50	399	925.07	922.73	0.6%	10.63	16.71	13.67	3	0.4	0.25	0.17	$ 399	$ -	$ -	$ 159,125	$ -	$ 159,125
F_GS_777					YES	0103116	0103115	1	1.00	437	867.80	856.30	2.6%	12.92	2.82	7.87	2	1.0	0.57	0.57	$ 278	$ -	$ -	$ 121,597	$ -	$ 121,597
F_GS_778					NO																					
F_GS_779					YES	0101167	BLPSWW	1	1.50	83	855.24	847.00	9.9%	13.09	12.46	12.78	3	4.7	1	0.67	$ 399	$ -	$ -	$ 33,173	$ -	$ 33,173
F_GS_782					NO																					
F_GS_783					NO																					
F_GS_784					NO																					
F_GS_785					NO																					
F_GS_786					YES	0102001	0102130	1	2.00	53	912.90	911.98	1.7%	10.10	10.87	10.48	3	1.8	0.23	0.12	$ 528	$ -	$ -	$ 27,963	$ -	$ 27,963
F_GS_789					NO																					
F_GS_790	83				YES	0101018	0101016	1	1.00	323	902.31	895.77	2.0%	15.63	9.36	12.50	3	2.8	0.68	0.68	$ 348	$ -	$ 400	$ 116,586	$ -	$ 116,586
F_GS_791					YES	0101014	0101012	1	1.00	167	883.39	882.29	0.7%	8.43	9.21	8.82	2	2.5	0.93	0.93	$ 278	$ -	$ -	$ 46,540	$ -	$ 46,540
F_GS_794					YES	0101039	0101038	1	1.00	354	881.54	877.06	1.3%	8.61	12.67	10.64	3	2.4	0.8	0.80	$ 348	$ -	$ -	$ 123,140	$ -	$ 123,140
F_GS_795					YES	0101038	0101036	1	1.75	857	877.06	871.17	0.7%	13.17	5.38	9.28	2	2.9	0.47	0.27	$ 371	$ -	$ -	$ 318,088	$ -	$ 318,088
F_GS_796					YES	0123089	0123086	1	1.25	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	2.9	0.64	0.51	$ 298	$ -	$ -	$ 88,917	$ -	$ 88,917
F_GS_797					YES	0101168	0101050	1	1.00	1,150	946.69	923.22	2.0%	8.01	4.94	6.48	2	1.5	0.43	0.43	$ 278	$ -	$ -	$ 319,647	$ -	$ 319,647
F_GS_798					NO																					
F_GS_799					YES	0127005	0127003	1	1.50	123	913.46	911.75	1.4%	2.48	0.81	1.64	2	0.0	0.1	0.07	$ 319	$ -	$ -	$ 39,342	$ -	$ 39,342
F_GS_801	38				NO																					
F_GS_803					YES	0101050	0101047	1	1.50	234	923.22	910.72	5.3%	4.94	10.23	7.59	2	1.9	0.24	0.16	$ 319	$ -	$ -	$ 74,614	$ -	$ 74,614
F_GS_805					NO																					
F_GS_806					YES	0101015	0101014	1	1.00	267	889.35	883.39	2.2%	9.58	8.43	9.01	2	2.4	0.81	0.81	$ 278	$ -	$ -	$ 74,112	$ -	$ 74,112
F_GS_807					YES	1601056	1601051	1	2.25	135	971.00	970.50	0.4%	11.44	11.50	11.47	3	15.5	1	0.44	$ 630	$ -	$ -	$ 85,082	$ -	$ 85,082
F_GS_808					YES	1601016	1601045	1	4.00	50	979.38	977.00	4.8%	6.55	7.87	7.21	2	41.3	0.68	0.17	$ 937	$ -	$ -	$ 46,850	$ -	$ 46,850
F_GS_809					NO																					
F_GS_810					YES	0101002	0101167	1	2.50	169	856.72	855.24	0.9%	9.06	13.09	11.08	3	4.6	0.96	0.38	$ 734	$ -	$ -	$ 123,921	$ -	$ 123,921
F_GS_812					NO																					
F_GS_813		20			YES	0136042	0136041	1	1.25	324	962.60	959.10	1.1%	12.04	12.08	12.06	3	1.1	0.67	0.54	$ 373	$ -	$ 1,119	$ 135,691	$ -	$ 135,691
F_GS_815					NO																					
F_GS_816					YES	0135004	0135001	1	2.00	557	950.06	945.79	0.8%	8.67	9.67	9.17	2	0.9	0.43	0.22	$ 422	$ -	$ -	$ 234,898	$ -	$ 234,898
F_GS_817	38				NO																					
F_GS_818		148			NO																					
F_GS_819					YES	0120137	0120023	1	1.50	144	1006.44	1005.79	0.5%	11.46	8.00	9.73	2	0.6	0.25	0.17	$ 319	$ -	$ -	$ 46,041	$ -	$ 46,041
F_GS_820					NO																					
F_GS_821					YES	0125054	0125046	1	1.00	332	920.68	917.53	0.9%	9.88	9.78	9.83	2	0.9	0.49	0.49	$ 278	$ -	$ -	$ 92,249	$ -	$ 92,249
F_GS_822					NO																					
F_GS_823					YES	0122043	0122044	1	1.50	455	913.26	905.87	1.6%	6.92	7.93	7.43	2	1.6	0.33	0.22	$ 319	$ -	$ -	$ 145,151	$ -	$ 145,151
F_GS_824					YES	0122026	0122025	1	1.75	289	905.12	902.44	0.9%	9.78	7.14	8.46	2	0.6	0.18	0.10	$ 371	$ -	$ -	$ 107,056	$ -	$ 107,056
F_GS_825		95			YES	0127003	0127001	1	1.50	240	911.75	905.51	2.6%	3.90	1.33	2.61	2	1.0	0.3	0.20	$ 319	$ -	$ 957	$ 136,980	$ -	$ 136,980
F_GS_826					YES	0128005	0128003	1	1.00	181	943.64	941.19	1.4%	10.61	10.96	10.79	3	0.6	0.66	0.66	$ 348	$ -	$ -	$ 62,845	$ -	$ 62,845
F_GS_827					YES	0128021	0123018	1	1.00	270	937.29	933.50	1.4%	9.67	10.50	10.09	3	1.2	0.56	0.56	$ 348	$ -	$ -	$ 94,012	$ -	$ 94,012
F_GS_828					NO																					

F_GS_829					NO																						
F_GS_830	222				YES	0101020	0101018	1	1.25	496	907.11	902.31	1.0%	15.73	15.63	15.68	4	2.6	0.57	0.46	$ 447	$ -	$ 514	$ 236,366	$ -	$ 236,366
F_GS_831					YES	0101012	0101039	1	2.50	138	882.29	881.54	0.5%	9.21	8.61	8.91	2	4.9	0.33	0.13	$ 587	$ -	$ -	$ 81,206	$ -	$ 81,206
F_GS_832					NO																						
F_GS_833					NO																						
F_GS_834					NO																						
F_GS_835					YES	0135025	0135023	1	1.00	305	952.69	950.09	0.9%	10.71	8.63	9.67	2	1.2	0.76	0.76	$ 278	$ -	$ -	$ 84,857	$ -	$ 84,857
F_GS_836	57				NO																						
F_GS_837					YES	0108018	0108017	1	1.00	454	915.39	906.42	2.0%	13.25	20.98	17.12	4	1.5	0.84	0.84	$ 417	$ -	$ -	$ 189,310	$ -	$ 189,310
F_GS_838					NO																						
F_GS_839					YES	0103054	0103196	1	2.00	473	872.53	869.97	0.5%	11.17	10.10	10.64	3	10.8	0.89	0.45	$ 528	$ -	$ -	$ 249,601	$ -	$ 249,601
F_GS_840					NO																						
F_GS_841					YES	0103003	BLPSWW	1	1.50	51	854.00	847.00	13.8%	13.44	14.25	13.85	3	10.3	1	0.67	$ 399	$ -	$ -	$ 20,197	$ -	$ 20,197
F_GS_842		335			NO																						
F_GS_843	67				YES	0113212	0113002	1	3.00	67	906.48	906.40	0.1%	15.10	14.63	14.87	3	11.0	0.99	0.33	$ 875	$ -	$ 1,006	$ 67,423	$ -	$ 67,423
F_GS_844					NO																						
F_GS_845					YES	0101036	0101034	1	1.00	793	871.17	865.17	0.8%	5.38	7.61	6.50	2	2.1	0.94	0.94	$ 278	$ -	$ -	$ 220,473	$ -	$ 220,473
F_GS_846					NO																						
F_GS_847					NO																						
F_GS_848					NO																						
F_GS_849					NO																						
F_GS_850					NO																						
F_CC_51					YES	0129001	0129008	1	1.00	190	909.32	909.27	0.0%	12.78	11.94	12.36	3	1.5	0.99	0.99	$ 348	$ -	$ -	$ 66,061	$ -	$ 66,061
F_CC_52					NO																						
F_CC_53					YES	0122044	0122040	1	1.50	70	905.87	903.92	2.8%	7.93	9.37	8.65	2	3.4	0.6	0.40	$ 319	$ -	$ -	$ 22,330	$ -	$ 22,330
F_CC_54					NO																						
F_CC_55					YES	0122239	0122033	1	1.00	40	887.30	884.63	6.7%	10.10	12.67	11.39	3	5.8	1	1.00	$ 348	$ -	$ -	$ 13,920	$ -	$ 13,920
F_CC_56					NO																						
F_CC_57					NO																						
F_CC_58					NO																						
F_CC_59					YES	0120032	0120004	1	1.00	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.6	0.77	0.77	$ 348	$ -	$ -	$ 13,920	$ -	$ 13,920
F_CC_60					NO																						
F_CC_61		20			YES	0135001	0135046	1	1.00	81	945.79	945.35	0.5%	9.67	8.92	9.30	2	1.0	1	1.00	$ 278	$ -	$ 834	$ 33,355	$ -	$ 33,355
F_CC_62	22				YES	0133049	0133056	1	1.00	31	942.64	942.77	-0.4%	9.73	9.69	9.71	2	0.7	1	1.00	$ 278	$ -	$ 320	$ 9,541	$ -	$ 9,541
F_CC_63	32				YES	0114022	0114005	1	1.00	40	950.00	950.03	-0.1%	8.25	8.16	8.21	2	0.2	0.68	0.68	$ 278	$ -	$ 320	$ 12,478	$ -	$ 12,478
F_CC_64					YES	0103196	0103053	1	1.50	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	7.5	1	0.67	$ 399	$ -	$ -	$ 13,965	$ -	$ 13,965
F_CC_65					NO																						
F_CC_66					NO																						
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																						
F_LS_02	47				NO																						
F_LS_03		48			NO																						
F_LS_04	104			169	NO																						
F_LS_05	62				NO																						
F_LS_06	47	95	41		NO																						
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																						
F_LS_51		23			NO																						
F_LS_52					NO																						
F_LS_53		180			NO																						
F_LS_54					NO																						
F_LS_55		435			NO																						
FORCE MAIN (NELSON COMPLEX)																								**$ 25,563,222**	**$ -**	**$ 25,563,222**
FORCE MAIN (TUKEY CREEK)																								**$ 2,765,000**	**$ -**	**$ 2,765,000**
PS_TurkeyCreek					YES	TCPSWW	0345082	1	3.00	3,500	-	-	-	-	-	-	2	45.0	-	-	$ 790	$ -	$ -	$ 2,765,000	$ -	$ 2,765,000
FORCE MAIN (MISSION MAIN)																								**$ 22,798,222**	**$ -**	**$ 22,798,222**
PS_Belinder	439				YES	BLPSWW	1601029	1	3.00	10,604	-	-	-	-	-	-	2	34.0	-	-	$ 790	$ -	$ 909	$ 8,429,409	$ -	$ 8,429,409
PS_BrushCreek	9,673				YES	BCPSWW	0113002	1	2.50	10,623	-	-	-	-	-	-	2	19.2	-	-	$ 658	$ -	$ 757	$ 7,947,561	$ -	$ 7,947,561
PS_RockCreek	5,030				YES	RCPSWW	1601016	1	3.00	7,047	-	-	-	-	-	-	2	34.0	-	-	$ 790	$ -	$ 909	$ 6,165,700	$ -	$ 6,165,700
PS_RoeVillage					YES	RVPSWW	1601037	1	0.67	351	-	-	-	-	-	-	2	0.6	-	-	$ 176	$ -	$ -	$ 61,776	$ -	$ 61,776
PS_Swatzell					YES	SZPSWW	0101168	1	0.67	1,101	-	-	-	-	-	-	2	2.8	-	-	$ 176	$ -	$ -	$ 193,776	$ -	$ 193,776

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

*SPS Expansion Cost Curve used for Prelim Runs

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 27,818,613**	**$ 6,649,650**	**$ 34,468,263**
TURKEY CREEK							**$ 6,755,400**	**$ 1,692,238**	**$ 8,447,638**
PS_TurkeyCreek	27.0	YES	TCPSWW	0345082	45.0	18.0	$ 6,755,400	$ 1,692,238	$ 8,447,638
MISSION MAIN							**$ 21,063,213**	**$ 4,957,412**	**$ 26,020,625**
PS_Belinder	11.6	YES	BLPSWW	1601029	34.0	22.4	$ 8,017,936	$ 2,105,896	$ 10,123,832
PS_BrushCreek	6.0	YES	BCPSWW	0113002	16.5	10.5	$ 4,393,485	$ 988,361	$ 5,381,846
PS_Granthurst	5.5	NO	GTPSWW	0123091	5.5		$ -	$ -	$ -
PS_MissionWoods	1.2	NO	MWPSWW	0101011	1.2		$ -	$ -	$ -
PS_RockCreek	15.5	YES	RCPSWW	1601016	34.0	18.5	$ 6,903,550	$ 1,739,245	$ 8,642,795
PS_RoeVillage	0.4	YES	RVPSWW	1601037	0.6	0.1	$ 679,565	$ 13,914	$ 693,479
PS_Swatzell	1.6	YES	SZPSWW	0101168	2.8	1.2	$ 1,068,678	$ 109,995	$ 1,178,673

OPTIMISATION SOLUTION SUMMARY:
STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
STORAGE FACILITY TOTAL						**$ 24,940,430**	**$ 68,160**	**$ 25,008,590**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ -**	**$ -**	**$ -**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST_01	F_ST_01_IN	NO						
F_ST_02	F_ST_02_IN	NO						
F_ST_03	F_ST_03_IN	NO						
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	NO						
F_ST_06	F_ST_06_IN	NO						
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST_51	F_ST_51_IN	NO						
F_ST_52	F_ST_52_IN	NO						
F_ST_53	F_ST_53_IN	NO						
F_ST_54	F_ST_54_IN	NO						
F_ST_55	F_ST_55_IN	NO						
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TOTAL)						**$ 24,940,430**	**$ 68,160**	**$ 25,008,590**
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TURKEY CREEK)						**$ 10,883,196**	**$ 27,546**	**$ 10,910,742**
F_ST-FPD_TC	F_ST-FPD_TC_IN	YES	4.0	24.1	1.76	$ 10,883,196	$ 27,546	$ 10,910,742
STORAGE FACILITY - FACILITY PROTECTION DEVICE (MISSION MAIN)						**$ 14,057,234**	**$ 40,614**	**$ 14,097,847**
F_ST-FPD_BC	F_ST-FPD_BC_IN	NO						
F_ST-FPD_BL	F_ST-FPD_BL_IN	YES	2.5	37.8	2.59	$ 14,057,234	$ 40,614	$ 14,097,847
F_ST-FPD_MW	F_ST-FPD_MW_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	4.0	8.5	0.00	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX								**$ -**	**$ -**	**$ -**
TURKEY CREEK								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek_PEFTF	TC_PEFTF_OUTFALL	22.0	NO	TC_PEFTF_WW	FMOutletEFB	0.0	0.0	$ -	$ -	$ -
MISSION MAIN								**$ -**	**$ -**	**$ -**
PS_Belinder_PEFTF	Belinder_Outfall	53.1	NO	BLPEFTFWW	Belinder_PEFTF_Tank	0.0	0.0	$ -	$ -	$ -
PS_Martway_PEFTF	Martway_Discharge	20.0	NO	Martway_HS_Wet_Well	Martway_Tank	0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	Nall_Outfall	20.0	NO	Nall_Wet_Well	Nall_Tank	0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
I/I REDUCTION

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	Scaling Factor	% Reduction	I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL						**$ -**	**$ -**	**$ -**
TURKEY CREEK TOTAL						**$ -**	**$ -**	**$ -**
FM_202	0309015	24	NO	1.00		$ -	$ -	$ -
FM_203	0310001	82	NO	1.00		$ -	$ -	$ -
FM_204	0320011	22	NO	1.00		$ -	$ -	$ -
FM_205	0323001	42	NO	1.00		$ -	$ -	$ -
FM_206	0331001	78	NO	1.00		$ -	$ -	$ -
FM_207	0336001	130	NO	1.00		$ -	$ -	$ -
FM_208	0341001	54	NO	1.00		$ -	$ -	$ -
FM_209	0323131	56	NO	1.00		$ -	$ -	$ -
FM_210	0327001	31	NO	1.00		$ -	$ -	$ -
FM_211	0321001	3	NO	1.00		$ -	$ -	$ -
FM_TC PS	0301003	41	NO	1.00		$ -	$ -	$ -
MISSION MAIN TOTAL						**$ -**	**$ -**	**$ -**
FM_1	0115001	53	NO	1.00		$ -	$ -	$ -
FM_101, 102	0107004	63	NO	1.00		$ -	$ -	$ -
FM_103	0108002	54	NO	1.00		$ -	$ -	$ -
FM_104, 105	0108020	53	NO	1.00		$ -	$ -	$ -
FM_106, 107	0110018	45	NO	1.00		$ -	$ -	$ -
FM_108	0115043	24	NO	1.00		$ -	$ -	$ -
FM_109, 110	0123002	126	NO	1.00		$ -	$ -	$ -
FM_111	0122027	2	NO	1.00		$ -	$ -	$ -
FM_112	0112058	14	NO	1.00		$ -	$ -	$ -
FM_113, 114	0122010	213	NO	1.00		$ -	$ -	$ -
FM_115, 116	0126030	28	NO	1.00		$ -	$ -	$ -
FM_117	0133060	5	NO	1.00		$ -	$ -	$ -
FM_118	0142001	7	NO	1.00		$ -	$ -	$ -
FM_119	0140014	17	NO	1.00		$ -	$ -	$ -
FM_12, 13	0133010	48	NO	1.00		$ -	$ -	$ -
FM_120	0141096	3	NO	1.00		$ -	$ -	$ -
FM_121, 122	0139008	21	NO	1.00		$ -	$ -	$ -
FM_123, 124	0115022	9	NO	1.00		$ -	$ -	$ -
FM_14, 15, 16	0135002	71	NO	1.00		$ -	$ -	$ -
FM_17, 18	0136001	110	NO	1.00		$ -	$ -	$ -
FM_2, 3	0103004	93	NO	1.00		$ -	$ -	$ -
FM_4	0113050	51	NO	1.00		$ -	$ -	$ -
FM_5, 7	0103012	66	NO	1.00		$ -	$ -	$ -
FM_6, 19	0101010	53	NO	1.00		$ -	$ -	$ -

FM_9, 10	0134015	17	NO	1.00		$ -	$ -	$ -
FM_BC PS	0129005	30	NO	1.00		$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	1.00		$ -	$ -	$ -
FM_RC PS	0112006	66	NO	1.00		$ -	$ -	$ -
FM_ WWTF	1601002	5	NO	1.00		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL COST				**$ 40,554,484**	**$ 4,464,083**	**$ 45,018,567**
Nelson_ATF	45	114.1	69.1	$ 40,554,484	$ 4,464,083	$ 45,018,567
0345082.1	29.1	45.1	16.0	$ 9,384,388	$ 1,032,998	$ 10,417,385
1601051.1	15.9	69.1	53.1	$ 31,170,096	$ 3,431,085	$ 34,601,182

Preliminary Optimization Results

10-Year/5-Year, PEFTFs Decommissioned
All Options

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
GRAVITY SEWER (NELSON COMPLEX)																								**$ 30,005,338**	**$ -**	**$ 30,005,338**
GRAVITY SEWER (TUKEY CREEK)																								**$ 13,025,746**	**$ -**	**$ 13,025,746**
F_GS_006		184			NO																					
F_GS_010		138			NO																					
F_GS_011					YES	0341009	0341159	1	2.00	215	966.78	966.40	0.2%	19.19	18.59	18.89	4	3.3	0.96	0.48	$ 633	$ -	$ -	$ 135,949	$ -	$ 135,949
F_GS_012		829			NO																					
F_GS_015					NO																					
F_GS_017					NO																					
F_GS_018					YES	0340106	0340091	1	1.00	980	1013.43	1007.03	0.7%	13.84	10.12	11.98	3	0.4	0.4	0.40	$ 348	$ -	$ -	$ 341,012	$ -	$ 341,012
F_GS_019					NO																					
F_GS_021	85				NO																					
F_GS_022					YES	0339003	0338027	1	1.00	423	1009.67	999.23	2.5%	8.73	8.85	8.79	2	1.1	0.49	0.49	$ 278	$ -	$ -	$ 117,486	$ -	$ 117,486
F_GS_023					NO																					
F_GS_024					NO																					
F_GS_025					NO																					
F_GS_026					NO																					
F_GS_031					NO																					
F_GS_034					NO																					
F_GS_038	56				NO																					
F_GS_039					NO																					
F_GS_040					NO																					
F_GS_043					NO																					
F_GS_045	104			169	YES	0335012	0335005	1	2.25	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	12.5	0.92	0.41	$ 630	$ -	$ 3,005	$ 1,705,920	$ -	$ 1,705,920
F_GS_056					YES	0332011	0332002	1	1.00	576	969.79	958.55	2.0%	5.06	3.48	4.27	2	0.6	0.4	0.40	$ 278	$ -	$ -	$ 160,159	$ -	$ 160,159
F_GS_060					NO																					
F_GS_062		95			NO																					
F_GS_064		283			NO																					
F_GS_065					NO																					
F_GS_067	50				NO																					
F_GS_068	57				YES	0327053	0327044	1	1.00	360	1007.08	1000.05	2.0%	9.27	12.76	11.02	3	0.9	0.38	0.38	$ 348	$ -	$ 400	$ 128,209	$ -	$ 128,209
F_GS_069	68				NO																					
F_GS_070	43				NO																					
F_GS_071					NO																					
F_GS_072					NO																					
F_GS_074					YES	0326024	0326003	1	1.00	578	999.24	996.91	0.4%	13.12	11.76	12.44	3	0.8	0.51	0.51	$ 348	$ -	$ -	$ 201,228	$ -	$ 201,228
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	980.41	1.2%	9.50	7.95	8.72	2	0.8	0.49	0.49	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_076					NO																					
F_GS_078					NO																					
F_GS_079					NO																					
F_GS_080					NO																					
F_GS_081					YES	0325044	0325036	1	1.00	418	1011.90	1008.16	0.9%	8.62	5.76	7.19	2	0.9	0.58	0.58	$ 278	$ -	$ -	$ 116,204	$ -	$ 116,204
F_GS_082					NO																					
F_GS_084					NO																					
F_GS_085					NO																					
F_GS_086					YES	0323131	0323127	1	1.00	1,057	980.41	969.24	1.1%	12.02	16.79	14.41	3	1.9	0.84	0.84	$ 348	$ -	$ -	$ 367,913	$ -	$ 367,913
F_GS_087					NO																					
F_GS_089					YES	0323019	0323013	1	1.00	953	961.12	953.50	0.8%	10.12	12.15	11.14	3	2.2	0.94	0.94	$ 348	$ -	$ -	$ 331,665	$ -	$ 331,665
F_GS_093		98			YES	0323008	0320200	1	1.00	1,548	949.07	941.29	0.5%	12.15	19.91	16.03	4	1.7	1	1.00	$ 417	$ -	$ 1,251	$ 727,123	$ -	$ 727,123
F_GS_095					NO																					
F_GS_096					NO																					
F_GS_097		25			NO																					
F_GS_098					NO																					

F_GS_106					NO																					
F_GS_107		204			NO																					
F_GS_110					YES	0315011	0315010	1	1.50	163	933.22	932.20	0.6%	6.31	9.84	8.08	2	0.8	0.34	0.23	$ 319	$ -	$ -	$ 52,137	$ -	$ 52,137
F_GS_111					NO																					
F_GS_112					YES	0310205	0310012	1	1.00	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.4	0.78	0.78	$ 417	$ -	$ -	$ 434,981	$ -	$ 434,981
F_GS_113	47				YES	0310012	0310002	1	2.00	3,131	886.38	871.09	0.5%	23.10	27.08	25.09	4	11.0	1	0.50	$ 633	$ -	$ 728	$ 1,986,338	$ -	$ 1,986,338
F_GS_116					NO																					
F_GS_118					YES	0309231	0309022	1	1.00	268	922.91	916.69	2.3%	9.09	12.01	10.55	3	1.6	0.53	0.53	$ 348	$ -	$ -	$ 93,368	$ -	$ 93,368
F_GS_120		36			YES	0310002	0301024	1	2.00	708	871.09	868.77	0.3%	27.08	17.08	22.08	4	9.9	1	0.50	$ 633	$ -	$ 1,899	$ 493,601	$ -	$ 493,601
F_GS_121				128	YES	0301024	0301018	1	2.00	1,885	868.77	861.39	0.4%	17.08	18.43	17.76	4	9.7	1	0.50	$ 633	$ -	$ 4,431	$ 1,679,400	$ -	$ 1,679,400
F_GS_124	62				NO																					
F_GS_126	47	95	41		YES	0301009	0301001	1	2.00	2,504	846.64	834.00	0.5%	19.14	19.92	19.53	4	11.0	1	0.50	$ 633	$ -	$ 1,879	$ 1,812,951	$ -	$ 1,812,951
F_GS_127	48				YES	0323013	0323008	1	1.50	629	953.50	949.07	0.7%	12.15	12.15	12.15	3	3.7	0.79	0.53	$ 399	$ -	$ 459	$ 253,678	$ -	$ 253,678
F_GS_129					YES	0332120	0332119	1	1.00	400	992.79	987.80	1.2%	10.59	9.46	10.03	3	0.7	0.42	0.42	$ 348	$ -	$ -	$ 139,210	$ -	$ 139,210
F_GS_130					YES	0332119	0332118	1	1.00	117	987.80	987.32	0.4%	9.46	9.95	9.71	2	0.7	0.49	0.49	$ 278	$ -	$ -	$ 32,643	$ -	$ 32,643
F_GS_131		62			YES	0335005	0331011	1	2.00	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	10.0	0.9	0.45	$ 633	$ -	$ 1,899	$ 1,550,065	$ -	$ 1,550,065
F_GS_133	34				NO																					
GRAVITY SEWER (MISSION MAIN)																								**$ 16,979,592**	**$ -**	**$ 16,979,592**
F_GS_502					NO																					
F_GS_503					NO																					
F_GS_505					YES	0141046	0141010	1	1.00	424	1003.78	1001.90	0.4%	6.08	11.21	8.65	2	0.4	0.44	0.44	$ 278	$ -	$ -	$ 117,739	$ -	$ 117,739
F_GS_506					NO																					
F_GS_507					NO																					
F_GS_509					NO																					
F_GS_510					NO																					
F_GS_511					NO																					
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.3	0.44	0.44	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_513					YES	0142016	0142001	1	1.50	95	997.15	996.11	1.1%	6.85	10.50	8.68	2	0.7	0.28	0.19	$ 319	$ -	$ -	$ 30,244	$ -	$ 30,244
F_GS_514					NO																					
F_GS_515		19			YES	0136046	0136042	1	1.00	777	979.01	962.60	2.1%	9.33	10.64	9.99	2	0.8	0.67	0.67	$ 278	$ -	$ 834	$ 226,650	$ -	$ 226,650
F_GS_519		180			YES	0140006	0136006	1	1.00	1,204	955.06	944.71	0.9%	15.52	5.99	10.75	3	1.1	0.76	0.76	$ 348	$ -	$ 1,044	$ 544,275	$ -	$ 544,275
F_GS_520					NO																					
F_GS_522	89				YES	0139015	0139014	1	1.50	318	1000.68	998.96	0.5%	11.61	12.58	12.10	3	0.8	0.33	0.22	$ 399	$ -	$ 459	$ 132,064	$ -	$ 132,064
F_GS_523	100				YES	0139013	0139010	1	1.00	1,049	991.40	975.42	1.5%	12.49	10.46	11.48	3	0.8	0.43	0.43	$ 348	$ -	$ 400	$ 370,152	$ -	$ 370,152
F_GS_524					NO																					
F_GS_525					NO																					
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1020.87	1.7%	7.82	9.14	8.48	2	0.6	0.42	0.42	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_532					NO																					
F_GS_533					NO																					
F_GS_534					NO																					
F_GS_535					YES	0137004	0137001	1	1.50	225	976.90	975.97	0.4%	9.43	9.47	9.45	2	1.1	0.45	0.30	$ 319	$ -	$ -	$ 71,619	$ -	$ 71,619
F_GS_538					NO																					
F_GS_539					NO																					
F_GS_540					NO																					
F_GS_541					NO																					
F_GS_542		172			NO																					
F_GS_543					NO																					
F_GS_545		50			NO																					
F_GS_546	189				NO																					
F_GS_547	66	109			NO																					
F_GS_548	40				NO																					
F_GS_549					YES	0133034	0133002	1	1.75	806	926.33	923.05	0.4%	14.04	13.58	13.81	3	4.3	0.84	0.48	$ 464	$ -	$ -	$ 374,081	$ -	$ 374,081
F_GS_551					YES	0134174	0134230	1	1.00	414	967.89	955.54	3.0%	8.02	7.15	7.59	2	0.8	0.32	0.32	$ 278	$ -	$ -	$ 115,173	$ -	$ 115,173
F_GS_553					NO																					
F_GS_554					NO																					
F_GS_555					NO																					
F_GS_556		125			NO																					
F_GS_557		15			NO																					
F_GS_558					NO																					
F_GS_559					YES	0130029	0130024	1	1.00	305	939.48	933.49	2.0%	10.46	8.23	9.35	2	0.8	0.36	0.36	$ 278	$ -	$ -	$ 84,690	$ -	$ 84,690
F_GS_560					YES	0130024	0130001	1	1.00	740	933.49	918.28	2.1%	9.73	9.77	9.75	2	0.9	0.37	0.37	$ 278	$ -	$ -	$ 205,631	$ -	$ 205,631
F_GS_562	46				NO																					
F_GS_563					NO																					

F_GS_564					NO																				
F_GS_565					NO																				
F_GS_566					NO																				
F_GS_567					NO																				
F_GS_568					NO																				
F_GS_569					NO																				
F_GS_570	42				NO																				
F_GS_575					YES	0129008	0126009	1	1.25	301	909.27	907.87	0.5%	11.94	11.83	11.89	3	1.8	0.7	0.56	$ 373	$ -	$ -	$ 112,396	$ -	$ 112,396
F_GS_576					NO																				
F_GS_577					NO																				
F_GS_579	63	109			NO																				
F_GS_580		83			YES	0126004	0122033	1	1.75	1,863	891.51	884.63	0.4%	9.63	12.67	11.15	3	4.7	0.83	0.47	$ 464	$ -	$ 1,392	$ 941,671	$ -	$ 941,671
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.37	0.37	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_585					NO																				
F_GS_586					NO																				
F_GS_588					NO																				
F_GS_589					NO																				
F_GS_590	39				YES	0125007	0125003	1	1.00	1,317	940.00	924.35	1.2%	16.44	7.08	11.76	3	1.1	0.54	0.54	$ 348	$ -	$ 400	$ 460,506	$ -	$ 460,506
F_GS_592					NO																				
F_GS_593					NO																				
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	948.48	1.0%	11.09	10.36	10.73	3	0.7	0.4	0.40	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_598					YES	0124007	0124006	1	1.00	337	937.00	936.21	0.2%	12.15	6.82	9.49	2	0.7	0.44	0.44	$ 278	$ -	$ -	$ 93,717	$ -	$ 93,717
F_GS_599					YES	0124006	0122058	1	1.00	698	936.21	916.48	2.8%	6.82	7.02	6.92	2	0.7	0.3	0.30	$ 278	$ -	$ -	$ 193,913	$ -	$ 193,913
F_GS_600					NO																				
F_GS_601					NO																				
F_GS_603					YES	0122053	0122051	1	1.00	906	902.80	889.77	1.4%	7.67	7.50	7.59	2	1.2	0.54	0.54	$ 278	$ -	$ -	$ 251,946	$ -	$ 251,946
F_GS_604	36				NO																				
F_GS_608		23			NO																				
F_GS_612					NO																				
F_GS_613					NO																				
F_GS_614					YES	0122061	0122024	1	1.00	707	908.97	901.26	1.1%	9.98	8.32	9.15	2	0.5	0.66	0.66	$ 278	$ -	$ -	$ 196,654	$ -	$ 196,654
F_GS_615	32				NO																				
F_GS_616					NO																				
F_GS_617					NO																				
F_GS_619					YES	0122019	0122018	1	1.50	457	880.74	878.77	0.4%	14.42	13.28	13.85	3	4.4	1	0.67	$ 399	$ -	$ -	$ 182,175	$ -	$ 182,175
F_GS_620		742			NO																				
F_GS_621					NO																				
F_GS_623					NO																				
F_GS_624					NO																				
F_GS_625					NO																				
F_GS_626					NO																				
F_GS_627					YES	0132028	0132012	1	1.00	424	965.35	959.29	1.4%	11.00	9.23	10.12	3	1.1	0.47	0.47	$ 348	$ -	$ -	$ 147,608	$ -	$ 147,608
F_GS_628					NO																				
F_GS_629					YES	0132172	0132029	1	1.25	376	973.25	967.26	1.6%	10.68	10.36	10.52	3	0.6	0.27	0.22	$ 373	$ -	$ -	$ 140,084	$ -	$ 140,084
F_GS_630					YES	0132040	0132039	1	1.00	228	986.07	985.03	0.5%	9.16	10.77	9.97	2	0.4	0.45	0.45	$ 278	$ -	$ -	$ 63,365	$ -	$ 63,365
F_GS_632					NO																				
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	980.63	0.6%	11.15	11.05	11.10	3	0.7	0.43	0.43	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_635					NO																				
F_GS_636					NO																				
F_GS_640					YES	0123018	0123015	1	1.00	1,071	933.50	922.91	1.0%	10.50	8.23	9.37	2	1.5	0.79	0.79	$ 278	$ -	$ -	$ 297,774	$ -	$ 297,774
F_GS_641					NO																				
F_GS_642					YES	0123091	0123089	1	1.00	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	2.4	0.53	0.53	$ 278	$ -	$ -	$ 218,022	$ -	$ 218,022
F_GS_643					NO																				
F_GS_644					NO																				
F_GS_645					NO																				
F_GS_646					NO																				
F_GS_647					YES	0123086	0123028	1	1.50	517	914.76	911.00	0.7%	8.97	8.60	8.79	2	5.3	0.7	0.47	$ 319	$ -	$ -	$ 164,984	$ -	$ 164,984
F_GS_649		31			NO																				
F_GS_650					YES	0123046	0123025	1	1.50	169	906.92	901.90	3.0%	9.32	7.08	8.20	2	4.0	0.55	0.37	$ 319	$ -	$ -	$ 53,965	$ -	$ 53,965
F_GS_651					YES	0123025	0123005	1	1.25	335	901.90	898.80	0.9%	10.38	7.52	8.95	2	3.5	0.77	0.62	$ 298	$ -	$ -	$ 99,726	$ -	$ 99,726
F_GS_652		66			YES	0123005	0123004	1	1.25	396	898.80	891.28	1.9%	8.04	10.83	9.44	2	6.2	0.97	0.78	$ 298	$ -	$ 894	$ 157,253	$ -	$ 157,253
F_GS_653					YES	0123004	0123021	1	1.50	144	891.28	888.99	1.6%	10.83	10.48	10.66	3	6.3	0.82	0.55	$ 399	$ -	$ -	$ 57,644	$ -	$ 57,644
F_GS_654		148			YES	0123021	0103042	1	1.25	1,374	888.99	873.73	1.1%	11.58	8.58	10.08	3	3.6	0.8	0.64	$ 373	$ -	$ 1,119	$ 622,556	$ -	$ 622,556

F_GS_655		71			YES	0103042	0103026	1	2.00	385	873.73	873.02	0.2%	9.57	11.58	10.58	3	8.3	0.93	0.47	$ 528	$ -	$ 1,584	$ 277,670	$ -	$ 277,670
F_GS_656	135	46			YES	0103026	0103038	1	2.00	1,642	873.02	863.64	0.6%	11.58	8.07	9.83	2	10.7	0.7	0.35	$ 422	$ -	$ 684	$ 740,280	$ -	$ 740,280
F_GS_659		189			NO																					
F_GS_662					NO																					
F_GS_663					NO																					
F_GS_664					NO																					
F_GS_670					NO																					
F_GS_671					NO																					
F_GS_672					NO																					
F_GS_675					NO																					
F_GS_676					NO																					
F_GS_677					YES	0115176	0115016	1	1.50	197	942.95	942.08	0.4%	11.49	12.80	12.15	3	1.3	0.98	0.65	$ 399	$ -	$ -	$ 78,531	$ -	$ 78,531
F_GS_678					YES	0115139	0115137	1	1.25	70	959.90	956.90	4.3%	7.48	5.98	6.73	2	0.7	0.46	0.37	$ 298	$ -	$ -	$ 20,860	$ -	$ 20,860
F_GS_679					NO																					
F_GS_681		43			NO																					
F_GS_682					NO																					
F_GS_683	59				NO																					
F_GS_684					YES	0120023	0120016	1	1.00	1,206	1005.79	987.46	1.5%	8.00	7.61	7.81	2	0.7	0.47	0.47	$ 278	$ -	$ -	$ 335,221	$ -	$ 335,221
F_GS_685					NO																					
F_GS_686	38				NO																					
F_GS_687	11				NO																					
F_GS_689					NO																					
F_GS_691	111				NO																					
F_GS_692					NO																					
F_GS_694					YES	0113043	0113040	1	1.50	163	922.82	920.89	1.2%	8.88	12.20	10.54	3	2.6	1	0.67	$ 399	$ -	$ -	$ 65,169	$ -	$ 65,169
F_GS_696					YES	1601045	1601056	1	3.00	2,937	977.00	971.00	0.2%	7.87	11.44	9.65	2	23.6	0.89	0.30	$ 700	$ -	$ -	$ 2,056,033	$ -	$ 2,056,033
F_GS_698					YES	0114083	0114015	1	1.00	427	972.90	969.77	0.7%	9.73	8.84	9.29	2	0.5	0.39	0.39	$ 278	$ -	$ -	$ 118,581	$ -	$ 118,581
F_GS_699					YES	0114012	0114011	1	1.50	53	963.25	962.62	1.2%	6.46	8.55	7.51	2	2.5	0.89	0.59	$ 319	$ -	$ -	$ 17,015	$ -	$ 17,015
F_GS_700	36				NO																					
F_GS_701	65				NO																					
F_GS_702					NO																					
F_GS_703					NO																					
F_GS_705					NO																					
F_GS_706					NO																					
F_GS_707					NO																					
F_GS_708					YES	0113224	RCPSWW	1	5.00	35	905.26	896.50	25.0%	17.64	12.00	14.82	3	55.5	1	0.20	$ 1,454	$ -	$ -	$ 50,890	$ -	$ 50,890
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.2	0.43	0.43	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.25	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.1	0.63	0.50	$ 373	$ -	$ 429	$ 209,836	$ -	$ 209,836
F_GS_711	149				YES	0112016	0113002	1	1.25	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.5	1	0.80	$ 373	$ -	$ 429	$ 129,227	$ -	$ 129,227
F_GS_712	18				NO																					
F_GS_714	40				YES	0113002	0113224	1	1.50	40	906.40	905.26	2.8%	14.63	17.33	15.98	4	6.8	1	0.67	$ 479	$ -	$ 551	$ 22,040	$ -	$ 22,040
F_GS_716					NO																					
F_GS_717					YES	0110009	0110008	1	2.50	70	924.08	923.25	1.2%	11.08	10.33	10.71	3	0.6	0.14	0.06	$ 734	$ -	$ -	$ 51,380	$ -	$ 51,380
F_GS_718					NO																					
F_GS_719					NO																					
F_GS_720	170				NO																					
F_GS_723		55			NO																					
F_GS_724					NO																					
F_GS_726					NO																					
F_GS_727					NO																					
F_GS_728					NO																					
F_GS_729					NO																					
F_GS_730	63				NO																					
F_GS_731		35			NO																					
F_GS_732	34	21			YES	0108022	0108019	1	1.50	491	920.45	916.72	0.8%	20.23	13.91	17.07	4	1.4	0.66	0.44	$ 479	$ -	$ 892	$ 258,467	$ -	$ 258,467
F_GS_733	126				YES	0108016	0108005	1	2.25	484	897.11	888.14	1.9%	8.92	10.10	9.51	2	1.7	0.59	0.26	$ 504	$ -	$ 580	$ 253,446	$ -	$ 253,446
F_GS_736					NO																					
F_GS_737		34			YES	0108034	0108003	1	1.50	528	891.01	887.47	0.7%	5.88	10.01	7.95	2	0.1	0.52	0.35	$ 319	$ -	$ 957	$ 190,005	$ -	$ 190,005
F_GS_738					NO																					
F_GS_739					NO																					
F_GS_740					NO																					
F_GS_741					YES	0107030	0107027	1	1.00	531	922.83	910.13	2.4%	6.48	7.26	6.87	2	1.1	0.47	0.47	$ 278	$ -	$ -	$ 147,668	$ -	$ 147,668
F_GS_742					NO																					

F_GS_743	50				NO																					
F_GS_744	50				NO																					
F_GS_745					YES	0107097	0107019	1	1.00	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.3	0.34	0.34	$ 278	$ -	$ -	$ 449,128	$ -	$ 449,128
F_GS_748					YES	0107017	0107015	1	1.00	652	946.93	936.29	1.6%	7.75	7.65	7.70	2	0.7	0.55	0.55	$ 278	$ -	$ -	$ 181,209	$ -	$ 181,209
F_GS_750					NO																					
F_GS_751					NO																					
F_GS_752					NO																					
F_GS_753					NO																					
F_GS_754		43			YES	0107001	0106009	1	1.50	863	883.98	879.29	0.5%	12.67	8.84	10.76	3	4.4	0.84	0.56	$ 399	$ -	$ 1,197	$ 379,114	$ -	$ 379,114
F_GS_755		53			YES	0106009	0106006	1	1.50	784	879.29	874.69	0.6%	10.92	11.25	11.09	3	4.7	0.93	0.62	$ 399	$ -	$ 1,197	$ 354,883	$ -	$ 354,883
F_GS_757					NO																					
F_GS_758	35				NO																					
F_GS_759		44			NO																					
F_GS_766					NO																					
F_GS_767					YES	0103104	0103103	1	1.25	50	911.61	907.37	8.5%	3.22	4.81	4.02	2	1.0	0.41	0.33	$ 298	$ -	$ -	$ 14,900	$ -	$ 14,900
F_GS_770					NO																					
F_GS_771					YES	0103226	0103089	1	1.00	203	899.84	896.71	1.5%	8.16	8.90	8.53	2	1.1	0.55	0.55	$ 278	$ -	$ -	$ 56,467	$ -	$ 56,467
F_GS_772					NO																					
F_GS_773	74				YES	0103056	0103054	1	1.75	327	876.48	872.53	1.2%	6.85	11.17	9.01	2	3.0	0.68	0.39	$ 371	$ -	$ 427	$ 125,564	$ -	$ 125,564
F_GS_774		49			YES	0103053	0103069	1	1.50	1,236	869.59	865.44	0.3%	11.37	9.18	10.27	3	4.3	1	0.67	$ 399	$ -	$ 1,197	$ 532,067	$ -	$ 532,067
F_GS_775					YES	0103049	0103046	1	1.25	576	861.42	859.50	0.3%	12.32	10.37	11.34	3	3.2	0.89	0.71	$ 373	$ -	$ -	$ 214,785	$ -	$ 214,785
F_GS_776					YES	0103121	0103120	1	1.00	399	925.07	922.73	0.6%	10.63	16.71	13.67	3	0.4	0.39	0.39	$ 348	$ -	$ -	$ 138,786	$ -	$ 138,786
F_GS_777					YES	0103116	0103115	1	1.00	437	867.80	856.30	2.6%	12.92	2.82	7.87	2	1.0	0.58	0.58	$ 278	$ -	$ -	$ 121,597	$ -	$ 121,597
F_GS_778					YES	0103115	0101167	1	1.00	50	856.30	855.24	2.1%	12.59	12.49	12.54	3	1.2	1	1.00	$ 348	$ -	$ -	$ 17,400	$ -	$ 17,400
F_GS_779					NO																					
F_GS_782					NO																					
F_GS_783					YES	0102044	0102027	1	1.75	165	924.36	923.80	0.3%	8.88	7.52	8.20	2	0.1	0.12	0.07	$ 371	$ -	$ -	$ 61,293	$ -	$ 61,293
F_GS_784					NO																					
F_GS_785					YES	0102124	0102001	1	1.50	176	914.10	912.90	0.7%	8.40	10.10	9.25	2	1.2	0.59	0.39	$ 319	$ -	$ -	$ 56,182	$ -	$ 56,182
F_GS_786					NO																					
F_GS_789					NO																					
F_GS_790	83				YES	0101018	0101016	1	1.00	323	902.31	895.77	2.0%	15.63	9.36	12.50	3	1.5	0.42	0.42	$ 348	$ -	$ 400	$ 116,586	$ -	$ 116,586
F_GS_791					NO																					
F_GS_794					NO																					
F_GS_795					NO																					
F_GS_796					YES	0123089	0123086	1	1.50	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	2.8	0.53	0.35	$ 319	$ -	$ -	$ 95,183	$ -	$ 95,183
F_GS_797					NO																					
F_GS_798					NO																					
F_GS_799					NO																					
F_GS_801	38				NO																					
F_GS_803					NO																					
F_GS_805					YES	0101016	0101015	1	1.75	156	895.77	889.35	4.1%	9.36	9.58	9.47	2	1.6	0.33	0.19	$ 371	$ -	$ -	$ 57,969	$ -	$ 57,969
F_GS_806					NO																					
F_GS_807					YES	1601056	1601051	1	2.00	135	971.00	970.50	0.4%	11.44	11.50	11.47	3	10.9	1	0.50	$ 528	$ -	$ -	$ 71,306	$ -	$ 71,306
F_GS_808					YES	1601016	1601045	1	2.50	50	979.38	977.00	4.8%	6.55	7.87	7.21	2	20.4	0.92	0.37	$ 587	$ -	$ -	$ 29,350	$ -	$ 29,350
F_GS_809					NO																					
F_GS_810					YES	0101002	0101167	1	2.25	169	856.72	855.24	0.9%	9.06	13.09	11.08	3	3.3	1	0.44	$ 630	$ -	$ -	$ 106,363	$ -	$ 106,363
F_GS_812					NO																					
F_GS_813		20			NO																					
F_GS_815					NO																					
F_GS_816					NO																					
F_GS_817	38				NO																					
F_GS_818		148			NO																					
F_GS_819					YES	0120137	0120023	1	1.25	144	1006.44	1005.79	0.5%	11.46	8.00	9.73	2	0.6	0.29	0.23	$ 298	$ -	$ -	$ 43,010	$ -	$ 43,010
F_GS_820					NO																					
F_GS_821					NO																					
F_GS_822					NO																					
F_GS_823					NO																					
F_GS_824					NO																					
F_GS_825		95			NO																					
F_GS_826					NO																					
F_GS_827					YES	0128021	0123018	1	1.00	270	937.29	933.50	1.4%	9.67	10.50	10.09	3	1.0	0.5	0.50	$ 348	$ -	$ -	$ 94,012	$ -	$ 94,012
F_GS_828					YES	0123034	0123010	1	1.50	208	918.99	917.40	0.8%	11.00	9.19	10.10	3	2.4	0.42	0.28	$ 399	$ -	$ -	$ 82,836	$ -	$ 82,836

F_GS_829					YES	0123010	0123086	1	1.50	190	917.40	914.76	1.4%	9.19	8.97	9.08	2	2.6	0.58	0.39	$ 319	$ -	$ -	$ 60,613	$ -	$ 60,613
F_GS_830	222				YES	0101020	0101018	1	1.00	496	907.11	902.31	1.0%	15.73	15.63	15.68	4	1.4	0.54	0.54	$ 417	$ -	$ 480	$ 220,612	$ -	$ 220,612
F_GS_831					YES	0101012	0101039	1	1.25	138	882.29	881.54	0.5%	9.21	8.61	8.91	2	2.0	0.62	0.50	$ 298	$ -	$ -	$ 41,225	$ -	$ 41,225
F_GS_832					NO																					
F_GS_833					NO																					
F_GS_834					NO																					
F_GS_835					YES	0135025	0135023	1	1.00	305	952.69	950.09	0.9%	10.71	8.63	9.67	2	1.2	0.76	0.76	$ 278	$ -	$ -	$ 84,857	$ -	$ 84,857
F_GS_836	57				NO																					
F_GS_837					NO																					
F_GS_838					YES	0108023	0108032	1	1.00	142	924.66	923.24	1.0%	18.00	11.42	14.71	3	0.7	0.68	0.68	$ 348	$ -	$ -	$ 49,531	$ -	$ 49,531
F_GS_839					YES	0103054	0103196	1	2.00	473	872.53	869.97	0.5%	11.17	10.10	10.64	3	9.9	0.96	0.48	$ 528	$ -	$ -	$ 249,601	$ -	$ 249,601
F_GS_840					NO																					
F_GS_841					YES	0103003	BLPSWW	1	2.00	51	854.00	847.00	13.8%	13.44	14.25	13.85	3	13.3	1	0.50	$ 528	$ -	$ -	$ 26,727	$ -	$ 26,727
F_GS_842		335			NO																					
F_GS_843	67				YES	0113212	0113002	1	4.00	67	906.48	906.40	0.1%	15.10	14.63	14.87	3	13.6	1	0.25	$ 1,171	$ -	$ 1,347	$ 90,277	$ -	$ 90,277
F_GS_844					YES	0101010	0101008	1	1.25	357	878.28	876.44	0.5%	7.08	6.15	6.62	2	0.9	0.69	0.55	$ 298	$ -	$ -	$ 106,511	$ -	$ 106,511
F_GS_845					NO																					
F_GS_846					NO																					
F_GS_847					NO																					
F_GS_848					NO																					
F_GS_849					NO																					
F_GS_850					NO																					
F_CC_51					NO																					
F_CC_52					NO																					
F_CC_53					NO																					
F_CC_54					NO																					
F_CC_55					NO																					
F_CC_56					YES	0122006	0122019	1	3.50	40	883.06	880.74	5.8%	12.51	14.42	13.47	3	6.2	0.72	0.21	$ 1,029	$ -	$ -	$ 41,160	$ -	$ 41,160
F_CC_57					YES	0103038	0103018	1	4.00	80	863.64	861.68	2.5%	8.07	8.57	8.32	2	15.5	0.54	0.14	$ 937	$ -	$ -	$ 74,960	$ -	$ 74,960
F_CC_58					YES	0101011	0101039	1	1.25	92	881.16	881.54	-0.4%	8.42	8.61	8.52	2	0.5	0.8	0.64	$ 298	$ -	$ -	$ 27,267	$ -	$ 27,267
F_CC_59					YES	0120032	0120004	1	1.75	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.8	0.73	0.42	$ 464	$ -	$ -	$ 18,560	$ -	$ 18,560
F_CC_60					YES	0108028	0108017	1	1.25	31	907.35	906.42	3.0%	20.54	20.98	20.76	4	0.4	0.77	0.62	$ 447	$ -	$ -	$ 13,763	$ -	$ 13,763
F_CC_61		20			YES	0135001	0135046	1	1.00	81	945.79	945.35	0.5%	9.67	8.92	9.30	2	0.7	0.95	0.95	$ 278	$ -	$ 834	$ 33,355	$ -	$ 33,355
F_CC_62	22				NO																					
F_CC_63	32				NO																					
F_CC_64					YES	0103196	0103053	1	2.00	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	4.7	1	0.50	$ 528	$ -	$ -	$ 18,480	$ -	$ 18,480
F_CC_65					NO																					
F_CC_66					NO																					
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																					
F_LS_02	47				NO																					
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					
F_LS_52					NO																					
F_LS_53		180			NO																					
F_LS_54					NO																					
F_LS_55		435			NO																					
FORCE MAIN (NELSON COMPLEX)																								**$ 11,256,185**	**$ -**	**$ 11,256,185**
FORCE MAIN (TUKEY CREEK)																								**$ 2,765,000**	**$ -**	**$ 2,765,000**
PS_TurkeyCreek					YES	TCPSWW	0345082	1	3.00	3,500	-	-	-	-	-	-	2	45.0	-	-	$ 790	$ -	$ -	$ 2,765,000	$ -	$ 2,765,000
FORCE MAIN (MISSION MAIN)																								**$ 8,491,185**	**$ -**	**$ 8,491,185**
PS_Belinder	439				YES	BLPSWW	1601029	1	3.00	10,604	-	-	-	-	-	-	2	34.0	-	-	$ 790	$ -	$ 909	$ 8,429,409	$ -	$ 8,429,409
PS_BrushCreek	9,673				NO			1		10,623	-	-	-	-	-	-	2		-	-						
PS_RockCreek	5,030				NO			1		7,047	-	-	-	-	-	-	2		-	-						
PS_RoeVillage					YES	RVPSWW	1601037	1	0.67	351	-	-	-	-	-	-	2	0.6	-	-	$ 176	$ -	$ -	$ 61,776	$ -	$ 61,776
PS_Swatzell					NO			1		1,101	-	-	-	-	-	-	2		-	-						

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

*SPS Expansion Cost Curve used for Prelim Runs

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 15,452,901**	**$ 3,812,048**	**$ 19,264,949**
TURKEY CREEK							**$ 6,755,400**	**$ 1,692,238**	**$ 8,447,638**
PS_TurkeyCreek	27.0	YES	TCPSWW	0345082	45.0	18.0	$ 6,755,400	$ 1,692,238	$ 8,447,638
MISSION MAIN							**$ 8,697,501**	**$ 2,119,810**	**$ 10,817,311**
PS_Belinder	11.6	YES	BLPSWW	1601029	34.0	22.4	$ 8,017,936	$ 2,105,896	$ 10,123,832
PS_BrushCreek	6.0	NO	BCPSWW	0113002	6.0		$ -	$ -	$ -
PS_Granthurst	5.5	NO	GTPSWW	0123091	5.0		$ -	$ -	$ -
PS_MissionWoods	1.2	NO	MWPSWW	0101011	0.9		$ -	$ -	$ -
PS_RockCreek	15.5	NO	RCPSWW	1601016	15.5		$ -	$ -	$ -
PS_RoeVillage	0.4	YES	RVPSWW	1601037	0.6	0.1	$ 679,565	$ 13,914	$ 693,479
PS_Swatzell	1.6	NO	SZPSWW	0101168	1.6		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
STORAGE FACILITY TOTAL						**$ 53,846,202**	**$ 147,648**	**$ 53,993,849**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ 22,192,340**	**$ 51,848**	**$ 22,244,189**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ 14,506,016**	**$ 37,464**	**$ 14,543,480**
F_ST_01	F_ST_01_IN	YES	3.0	1.6	0.13	$ 1,704,696	$ 2,021	$ 1,706,718
F_ST_02	F_ST_02_IN	NO						
F_ST_03	F_ST_03_IN	YES	4.5	11.0	2.26	$ 12,801,320	$ 35,443	$ 12,836,763
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	NO						
F_ST_06	F_ST_06_IN	NO						
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ 7,686,324**	**$ 14,384**	**$ 7,700,708**
F_ST_51	F_ST_51_IN	YES	3.0	7.0	0.92	$ 7,686,324	$ 14,384	$ 7,700,708
F_ST_52	F_ST_52_IN	NO						
F_ST_53	F_ST_53_IN	NO						
F_ST_54	F_ST_54_IN	NO						
F_ST_55	F_ST_55_IN	NO						
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TOTAL)						**$ 31,653,861**	**$ 95,799**	**$ 31,749,661**
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	YES	5.5	0.0	0.00	$ -	$ -	$ -
STORAGE FACILITY - FACILITY PROTECTION DEVICE (MISSION MAIN)						**$ 31,653,861**	**$ 95,799**	**$ 31,749,661**
F_ST-FPD_BC	F_ST-FPD_BC_IN	YES	2.0	7.9	3.95	$ 19,225,510	$ 61,892	$ 19,287,402
F_ST-FPD_BL	F_ST-FPD_BL_IN	YES	3.0	0.0	0.00	$ -	$ -	$ -
F_ST-FPD_MW	F_ST-FPD_MW_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	5.5	9.0	2.16	$ 12,428,351	$ 33,907	$ 12,462,259

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX								**$ -**	**$ -**	**$ -**
TURKEY CREEK								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek_PEFTF	TC_PEFTF_OUTFALL	22.0	NO	TC_PEFTF_WW	FMOutletEFB	0.0	0.0	$ -	$ -	$ -
MISSION MAIN								**$ -**	**$ -**	**$ -**
PS_Belinder_PEFTF	Belinder_Outfall	53.1	NO	BLPEFTFWW	Belinder_PEFTF_Tank	0.0	0.0	$ -	$ -	$ -
PS_Martway_PEFTF	Martway_Discharge	20.0	NO	Martway_HS_Wet_Well	Martway_Tank	0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	Nall_Outfall	20.0	NO	Nall_Wet_Well	Nall_Tank	0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
I/I REDUCTION

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	Scaling Factor	% Reduction	I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL						**$ 30,326,461**	**$ -**	**$ 30,326,461**
TURKEY CREEK TOTAL						**$ 9,407,147**	**$ -**	**$ 9,407,147**
FM_202	0309015	24	NO	1.00		$ -	$ -	$ -
FM_203	0310001	82	NO	1.00		$ -	$ -	$ -
FM_204	0320011	22	NO	1.00		$ -	$ -	$ -
FM_205	0323001	42	NO	1.00		$ -	$ -	$ -
FM_206	0331001	78	NO	1.00		$ -	$ -	$ -
FM_207	0336001	130	YES	0.80	20%	$ 5,511,401	$ -	$ 5,511,401
FM_208	0341001	54	YES	0.85	15%	$ 2,089,125	$ -	$ 2,089,125
FM_209	0323131	56	YES	0.85	15%	$ 917,006	$ -	$ 917,006
FM_210	0327001	31	YES	0.80	20%	$ 889,615	$ -	$ 889,615
FM_211	0321001	3	NO	1.00		$ -	$ -	$ -
FM_TC PS	0301003	41	NO	1.00		$ -	$ -	$ -
MISSION MAIN TOTAL						**$ 20,919,314**	**$ -**	**$ 20,919,314**
FM_1	0115001	53	NO	1.00		$ -	$ -	$ -
FM_101, 102	0107004	63	NO	1.00		$ -	$ -	$ -
FM_103	0108002	54	YES	0.80	20%	$ 1,106,599	$ -	$ 1,106,599
FM_104, 105	0108020	53	YES	0.80	20%	$ 1,381,859	$ -	$ 1,381,859
FM_106, 107	0110018	45	NO	1.00		$ -	$ -	$ -
FM_108	0115043	24	NO	1.00		$ -	$ -	$ -
FM_109, 110	0123002	126	YES	0.90	10%	$ 1,102,106	$ -	$ 1,102,106
FM_111	0122027	2	YES	0.90	10%	$ 112,356	$ -	$ 112,356
FM_112	0112058	14	YES	0.80	20%	$ 322,660	$ -	$ 322,660
FM_113, 114	0122010	213	YES	0.70	30%	$ 8,601,069	$ -	$ 8,601,069
FM_115, 116	0126030	28	NO	1.00		$ -	$ -	$ -
FM_117	0133060	5	NO	1.00		$ -	$ -	$ -
FM_118	0142001	7	YES	0.90	10%	$ 186,808	$ -	$ 186,808
FM_119	0140014	17	YES	0.80	20%	$ 630,398	$ -	$ 630,398
FM_12, 13	0133010	48	YES	0.80	20%	$ 796,792	$ -	$ 796,792
FM_120	0141096	3	YES	0.90	10%	$ 188,183	$ -	$ 188,183
FM_121, 122	0139008	21	YES	0.95	5%	$ 238,809	$ -	$ 238,809
FM_123, 124	0115022	9	NO	1.00		$ -	$ -	$ -
FM_14, 15, 16	0135002	71	YES	0.90	10%	$ 1,036,493	$ -	$ 1,036,493
FM_17, 18	0136001	110	YES	0.95	5%	$ 550,129	$ -	$ 550,129
FM_2, 3	0103004	93	NO	1.00		$ -	$ -	$ -
FM_4	0113050	51	YES	0.90	10%	$ 718,143	$ -	$ 718,143
FM_5, 7	0103012	66	NO	1.00		$ -	$ -	$ -
FM_6, 19	0101010	53	YES	0.70	30%	$ 2,876,750	$ -	$ 2,876,750

FM_9, 10	0134015	17	YES	0.80	20%	$ 614,300	$ -	$ 614,300
FM_BC PS	0129005	30	NO	1.00		$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	1.00		$ -	$ -	$ -
FM_RC PS	0112006	66	YES	0.90	10%	$ 455,861	$ -	$ 455,861
FM_ WWTF	1601002	5	NO	1.00		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL COST				**$ 33,761,598**	**$ 3,268,352**	**$ 37,029,951**
Nelson_ATF	45	95.6	50.6	$ 33,761,598	$ 3,268,352	$ 37,029,951
0345082.1	29.1	45.0	15.9	$ 10,631,357	$ 1,029,188	$ 11,660,545
1601051.1	15.9	50.6	34.6	$ 23,130,241	$ 2,239,165	$ 25,369,406

Preliminary Optimization Results

10-Year/5-Year, PEFTFs Remain
All Options (No ATF)

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
GRAVITY SEWER (NELSON COMPLEX)																								**$ 32,160,469**	**$ -**	**$ 32,160,469**
GRAVITY SEWER (TUKEY CREEK)																								**$ 8,645,745**	**$ -**	**$ 8,645,745**
F_GS_006		184			NO																					
F_GS_010		138			NO																					
F_GS_011					NO																					
F_GS_012		829			NO																					
F_GS_015					YES	0340046	0340045	1	1.50	480	1024.18	1019.60	1.0%	15.78	15.55	15.67	4	0.6	0.29	0.19	$ 479	$ -	$ -	$ 229,987	$ -	$ 229,987
F_GS_017					YES	0340003	0338019	1	1.25	948	988.18	977.03	1.2%	13.10	11.46	12.28	3	1.7	0.72	0.58	$ 373	$ -	$ -	$ 353,597	$ -	$ 353,597
F_GS_018					YES	0340106	0340091	1	1.00	980	1013.43	1007.03	0.7%	13.84	10.12	11.98	3	0.4	0.41	0.41	$ 348	$ -	$ -	$ 341,012	$ -	$ 341,012
F_GS_019					NO																					
F_GS_021	85				NO																					
F_GS_022					YES	0339003	0338027	1	1.00	423	1009.67	999.23	2.5%	8.73	8.85	8.79	2	1.1	0.51	0.51	$ 278	$ -	$ -	$ 117,486	$ -	$ 117,486
F_GS_023					NO																					
F_GS_024					YES	0338024	0338019	1	2.00	732	988.39	977.03	1.6%	11.66	11.95	11.81	3	1.8	0.6	0.30	$ 528	$ -	$ -	$ 386,517	$ -	$ 386,517
F_GS_025					NO																					
F_GS_026					NO																					
F_GS_031					YES	0337139	0337131	1	1.75	261	1014.81	1012.51	0.9%	9.52	13.75	11.64	3	1.1	0.33	0.19	$ 464	$ -	$ -	$ 121,085	$ -	$ 121,085
F_GS_034					NO																					
F_GS_038	56				NO																					
F_GS_039					NO																					
F_GS_040					YES	0336141	0336139	1	1.50	448	975.07	970.17	1.1%	18.79	9.73	14.26	3	2.6	0.6	0.40	$ 399	$ -	$ -	$ 178,644	$ -	$ 178,644
F_GS_043					NO																					
F_GS_045	104			169	YES	0335012	0335005	1	2.25	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	12.6	0.97	0.43	$ 630	$ -	$ 3,005	$ 1,705,920	$ -	$ 1,705,920
F_GS_056					YES	0332011	0332002	1	1.25	576	969.79	958.55	2.0%	5.06	3.48	4.27	2	0.7	0.3	0.24	$ 298	$ -	$ -	$ 171,681	$ -	$ 171,681
F_GS_060					YES	0331181	0331019	1	1.00	127	949.26	948.58	0.5%	5.65	11.34	8.50	2	0.9	0.75	0.75	$ 278	$ -	$ -	$ 35,431	$ -	$ 35,431
F_GS_062		95			NO																					
F_GS_064		283			NO																					
F_GS_065					NO																					
F_GS_067	50				NO																					
F_GS_068	57				YES	0327053	0327044	1	1.50	360	1007.08	1000.05	2.0%	9.27	12.76	11.02	3	1.0	0.23	0.15	$ 399	$ -	$ 459	$ 147,020	$ -	$ 147,020
F_GS_069	68				NO																					
F_GS_070	43				NO																					
F_GS_071					NO																					
F_GS_072					NO																					
F_GS_074					YES	0326024	0326003	1	1.25	578	999.24	996.91	0.4%	13.12	11.76	12.44	3	0.8	0.39	0.31	$ 373	$ -	$ -	$ 215,684	$ -	$ 215,684
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	980.41	1.2%	9.50	7.95	8.72	2	0.8	0.49	0.49	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_076					NO																					
F_GS_078					NO																					
F_GS_079					YES	0325048	0325047	1	2.00	176	1015.23	1014.99	0.1%	9.00	11.56	10.28	3	1.1	0.32	0.16	$ 528	$ -	$ -	$ 92,680	$ -	$ 92,680
F_GS_080					NO																					
F_GS_081					YES	0325044	0325036	1	1.25	418	1011.90	1008.16	0.9%	8.62	5.76	7.19	2	1.0	0.45	0.36	$ 298	$ -	$ -	$ 124,564	$ -	$ 124,564
F_GS_082					NO																					
F_GS_084					NO																					
F_GS_085					NO																					
F_GS_086					YES	0323131	0323127	1	1.50	1,057	980.41	969.24	1.1%	12.02	16.79	14.41	3	2.3	0.7	0.47	$ 399	$ -	$ -	$ 421,831	$ -	$ 421,831
F_GS_087					NO																					
F_GS_089					YES	0323019	0323013	1	1.00	953	961.12	953.50	0.8%	10.12	12.15	11.14	3	2.2	0.92	0.92	$ 348	$ -	$ -	$ 331,665	$ -	$ 331,665
F_GS_093		98			YES	0323008	0320200	1	1.50	1,548	949.07	941.29	0.5%	12.15	19.91	16.03	4	4.1	0.85	0.57	$ 479	$ -	$ 1,437	$ 835,232	$ -	$ 835,232
F_GS_095					NO																					
F_GS_096					NO																					
F_GS_097		25			NO																					
F_GS_098					NO																					

F_GS_106					NO																					
F_GS_107		204			NO																					
F_GS_110					YES	0315011	0315010	1	1.25	163	933.22	932.20	0.6%	6.31	9.84	8.08	2	0.7	0.42	0.34	$ 298	$ -	$ -	$ 48,705	$ -	$ 48,705
F_GS_111					NO																					
F_GS_112					YES	0310205	0310012	1	1.25	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.5	0.7	0.56	$ 447	$ -	$ -	$ 466,275	$ -	$ 466,275
F_GS_113	47				NO																					
F_GS_116					NO																					
F_GS_118					YES	0309231	0309022	1	1.25	268	922.91	916.69	2.3%	9.09	12.01	10.55	3	1.7	0.41	0.33	$ 373	$ -	$ -	$ 100,076	$ -	$ 100,076
F_GS_120		36			NO																					
F_GS_121				128	NO																					
F_GS_124	62				NO																					
F_GS_126	47	95	41		NO																					
F_GS_127	48				YES	0323013	0323008	1	1.75	629	953.50	949.07	0.7%	12.15	12.15	12.15	3	4.0	0.54	0.31	$ 464	$ -	$ 534	$ 295,015	$ -	$ 295,015
F_GS_129					YES	0332120	0332119	1	1.25	400	992.79	987.80	1.2%	10.59	9.46	10.03	3	0.8	0.31	0.25	$ 373	$ -	$ -	$ 149,211	$ -	$ 149,211
F_GS_130					YES	0332119	0332118	1	1.50	117	987.80	987.32	0.4%	9.46	9.95	9.71	2	0.8	0.31	0.21	$ 319	$ -	$ -	$ 37,457	$ -	$ 37,457
F_GS_131		62			YES	0335005	0331011	1	2.00	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	10.1	0.91	0.46	$ 633	$ -	$ 1,899	$ 1,550,065	$ -	$ 1,550,065
F_GS_133	34				YES	0327054	0327053	1	1.25	77	1008.25	1007.08	1.5%	8.91	8.40	8.66	2	0.4	0.25	0.20	$ 298	$ -	$ 343	$ 24,399	$ -	$ 24,399
GRAVITY SEWER (MISSION MAIN)																								**$ 23,514,724**	**$ -**	**$ 23,514,724**
F_GS_502					YES	0141096	0141021	1	1.50	232	1006.50	1000.80	2.5%	8.69	10.19	9.44	2	1.0	0.39	0.26	$ 319	$ -	$ -	$ 74,145	$ -	$ 74,145
F_GS_503					NO																					
F_GS_505					YES	0141046	0141010	1	1.00	424	1003.78	1001.90	0.4%	6.08	11.21	8.65	2	0.4	0.46	0.46	$ 278	$ -	$ -	$ 117,739	$ -	$ 117,739
F_GS_506					NO																					
F_GS_507					YES	0141005	0141003	1	1.00	404	991.61	988.22	0.8%	8.90	9.31	9.11	2	0.5	0.56	0.56	$ 278	$ -	$ -	$ 112,309	$ -	$ 112,309
F_GS_509					NO																					
F_GS_510					YES	0140021	0140017	1	2.00	575	1019.42	1009.89	1.7%	10.86	12.08	11.47	3	0.6	0.18	0.09	$ 528	$ -	$ -	$ 303,700	$ -	$ 303,700
F_GS_511					NO																					
F_GS_512					YES	0140050	0140014	1	1.75	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.4	0.24	0.14	$ 371	$ -	$ -	$ 129,557	$ -	$ 129,557
F_GS_513					YES	0142016	0142001	1	2.00	95	997.15	996.11	1.1%	6.85	10.50	8.68	2	0.7	0.22	0.11	$ 422	$ -	$ -	$ 40,010	$ -	$ 40,010
F_GS_514					NO																					
F_GS_515		19			YES	0136046	0136042	1	1.00	777	979.01	962.60	2.1%	9.33	10.64	9.99	2	0.8	0.67	0.67	$ 278	$ -	$ 834	$ 226,650	$ -	$ 226,650
F_GS_519		180			YES	0140006	0136006	1	1.50	1,204	955.06	944.71	0.9%	15.52	5.99	10.75	3	1.3	0.66	0.44	$ 399	$ -	$ 1,197	$ 624,040	$ -	$ 624,040
F_GS_520					YES	0136028	0136089	1	1.00	851	978.57	974.64	0.5%	18.63	1.76	10.20	3	0.4	0.38	0.38	$ 348	$ -	$ -	$ 296,294	$ -	$ 296,294
F_GS_522	89				YES	0139015	0139014	1	1.50	318	1000.68	998.96	0.5%	11.61	12.58	12.10	3	0.7	0.32	0.21	$ 399	$ -	$ 459	$ 132,064	$ -	$ 132,064
F_GS_523	100				YES	0139013	0139010	1	1.00	1,049	991.40	975.42	1.5%	12.49	10.46	11.48	3	0.8	0.42	0.42	$ 348	$ -	$ 400	$ 370,152	$ -	$ 370,152
F_GS_524					YES	0139021	0139043	1	1.50	340	970.00	967.23	0.8%	13.22	16.29	14.76	3	2.2	0.51	0.34	$ 399	$ -	$ -	$ 135,616	$ -	$ 135,616
F_GS_525					YES	0139042	0139041	1	2.00	221	966.08	964.92	0.5%	14.71	11.15	12.93	3	1.7	0.35	0.18	$ 528	$ -	$ -	$ 116,804	$ -	$ 116,804
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1020.87	1.7%	7.82	9.14	8.48	2	0.7	0.43	0.43	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_532					YES	0137017	0137016	1	1.00	406	991.83	987.13	1.2%	9.57	11.13	10.35	3	0.5	0.34	0.34	$ 348	$ -	$ -	$ 141,267	$ -	$ 141,267
F_GS_533					YES	0137016	0137014	1	1.50	318	987.13	984.90	0.7%	11.13	8.64	9.89	2	0.6	0.24	0.16	$ 319	$ -	$ -	$ 101,404	$ -	$ 101,404
F_GS_534					NO																					
F_GS_535					YES	0137004	0137001	1	1.50	225	976.90	975.97	0.4%	9.43	9.47	9.45	2	1.2	0.46	0.31	$ 319	$ -	$ -	$ 71,619	$ -	$ 71,619
F_GS_538					NO																					
F_GS_539					NO																					
F_GS_540					NO																					
F_GS_541					NO																					
F_GS_542		172			NO																					
F_GS_543					YES	0135023	0135022	1	1.00	82	950.09	949.53	0.7%	8.63	9.37	9.00	2	1.9	1	1.00	$ 278	$ -	$ -	$ 22,916	$ -	$ 22,916
F_GS_545		50			NO																					
F_GS_546	189				YES	0136007	0133054	1	1.50	226	939.66	939.24	0.2%	12.42	12.94	12.68	3	3.2	1	0.67	$ 399	$ -	$ 459	$ 101,519	$ -	$ 101,519
F_GS_547	66	109			YES	Nall_Sluice	0133043	1	1.25	890	938.00	933.10	0.6%	14.62	10.77	12.70	3	3.3	0.86	0.69	$ 373	$ -	$ 857	$ 416,869	$ -	$ 416,869
F_GS_548	40				YES	0133043	0133034	1	1.75	1,930	933.10	926.33	0.4%	11.42	13.51	12.47	3	5.9	0.87	0.50	$ 464	$ -	$ 534	$ 898,066	$ -	$ 898,066
F_GS_549					NO																					
F_GS_551					YES	0134174	0134230	1	1.00	414	967.89	955.54	3.0%	8.02	7.15	7.59	2	0.9	0.34	0.34	$ 278	$ -	$ -	$ 115,173	$ -	$ 115,173
F_GS_553					NO																					
F_GS_554					NO																					
F_GS_555					YES	0133002	BCPSWW	1	1.25	30	923.05	916.50	21.8%	14.08	13.50	13.79	3	2.7	1	0.80	$ 373	$ -	$ -	$ 11,190	$ -	$ 11,190
F_GS_556		125			NO																					
F_GS_557		15			NO																					
F_GS_558					YES	0130043	0130039	1	1.25	449	949.36	947.38	0.4%	12.65	13.54	13.10	3	0.6	0.35	0.28	$ 373	$ -	$ -	$ 167,574	$ -	$ 167,574
F_GS_559					YES	0130029	0130024	1	1.25	305	939.48	933.49	2.0%	10.46	8.23	9.35	2	0.9	0.28	0.22	$ 298	$ -	$ -	$ 90,783	$ -	$ 90,783
F_GS_560					YES	0130024	0130001	1	1.75	740	933.49	918.28	2.1%	9.73	9.77	9.75	2	1.1	0.19	0.11	$ 371	$ -	$ -	$ 274,421	$ -	$ 274,421
F_GS_562	46				YES	0129126	0129121	1	1.75	286	981.31	978.22	1.1%	11.67	12.95	12.31	3	0.5	0.22	0.13	$ 464	$ -	$ 534	$ 135,906	$ -	$ 135,906
F_GS_563					YES	0129121	0129026	1	1.25	140	978.22	977.07	0.8%	12.95	9.14	11.05	3	0.3	0.32	0.26	$ 373	$ -	$ -	$ 52,179	$ -	$ 52,179

F_GS_564					NO																					
F_GS_565					NO																					
F_GS_566					NO																					
F_GS_567					NO																					
F_GS_568					YES	0129019	0129018	1	1.50	311	945.36	941.26	1.3%	13.17	10.71	11.94	3	1.2	0.28	0.19	$ 399	$ -	$ -	$ 124,013	$ -	$ 124,013
F_GS_569					YES	0129037	0129018	1	1.50	436	944.80	941.26	0.8%	11.78	10.60	11.19	3	0.4	0.18	0.12	$ 399	$ -	$ -	$ 174,044	$ -	$ 174,044
F_GS_570	42				NO																					
F_GS_575					YES	0129008	0126009	1	2.25	301	909.27	907.87	0.5%	11.94	11.83	11.89	3	4.0	0.41	0.18	$ 630	$ -	$ -	$ 189,838	$ -	$ 189,838
F_GS_576					YES	0126009	0126005	1	1.25	1,223	907.87	902.66	0.4%	11.83	8.60	10.22	3	2.5	0.73	0.58	$ 373	$ -	$ -	$ 456,168	$ -	$ 456,168
F_GS_577					YES	0126005	0126044	1	1.00	359	902.66	893.65	2.5%	8.60	11.48	10.04	3	3.0	0.86	0.86	$ 348	$ -	$ -	$ 124,873	$ -	$ 124,873
F_GS_579	63	109			NO																					
F_GS_580		83			YES	0126004	0122033	1	1.75	1,863	891.51	884.63	0.4%	9.63	12.67	11.15	3	5.6	0.92	0.53	$ 464	$ -	$ 1,392	$ 941,671	$ -	$ 941,671
F_GS_582					NO																					
F_GS_585					YES	0131012	0126039	1	1.25	598	933.75	927.28	1.1%	11.50	10.96	11.23	3	0.6	0.38	0.30	$ 373	$ -	$ -	$ 222,882	$ -	$ 222,882
F_GS_586					NO																					
F_GS_588					NO																					
F_GS_589					YES	0125009	0125007	1	1.00	142	942.88	940.00	2.0%	15.46	15.34	15.40	4	0.5	0.29	0.29	$ 417	$ -	$ -	$ 59,339	$ -	$ 59,339
F_GS_590	39				YES	0125007	0125003	1	1.25	1,317	940.00	924.35	1.2%	16.44	7.08	11.76	3	1.3	0.34	0.27	$ 373	$ -	$ 429	$ 493,599	$ -	$ 493,599
F_GS_592					YES	0125003	0125002	1	1.25	243	924.35	915.18	3.8%	7.08	7.54	7.31	2	1.3	0.3	0.24	$ 298	$ -	$ -	$ 72,277	$ -	$ 72,277
F_GS_593					YES	0125020	0125021	1	1.25	348	913.24	911.73	0.4%	14.75	11.22	12.99	3	0.2	0.21	0.17	$ 373	$ -	$ -	$ 129,823	$ -	$ 129,823
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	948.48	1.0%	11.09	10.36	10.73	3	0.8	0.41	0.41	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_598					YES	0124007	0124006	1	1.00	337	937.00	936.21	0.2%	12.15	6.82	9.49	2	0.7	0.46	0.46	$ 278	$ -	$ -	$ 93,717	$ -	$ 93,717
F_GS_599					YES	0124006	0122058	1	1.00	698	936.21	916.48	2.8%	6.82	7.02	6.92	2	0.7	0.53	0.53	$ 278	$ -	$ -	$ 193,913	$ -	$ 193,913
F_GS_600					NO																					
F_GS_601					YES	0122137	0122053	1	1.25	479	907.50	902.80	1.0%	11.08	7.67	9.38	2	0.4	0.61	0.49	$ 298	$ -	$ -	$ 142,593	$ -	$ 142,593
F_GS_603					NO																					
F_GS_604	36				YES	0122051	0122239	1	1.50	312	889.77	887.30	0.8%	13.23	10.10	11.67	3	3.7	0.66	0.44	$ 399	$ -	$ 459	$ 126,511	$ -	$ 126,511
F_GS_608		23			YES	0122033	0122019	1	1.75	980	884.63	880.74	0.4%	12.67	14.42	13.55	3	6.9	1	0.57	$ 464	$ -	$ 1,392	$ 476,344	$ -	$ 476,344
F_GS_612					NO																					
F_GS_613					YES	0122208	0122061	1	1.25	337	912.98	908.97	1.2%	9.88	8.55	9.22	2	0.5	0.6	0.48	$ 298	$ -	$ -	$ 100,307	$ -	$ 100,307
F_GS_614					NO																					
F_GS_615	32				YES	0122024	0122120	1	1.00	357	901.26	894.00	2.0%	8.32	9.75	9.04	2	0.9	0.37	0.37	$ 278	$ -	$ 320	$ 100,456	$ -	$ 100,456
F_GS_616					NO																					
F_GS_617					NO																					
F_GS_619					YES	0122019	0122018	1	2.50	457	880.74	878.77	0.4%	14.42	13.28	13.85	3	11.0	1	0.40	$ 734	$ -	$ -	$ 335,130	$ -	$ 335,130
F_GS_620		742			NO																					
F_GS_621					NO																					
F_GS_623					NO																					
F_GS_624					YES	0132002	GTPSWW	1	1.75	35	938.37	931.00	21.1%	10.84	4.00	7.42	2	2.9	0.26	0.15	$ 371	$ -	$ -	$ 12,985	$ -	$ 12,985
F_GS_625					YES	0132017	0132174	1	1.75	188	950.20	949.08	0.6%	10.24	12.16	11.20	3	0.4	0.56	0.32	$ 464	$ -	$ -	$ 87,200	$ -	$ 87,200
F_GS_626					NO																					
F_GS_627					YES	0132028	0132012	1	1.50	424	965.35	959.29	1.4%	11.00	9.23	10.12	3	1.4	0.29	0.19	$ 399	$ -	$ -	$ 169,240	$ -	$ 169,240
F_GS_628					NO																					
F_GS_629					YES	0132172	0132029	1	1.25	376	973.25	967.26	1.6%	10.68	10.36	10.52	3	0.7	0.29	0.23	$ 373	$ -	$ -	$ 140,084	$ -	$ 140,084
F_GS_630					YES	0132040	0132039	1	1.00	228	986.07	985.03	0.5%	9.16	10.77	9.97	2	0.5	0.49	0.49	$ 278	$ -	$ -	$ 63,365	$ -	$ 63,365
F_GS_632					YES	0132088	0132078	1	1.00	353	995.10	992.60	0.7%	8.75	10.16	9.46	2	0.5	0.37	0.37	$ 278	$ -	$ -	$ 98,115	$ -	$ 98,115
F_GS_633					YES	0132072	0132069	1	1.25	792	985.59	980.63	0.6%	11.15	11.05	11.10	3	0.8	0.35	0.28	$ 373	$ -	$ -	$ 295,580	$ -	$ 295,580
F_GS_635					NO																					
F_GS_636					NO																					
F_GS_640					YES	0123018	0123015	1	1.00	1,071	933.50	922.91	1.0%	10.50	8.23	9.37	2	1.7	0.81	0.81	$ 278	$ -	$ -	$ 297,774	$ -	$ 297,774
F_GS_641					NO																					
F_GS_642					YES	0123091	0123089	1	1.00	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	2.7	0.57	0.57	$ 278	$ -	$ -	$ 218,022	$ -	$ 218,022
F_GS_643					NO																					
F_GS_644					NO																					
F_GS_645					NO																					
F_GS_646					YES	0123035	0123034	1	2.25	307	919.54	918.99	0.2%	12.04	11.00	11.52	3	1.8	0.3	0.13	$ 630	$ -	$ -	$ 193,127	$ -	$ 193,127
F_GS_647					YES	0123086	0123028	1	1.25	517	914.76	911.00	0.7%	8.97	8.60	8.79	2	3.7	0.77	0.62	$ 298	$ -	$ -	$ 154,123	$ -	$ 154,123
F_GS_649		31			YES	0123028	0123046	1	1.25	350	911.00	906.92	1.2%	8.60	9.32	8.96	2	3.1	0.7	0.56	$ 298	$ -	$ 894	$ 122,754	$ -	$ 122,754
F_GS_650					YES	0123046	0123025	1	1.25	169	906.92	901.90	3.0%	9.32	7.08	8.20	2	4.1	0.79	0.63	$ 298	$ -	$ -	$ 50,413	$ -	$ 50,413
F_GS_651					YES	0123025	0123005	1	1.25	335	901.90	898.80	0.9%	10.38	7.52	8.95	2	4.0	0.9	0.72	$ 298	$ -	$ -	$ 99,726	$ -	$ 99,726
F_GS_652		66			YES	0123005	0123004	1	1.50	396	898.80	891.28	1.9%	8.04	10.83	9.44	2	7.8	0.85	0.57	$ 319	$ -	$ 957	$ 168,335	$ -	$ 168,335
F_GS_653					YES	0123004	0123021	1	1.50	144	891.28	888.99	1.6%	10.83	10.48	10.66	3	7.4	0.93	0.62	$ 399	$ -	$ -	$ 57,644	$ -	$ 57,644
F_GS_654		148			YES	0123021	0103042	1	1.25	1,374	888.99	873.73	1.1%	11.58	8.58	10.08	3	3.9	0.81	0.65	$ 373	$ -	$ 1,119	$ 622,556	$ -	$ 622,556

F_GS_655		71			YES	0103042	0103026	1	2.50	385	873.73	873.02	0.2%	9.57	11.58	10.58	3	12.0	0.8	0.32	$ 734	$ -	$ 2,202	$ 386,003	$ -	$ 386,003
F_GS_656	135	46			YES	0103026	0103038	1	2.00	1,642	873.02	863.64	0.6%	11.58	8.07	9.83	2	11.1	0.75	0.38	$ 422	$ -	$ 684	$ 740,280	$ -	$ 740,280
F_GS_659		189			YES	0103018	0103011	1	2.00	2,885	862.48	854.67	0.3%	8.57	9.92	9.25	2	6.4	0.85	0.43	$ 422	$ -	$ 1,266	$ 1,376,796	$ -	$ 1,376,796
F_GS_662					NO																					
F_GS_663					YES	0103065	0103064	1	6.00	70	853.81	853.75	0.1%	12.91	13.25	13.08	3	5.7	0.87	0.15	$ 2,329	$ -	$ -	$ 163,030	$ -	$ 163,030
F_GS_664					YES	0103064	BLPSWW	1	5.00	70	853.75	847.00	9.6%	13.25	13.55	13.40	3	5.5	1	0.20	$ 1,454	$ -	$ -	$ 101,780	$ -	$ 101,780
F_GS_670					NO																					
F_GS_671					YES	0119033	0119032	1	1.75	112	957.68	957.67	0.0%	11.86	14.65	13.26	3	1.2	0.47	0.27	$ 464	$ -	$ -	$ 51,931	$ -	$ 51,931
F_GS_672					NO																					
F_GS_675					NO																					
F_GS_676					YES	0115191	0115017	1	1.75	93	943.38	943.32	0.1%	14.62	13.83	14.23	3	4.9	0.76	0.43	$ 464	$ -	$ -	$ 43,324	$ -	$ 43,324
F_GS_677					NO																					
F_GS_678					YES	0115139	0115137	1	1.50	70	959.90	956.90	4.3%	7.48	5.98	6.73	2	0.5	0.22	0.15	$ 319	$ -	$ -	$ 22,330	$ -	$ 22,330
F_GS_679					NO																					
F_GS_681		43			NO																					
F_GS_682					YES	0115183	0115010	1	1.50	121	930.58	929.98	0.5%	13.29	9.83	11.56	3	2.7	0.65	0.43	$ 399	$ -	$ -	$ 48,147	$ -	$ 48,147
F_GS_683	59				YES	0115197	0115003	1	2.00	151	928.18	925.60	1.7%	15.82	15.03	15.43	4	5.5	0.62	0.31	$ 633	$ -	$ 728	$ 101,536	$ -	$ 101,536
F_GS_684					NO																					
F_GS_685					YES	0120014	0120013	1	1.00	180	983.77	981.77	1.1%	5.65	8.92	7.29	2	0.4	0.36	0.36	$ 278	$ -	$ -	$ 50,026	$ -	$ 50,026
F_GS_686	38				NO																					
F_GS_687	11				YES	0120004	0120002	1	1.00	841	963.50	955.19	1.0%	13.05	11.83	12.44	3	0.9	0.47	0.47	$ 348	$ -	$ 400	$ 293,155	$ -	$ 293,155
F_GS_689					YES	0120001	0113054	1	2.00	254	945.50	943.00	1.0%	14.00	12.40	13.20	3	1.2	0.37	0.19	$ 528	$ -	$ -	$ 133,985	$ -	$ 133,985
F_GS_691	111				NO																					
F_GS_692					NO																					
F_GS_694					YES	0113043	0113040	1	1.25	163	922.82	920.89	1.2%	8.88	12.20	10.54	3	1.8	1	0.80	$ 373	$ -	$ -	$ 60,922	$ -	$ 60,922
F_GS_696					NO																					
F_GS_698					YES	0114083	0114015	1	2.25	427	972.90	969.77	0.7%	9.73	8.84	9.29	2	0.6	0.16	0.07	$ 504	$ -	$ -	$ 214,981	$ -	$ 214,981
F_GS_699					NO																					
F_GS_700	36				NO																					
F_GS_701	65				NO																					
F_GS_702					NO																					
F_GS_703					NO																					
F_GS_705					YES	0113221	0113220	1	1.50	70	908.95	908.86	0.1%	22.83	27.40	25.12	4	3.3	1	0.67	$ 479	$ -	$ -	$ 33,530	$ -	$ 33,530
F_GS_706					NO																					
F_GS_707					NO																					
F_GS_708					YES	0113224	RCPSWW	1	6.00	35	905.26	896.50	25.0%	17.64	12.00	14.82	3	42.6	0.92	0.15	$ 2,329	$ -	$ -	$ 81,515	$ -	$ 81,515
F_GS_709					NO																					
F_GS_710	39				NO																					
F_GS_711	149				YES	0112016	0113002	1	1.00	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	0.9	1	1.00	$ 348	$ -	$ 400	$ 120,529	$ -	$ 120,529
F_GS_712	18				NO																					
F_GS_714	40				YES	0113002	0113224	1	2.00	40	906.40	905.26	2.8%	14.63	17.33	15.98	4	9.3	1	0.50	$ 633	$ -	$ 728	$ 29,120	$ -	$ 29,120
F_GS_716					NO																					
F_GS_717					YES	0110009	0110008	1	2.50	70	924.08	923.25	1.2%	11.08	10.33	10.71	3	0.6	0.14	0.06	$ 734	$ -	$ -	$ 51,380	$ -	$ 51,380
F_GS_718					NO																					
F_GS_719					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	2.00	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	5.5	0.75	0.38	$ 528	$ -	$ 1,584	$ 474,043	$ -	$ 474,043
F_GS_724					YES	0109195	0109155	1	1.50	202	969.95	968.01	1.0%	3.23	7.98	5.61	2	0.6	0.32	0.21	$ 319	$ -	$ -	$ 64,457	$ -	$ 64,457
F_GS_726					NO																					
F_GS_727					YES	0109084	0109192	1	1.75	255	958.47	954.23	1.7%	7.35	7.90	7.63	2	1.7	0.25	0.14	$ 371	$ -	$ -	$ 94,713	$ -	$ 94,713
F_GS_728					YES	0109192	0109201	1	1.00	222	954.23	952.11	1.0%	8.65	8.25	8.45	2	1.5	0.71	0.71	$ 278	$ -	$ -	$ 61,744	$ -	$ 61,744
F_GS_729					YES	0109040	0109036	1	1.75	211	950.60	950.21	0.2%	7.50	8.86	8.18	2	0.3	0.19	0.11	$ 371	$ -	$ -	$ 78,340	$ -	$ 78,340
F_GS_730	63				YES	0109019	0108023	1	1.25	807	933.20	924.66	1.1%	8.88	12.66	10.77	3	1.9	0.59	0.47	$ 373	$ -	$ 429	$ 304,534	$ -	$ 304,534
F_GS_731		35			YES	0109198	0109019	1	1.75	325	936.21	933.20	0.9%	10.83	7.83	9.33	2	2.4	0.38	0.22	$ 371	$ -	$ 1,113	$ 146,806	$ -	$ 146,806
F_GS_732	34	21			NO																					
F_GS_733	126				YES	0108016	0108005	1	1.00	484	897.11	888.14	1.9%	8.92	10.10	9.51	2	2.7	0.86	0.86	$ 278	$ -	$ 320	$ 139,808	$ -	$ 139,808
F_GS_736					YES	0108017	0108016	1	1.75	480	906.42	897.11	1.9%	20.98	8.92	14.95	3	2.6	0.35	0.20	$ 464	$ -	$ -	$ 222,493	$ -	$ 222,493
F_GS_737		34			NO																					
F_GS_738					NO																					
F_GS_739					NO																					
F_GS_740					NO																					
F_GS_741					NO																					
F_GS_742					NO																					

F_GS_743	50				YES	0107176	0107175	1	2.00	151	898.92	897.70	0.8%	8.80	8.26	8.53	2	1.1	0.26	0.13	$ 422	$ -	$ 485	$ 66,725	$ -	$ 66,725
F_GS_744	50				NO																					
F_GS_745					NO																					
F_GS_748					NO																					
F_GS_750					NO																					
F_GS_751					NO																					
F_GS_752					NO																					
F_GS_753					NO																					
F_GS_754		43			NO																					
F_GS_755		53			NO																					
F_GS_757					NO																					
F_GS_758	35				YES	0106166	0106003	1	1.50	212	873.06	871.30	0.8%	6.26	13.59	9.93	2	2.9	0.59	0.39	$ 319	$ -	$ 367	$ 69,263	$ -	$ 69,263
F_GS_759		44			YES	0106003	0103053	1	1.75	598	871.30	869.59	0.3%	14.63	11.37	13.00	3	3.0	0.77	0.44	$ 464	$ -	$ 1,392	$ 318,392	$ -	$ 318,392
F_GS_766					YES	0105002	0105001	1	2.25	171	904.87	904.29	0.3%	9.29	9.01	9.15	2	0.6	0.19	0.08	$ 504	$ -	$ -	$ 86,285	$ -	$ 86,285
F_GS_767					YES	0103104	0103103	1	2.00	50	911.61	907.37	8.5%	3.22	4.81	4.02	2	1.1	0.23	0.12	$ 422	$ -	$ -	$ 21,100	$ -	$ 21,100
F_GS_770					YES	0103059	0103195	1	1.25	116	888.23	886.82	1.2%	8.88	7.52	8.20	2	2.3	0.57	0.46	$ 298	$ -	$ -	$ 34,598	$ -	$ 34,598
F_GS_771					YES	0103226	0103089	1	1.00	203	899.84	896.71	1.5%	8.16	8.90	8.53	2	1.1	0.55	0.55	$ 278	$ -	$ -	$ 56,467	$ -	$ 56,467
F_GS_772					YES	0103192	0103056	1	1.25	70	877.54	876.48	1.5%	7.63	6.85	7.24	2	1.8	1	0.80	$ 298	$ -	$ -	$ 20,860	$ -	$ 20,860
F_GS_773	74				NO																					
F_GS_774		49			YES	0103053	0103069	1	2.00	1,236	869.59	865.44	0.3%	11.37	9.18	10.27	3	7.7	0.97	0.49	$ 528	$ -	$ 1,584	$ 704,089	$ -	$ 704,089
F_GS_775					YES	0103049	0103046	1	1.75	576	861.42	859.50	0.3%	12.32	10.37	11.34	3	6.3	0.82	0.47	$ 464	$ -	$ -	$ 267,185	$ -	$ 267,185
F_GS_776					YES	0103121	0103120	1	1.50	399	925.07	922.73	0.6%	10.63	16.71	13.67	3	0.4	0.25	0.17	$ 399	$ -	$ -	$ 159,125	$ -	$ 159,125
F_GS_777					YES	0103116	0103115	1	1.00	437	867.80	856.30	2.6%	12.92	2.82	7.87	2	1.0	0.57	0.57	$ 278	$ -	$ -	$ 121,597	$ -	$ 121,597
F_GS_778					NO																					
F_GS_779					YES	0101167	BLPSWW	1	3.00	83	855.24	847.00	9.9%	13.09	12.46	12.78	3	5.1	1	0.33	$ 875	$ -	$ -	$ 72,748	$ -	$ 72,748
F_GS_782					NO																					
F_GS_783					YES	0102044	0102027	1	2.25	165	924.36	923.80	0.3%	8.88	7.52	8.20	2	0.1	0.09	0.04	$ 504	$ -	$ -	$ 83,266	$ -	$ 83,266
F_GS_784					NO																					
F_GS_785					YES	0102124	0102001	1	1.50	176	914.10	912.90	0.7%	8.40	10.10	9.25	2	1.2	0.59	0.39	$ 319	$ -	$ -	$ 56,182	$ -	$ 56,182
F_GS_786					NO																					
F_GS_789					NO																					
F_GS_790	83				YES	0101018	0101016	1	1.00	323	902.31	895.77	2.0%	15.63	9.36	12.50	3	1.6	0.49	0.49	$ 348	$ -	$ 400	$ 116,586	$ -	$ 116,586
F_GS_791					NO																					
F_GS_794					NO																					
F_GS_795					NO																					
F_GS_796					YES	0123089	0123086	1	1.25	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	2.9	0.66	0.53	$ 298	$ -	$ -	$ 88,917	$ -	$ 88,917
F_GS_797					NO																					
F_GS_798					NO																					
F_GS_799					NO																					
F_GS_801	38				YES	0127001	0126012	1	2.25	230	905.51	895.59	4.3%	4.42	7.53	5.97	2	0.9	0.12	0.05	$ 504	$ -	$ 580	$ 118,570	$ -	$ 118,570
F_GS_803					NO																					
F_GS_805					NO																					
F_GS_806					NO																					
F_GS_807					NO																					
F_GS_808					YES	1601016	1601045	1	2.00	50	979.38	977.00	4.8%	6.55	7.87	7.21	2	8.4	0.72	0.36	$ 422	$ -	$ -	$ 21,100	$ -	$ 21,100
F_GS_809					NO																					
F_GS_810					YES	0101002	0101167	1	2.00	169	856.72	855.24	0.9%	9.06	13.09	11.08	3	2.9	1	0.50	$ 528	$ -	$ -	$ 89,142	$ -	$ 89,142
F_GS_812					NO																					
F_GS_813		20			NO																					
F_GS_815					NO																					
F_GS_816					NO																					
F_GS_817	38				YES	0135001	0133056	1	2.50	345	946.13	943.11	0.9%	9.67	9.38	9.53	2	0.9	0.37	0.15	$ 587	$ -	$ 675	$ 206,152	$ -	$ 206,152
F_GS_818		148			NO																					
F_GS_819					YES	0120137	0120023	1	1.50	144	1006.44	1005.79	0.5%	11.46	8.00	9.73	2	0.7	0.81	0.54	$ 319	$ -	$ -	$ 46,041	$ -	$ 46,041
F_GS_820					NO																					
F_GS_821					NO																					
F_GS_822					NO																					
F_GS_823					NO																					
F_GS_824					NO																					
F_GS_825		95			NO																					
F_GS_826					YES	0128005	0128003	1	2.00	181	943.64	941.19	1.4%	10.61	10.96	10.79	3	0.6	0.4	0.20	$ 528	$ -	$ -	$ 95,352	$ -	$ 95,352
F_GS_827					YES	0128021	0123018	1	1.50	270	937.29	933.50	1.4%	9.67	10.50	10.09	3	1.1	0.34	0.23	$ 399	$ -	$ -	$ 107,790	$ -	$ 107,790
F_GS_828					YES	0123034	0123010	1	2.00	208	918.99	917.40	0.8%	11.00	9.19	10.10	3	2.8	0.53	0.27	$ 528	$ -	$ -	$ 109,618	$ -	$ 109,618

F_GS_829					NO																					
F_GS_830	222				YES	0101020	0101018	1	1.00	496	907.11	902.31	1.0%	15.73	15.63	15.68	4	1.4	0.53	0.53	$ 417	$ -	$ 480	$ 220,612	$ -	$ 220,612
F_GS_831					YES	0101012	0101039	1	1.75	138	882.29	881.54	0.5%	9.21	8.61	8.91	2	2.2	0.45	0.26	$ 371	$ -	$ -	$ 51,324	$ -	$ 51,324
F_GS_832					YES	0101004	0101003	1	2.25	171	860.49	859.98	0.3%	5.69	6.45	6.07	2	0.8	0.16	0.07	$ 504	$ -	$ -	$ 86,275	$ -	$ 86,275
F_GS_833					NO																					
F_GS_834					NO																					
F_GS_835					YES	0135025	0135023	1	1.00	305	952.69	950.09	0.9%	10.71	8.63	9.67	2	1.1	0.76	0.76	$ 278	$ -	$ -	$ 84,857	$ -	$ 84,857
F_GS_836	57				NO																					
F_GS_837					NO																					
F_GS_838					NO																					
F_GS_839					YES	0103054	0103196	1	2.00	473	872.53	869.97	0.5%	11.17	10.10	10.64	3	9.4	0.73	0.37	$ 528	$ -	$ -	$ 249,601	$ -	$ 249,601
F_GS_840					YES	0103005	0103003	1	1.50	344	861.90	854.00	2.3%	9.53	9.63	9.58	2	5.3	0.72	0.48	$ 319	$ -	$ -	$ 109,659	$ -	$ 109,659
F_GS_841					YES	0103003	BLPSWW	1	1.75	51	854.00	847.00	13.8%	13.44	14.25	13.85	3	3.0	1	0.57	$ 464	$ -	$ -	$ 23,488	$ -	$ 23,488
F_GS_842		335			NO																					
F_GS_843	67				YES	0113212	0113002	1	4.50	67	906.48	906.40	0.1%	15.10	14.63	14.87	3	17.5	0.9	0.20	$ 1,313	$ -	$ 1,510	$ 101,201	$ -	$ 101,201
F_GS_844					NO																					
F_GS_845					NO																					
F_GS_846					NO																					
F_GS_847					YES	rush_Creek_Bypa	0129006	1	1.25	508	926.85	919.16	1.5%	11.36	6.51	8.94	2	1.5	0.55	0.44	$ 298	$ -	$ -	$ 151,366	$ -	$ 151,366
F_GS_848					YES	0129004	0129001	1	2.00	1,215	916.90	909.32	0.6%	10.63	12.78	11.71	3	3.3	0.52	0.26	$ 528	$ -	$ -	$ 641,451	$ -	$ 641,451
F_GS_849					NO																					
F_GS_850					NO																					
F_CC_51					YES	0129001	0129008	1	1.50	190	909.32	909.27	0.0%	12.78	11.94	12.36	3	2.9	0.71	0.47	$ 399	$ -	$ -	$ 75,742	$ -	$ 75,742
F_CC_52					YES	0126012	0126044	1	1.50	60	895.59	893.65	3.2%	12.36	14.38	13.37	3	5.0	1	0.67	$ 399	$ -	$ -	$ 23,940	$ -	$ 23,940
F_CC_53					YES	0122044	0122040	1	1.75	70	905.87	903.92	2.8%	7.93	9.37	8.65	2	1.6	0.37	0.21	$ 371	$ -	$ -	$ 25,970	$ -	$ 25,970
F_CC_54					YES	0128002	0128003	1	1.00	37	941.35	941.19	0.4%	10.75	10.96	10.86	3	0.2	1	1.00	$ 348	$ -	$ -	$ 12,890	$ -	$ 12,890
F_CC_55					YES	0122239	0122033	1	1.75	40	887.30	884.63	6.7%	10.10	12.67	11.39	3	6.5	0.83	0.47	$ 464	$ -	$ -	$ 18,560	$ -	$ 18,560
F_CC_56					YES	0122006	0122019	1	6.00	40	883.06	880.74	5.8%	12.51	14.42	13.47	3	2.5	0.52	0.09	$ 2,329	$ -	$ -	$ 93,160	$ -	$ 93,160
F_CC_57					NO																					
F_CC_58					YES	0101011	0101039	1	1.25	92	881.16	881.54	-0.4%	8.42	8.61	8.52	2	0.6	0.87	0.70	$ 298	$ -	$ -	$ 27,267	$ -	$ 27,267
F_CC_59					YES	0120032	0120004	1	1.00	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.6	0.72	0.72	$ 348	$ -	$ -	$ 13,920	$ -	$ 13,920
F_CC_60					YES	0108028	0108017	1	1.00	31	907.35	906.42	3.0%	20.54	20.98	20.76	4	1.7	0.48	0.48	$ 417	$ -	$ -	$ 12,839	$ -	$ 12,839
F_CC_61		20			YES	0135001	0135046	1	2.25	81	945.79	945.35	0.5%	9.67	8.92	9.30	2	0.6	0.4	0.18	$ 504	$ -	$ 1,512	$ 60,471	$ -	$ 60,471
F_CC_62	22				NO																					
F_CC_63	32				YES	0114022	0114005	1	2.25	40	950.00	950.03	-0.1%	8.25	8.16	8.21	2	0.2	0.31	0.14	$ 504	$ -	$ 580	$ 22,617	$ -	$ 22,617
F_CC_64					YES	0103196	0103053	1	2.00	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	6.6	0.83	0.42	$ 528	$ -	$ -	$ 18,480	$ -	$ 18,480
F_CC_65					YES	0133034	0133005	1	2.25	171	926.33	925.83	0.3%	14.04	13.83	13.94	3	5.2	0.97	0.43	$ 630	$ -	$ -	$ 107,699	$ -	$ 107,699
F_CC_66					NO																					
LINEAR STORAGE (NELSON COMPLEX)																								**$ 1,999,415**	**$ -**	**$ 1,999,415**
LINEAR STORAGE (TUKEY CREEK)																								**$ 1,999,415**	**$ -**	**$ 1,999,415**
F_LS_01				128	NO																					
F_LS_02	47				YES	F_LS_02a	F_LS_02b	1	5.00	1,139	881.00	879.00	0.2%	28.00	24.00	26.00	4	6.3	0.98	0.20	$ 1,745	$ -	$ 2,007	$ 1,999,415	$ -	$ 1,999,415
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					
F_LS_52					NO																					
F_LS_53		180			NO																					
F_LS_54					NO																					
F_LS_55		435			NO																					
FORCE MAIN (NELSON COMPLEX)																								**$ 61,776**	**$ -**	**$ 61,776**
FORCE MAIN (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek					NO			1		3,500	-	-	-	-	-	-	2		-	-						
FORCE MAIN (MISSION MAIN)																								**$ 61,776**	**$ -**	**$ 61,776**
PS_Belinder	439				NO			1		10,604	-	-	-	-	-	-	2		-	-						
PS_BrushCreek	9,673				NO			1		10,623	-	-	-	-	-	-	2		-	-						
PS_RockCreek	5,030				NO			1		7,047	-	-	-	-	-	-	2		-	-						
PS_RoeVillage					YES	RVPSWW	1601037	1	0.67	351	-	-	-	-	-	-	2	0.6	-	-	$ 176	$ -	$ -	$ 61,776	$ -	$ 61,776
PS_Swatzell					NO			1		1,101	-	-	-	-	-	-	2		-	-						

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

*SPS Expansion Cost Curve used for Prelim Runs

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 679,565**	**$ 13,914**	**$ 693,479**
TURKEY CREEK							**$ -**	**$ -**	**$ -**
PS_TurkeyCreek	27.0	NO	TCPSWW	0345082	27.0		$ -	$ -	$ -
MISSION MAIN							**$ 679,565**	**$ 13,914**	**$ 693,479**
PS_Belinder	11.6	NO	BLPSWW	1601029	6.6		$ -	$ -	$ -
PS_BrushCreek	6.0	NO	BCPSWW	0113002	6.0		$ -	$ -	$ -
PS_Granthurst	5.5	NO	GTPSWW	0123091	5.5		$ -	$ -	$ -
PS_MissionWoods	1.2	NO	MWPSWW	0101011	0.9		$ -	$ -	$ -
PS_RockCreek	15.5	NO	RCPSWW	1601016	10.5		$ -	$ -	$ -
PS_RoeVillage	0.4	YES	RVPSWW	1601037	0.6	0.1	$ 679,565	$ 13,914	$ 693,479
PS_Swatzell	1.6	NO	SZPSWW	0101168	1.6		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
STORAGE FACILITY TOTAL						**$ 70,295,076**	**$ 216,842**	**$ 70,511,918**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ 28,689,048**	**$ 80,068**	**$ 28,769,116**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ 28,689,048**	**$ 80,068**	**$ 28,769,116**
F_ST_01	F_ST_01_IN	YES	3.0	1.3	0.09	$ 1,202,538	$ 1,426	$ 1,203,964
F_ST_02	F_ST_02_IN	NO						
F_ST_03	F_ST_03_IN	YES	3.0	12.3	2.69	$ 14,411,173	$ 42,071	$ 14,453,244
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	YES	4.0	11.4	2.33	$ 13,075,337	$ 36,571	$ 13,111,908
F_ST_06	F_ST_06_IN	NO						
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST_51	F_ST_51_IN	NO						
F_ST_52	F_ST_52_IN	NO						
F_ST_53	F_ST_53_IN	NO						
F_ST_54	F_ST_54_IN	NO						
F_ST_55	F_ST_55_IN	NO						
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TOTAL)						**$ 41,606,028**	**$ 136,774**	**$ 41,742,802**
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	YES	4.8	0.0	0.00	$ -	$ -	$ -
STORAGE FACILITY - FACILITY PROTECTION DEVICE (MISSION MAIN)						**$ 41,606,028**	**$ 136,774**	**$ 41,742,802**
F_ST-FPD_BC	F_ST-FPD_BC_IN	YES	1.5	7.9	4.02	$ 19,472,887	$ 62,911	$ 19,535,798
F_ST-FPD_BL	F_ST-FPD_BL_IN	YES	3.0	0.0	0.00	$ -	$ -	$ -
F_ST-FPD_MW	F_ST-FPD_MW_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	5.0	15.9	4.71	$ 22,133,141	$ 73,863	$ 22,207,004

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX								**$ 66,115,833**	**$ 4,856,081**	**$ 70,971,914**
TURKEY CREEK								**$ 22,000,962**	**$ 1,061,284**	**$ 23,062,246**
PS_TurkeyCreek_PEFTF	TC_PEFTF_OUTFALL	22.0	YES	TC_PEFTF_WW	FMOutletEFB	13.2	5.4	$ 22,000,962	$ 1,061,284	$ 23,062,246
MISSION MAIN								**$ 44,114,871**	**$ 3,794,797**	**$ 47,909,668**
PS_Belinder_PEFTF	Belinder_Outfall	53.1	YES	BLPEFTFWW	Belinder_PEFTF_Tank	47.3	20.5	$ 44,114,871	$ 3,794,797	$ 47,909,668
PS_Martway_PEFTF	Martway_Discharge	20.0	NO	Martway_HS_Wet_Well	Martway_Tank	0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	Nall_Outfall	20.0	NO	Nall_Wet_Well	Nall_Tank	0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
I/I REDUCTION

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	Scaling Factor	% Reduction	I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL						**$ 28,578,375**	**$ -**	**$ 28,578,375**
TURKEY CREEK TOTAL						**$ 8,614,576**	**$ -**	**$ 8,614,576**
FM_202	0309015	24	NO	1.00		$ -	$ -	$ -
FM_203	0310001	82	NO	1.00		$ -	$ -	$ -
FM_204	0320011	22	NO	1.00		$ -	$ -	$ -
FM_205	0323001	42	NO	1.00		$ -	$ -	$ -
FM_206	0331001	78	NO	1.00		$ -	$ -	$ -
FM_207	0336001	130	YES	0.85	15%	$ 3,674,268	$ -	$ 3,674,268
FM_208	0341001	54	YES	0.80	20%	$ 3,133,687	$ -	$ 3,133,687
FM_209	0323131	56	YES	0.85	15%	$ 917,006	$ -	$ 917,006
FM_210	0327001	31	YES	0.80	20%	$ 889,615	$ -	$ 889,615
FM_211	0321001	3	NO	1.00		$ -	$ -	$ -
FM_TC PS	0301003	41	NO	1.00		$ -	$ -	$ -
MISSION MAIN TOTAL						**$ 19,963,799**	**$ -**	**$ 19,963,799**
FM_1	0115001	53	YES	0.95	5%	$ 371,708	$ -	$ 371,708
FM_101, 102	0107004	63	YES	0.70	30%	$ 2,301,291	$ -	$ 2,301,291
FM_103	0108002	54	YES	0.80	20%	$ 1,106,599	$ -	$ 1,106,599
FM_104, 105	0108020	53	YES	0.90	10%	$ 583,348	$ -	$ 583,348
FM_106, 107	0110018	45	NO	1.00		$ -	$ -	$ -
FM_108	0115043	24	NO	1.00		$ -	$ -	$ -
FM_109, 110	0123002	126	NO	1.00		$ -	$ -	$ -
FM_111	0122027	2	NO	1.00		$ -	$ -	$ -
FM_112	0112058	14	YES	0.75	25%	$ 458,084	$ -	$ 458,084
FM_113, 114	0122010	213	YES	0.75	25%	$ 6,451,847	$ -	$ 6,451,847
FM_115, 116	0126030	28	YES	0.85	15%	$ 1,185,585	$ -	$ 1,185,585
FM_117	0133060	5	YES	0.95	5%	$ 106,220	$ -	$ 106,220
FM_118	0142001	7	YES	0.95	5%	$ 80,530	$ -	$ 80,530
FM_119	0140014	17	YES	0.80	20%	$ 630,398	$ -	$ 630,398
FM_12, 13	0133010	48	NO	1.00		$ -	$ -	$ -
FM_120	0141096	3	YES	0.95	5%	$ 81,123	$ -	$ 81,123
FM_121, 122	0139008	21	YES	0.90	10%	$ 553,973	$ -	$ 553,973
FM_123, 124	0115022	9	NO	1.00		$ -	$ -	$ -
FM_14, 15, 16	0135002	71	YES	0.95	5%	$ 446,815	$ -	$ 446,815
FM_17, 18	0136001	110	NO	1.00		$ -	$ -	$ -
FM_2, 3	0103004	93	NO	1.00		$ -	$ -	$ -
FM_4	0113050	51	YES	0.80	20%	$ 1,701,167	$ -	$ 1,701,167
FM_5, 7	0103012	66	NO	1.00		$ -	$ -	$ -
FM_6, 19	0101010	53	YES	0.70	30%	$ 2,876,750	$ -	$ 2,876,750

FM_9, 10	0134015	17	YES	0.90	10%	$ 259,325	$ -	$ 259,325
FM_BC PS	0129005	30	NO	1.00		$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	1.00		$ -	$ -	$ -
FM_RC PS	0112006	66	YES	0.85	15%	$ 769,037	$ -	$ 769,037
FM_ WWTF	1601002	5	NO	1.00		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL COST				**$ -**	**$ -**	**$ -**
Nelson_ATF	45	45.2	0.0	$ -	$ -	$ -
0345082.1	29.1	27.0	0.0	$ -	$ -	$ -
1601051.1	15.9	18.2	0.0	$ -	$ -	$ -

Preliminary Optimization Results

10-Year/1-Year, PEFTFs Decommissioned
All Options

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
GRAVITY SEWER (NELSON COMPLEX)																								**$ 57,227,643**	**$ -**	**$ 57,227,643**
GRAVITY SEWER (TUKEY CREEK)																								**$ 33,335,820**	**$ -**	**$ 33,335,820**
F_GS_006		184			NO																					
F_GS_010		138			YES	0341012	0341009	1	1.75	1,224	969.93	966.78	0.3%	16.49	19.19	17.84	4	3.8	0.82	0.47	$ 557	$ -	$ 1,671	$ 835,233	$ -	$ 835,233
F_GS_011					NO																					
F_GS_012		829			YES	0341008	0341004	1	1.75	1,416	965.05	960.51	0.3%	12.50	17.88	15.19	4	4.7	0.84	0.48	$ 557	$ -	$ 1,671	$ 1,712,045	$ -	$ 1,712,045
F_GS_015					NO																					
F_GS_017					YES	0340003	0338019	1	1.00	948	988.18	977.03	1.2%	13.10	11.46	12.28	3	1.8	0.65	0.65	$ 348	$ -	$ -	$ 329,897	$ -	$ 329,897
F_GS_018					YES	0340106	0340091	1	1.00	980	1013.43	1007.03	0.7%	13.84	10.12	11.98	3	0.5	0.68	0.68	$ 348	$ -	$ -	$ 341,012	$ -	$ 341,012
F_GS_019					NO																					
F_GS_021	85				NO																					
F_GS_022					YES	0339003	0338027	1	1.25	423	1009.67	999.23	2.5%	8.73	8.85	8.79	2	1.4	0.41	0.33	$ 298	$ -	$ -	$ 125,938	$ -	$ 125,938
F_GS_023					YES	0338026	0338024	1	2.00	548	994.13	988.39	1.0%	15.47	11.66	13.57	3	1.7	0.61	0.31	$ 528	$ -	$ -	$ 289,471	$ -	$ 289,471
F_GS_024					NO																					
F_GS_025					YES	0338019	0338015	1	1.25	1,260	977.03	967.68	0.7%	11.95	12.19	12.07	3	3.3	0.91	0.73	$ 373	$ -	$ -	$ 469,797	$ -	$ 469,797
F_GS_026					NO																					
F_GS_031					YES	0337139	0337131	1	1.50	261	1014.81	1012.51	0.9%	9.52	13.75	11.64	3	1.2	0.43	0.29	$ 399	$ -	$ -	$ 104,123	$ -	$ 104,123
F_GS_034					YES	0337079	0337074	1	1.00	220	1022.09	1020.65	0.7%	12.36	12.84	12.60	3	0.6	0.53	0.53	$ 348	$ -	$ -	$ 76,630	$ -	$ 76,630
F_GS_038	56				YES	0337046	0336176	1	1.50	933	995.71	987.40	0.9%	11.53	15.43	13.48	3	2.5	0.72	0.48	$ 399	$ -	$ 459	$ 375,811	$ -	$ 375,811
F_GS_039					NO																					
F_GS_040					YES	0336141	0336139	1	1.50	448	975.07	970.17	1.1%	18.79	9.73	14.26	3	3.1	0.69	0.46	$ 399	$ -	$ -	$ 178,644	$ -	$ 178,644
F_GS_043					YES	0336028	0336002	1	1.25	890	961.12	954.12	0.8%	10.11	13.39	11.75	3	3.2	0.86	0.69	$ 373	$ -	$ -	$ 332,101	$ -	$ 332,101
F_GS_045	104			169	YES	0335012	0335005	1	2.50	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	16.7	0.83	0.33	$ 734	$ -	$ 3,501	$ 1,987,462	$ -	$ 1,987,462
F_GS_056					YES	0332011	0332002	1	1.00	576	969.79	958.55	2.0%	5.06	3.48	4.27	2	0.6	0.4	0.40	$ 278	$ -	$ -	$ 160,159	$ -	$ 160,159
F_GS_060					NO																					
F_GS_062		95			YES	0331010	0331003	1	2.25	2,882	927.49	920.78	0.2%	16.86	12.18	14.52	3	12.7	0.9	0.40	$ 630	$ -	$ 1,890	$ 1,934,847	$ -	$ 1,934,847
F_GS_064		283			YES	0331003	0320005	1	3.50	1,491	920.78	917.38	0.2%	13.18	11.99	12.59	3	24.8	0.9	0.26	$ 1,029	$ -	$ 3,087	$ 2,117,139	$ -	$ 2,117,139
F_GS_065					YES	0320004	0320185	1	1.00	80	913.63	913.24	0.5%	18.78	17.24	18.01	4	3.0	1	1.00	$ 417	$ -	$ -	$ 33,264	$ -	$ 33,264
F_GS_067	50				YES	0327094	0327053	1	1.00	836	1013.73	1007.08	0.8%	9.58	9.27	9.43	2	0.5	0.39	0.39	$ 278	$ -	$ 320	$ 234,486	$ -	$ 234,486
F_GS_068	57				YES	0327053	0327044	1	1.00	360	1007.08	1000.05	2.0%	9.27	12.76	11.02	3	1.1	0.43	0.43	$ 348	$ -	$ 400	$ 128,209	$ -	$ 128,209
F_GS_069	68				YES	0327044	0327032	1	1.25	637	1000.05	995.11	0.8%	13.67	11.57	12.62	3	1.2	0.7	0.56	$ 373	$ -	$ 429	$ 241,532	$ -	$ 241,532
F_GS_070	43				YES	0327031	0327007	1	1.00	793	991.66	982.57	1.1%	14.81	7.90	11.36	3	1.5	0.69	0.69	$ 348	$ -	$ 400	$ 278,123	$ -	$ 278,123
F_GS_071					NO																					
F_GS_072					NO																					
F_GS_074					YES	0326024	0326003	1	1.75	578	999.24	996.91	0.4%	13.12	11.76	12.44	3	1.0	0.29	0.17	$ 464	$ -	$ -	$ 268,303	$ -	$ 268,303
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	980.41	1.2%	9.50	7.95	8.72	2	1.0	0.54	0.54	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_076					NO																					
F_GS_078					YES	0325102	0325083	1	1.00	288	1027.47	1025.20	0.8%	10.14	9.53	9.83	2	0.3	0.3	0.30	$ 278	$ -	$ -	$ 80,103	$ -	$ 80,103
F_GS_079					YES	0325048	0325047	1	2.50	176	1015.23	1014.99	0.1%	9.00	11.56	10.28	3	1.6	0.52	0.21	$ 734	$ -	$ -	$ 128,839	$ -	$ 128,839
F_GS_080					NO																					
F_GS_081					YES	0325044	0325036	1	1.00	418	1011.90	1008.16	0.9%	8.62	5.76	7.19	2	1.2	0.77	0.77	$ 278	$ -	$ -	$ 116,204	$ -	$ 116,204
F_GS_082					NO																					
F_GS_084					YES	0325006	0325003	1	1.50	220	991.19	988.62	1.2%	12.32	11.51	11.92	3	1.7	0.66	0.44	$ 399	$ -	$ -	$ 87,856	$ -	$ 87,856
F_GS_085					YES	0325001	0323131	1	1.00	365	983.60	980.41	0.9%	12.68	12.02	12.35	3	1.3	0.62	0.62	$ 348	$ -	$ -	$ 126,881	$ -	$ 126,881
F_GS_086					YES	0323131	0323127	1	1.25	1,057	980.41	969.24	1.1%	12.02	16.79	14.41	3	2.4	0.77	0.62	$ 373	$ -	$ -	$ 394,343	$ -	$ 394,343
F_GS_087					NO																					
F_GS_089					YES	0323019	0323013	1	1.25	953	961.12	953.50	0.8%	10.12	12.15	11.14	3	3.9	0.87	0.70	$ 373	$ -	$ -	$ 355,491	$ -	$ 355,491
F_GS_093		98			YES	0323008	0320200	1	1.50	1,548	949.07	941.29	0.5%	12.15	19.91	16.03	4	4.6	0.89	0.59	$ 479	$ -	$ 1,437	$ 835,232	$ -	$ 835,232
F_GS_095					NO																					
F_GS_096					YES	0320014	0320013	1	1.75	377	930.00	928.91	0.3%	10.91	11.17	11.04	3	5.2	0.93	0.53	$ 464	$ -	$ -	$ 174,775	$ -	$ 174,775
F_GS_097		25			YES	0320003	0320001	1	2.50	677	911.54	909.98	0.2%	10.15	10.50	10.33	3	17.7	0.97	0.39	$ 734	$ -	$ 2,202	$ 533,831	$ -	$ 533,831
F_GS_098					YES	0310025	0310022	1	3.00	895	902.40	899.77	0.3%	14.10	13.51	13.81	3	23.7	1	0.33	$ 875	$ -	$ -	$ 783,204	$ -	$ 783,204

F_GS_106					NO																					
F_GS_107		204			YES	0310018	0310012	1	2.50	1,757	891.29	886.38	0.3%	18.63	23.10	20.87	4	16.9	1	0.40	$ 881	$ -	$ 2,643	$ 1,907,427	$ -	$ 1,907,427
F_GS_110					YES	0315011	0315010	1	1.00	163	933.22	932.20	0.6%	6.31	9.84	8.08	2	0.7	0.54	0.54	$ 278	$ -	$ -	$ 45,436	$ -	$ 45,436
F_GS_111					NO																					
F_GS_112					YES	0310205	0310012	1	1.00	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.4	0.78	0.78	$ 417	$ -	$ -	$ 434,981	$ -	$ 434,981
F_GS_113	47				YES	0310012	0310002	1	2.50	3,134	886.38	871.09	0.5%	23.10	27.08	25.09	4	21.0	0.94	0.38	$ 881	$ -	$ 1,013	$ 2,767,444	$ -	$ 2,767,444
F_GS_116					NO																					
F_GS_118					YES	0309231	0309022	1	1.00	268	922.91	916.69	2.3%	9.09	12.01	10.55	3	1.6	0.53	0.53	$ 348	$ -	$ -	$ 93,368	$ -	$ 93,368
F_GS_120		36			YES	0310002	0301024	1	5.00	708	871.09	868.77	0.3%	27.08	17.08	22.08	4	37.9	0.46	0.09	$ 1,745	$ -	$ 5,235	$ 1,360,716	$ -	$ 1,360,716
F_GS_121				128	YES	0301024	0301018	1	3.50	1,885	868.77	861.39	0.4%	17.08	18.43	17.76	4	33.5	0.85	0.24	$ 1,235	$ -	$ 8,645	$ 3,276,554	$ -	$ 3,276,554
F_GS_124	62				YES	0301012	0301009	1	3.00	1,435	852.01	846.64	0.4%	18.84	19.14	18.99	4	26.0	0.86	0.29	$ 1,050	$ -	$ 1,208	$ 1,516,368	$ -	$ 1,516,368
F_GS_126	47	95	41		YES	0301009	0301001	1	3.00	2,504	846.64	834.00	0.5%	19.14	19.92	19.53	4	29.6	0.96	0.32	$ 1,050	$ -	$ 3,117	$ 3,007,284	$ -	$ 3,007,284
F_GS_127	48				YES	0323013	0323008	1	1.25	629	953.50	949.07	0.7%	12.15	12.15	12.15	3	3.6	0.88	0.70	$ 373	$ -	$ 429	$ 237,144	$ -	$ 237,144
F_GS_129					YES	0332120	0332119	1	1.00	400	992.79	987.80	1.2%	10.59	9.46	10.03	3	0.7	0.42	0.42	$ 348	$ -	$ -	$ 139,210	$ -	$ 139,210
F_GS_130					YES	0332119	0332118	1	1.00	117	987.80	987.32	0.4%	9.46	9.95	9.71	2	0.7	0.49	0.49	$ 278	$ -	$ -	$ 32,643	$ -	$ 32,643
F_GS_131		62			YES	0335005	0331011	1	2.50	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	16.3	0.91	0.36	$ 881	$ -	$ 2,643	$ 2,157,358	$ -	$ 2,157,358
F_GS_133	34				YES	0327054	0327053	1	1.25	77	1008.25	1007.08	1.5%	8.91	8.40	8.66	2	0.5	0.28	0.22	$ 298	$ -	$ 343	$ 24,399	$ -	$ 24,399
GRAVITY SEWER (MISSION MAIN)																								**$ 23,891,824**	**$ -**	**$ 23,891,824**
F_GS_502					YES	0141096	0141021	1	1.50	232	1006.50	1000.80	2.5%	8.69	10.19	9.44	2	1.0	0.51	0.34	$ 319	$ -	$ -	$ 74,145	$ -	$ 74,145
F_GS_503					NO																					
F_GS_505					YES	0141046	0141010	1	1.00	424	1003.78	1001.90	0.4%	6.08	11.21	8.65	2	0.4	0.46	0.46	$ 278	$ -	$ -	$ 117,739	$ -	$ 117,739
F_GS_506					NO																					
F_GS_507					NO																					
F_GS_509					YES	0140079	0140024	1	1.25	227	1041.55	1039.73	0.8%	10.21	9.83	10.02	3	0.5	0.32	0.26	$ 373	$ -	$ -	$ 84,839	$ -	$ 84,839
F_GS_510					YES	0140021	0140017	1	1.25	575	1019.42	1009.89	1.7%	10.86	12.08	11.47	3	0.7	0.34	0.27	$ 373	$ -	$ -	$ 214,546	$ -	$ 214,546
F_GS_511					YES	0140015	0140014	1	3.00	340	990.99	988.68	0.7%	10.96	10.50	10.73	3	1.1	0.18	0.06	$ 875	$ -	$ -	$ 297,133	$ -	$ 297,133
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.4	0.52	0.52	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_513					YES	0142016	0142001	1	1.00	95	997.15	996.11	1.1%	6.85	10.50	8.68	2	0.8	0.98	0.98	$ 278	$ -	$ -	$ 26,357	$ -	$ 26,357
F_GS_514					NO																					
F_GS_515		19			YES	0136046	0136042	1	1.25	777	979.01	962.60	2.1%	9.33	10.64	9.99	2	0.9	0.63	0.50	$ 298	$ -	$ 894	$ 242,956	$ -	$ 242,956
F_GS_519		180			YES	0140006	0136006	1	1.25	1,204	955.06	944.71	0.9%	15.52	5.99	10.75	3	1.3	0.7	0.56	$ 373	$ -	$ 1,119	$ 583,376	$ -	$ 583,376
F_GS_520					YES	0136028	0136089	1	1.00	851	978.57	974.64	0.5%	18.63	1.76	10.20	3	0.4	0.38	0.38	$ 348	$ -	$ -	$ 296,294	$ -	$ 296,294
F_GS_522	89				YES	0139015	0139014	1	1.00	318	1000.68	998.96	0.5%	11.61	12.58	12.10	3	0.9	0.81	0.81	$ 348	$ -	$ 400	$ 115,154	$ -	$ 115,154
F_GS_523	100				YES	0139013	0139010	1	1.00	1,049	991.40	975.42	1.5%	12.49	10.46	11.48	3	0.8	0.44	0.44	$ 348	$ -	$ 400	$ 370,152	$ -	$ 370,152
F_GS_524					NO																					
F_GS_525					NO																					
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1020.87	1.7%	7.82	9.14	8.48	2	0.7	0.44	0.44	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_532					YES	0137017	0137016	1	1.00	406	991.83	987.13	1.2%	9.57	11.13	10.35	3	0.5	0.55	0.55	$ 348	$ -	$ -	$ 141,267	$ -	$ 141,267
F_GS_533					NO																					
F_GS_534					NO																					
F_GS_535					YES	0137004	0137001	1	1.00	225	976.90	975.97	0.4%	9.43	9.47	9.45	2	1.1	0.78	0.78	$ 278	$ -	$ -	$ 62,414	$ -	$ 62,414
F_GS_538					YES	0135040	0135039	1	1.00	222	968.20	965.84	1.1%	8.28	7.88	8.08	2	0.5	0.65	0.65	$ 278	$ -	$ -	$ 61,627	$ -	$ 61,627
F_GS_539					NO																					
F_GS_540					NO																					
F_GS_541					NO																					
F_GS_542		172			NO																					
F_GS_543					YES	0135023	0135022	1	1.00	82	950.09	949.53	0.7%	8.63	9.37	9.00	2	1.9	1	1.00	$ 278	$ -	$ -	$ 22,916	$ -	$ 22,916
F_GS_545		50			NO																					
F_GS_546	189				YES	0136007	0133054	1	2.50	226	939.66	939.24	0.2%	12.42	12.94	12.68	3	7.5	1	0.40	$ 734	$ -	$ 844	$ 186,683	$ -	$ 186,683
F_GS_547	66	109			YES	Nall_Sluice	0133043	1	1.00	890	938.00	933.10	0.6%	14.62	10.77	12.70	3	2.2	1	1.00	$ 348	$ -	$ 800	$ 388,912	$ -	$ 388,912
F_GS_548	40				YES	0133043	0133034	1	1.75	1,930	933.10	926.33	0.4%	11.42	13.51	12.47	3	6.2	0.83	0.47	$ 464	$ -	$ 534	$ 898,066	$ -	$ 898,066
F_GS_549					YES	0133034	0133002	1	2.00	806	926.33	923.05	0.4%	14.04	13.58	13.81	3	6.6	0.9	0.45	$ 528	$ -	$ -	$ 425,679	$ -	$ 425,679
F_GS_551					YES	0134174	0134230	1	1.00	414	967.89	955.54	3.0%	8.02	7.15	7.59	2	1.0	0.36	0.36	$ 278	$ -	$ -	$ 115,173	$ -	$ 115,173
F_GS_553					YES	0134021	0134135	1	1.50	465	952.00	946.16	1.3%	11.88	7.74	9.81	2	1.6	0.55	0.37	$ 319	$ -	$ -	$ 148,290	$ -	$ 148,290
F_GS_554					NO																					
F_GS_555					YES	0133002	BCPSWW	1	1.25	30	923.05	916.50	21.8%	14.08	13.50	13.79	3	2.7	1	0.80	$ 373	$ -	$ -	$ 11,190	$ -	$ 11,190
F_GS_556		125			NO																					
F_GS_557		15			NO																					
F_GS_558					NO																					
F_GS_559					YES	0130029	0130024	1	1.00	305	939.48	933.49	2.0%	10.46	8.23	9.35	2	0.8	0.36	0.36	$ 278	$ -	$ -	$ 84,690	$ -	$ 84,690
F_GS_560					YES	0130024	0130001	1	1.50	740	933.49	918.28	2.1%	9.73	9.77	9.75	2	1.0	0.22	0.15	$ 319	$ -	$ -	$ 235,958	$ -	$ 235,958
F_GS_562	46				YES	0129126	0129121	1	1.00	286	981.31	978.22	1.1%	11.67	12.95	12.31	3	0.4	0.51	0.51	$ 348	$ -	$ 400	$ 101,907	$ -	$ 101,907
F_GS_563					NO																					

F_GS_564					NO																				
F_GS_565					NO																				
F_GS_566					NO																				
F_GS_567					NO																				
F_GS_568					NO																				
F_GS_569					NO																				
F_GS_570	42				NO																				
F_GS_575					NO																				
F_GS_576					NO																				
F_GS_577					NO																				
F_GS_579	63	109			NO																				
F_GS_580		83			YES	0126004	0122033	1	1.50	1,863	891.51	884.63	0.4%	9.63	12.67	11.15	3	4.2	0.92	0.61	$ 399	$ -	$ 1,197	$ 809,756	$ -	$ 809,756
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.37	0.37	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_585					NO																				
F_GS_586					NO																				
F_GS_588					NO																				
F_GS_589					YES	0125009	0125007	1	1.50	142	942.88	940.00	2.0%	15.46	15.34	15.40	4	0.5	0.17	0.11	$ 479	$ -	$ -	$ 68,162	$ -	$ 68,162
F_GS_590	39				YES	0125007	0125003	1	1.50	1,317	940.00	924.35	1.2%	16.44	7.08	11.76	3	1.2	0.25	0.17	$ 399	$ -	$ 459	$ 528,009	$ -	$ 528,009
F_GS_592					YES	0125003	0125002	1	2.00	243	924.35	915.18	3.8%	7.08	7.54	7.31	2	1.4	0.16	0.08	$ 422	$ -	$ -	$ 102,352	$ -	$ 102,352
F_GS_593					NO																				
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	948.48	1.0%	11.09	10.36	10.73	3	0.7	0.4	0.40	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_598					YES	0124007	0124006	1	1.25	337	937.00	936.21	0.2%	12.15	6.82	9.49	2	0.7	0.32	0.26	$ 298	$ -	$ -	$ 100,459	$ -	$ 100,459
F_GS_599					YES	0124006	0122058	1	1.50	698	936.21	916.48	2.8%	6.82	7.02	6.92	2	0.7	0.23	0.15	$ 319	$ -	$ -	$ 222,512	$ -	$ 222,512
F_GS_600					NO																				
F_GS_601					YES	0122137	0122053	1	2.50	479	907.50	902.80	1.0%	11.08	7.67	9.38	2	0.5	0.55	0.22	$ 587	$ -	$ -	$ 280,880	$ -	$ 280,880
F_GS_603					NO																				
F_GS_604	36				NO																				
F_GS_608		23			YES	0122033	0122019	1	2.00	980	884.63	880.74	0.4%	12.67	14.42	13.55	3	6.2	1	0.50	$ 528	$ -	$ 1,584	$ 542,047	$ -	$ 542,047
F_GS_612					NO																				
F_GS_613					NO																				
F_GS_614					YES	0122061	0122024	1	1.25	707	908.97	901.26	1.1%	9.98	8.32	9.15	2	0.7	0.28	0.22	$ 298	$ -	$ -	$ 210,802	$ -	$ 210,802
F_GS_615	32				YES	0122024	0122120	1	1.25	357	901.26	894.00	2.0%	8.32	9.75	9.04	2	1.1	0.3	0.24	$ 298	$ -	$ 343	$ 107,683	$ -	$ 107,683
F_GS_616					NO																				
F_GS_617					YES	0122118	0122019	1	1.50	412	886.89	880.74	1.5%	10.08	14.42	12.25	3	1.3	0.63	0.42	$ 399	$ -	$ -	$ 164,504	$ -	$ 164,504
F_GS_619					NO																				
F_GS_620		742			NO																				
F_GS_621					NO																				
F_GS_623					NO																				
F_GS_624					YES	0132002	GTPSWW	1	2.25	35	938.37	931.00	21.1%	10.84	4.00	7.42	2	2.9	0.18	0.08	$ 504	$ -	$ -	$ 17,640	$ -	$ 17,640
F_GS_625					NO																				
F_GS_626					NO																				
F_GS_627					YES	0132028	0132012	1	1.00	424	965.35	959.29	1.4%	11.00	9.23	10.12	3	1.2	0.49	0.49	$ 348	$ -	$ -	$ 147,608	$ -	$ 147,608
F_GS_628					YES	0132029	0132028	1	1.00	363	967.26	965.35	0.5%	13.04	11.00	12.02	3	0.7	0.46	0.46	$ 348	$ -	$ -	$ 126,209	$ -	$ 126,209
F_GS_629					YES	0132172	0132029	1	1.00	376	973.25	967.26	1.6%	10.68	10.36	10.52	3	0.6	0.37	0.37	$ 348	$ -	$ -	$ 130,695	$ -	$ 130,695
F_GS_630					YES	0132040	0132039	1	1.25	228	986.07	985.03	0.5%	9.16	10.77	9.97	2	0.5	0.37	0.30	$ 298	$ -	$ -	$ 67,923	$ -	$ 67,923
F_GS_632					NO																				
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	980.63	0.6%	11.15	11.05	11.10	3	0.7	0.45	0.45	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_635					NO																				
F_GS_636					NO																				
F_GS_640					YES	0123018	0123015	1	1.50	1,071	933.50	922.91	1.0%	10.50	8.23	9.37	2	1.7	0.67	0.45	$ 319	$ -	$ -	$ 341,690	$ -	$ 341,690
F_GS_641					NO																				
F_GS_642					YES	0123091	0123089	1	1.25	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	4.7	0.57	0.46	$ 298	$ -	$ -	$ 233,707	$ -	$ 233,707
F_GS_643					NO																				
F_GS_644					NO																				
F_GS_645					NO																				
F_GS_646					NO																				
F_GS_647					YES	0123086	0123028	1	1.50	517	914.76	911.00	0.7%	8.97	8.60	8.79	2	5.8	0.91	0.61	$ 319	$ -	$ -	$ 164,984	$ -	$ 164,984
F_GS_649		31			NO																				
F_GS_650					YES	0123046	0123025	1	1.50	169	906.92	901.90	3.0%	9.32	7.08	8.20	2	5.8	0.71	0.47	$ 319	$ -	$ -	$ 53,965	$ -	$ 53,965
F_GS_651					YES	0123025	0123005	1	1.25	335	901.90	898.80	0.9%	10.38	7.52	8.95	2	4.9	0.94	0.75	$ 298	$ -	$ -	$ 99,726	$ -	$ 99,726
F_GS_652		66			YES	0123005	0123004	1	1.50	396	898.80	891.28	1.9%	8.04	10.83	9.44	2	9.0	0.77	0.51	$ 319	$ -	$ 957	$ 168,335	$ -	$ 168,335
F_GS_653					YES	0123004	0123021	1	2.25	144	891.28	888.99	1.6%	10.83	10.48	10.66	3	9.3	0.51	0.23	$ 630	$ -	$ -	$ 91,016	$ -	$ 91,016
F_GS_654		148			YES	0123021	0103042	1	1.50	1,374	888.99	873.73	1.1%	11.58	8.58	10.08	3	5.4	0.72	0.48	$ 399	$ -	$ 1,197	$ 665,951	$ -	$ 665,951

F_GS_655		71			YES	0103042	0103026	1	2.25	385	873.73	873.02	0.2%	9.57	11.58	10.58	3	10.4	0.91	0.40	$ 630	$ -	$ 1,890	$ 331,311	$ -	$ 331,311
F_GS_656	135	46			YES	0103026	0103038	1	2.00	1,642	873.02	863.64	0.6%	11.58	8.07	9.83	2	10.9	0.71	0.36	$ 422	$ -	$ 684	$ 740,280	$ -	$ 740,280
F_GS_659		189			YES	0103018	0103011	1	2.25	2,885	862.48	854.67	0.3%	8.57	9.92	9.25	2	10.1	0.99	0.44	$ 504	$ -	$ 1,512	$ 1,644,326	$ -	$ 1,644,326
F_GS_662					YES	0103011	0103065	1	2.25	80	853.87	853.81	0.1%	9.92	12.91	11.42	3	8.3	1	0.44	$ 630	$ -	$ -	$ 50,400	$ -	$ 50,400
F_GS_663					YES	0103065	0103064	1	5.00	70	853.81	853.75	0.1%	12.91	13.25	13.08	3	25.9	1	0.20	$ 1,454	$ -	$ -	$ 101,780	$ -	$ 101,780
F_GS_664					YES	0103064	BLPSWW	1	3.50	70	853.75	847.00	9.6%	13.25	13.55	13.40	3	29.1	1	0.29	$ 1,029	$ -	$ -	$ 72,030	$ -	$ 72,030
F_GS_670					NO																					
F_GS_671					YES	0119033	0119032	1	2.00	112	957.68	957.67	0.0%	11.86	14.65	13.26	3	1.2	0.41	0.21	$ 528	$ -	$ -	$ 59,094	$ -	$ 59,094
F_GS_672					NO																					
F_GS_675					NO																					
F_GS_676					YES	0115191	0115017	1	1.50	93	943.38	943.32	0.1%	14.62	13.83	14.23	3	4.5	0.9	0.60	$ 399	$ -	$ -	$ 37,255	$ -	$ 37,255
F_GS_677					NO																					
F_GS_678					YES	0115139	0115137	1	1.00	70	959.90	956.90	4.3%	7.48	5.98	6.73	2	0.6	0.61	0.61	$ 278	$ -	$ -	$ 19,460	$ -	$ 19,460
F_GS_679					NO																					
F_GS_681		43			NO																					
F_GS_682					NO																					
F_GS_683	59				NO																					
F_GS_684					YES	0120023	0120016	1	1.00	1,206	1005.79	987.46	1.5%	8.00	7.61	7.81	2	0.8	0.51	0.51	$ 278	$ -	$ -	$ 335,221	$ -	$ 335,221
F_GS_685					YES	0120014	0120013	1	1.25	180	983.77	981.77	1.1%	5.65	8.92	7.29	2	0.5	0.32	0.26	$ 298	$ -	$ -	$ 53,625	$ -	$ 53,625
F_GS_686	38				NO																					
F_GS_687	11				YES	0120004	0120002	1	1.00	841	963.50	955.19	1.0%	13.05	11.83	12.44	3	1.3	0.58	0.58	$ 348	$ -	$ 400	$ 293,155	$ -	$ 293,155
F_GS_689					NO																					
F_GS_691	111				NO																					
F_GS_692					YES	0113050	0113044	1	2.00	934	937.87	926.49	1.2%	14.71	10.40	12.56	3	3.3	0.65	0.33	$ 528	$ -	$ -	$ 492,994	$ -	$ 492,994
F_GS_694					YES	0113043	0113040	1	1.75	163	922.82	920.89	1.2%	8.88	12.20	10.54	3	3.5	1	0.57	$ 464	$ -	$ -	$ 75,785	$ -	$ 75,785
F_GS_696					YES	1601045	1601056	1	2.00	2,937	977.00	971.00	0.2%	7.87	11.44	9.65	2	8.6	0.92	0.46	$ 422	$ -	$ -	$ 1,239,494	$ -	$ 1,239,494
F_GS_698					YES	0114083	0114015	1	1.25	427	972.90	969.77	0.7%	9.73	8.84	9.29	2	0.5	0.31	0.25	$ 298	$ -	$ -	$ 127,112	$ -	$ 127,112
F_GS_699					NO																					
F_GS_700	36				NO																					
F_GS_701	65				NO																					
F_GS_702					NO																					
F_GS_703					NO																					
F_GS_705					NO																					
F_GS_706					YES	0112048	0112042	1	1.75	381	947.39	946.00	0.4%	15.72	12.38	14.05	3	0.9	0.66	0.38	$ 464	$ -	$ -	$ 176,719	$ -	$ 176,719
F_GS_707					NO																					
F_GS_708					YES	0113224	RCPSWW	1	2.50	35	905.26	896.50	25.0%	17.64	12.00	14.82	3	19.0	1	0.40	$ 734	$ -	$ -	$ 25,690	$ -	$ 25,690
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.2	0.43	0.43	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.50	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.1	0.61	0.41	$ 399	$ -	$ 459	$ 224,467	$ -	$ 224,467
F_GS_711	149				YES	0112016	0113002	1	1.00	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.3	1	1.00	$ 348	$ -	$ 400	$ 120,529	$ -	$ 120,529
F_GS_712	18				NO																					
F_GS_714	40				YES	0113002	0113224	1	1.50	40	906.40	905.26	2.8%	14.63	17.33	15.98	4	7.2	1	0.67	$ 479	$ -	$ 551	$ 22,040	$ -	$ 22,040
F_GS_716					NO																					
F_GS_717					YES	0110009	0110008	1	1.50	70	924.08	923.25	1.2%	11.08	10.33	10.71	3	0.6	0.26	0.17	$ 399	$ -	$ -	$ 27,930	$ -	$ 27,930
F_GS_718					YES	0110004	0108071	1	1.25	253	913.77	911.89	0.7%	8.83	14.04	11.43	3	0.1	0.29	0.23	$ 373	$ -	$ -	$ 94,197	$ -	$ 94,197
F_GS_719					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	1.00	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	1.7	1	1.00	$ 348	$ -	$ 1,044	$ 312,437	$ -	$ 312,437
F_GS_724					NO																					
F_GS_726					NO																					
F_GS_727					NO																					
F_GS_728					NO																					
F_GS_729					YES	0109040	0109036	1	1.00	211	950.60	950.21	0.2%	7.50	8.86	8.18	2	0.2	0.33	0.33	$ 278	$ -	$ -	$ 58,702	$ -	$ 58,702
F_GS_730	63				NO																					
F_GS_731		35			YES	0109198	0109019	1	2.50	325	936.21	933.20	0.9%	10.83	7.83	9.33	2	2.3	0.23	0.09	$ 587	$ -	$ 1,761	$ 232,278	$ -	$ 232,278
F_GS_732	34	21			NO																					
F_GS_733	126				YES	0108016	0108005	1	1.50	484	897.11	888.14	1.9%	8.92	10.10	9.51	2	1.6	0.64	0.43	$ 319	$ -	$ 367	$ 160,402	$ -	$ 160,402
F_GS_736					NO																					
F_GS_737		34			NO																					
F_GS_738					NO																					
F_GS_739					NO																					
F_GS_740					NO																					
F_GS_741					YES	0107030	0107027	1	1.00	531	922.83	910.13	2.4%	6.48	7.26	6.87	2	0.9	0.42	0.42	$ 278	$ -	$ -	$ 147,668	$ -	$ 147,668
F_GS_742					YES	0107031	0107030	1	2.25	245	926.20	922.83	1.4%	10.91	6.48	8.70	2	1.2	0.15	0.07	$ 504	$ -	$ -	$ 123,319	$ -	$ 123,319

F_GS_743	50				NO																					
F_GS_744	50				NO																					
F_GS_745					YES	0107097	0107019	1	1.00	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.3	0.3	0.30	$ 278	$ -	$ -	$ 449,128	$ -	$ 449,128
F_GS_748					NO																					
F_GS_750					NO																					
F_GS_751					YES	0107010	0107021	1	2.00	35	913.88	913.30	1.7%	10.90	10.49	10.70	3	0.6	0.15	0.08	$ 528	$ -	$ -	$ 18,480	$ -	$ 18,480
F_GS_752					NO																					
F_GS_753					YES	0107170	0107006	1	1.50	215	908.34	904.85	1.6%	10.34	8.18	9.26	2	1.2	0.33	0.22	$ 319	$ -	$ -	$ 68,636	$ -	$ 68,636
F_GS_754		43			NO																					
F_GS_755		53			NO																					
F_GS_757					NO																					
F_GS_758	35				NO																					
F_GS_759		44			NO																					
F_GS_766					YES	0105002	0105001	1	2.25	171	904.87	904.29	0.3%	9.29	9.01	9.15	2	0.6	0.19	0.08	$ 504	$ -	$ -	$ 86,285	$ -	$ 86,285
F_GS_767					YES	0103104	0103103	1	1.00	50	911.61	907.37	8.5%	3.22	4.81	4.02	2	0.9	0.54	0.54	$ 278	$ -	$ -	$ 13,900	$ -	$ 13,900
F_GS_770					NO																					
F_GS_771					YES	0103226	0103089	1	1.00	203	899.84	896.71	1.5%	8.16	8.90	8.53	2	1.1	0.55	0.55	$ 278	$ -	$ -	$ 56,467	$ -	$ 56,467
F_GS_772					NO																					
F_GS_773	74				NO																					
F_GS_774		49			YES	0103053	0103069	1	2.25	1,236	869.59	865.44	0.3%	11.37	9.18	10.27	3	9.3	0.92	0.41	$ 630	$ -	$ 1,890	$ 840,106	$ -	$ 840,106
F_GS_775					YES	0103049	0103046	1	1.75	576	861.42	859.50	0.3%	12.32	10.37	11.34	3	6.7	0.87	0.50	$ 464	$ -	$ -	$ 267,185	$ -	$ 267,185
F_GS_776					YES	0103121	0103120	1	1.00	399	925.07	922.73	0.6%	10.63	16.71	13.67	3	0.4	0.39	0.39	$ 348	$ -	$ -	$ 138,786	$ -	$ 138,786
F_GS_777					YES	0103116	0103115	1	1.00	437	867.80	856.30	2.6%	12.92	2.82	7.87	2	1.0	0.58	0.58	$ 278	$ -	$ -	$ 121,597	$ -	$ 121,597
F_GS_778					YES	0103115	0101167	1	2.00	50	856.30	855.24	2.1%	12.59	12.49	12.54	3	1.3	1	0.50	$ 528	$ -	$ -	$ 26,400	$ -	$ 26,400
F_GS_779					YES	0101167	BLPSWW	1	2.00	83	855.24	847.00	9.9%	13.09	12.46	12.78	3	5.5	1	0.50	$ 528	$ -	$ -	$ 43,898	$ -	$ 43,898
F_GS_782					NO																					
F_GS_783					NO																					
F_GS_784					NO																					
F_GS_785					NO																					
F_GS_786					YES	0102001	0102130	1	2.00	53	912.90	911.98	1.7%	10.10	10.87	10.48	3	1.8	0.23	0.12	$ 528	$ -	$ -	$ 27,963	$ -	$ 27,963
F_GS_789					NO																					
F_GS_790	83				YES	0101018	0101016	1	1.00	323	902.31	895.77	2.0%	15.63	9.36	12.50	3	2.7	0.6	0.60	$ 348	$ -	$ 400	$ 116,586	$ -	$ 116,586
F_GS_791					YES	0101014	0101012	1	1.75	167	883.39	882.29	0.7%	8.43	9.21	8.82	2	3.6	0.67	0.38	$ 371	$ -	$ -	$ 62,109	$ -	$ 62,109
F_GS_794					YES	0101039	0101038	1	1.00	354	881.54	877.06	1.3%	8.61	12.67	10.64	3	2.4	0.79	0.79	$ 348	$ -	$ -	$ 123,140	$ -	$ 123,140
F_GS_795					YES	0101038	0101036	1	1.00	857	877.06	871.17	0.7%	13.17	5.38	9.28	2	2.0	0.83	0.83	$ 278	$ -	$ -	$ 238,352	$ -	$ 238,352
F_GS_796					YES	0123089	0123086	1	1.00	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	4.0	0.82	0.82	$ 278	$ -	$ -	$ 82,950	$ -	$ 82,950
F_GS_797					YES	0101168	0101050	1	1.00	1,150	946.69	923.22	2.0%	8.01	4.94	6.48	2	1.5	0.41	0.41	$ 278	$ -	$ -	$ 319,647	$ -	$ 319,647
F_GS_798					NO																					
F_GS_799					NO																					
F_GS_801	38				NO																					
F_GS_803					YES	0101050	0101047	1	3.00	234	923.22	910.72	5.3%	4.94	10.23	7.59	2	2.1	0.1	0.03	$ 700	$ -	$ -	$ 163,730	$ -	$ 163,730
F_GS_805					YES	0101016	0101015	1	1.25	156	895.77	889.35	4.1%	9.36	9.58	9.47	2	2.3	0.4	0.32	$ 298	$ -	$ -	$ 46,563	$ -	$ 46,563
F_GS_806					YES	0101015	0101014	1	1.25	267	889.35	883.39	2.2%	9.58	8.43	9.01	2	2.6	0.55	0.44	$ 298	$ -	$ -	$ 79,444	$ -	$ 79,444
F_GS_807					YES	1601056	1601051	1	3.00	135	971.00	970.50	0.4%	11.44	11.50	11.47	3	15.0	0.57	0.19	$ 875	$ -	$ -	$ 118,169	$ -	$ 118,169
F_GS_808					YES	1601016	1601045	1	5.00	50	979.38	977.00	4.8%	6.55	7.87	7.21	2	18.3	0.68	0.14	$ 1,163	$ -	$ -	$ 58,150	$ -	$ 58,150
F_GS_809					YES	1601029	1601045	1	4.00	30	978.50	977.00	5.0%	7.92	7.87	7.89	2	28.0	0.88	0.22	$ 937	$ -	$ -	$ 28,110	$ -	$ 28,110
F_GS_810					YES	0101002	0101167	1	1.75	169	856.72	855.24	0.9%	9.06	13.09	11.08	3	3.9	1	0.57	$ 464	$ -	$ -	$ 78,337	$ -	$ 78,337
F_GS_812					NO																					
F_GS_813		20			NO																					
F_GS_815					NO																					
F_GS_816					NO																					
F_GS_817	38				NO																					
F_GS_818		148			NO																					
F_GS_819					YES	0120137	0120023	1	2.00	144	1006.44	1005.79	0.5%	11.46	8.00	9.73	2	0.7	0.18	0.09	$ 422	$ -	$ -	$ 60,907	$ -	$ 60,907
F_GS_820					NO																					
F_GS_821					NO																					
F_GS_822					NO																					
F_GS_823					NO																					
F_GS_824					YES	0122026	0122025	1	1.25	289	905.12	902.44	0.9%	9.78	7.14	8.46	2	0.6	0.27	0.22	$ 298	$ -	$ -	$ 85,991	$ -	$ 85,991
F_GS_825		95			NO																					
F_GS_826					NO																					
F_GS_827					YES	0128021	0123018	1	1.25	270	937.29	933.50	1.4%	9.67	10.50	10.09	3	1.0	0.36	0.29	$ 373	$ -	$ -	$ 100,766	$ -	$ 100,766
F_GS_828					NO																					

F_GS_829					NO																					
F_GS_830	222				YES	0101020	0101018	1	1.00	496	907.11	902.31	1.0%	15.73	15.63	15.68	4	2.2	0.79	0.79	$ 417	$ -	$ 480	$ 220,612	$ -	$ 220,612
F_GS_831					YES	0101012	0101039	1	1.25	138	882.29	881.54	0.5%	9.21	8.61	8.91	2	4.0	0.82	0.66	$ 298	$ -	$ -	$ 41,225	$ -	$ 41,225
F_GS_832					NO																					
F_GS_833					NO																					
F_GS_834					NO																					
F_GS_835					YES	0135025	0135023	1	1.00	305	952.69	950.09	0.9%	10.71	8.63	9.67	2	1.3	1	1.00	$ 278	$ -	$ -	$ 84,857	$ -	$ 84,857
F_GS_836	57				NO																					
F_GS_837					NO																					
F_GS_838					NO																					
F_GS_839					YES	0103054	0103196	1	1.25	473	872.53	869.97	0.5%	11.17	10.10	10.64	3	4.4	1	0.80	$ 373	$ -	$ -	$ 176,328	$ -	$ 176,328
F_GS_840					NO																					
F_GS_841					NO																					
F_GS_842		335			NO																					
F_GS_843	67				NO																					
F_GS_844					NO																					
F_GS_845					YES	0101036	0101034	1	1.50	793	871.17	865.17	0.8%	5.38	7.61	6.50	2	2.9	0.57	0.38	$ 319	$ -	$ -	$ 252,989	$ -	$ 252,989
F_GS_846					NO																					
F_GS_847					YES	rush_Creek_Bypa	0129006	1	1.00	508	926.85	919.16	1.5%	11.36	6.51	8.94	2	0.7	0.5	0.50	$ 278	$ -	$ -	$ 141,207	$ -	$ 141,207
F_GS_848					NO																					
F_GS_849					NO																					
F_GS_850					NO																					
F_CC_51					YES	0129001	0129008	1	1.50	190	909.32	909.27	0.0%	12.78	11.94	12.36	3	0.7	1	0.67	$ 399	$ -	$ -	$ 75,742	$ -	$ 75,742
F_CC_52					NO																					
F_CC_53					YES	0122044	0122040	1	1.50	70	905.87	903.92	2.8%	7.93	9.37	8.65	2	1.3	0.41	0.27	$ 319	$ -	$ -	$ 22,330	$ -	$ 22,330
F_CC_54					YES	0128002	0128003	1	1.25	37	941.35	941.19	0.4%	10.75	10.96	10.86	3	0.2	0.52	0.42	$ 373	$ -	$ -	$ 13,816	$ -	$ 13,816
F_CC_55					NO																					
F_CC_56					YES	0122006	0122019	1	2.00	40	883.06	880.74	5.8%	12.51	14.42	13.47	3	5.0	1	0.50	$ 528	$ -	$ -	$ 21,120	$ -	$ 21,120
F_CC_57					YES	0103038	0103018	1	2.50	80	863.64	861.68	2.5%	8.07	8.57	8.32	2	11.9	0.68	0.27	$ 587	$ -	$ -	$ 46,960	$ -	$ 46,960
F_CC_58					NO																					
F_CC_59					YES	0120032	0120004	1	1.75	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.8	0.66	0.38	$ 464	$ -	$ -	$ 18,560	$ -	$ 18,560
F_CC_60					YES	0108028	0108017	1	1.00	31	907.35	906.42	3.0%	20.54	20.98	20.76	4	0.6	0.86	0.86	$ 417	$ -	$ -	$ 12,839	$ -	$ 12,839
F_CC_61		20			NO																					
F_CC_62	22				NO																					
F_CC_63	32				YES	0114022	0114005	1	1.00	40	950.00	950.03	-0.1%	8.25	8.16	8.21	2	0.2	0.69	0.69	$ 278	$ -	$ 320	$ 12,478	$ -	$ 12,478
F_CC_64					YES	0103196	0103053	1	2.50	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	7.4	0.67	0.27	$ 734	$ -	$ -	$ 25,690	$ -	$ 25,690
F_CC_65					YES	0133034	0133005	1	2.50	171	926.33	925.83	0.3%	14.04	13.83	13.94	3	3.1	0.74	0.30	$ 734	$ -	$ -	$ 125,477	$ -	$ 125,477
F_CC_66					NO																					
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																					
F_LS_02	47				NO																					
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					
F_LS_52					NO																					
F_LS_53		180			NO																					
F_LS_54					NO																					
F_LS_55		435			NO																					
FORCE MAIN (NELSON COMPLEX)																								**$ 8,119,770**	**$ -**	**$ 8,119,770**
FORCE MAIN (TUKEY CREEK)																								**$ 2,303,000**	**$ -**	**$ 2,303,000**
PS_TurkeyCreek					YES	TCPSWW	0345082	1	2.50	3,500	-	-	-	-	-	-	2	38.0	-	-	$ 658	$ -	$ -	$ 2,303,000	$ -	$ 2,303,000
FORCE MAIN (MISSION MAIN)																								**$ 5,816,770**	**$ -**	**$ 5,816,770**
PS_Belinder	439				YES	BLPSWW	1601029	1	2.00	10,604	-	-	-	-	-	-	2	20.0	-	-	$ 527	$ -	$ 606	$ 5,622,994	$ -	$ 5,622,994
PS_BrushCreek	9,673				NO			1		10,623	-	-	-	-	-	-	2		-	-						
PS_RockCreek	5,030				NO			1		7,047	-	-	-	-	-	-	2		-	-						
PS_RoeVillage					NO			1		351	-	-	-	-	-	-	2		-	-						
PS_Swatzell					YES	SZPSWW	0101168	1	0.67	1,101	-	-	-	-	-	-	2	2.8	-	-	$ 176	$ -	$ -	$ 193,776	$ -	$ 193,776

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

*SPS Expansion Cost Curve used for Prelim Runs

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 9,302,194**	**$ 1,933,852**	**$ 11,236,046**
TURKEY CREEK							**$ 4,555,300**	**$ 1,034,146**	**$ 5,589,446**
PS_TurkeyCreek	27.0	YES	TCPSWW	0345082	38.0	11.0	$ 4,555,300	$ 1,034,146	$ 5,589,446
MISSION MAIN							**$ 4,746,894**	**$ 899,707**	**$ 5,646,600**
PS_Belinder	11.6	YES	BLPSWW	1601029	20.0	8.4	$ 3,678,216	$ 789,711	$ 4,467,927
PS_BrushCreek	6.0	NO	BCPSWW	0113002	6.0		$ -	$ -	$ -
PS_Granthurst	5.5	NO	GTPSWW	0123091	5.2		$ -	$ -	$ -
PS_MissionWoods	1.2	NO	MWPSWW	0101011	1.2		$ -	$ -	$ -
PS_RockCreek	15.5	NO	RCPSWW	1601016	15.5		$ -	$ -	$ -
PS_RoeVillage	0.4	NO	RVPSWW	1601037	0.1		$ -	$ -	$ -
PS_Swatzell	1.6	YES	SZPSWW	0101168	2.8	1.2	$ 1,068,678	$ 109,995	$ 1,178,673

OPTIMISATION SOLUTION SUMMARY:
STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
STORAGE FACILITY TOTAL						**$ 28,588,801**	**$ 65,919**	**$ 28,654,720**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ -**	**$ -**	**$ -**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST_01	F_ST_01_IN	NO						
F_ST_02	F_ST_02_IN	NO						
F_ST_03	F_ST_03_IN	NO						
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	NO						
F_ST_06	F_ST_06_IN	NO						
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST_51	F_ST_51_IN	NO						
F_ST_52	F_ST_52_IN	NO						
F_ST_53	F_ST_53_IN	NO						
F_ST_54	F_ST_54_IN	NO						
F_ST_55	F_ST_55_IN	NO						
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TOTAL)						**$ 28,588,801**	**$ 65,919**	**$ 28,654,720**
STORAGE FACILITY - FACILITY PROTECTION DEVICE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	YES	5.0	0.0	0.00	$ -	$ -	$ -
STORAGE FACILITY - FACILITY PROTECTION DEVICE (MISSION MAIN)						**$ 28,588,801**	**$ 65,919**	**$ 28,654,720**
F_ST-FPD_BC	F_ST-FPD_BC_IN	YES	2.0	6.9	2.38	$ 13,265,627	$ 37,355	$ 13,302,982
F_ST-FPD_BL	F_ST-FPD_BL_IN	YES	3.5	9.1	0.68	$ 6,765,321	$ 10,592	$ 6,775,913
F_ST-FPD_MW	F_ST-FPD_MW_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	5.0	6.7	1.15	$ 8,557,853	$ 17,972	$ 8,575,825

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX								**$ -**	**$ -**	**$ -**
TURKEY CREEK								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek_PEFTF	TC_PEFTF_OUTFALL	22.0	NO	TC_PEFTF_WW	FMOutletEFB	0.0	0.0	$ -	$ -	$ -
MISSION MAIN								**$ -**	**$ -**	**$ -**
PS_Belinder_PEFTF	Belinder_Outfall	53.1	NO	BLPEFTFWW	Belinder_PEFTF_Tank	0.0	0.0	$ -	$ -	$ -
PS_Martway_PEFTF	Martway_Discharge	20.0	NO	Martway_HS_Wet_Well	Martway_Tank	0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	Nall_Outfall	20.0	NO	Nall_Wet_Well	Nall_Tank	0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
I/I REDUCTION

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	Scaling Factor	% Reduction	I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL						**$ 12,919,975**	**$ -**	**$ 12,919,975**
TURKEY CREEK TOTAL						**$ 802,224**	**$ -**	**$ 802,224**
FM_202	0309015	24	NO	1.00		$ -	$ -	$ -
FM_203	0310001	82	NO	1.00		$ -	$ -	$ -
FM_204	0320011	22	NO	1.00		$ -	$ -	$ -
FM_205	0323001	42	NO	1.00		$ -	$ -	$ -
FM_206	0331001	78	NO	1.00		$ -	$ -	$ -
FM_207	0336001	130	NO	1.00		$ -	$ -	$ -
FM_208	0341001	54	YES	0.95	5%	$ 802,224	$ -	$ 802,224
FM_209	0323131	56	NO	1.00		$ -	$ -	$ -
FM_210	0327001	31	NO	1.00		$ -	$ -	$ -
FM_211	0321001	3	NO	1.00		$ -	$ -	$ -
FM_TC PS	0301003	41	NO	1.00		$ -	$ -	$ -
MISSION MAIN TOTAL						**$ 12,117,752**	**$ -**	**$ 12,117,752**
FM_1	0115001	53	NO	1.00		$ -	$ -	$ -
FM_101, 102	0107004	63	YES	0.80	20%	$ 1,215,915	$ -	$ 1,215,915
FM_103	0108002	54	YES	0.95	5%	$ 201,380	$ -	$ 201,380
FM_104, 105	0108020	53	YES	0.80	20%	$ 1,381,859	$ -	$ 1,381,859
FM_106, 107	0110018	45	NO	1.00		$ -	$ -	$ -
FM_108	0115043	24	NO	1.00		$ -	$ -	$ -
FM_109, 110	0123002	126	YES	0.95	5%	$ 475,100	$ -	$ 475,100
FM_111	0122027	2	NO	1.00		$ -	$ -	$ -
FM_112	0112058	14	YES	0.90	10%	$ 136,210	$ -	$ 136,210
FM_113, 114	0122010	213	YES	0.70	30%	$ 8,601,069	$ -	$ 8,601,069
FM_115, 116	0126030	28	NO	1.00		$ -	$ -	$ -
FM_117	0133060	5	YES	0.95	5%	$ 106,220	$ -	$ 106,220
FM_118	0142001	7	NO	1.00		$ -	$ -	$ -
FM_119	0140014	17	NO	1.00		$ -	$ -	$ -
FM_12, 13	0133010	48	NO	1.00		$ -	$ -	$ -
FM_120	0141096	3	NO	1.00		$ -	$ -	$ -
FM_121, 122	0139008	21	NO	1.00		$ -	$ -	$ -
FM_123, 124	0115022	9	NO	1.00		$ -	$ -	$ -
FM_14, 15, 16	0135002	71	NO	1.00		$ -	$ -	$ -
FM_17, 18	0136001	110	NO	1.00		$ -	$ -	$ -
FM_2, 3	0103004	93	NO	1.00		$ -	$ -	$ -
FM_4	0113050	51	NO	1.00		$ -	$ -	$ -
FM_5, 7	0103012	66	NO	1.00		$ -	$ -	$ -
FM_6, 19	0101010	53	NO	1.00		$ -	$ -	$ -

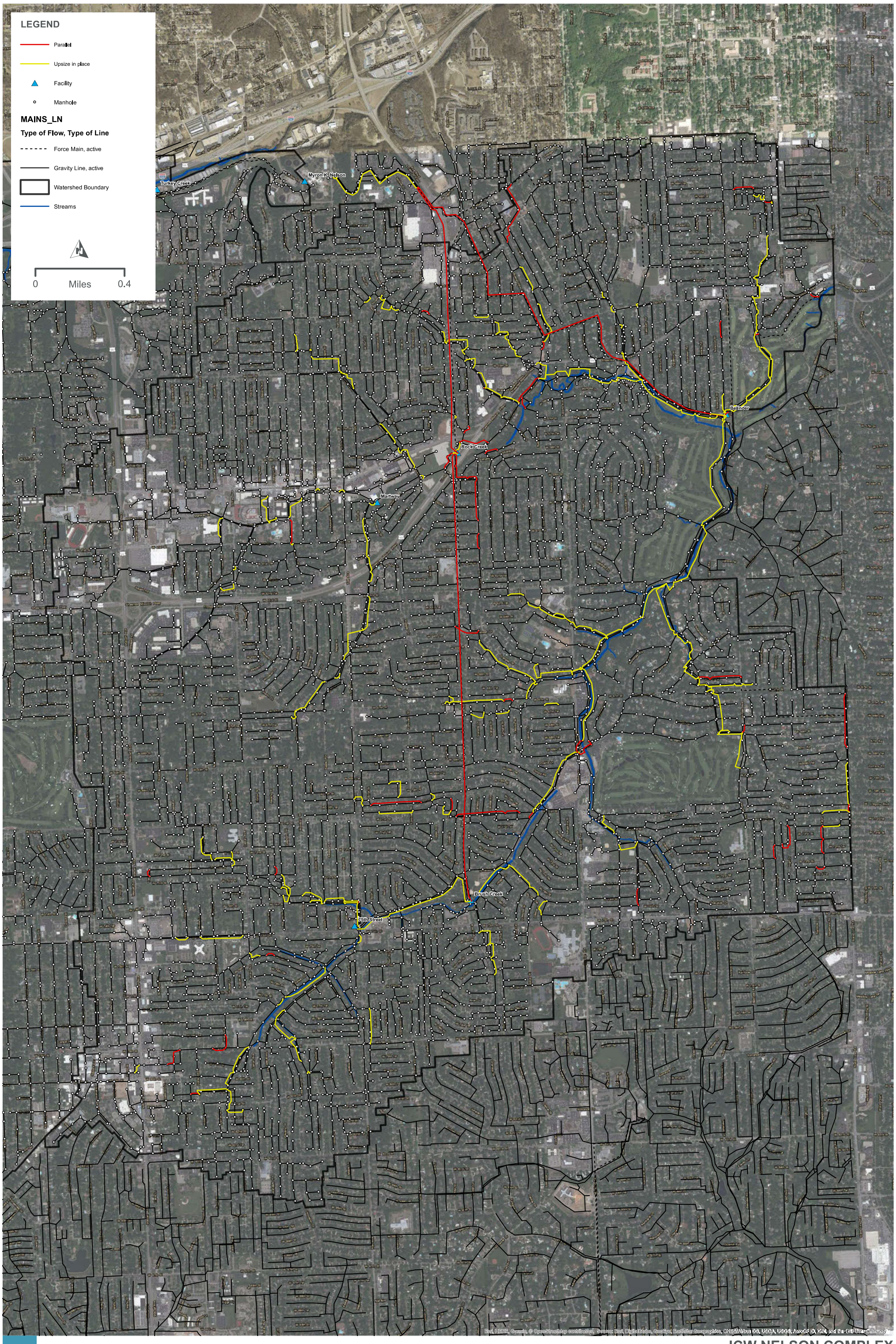
FM_9, 10	0134015	17	NO	1.00		$ -	$ -	$ -
FM_BC PS	0129005	30	NO	1.00		$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	1.00		$ -	$ -	$ -
FM_RC PS	0112006	66	NO	1.00		$ -	$ -	$ -
FM_ WWTF	1601002	5	NO	1.00		$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

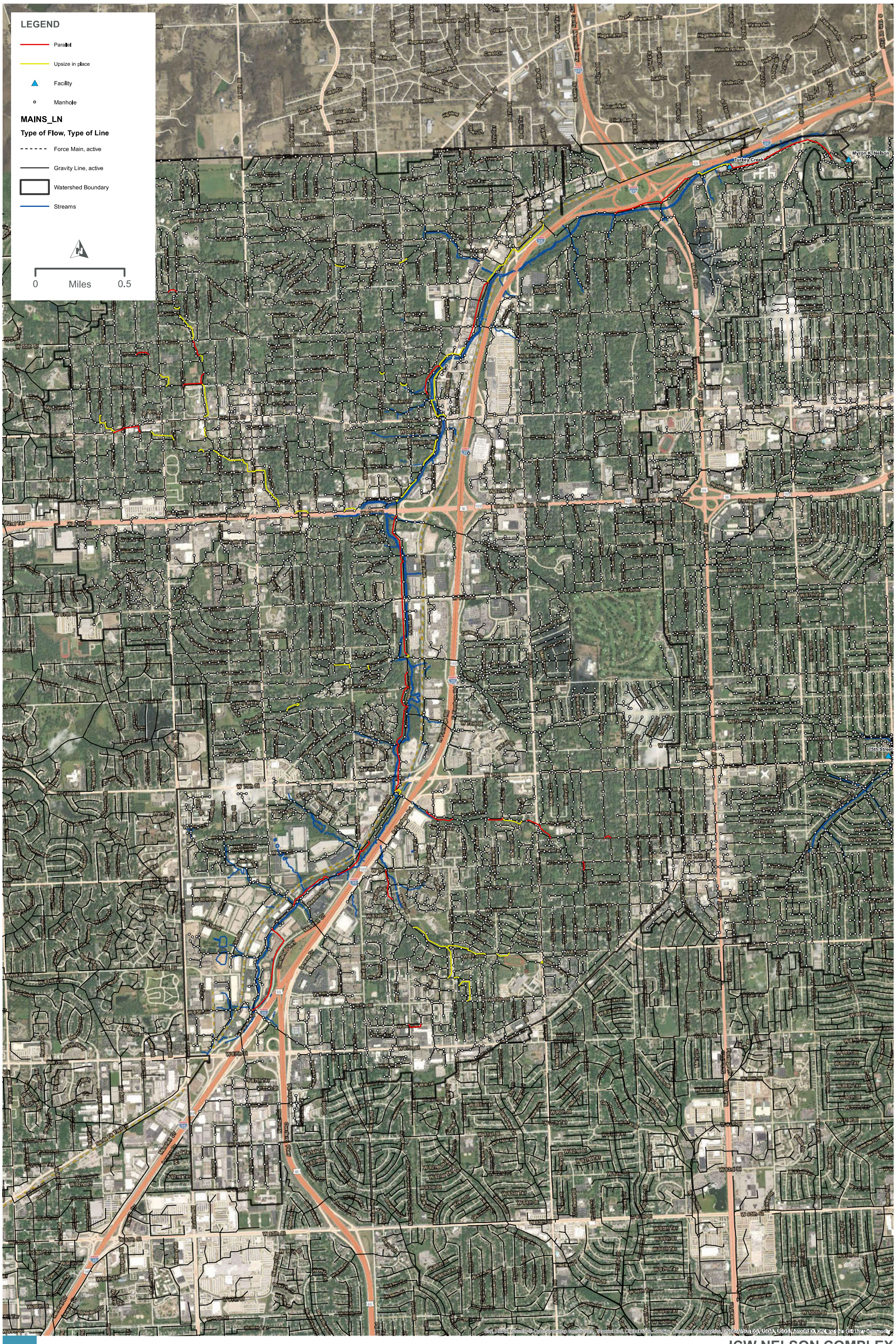
Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TOTAL COST				**$ 25,427,215**	**$ 1,877,103**	**$ 27,304,319**
Nelson_ATF	45	74.0	29.0	$ 25,427,215	$ 1,877,103	$ 27,304,319
0345082.1	29.1	38.1	8.9	$ 7,833,434	$ 578,285	$ 8,411,719
1601051.1	15.9	36.0	20.1	$ 17,593,781	$ 1,298,819	$ 18,892,600

Appendix C – Gravity Main Refined Upgrade Recommendations



JCW NELSON COMPLEX

MTM1 PARALLEL VS UPSIZE-IN-PLACE



JCW NELSON COMPLEX

SMTC PARALLEL VS UPSIZE-IN-PLACE

PATH: C:\USERS\KMASCHMANN\DESKTOP\JCW - GIS\MXDS & MAP PACKAGES\JCW NELSON UPSIZE V PARALLEL MTM1.MXD - USER: KMASCHMANN - DATE: 8/14/2018

(REPORT NAME)

Appendix D – Pump Station Refined Cost Curve Development

Brush Creek Pump Station Cost Curve

Description	New Parallel 12" FM, Upsize Station Capacity to 8.4 MGD		New Parallel 16" FM, Upsize Station Capacity to 10.8 MGD		New Parallel 20" FM, Upsize Station Capacity to 12.1 MGD		New Parallel 20" FM, Upsize Station Capacity to 12.1 MGD, New 1.7 MGD WWPS		New Parallel 24" FM, Upsize Station Capacity to 12.1 MGD, New 5.4 MGD WWPS		New Parallel 30" FM, Upsize Station Capacity to 12.1 MGD, New 7.9 MGD WWPS	
Firm Pump Station Capacity (MGD)	**5.5**	**8.4**	**8.4**	**10.8**	**10.8**	**12.1**	**12.1**	**13.8**	**13.8**	**17.5**	**17.5**	**20.0**
Concrete/Structural Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 49,000	$ 49,000	$ 153,000	$ 153,000	$ 224,000
Process Piping	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 16,000	$ 16,000	$ 49,000	$ 49,000	$ 72,000
Process Equipment	$ -	$ 115,000	$ 115,000	$ 148,000	$ 148,000	$ 165,000	$ 165,000	$ 189,000	$ 189,000	$ 239,000	$ 239,000	$ 273,000
Pumps	$ -	$ 329,000	$ 329,000	$ 423,000	$ 423,000	$ 474,000	$ 474,000	$ 531,000	$ 531,000	$ 654,000	$ 654,000	$ 738,000
Electrical	$ 50,000	$ 329,000	$ 329,000	$ 423,000	$ 423,000	$ 474,000	$ 474,000	$ 526,000	$ 526,000	$ 638,000	$ 638,000	$ 714,000
Building Improvements	$ -	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000
Subtotal, Itemized Costs	**$ 50,000**	**$ 983,000**	**$ 983,000**	**$ 1,204,000**	**$ 1,204,000**	**$ 1,323,000**	**$ 1,533,000**	**$ 1,731,000**	**$ 1,731,000**	**$ 2,153,000**	**$ 2,153,000**	**$ 2,441,000**
Site (5%)	$ 3,000	$ 50,000	$ 50,000	$ 61,000	$ 61,000	$ 67,000	$ 77,000	$ 87,000	$ 87,000	$ 108,000	$ 108,000	$ 123,000
Site Electrical (15%)	$ 8,000	$ 148,000	$ 148,000	$ 181,000	$ 181,000	$ 199,000	$ 230,000	$ 260,000	$ 260,000	$ 323,000	$ 323,000	$ 367,000
General Req., Demolition, Misc. (5%)	$ 3,000	$ 50,000	$ 50,000	$ 61,000	$ 61,000	$ 67,000	$ 77,000	$ 87,000	$ 87,000	$ 108,000	$ 108,000	$ 123,000
Subtotal, Itemized Costs and Direct Markups	**$ 64,000**	**$ 1,231,000**	**$ 1,231,000**	**$ 1,507,000**	**$ 1,507,000**	**$ 1,656,000**	**$ 1,917,000**	**$ 2,165,000**	**$ 2,165,000**	**$ 2,692,000**	**$ 2,692,000**	**$ 3,054,000**
Contractor Markup (17.5%)	$ 12,000	$ 216,000	$ 216,000	$ 264,000	$ 264,000	$ 290,000	$ 336,000	$ 379,000	$ 379,000	$ 472,000	$ 472,000	$ 535,000
Pump Station Construction Cost	**$ 76,000**	**$ 1,447,000**	**$ 1,447,000**	**$ 1,771,000**	**$ 1,771,000**	**$ 1,946,000**	**$ 2,253,000**	**$ 2,544,000**	**$ 2,544,000**	**$ 3,164,000**	**$ 3,164,000**	**$ 3,589,000**
Contingency and ELA (62.5%)	$ 48,000	$ 905,000	$ 905,000	$ 1,107,000	$ 1,107,000	$ 1,217,000	$ 1,409,000	$ 1,590,000	$ 1,590,000	$ 1,978,000	$ 1,978,000	$ 2,244,000
Total Pump Station Cost	**$ 124,000**	**$ 2,352,000**	**$ 2,352,000**	**$ 2,878,000**	**$ 2,878,000**	**$ 3,163,000**	**$ 3,662,000**	**$ 4,134,000**	**$ 4,134,000**	**$ 5,142,000**	**$ 5,142,000**	**$ 5,833,000**
Total Pump Station Cost ($M)	**$ 0.1**	**$ 2.4**	**$ 2.4**	**$ 2.9**	**$ 2.9**	**$ 3.2**	**$ 3.7**	**$ 4.1**	**$ 4.1**	**$ 5.1**	**$ 5.1**	**$ 5.8**
Forcemain Improvements	$ 1,978,000	$ 1,978,000	$ 2,637,000	$ 2,637,000	$ 3,296,000	$ 3,296,000	$ 3,296,000	$ 3,296,000	$ 3,955,000	$ 3,955,000	$ 4,944,000	$ 4,944,000
Contingency and ELA (62.5%)	$ 1,237,000	$ 1,237,000	$ 1,649,000	$ 1,649,000	$ 2,060,000	$ 2,060,000	$ 2,060,000	$ 2,060,000	$ 2,472,000	$ 2,472,000	$ 3,090,000	$ 3,090,000
Total Forcemain Cost	**$ 3,215,000**	**$ 3,215,000**	**$ 4,286,000**	**$ 4,286,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 6,427,000**	**$ 6,427,000**	**$ 8,034,000**	**$ 8,034,000**
Total Forcemain Base Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incremental Forcemain Cost	**$ 3,215,000**	**$ 3,215,000**	**$ 4,286,000**	**$ 4,286,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 5,356,000**	**$ 6,427,000**	**$ 6,427,000**	**$ 8,034,000**	**$ 8,034,000**
Incremental Forcemain Cost ($M)	**$ 3.2**	**$ 3.2**	**$ 4.3**	**$ 4.3**	**$ 5.4**	**$ 5.4**	**$ 5.4**	**$ 5.4**	**$ 6.4**	**$ 6.4**	**$ 8.0**	**$ 8.0**
Total Project Cost	**$ 3,339,000**	**$ 5,567,000**	**$ 6,638,000**	**$ 7,164,000**	**$ 8,234,000**	**$ 8,519,000**	**$ 9,018,000**	**$ 9,490,000**	**$ 10,561,000**	**$ 11,569,000**	**$ 13,176,000**	**$ 13,867,000**
Total Project Cost ($M)	**$ 3.3**	**$ 5.6**	**$ 6.6**	**$ 7.2**	**$ 8.2**	**$ 8.5**	**$ 9.0**	**$ 9.5**	**$ 10.6**	**$ 11.6**	**$ 13.2**	**$ 13.9**

Rock Creek Pump Station Cost Curve

Description	Extend Existing FM	Extend Existing FM, New Parallel 18" FM, Upsize Station Capacity to 19 MGD		New Parallel 24" FM, Upsize Station Capacity to 21.6 MGD		New Parallel 24" FM, Upsize Station Capacity to 21.6 MGD, New 2.7 MGD WWPS		New Parallel 30" FM, Upsize Station Capacity to 21.6 MGD, New 9.6 MGD WWPS		New Parallel 36" FM, Upsize Station Capacity to 21.6 MGD, New 17.9 MGD WWPS		New Parallel 42" FM, Upsize Station Capacity to 21.6 MGD, New 27.8 MGD WWPS	
Firm Pump Station Capacity (MGD)	**12.0**	**12.0**	**19.0**	**19.0**	**21.6**	**21.6**	**24.3**	**24.3**	**31.2**	**31.2**	**39.5**	**39.5**	**49.4**
Concrete/Structural Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ 77,000	$ 77,000	$ 272,000	$ 272,000	$ 507,000	$ 507,000	$ 787,000
Process Piping	$ -	$ -	$ -	$ -	$ -	$ -	$ 25,000	$ 25,000	$ 87,000	$ 87,000	$ 162,000	$ 162,000	$ 251,000
Process Equipment	$ -	$ -	$ 260,000	$ 260,000	$ 295,000	$ 295,000	$ 332,000	$ 332,000	$ 426,000	$ 426,000	$ 540,000	$ 540,000	$ 675,000
Pumps	$ -	$ -	$ 731,000	$ 731,000	$ 830,000	$ 830,000	$ 969,000	$ 969,000	$ 1,321,000	$ 1,321,000	$ 1,746,000	$ 1,746,000	$ 2,252,000
Electrical	$ -	$ -	$ 731,000	$ 731,000	$ 830,000	$ 830,000	$ 956,000	$ 956,000	$ 1,277,000	$ 1,277,000	$ 1,663,000	$ 1,663,000	$ 2,123,000
Building Improvements	$ -	$ -	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000
Subtotal, Itemized Costs	**$ -**	**$ -**	**$ 1,932,000**	**$ 1,932,000**	**$ 2,165,000**	**$ 2,165,000**	**$ 2,779,000**	**$ 2,779,000**	**$ 3,803,000**	**$ 3,803,000**	**$ 5,038,000**	**$ 5,038,000**	**$ 6,508,000**
Site (5%)	$ -	$ -	$ 97,000	$ 97,000	$ 109,000	$ 109,000	$ 139,000	$ 139,000	$ 191,000	$ 191,000	$ 252,000	$ 252,000	$ 326,000
Site Electrical (15%)	$ -	$ -	$ 290,000	$ 290,000	$ 325,000	$ 325,000	$ 417,000	$ 417,000	$ 571,000	$ 571,000	$ 756,000	$ 756,000	$ 977,000
General Req., Demolition, Misc. (5%)	$ -	$ -	$ 97,000	$ 97,000	$ 109,000	$ 109,000	$ 139,000	$ 139,000	$ 191,000	$ 191,000	$ 252,000	$ 252,000	$ 326,000
Subtotal, Itemized Costs and Direct Markups	**$ -**	**$ -**	**$ 2,416,000**	**$ 2,416,000**	**$ 2,708,000**	**$ 2,708,000**	**$ 3,474,000**	**$ 3,474,000**	**$ 4,756,000**	**$ 4,756,000**	**$ 6,298,000**	**$ 6,298,000**	**$ 8,137,000**
Contractor Markup (17.5%)	$ -	$ -	$ 423,000	$ 423,000	$ 474,000	$ 474,000	$ 608,000	$ 608,000	$ 833,000	$ 833,000	$ 1,103,000	$ 1,103,000	$ 1,424,000
Pump Station Construction Cost	**$ -**	**$ -**	**$ 2,839,000**	**$ 2,839,000**	**$ 3,182,000**	**$ 3,182,000**	**$ 4,082,000**	**$ 4,082,000**	**$ 5,589,000**	**$ 5,589,000**	**$ 7,401,000**	**$ 7,401,000**	**$ 9,561,000**
Contingency and ELA (62.5%)	$ -	$ -	$ 1,775,000	$ 1,775,000	$ 1,989,000	$ 1,989,000	$ 2,552,000	$ 2,552,000	$ 3,494,000	$ 3,494,000	$ 4,626,000	$ 4,626,000	$ 5,976,000
Total Pump Station Cost	**$ -**	**$ -**	**$ 4,614,000**	**$ 4,614,000**	**$ 5,171,000**	**$ 5,171,000**	**$ 6,634,000**	**$ 6,634,000**	**$ 9,083,000**	**$ 9,083,000**	**$ 12,027,000**	**$ 12,027,000**	**$ 15,537,000**
Total Pump Station Cost ($M)	**$ -**	**$ -**	**$ 4.6**	**$ 4.6**	**$ 5.2**	**$ 5.2**	**$ 6.6**	**$ 6.6**	**$ 9.1**	**$ 9.1**	**$ 12.0**	**$ 12.0**	**$ 15.5**
Forcemain Improvements	$ 947,000	$ 3,559,000	$ 3,559,000	$ 4,429,000	$ 4,429,000	$ 4,429,000	$ 4,429,000	$ 5,300,000	$ 5,300,000	$ 6,171,000	$ 6,171,000	$ 7,041,000	$ 7,041,000
Contingency and ELA (62.5%)	$ 592,000	$ 2,225,000	$ 2,225,000	$ 2,769,000	$ 2,769,000	$ 2,769,000	$ 2,769,000	$ 3,313,000	$ 3,313,000	$ 3,857,000	$ 3,857,000	$ 4,401,000	$ 4,401,000
Total Forcemain Cost	**$ 1,539,000**	**$ 5,784,000**	**$ 5,784,000**	**$ 7,198,000**	**$ 7,198,000**	**$ 7,198,000**	**$ 7,198,000**	**$ 8,613,000**	**$ 8,613,000**	**$ 10,028,000**	**$ 10,028,000**	**$ 11,442,000**	**$ 11,442,000**
Total Forcemain Base Cost	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000	$ 1,539,000
Incremental Forcemain Cost	**$ -**	**$ 4,245,000**	**$ 4,245,000**	**$ 5,659,000**	**$ 5,659,000**	**$ 5,659,000**	**$ 5,659,000**	**$ 7,074,000**	**$ 7,074,000**	**$ 8,489,000**	**$ 8,489,000**	**$ 9,903,000**	**$ 9,903,000**
Incremental Forcemain Cost ($M)	**$ -**	**$ 4.2**	**$ 4.2**	**$ 5.7**	**$ 5.7**	**$ 5.7**	**$ 5.7**	**$ 7.1**	**$ 7.1**	**$ 8.5**	**$ 8.5**	**$ 9.9**	**$ 9.9**
Total Project Cost	**$ -**	**$ 4,245,000**	**$ 8,859,000**	**$ 10,273,000**	**$ 10,830,000**	**$ 10,830,000**	**$ 12,293,000**	**$ 13,708,000**	**$ 16,157,000**	**$ 17,572,000**	**$ 20,516,000**	**$ 21,930,000**	**$ 25,440,000**
Total Project Cost ($M)	**$ -**	**$ 4.2**	**$ 8.9**	**$ 10.3**	**$ 10.8**	**$ 10.8**	**$ 12.3**	**$ 13.7**	**$ 16.2**	**$ 17.6**	**$ 20.5**	**$ 21.9**	**$ 25.4**

Belinder Pump Station Cost Curve

Description	Extend Existing FM, New Parallel 18" FM, Upsize Station Capacity to 19 MGD		New Parallel 24" FM, Upsize Station Capacity to 21.7 MGD		New Parallel 24" FM, Upsize Station Capacity to 24.3 MGD, Upsize DW Pump Suction Lines		New Parallel 30" FM, Upsize Station Capacity to 27.4 MGD, Upsize DW Pump Suction Lines		New Parallel 30" FM, Upsize DWPS, Replace PEFTF Pumps for 3.8 MGD to WWTF		New Parallel 36" FM, Upsize DWPS, Replace PEFTF Pumps for 12.1 MGD to WWTF		New Parallel 42" FM, Upsize DWPS, Replace PEFTF Pumps for 22 MGD to WWTF		New Parallel 48" FM, Upsize DWPS, Replace PEFTF Pumps for 33.5 MGD to WWTF		New Parallel 54" FM, Upsize DWPS, Replace PEFTF Pumps for 37.6 MGD to WWTF	
Firm Pump Station Capacity (MGD)	**10.6**	**19.0**	**19.0**	**21.6**	**21.7**	**24.3**	**24.3**	**27.4**	**27.4**	**31.2**	**31.2**	**39.5**	**39.5**	**49.4**	**49.4**	**60.9**	**60.9**	**65.0**
Concrete/Structural Improvements	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 10,000	$ 10,000	$ 30,000	$ 30,000	$ 53,000	$ 53,000	$ 81,000	$ 81,000	$ 91,000
Process Piping	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 58,000	$ 58,000	$ 183,000	$ 183,000	$ 333,000	$ 333,000	$ 506,000	$ 506,000	$ 568,000
Process Equipment	$ -	$ 260,000	$ 260,000	$ 295,000	$ 296,000	$ 332,000	$ 332,000	$ 374,000	$ 374,000	$ 426,000	$ 426,000	$ 539,000	$ 539,000	$ 674,000	$ 674,000	$ 831,000	$ 831,000	$ 887,000
Pumps	$ -	$ 1,074,000	$ 1,074,000	$ 1,221,000	$ 1,227,000	$ 1,374,000	$ 1,374,000	$ 1,549,000	$ 1,549,000	$ 1,811,000	$ 1,811,000	$ 2,383,000	$ 2,383,000	$ 3,064,000	$ 3,064,000	$ 3,856,000	$ 3,856,000	$ 4,138,000
Electrical	$ -	$ 1,074,000	$ 1,074,000	$ 1,221,000	$ 1,227,000	$ 1,374,000	$ 1,374,000	$ 1,549,000	$ 1,549,000	$ 1,787,000	$ 1,787,000	$ 2,307,000	$ 2,307,000	$ 2,927,000	$ 2,927,000	$ 3,646,000	$ 3,646,000	$ 3,903,000
Building Improvements	$ -	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000
Subtotal, Itemized Costs	**$ -**	**$ 2,618,000**	**$ 2,618,000**	**$ 2,947,000**	**$ 2,960,000**	**$ 3,290,000**	**$ 3,290,000**	**$ 3,682,000**	**$ 3,682,000**	**$ 4,512,000**	**$ 4,512,000**	**$ 5,862,000**	**$ 5,862,000**	**$ 7,471,000**	**$ 7,471,000**	**$ 9,340,000**	**$ 9,340,000**	**$10,007,000**
Site (5%)	$ -	$ 131,000	$ 131,000	$ 148,000	$ 148,000	$ 165,000	$ 165,000	$ 185,000	$ 185,000	$ 226,000	$ 226,000	$ 294,000	$ 294,000	$ 374,000	$ 374,000	$ 467,000	$ 467,000	$ 501,000
Site Electrical (15%)	$ -	$ 393,000	$ 393,000	$ 443,000	$ 444,000	$ 494,000	$ 494,000	$ 553,000	$ 553,000	$ 677,000	$ 677,000	$ 880,000	$ 880,000	$ 1,121,000	$ 1,121,000	$ 1,401,000	$ 1,401,000	$ 1,502,000
General Req., Demolition, Misc. (5%)	$ -	$ 131,000	$ 131,000	$ 148,000	$ 148,000	$ 165,000	$ 165,000	$ 185,000	$ 185,000	$ 226,000	$ 226,000	$ 294,000	$ 294,000	$ 374,000	$ 374,000	$ 467,000	$ 467,000	$ 501,000
Subtotal, Itemized Costs and Direct Markups	**$ -**	**$ 3,273,000**	**$ 3,273,000**	**$ 3,686,000**	**$ 3,700,000**	**$ 4,114,000**	**$ 4,114,000**	**$ 4,605,000**	**$ 4,605,000**	**$ 5,641,000**	**$ 5,641,000**	**$ 7,330,000**	**$ 7,330,000**	**$ 9,340,000**	**$ 9,340,000**	**$11,675,000**	**$11,675,000**	**$12,511,000**
Contractor Markup (17.5%)	$ -	$ 573,000	$ 573,000	$ 646,000	$ 648,000	$ 720,000	$ 720,000	$ 806,000	$ 806,000	$ 988,000	$ 988,000	$ 1,283,000	$ 1,283,000	$ 1,635,000	$ 1,635,000	$ 2,044,000	$ 2,044,000	$ 2,190,000
Pump Station Construction Cost	**$ -**	**$ 3,846,000**	**$ 3,846,000**	**$ 4,332,000**	**$ 4,348,000**	**$ 4,834,000**	**$ 4,834,000**	**$ 5,411,000**	**$ 5,411,000**	**$ 6,629,000**	**$ 6,629,000**	**$ 8,613,000**	**$ 8,613,000**	**$10,975,000**	**$10,975,000**	**$13,719,000**	**$13,719,000**	**$14,701,000**
Contingency and ELA (62.5%)	$ -	$ 2,404,000	$ 2,404,000	$ 2,708,000	$ 2,718,000	$ 3,022,000	$ 3,022,000	$ 3,382,000	$ 3,382,000	$ 4,144,000	$ 4,144,000	$ 5,384,000	$ 5,384,000	$ 6,860,000	$ 6,860,000	$ 8,575,000	$ 8,575,000	$ 9,189,000
Total Pump Station Cost	**$ -**	**$ 6,250,000**	**$ 6,250,000**	**$ 7,040,000**	**$ 7,066,000**	**$ 7,856,000**	**$ 7,856,000**	**$ 8,793,000**	**$ 8,793,000**	**$10,773,000**	**$10,773,000**	**$13,997,000**	**$13,997,000**	**$17,835,000**	**$17,835,000**	**$22,294,000**	**$22,294,000**	**$23,890,000**
Total Pump Station Cost ($M)	**$ -**	**$ 6.3**	**$ 6.3**	**$ 7.0**	**$ 7.1**	**$ 7.9**	**$ 7.9**	**$ 8.8**	**$ 8.8**	**$ 10.8**	**$ 10.8**	**$ 14.0**	**$ 14.0**	**$ 17.8**	**$ 17.8**	**$ 22.3**	**$ 22.3**	**$ 23.9**
Forcemain Improvements	$ 4,340,000	$ 4,340,000	$ 5,470,000	$ 5,470,000	$ 5,470,000	$ 5,470,000	$ 6,601,000	$ 6,601,000	$ 6,601,000	$ 6,601,000	$ 7,732,000	$ 7,732,000	$ 8,863,000	$ 8,863,000	$ 9,994,000	$ 9,994,000	$11,125,000	$11,125,000
Contingency and ELA (62.5%)	$ 2,713,000	$ 2,713,000	$ 3,419,000	$ 3,419,000	$ 3,419,000	$ 3,419,000	$ 4,126,000	$ 4,126,000	$ 4,126,000	$ 4,126,000	$ 4,833,000	$ 4,833,000	$ 5,540,000	$ 5,540,000	$ 6,247,000	$ 6,247,000	$ 6,954,000	$ 6,954,000
Total Forcemain Cost	**$ 7,053,000**	**$ 7,053,000**	**$ 8,889,000**	**$ 8,889,000**	**$ 8,889,000**	**$ 8,889,000**	**$10,727,000**	**$10,727,000**	**$10,727,000**	**$10,727,000**	**$12,565,000**	**$12,565,000**	**$14,403,000**	**$14,403,000**	**$16,241,000**	**$16,241,000**	**$18,079,000**	**$18,079,000**
Total Forcemain Base Cost	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000	$ 7,053,000
Incremental Forcemain Cost	**$ -**	**$ -**	**$ 1,836,000**	**$ 1,836,000**	**$ 1,836,000**	**$ 1,836,000**	**$ 3,674,000**	**$ 3,674,000**	**$ 3,674,000**	**$ 3,674,000**	**$ 5,512,000**	**$ 5,512,000**	**$ 7,350,000**	**$ 7,350,000**	**$ 9,188,000**	**$ 9,188,000**	**$11,026,000**	**$11,026,000**
Incremental Forcemain Cost ($M)	**$ -**	**$ -**	**$ 1.8**	**$ 1.8**	**$ 1.8**	**$ 1.8**	**$ 3.7**	**$ 3.7**	**$ 3.7**	**$ 3.7**	**$ 5.5**	**$ 5.5**	**$ 7.4**	**$ 7.4**	**$ 9.2**	**$ 9.2**	**$ 11.0**	**$ 11.0**
Total Project Cost	**$ -**	**$ 6,250,000**	**$ 8,086,000**	**$ 8,876,000**	**$ 8,902,000**	**$ 9,692,000**	**$11,530,000**	**$12,467,000**	**$12,467,000**	**$14,447,000**	**$16,285,000**	**$19,509,000**	**$21,347,000**	**$25,185,000**	**$27,023,000**	**$31,482,000**	**$33,320,000**	**$34,916,000**
Total Project Cost ($M)	**$ -**	**$ 6.3**	**$ 8.1**	**$ 8.9**	**$ 8.9**	**$ 9.7**	**$ 11.5**	**$ 12.5**	**$ 12.5**	**$ 14.4**	**$ 16.3**	**$ 19.5**	**$ 21.3**	**$ 25.2**	**$ 27.0**	**$ 31.5**	**$ 33.3**	**$ 34.9**

Turkey Creek Pump Station Cost Curve

Description	Extend Existing FMs, Replace Pumps for Higher Head Condition		Upsize FM A from 24" to 30", Upsize DWPS to 36 MGD		Upsize FM A from 24" to 36", Upsize DWPS to 36 MGD, Replace PEFTF Pumps for 10 MGD to WWTF		Upsize FM A from 24" to 42", Upsize DWPS to 36 MGD, Replace PEFTF Pumps for 20 MGD to WWTF		Upsize FM A from 24" to 48", Upsize DWPS to 36 MGD, Replace PEFTF Pumps for 24 MGD to WWTF	
Firm Pump Station Capacity (MGD)	**27**	**31**	**31**	**36**	**36**	**46**	**46**	**56**	**56**	**60**
Concrete/Structural Improvements	$ -	$ -	$ -	$ -	$ -	$ 25,000	$ 25,000	$ 49,000	$ 49,000	$ 58,000
Process Piping	$ -	$ -	$ -	$ -	$ -	$ 158,000	$ 158,000	$ 307,000	$ 307,000	$ 363,000
Process Equipment	$ -	$ -	$ -	$ -	$ -	$ 142,000	$ 142,000	$ 277,000	$ 277,000	$ 328,000
Pumps	$ 1,467,000	$ 1,695,000	$ 1,695,000	$ 1,956,000	$ 1,956,000	$ 2,381,000	$ 2,381,000	$ 2,785,000	$ 2,785,000	$ 2,936,000
Electrical	$ 1,334,000	$ 1,541,000	$ 1,541,000	$ 1,778,000	$ 1,778,000	$ 2,164,000	$ 2,164,000	$ 2,532,000	$ 2,532,000	$ 2,669,000
Building Improvements	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 210,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000	$ 420,000
Subtotal, Itemized Costs	**$ 3,011,000**	**$ 3,446,000**	**$ 3,446,000**	**$ 3,944,000**	**$ 3,944,000**	**$ 5,290,000**	**$ 5,290,000**	**$ 6,370,000**	**$ 6,370,000**	**$ 6,774,000**
Site (5%)	$ 151,000	$ 173,000	$ 173,000	$ 198,000	$ 198,000	$ 265,000	$ 265,000	$ 319,000	$ 319,000	$ 339,000
Site Electrical (15%)	$ 452,000	$ 517,000	$ 517,000	$ 592,000	$ 592,000	$ 794,000	$ 794,000	$ 956,000	$ 956,000	$ 1,017,000
General Req., Demolition, Misc. (5%)	$ 151,000	$ 173,000	$ 173,000	$ 198,000	$ 198,000	$ 265,000	$ 265,000	$ 319,000	$ 319,000	$ 339,000
Subtotal, Itemized Costs and Direct Markups	**$ 3,765,000**	**$ 4,309,000**	**$ 4,309,000**	**$ 4,932,000**	**$ 4,932,000**	**$ 6,614,000**	**$ 6,614,000**	**$ 7,964,000**	**$ 7,964,000**	**$ 8,469,000**
Contractor Markup (17.5%)	$ 659,000	$ 755,000	$ 755,000	$ 864,000	$ 864,000	$ 1,158,000	$ 1,158,000	$ 1,394,000	$ 1,394,000	$ 1,483,000
Pump Station Construction Cost	**$ 4,424,000**	**$ 5,064,000**	**$ 5,064,000**	**$ 5,796,000**	**$ 5,796,000**	**$ 7,772,000**	**$ 7,772,000**	**$ 9,358,000**	**$ 9,358,000**	**$ 9,952,000**
Contingency and ELA (62.5%)	$ 2,765,000	$ 3,165,000	$ 3,165,000	$ 3,623,000	$ 3,623,000	$ 4,858,000	$ 4,858,000	$ 5,849,000	$ 5,849,000	$ 6,220,000
Total Pump Station Cost	**$ 7,189,000**	**$ 8,229,000**	**$ 8,229,000**	**$ 9,419,000**	**$ 9,419,000**	**$ 12,630,000**	**$ 12,630,000**	**$ 15,207,000**	**$ 15,207,000**	**$ 16,172,000**
Total Pump Station Cost ($M)	**$ 7.2**	**$ 8.2**	**$ 8.2**	**$ 9.4**	**$ 9.4**	**$ 12.6**	**$ 12.6**	**$ 15.2**	**$ 15.2**	**$ 16.2**
Forcemain Improvements	$ 1,022,000	$ 1,022,000	$ 2,592,000	$ 2,592,000	$ 2,996,000	$ 2,996,000	$ 3,401,000	$ 3,401,000	$ 3,806,000	$ 3,806,000
Contingency and ELA (62.5%)	$ 639,000	$ 639,000	$ 1,620,000	$ 1,620,000	$ 1,873,000	$ 1,873,000	$ 2,126,000	$ 2,126,000	$ 2,379,000	$ 2,379,000
Total Forcemain Cost	**$ 1,661,000**	**$ 1,661,000**	**$ 4,212,000**	**$ 4,212,000**	**$ 4,869,000**	**$ 4,869,000**	**$ 5,527,000**	**$ 5,527,000**	**$ 6,185,000**	**$ 6,185,000**
Total Forcemain Base Cost	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000	$ 1,661,000
Incremental Forcemain Cost	**$ -**	**$ -**	**$ 2,551,000**	**$ 2,551,000**	**$ 3,208,000**	**$ 3,208,000**	**$ 3,866,000**	**$ 3,866,000**	**$ 4,524,000**	**$ 4,524,000**
Incremental Forcemain Cost ($M)	**$ -**	**$ -**	**$ 2.6**	**$ 2.6**	**$ 3.2**	**$ 3.2**	**$ 3.9**	**$ 3.9**	**$ 4.5**	**$ 4.5**
Total Project Cost	**$ 7,189,000**	**$ 8,229,000**	**$ 10,780,000**	**$ 11,970,000**	**$ 12,627,000**	**$ 15,838,000**	**$ 16,496,000**	**$ 19,073,000**	**$ 19,731,000**	**$ 20,696,000**
Total Project Cost ($M)	**$ 7.2**	**$ 8.2**	**$ 10.8**	**$ 12.0**	**$ 12.6**	**$ 15.8**	**$ 16.5**	**$ 19.1**	**$ 19.7**	**$ 20.7**

Appendix E – PEFTF Refined Cost Curve Development

75th/Nall PEFTF Cost Curve

PEFTF Capacity (MGD)	10	20
Disc Filters(1)	$ 1,770,000	$ 3,540,000
Chemical Storage and Feed, Hypochlorite(2)	$ 155,000	$ 309,000
Chemical Storage and Feed, Bisulfite(2)	$ 121,000	$ 242,000
Contact Basin Improvements, Hypochlorite(3)	$ -	$ -
Contact Basin Improvements, Bisulfite(2)	$ -	$ -
Pumps	$ 157,000	$ 313,000
Electrical	$ 143,000	$ 285,000
Process Piping	$ 151,000	$ 302,000
Process Equipment	$ 137,000	$ 273,000
Subtotal, Itemized Costs	**$ 2,634,000**	**$ 5,264,000**
Yard Piping (5%)	$ 132,000	$ 264,000
Site (5%)	$ 132,000	$ 264,000
Site Electrical (15%)	$ 396,000	$ 790,000
General Req., Demolition, Misc. (5%)	$ 132,000	$ 264,000
Subtotal, Itemized Costs and Direct Markups	**$ 3,426,000**	**$ 6,846,000**
Contractor Markup (17.5%)	$ 600,000	$ 1,199,000
PEFTF Construction Cost	**$ 4,026,000**	**$ 8,045,000**
Contingency and ELA (62.5%)	$ 2,517,000	$ 5,029,000
Total PEFTF Project Cost	**$ 6,543,000**	**$ 13,074,000**
Total PEFTF Project Cost ($M)	**$ 6.5**	**$ 13.1**

Notes:
(1) Based on $177,000/MGD unit cost from JCW THC WWTF for disc filter improvements
(2) Based upon cost estimate from TCPS TM #5

Martway PEFTF Cost Curve

PEFTF Capacity (MGD)	**10**	**19**	**19**	**20**
Disc Filters[1]	$ 1,770,000	$ 3,363,000	$ 3,363,000	$ 3,540,000
Chemical Storage and Feed, Hypochlorite[2]	$ 155,000	$ 294,000	$ 294,000	$ 309,000
Chemical Storage and Feed, Bisulfite[2]	$ 121,000	$ 230,000	$ 230,000	$ 242,000
Contact Basin Improvements, Hypochlorite[3]	$ -	$ -	$ 50,000	$ 50,000
Contact Basin Improvements, Bisulfite[2]	$ -	$ -	$ 30,000	$ 30,000
Pumps	$ 157,000	$ 298,000	$ 298,000	$ 313,000
Electrical	$ 143,000	$ 271,000	$ 271,000	$ 285,000
Process Piping	$ 151,000	$ 287,000	$ 287,000	$ 302,000
Process Equipment	$ 137,000	$ 260,000	$ 260,000	$ 273,000
Subtotal, Itemized Costs	**$ 2,634,000**	**$ 5,003,000**	**$ 5,083,000**	**$ 5,344,000**
Yard Piping (5%)	$ 132,000	$ 251,000	$ 255,000	$ 268,000
Site (5%)	$ 132,000	$ 251,000	$ 255,000	$ 268,000
Site Electrical (15%)	$ 396,000	$ 751,000	$ 763,000	$ 802,000
General Req., Demolition, Misc. (5%)	$ 132,000	$ 251,000	$ 255,000	$ 268,000
Subtotal, Itemized Costs and Direct Markups	**$ 3,426,000**	**$ 6,507,000**	**$ 6,611,000**	**$ 6,950,000**
Contractor Markup (17.5%)	$ 600,000	$ 1,139,000	$ 1,157,000	$ 1,217,000
PEFTF Construction Cost	**$ 4,026,000**	**$ 7,646,000**	**$ 7,768,000**	**$ 8,167,000**
Contingency and ELA (62.5%)	$ 2,517,000	$ 4,779,000	$ 4,855,000	$ 5,105,000
Total PEFTF Project Cost	**$ 6,543,000**	**$ 12,425,000**	**$ 12,623,000**	**$ 13,272,000**
Total PEFTF Project Cost ($M)	**$ 6.5**	**$ 12.4**	**$ 12.6**	**$ 13.3**

Notes:

(1) Based on $117,000/MGD unit cost from JCW THC WWTF for disc filter improvements

(2) Based upon cost estimate from TCPS TM #5

Belinder PEFTF Cost Curve

PEFTF Capacity (MGD)	21	42	65	85	85	90
Disc Filters[1]	$ 3,717,000	$ 7,434,000	$ 11,505,000	$ 15,045,000	$ 15,045,000	$ 15,930,000
PEFTF Substructure Improvements[4]	$ 114,000	$ 227,000	$ 351,000	$ 459,000	$ 459,000	$ 486,000
Chemical Storage and Feed, Hypochlorite[2]	$ 325,000	$ 649,000	$ 1,005,000	$ 1,314,000	$ 1,314,000	$ 1,391,000
Chemical Storage and Feed, Bisulfite[2]	$ 255,000	$ 509,000	$ 787,000	$ 1,029,000	$ 1,029,000	$ 1,089,000
Contact Basin Improvements, Hypochlorite[3]	$ -	$ -	$ -	$ -	$ 50,000	$ 50,000
Contact Basin Improvements, Bisulfite[2]	$ 60,000	$ 60,000	$ 90,000	$ 120,000	$ 120,000	$ 130,000
Pumps	$ 318,000	$ 636,000	$ 984,000	$ 1,287,000	$ 1,287,000	$ 1,362,000
Electrical	$ 289,000	$ 578,000	$ 895,000	$ 1,170,000	$ 1,170,000	$ 1,238,000
Process Piping	$ 318,000	$ 635,000	$ 982,000	$ 1,284,000	$ 1,284,000	$ 1,359,000
Process Equipment	$ 287,000	$ 573,000	$ 887,000	$ 1,160,000	$ 1,160,000	$ 1,228,000
Subtotal, Itemized Costs	**$ 5,683,000**	**$ 11,301,000**	**$ 17,486,000**	**$ 22,868,000**	**$ 22,918,000**	**$ 24,263,000**
Yard Piping (5%)	$ 285,000	$ 566,000	$ 875,000	$ 1,144,000	$ 1,146,000	$ 1,214,000
Site (5%)	$ 285,000	$ 566,000	$ 875,000	$ 1,144,000	$ 1,146,000	$ 1,214,000
Site Electrical (15%)	$ 853,000	$ 1,696,000	$ 2,623,000	$ 3,431,000	$ 3,438,000	$ 3,640,000
General Req., Demolition, Misc. (5%)	$ 285,000	$ 566,000	$ 875,000	$ 1,144,000	$ 1,146,000	$ 1,214,000
Subtotal, Itemized Costs and Direct Markups	**$ 7,391,000**	**$ 14,695,000**	**$ 22,734,000**	**$ 29,731,000**	**$ 29,794,000**	**$ 31,545,000**
Contractor Markup (17.5%)	$ 1,294,000	$ 2,572,000	$ 3,979,000	$ 5,203,000	$ 5,214,000	$ 5,521,000
PEFTF Construction Cost	**$ 8,685,000**	**$ 17,267,000**	**$ 26,713,000**	**$ 34,934,000**	**$ 35,008,000**	**$ 37,066,000**
Contingency and ELA (62.5%)	$ 5,429,000	$ 10,792,000	$ 16,696,000	$ 21,834,000	$ 21,880,000	$ 23,167,000
Total PEFTF Project Cost	**$ 14,114,000**	**$ 28,059,000**	**$ 43,409,000**	**$ 56,768,000**	**$ 56,888,000**	**$ 60,233,000**
Total PEFTF Project Cost ($M)	**$ 14.1**	**$ 28.1**	**$ 43.4**	**$ 56.8**	**$ 56.9**	**$ 60.2**
Total PEFTF Project Cost	**$ 14,114,000**	**$ 28,059,000**	**$ 43,409,000**	**$ 56,768,000**	**$ 56,888,000**	**$ 60,233,000**
Total PEFTF Project Cost ($M)	**$ 14.1**	**$ 28.1**	**$ 43.4**	**$ 56.8**	**$ 56.9**	**$ 60.2**

Notes:

(1) Based on $177,000/MGD unit cost from JCW THC WWTF for disc filter improvements

(2) Based upon cost estimate from TCPS TM #5

(3) Assumed lump sum cost to raise elevation of weirs/baffle walls

(4) Based upon $5,400/MGD unit cost for structural concrete to support new filters above existing basin.

Turkey Creek PEFTF Cost Curve

PEFTF Capacity (MGD)	**11**	**22**
Disc Filters[1]	$ 1,947,000	$ 3,894,000
Chemical Storage and Feed, Hypochlorite[2]	$ 170,000	$ 340,000
Chemical Storage and Feed, Bisulfite[2]	$ 134,000	$ 267,000
Contact Basin Improvements, Hypochlorite[3]	$ 126,000	$ 126,000
Contact Basin Improvements, Bisulfite[2]	$ 30,000	$ 30,000
Pumps	$ 233,000	$ 466,000
Electrical	$ 212,000	$ 424,000
Process Piping	$ 167,000	$ 333,000
Process Equipment	$ 150,000	$ 300,000
Subtotal, Itemized Costs	**$ 3,169,000**	**$ 6,180,000**
Yard Piping (5%)	$ 159,000	$ 309,000
Site (5%)	$ 159,000	$ 309,000
Site Electrical (15%)	$ 476,000	$ 927,000
General Req., Demolition, Misc. (5%)	$ 159,000	$ 309,000
Subtotal, Itemized Costs and Direct Markups	**$ 4,122,000**	**$ 8,034,000**
Contractor Markup (17.5%)	$ 722,000	$ 1,406,000
PEFTF Construction Cost	**$ 4,844,000**	**$ 9,440,000**
Contingency and ELA (62.5%)	$ 3,028,000	$ 5,900,000
Total PEFTF Project Cost	**$ 7,872,000**	**$ 15,340,000**
Total PEFTF Project Cost ($M)	**$ 7.9**	**$ 15.3**

Notes:

(1) Based on $117,000/MGD unit cost from JCW THC WWTF for disc filter improvements

(2) Based upon cost estimate from TCPS TM #5

(3) Assumes 5 baffle walls within existing basin. Fixed cost

Nelson Complex Collection System Wet Weather Plan Technical Memorandum #4 Refined Optimization Findings

January 2019

JOHNSON COUNTY KANSAS
Wastewater

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ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
GPD	Gallons per Day
GPM	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
MGAL	Million Gallons
MGD	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/l	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NH3-N	Ammonia Nitrogen
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
$Pro2D^2$	Professional Process Design and Dynamics Whole Plant Simulator by CH2M

PS	Pump Station
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

Note: Portions of the project approach and information presented in this technical memorandum (TM) were subsequently updated and new alternative naming conventions were adopted as the project progressed. Changes are noted in italics, where practicable. In general, information presented in TM 6 or the Phase 1 Integrated Management Plan supersedes conflicting information presented in this TM.

1 Introduction

1.1 Background & Purpose

The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two Wastewater Treatment Facility (WWTF) trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or discharge directly from the collection system to the creek after providing primary treatment and disinfection. In the Mission Main watershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flows to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow to the WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the WWTF. On the Turkey Creek side, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the WWTF.

JCW is developing a long term plan to address wet weather flows within the Turkey Creek and Mission Main watersheds. Several upgrade alternatives are being considered for both watersheds including:

- Conveyance Upgrades
  - Gravity
  - Pump Station/Forcemain
- Storage
  - Shallow Underground
  - Linear/Tunnel
- I/I Reduction
- PEFTF Upgrades
- Auxiliary Treatment at the Nelson Complex.

Optimization is being used as a tool in the planning process to identify the most cost-effective combination of these alternatives that will meet JCW's desired level of service (LOS). This technical memorandum (TM 4) serves to document the refined optimization approach and present results.

1.2 Optimization Approach

Optimization is an iterative process that begins with preliminary optimization and alternatives analysis. During preliminary optimization, all feasible alternatives were included in the analysis in order to complete a thorough evaluation of alternatives and complete the following objectives:

- Investigate a wide range of scenarios and sensitivities to identify consistent trends
- Evaluate potential level of service scenarios to establish incremental costs to achieve varying levels of service and identify common/divergent improvements required among scenarios

- Identify key assumptions/alternatives that require further refinement and screening prior to the refined optimization
- Identify and screen likely sites for major improvements projects (e.g. storage facilities)
- Identify which cost assumptions are most sensitive, so they can be further developed in the refined optimization analysis.

The results of the preliminary optimization were used to identify alternatives and costs needing further evaluation and refinement. These updated alternatives and refined costs are documented in TM 3 (*Preliminary Optimization Findings and Alternatives Screening*, September 2018) and were used in the refined optimization.

The results of the refined optimization, presented herein, will be used to inform further development of selected alternatives and develop and prioritize major projects to be included in the long-term plan.

1.3 TM Organization

The contents of this TM are organized into three sections. Section 2 and Section 3 describe the refined optimization analysis approach and findings. Section 4 summarizes the key trends observed during refined optimization and presents the next steps in the optimization and alternatives development process.

2 Refined Optimization Approach

Based on the alternatives screening and cost refinement presented in TM 3 (*Preliminary Optimization Findings and Alternatives Screening*, September 2018), the following refinements were made to the optimization inputs during the Refined Optimization:

- Gravity pipe replacement alternatives were included in place of some of the parallel pipe alternatives based on an assessment of construction feasibility and asset condition. Replacement was selected where relief sewers already exist throughout Mission Main. Cost curves remain unchanged from preliminary optimization.
- The location and maximum size (volume) of allowable underground storage facilities were refined based on feasibility assessment. Cost curves remain unchanged from preliminary optimization.
- Storage at Belinder, Turkey Creek, and Rock Creek was constrained to tunnel storage at a cost of $8 per gallon.
- A baseline level of I/I reduction (15% in Turkey Creek and 10% in Mission Main) was applied in all optimization scenarios (including the conveyance-only scenario). This level of I/I reduction represents the projected I/I reduction achieved from rehabilitation of pipes and manholes through JCW's Collection System Asset Management Program. (CSAMP). The projected costs to achieve this baseline I/I reduction ($30M) is included in the optimization solution cost summaries.
- The ATF approach was modified such that the initial 7 MGD (above the 45 MGD WWTF throughput) would be included in the WWTF cost estimate. 52 MGD was considered to be the baseline WWTF flow for the optimization; costs for any additional ATF capacity were included in the optimization. The ATF cost curve remains unchanged from preliminary optimization.
- Site-specific cost curves were developed for each major pump station and PEFTF based on recent local HDR projects. Industry design standards were utilized to identify the break points in peak flow capacity at which a new wet weather facility would assume to be required.
- Pump station and forcemain cost curves were modified to account for the proposed new Headworks building location in the northeast corner of the existing WWTF site. For the Turkey Creek treatment train, these improvements include costs for additional pumping head and required forcemain extensions for the Turkey Creek PS. For the Mission Main treatment train, this includes forcemain extensions for the Belinder PS and Rock Creek PS since the new pumping head condition will be similar to the existing condition. These initial improvement costs will be included in the WWTF cost estimate. Any costs for pump station or forcemain capacity improvements beyond this baseline were included in the optimization.

Additional details regarding the refined optimization process include:

- Finer increments for pump station capacity, PEFTF capacity, and storage inlet decisions were developed and used.
- The refined optimization scenarios were processed for extended periods to achieve convergence (over 50,000 evaluations of different solution configurations were completed for some scenarios).

- The refined optimization was based on the 5-year/10-year design storm scenario. That is, facility protection devices contain the 5-year design storm but can discharge in the 10-year design storm, infrastructure downstream of an FPD was designed for the 5-year design storm, and all other network improvements were designed for the 10-year design storm.

The improvement alternatives evaluated in the refined optimization are shown in Figure 1.

The refined optimization results are presented in Section 3:

1. Preferred optimization solutions without and with PEFTF upgrade alternatives *(ultimately referred to as Alternative 1: Eliminate PEFTFs through Wet Weather Management and Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment, respectively)*
2. Additional optimization scenarios
3. I/I reduction sensitivity analysis

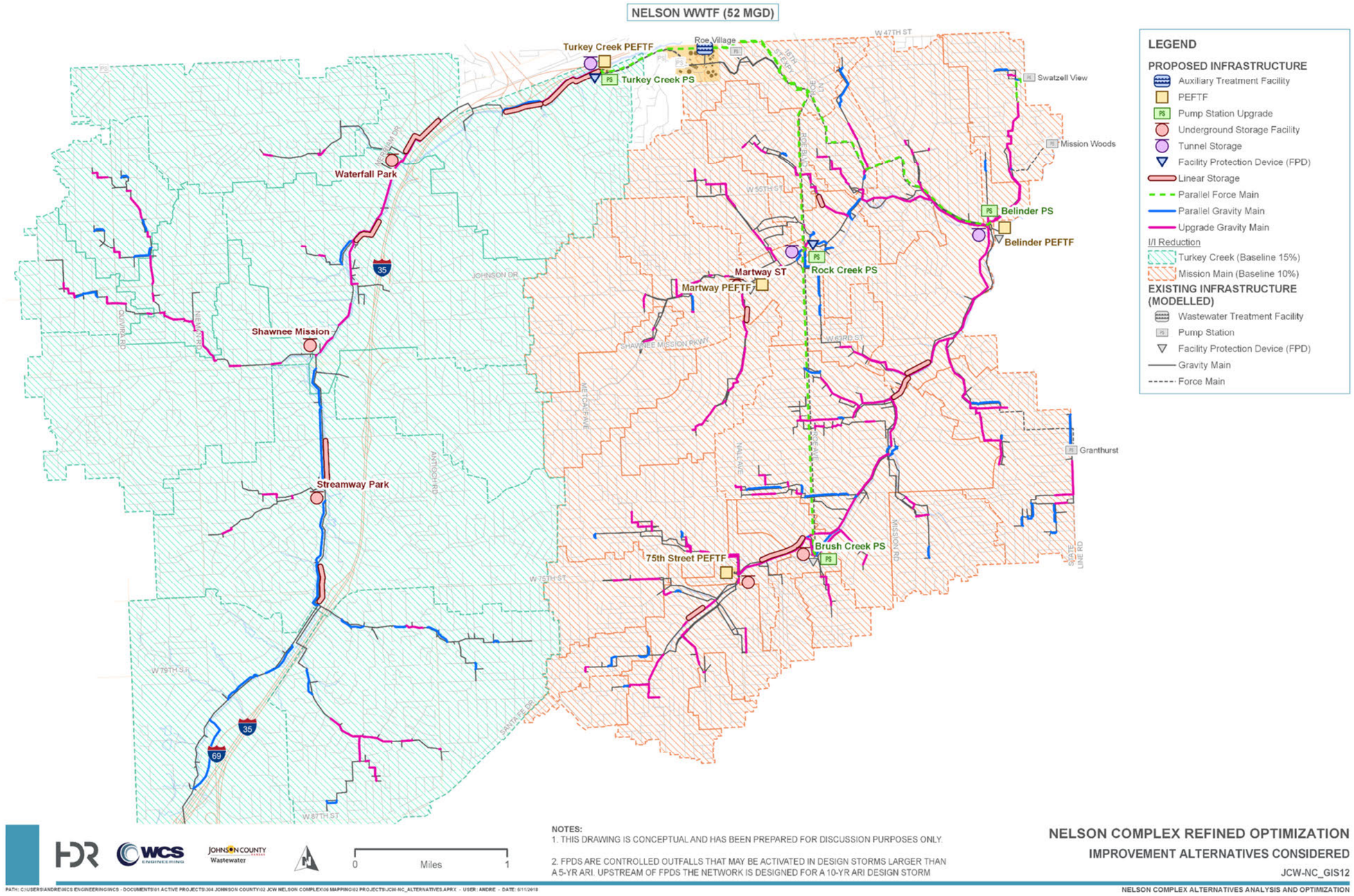


Figure 1: Improvement Alternatives Evaluated in Refined Optimization

3 Refined Optimization Results

3.1 Preferred Optimization Solutions

This section presents the preferred optimization solutions for the scenarios with and without PEFTF upgrade alternatives considered. The preferred solution with PEFTF upgrades is also the least-cost solution for this scenario; however, the preferred solution without PEFTF upgrades avoids alternatives that were selected in the least-cost solution and were considered to present operational or construction challenges (Belinder tunnel storage and utilization of existing storage at decommissioned PEFTFs). The least-cost solution without PEFTF upgrades is presented in the following section along with other scenarios and sensitivities. The solution cost summary for the preferred optimization scenario without PEFTFs is presented in Table 1.

Table 1: Cost Summary of Preferred Optimized Solution without PEFTFs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) [1]	Turkey Creek 20-yr PV Total Cost ($M) [1]	Mission Main 20-yr PV Total Cost ($M) [1]	20-yr PV Total Cost ($M) [1]
Gravity Sewers	28.80	-	9.52	19.27	**28.80**
Pumping Station Upgrades	37.77	6.71	13.23	31.24	**44.48**
Force Mains	18.06	-	3.21	14.85	**18.06**
Underground Storage Facilities	40.38	0.11	19.48	21.02	**40.49**
Linear Storages	-	-	-	-	**-**
PEFTF Upgrades	-	-	-	-	**-**
Baseline I/I Reduction	30.00	-	17.19	12.81	**30.00**
Additional I/I Reduction	13.89	-	3.18	10.71	**13.89**
Auxiliary Treatment Facility	40.76	4.50	6.21	39.05	**45.26**
TOTAL	**209.65**	**11.32**	**72.02**	**148.95**	**220.97**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

In Turkey Creek, the preferred solution without PEFTFs is characterized by:

- Approximately 8,600 LF of parallel gravity main and 7,000 LF of replace/upsize gravity main
- Upgrade of the Turkey Creek PS to 43.2 MGD with a parallel 36” forcemain (3,500 LF)
- Two underground storage facilities:
  - South Turkey Creek – 2.1 MG
  - North Turkey Creek – 0.8 MG
- A selected overall I/I reduction in Turkey Creek of 17%

In Mission Main, the preferred solution without PEFTFs is characterized by:

- Approximately 7,600 LF of parallel gravity main and 30,800 LF of replace/upsize gravity main
- Upgrade of the Belinder PS to 53.5 MGD with a parallel 48” forcemain (10,600 LF)

- Upgrade of the Rock Creek PS to 24.3 MGD with a parallel 24" forcemain (7,000 LF)
- Brush Creek underground storage facility – 4.4 MG
- A selected overall I/I reduction in Mission Main of 15%

The solution cost summary for the preferred optimization scenario with PEFTFs is presented in Table 2.

Table 2: Cost Summary of Preferred Optimized Solution with PEFTFs

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) [1]	Turkey Creek 20-yr PV Total Cost ($M) [1]	Mission Main 20-yr PV Total Cost ($M) [1]	20-yr PV Total Cost ($M) [1]
Gravity Sewers	27.12	-	9.69	17.43	**27.12**
Pumping Station Upgrades	-	-	-	-	**-**
Force Mains	-	-	-	-	**-**
Underground Storage Facilities	20.91	0.05	20.96	0.00	**20.96**
Linear Storages	-	-	-	7.42	**7.42**
PEFTF Upgrades	55.21	6.61	11.95	49.87	**61.82**
Baseline I/I Reduction	30.00	-	17.19	12.81	**30.00**
Additional I/I Reduction	9.49	-	2.13	7.35	**9.49**
Auxiliary Treatment Facility	-	-	-	-	**-**
TOTAL	**142.72**	**6.66**	**61.92**	**94.88**	**156.80**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

The optimized solutions with and without PEFTFs have very similar overall strategies. The only significant differences occur at the major facilities. In the solution with PEFTF upgrades allowed:

- The Turkey Creek PS upgrade is exchanged for a PEFTF upgrade;
- The Belinder PS upgrade is exchanged for a PEFTF upgrade;
- The Rock Creek PS upgrade is exchanged for linear storage;
- The Brush Creek storage is exchanged for a PEFTF upgrade at 75th/Nall; and
- The ATF upgrade is not required, as peak excess flows are treated at the upgraded PEFTFs.

Decommissioning the PEFTFs requires major facility upgrades at an approximate $64M additional cost for Turkey Creek and Mission Main. Note that PEFTF decommissioning costs have not been included in this study, which would further increase the differential costs. To determine the differential cost to decommission each PEFTF, the Nelson watersheds were divided by areas of sewer network contributing to each PEFTF. The capital cost for each alternative (I/I reduction, conveyance improvements, storage, and ATF) was summarized for the preferred No PEFTF solution and the preferred With PEFTF solution. Detailed differential costs to decommission each PEFTF are presented in Table 3 through Table 7.

Table 3: Differential Cost to Decommission Turkey Creek PEFTF

Turkey Creek	PV Cost ($M) No PEFTF Preferred Solution [1]	PV Cost ($M) With PEFTF Preferred Solution [1]	Delta ($M)
Baseline I/I Reduction	17.19	17.19	0
Additional I/I Reduction	3.18	2.13	1.05
Gravity	9.52	9.69	-0.17
Storage	19.48	20.96	-1.48
Pump Station	13.23	0	13.23
Forcemain	3.21	0	3.21
PEFTF	0	11.95	-11.95
ATF	6.21	0	6.21
Total	**72.02**	**61.92**	**10.10**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

Table 4: Differential Cost to Decommission Mission Main PEFTFs

Mission Main (All PEFTFs)	PV Cost ($M) No PEFTF Preferred Solution [1]	PV Cost ($M) With PEFTF Preferred Solution [1]	Delta ($M)
Baseline I/I Reduction	12.81	12.81	0
Additional I/I Reduction	10.71	7.35	3.36
Gravity	19.27	17.43	1.84
Storage	21.02	6.61	14.41
Pump Station	31.24	0	31.24
Forcemain	14.85	0	14.85
PEFTF	0	49.87	-49.87
ATF	39.05	0	39.05
Total	**148.95**	**94.07**	**54.88**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

Table 5: Differential Cost to Decommission 75th/Nall PEFTF

Mission Main (75th/Nall PEFTF)	PV Cost ($M) No PEFTF Preferred Solution [1]	PV Cost ($M) With PEFTF Preferred Solution [1]	Delta ($M)
Baseline I/I Reduction[2]	-	-	-
Additional I/I Reduction	0.98	0.98	0.00
Gravity	6.02	2.96	3.06
Storage	21.02	0	21.02
Pump Station	0	0	0
Forcemain	0	0	0
PEFTF	0	11.01	-11.01
ATF	0	0	0
Total	**28.02**	**14.95**	**13.07**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

[2] Does not include baseline I/I costs common to both scenarios

Table 6: Differential Cost to Decommission Martway PEFTF

Mission Main (Martway PEFTF)	PV Cost ($M) No PEFTF Preferred Solution (1)	PV Cost ($M) With PEFTF Preferred Solution (1)	Delta ($M)
Baseline I/I Reduction(2)	-	-	-
Additional I/I Reduction	1.70	0.49	1.21
Gravity	0.90	0.87	0.03
Storage	0	6.61	-6.61
Pump Station	7.79	0	7.79
Forcemain	5.66	0	5.66
PEFTF	0	7.40	-7.40
ATF	12.20	0	12.20
Total	**28.25**	**15.37**	**12.88**

(1) Costs do not include operation and maintenance costs that are common among alternatives.
(2) Does not include baseline I/I costs common to both scenarios

Table 7: Differential Cost to Decommission Belinder PEFTF

Mission Main (Belinder PEFTF)	PV Cost ($M) No PEFTF Preferred Solution (1)	PV Cost ($M) With PEFTF Preferred Solution (1)	Delta ($M)
Baseline I/I Reduction(2)	-	-	-
Additional I/I Reduction	8.03	5.88	2
Gravity	12.35	13.60	-1.25
Storage	0	0	0
Pump Station	23.45	0	23.45
Forcemain	9.19	0	9.19
PEFTF	0	31.46	-31.46
ATF	26.85	0	26.85
Total	**79.87**	**50.94**	**28.94**

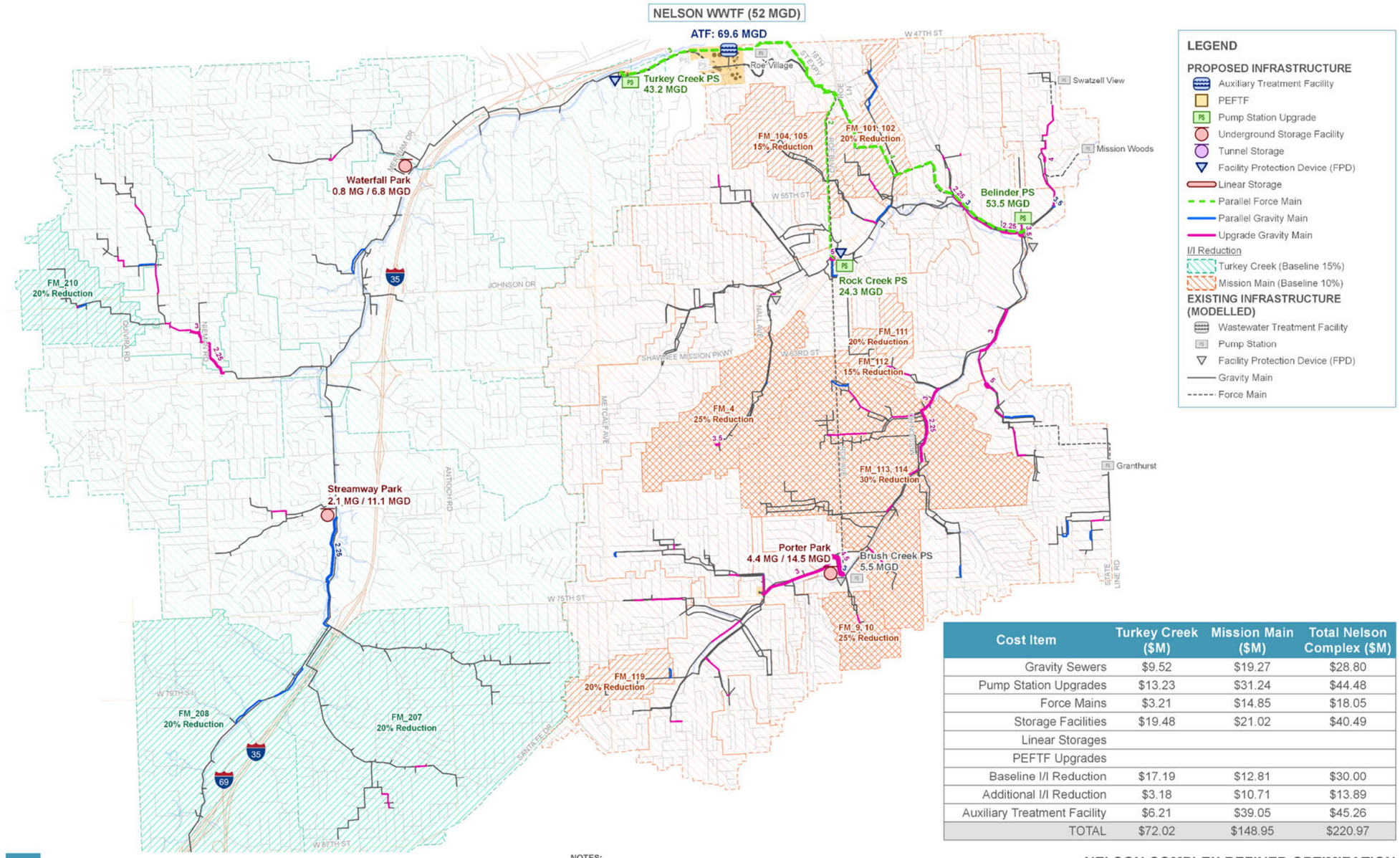
(1) Costs do not include operation and maintenance costs that are common among alternatives.
(2) Does not include baseline I/I costs common to both scenarios

Of the four facilities, Turkey Creek PEFTF was found to be the most cost effective to decommission relative to the cost of PEFTF upgrades. Decommissioning the Turkey Creek PEFTF would require upgrading the pump station and forcemain as well as expanding the ATF at Nelson, at a differential cost of approximately $10M compared to the cost of upgrading the PEFTF.

Decommissioning 75th/Nall PEFTF would require additional targeted I/I reduction, gravity upgrades, and a large underground storage facility near Brush Creek PS, at a differential cost of approximately $13M compared to the cost to upgrade the PEFTF. Decommissioning Martway PEFTF would require additional targeted I/I reduction, a substantial pump station and forcemain upgrade at Rock Creek, as well as an ATF expansion at Nelson, at a differential cost of approximately $13M compared to the cost to upgrade the PEFTF.

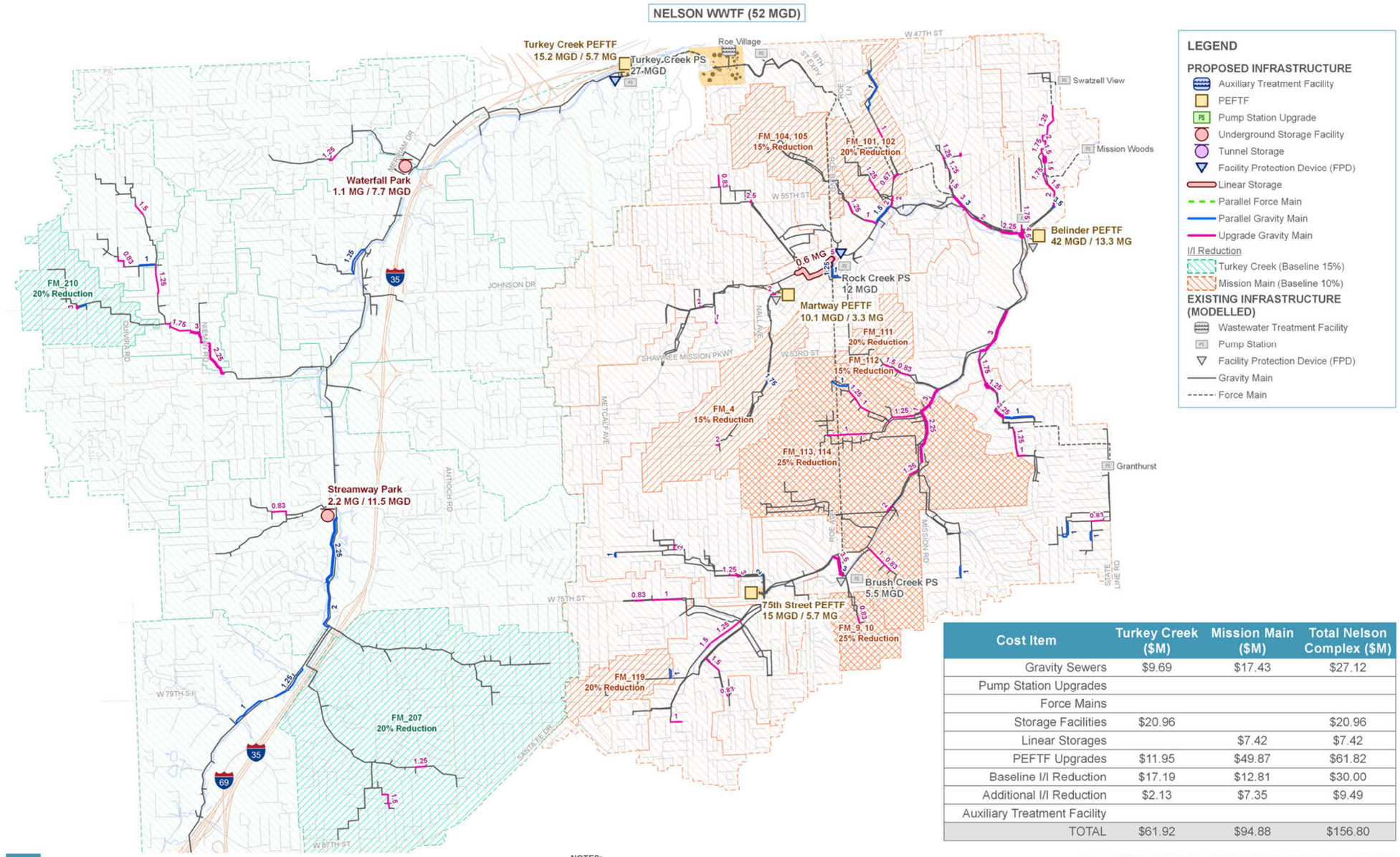
Belinder PEFTF was found to be the most cost prohibitive to decommission. Decommissioning the PEFTF would require upgrading the pump station and forcemain as well as expanding the ATF at Nelson, at a differential cost of approximately $29M compared to the cost of upgrading the PEFTF. These differential costs will be considered when prioritizing projects in the long-term plan.

The preferred optimization solution figures without PEFTFs and with PEFTFs are presented in Figure 2 and Figure 3, respectively.



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.52	$19.27	$28.80
Pump Station Upgrades	$13.23	$31.24	$44.48
Force Mains	$3.21	$14.85	$18.05
Storage Facilities	$19.48	$21.02	$40.49
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.18	$10.71	$13.89
Auxiliary Treatment Facility	$6.21	$39.05	$45.26
TOTAL	$72.02	$148.95	$220.97

Figure 2: Refined Optimization Solution - Preferred Solution without PEFTF



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.69	$17.43	$27.12
Pump Station Upgrades			
Force Mains			
Storage Facilities	$20.96		$20.96
Linear Storages		$7.42	$7.42
PEFTF Upgrades	$11.95	$49.87	$61.82
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$2.13	$7.35	$9.49
Auxiliary Treatment Facility			
TOTAL	$61.92	$94.88	$156.80

Figure 3: Refined Optimization Solution - Preferred Solution with PEFTFs

3.2 Additional Optimization Scenarios

A wide range of scenarios were evaluated as part of the refined optimization analysis. Key scenarios of interest that are discussed in this section include:

1. Least-cost solution without PEFTF upgrade alternatives (different from preferred solution which excluded alternatives that were considered to have construction or operational challenges)
2. Alternate least-cost solution without PEFTF with Brush Creek pumping directly to Nelson WWTF
3. Optimized solution with PEFTF upgrade alternatives and without linear storage upstream of Rock Creek
4. Optimized Conveyance-Only – optimization scenario without storage, PEFTF or I/I reduction alternatives
5. Optimized solution w/o PEFTF and w/o ATF – the purpose of this sensitivity was to determine the cost and solution layout to avoid a new Auxiliary Treatment Facility or upgraded PEFTFs, addressing peak flows through only storage and I/I reduction.

For ease of comparison, solution figures for each of the above scenarios are presented in **Appendix B** along with the preferred solutions. The solution costs for each refined optimization scenario are compared in Table 8, and in the cost-effective analysis curves shown in Figure 4 and Figure 5.

Table 8: Summary of Refined Optimization Solution Costs

Solution	Initial Capital Cost ($M)	20-yr O&M Cost ($M) (1)	Turkey Creek 20-yr PV Total Cost ($M) (1)	Mission Main 20-yr PV Total Cost ($M) (1)	20-yr PV Total Cost ($M) (1)
Preferred Solution w/o PEFTF	209.65	11.32	72.02	148.95	**220.97**
Least-Cost Solution w/o PEFTF	196.74	8.30	72.79	132.25	**205.04**
Alternate solution w/o PEFTF (Brush Creek direct to WWTF)	197.23	7.55	72.88	131.89	**204.77**
Preferred Solution w/ PEFTF	142.72	6.66	61.92	94.88	**156.80**
Solution w/ PEFTF and w/o Rock Creek linear storage	160.81	6.87	61.92	105.76	**167.68**
Optimized Conveyance-Only	216.82	15.48	82.87	149.43	**232.31**
Optimized w/o PEFTF and w/o ATF	279.21	0.49	99.80	179.90	**279.70**

(1) Costs do not include operation and maintenance costs that are common among alternatives.

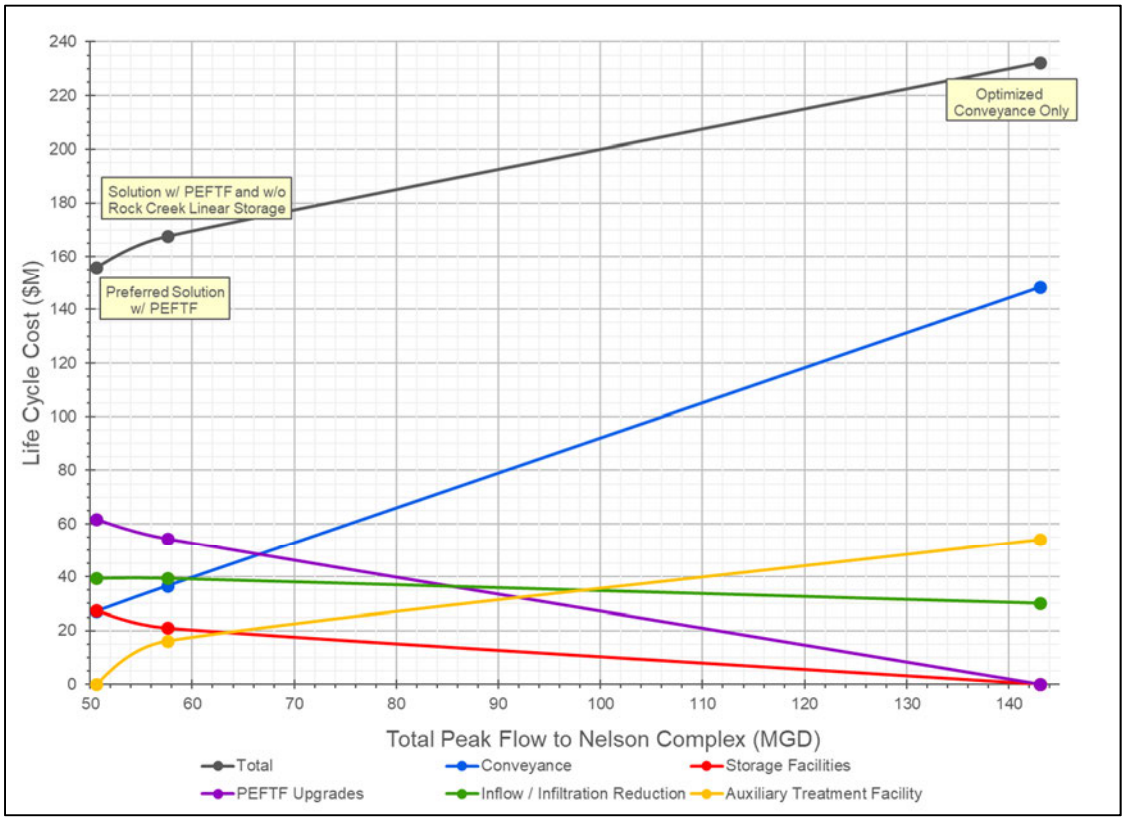


Figure 4: Cost-Effective Analysis Curve (with PEFTF)

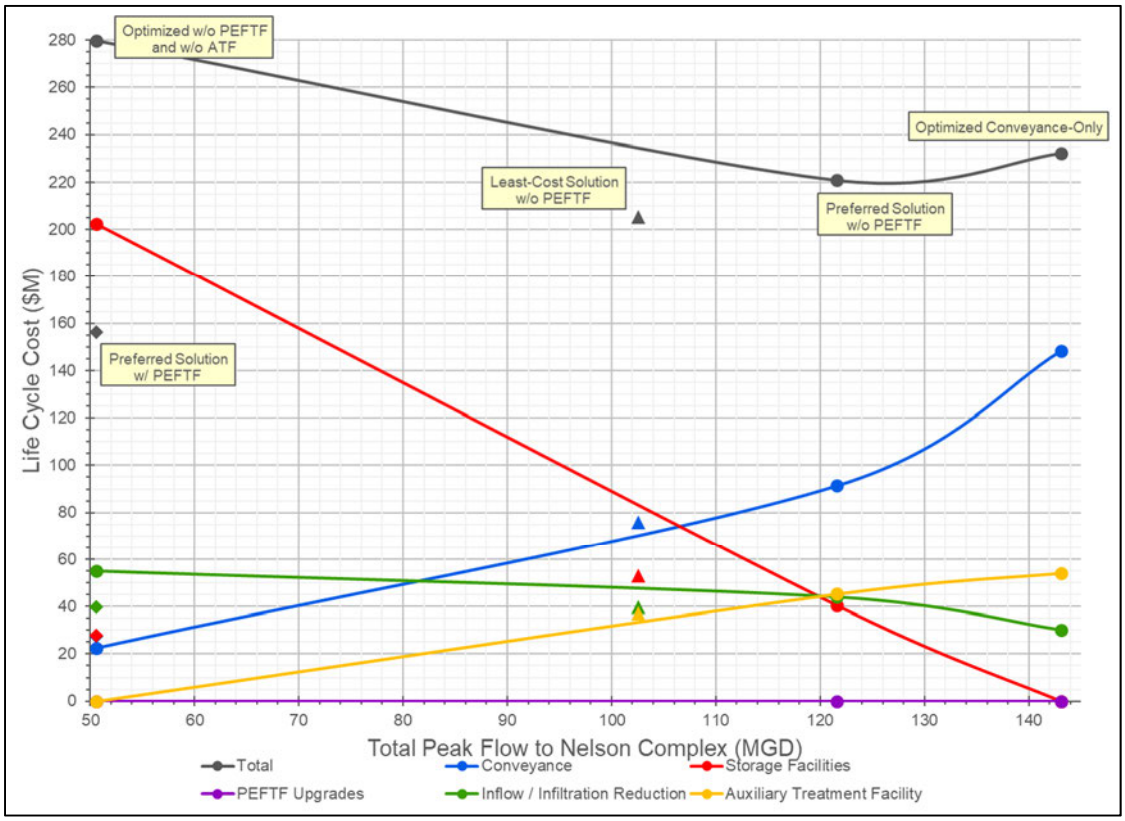


Figure 5: Cost-Effective Analysis Curve (without PEFTF)

The differences between the least-cost and the preferred solution without PEFTF upgrades are:

1. The least-cost solution has a 1.5 MG tunnel storage at Belinder that reduces the Belinder pump upgrade size from 53.5 MGD to 39.5 MGD, the Belinder force main upgrade from 4 ft to 3 ft, and achieves a net cost saving of $10.0 M when compared to the preferred solution that does not have the tunnel storage at Belinder.
2. The least-cost solution utilizes existing storage at the decommissioned PEFTF sites (0.61 MG at Martway and 0.52 MG at Nall) and achieves a net cost saving of $5.9 M when compared to the preferred solution that does not utilize existing storage at these sites.

The alternate least-cost solution without PEFTF upgrades has Brush Creek pumping directly to the Nelson WWTF. In this scenario, the optimization selected to avoid the Rock Creek pump upgrade by including additional I/I reduction in the upstream flow meter basins. The Brush Creek pump capacity is also unchanged; however, an allowance of $3M is included to provide additional operating head capacity and a new force main downstream of Rock Creek so that Brush Creek has a dedicated main and does not need to share the Rock Creek force main. The total estimated cost of this scenario is effectively the same as the original least-cost solution (with Brush Creek discharging to Rock Creek then being re-pumped to the WWTF). Further investigation is recommended to confirm the cost of providing additional operating head capacity and/or forcemain improvements since the $3M allowance is an unverified assumption.

3.3 I/I Reduction Sensitivity Analysis

The purpose of the I/I reduction sensitivity analysis was to determine how the optimized solution may be affected if the cost of I/I reduction turns out to be higher or lower than assumed, or if the effectiveness of I/I reduction turns out to be significantly less than assumed. The following scenarios were performed:

1. I/I reduction cost increased by 30% (baseline I/I reduction cost remain set at $30M)
2. I/I reduction cost decreased by 30% (baseline I/I reduction costs remain set at $30M)
3. I/I reduction effectiveness decreased by 50% (effectiveness of baseline I/I reduction and additional I/I reduction both decreased)

For ease of comparison, solution figures for each of the above scenarios are presented in **Appendix C**. The solution costs for each refined optimization scenario are compared in Table 9.

Table 9: Summary of Refined I/I Reduction Sensitivity Analysis Costs

Solution	Initial Capital Cost ($M)	20-yr O&M Cost ($M) [1]	Turkey Creek 20-yr PV Total Cost ($M) [1]	Mission Main 20-yr PV Total Cost ($M) [1]	20-yr PV Total Cost ($M) [1]
Preferred Solution w/o PEFTF	209.65	11.32	72.02	148.95	**220.97**
I/I Reduction Cost Increased by 30%	202.13	10.49	72.40	140.22	**212.62**
I/I Reduction Cost Decreased by 30%	197.28	10.45	71.24	136.49	**207.73**
I/I Reduction Effectiveness Decreased by 50%	232.37	16.06	95.91	152.52	**248.43**

[1] Costs do not include operation and maintenance costs that are common among alternatives.

The I/I reduction cost sensitivity analysis utilized the same baseline I/I reduction cost ($30M) as the base optimization scenarios. Costs above the baseline (private and/or additional public sector reduction) were increased and decreased by 30% to evaluate the sensitivity of cost to the overall solution. The I/I reduction cost sensitivity (+/- 30%) demonstrates that the overall solution strategy is not sensitive to the cost of I/I reduction within the bounds tested. Therefore, the I/I reduction (beyond the baseline) in the optimized solution should be targeted even if the cost varies from the assumed rate. The location and size of major facilities in the solution did not change significantly when the cost of I/I reduction was varied +/- 30%.

The I/I reduction scenario with the effectiveness of I/I reduction reduced by 50% provides conservative sizing for new infrastructure in a worst-case scenario (i.e. if baseline I/I reduction achieved in Turkey Creek and Mission Main is only 7.5% and 5% respectively, and the maximum achievable I/I reduction turns out to be only 15% in the target catchments). In Turkey Creek, this scenario demonstrates that the size of pipe upgrades is not significantly affected; however, the two storage facilities selected in the preferred solution are substituted for additional conveyance improvements (most likely because of site constraints limiting the maximum size of the storage facilities). A similar trend is observed in Mission Main; the primary difference is that the Brush Creek storage is substituted for a Brush Creek pump upgrade. As part of the long-term plan, it is important to monitor and evaluate the effectiveness of ongoing I/I reduction efforts and re-evaluate the overall solution strategy as necessary.

4 Refined Optimization Summary & Next Steps

The refined optimization includes significantly more detail than the preliminary optimization. The intent of refined optimization was to:

- Determine cost-effective, feasible improvements using the refined unit costs and alternative constraints identified during the Alternatives Screening;
- Demonstrate the additional cost to avoid cost-effective alternatives that may have complex construction requirements; and
- Identify key sensitivities that may affect the overall solution strategy.

Present value total costs for each scenario and sensitivity are summarized in Table 10.

Table 10: Solution PV Total Cost Summary

Solution	20-yr PV Total Cost ($M) [1]
Preferred Solution w/o PEFTF	220.97
Least-Cost Solution w/o PEFTF	205.04
Alternate solution w/o PEFTF (Brush Creek direct to WWTF)	204.77
Preferred Solution w/ PEFTF	156.80
Solution w/ PEFTF and w/o Rock Creek linear storage	167.68
Optimized Conveyance-Only	232.31
Optimized w/o PEFTF and w/o ATF	279.70
I/I Reduction Cost Increased by 30%	212.62
I/I Reduction Cost Decreased by 30%	207.73
I/I Reduction Effectiveness Decreased by 50%	248.43

[1] Costs do not include operation and maintenance costs that are common among alternatives.

In Turkey Creek, the preferred solution without PEFTFs is characterized by:

- Approximately 8,600 LF of parallel gravity main and 7,000 LF of replace/upsize gravity main
- Upgrade of the Turkey Creek PS to 43.2 MGD with a parallel 36” forcemain (3,500 LF)
- Two underground storage facilities:
  - South Turkey Creek – 2.1 MG
  - North Turkey Creek – 0.8 MG
- A selected overall I/I reduction in Turkey Creek of 17%

In Mission Main, the preferred solution without PEFTFs is characterized by:

- Approximately 7,600 LF of parallel gravity main and 30,800 LF of replace/upsize gravity main
- Upgrade of the Belinder PS to 53.5 MGD with a parallel 48” forcemain (10,600 LF)
- Upgrade of the Rock Creek PS to 24.3 MGD with a parallel 24” forcemain (7,000 LF)
- Brush Creek underground storage facility – 4.4 MG

- A selected overall I/I reduction in Mission Main of 15%

The optimized solutions with and without PEFTFs have very similar overall strategies. The only significant differences are at the major facilities. In the solution with PEFTFs:

- The Turkey Creek PS upgrade is exchanged for the PEFTF upgrade
- The Belinder PS upgrade is exchanged for the PEFTF upgrade
- The Rock Creek PS upgrade is exchanged for linear storage
- The Brush Creek storage is exchanged for an upgrade at 75th/Nall PEFTF
- The large ATF required in the preferred solution without PEFTFs to accommodate the additional flow passed forward by pump station upgrades is no longer required. Peak excess flows are instead treated at the upgraded PEFTFs.

Comparing the refined optimization solutions, the following trends are observed.

1. The preferred solution with PEFTFs is approximately $64.2M less than the preferred solution without PEFTFs.
2. The ATF is not required in the preferred solution with PEFTF; however, it is a key component of the overall wet-weather control strategy if PEFTFs are eliminated. The cost to avoid the ATF is estimated at $75M (comparing the least cost no PEFTF solution with the Optimized w/o PEFTF and w/o ATF solution). In addition to monetary costs, the solution without ATF also includes some improvements that would be very challenging or impossible to construct in dense residential areas.
3. The I/I cost sensitivity (+/- 30% cost) demonstrated that the overall strategy is not sensitive to the cost of additional I/I reduction (beyond the baseline) and that the I/I targets in some basins can be adjusted without significantly affecting the overall strategy.
4. The I/I effectiveness sensitivity (-50% effectiveness) indicates that the overall strategy is sensitive to lower I/I reduction effectiveness. Ongoing I/I reduction efforts should be monitored and the overall strategy re-evaluated as necessary throughout the execution of the long-term plan.

Next steps in the optimization and long-term plan development process include:

1. Alternatives Development: complete additional review of the selected improvements to verify cost and feasibility and run additional scenarios or sensitivity analyses, if required.
2. Prioritization Analysis: Run an initial prioritization analysis with pump stations locked in at existing capacity (i.e. assume pump upgrades will be completed last) and prioritize upstream improvements based on manhole flooding reduction.
3. NPV and Triple Bottom Line Analysis

Appendix A References

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GBA. *Turkey Creek/Mission Main Pilot Area Flow Monitoring Report*. September 2010.

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GBA. Annual Bypass Manhole Flow Depth Monitoring Progress Report 2010. May 2010.

CH2M HILL. *Draft Technical Memorandum #2: Inventory Verification, Hydraulic Model Development and Model Calibration*. March 2010.

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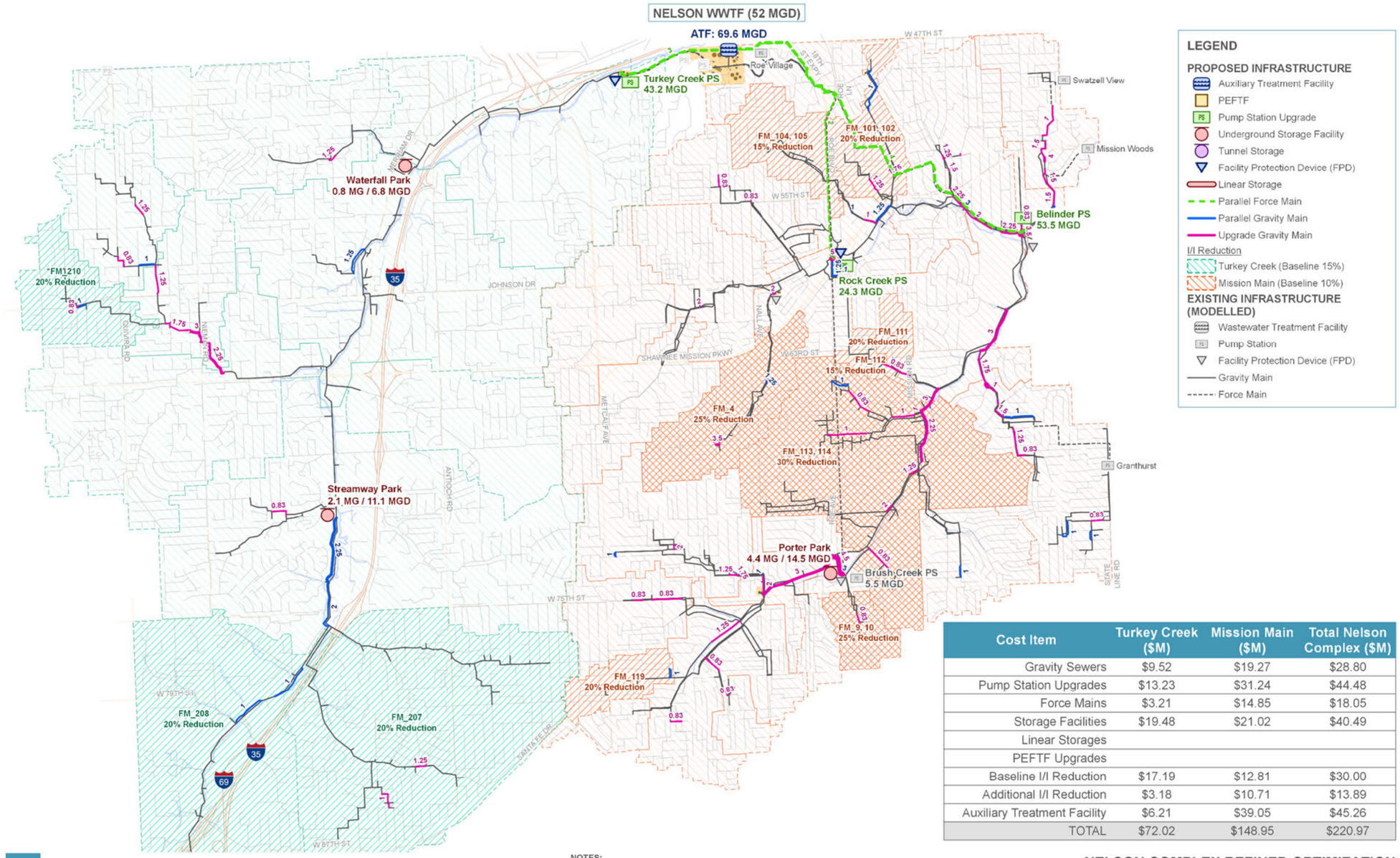
Appendix B – Refined Optimization Scenario Figures



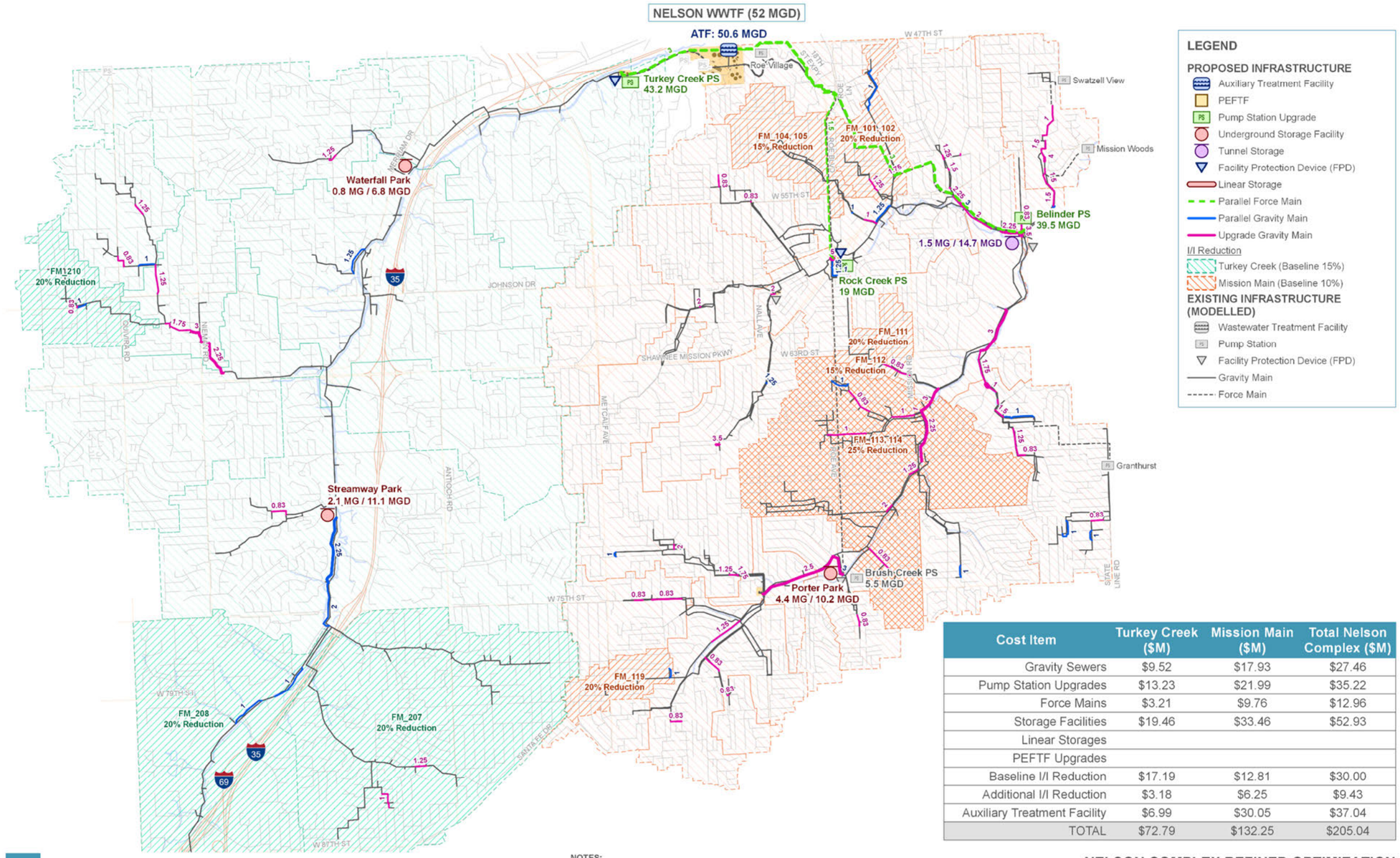
Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.52	$19.27	$28.80
Pump Station Upgrades	$13.23	$31.24	$44.48
Force Mains	$3.21	$14.85	$18.05
Storage Facilities	$19.48	$21.02	$40.49
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.18	$10.71	$13.89
Auxiliary Treatment Facility	$6.21	$39.05	$45.26
TOTAL	$72.02	$148.95	$220.97

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
PREFERRED SOLUTION W/O PEFTF

NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 6: Preferred Solution without PEFTF Upgrades



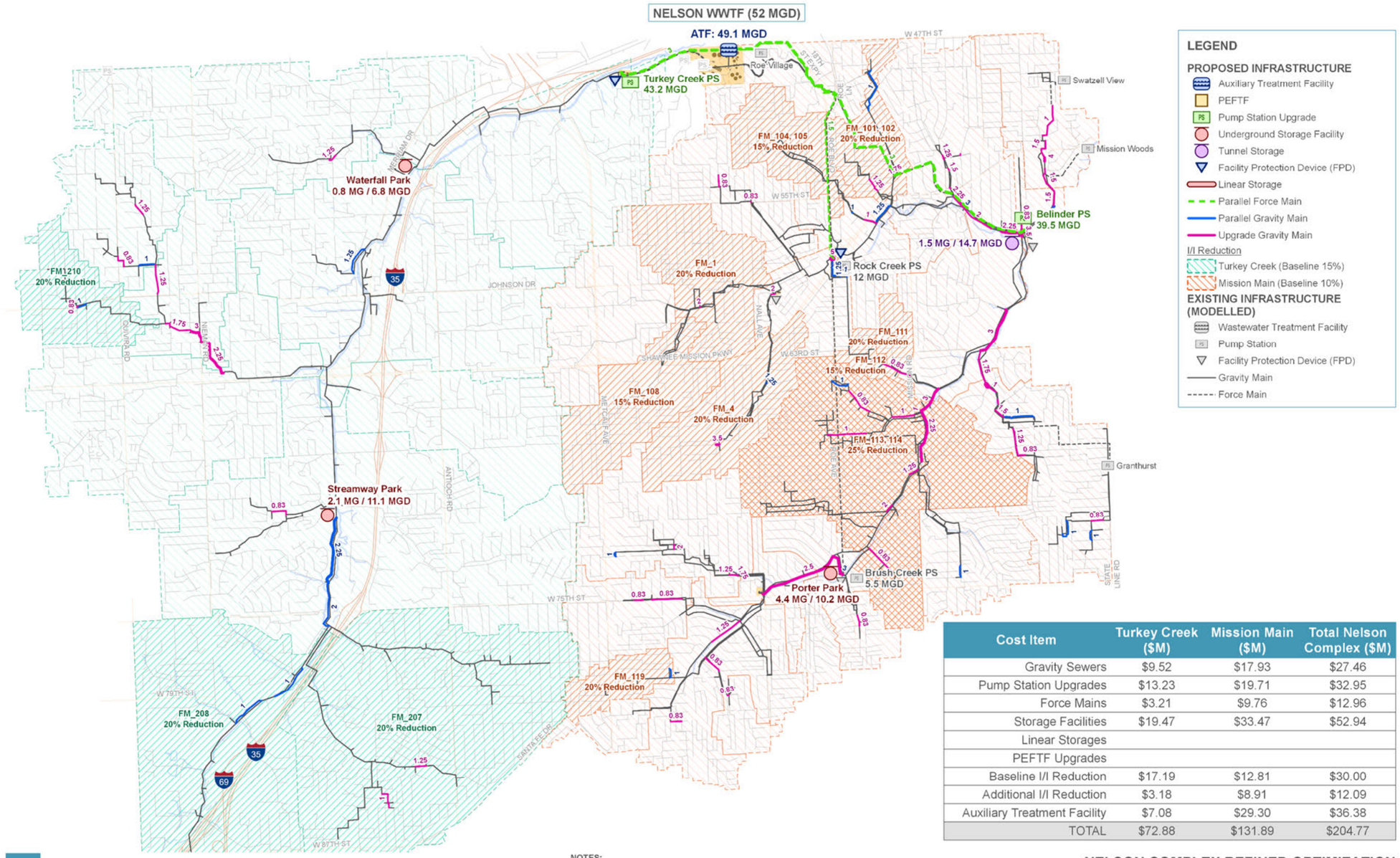
Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.52	$17.93	$27.46
Pump Station Upgrades	$13.23	$21.99	$35.22
Force Mains	$3.21	$9.76	$12.96
Storage Facilities	$19.46	$33.46	$52.93
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.18	$6.25	$9.43
Auxiliary Treatment Facility	$6.99	$30.05	$37.04
TOTAL	$72.79	$132.25	$205.04

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
LEAST COST SOLUTION W/O PEFTF

NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 7: Least-Cost Solution without PEFTF Upgrades



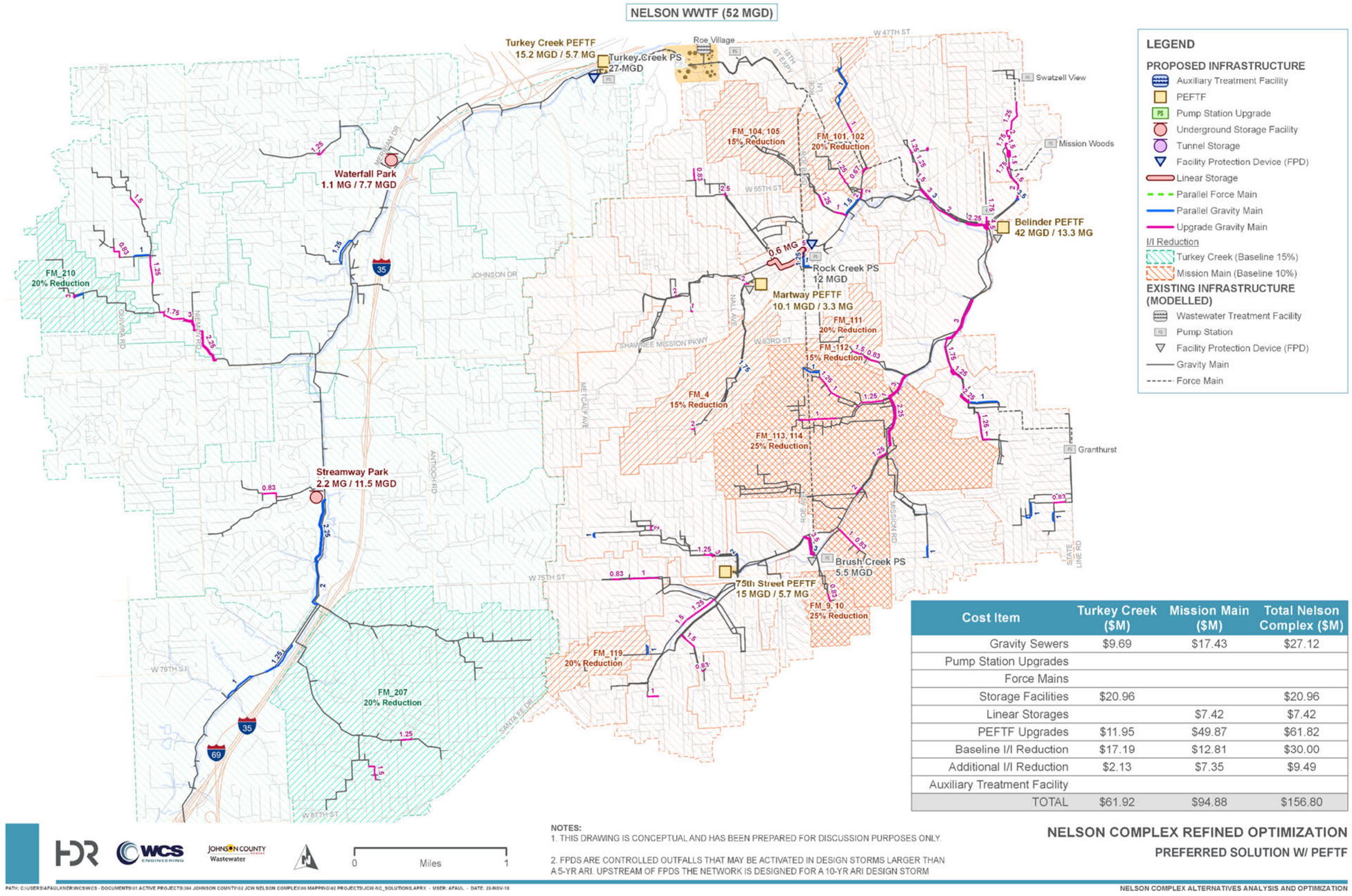
Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.52	$17.93	$27.46
Pump Station Upgrades	$13.23	$19.71	$32.95
Force Mains	$3.21	$9.76	$12.96
Storage Facilities	$19.47	$33.47	$52.94
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.18	$8.91	$12.09
Auxiliary Treatment Facility	$7.08	$29.30	$36.38
TOTAL	$72.88	$131.89	$204.77

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
ALTERNATIVE SOLUTION (BRUSH CREEK DIRECT TO WWTF)

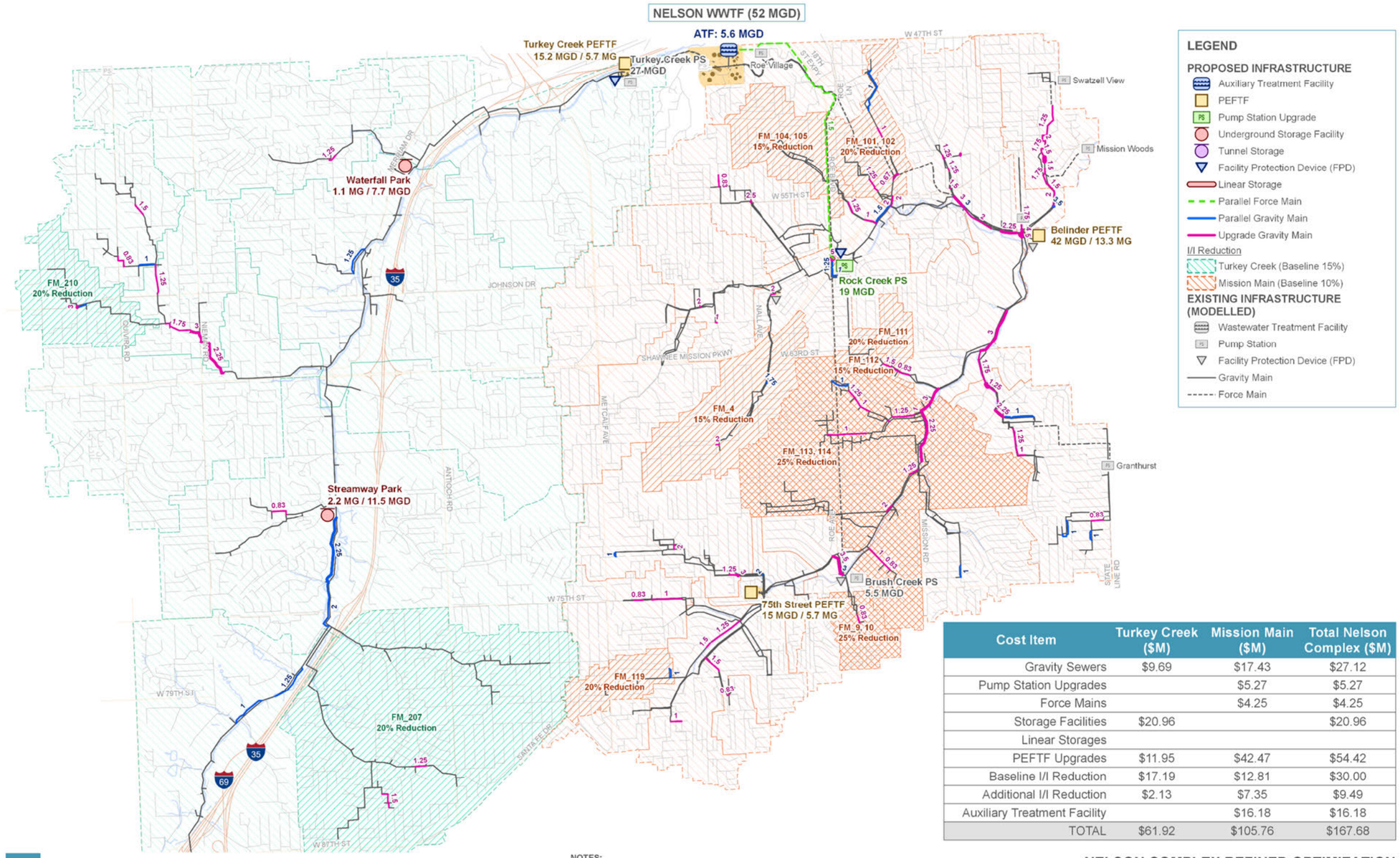
NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 8: Alternative Solution without PEFTF (Brush Creek direct to WWTF)



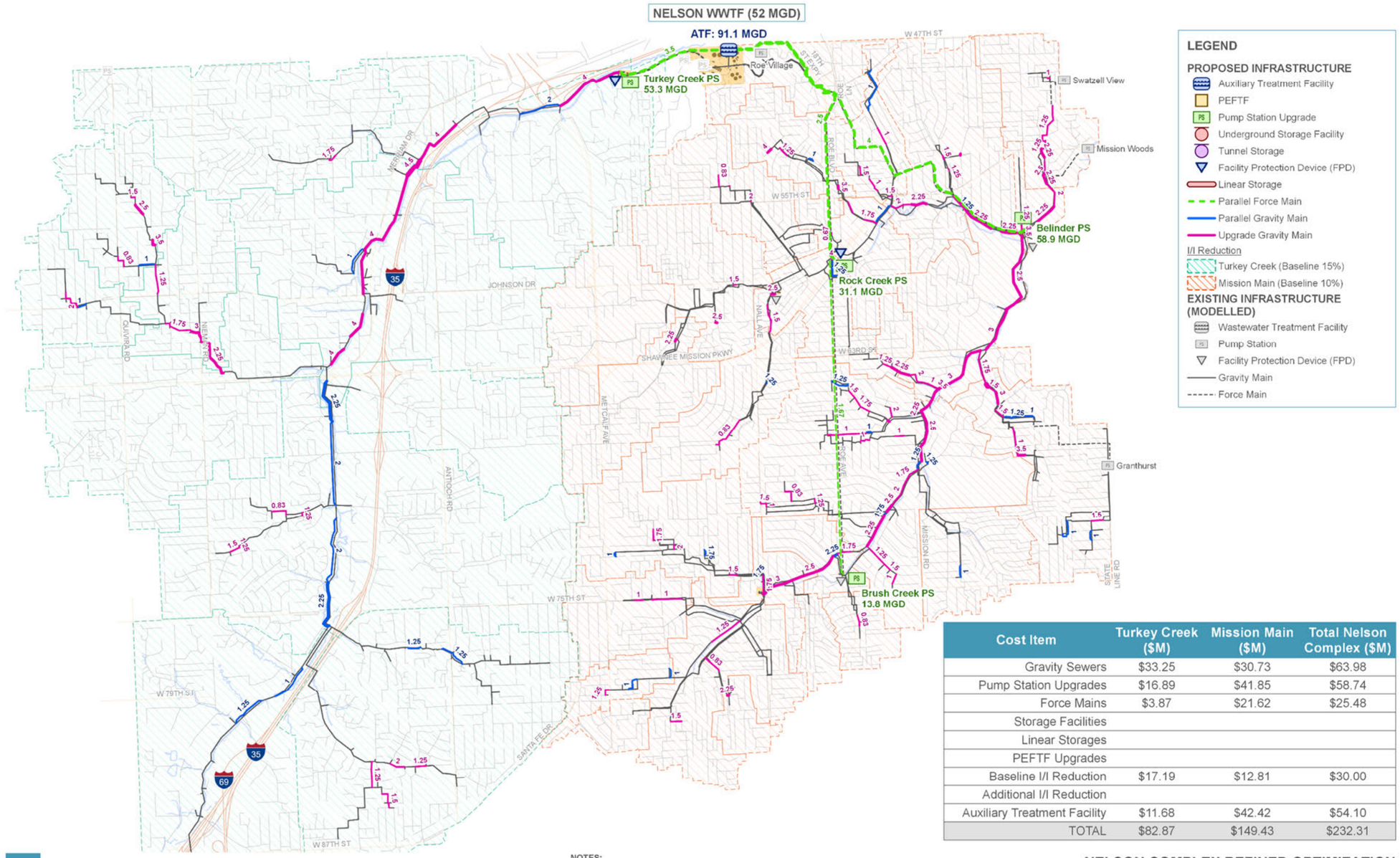
Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.69	$17.43	$27.12
Pump Station Upgrades			
Force Mains			
Storage Facilities	$20.96		$20.96
Linear Storages		$7.42	$7.42
PEFTF Upgrades	$11.95	$49.87	$61.82
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$2.13	$7.35	$9.49
Auxiliary Treatment Facility			
TOTAL	$61.92	$94.88	$156.80

Figure 9: Preferred Solution with PEFTF Upgrades



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.69	$17.43	$27.12
Pump Station Upgrades		$5.27	$5.27
Force Mains		$4.25	$4.25
Storage Facilities	$20.96		$20.96
Linear Storages			
PEFTF Upgrades	$11.95	$42.47	$54.42
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$2.13	$7.35	$9.49
Auxiliary Treatment Facility		$16.18	$16.18
TOTAL	$61.92	$105.76	$167.68

Figure 10: Solution with PEFTF Upgrades, without Rock Creek Linear Storage



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$33.25	$30.73	$63.98
Pump Station Upgrades	$16.89	$41.85	$58.74
Force Mains	$3.87	$21.62	$25.48
Storage Facilities			
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction			
Auxiliary Treatment Facility	$11.68	$42.42	$54.10
TOTAL	$82.87	$149.43	$232.31

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
OPTIMIZED CONVEYANCE-ONLY

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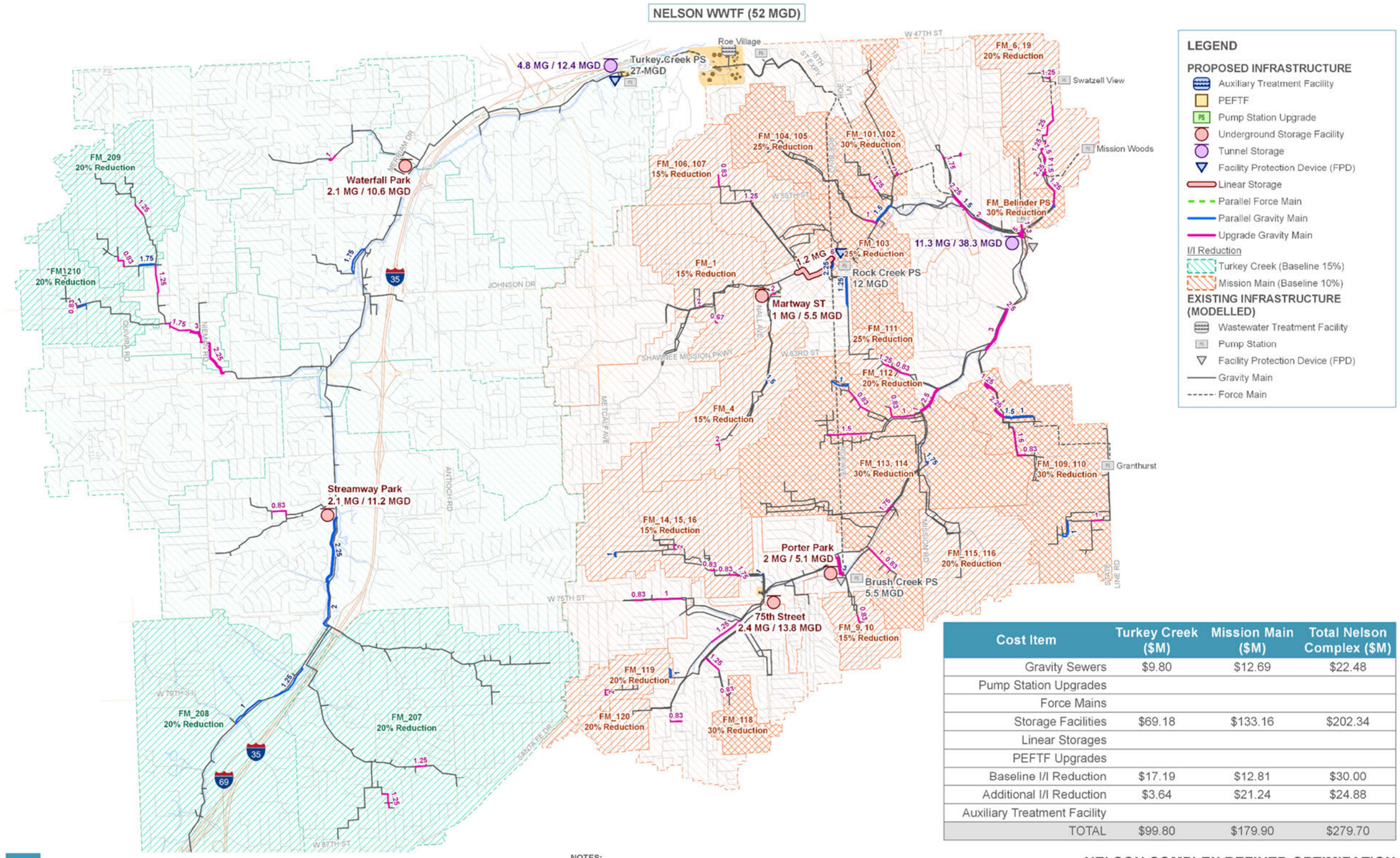
NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 11: Optimized Conveyance-Only Solution



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.80	$12.69	$22.48
Pump Station Upgrades			
Force Mains			
Storage Facilities	$69.18	$133.16	$202.34
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.64	$21.24	$24.88
Auxiliary Treatment Facility			
TOTAL	$99.80	$179.90	$279.70

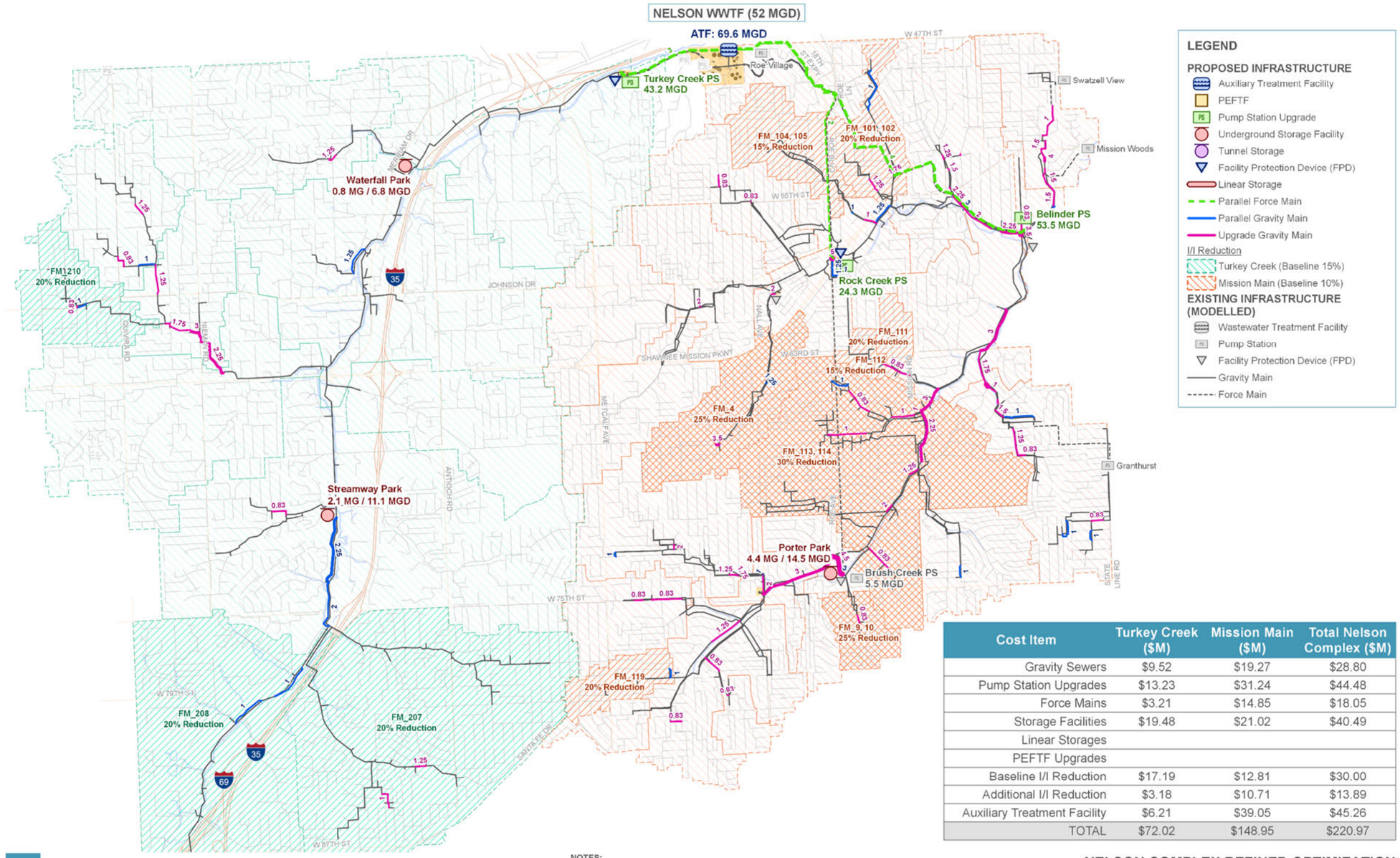
NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
OPTIMIZED W/O PEFTF AND W/O ATF

NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

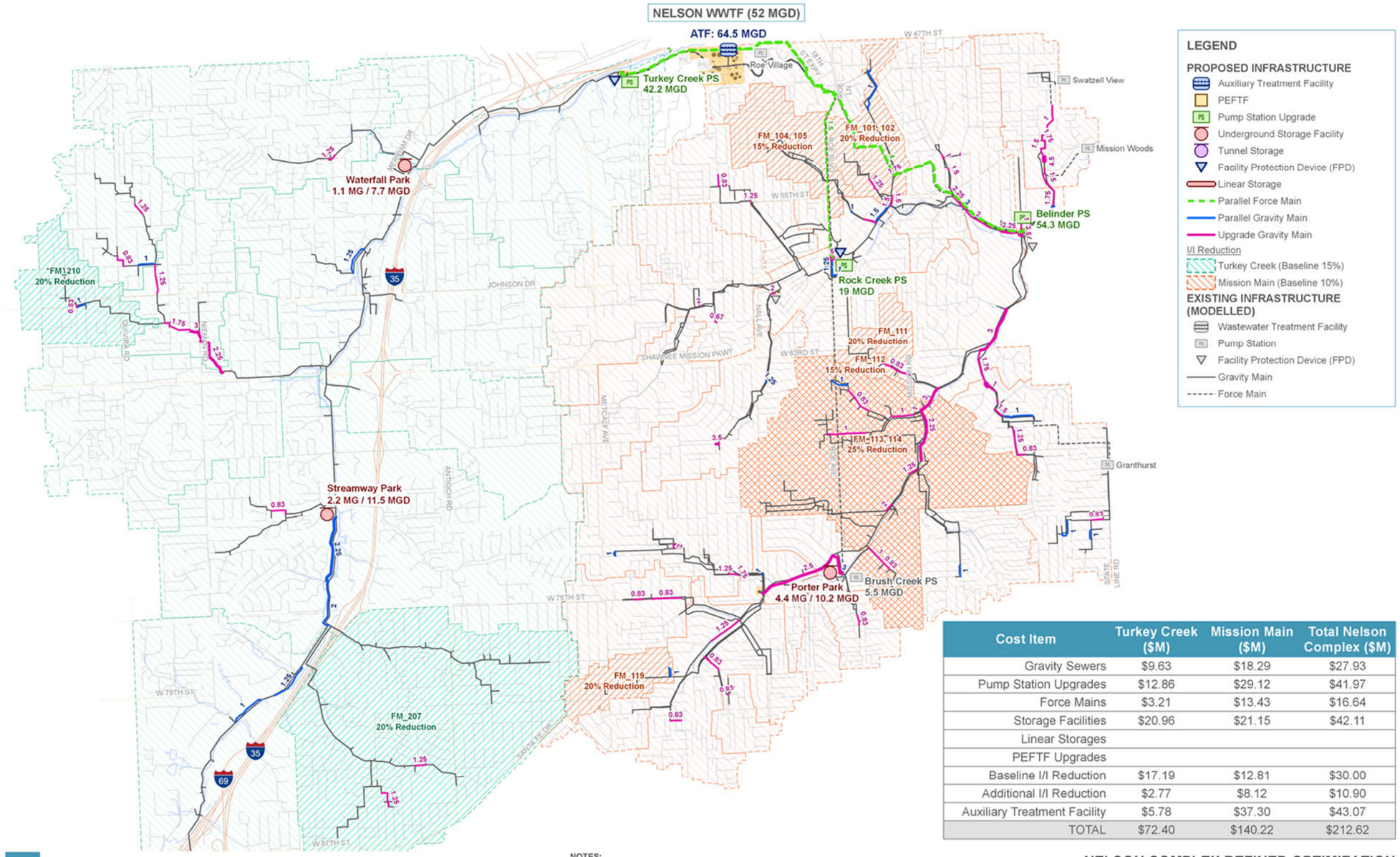
Figure 12: Optimized Solution without PEFTF or ATF Upgrades

Appendix C – Refined Optimization I/I Sensitivity Figures



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.52	$19.27	$28.80
Pump Station Upgrades	$13.23	$31.24	$44.48
Force Mains	$3.21	$14.85	$18.05
Storage Facilities	$19.48	$21.02	$40.49
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$3.18	$10.71	$13.89
Auxiliary Treatment Facility	$6.21	$39.05	$45.26
TOTAL	$72.02	$148.95	$220.97

Figure 13: Preferred Solution without PEFTF Upgrades



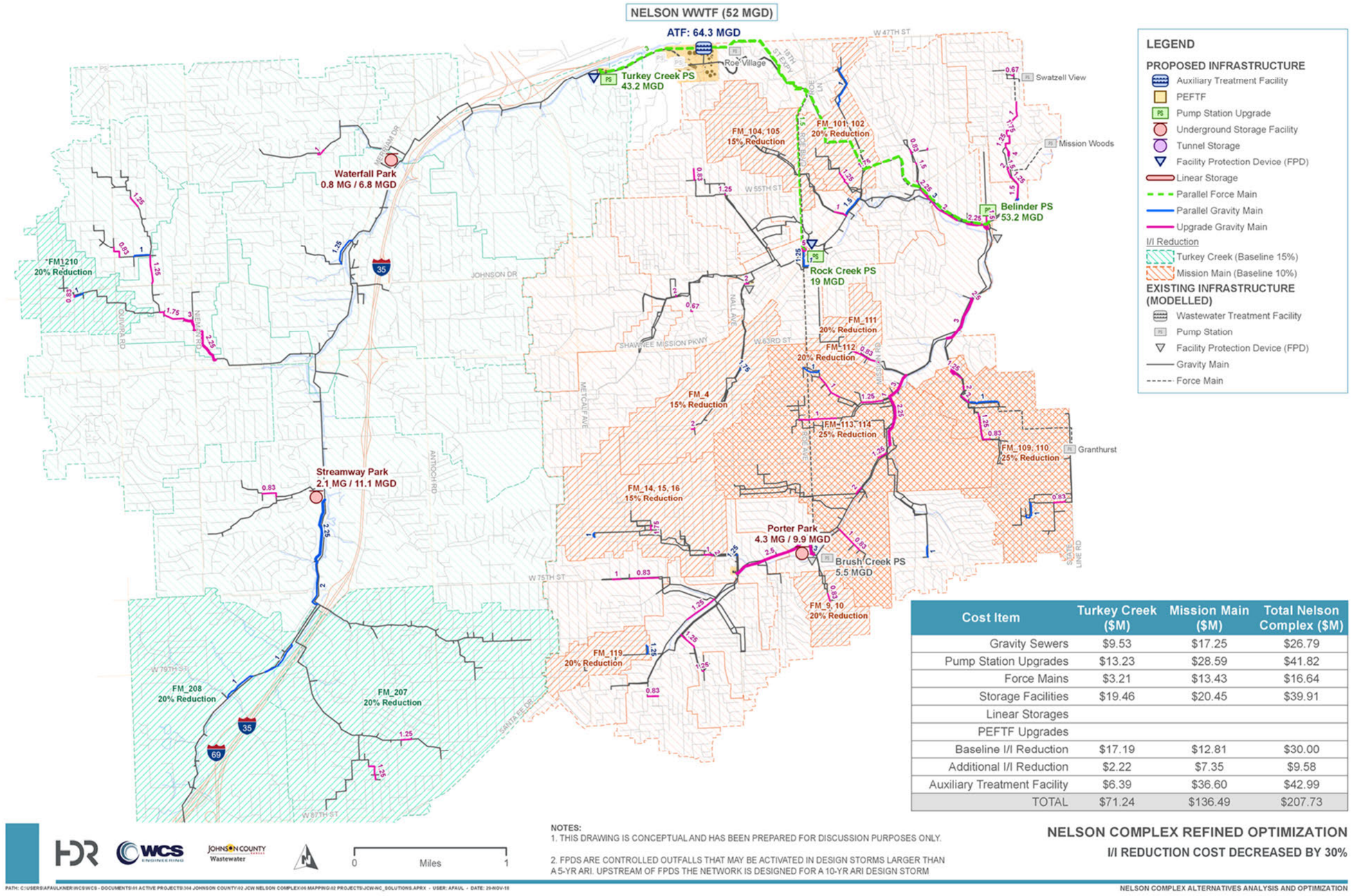
Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.63	$18.29	$27.93
Pump Station Upgrades	$12.86	$29.12	$41.97
Force Mains	$3.21	$13.43	$16.64
Storage Facilities	$20.96	$21.15	$42.11
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$2.77	$8.12	$10.90
Auxiliary Treatment Facility	$5.78	$37.30	$43.07
TOTAL	$72.40	$140.22	$212.62

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
I/I REDUCTION COST INCREASED BY 30%

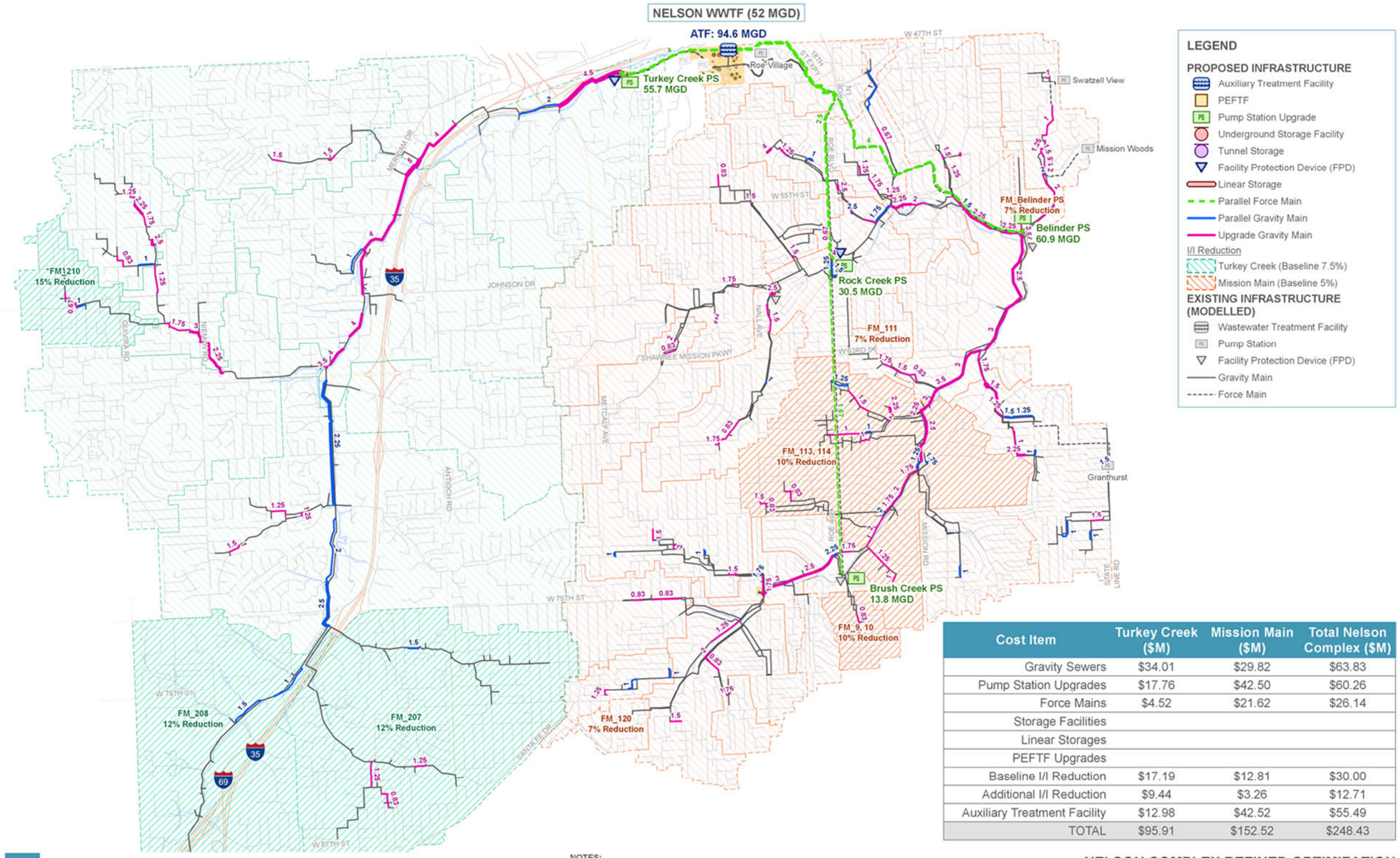
NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 14: I/I Reduction Cost +30% Sensitivity (without PEFTF Upgrades)



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$9.53	$17.25	$26.79
Pump Station Upgrades	$13.23	$28.59	$41.82
Force Mains	$3.21	$13.43	$16.64
Storage Facilities	$19.46	$20.45	$39.91
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$2.22	$7.35	$9.58
Auxiliary Treatment Facility	$6.39	$36.60	$42.99
TOTAL	$71.24	$136.49	$207.73

Figure 15: I/I Reduction Cost -30% Sensitivity (without PEFTF Upgrades)



Cost Item	Turkey Creek ($M)	Mission Main ($M)	Total Nelson Complex ($M)
Gravity Sewers	$34.01	$29.82	$63.83
Pump Station Upgrades	$17.76	$42.50	$60.26
Force Mains	$4.52	$21.62	$26.14
Storage Facilities			
Linear Storages			
PEFTF Upgrades			
Baseline I/I Reduction	$17.19	$12.81	$30.00
Additional I/I Reduction	$9.44	$3.26	$12.71
Auxiliary Treatment Facility	$12.98	$42.52	$55.49
TOTAL	$95.91	$152.52	$248.43

NOTES:
1. THIS DRAWING IS CONCEPTUAL AND HAS BEEN PREPARED FOR DISCUSSION PURPOSES ONLY.
2. FPDS ARE CONTROLLED OUTFALLS THAT MAY BE ACTIVATED IN DESIGN STORMS LARGER THAN A 5-YR ARI. UPSTREAM OF FPDS THE NETWORK IS DESIGNED FOR A 10-YR ARI DESIGN STORM

NELSON COMPLEX REFINED OPTIMIZATION
I/I REDUCTION EFFECTIVENESS DECREASED BY 50%

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NELSON COMPLEX ALTERNATIVES ANALYSIS AND OPTIMIZATION

Figure 16: I/I Reduction Effectiveness -50% Sensitivity (without PEFTF Upgrades)

Appendix D – Refined Optimization Solution Summary Spreadsheets

Refined Optimization Results

10-Year/5-Year

Preferred No PEFTF Solution

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model (Y/N)	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
NELSON COMPLEX GRAVITY SEWER TOTAL																								**$ 28,795,102**	**$ -**	**$ 28,795,102**
PARALLEL GRAVITY SEWER (NELSON COMPLEX)																								**$ 8,515,482**	**$ -**	**$ 8,515,482**
UPGRADE GRAVITY SEWER (NELSON COMPLEX)																								**$ 20,279,620**	**$ -**	**$ 20,279,620**
PARALLEL GRAVITY SEWER (TUKEY CREEK)										**8,637**														**$ 5,946,941**	**$ -**	**$ 5,946,941**
F_GS_006		184			NO																					
F_GS_010		138			YES	0341012	0341009	1	1.00	1,224	969.93	966.78	0.3%	16.49	19.19	17.84	4	1.3	1	1.00	$ 417	$ -	$ 1,251	$ 625,300	$ -	$ 625,300
F_GS_011					NO																					
F_GS_012		829			YES	0341008	0341004	1	1.00	1,416	965.05	960.51	0.3%	12.50	17.88	15.19	4	1.4	1	1.00	$ 417	$ -	$ 1,251	$ 1,281,729	$ -	$ 1,281,729
F_GS_015					NO																					
F_GS_026					NO																					
F_GS_031					NO																					
F_GS_034					NO																					
F_GS_038	56				NO																					
F_GS_040					NO																					
F_GS_043					NO																					
F_GS_045	104			169	YES	0335012	0335005	1	2.00	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	10.7	0.96	0.48	$ 528	$ -	$ 2,518	$ 1,429,659	$ -	$ 1,429,659
F_GS_062		95			NO																					
F_GS_064		283			NO																					
F_GS_068	57				YES	0327053	0327044	1	1.00	360	1007.08	1000.96	1.7%	9.27	12.76	11.02	3	0.9	0.38	0.38	$ 348	$ -	$ 400	$ 128,209	$ -	$ 128,209
F_GS_069	68				NO																					
F_GS_072					NO																					
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	984.48	0.5%	9.50	7.95	8.72	2	0.8	0.49	0.49	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_078					NO																					
F_GS_082					NO																					
F_GS_085					NO																					
F_GS_112					YES	0310205	0310012	1	1.25	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.3	0.69	0.55	$ 447	$ -	$ -	$ 466,275	$ -	$ 466,275
F_GS_124	62				NO																					
F_GS_131		62			YES	0335005	0331011	1	2.25	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	11.9	0.77	0.34	$ 756	$ -	$ 2,268	$ 1,851,263	$ -	$ 1,851,263
UPGRADE GRAVITY SEWER (TUKEY CREEK)										**6,992**														**$ 3,576,275**	**$ -**	**$ 3,576,275**
U_GS_017					NO																					
U_GS_018					YES	0340106	0340091	1	1.00	690	1013.430	1007.23	0.9%	13.84	10.12	11.98	3	0.9	0.5	0.45	$ 348	$ -	$ -	$ 240,197	$ -	$ 240,197
U_GS_019					NO																					
U_GS_021	46				NO																					
U_GS_022					YES	0339003	0338027	1	1.25	361	1009.670	1005.94	1.0%	8.73	15.56	12.15	3	2.0	0.5	0.40	$ 373	$ -	$ -	$ 134,653	$ -	$ 134,653
U_GS_023					NO																					
U_GS_024					NO																					
U_GS_025					NO																					
U_GS_039					NO																					
U_GS_056					YES	0332011	0332002	1	0.83	608	969.790	965.95	0.6%	5.06	10.88	7.97	2	0.9	0.7	0.83	$ 257	$ -	$ -	$ 156,168	$ -	$ 156,168
U_GS_060					NO																					
U_GS_065					NO																					
U_GS_067	50				NO																					
U_GS_070	43				NO																					
U_GS_071					NO																					
U_GS_074					YES	0326024	0326003	1	0.83	532	999.240	996.97	0.4%	13.12	11.76	12.44	3	1.1	0.9	1.05	$ 321	$ -	$ -	$ 170,660	$ -	$ 170,660
U_GS_076					NO																					
U_GS_079					NO																					
U_GS_080					NO																					
U_GS_081					YES	0325044	0325036	1	1.25	411	1011.900	1008.18	0.9%	8.62	5.76	7.19	2	1.6	0.5	0.40	$ 298	$ -	$ -	$ 122,567	$ -	$ 122,567
U_GS_084					NO																					
U_GS_086					YES	0323131	0323127	1	1.25	949	980.410	969.24	1.2%	12.02	16.79	14.41	3	3.9	1.0	0.80	$ 373	$ -	$ -	$ 354,037	$ -	$ 354,037
U_GS_087					NO																					
U_GS_089					YES	0323019	0323013	1	1.75	1,003	961.120	953.55	0.8%	10.12	12.15	11.14	3	7.4	0.9	0.50	$ 464	$ -	$ -	$ 465,392	$ -	$ 465,392
U_GS_093		98			YES	0323008	0320200	1	2.25	1,458	949.070	941.44	0.5%	12.15	19.91	16.03	4	10.3	0.9	0.38	$ 756	$ -	$ 2,268	$ 1,250,613	$ -	$ 1,250,613
U_GS_095					NO																					
U_GS_096					NO																					
U_GS_097		25			NO																					
U_GS_098					NO																					
U_GS_106					NO																					
U_GS_107		204			NO																					
U_GS_110					NO																					
U_GS_111					NO																					
U_GS_113	47				NO																					
U_GS_116					NO																					
U_GS_118					YES	0309231	0309022	1	1.25	293	922.910	916.69	2.1%	9.09	12.01	10.55	3	2.3	0.5	0.36	$ 373	$ -	$ -	$ 109,188	$ -	$ 109,188
U_GS_120		36			NO																					
U_GS_121				128	NO																					
U_GS_126	47	95	41		NO																					
U_GS_127	48				YES	0323013	0323008	1	3.00	629	953.500	949.27	0.7%	12.15	12.15	12.15	3	8.1	0.4	0.13	$ 875	$ -	$ 1,006	$ 556,652	$ -	$ 556,652
U_GS_129					NO																					
U_GS_130					NO																					
U_GS_133	34				YES	0327054	0327053	1	0.83	58	1008.250	1007.95	0.5%	8.91	9.27	9.09	2	0.6	0.6	0.67	$ 257	$ -	$ 296	$ 16,148	$ -	$ 16,148
PARALLEL GRAVITY SEWER (MISSION MAIN)										**7,596**														**$ 2,568,542**	**$ -**	**$ 2,568,542**
F_GS_502					NO																					
F_GS_510					NO																					
F_GS_511					NO																					
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.3	0.44	0.44	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_525					NO																					
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1022.98	0.6%	7.82	9.14	8.48	2	0.6	0.42	0.42	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_538					NO																					
F_GS_555					YES	0133167	BCPSWW	1	3.00	30	923.51	922.50	3.4%	13.69	14.00	13.85	3	26.9	1	0.33	$ 875	$ -	$ -	$ 26,250	$ -	$ 26,250
F_GS_564					NO																					
F_GS_568					NO																					
F_GS_570	42				NO																					
F_GS_579	63	109			NO																					
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.35	0.35	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_592					NO																					
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	949.00	0.9%	11.09	10.36	10.73	3	0.7	0.4	0.40	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354

F_GS_621					NO																					
F_GS_624					NO																					
F_GS_628					NO																					
F_GS_629					YES	0132172	0132029	1	1.00	376	973.25	969.94	0.9%	10.68	10.36	10.52	3	0.6	0.36	0.36	$ 348	$ -	$ -	$ 130,695	$ -	$ 130,695
F_GS_630					NO																					
F_GS_632					NO																					
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	981.43	0.5%	11.15	11.05	11.10	3	0.7	0.43	0.43	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_642					YES	0123091	0123089	1	1.00	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	2.4	0.54	0.54	$ 278	$ -	$ -	$ 218,022	$ -	$ 218,022
F_GS_679					NO																					
F_GS_706					NO																					
F_GS_707					NO																					
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.2	0.43	0.43	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.25	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.1	0.63	0.50	$ 373	$ -	$ 429	$ 209,836	$ -	$ 209,836
F_GS_711	149				YES	0112016	0113002	1	1.25	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.4	1	0.80	$ 373	$ -	$ 429	$ 129,227	$ -	$ 129,227
F_GS_712	18				NO																					
F_GS_716					NO																					
F_GS_718					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	1.25	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	2.7	1	0.80	$ 373	$ -	$ 1,119	$ 334,883	$ -	$ 334,883
F_GS_729					NO																					
F_GS_737		34			NO																					
F_GS_745					YES	0107097	0107019	1	1.00	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.3	0.3	0.30	$ 278	$ -	$ -	$ 449,128	$ -	$ 449,128
F_GS_753					NO																					
F_GS_776					NO																					
F_GS_782					NO																					
F_GS_785					NO																					
F_GS_789					NO																					
F_GS_796					YES	0123089	0123086	1	1.00	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	2.4	0.73	0.73	$ 278	$ -	$ -	$ 82,950	$ -	$ 82,950
F_GS_799					NO																					
F_GS_801	38				NO																					
F_GS_820					NO																					
F_GS_825		95			NO																					
F_GS_826					NO																					
F_GS_849					NO																					
F_CC_51					NO																					
F_CC_54					NO																					
F_CC_58					NO																					
F_CC_59					YES	0120032	0120004	1	1.25	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.7	0.75	0.60	$ 373	$ -	$ -	$ 14,920	$ -	$ 14,920
F_CC_60					YES	0108028	0108017	1	1.00	31	907.35	906.42	3.0%	20.54	20.98	20.76	4	0.6	0.89	0.89	$ 417	$ -	$ -	$ 12,839	$ -	$ 12,839
F_CC_62	22				YES	0133049	0133056	1	1.00	31	942.64	942.77	-0.4%	9.73	9.69	9.71	2	2.1	0.91	0.91	$ 278	$ -	$ 320	$ 9,541	$ -	$ 9,541
F_CC_64					YES	0103196	0103053	1	3.00	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	3.1	1	0.33	$ 875	$ -	$ -	$ 30,625	$ -	$ 30,625
F_CC_65					NO																					
F_CC_66					YES	0101007	0101036	1	3.50	25	871.45	871.17	1.1%	4.85	5.38	5.12	2	1.3	0.76	0.22	$ 823	$ -	$ -	$ 20,575	$ -	$ 20,575
UPGRADE GRAVITY SEWER (MISSION MAIN)										**30,797**														**$ 16,703,345**	**$ -**	**$ 16,703,345**
U_GS_503					NO																					
U_GS_505					YES	0141046	0141010	1	0.83	370	1003.780	1002.30	0.4%	6.08	11.21	8.65	2	0.6	0.55	0.66	$ 257	$ -	$ -	$ 95,090	$ -	$ 95,090
U_GS_506					NO																					
U_GS_507					NO																					
U_GS_509					NO																					
U_GS_513					YES	0142016	0142001	1	0.83	80	997.147	996.11	1.3%	6.85	10.50	8.68	2	1.0	0.62	0.75	$ 257	$ -	$ -	$ 20,560	$ -	$ 20,560
U_GS_514					NO																					
U_GS_515		19			YES	0136046	0136042	1	0.83	644	979.010	964.00	2.3%	9.33	12.04	10.69	3	1.6	1	1.20	$ 321	$ -	$ 963	$ 218,918	$ -	$ 218,918
U_GS_519		180			YES	0140006	0136006	1	1.25	1,204	955.060	947.47	0.6%	15.52	5.99	10.75	3	2.4	0.64	0.51	$ 373	$ -	$ 1,119	$ 583,372	$ -	$ 583,372
U_GS_520					NO																					
U_GS_522	89				YES	0139015	0139014	1	0.83	300	1000.680	998.98	0.6%	11.61	12.58	12.10	3	1.1	0.86	1.04	$ 321	$ -	$ 369	$ 100,570	$ -	$ 100,570
U_GS_523	100				YES	0139013	0139010	1	0.83	1,025	991.400	975.45	1.6%	12.49	10.46	11.48	3	1.5	0.73	0.88	$ 321	$ -	$ 369	$ 333,835	$ -	$ 333,835
U_GS_524					NO																					
U_GS_532					NO																					
U_GS_533					NO																					
U_GS_534					NO																					
U_GS_535					YES	0137004	0137001	1	2.00	112	976.900	976.24	0.6%	9.43	9.47	9.45	2	1.7	0.28	0.14	$ 422	$ -	$ -	$ 47,264	$ -	$ 47,264
U_GS_539					NO																					
U_GS_540					NO																					
U_GS_541					NO																					
U_GS_542		172			NO																					
U_GS_543					YES	0135023	0135022	1	1.75	46	950.090	950.01	0.2%	8.63	9.37	9.00	2	4.1	0.57	0.33	$ 371	$ -	$ -	$ 17,238	$ -	$ 17,238
U_GS_545		50			YES	0133049	0133024	1	2.00	564	942.640	938.95	0.7%	9.73	11.62	10.68	3	4.4	1	0.50	$ 528	$ -	$ 1,584	$ 350,492	$ -	$ 350,492
U_GS_546	181				NO																					
U_GS_547	66	109			YES	Nall_Sluice	0133043	1	3.00	876	938.000	933.75	0.5%	14.62	11.42	13.02	3	18.0	0.61	0.20	$ 875	$ -	$ 2,011	$ 965,699	$ -	$ 965,699
U_GS_548	40				YES	0133043	0133034	1	3.00	1,888	933.100	926.86	0.3%	11.42	14.04	12.73	3	18.0	0.7	0.23	$ 875	$ -	$ 1,006	$ 1,657,192	$ -	$ 1,657,192
U_GS_549					YES	0133034	BCPSWW	1	4.50	802	926.330	923.00	0.4%	14.04	20.00	17.02	4	20.7	0.96	0.21	$ 1,575	$ -	$ -	$ 1,262,363	$ -	$ 1,262,363
U_GS_551					YES	0134174	0134230	1	0.83	380	967.890	957.79	2.7%	8.02	9.40	8.71	2	1.7	0.65	0.78	$ 257	$ -	$ -	$ 97,557	$ -	$ 97,557
U_GS_553					NO																					
U_GS_554					NO																					
U_GS_556		125			NO																					
U_GS_557		15			NO																					
U_GS_558					NO																					
U_GS_559					YES	0130029	0130024	1	0.83	272	939.480	934.99	1.7%	10.46	9.73	10.10	3	1.4	0.65	0.78	$ 321	$ -	$ -	$ 87,312	$ -	$ 87,312
U_GS_560					YES	0130024	0130001	1	0.83	714	933.490	919.79	1.9%	9.73	11.28	10.51	3	1.5	0.7	0.84	$ 321	$ -	$ -	$ 229,227	$ -	$ 229,227
U_GS_562	46				NO																					
U_GS_563					NO																					
U_GS_565					NO																					
U_GS_566					NO																					
U_GS_567					NO																					
U_GS_569					NO																					
U_GS_575					YES	0129008	0126009	1	2.00	281	909.270	907.87	0.5%	11.94	11.83	11.89	3	3.1	0.44	0.22	$ 528	$ -	$ -	$ 148,259	$ -	$ 148,259
U_GS_576					NO																					
U_GS_577					YES	0126005	0126044	1	1.25	329	902.660	896.55	1.9%	8.60	14.38	11.49	3	3.7	0.59	0.47	$ 373	$ -	$ -	$ 122,746	$ -	$ 122,746
U_GS_580		83			YES	0126004	0122033	1	2.25	1,812	891.510	884.93	0.4%	9.63	12.67	11.15	3	11.8	0.88	0.39	$ 630	$ -	$ 1,890	$ 1,246,502	$ -	$ 1,246,502
U_GS_585					NO																					
U_GS_586					NO																					
U_GS_588					NO																					
U_GS_589					NO																					
U_GS_590	39				YES	0125007	0125003	1	1.00	1,293	940.000	924.45	1.2%	16.44	7.08	11.76	3	2.1	0.73	0.73	$ 348	$ -	$ 400	$ 451,994	$ -	$ 451,994
U_GS_593					NO																					
U_GS_598					YES	0124007	0124006	1	0.83	331	937.000	936.21	0.2%	12.15	6.82	9.49	2	1.0	0.76	0.92	$ 257	$ -	$ -	$ 85,067	$ -	$ 85,067
U_GS_599					YES	0124006	0122058	1	0.83	649	936.210	920.83	2.4%	6.82	11.37	9.10	2	1.3	0.52	0.63	$ 257	$ -	$ -	$ 166,793	$ -	$ 166,793
U_GS_600					NO																					
U_GS_601					NO																					
U_GS_603					YES	0122053	0122051	1	1.00	755	902.800	895.50	1.0%	7.67	13.23	10.45	3	2.2	0.8	0.80	$ 348	$ -	$ -	$ 262,740	$ -	$ 262,740
U_GS_604	36				NO																					
U_GS_608		23			YES	0122033	0122019	1	3.00	959	884.630	880.94	0.4%	12.67	14.42	13.55	3	17.1	1	0.33	$ 875	$ -	$ 2,625	$ 879,463	$ -	$ 879,463

U_GS_612					NO																						
U_GS_613					YES	0122208	0122061	1	0.83	300	912.980	910.40	0.9%	9.88	9.98	9.93	2	1.0	0.65	0.78	$ 257	$ -	$ -	$ 77,100	$ -	$ 77,100
U_GS_614					YES	0122061	0122024	1	0.83	665	908.970	901.68	1.1%	9.98	8.32	9.15	2	1.2	0.87	1.05	$ 257	$ -	$ -	$ 170,905	$ -	$ 170,905
U_GS_615	32				NO																						
U_GS_616					NO																						
U_GS_617					NO																						
U_GS_619					NO																						
U_GS_620		742			NO																						
U_GS_623					NO																						
U_GS_626					NO																						
U_GS_627					YES	0132028	0132012	1	0.83	401	965.350	960.10	1.3%	11.00	10.04	10.52	3	1.9	0.94	1.13	$ 321	$ -	$ -	$ 128,721	$ -	$ 128,721
U_GS_635					NO																						
U_GS_636					NO																						
U_GS_640					YES	0123018	0123015	1	1.25	966	933.500	922.91	1.1%	10.50	8.23	9.37	2	2.3	0.51	0.41	$ 298	$ -	$ -	$ 287,791	$ -	$ 287,791
U_GS_641					NO																						
U_GS_643					NO																						
U_GS_644					NO																						
U_GS_645					NO																						
U_GS_646					NO																						
U_GS_647					YES	0123086	0123028	1	1.50	350	914.760	911.52	0.9%	8.97	8.60	8.79	2	4.8	0.65	0.43	$ 319	$ -	$ -	$ 111,650	$ -	$ 111,650
U_GS_649		31			NO																						
U_GS_650					YES	0123046	0123025	1	2.00	142	906.920	905.20	1.2%	9.32	10.38	9.85	2	7.2	1	0.50	$ 422	$ -	$ -	$ 60,075	$ -	$ 60,075
U_GS_651					NO																						
U_GS_652		66			YES	0123005	0123004	1	1.00	314	898.800	891.28	2.4%	8.04	10.83	9.44	2	3.6	0.88	0.88	$ 278	$ -	$ 834	$ 124,134	$ -	$ 124,134
U_GS_653					YES	0123004	0123021	1	5.00	102	891.280	890.09	1.2%	10.83	11.58	11.21	3	8.4	0.17	0.03	$ 1,454	$ -	$ -	$ 148,071	$ -	$ 148,071
U_GS_654		148			YES	0123021	0103042	1	1.75	1,179	888.990	874.72	1.2%	11.58	9.57	10.58	3	8.5	0.73	0.42	$ 464	$ -	$ 1,392	$ 683,888	$ -	$ 683,888
U_GS_655		71			YES	0103042	0103026	1	3.00	182	873.730	873.12	0.3%	9.57	11.58	10.58	3	26.0	0.73	0.24	$ 875	$ -	$ 2,625	$ 282,634	$ -	$ 282,634
U_GS_656	135	46			YES	0103026	0103038	1	3.00	1,499	873.020	863.94	0.6%	11.58	8.07	9.83	2	26.4	0.71	0.24	$ 700	$ -	$ 1,135	$ 1,127,707	$ -	$ 1,127,707
U_GS_659		189			NO																						
U_GS_662					YES	0103011	0103065	1	4.00	67	853.870	853.82	0.1%	9.92	12.91	11.42	3	7.1	0.63	0.16	$ 1,171	$ -	$ -	$ 78,754	$ -	$ 78,754
U_GS_663					YES	0103065	0103064	1	4.50	53	853.810	853.79	0.0%	12.91	13.25	13.08	3	26.6	0.55	0.12	$ 1,313	$ -	$ -	$ 70,224	$ -	$ 70,224
U_GS_664					NO																						
U_GS_670					NO																						
U_GS_671					NO																						
U_GS_672					NO																						
U_GS_675					NO																						
U_GS_676					YES	0115191	0115017	1	2.00	27	943.380	943.35	0.1%	14.62	13.83	14.23	3	6.6	0.61	0.31	$ 528	$ -	$ -	$ 14,037	$ -	$ 14,037
U_GS_677					NO																						
U_GS_678					NO																						
U_GS_681		43			NO																						
U_GS_682					NO																						
U_GS_683	59				NO																						
U_GS_684					NO																						
U_GS_685					NO																						
U_GS_686	38				NO																						
U_GS_687	11				NO																						
U_GS_689					NO																						
U_GS_691	111				NO																						
U_GS_692					NO																						
U_GS_694					YES	0113043	0113040	1	2.00	125	922.820	922.19	0.5%	8.88	13.50	11.19	3	4.8	0.95	0.48	$ 528	$ -	$ -	$ 65,988	$ -	$ 65,988
U_GS_698					YES	0114083	0114015	1	0.83	409	972.900	970.50	0.6%	9.73	9.57	9.65	2	0.8	0.62	0.75	$ 257	$ -	$ -	$ 105,113	$ -	$ 105,113
U_GS_699					NO																						
U_GS_700	36				NO																						
U_GS_701	65				NO																						
U_GS_702					NO																						
U_GS_703					NO																						
U_GS_705					NO																						
U_GS_708					YES	0113224	RCPSWW	1	5.00	20	905.300	905.22	0.4%	17.64	20.00	18.82	4	42.1	1	0.20	$ 1,745	$ -	$ -	$ 34,900	$ -	$ 34,900
U_GS_714	27				YES	0113002	0113224	1	8.00	27	906.400	905.60	3.0%	14.63	17.64	16.14	4	31.9	0.61	0.08	$ 4,429	$ -	$ 5,093	$ 137,511	$ -	$ 137,511
U_GS_717					NO																						
U_GS_719					NO																						
U_GS_724					NO																						
U_GS_726					NO																						
U_GS_727					NO																						
U_GS_728					NO																						
U_GS_730	63				NO																						
U_GS_731		35			NO																						
U_GS_732	34	21			NO																						
U_GS_733	126				YES	0108016	0108005	1	1.00	457	897.110	892.87	0.9%	8.92	10.10	9.51	2	2.3	0.9	0.90	$ 278	$ -	$ 320	$ 132,265	$ -	$ 132,265
U_GS_736					NO																						
U_GS_738					NO																						
U_GS_739					NO																						
U_GS_740					NO																						
U_GS_741					YES	0107030	0107027	1	1.25	507	922.830	911.10	2.3%	6.48	7.26	6.87	2	1.8	0.4	0.32	$ 298	$ -	$ -	$ 151,116	$ -	$ 151,116
U_GS_742					NO																						
U_GS_743	50				NO																						
U_GS_744	50				NO																						
U_GS_748					NO																						
U_GS_750					NO																						
U_GS_751					YES	0107010	0107021	1	1.75	20	913.880	913.63	1.3%	10.90	10.82	10.86	3	1.1	0.22	0.13	$ 464	$ -	$ -	$ 9,280	$ -	$ 9,280
U_GS_752					NO																						
U_GS_754		43			NO																						
U_GS_755		53			NO																						
U_GS_757					NO																						
U_GS_758	35				NO																						
U_GS_759		44			NO																						
U_GS_766					NO																						
U_GS_767					YES	0103104	0103103	1	1.50	38	911.610	911.46	0.4%	3.22	8.90	6.06	2	1.5	0.4	0.27	$ 319	$ -	$ -	$ 12,122	$ -	$ 12,122
U_GS_770					YES	0103059	0103195	1	1.50	63	888.230	887.25	1.6%	8.88	7.95	8.42	2	4.2	0.51	0.34	$ 319	$ -	$ -	$ 20,097	$ -	$ 20,097
U_GS_771					YES	0103226	0103089	1	1.25	150	899.840	897.01	1.9%	8.16	8.90	8.53	2	1.7	0.38	0.30	$ 298	$ -	$ -	$ 44,730	$ -	$ 44,730
U_GS_772					YES	0103192	0103056	1	1.25	44	877.540	877.25	0.7%	7.63	6.85	7.24	2	1.8	0.99	0.79	$ 298	$ -	$ -	$ 13,112	$ -	$ 13,112
U_GS_773	74				NO																						
U_GS_774		49			YES	0103053	0103069	1	2.00	1,186	869.590	865.54	0.3%	11.37	9.18	10.27	3	10.1	1	0.50	$ 528	$ -	$ 1,584	$ 677,884	$ -	$ 677,884
U_GS_775					YES	0103049	0103046	1	2.25	536	861.420	859.61	0.3%	12.32	10.37	11.34	3	10.1	0.72	0.32	$ 630	$ -	$ -	$ 337,445	$ -	$ 337,445
U_GS_777					YES	0103116	0103115	1	0.83	411	867.800	866.07	0.4%	12.92	12.59	12.76	3	1.4	0.89	1.07	$ 321	$ -	$ -	$ 131,927	$ -	$ 131,927
U_GS_778					YES	0103115	0101167	1	2.25	34	856.300	855.84	1.4%	12.59	13.09	12.84	3	1.4	0.2	0.09	$ 630	$ -	$ -	$ 21,312	$ -	$ 21,312
U_GS_779					YES	0101167	BLPSWW	1	3.50	85	855.240	854.79	0.5%	13.09	20.25	16.67	4	6.6	0.31	0.09	$ 1,235	$ -	$ -	$ 105,195	$ -	$ 105,195
U_GS_783					NO																						
U_GS_784					NO																						
U_GS_786					NO																						
U_GS_790	83				YES	0101018	0101016	1	1.50	330	902.310	895.82	2.0%	15.63	9.36	12.50	3	4.6	0.53	0.35	$ 399	$ -	$ 459	$ 136,560	$ -	$ 136,560
U_GS_791					YES	0101014	0101012	1	1.75	156	883.390	882.29	0.7%	8.43	9.21	8.82	2	4.3	1	0.57	$ 371	$ -	$ -	$ 57,876	$ -	$ 57,876

U_GS_794					YES	0101039	0101038	1	1.50	286	881.540	877.56	1.4%	8.61	13.17	10.89	3	3.7	0.74	0.49	$ 399	$ -	$ -	$ 114,114	$ -	$ 114,114
U_GS_795					NO																					
U_GS_797					YES	0101168	0101050	1	1.00	1,221	946.690	923.52	1.9%	8.01	4.94	6.48	2	2.9	0.78	0.78	$ 278	$ -	$ -	$ 339,299	$ -	$ 339,299
U_GS_798					NO																					
U_GS_803					NO																					
U_GS_805					YES	0101016	0101015	1	4.00	125	895.770	889.35	5.1%	9.36	9.58	9.47	2	4.6	0.54	0.14	$ 937	$ -	$ -	$ 117,125	$ -	$ 117,125
U_GS_806					NO																					
U_GS_810					NO																					
U_GS_812					NO																					
U_GS_813		20			NO																					
U_GS_815					NO																					
U_GS_816					NO																					
U_GS_817	38				NO																					
U_GS_818		148			NO																					
U_GS_819					YES	0120137	0120023	1	3.50	120	1006.440	1005.79	0.5%	11.46	8.00	9.73	2	0.8	0.23	0.07	$ 823	$ -	$ -	$ 98,760	$ -	$ 98,760
U_GS_821					NO																					
U_GS_822					NO																					
U_GS_823					NO																					
U_GS_824					NO																					
U_GS_827					YES	0128021	0123018	1	0.83	246	937.290	934.04	1.3%	9.67	10.50	10.09	3	1.6	0.84	1.01	$ 321	$ -	$ -	$ 78,966	$ -	$ 78,966
U_GS_828					NO																					
U_GS_829					NO																					
U_GS_830	222				YES	0101020	0101018	1	1.50	400	907.110	902.41	1.2%	15.73	15.63	15.68	4	4.5	0.58	0.39	$ 479	$ -	$ 551	$ 207,559	$ -	$ 207,559
U_GS_831					YES	0101012	0101039	1	1.50	150	882.290	881.84	0.3%	9.21	8.61	8.91	2	3.7	0.68	0.45	$ 319	$ -	$ -	$ 47,888	$ -	$ 47,888
U_GS_832					NO																					
U_GS_833					NO																					
U_GS_834					NO																					
U_GS_835					YES	0135025	0135023	1	1.25	276	952.690	950.33	0.9%	10.71	8.63	9.67	2	1.9	0.58	0.46	$ 298	$ -	$ -	$ 82,285	$ -	$ 82,285
U_GS_836	57				NO																					
U_GS_837					NO																					
U_GS_838					NO																					
U_GS_839					YES	0103054	0103196	1	2.25	476	872.530	872.01	0.1%	11.17	10.10	10.64	3	12.6	0.84	0.37	$ 630	$ -	$ -	$ 299,620	$ -	$ 299,620
U_GS_840					NO																					
U_GS_841					NO																					
U_GS_842		335			NO																					
U_GS_843	67				NO																					
U_GS_844					YES	0101010	0101008	1	1.25	348	878.280	876.54	0.5%	7.08	6.15	6.62	2	1.9	0.57	0.46	$ 298	$ -	$ -	$ 103,704	$ -	$ 103,704
U_GS_845					NO																					
U_GS_846					YES	0101008	0101007	1	1.50	483	876.440	871.55	1.0%	6.15	4.85	5.50	2	1.9	0.68	0.45	$ 319	$ -	$ -	$ 154,074	$ -	$ 154,074
U_GS_847					NO																					
U_GS_848					NO																					
U_GS_850					NO																					
U_CC_52					NO																					
U_CC_53					NO																					
U_CC_55					YES	0122239	0122033	1	1.00	34	887.300	887.58	-0.8%	10.10	12.67	11.39	3	1.1	0.37	0.37	$ 348	$ -	$ -	$ 11,717	$ -	$ 11,717
U_CC_56					NO																					
U_CC_57					YES	0103038	0103018	1	3.00	68	863.640	862.57	1.6%	8.07	8.57	8.32	2	5.0	0.51	0.17	$ 700	$ -	$ -	$ 47,600	$ -	$ 47,600
U_CC_61		20			NO																					
U_CC_63	32				YES	0114022	0114005	1	0.83	35	950.000	950.53	-1.5%	8.25	8.16	8.21	2	0.0	0.08	0.10	$ 257	$ -	$ 296	$ 10,256	$ -	$ 10,256
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																					
F_LS_02	47				NO																					
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					
F_LS_52					NO																					
F_LS_53		180			NO																					
F_LS_54					NO																					
F_LS_55		435			NO																					
FORCE MAIN (NELSON COMPLEX)																								**$ 18,055,000**	**$ -**	**$ 18,055,000**
FORCE MAIN (TUKEY CREEK)																								**$ 3,208,000**	**$ -**	**$ 3,208,000**
PS_TurkeyCreek					YES	TCPSWW	NC_DummyJct_ATF_2	1	3.00	3,500	-	-	-	-	-	-	2	43.6	-	-	-	-	-	$ 3,208,000	$ -	$ 3,208,000
FORCE MAIN (MISSION MAIN)																								**$ 14,847,000**	**$ -**	**$ 14,847,000**
PS_Belinder					YES	BLPSWW	NC_DummyJct_ATF_2	1	4.00	10,604	-	-	-	-	-	-	2	60.9	-	-	-	-	-	$ 9,188,000	$ -	$ 9,188,000
EX_PS_BrushCreek					NO			1		10,623	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
F_PS_BrushCreek					NO			1		10,623	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
PS_RockCreek					YES	RCPSWW	NC_DummyJct_ATF_2	1	2.00	7,047	-	-	-	-	-	-	2	24.3	-	-	-	-	-	$ 5,659,000	$ -	$ 5,659,000

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)	FM Capital Cost ($)	PS & RM Total 20yr PV Cost ($)
NELSON COMPLEX							**$ 37,771,199**	**$ 6,707,280**	**$ 44,478,479**	**$ 18,055,000**	**$ 62,533,479**
TURKEY CREEK							**$ 11,715,186**	**$ 1,518,408**	**$ 13,233,594**	**$ 3,208,000**	**$ 16,441,594**
PS_TurkeyCreek	27.0	YES	TCPSWW	NC_DummyJct_ATF_2	43.2	16.2	$ 11,715,186	$ 1,518,408	$ 13,233,594	$ 3,208,000	$ 16,441,594
MISSION MAIN							**$ 26,056,013**	**$ 5,188,872**	**$ 31,244,885**	**$ 14,847,000**	**$ 46,091,885**
PS_Belinder	10.6	YES	BLPSWW	NC_DummyJct_ATF_2	53.5	42.9	$ 19,422,009	$ 4,032,510	$ 23,454,519	$ 9,188,000	$ 32,642,519
EX_PS_BrushCreek	5.5	NO	BCPSWW	0113002	5.5		$ -	$ -	$ -	$ -	$ -
F_PS_BrushCreek	5.5	NO					$ -	$ -	$ -	$ -	$ -
PS_RockCreek	12.0	YES	RCPSWW	NC_DummyJct_ATF_2	24.3	12.3	$ 6,634,004	$ 1,156,363	$ 7,790,366	$ 5,659,000	$ 13,449,366

OPTIMISATION SOLUTION SUMMARY: STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
NELSON COMPLEXT STORAGE FACILITY TOTAL						**$ 40,379,169**	**$ 114,461**	**$ 40,493,630**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ 40,379,169**	**$ 114,461**	**$ 40,493,630**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ 19,429,632**	**$ 45,471**	**$ 19,475,103**
F_ST_03	F_ST_03_IN	YES	3.5	11.1	2.07	$ 12,074,412	$ 32,450	$ 12,106,862
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	YES	5.5	6.8	0.83	$ 7,355,220	$ 13,021	$ 7,368,241
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ 20,949,537**	**$ 68,990**	**$ 21,018,527**
F_ST_51	F_ST_51_IN	NO						
F_ST_BC	F_ST_BC_IN	YES	2.5	14.5	4.40	$ 20,949,537	$ 68,990	$ 21,018,527
F_ST_MW	F_ST_MW_IN	NO						
TUNNEL STORAGE @ FACILITY PROTECTION DEVICES (NELSON COMPLEX)						**$ -**	**$ -**	**$ -**
TUNNEL STORAGE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	NO						
TUNNEL STORAGE (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST-FPD_BL	F_ST-FPD_BL_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	NO						

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX PEFTF TOTAL								**$ -**	**$ -**	**$ -**
TURKEY CREEK								**$ -**	**$ -**	**$ -**
PS_TurkeyCreek_PEFTF	PEFTF_TC_Discharge	22.0	NO			0.0	0.0	$ -	$ -	$ -
MISSION MAIN								**$ -**	**$ -**	**$ -**
PS_Belinder_PEFTF	PEFTF_BL_Discharge	53.1	NO			0.0	0.0	$ -	$ -	$ -
PS_Martway_PEFTF	PEFTF_MW_Discharge	20.0	NO			0.0	0.0	$ -	$ -	$ -
PS_Nall_PEFTF	PEFTF_Nall_Discharge	20.0	NO			0.0	0.0	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	BASELINE Factor	Scaling Factor	% Reduction	BASELINE Cost ($)	ADDITIONAL I&I Costs: I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX I/I REDUCTION TOTAL							**$ 41,555,390**	**$ 13,885,719**	**$ -**	**$ 13,885,719**
TURKEY CREEK TOTAL							**$ 23,612,999**	**$ 3,178,234**	**$ -**	**$ 3,178,234**
FM_202	0309015	24	NO	0.85	0.850		$ 2,276,558	$ -	$ -	$ -
FM_203	0310001	82	NO	0.85	0.850		$ 3,088,151	$ -	$ -	$ -
FM_204	0320011	22	NO	0.85	0.850		$ 2,655,953	$ -	$ -	$ -
FM_205	0323001	42	NO	0.85	0.850		$ 865,729	$ -	$ -	$ -
FM_206	0331001	78	NO	0.85	0.850		$ 4,210,628	$ -	$ -	$ -
FM_207	0336001	130	YES	0.85	0.800	20%	$ 3,674,268	$ 1,837,134	$ -	$ 1,837,134
FM_208	0341001	54	YES	0.85	0.800	20%	$ 2,089,125	$ 1,044,562	$ -	$ 1,044,562
FM_209	0323131	56	NO	0.85	0.850		$ 917,006	$ -	$ -	$ -
FM_210	0327001	31	YES	0.85	0.800	20%	$ 593,077	$ 296,538	$ -	$ 296,538
FM_211	0321001	3	NO	0.85	0.850		$ 936,380	$ -	$ -	$ -
FM_TC PS	0301003	41	NO	0.85	0.850		$ 2,306,127	$ -	$ -	$ -
MISSION MAIN TOTAL							**$ 17,942,391**	**$ 10,707,484**	**$ -**	**$ 10,707,484**
FM_1	0115001	53	NO	0.90	0.90		$ 862,265	$ -	$ -	$ -
FM_101, 102	0107004	63	YES	0.90	0.80	20%	$ 513,295	$ 702,619	$ -	$ 702,619
FM_103	0108002	54	NO	0.90	0.90		$ 467,148	$ -	$ -	$ -
FM_104, 105	0108020	53	YES	0.90	0.85	15%	$ 583,348	$ 400,758	$ -	$ 400,758
FM_106, 107	0110018	45	NO	0.90	0.90		$ 776,694	$ -	$ -	$ -
FM_108	0115043	24	NO	0.90	0.90		$ 726,158	$ -	$ -	$ -
FM_109, 110	0123002	126	NO	0.90	0.90		$ 1,102,106	$ -	$ -	$ -
FM_111	0122027	2	YES	0.90	0.80	20%	$ 112,356	$ 153,798	$ -	$ 153,798
FM_112	0112058	14	YES	0.90	0.85	15%	$ 136,210	$ 93,576	$ -	$ 93,576
FM_113, 114	0122010	213	YES	0.90	0.70	30%	$ 1,918,439	$ 6,682,630	$ -	$ 6,682,630
FM_115, 116	0126030	28	NO	0.90	0.90		$ 702,779	$ -	$ -	$ -
FM_117	0133060	5	NO	0.90	0.90		$ 246,403	$ -	$ -	$ -
FM_118	0142001	7	NO	0.90	0.90		$ 186,808	$ -	$ -	$ -
FM_119	0140014	17	YES	0.90	0.80	20%	$ 266,121	$ 364,277	$ -	$ 364,277
FM_12, 13	0133010	48	NO	0.90	0.90		$ 336,364	$ -	$ -	$ -
FM_120	0141096	3	NO	0.90	0.90		$ 188,183	$ -	$ -	$ -
FM_121, 122	0139008	21	NO	0.90	0.90		$ 553,973	$ -	$ -	$ -
FM_123, 124	0115022	9	NO	0.90	0.90		$ 687,268	$ -	$ -	$ -
FM_14, 15, 16	0135002	71	NO	0.90	0.90		$ 1,036,493	$ -	$ -	$ -
FM_17, 18	0136001	110	NO	0.90	0.90		$ 1,276,154	$ -	$ -	$ -
FM_2, 3	0103004	93	NO	0.90	0.90		$ 1,473,083	$ -	$ -	$ -
FM_4	0113050	51	YES	0.90	0.75	25%	$ 718,143	$ 1,697,023	$ -	$ 1,697,023
FM_5, 7	0103012	66	NO	0.90	0.90		$ 743,095	$ -	$ -	$ -
FM_6, 19	0101010	53	NO	0.90	0.90		$ 641,649	$ -	$ -	$ -
FM_9, 10	0134015	17	YES	0.90	0.75	25%	$ 259,325	$ 612,803	$ -	$ 612,803
FM_BC PS	0129005	30	NO	0.90	0.90		$ 314,696	$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	0.90	0.90		$ 108,212	$ -	$ -	$ -
FM_RC PS	0112006	66	NO	0.90	0.90		$ 455,861	$ -	$ -	$ -
FM_ WWTF	1601002	5	NO	0.90	0.90		$ 549,761	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TREATMENT FACILITY TOTAL COST				**$ 40,759,415**	**$ 4,501,118**	**$ 45,260,534**
Nelson_ATF	52	121.6	69.6	$ 40,759,415	$ 4,501,118	$ 45,260,534
PS_TurkeyCreek	33.6	43.2	9.6	$ 5,590,080	$ 617,320	$ 6,207,400
Mission Main Catchment	18.4	78.5	60.1	$ 35,169,335	$ 3,883,798	$ 39,053,133

Refined Optimization Results

10-Year/5-Year

Preferred With PEFTF Solution

OPTIMISATION SOLUTION SUMMARY:
GRAVITY SEWERS, FORCE MAINS & LINEAR STORAGE

*Requires manually entered value

(NOT Including Staging Discount)

Model ID	Arterial Crossing (ft)	Stream Crossing (ft)	Highway Crossing (ft)	Railroad Crossing (ft)	Operating in Solution Model (Y/N)	U/S ID	D/S ID	Barrels	Diameter (ft)	Total Length (ft)	U/S IL (ft AHD)	D/S IL (ft AHD)	Slope (%)	U/S Depth (ft)	D/S Depth (ft)	Average Depth (ft)	Depth Ref	Peak Flow (MGD)	Max Flow Depth (ft)	d/D	Capital Cost ($/ft)	Annual O&M Cost ($/ft)	Crossing Capital Cost ($/ft)	TOTAL Capital Cost ($)	TOTAL 20yr O&M Cost ($)	TOTAL 20yr PV Cost ($)
NELSON COMPLEX GRAVITY SEWER TOTAL																								**$ 27,120,748**	**$ -**	**$ 27,120,748**
PARALLEL GRAVITY SEWER (NELSON COMPLEX)																								**$ 8,612,688**	**$ -**	**$ 8,612,688**
UPGRADE GRAVITY SEWER (NELSON COMPLEX)																								**$ 18,508,059**	**$ -**	**$ 18,508,059**
PARALLEL GRAVITY SEWER (TUKEY CREEK)																								**$ 6,039,151**	**$ -**	**$ 6,039,151**
F_GS_006		184			NO																					
F_GS_010		138			YES	0341012	0341009	1	1.00	1,224	969.93	966.78	0.3%	16.49	19.19	17.84	4	1.4	1	1.00	$ 417	$ -	$ 1,251	$ 625,300	$ -	$ 625,300
F_GS_011					NO																					
F_GS_012		829			YES	0341008	0341004	1	1.25	1,416	965.05	960.51	0.3%	12.50	17.88	15.19	4	2.5	1	0.80	$ 447	$ -	$ 1,341	$ 1,373,939	$ -	$ 1,373,939
F_GS_015					NO																					
F_GS_026					NO																					
F_GS_031					NO																					
F_GS_034					NO																					
F_GS_038	56				NO																					
F_GS_040					NO																					
F_GS_043					NO																					
F_GS_045	104			169	YES	0335012	0335005	1	2.00	1,678	948.45	942.04	0.4%	10.55	14.02	12.29	3	10.8	0.98	0.49	$ 528	$ -	$ 2,518	$ 1,429,659	$ -	$ 1,429,659
F_GS_062		95			NO																					
F_GS_064		283			NO																					
F_GS_068	57				YES	0327053	0327044	1	1.00	360	1007.08	1000.96	1.7%	9.27	12.76	11.02	3	0.9	0.38	0.38	$ 348	$ -	$ 400	$ 128,209	$ -	$ 128,209
F_GS_069	68				NO																					
F_GS_072					NO																					
F_GS_075					YES	0326001	0323131	1	1.00	592	987.50	984.48	0.5%	9.50	7.95	8.72	2	0.8	0.49	0.49	$ 278	$ -	$ -	$ 164,507	$ -	$ 164,507
F_GS_078					NO																					
F_GS_082					NO																					
F_GS_085					NO																					
F_GS_112					YES	0310205	0310012	1	1.25	1,043	896.70	886.38	1.0%	7.69	23.10	15.40	4	1.3	0.69	0.55	$ 447	$ -	$ -	$ 466,275	$ -	$ 466,275
F_GS_124	62				NO																					
F_GS_131		62			YES	0335005	0331011	1	2.25	2,325	942.04	933.23	0.4%	14.02	19.69	16.86	4	12.2	0.79	0.35	$ 756	$ -	$ 2,268	$ 1,851,263	$ -	$ 1,851,263
UPGRADE GRAVITY SEWER (TUKEY CREEK)																								**$ 3,647,907**	**$ -**	**$ 3,647,907**
U_GS_017					NO																					
U_GS_018					YES	0340106	0340091	1	1.50	690	1013.430	1007.23	0.9%	13.84	10.12	11.98	3	0.9	0.3	0.17	$ 399	$ -	$ -	$ 275,399	$ -	$ 275,399
U_GS_019					NO																					
U_GS_021	46				NO																					
U_GS_022					YES	0339003	0338027	1	1.25	361	1009.670	1005.94	1.0%	8.73	15.56	12.15	3	2.0	0.5	0.40	$ 373	$ -	$ -	$ 134,653	$ -	$ 134,653
U_GS_023					NO																					
U_GS_024					NO																					
U_GS_025					NO																					
U_GS_039					NO																					
U_GS_056					YES	0332011	0332002	1	0.83	608	969.790	965.95	0.6%	5.06	10.88	7.97	2	0.9	0.7	0.83	$ 257	$ -	$ -	$ 156,168	$ -	$ 156,168
U_GS_060					NO																					
U_GS_065					NO																					
U_GS_067	50				NO																					
U_GS_070	43				NO																					
U_GS_071					NO																					
U_GS_074					YES	0326024	0326003	1	0.83	532	999.240	996.97	0.4%	13.12	11.76	12.44	3	1.1	0.9	1.05	$ 321	$ -	$ -	$ 170,660	$ -	$ 170,660
U_GS_076					NO																					
U_GS_079					NO																					
U_GS_080					NO																					
U_GS_081					YES	0325044	0325036	1	1.50	411	1011.900	1008.18	0.9%	8.62	5.76	7.19	2	1.6	0.4	0.27	$ 319	$ -	$ -	$ 131,205	$ -	$ 131,205
U_GS_084					NO																					
U_GS_086					YES	0323131	0323127	1	1.25	949	980.410	969.24	1.2%	12.02	16.79	14.41	3	3.9	1.0	0.80	$ 373	$ -	$ -	$ 354,037	$ -	$ 354,037
U_GS_087					NO																					
U_GS_089					YES	0323019	0323013	1	1.75	1,003	961.120	953.55	0.8%	10.12	12.15	11.14	3	7.4	0.9	0.50	$ 464	$ -	$ -	$ 465,392	$ -	$ 465,392
U_GS_093		98			YES	0323008	0320200	1	2.25	1,458	949.070	941.44	0.5%	12.15	19.91	16.03	4	10.3	0.9	0.38	$ 756	$ -	$ 2,268	$ 1,250,613	$ -	$ 1,250,613
U_GS_095					NO																					
U_GS_096					NO																					
U_GS_097		25			NO																					
U_GS_098					NO																					
U_GS_106					NO																					
U_GS_107		204			NO																					

U_GS_110					NO																					
U_GS_111					NO																					
U_GS_113	47				NO																					
U_GS_116					NO																					
U_GS_118					YES	0309231	0309022	1	1.25	293	922.910	916.69	2.1%	9.09	12.01	10.55	3	2.3	0.5	0.36	$ 373	$ -	$ -	$ 109,188	$ -	$ 109,188
U_GS_120		36			NO																					
U_GS_121				128	NO																					
U_GS_126	47	95	41		NO																					
U_GS_127	48				YES	0323013	0323008	1	3.00	629	953.500	949.27	0.7%	12.15	12.15	12.15	3	8.1	0.4	0.13	$ 875	$ -	$ 1,006	$ 556,652	$ -	$ 556,652
U_GS_129					NO																					
U_GS_130					NO																					
U_GS_133	34				YES	0327054	0327053	1	3.00	58	1008.250	1007.95	0.5%	8.91	9.27	9.09	2	0.6	0.1	0.03	$ 700	$ -	$ 805	$ 43,941	$ -	$ 43,941
PARALLEL GRAVITY SEWER (MISSION MAIN)																								**$ 2,573,537**	**$ -**	**$ 2,573,537**
F_GS_502					NO																					
F_GS_510					NO																					
F_GS_511					NO																					
F_GS_512					YES	0140050	0140014	1	1.00	349	990.38	988.68	0.5%	8.72	10.50	9.61	2	0.3	0.44	0.44	$ 278	$ -	$ -	$ 97,080	$ -	$ 97,080
F_GS_525					NO																					
F_GS_526					YES	0138020	0138019	1	1.00	197	1024.13	1022.98	0.6%	7.82	9.14	8.48	2	0.6	0.42	0.42	$ 278	$ -	$ -	$ 54,646	$ -	$ 54,646
F_GS_538					NO																					
F_GS_555					YES	0133167	BCPSWW	1	3.00	30	923.51	922.50	3.4%	13.69	14.00	13.85	3	22.0	1	0.33	$ 875	$ -	$ -	$ 26,250	$ -	$ 26,250
F_GS_564					NO																					
F_GS_568					NO																					
F_GS_570	42				NO																					
F_GS_579	63	109			NO																					
F_GS_582					YES	0131009	0131008	1	1.00	407	972.66	970.66	0.5%	15.88	14.31	15.10	4	0.4	0.35	0.35	$ 417	$ -	$ -	$ 169,819	$ -	$ 169,819
F_GS_592					NO																					
F_GS_595	51				YES	0124019	0124011	1	1.00	634	954.70	949.00	0.9%	11.09	10.36	10.73	3	0.8	0.41	0.41	$ 348	$ -	$ 400	$ 223,354	$ -	$ 223,354
F_GS_621					NO																					
F_GS_624					NO																					
F_GS_628					NO																					
F_GS_629					YES	0132172	0132029	1	1.00	376	973.25	969.94	0.9%	10.68	10.36	10.52	3	0.6	0.36	0.36	$ 348	$ -	$ -	$ 130,695	$ -	$ 130,695
F_GS_630					NO																					
F_GS_632					NO																					
F_GS_633					YES	0132072	0132069	1	1.00	792	985.59	981.43	0.5%	11.15	11.05	11.10	3	0.7	0.43	0.43	$ 348	$ -	$ -	$ 275,769	$ -	$ 275,769
F_GS_642					YES	0123091	0123089	1	1.00	784	951.69	930.87	2.7%	8.22	6.21	7.22	2	2.4	0.54	0.54	$ 278	$ -	$ -	$ 218,022	$ -	$ 218,022
F_GS_679					NO																					
F_GS_706					NO																					
F_GS_707					NO																					
F_GS_709					YES	0112022	0112018	1	1.00	282	927.88	924.89	1.1%	4.84	12.21	8.53	2	1.2	0.44	0.44	$ 278	$ -	$ -	$ 78,382	$ -	$ 78,382
F_GS_710	39				YES	0112018	0112016	1	1.00	557	924.89	909.70	2.7%	12.21	8.48	10.35	3	1.0	0.68	0.68	$ 348	$ -	$ 400	$ 195,763	$ -	$ 195,763
F_GS_711	149				YES	0112016	0113002	1	1.25	324	909.70	906.40	1.0%	8.48	14.63	11.56	3	1.5	1	0.80	$ 373	$ -	$ 429	$ 129,227	$ -	$ 129,227
F_GS_712	18				NO																					
F_GS_716					NO																					
F_GS_718					NO																					
F_GS_720	170				NO																					
F_GS_723		55			YES	0108005	0107002	1	1.50	788	888.14	883.99	0.5%	10.10	13.19	11.65	3	4.2	0.93	0.62	$ 399	$ -	$ 1,197	$ 358,226	$ -	$ 358,226
F_GS_729					NO																					
F_GS_737		34			NO																					
F_GS_745					YES	0107097	0107019	1	1.00	1,616	972.90	965.63	0.4%	10.10	8.57	9.34	2	0.3	0.3	0.30	$ 278	$ -	$ -	$ 449,128	$ -	$ 449,128
F_GS_753					NO																					
F_GS_776					NO																					
F_GS_782					NO																					
F_GS_785					NO																					
F_GS_789					NO																					
F_GS_796					YES	0123089	0123086	1	1.00	298	930.87	914.76	5.4%	6.21	8.97	7.59	2	2.4	0.65	0.65	$ 278	$ -	$ -	$ 82,950	$ -	$ 82,950
F_GS_799					NO																					
F_GS_801	38				NO																					
F_GS_820					NO																					
F_GS_825		95			NO																					
F_GS_826					NO																					
F_GS_849					NO																					
F_CC_51					NO																					
F_CC_54					NO																					
F_CC_58					NO																					
F_CC_59					YES	0120032	0120004	1	1.75	40	961.50	963.50	-5.0%	16.32	13.05	14.69	3	0.8	0.71	0.41	$ 464	$ -	$ -	$ 18,560	$ -	$ 18,560
F_CC_60					NO																					
F_CC_62	22				YES	0133049	0133056	1	2.00	31	942.64	942.77	-0.4%	9.73	9.69	9.71	2	0.8	0.68	0.34	$ 422	$ -	$ 485	$ 14,466	$ -	$ 14,466
F_CC_64					YES	0103196	0103053	1	3.00	35	869.97	869.59	1.1%	10.10	11.37	10.73	3	3.6	1	0.33	$ 875	$ -	$ -	$ 30,625	$ -	$ 30,625
F_CC_65					NO																					
F_CC_66					YES	0101007	0101036	1	3.50	25	871.45	871.17	1.1%	4.85	5.38	5.12	2	1.3	0.66	0.19	$ 823	$ -	$ -	$ 20,575	$ -	$ 20,575
UPGRADE GRAVITY SEWER (MISSION MAIN)																								**$ 14,860,152**	**$ -**	**$ 14,860,152**
U_GS_503					NO																					

U_GS_505					YES	0141046	0141010	1	1.00	370	1003.780	1002.30	0.4%	6.08	11.21	8.65	2	0.6	0.41	0.41	$ 278	$ -	$ -	$ 102,860	$ -	$ 102,860
U_GS_506					NO																					
U_GS_507					NO																					
U_GS_509					NO																					
U_GS_513					YES	0142016	0142001	1	0.83	80	997.147	996.11	1.3%	6.85	10.50	8.68	2	1.0	0.62	0.75	$ 257	$ -	$ -	$ 20,560	$ -	$ 20,560
U_GS_514					NO																					
U_GS_515		19			YES	0136046	0136042	1	1.50	644	979.010	964.00	2.3%	9.33	12.04	10.69	3	1.6	0.63	0.42	$ 399	$ -	$ 1,197	$ 272,114	$ -	$ 272,114
U_GS_519		180			YES	0140006	0136006	1	1.25	1,204	955.060	947.47	0.6%	15.52	5.99	10.75	3	2.4	0.64	0.51	$ 373	$ -	$ 1,119	$ 583,372	$ -	$ 583,372
U_GS_520					NO																					
U_GS_522	89				YES	0139015	0139014	1	0.83	300	1000.680	998.98	0.6%	11.61	12.58	12.10	3	1.1	0.86	1.04	$ 321	$ -	$ 369	$ 100,570	$ -	$ 100,570
U_GS_523	100				YES	0139013	0139010	1	1.00	1,025	991.400	975.45	1.6%	12.49	10.46	11.48	3	1.5	0.52	0.52	$ 348	$ -	$ 400	$ 361,911	$ -	$ 361,911
U_GS_524					NO																					
U_GS_532					NO																					
U_GS_533					NO																					
U_GS_534					NO																					
U_GS_535					YES	0137004	0137001	1	2.00	112	976.900	976.24	0.6%	9.43	9.47	9.45	2	1.7	0.28	0.14	$ 422	$ -	$ -	$ 47,264	$ -	$ 47,264
U_GS_539					NO																					
U_GS_540					NO																					
U_GS_541					NO																					
U_GS_542		172			NO																					
U_GS_543					YES	0135023	0135022	1	3.00	46	950.090	950.01	0.2%	8.63	9.37	9.00	2	4.2	0.31	0.10	$ 700	$ -	$ -	$ 32,525	$ -	$ 32,525
U_GS_545		50			NO																					
U_GS_546	181				NO																					
U_GS_547	66	109			NO																					
U_GS_548	40				NO																					
U_GS_549					YES	0133034	BCPSWW	1	3.50	802	926.330	923.00	0.4%	14.04	20.00	17.02	4	18.5	1	0.29	$ 1,235	$ -	$ -	$ 989,853	$ -	$ 989,853
U_GS_551					YES	0134174	0134230	1	0.83	380	967.890	957.79	2.7%	8.02	9.40	8.71	2	1.7	0.65	0.78	$ 257	$ -	$ -	$ 97,557	$ -	$ 97,557
U_GS_553					NO																					
U_GS_554					NO																					
U_GS_556		125			NO																					
U_GS_557		15			NO																					
U_GS_558					NO																					
U_GS_559					YES	0130029	0130024	1	0.83	272	939.480	934.99	1.7%	10.46	9.73	10.10	3	1.5	0.68	0.82	$ 321	$ -	$ -	$ 87,312	$ -	$ 87,312
U_GS_560					YES	0130024	0130001	1	1.00	714	933.490	919.79	1.9%	9.73	11.28	10.51	3	1.6	0.52	0.52	$ 348	$ -	$ -	$ 248,508	$ -	$ 248,508
U_GS_562	46				NO																					
U_GS_563					NO																					
U_GS_565					NO																					
U_GS_566					NO																					
U_GS_567					NO																					
U_GS_569					NO																					
U_GS_575					YES	0129008	0126009	1	2.00	281	909.270	907.87	0.5%	11.94	11.83	11.89	3	3.3	0.46	0.23	$ 528	$ -	$ -	$ 148,259	$ -	$ 148,259
U_GS_576					NO																					
U_GS_577					YES	0126005	0126044	1	1.25	329	902.660	896.55	1.9%	8.60	14.38	11.49	3	3.9	0.61	0.49	$ 373	$ -	$ -	$ 122,746	$ -	$ 122,746
U_GS_580		83			YES	0126004	0122033	1	2.25	1,812	891.510	884.93	0.4%	9.63	12.67	11.15	3	11.9	1	0.44	$ 630	$ -	$ 1,890	$ 1,246,502	$ -	$ 1,246,502
U_GS_585					NO																					
U_GS_586					NO																					
U_GS_588					NO																					
U_GS_589					NO																					
U_GS_590	39				YES	0125007	0125003	1	1.00	1,293	940.000	924.45	1.2%	16.44	7.08	11.76	3	2.3	0.77	0.77	$ 348	$ -	$ 400	$ 451,994	$ -	$ 451,994
U_GS_593					NO																					
U_GS_598					YES	0124007	0124006	1	1.25	331	937.000	936.21	0.2%	12.15	6.82	9.49	2	1.1	0.43	0.34	$ 298	$ -	$ -	$ 98,638	$ -	$ 98,638
U_GS_599					YES	0124006	0122058	1	1.00	649	936.210	920.83	2.4%	6.82	11.37	9.10	2	1.4	0.41	0.41	$ 278	$ -	$ -	$ 180,422	$ -	$ 180,422
U_GS_600					NO																					
U_GS_601					NO																					
U_GS_603					YES	0122053	0122051	1	1.25	755	902.800	895.50	1.0%	7.67	13.23	10.45	3	2.2	0.52	0.42	$ 373	$ -	$ -	$ 281,615	$ -	$ 281,615
U_GS_604	36				NO																					
U_GS_608		23			YES	0122033	0122019	1	3.00	959	884.630	880.94	0.4%	12.67	14.42	13.55	3	17.4	1	0.33	$ 875	$ -	$ 2,625	$ 879,463	$ -	$ 879,463
U_GS_612					NO																					
U_GS_613					YES	0122208	0122061	1	1.50	300	912.980	910.40	0.9%	9.88	9.98	9.93	2	1.0	0.27	0.18	$ 319	$ -	$ -	$ 95,700	$ -	$ 95,700
U_GS_614					YES	0122061	0122024	1	0.83	665	908.970	901.68	1.1%	9.98	8.32	9.15	2	1.2	0.87	1.05	$ 257	$ -	$ -	$ 170,905	$ -	$ 170,905
U_GS_615	32				NO																					
U_GS_616					NO																					
U_GS_617					NO																					
U_GS_619					NO																					
U_GS_620		742			NO																					
U_GS_623					NO																					
U_GS_626					NO																					
U_GS_627					YES	0132028	0132012	1	0.83	401	965.350	960.10	1.3%	11.00	10.04	10.52	3	1.9	0.94	1.13	$ 321	$ -	$ -	$ 128,721	$ -	$ 128,721
U_GS_635					NO																					
U_GS_636					NO																					
U_GS_640					YES	0123018	0123015	1	1.25	966	933.500	922.91	1.1%	10.50	8.23	9.37	2	2.3	0.51	0.41	$ 298	$ -	$ -	$ 287,791	$ -	$ 287,791
U_GS_641					NO																					
U_GS_643					NO																					

U_GS_644					NO																					
U_GS_645					NO																					
U_GS_646					NO																					
U_GS_647					YES	0123086	0123028	1	2.25	350	914.760	911.52	0.9%	8.97	8.60	8.79	2	5.3	0.36	0.16	$ 504	$ -	$ -	$ 176,400	$ -	$ 176,400
U_GS_649		31			NO																					
U_GS_650					YES	0123046	0123025	1	2.00	142	906.920	905.20	1.2%	9.32	10.38	9.85	2	7.3	1	0.50	$ 422	$ -	$ -	$ 60,075	$ -	$ 60,075
U_GS_651					NO																					
U_GS_652		66			YES	0123005	0123004	1	1.25	314	898.800	891.28	2.4%	8.04	10.83	9.44	2	6.5	0.9	0.72	$ 298	$ -	$ 894	$ 133,064	$ -	$ 133,064
U_GS_653					YES	0123004	0123021	1	5.00	102	891.280	890.09	1.2%	10.83	11.58	11.21	3	8.4	0.21	0.04	$ 1,454	$ -	$ -	$ 148,071	$ -	$ 148,071
U_GS_654		148			YES	0123021	0103042	1	1.75	1,179	888.990	874.72	1.2%	11.58	9.57	10.58	3	8.5	0.73	0.42	$ 464	$ -	$ 1,392	$ 683,888	$ -	$ 683,888
U_GS_655		71			YES	0103042	0103026	1	3.00	182	873.730	873.12	0.3%	9.57	11.58	10.58	3	26.3	0.73	0.24	$ 875	$ -	$ 2,625	$ 282,634	$ -	$ 282,634
U_GS_656	135	46			YES	0103026	0103038	1	3.00	1,499	873.020	863.94	0.6%	11.58	8.07	9.83	2	26.8	0.72	0.24	$ 700	$ -	$ 1,135	$ 1,127,707	$ -	$ 1,127,707
U_GS_659		189			NO																					
U_GS_662					YES	0103011	0103065	1	5.00	67	853.870	853.82	0.1%	9.92	12.91	11.42	3	6.3	0.84	0.17	$ 1,454	$ -	$ -	$ 97,787	$ -	$ 97,787
U_GS_663					YES	0103065	0103064	1	5.00	53	853.810	853.79	0.0%	12.91	13.25	13.08	3	17.8	0.84	0.17	$ 1,454	$ -	$ -	$ 77,766	$ -	$ 77,766
U_GS_664					NO																					
U_GS_670					NO																					
U_GS_671					NO																					
U_GS_672					NO																					
U_GS_675					NO																					
U_GS_676					YES	0115191	0115017	1	2.00	27	943.380	943.35	0.1%	14.62	13.83	14.23	3	6.6	0.61	0.31	$ 528	$ -	$ -	$ 14,037	$ -	$ 14,037
U_GS_677					NO																					
U_GS_678					YES	0115139	0115137	1	1.00	54	959.900	959.50	0.7%	7.48	8.58	8.03	2	0.8	0.44	0.44	$ 278	$ -	$ -	$ 15,012	$ -	$ 15,012
U_GS_681		43			NO																					
U_GS_682					NO																					
U_GS_683	59				NO																					
U_GS_684					NO																					
U_GS_685					NO																					
U_GS_686	38				NO																					
U_GS_687	11				NO																					
U_GS_689					NO																					
U_GS_691	111				NO																					
U_GS_692					NO																					
U_GS_694					YES	0113043	0113040	1	2.00	125	922.820	922.19	0.5%	8.88	13.50	11.19	3	5.4	1	0.50	$ 528	$ -	$ -	$ 65,988	$ -	$ 65,988
U_GS_698					YES	0114083	0114015	1	0.83	409	972.900	970.50	0.6%	9.73	9.57	9.65	2	0.8	0.62	0.75	$ 257	$ -	$ -	$ 105,113	$ -	$ 105,113
U_GS_699					NO																					
U_GS_700	36				NO																					
U_GS_701	65				NO																					
U_GS_702					NO																					
U_GS_703					NO																					
U_GS_705					NO																					
U_GS_708					YES	0113224	RCPSWW	1	5.00	20	905.300	905.22	0.4%	17.64	20.00	18.82	4	22.5	1	0.20	$ 1,745	$ -	$ -	$ 34,900	$ -	$ 34,900
U_GS_714	27				YES	0113002	0113224	1	8.00	27	906.400	905.60	3.0%	14.63	17.64	16.14	4	20.2	0.61	0.08	$ 4,429	$ -	$ 5,093	$ 137,511	$ -	$ 137,511
U_GS_717					NO																					
U_GS_719					NO																					
U_GS_724					NO																					
U_GS_726					NO																					
U_GS_727					NO																					
U_GS_728					NO																					
U_GS_730	63				NO																					
U_GS_731		35			NO																					
U_GS_732	34	21			NO																					
U_GS_733	126				YES	0108016	0108005	1	1.00	457	897.110	892.87	0.9%	8.92	10.10	9.51	2	2.3	0.9	0.90	$ 278	$ -	$ 320	$ 132,265	$ -	$ 132,265
U_GS_736					NO																					
U_GS_738					NO																					
U_GS_739					NO																					
U_GS_740					NO																					
U_GS_741					YES	0107030	0107027	1	1.25	507	922.830	911.10	2.3%	6.48	7.26	6.87	2	1.8	0.4	0.32	$ 298	$ -	$ -	$ 151,116	$ -	$ 151,116
U_GS_742					NO																					
U_GS_743	50				NO																					
U_GS_744	50				YES	0107175	0107001	1	2.00	277	897.700	886.67	4.0%	9.25	12.67	10.96	3	3.0	0.25	0.13	$ 528	$ -	$ 607	$ 150,267	$ -	$ 150,267
U_GS_748					YES	0107017	0107015	1	1.00	622	946.930	936.39	1.7%	7.75	7.65	7.70	2	1.0	0.46	0.46	$ 278	$ -	$ -	$ 172,916	$ -	$ 172,916
U_GS_750					NO																					
U_GS_751					YES	0107010	0107021	1	3.50	20	913.880	913.63	1.3%	10.90	10.82	10.86	3	1.1	0.09	0.03	$ 1,029	$ -	$ -	$ 20,580	$ -	$ 20,580
U_GS_752					YES	0107021	0107170	1	0.67	218	913.300	909.51	1.7%	10.82	10.34	10.58	3	1.1	1	1.49	$ 258	$ -	$ -	$ 56,244	$ -	$ 56,244
U_GS_754		43			NO																					
U_GS_755		53			NO																					
U_GS_757					NO																					
U_GS_758	35				NO																					
U_GS_759		44			NO																					
U_GS_766					NO																					
U_GS_767					YES	0103104	0103103	1	2.25	38	911.610	911.46	0.4%	3.22	8.90	6.06	2	1.5	0.24	0.11	$ 504	$ -	$ -	$ 19,152	$ -	$ 19,152
U_GS_770					YES	0103059	0103195	1	1.25	63	888.230	887.25	1.6%	8.88	7.95	8.42	2	4.2	0.7	0.56	$ 298	$ -	$ -	$ 18,774	$ -	$ 18,774

U_GS_771					YES	0103226	0103089	1	1.25	150	899.840	897.01	1.9%	8.16	8.90	8.53	2	1.7	0.38	0.30	$ 298	$ -	$ -	$ 44,730	$ -	$ 44,730
U_GS_772					YES	0103192	0103056	1	1.50	44	877.540	877.25	0.7%	7.63	6.85	7.24	2	1.8	0.56	0.37	$ 319	$ -	$ -	$ 14,036	$ -	$ 14,036
U_GS_773	74				NO																					
U_GS_774		49			YES	0103053	0103069	1	2.00	1,186	869.590	865.54	0.3%	11.37	9.18	10.27	3	10.1	1	0.50	$ 528	$ -	$ 1,584	$ 677,884	$ -	$ 677,884
U_GS_775					YES	0103049	0103046	1	2.25	536	861.420	859.61	0.3%	12.32	10.37	11.34	3	10.1	0.72	0.32	$ 630	$ -	$ -	$ 337,445	$ -	$ 337,445
U_GS_777					YES	0103116	0103115	1	1.75	411	867.800	866.07	0.4%	12.92	12.59	12.76	3	1.4	0.3	0.17	$ 464	$ -	$ -	$ 190,698	$ -	$ 190,698
U_GS_778					YES	0103115	0101167	1	3.50	34	856.300	855.84	1.4%	12.59	13.09	12.84	3	1.7	0.56	0.16	$ 1,029	$ -	$ -	$ 34,810	$ -	$ 34,810
U_GS_779					YES	0101167	BLPSWW	1	4.00	85	855.240	854.79	0.5%	13.09	20.25	16.67	4	6.5	0.79	0.20	$ 1,406	$ -	$ -	$ 119,760	$ -	$ 119,760
U_GS_783					NO																					
U_GS_784					NO																					
U_GS_786					NO																					
U_GS_790	83				YES	0101018	0101016	1	1.50	330	902.310	895.82	2.0%	15.63	9.36	12.50	3	4.6	0.53	0.35	$ 399	$ -	$ 459	$ 136,560	$ -	$ 136,560
U_GS_791					YES	0101014	0101012	1	1.50	156	883.390	882.29	0.7%	8.43	9.21	8.82	2	4.2	1	0.67	$ 319	$ -	$ -	$ 49,764	$ -	$ 49,764
U_GS_794					YES	0101039	0101038	1	1.50	286	881.540	877.56	1.4%	8.61	13.17	10.89	3	3.6	0.74	0.49	$ 399	$ -	$ -	$ 114,114	$ -	$ 114,114
U_GS_795					NO																					
U_GS_797					YES	0101168	0101050	1	1.25	1,221	946.690	923.52	1.9%	8.01	4.94	6.48	2	2.9	0.52	0.42	$ 298	$ -	$ -	$ 363,709	$ -	$ 363,709
U_GS_798					NO																					
U_GS_803					YES	0101050	0101047	1	2.00	266	923.220	911.72	4.3%	4.94	11.23	8.09	2	3.0	0.22	0.11	$ 422	$ -	$ -	$ 112,252	$ -	$ 112,252
U_GS_805					YES	0101016	0101015	1	5.00	125	895.770	889.35	5.1%	9.36	9.58	9.47	2	4.6	0.41	0.08	$ 1,163	$ -	$ -	$ 145,375	$ -	$ 145,375
U_GS_806					NO																					
U_GS_810					NO																					
U_GS_812					YES	0140008	0140007	1	1.50	195	962.930	961.57	0.7%	11.65	16.30	13.98	3	2.1	0.42	0.28	$ 399	$ -	$ -	$ 77,805	$ -	$ 77,805
U_GS_813		20			NO																					
U_GS_815					NO																					
U_GS_816					NO																					
U_GS_817	38				NO																					
U_GS_818		148			NO																					
U_GS_819					YES	0120137	0120023	1	2.00	120	1006.440	1005.79	0.5%	11.46	8.00	9.73	2	0.8	0.89	0.45	$ 422	$ -	$ -	$ 50,640	$ -	$ 50,640
U_GS_821					NO																					
U_GS_822					NO																					
U_GS_823					NO																					
U_GS_824					NO																					
U_GS_827					YES	0128021	0123018	1	1.00	246	937.290	934.04	1.3%	9.67	10.50	10.09	3	1.6	0.57	0.57	$ 348	$ -	$ -	$ 85,608	$ -	$ 85,608
U_GS_828					NO																					
U_GS_829					NO																					
U_GS_830	222				YES	0101020	0101018	1	1.75	400	907.110	902.41	1.2%	15.73	15.63	15.68	4	4.5	0.45	0.26	$ 557	$ -	$ 641	$ 241,418	$ -	$ 241,418
U_GS_831					YES	0101012	0101039	1	1.75	150	882.290	881.84	0.3%	9.21	8.61	8.91	2	3.6	0.54	0.31	$ 371	$ -	$ -	$ 55,695	$ -	$ 55,695
U_GS_832					NO																					
U_GS_833					NO																					
U_GS_834					NO																					
U_GS_835					YES	0135025	0135023	1	1.25	276	952.690	950.33	0.9%	10.71	8.63	9.67	2	1.9	0.54	0.43	$ 298	$ -	$ -	$ 82,285	$ -	$ 82,285
U_GS_836	57				NO																					
U_GS_837					YES	0108018	0108017	1	1.25	403	915.390	906.52	2.2%	13.25	20.98	17.12	4	2.1	0.7	0.56	$ 447	$ -	$ -	$ 180,141	$ -	$ 180,141
U_GS_838					NO																					
U_GS_839					YES	0103054	0103196	1	3.00	476	872.530	872.01	0.1%	11.17	10.10	10.64	3	13.2	0.59	0.20	$ 875	$ -	$ -	$ 416,140	$ -	$ 416,140
U_GS_840					NO																					
U_GS_841					YES	0103003	BLPSWW	1	3.50	36	854.000	853.96	0.1%	13.44	20.25	16.85	4	7.4	0.56	0.16	$ 1,235	$ -	$ -	$ 44,791	$ -	$ 44,791
U_GS_842		335			NO																					
U_GS_843	67				NO																					
U_GS_844					YES	0101010	0101008	1	1.50	348	878.280	876.54	0.5%	7.08	6.15	6.62	2	1.9	0.43	0.29	$ 319	$ -	$ -	$ 111,012	$ -	$ 111,012
U_GS_845					NO																					
U_GS_846					YES	0101008	0101007	1	2.00	483	876.440	871.55	1.0%	6.15	4.85	5.50	2	1.9	0.62	0.31	$ 422	$ -	$ -	$ 203,822	$ -	$ 203,822
U_GS_847					NO																					
U_GS_848					NO																					
U_GS_850					NO																					
U_CC_52					NO																					
U_CC_53					YES	0122044	0122040	1	1.00	58	905.870	905.53	0.6%	7.93	9.37	8.65	2	1.4	0.64	0.64	$ 278	$ -	$ -	$ 16,124	$ -	$ 16,124
U_CC_55					YES	0122239	0122033	1	1.00	34	887.300	887.58	-0.8%	10.10	12.67	11.39	3	1.8	0.48	0.48	$ 348	$ -	$ -	$ 11,717	$ -	$ 11,717
U_CC_56					NO																					
U_CC_57					NO																					
U_CC_61		20			NO																					
U_CC_63	32				YES	0114022	0114005	1	2.50	35	950.000	950.53	-1.5%	8.25	8.16	8.21	2	0.0	0.03	0.01	$ 587	$ -	$ 675	$ 23,390	$ -	$ 23,390
LINEAR STORAGE (NELSON COMPLEX)																								**$ -**	**$ -**	**$ -**
LINEAR STORAGE (TUKEY CREEK)																								**$ -**	**$ -**	**$ -**
F_LS_01				128	NO																					
F_LS_02	47				NO																					
F_LS_03		48			NO																					
F_LS_04	104			169	NO																					
F_LS_05	62				NO																					
F_LS_06	47	95	41		NO																					
LINEAR STORAGE (MISSION MAIN)																								**$ -**	**$ -**	**$ -**
F_LS_50	40				NO																					
F_LS_51		23			NO																					

F_LS_52					NO																				
F_LS_53		180			NO																				
F_LS_54					NO																				
F_LS_55		435			NO																				
FORCE MAIN (NELSON COMPLEX)																							**$ -**	**$ -**	**$ -**
FORCE MAIN (TUKEY CREEK)																							**$ -**	**$ -**	**$ -**
PS_TurkeyCreek					NO			1		3,500	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
FORCE MAIN (MISSION MAIN)																							**$ -**	**$ -**	**$ -**
PS_Belinder					NO			1		10,604	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
EX_PS_BrushCreek					NO			1		10,623	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
F_PS_BrushCreek					NO			1		10,623	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -
PS_RockCreek					NO			1		7,047	-	-	-	-	-	-	2		-	-	-	-	-	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

Model ID	Existing Capacity (MGD)	Upgraded in Solution Model	U/S ID	D/S ID	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	PS Capital Cost ($)	PS 20yr O&M Cost ($)	PS Total 20yr PV Cost ($)	FM Capital Cost ($)	PS & RM Total 20yr PV Cost ($)
NELSON COMPLEX							**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
TURKEY CREEK							**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
PS_TurkeyCreek	27.0	NO	TCPSWW	NC_DummyJct_ATF_2	27.0		$ -	$ -	$ -	$ -	$ -
MISSION MAIN							**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
PS_Belinder	10.6	NO	BLPSWW	NC_DummyJct_ATF_2	10.6		$ -	$ -	$ -	$ -	$ -
EX_PS_BrushCreek	5.5	NO			5.5		$ -	$ -	$ -	$ -	$ -
F_PS_BrushCreek	5.5	NO					$ -	$ -	$ -	$ -	$ -
PS_RockCreek	12.0	NO	RCPSWW	NC_DummyJct_ATF_2	12.0		$ -	$ -	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY: STORAGE FACILITIES

*Requires manually entered value

7.48052 *gallons / ft^3

Model ID	Inflow Weir ID	Operating in Solution Model	Inlet Weir Height (ft)	Peak Inflow (MGD)	Storage Volume (MG)	ST+PS Capital Cost ($)	PS 20yr O&M Cost ($)	ST+PS Total 20yr PV Cost ($)
NELSON COMPLEXT STORAGE FACILITY TOTAL						**$ 27,507,953**	**$ 61,469**	**$ 27,569,422**
UNDERGROUND STORAGE FACILITY (NELSON COMPLEX)						**$ 20,906,282**	**$ 51,551**	**$ 20,957,833**
UNDERGROUND STORAGE FACILITY (TURKEY CREEK)						**$ 20,906,282**	**$ 51,551**	**$ 20,957,833**
F_ST_03	F_ST_03_IN	YES	3.5	11.5	2.18	$ 12,500,661	$ 34,205	$ 12,534,867
F_ST_04	F_ST_04_IN	NO						
F_ST_05	F_ST_05_IN	YES	5.0	7.7	1.11	$ 8,405,621	$ 17,345	$ 8,422,966
UNDERGROUND STORAGE FACILITY (MISSION MAIN)						**$ -**	**$ -**	**$ -**
F_ST_51	F_ST_51_IN	NO						
F_ST_BC	F_ST_BC_IN	YES	3.1	0.0	0.00	$ -	$ -	$ -
F_ST_MW	F_ST_MW_IN	NO						
TUNNEL STORAGE @ FACILITY PROTECTION DEVICES (NELSON COMPLEX)						**$ 6,601,671**	**$ 9,918**	**$ 6,611,590**
TUNNEL STORAGE (TURKEY CREEK)						**$ -**	**$ -**	**$ -**
F_ST-FPD_TC	F_ST-FPD_TC_IN	NO						
TUNNEL STORAGE (MISSION MAIN)						**$ 6,601,671**	**$ 9,918**	**$ 6,611,590**
F_ST-FPD_BL	F_ST-FPD_BL_IN	NO						
F_ST-FPD_RC	F_ST-FPD_RC_IN	YES	5.5	6.9	0.63	$ 6,601,671	$ 9,918	$ 6,611,590

OPTIMISATION SOLUTION SUMMARY:
PEAK EXTRANEOUS FLOW TREATMENT FACILITY

*Requires manually entered value

Model PEFTF PS ID	Model PEFTF OF ID	Existing Capacity (MGD)	Active in Solution Model	U/S ID	D/S ID	Peak 5yr OF Flow (MGD)	Peak 5yr OF Volume (MG)	PEFTF Capital Cost ($)	PEFTF 20yr O&M Cost ($)	PEFTF Total 20yr PV Cost ($)
NELSON COMPLEX PEFTF TOTAL								**$ 55,209,202**	**$ 6,610,059**	**$ 61,819,260**
TURKEY CREEK								**$ 10,731,564**	**$ 1,221,569**	**$ 11,953,132**
PS_TurkeyCreek_PEFTF	PEFTF_TC_Discharge	22.0	YES	TC_PEFTF_WW	EFBOUT	15.2	5.7	$ 10,731,564	$ 1,221,569	$ 11,953,132
MISSION MAIN								**$ 44,477,638**	**$ 5,388,490**	**$ 49,866,128**
PS_Belinder_PEFTF	PEFTF_BL_Discharge	53.1	YES	BLPEFTFWW	Belinder_Effluent	42.0	13.3	$ 28,082,346	$ 3,375,535	$ 31,457,881
PS_Martway_PEFTF	PEFTF_MW_Discharge	20.0	YES	Martway_HS_Wet_Well	Martway_Tank	10.1	3.3	$ 6,586,792	$ 808,410	$ 7,395,202
PS_Nall_PEFTF	PEFTF_Nall_Discharge	20.0	YES	Nall_Wet_Well	Nall_Tank	15.0	5.7	$ 9,808,500	$ 1,204,545	$ 11,013,045

OPTIMISATION SOLUTION SUMMARY:
SEWAGE PUMP STATIONS

*Requires manually entered value

Catchment ID	Linked Node ID	No. of MHs with Inflow	Operating in Solution Model	BASELINE Factor	Scaling Factor	% Reduction	BASELINE Cost ($)	ADDITIONAL I&I Costs: I&I Capital Cost ($)	I&I 20yr O&M Cost ($)	I&I Total 20yr PV Cost ($)
NELSON COMPLEX I/I REDUCTION TOTAL							**$ 41,555,390**	**$ 9,488,274**	**$ -**	**$ 9,488,274**
TURKEY CREEK TOTAL							**$ 23,612,999**	**$ 2,133,672**	**$ -**	**$ 2,133,672**
FM_202	0309015	24	NO	0.85	0.85		$ 2,276,558	$ -	$ -	$ -
FM_203	0310001	82	NO	0.85	0.85		$ 3,088,151	$ -	$ -	$ -
FM_204	0320011	22	NO	0.85	0.85		$ 2,655,953	$ -	$ -	$ -
FM_205	0323001	42	NO	0.85	0.85		$ 865,729	$ -	$ -	$ -
FM_206	0331001	78	NO	0.85	0.85		$ 4,210,628	$ -	$ -	$ -
FM_207	0336001	130	YES	0.85	0.80	20%	$ 3,674,268	$ 1,837,134	$ -	$ 1,837,134
FM_208	0341001	54	NO	0.85	0.85		$ 2,089,125	$ -	$ -	$ -
FM_209	0323131	56	NO	0.85	0.85		$ 917,006	$ -	$ -	$ -
FM_210	0327001	31	YES	0.85	0.80	20%	$ 593,077	$ 296,538	$ -	$ 296,538
FM_211	0321001	3	NO	0.85	0.85		$ 936,380	$ -	$ -	$ -
FM_TC PS	0301003	41	NO	0.85	0.85		$ 2,306,127	$ -	$ -	$ -
MISSION MAIN TOTAL							**$ 17,942,391**	**$ 7,354,602**	**$ -**	**$ 7,354,602**
FM_1	0115001	53	NO	0.90	0.90		$ 862,265	$ -	$ -	$ -
FM_101, 102	0107004	63	YES	0.90	0.80	20%	$ 513,295	$ 702,619	$ -	$ 702,619
FM_103	0108002	54	NO	0.90	0.90		$ 467,148	$ -	$ -	$ -
FM_104, 105	0108020	53	YES	0.90	0.85	15%	$ 583,348	$ 400,758	$ -	$ 400,758
FM_106, 107	0110018	45	NO	0.90	0.90		$ 776,694	$ -	$ -	$ -
FM_108	0115043	24	NO	0.90	0.90		$ 726,158	$ -	$ -	$ -
FM_109, 110	0123002	126	NO	0.90	0.90		$ 1,102,106	$ -	$ -	$ -
FM_111	0122027	2	YES	0.90	0.80	20%	$ 112,356	$ 153,798	$ -	$ 153,798
FM_112	0112058	14	YES	0.90	0.85	15%	$ 136,210	$ 93,576	$ -	$ 93,576
FM_113, 114	0122010	213	YES	0.90	0.75	25%	$ 1,918,439	$ 4,533,408	$ -	$ 4,533,408
FM_115, 116	0126030	28	NO	0.90	0.90		$ 702,779	$ -	$ -	$ -
FM_117	0133060	5	NO	0.90	0.90		$ 246,403	$ -	$ -	$ -
FM_118	0142001	7	NO	0.90	0.90		$ 186,808	$ -	$ -	$ -
FM_119	0140014	17	YES	0.90	0.80	20%	$ 266,121	$ 364,277	$ -	$ 364,277
FM_12, 13	0133010	48	NO	0.90	0.90		$ 336,364	$ -	$ -	$ -
FM_120	0141096	3	NO	0.90	0.90		$ 188,183	$ -	$ -	$ -
FM_121, 122	0139008	21	NO	0.90	0.90		$ 553,973	$ -	$ -	$ -
FM_123, 124	0115022	9	NO	0.90	0.90		$ 687,268	$ -	$ -	$ -
FM_14, 15, 16	0135002	71	NO	0.90	0.90		$ 1,036,493	$ -	$ -	$ -
FM_17, 18	0136001	110	NO	0.90	0.90		$ 1,276,154	$ -	$ -	$ -
FM_2, 3	0103004	93	NO	0.90	0.90		$ 1,473,083	$ -	$ -	$ -
FM_4	0113050	51	YES	0.90	0.85	15%	$ 718,143	$ 493,362	$ -	$ 493,362
FM_5, 7	0103012	66	NO	0.90	0.90		$ 743,095	$ -	$ -	$ -
FM_6, 19	0101010	53	NO	0.90	0.90		$ 641,649	$ -	$ -	$ -
FM_9, 10	0134015	17	YES	0.90	0.75	25%	$ 259,325	$ 612,803	$ -	$ 612,803
FM_BC PS	0129005	30	NO	0.90	0.90		$ 314,696	$ -	$ -	$ -
FM_Belinder PS	0101001	12	NO	0.90	0.90		$ 108,212	$ -	$ -	$ -
FM_RC PS	0112006	66	NO	0.90	0.90		$ 455,861	$ -	$ -	$ -
FM_ WWTF	1601002	5	NO	0.90	0.90		$ 549,761	$ -	$ -	$ -

OPTIMISATION SOLUTION SUMMARY:
AUXILIARY TREATMENT FACILITY

*Requires manually entered value

Treatment Facility ID	Existing Capacity (MGD)	Peak 5yr Flow (MGD)	Capacity Upgrade (MGD)	Capital Cost ($)	20yr O&M Cost ($)	Total 20yr PV Cost ($)
NELSON COMPLEX TREATMENT FACILITY TOTAL COST				**$ -**	**$ -**	**$ -**
Nelson_ATF	52	50.6	-1.4	$ -	$ -	$ -
PS_TurkeyCreek	33.6	27.0	0.0	$ -	$ -	$ -
Mission Main Catchment	18.4	23.6	-1.4	$ -	$ -	$ -

Nelson Complex Collection System Wet Weather Plan

Technical Memorandum #5
Water Quality Modeling

August 2019

JOHNSON COUNTY KANSAS
Wastewater

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ACRONYMS AND ABBREVIATIONS

ADDF	Average Daily Dry Weather Flow
BNR	Biological Nutrient Removal
DEM	Digital Elevation Model
EMC	Event Mean Concentration
IQR	Interquartile Range
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KDHE	Kansas Department of Health and Environment
MG	Million Gallons
mgd	Million Gallons per Day
MH	Manhole
mg/L	Milligrams/liter
MS4	Municipal Separate Storm Sewer System
MTM1	Mission Township Main Sewer District No. 1
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
PEFTF	Peak Excess Flow Treatment Facility
PS	Pump Station
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
SWMM	Storm Water Management Model
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

WQP	Water Quality Portal
WWTF	Wastewater Treatment Facility

Note: Portions of the project approach and information presented in this technical memorandum (TM) were subsequently updated and new alternative naming conventions were adopted as the project progressed. Changes are noted in italics, where practicable. In general, information presented in TM 6 or the Phase 1 Integrated Management Plan supersedes conflicting information presented in this TM.

1 Introduction

The Myron K. Nelson Complex Wastewater Treatment Facility (Nelson Complex WWTF) consists of separate treatment trains servicing two main tributary sewersheds – Turkey Creek (SMTC) and Mission Main (MTM1). The sewersheds were originally serviced by two separate WWTFs sharing a common site. These facilities have since been consolidated into a single facility with two distinct process trains that share common disinfection and biosolids facilities and single permitted outfall that discharges to Turkey Creek. The combined service area for the Nelson Complex WWTF totals approximately 18,002 acres and is nearly built-out with a primary land use of suburban residential development (Figure 1).

Four Peak Excess Flow Treatment Facilities (PEFTFs) are located within the sewersheds which either store excess wet weather flow and return it to the collection system after the storm passes, or which discharge directly to receiving streams after providing screening, primary treatment, and disinfection. In the Mission Main sewershed, the 75th and Nall PEFTF operates in conjunction with the Brush Creek Pump Station (PS), which pumps flow to the Rock Creek PS. The Martway PEFTF operates in conjunction with the Rock Creek PS, which pumps flow directly to the Nelson Complex WWTF. Similarly, the Belinder PEFTF and PS operate in concert with the PS pumping to the Nelson Complex WWTF. In the Turkey Creek watershed, the Turkey Creek PEFTF and PS operate in concert with the PS pumping to the Nelson Complex WWTF.

The Nelson Complex WWTF, satellite PSs, and PEFTFs face a number of significant challenges. Many of the facilities are beyond their useful life and the treatment facility requires significant upgrades to meet increasingly stringent regulatory requirements. In addition, collection system wet weather issues, including sanitary sewer overflows (SSOs) and in-system bypasses, need to be addressed. Identifying an optimal plan to address these issues requires consideration of several factors including issues of sustainability, regulatory requirements, environmental impacts, economics, and logistics. Environmental impacts, or more specifically water quality impacts, are the subject of this technical memorandum (TM 5).

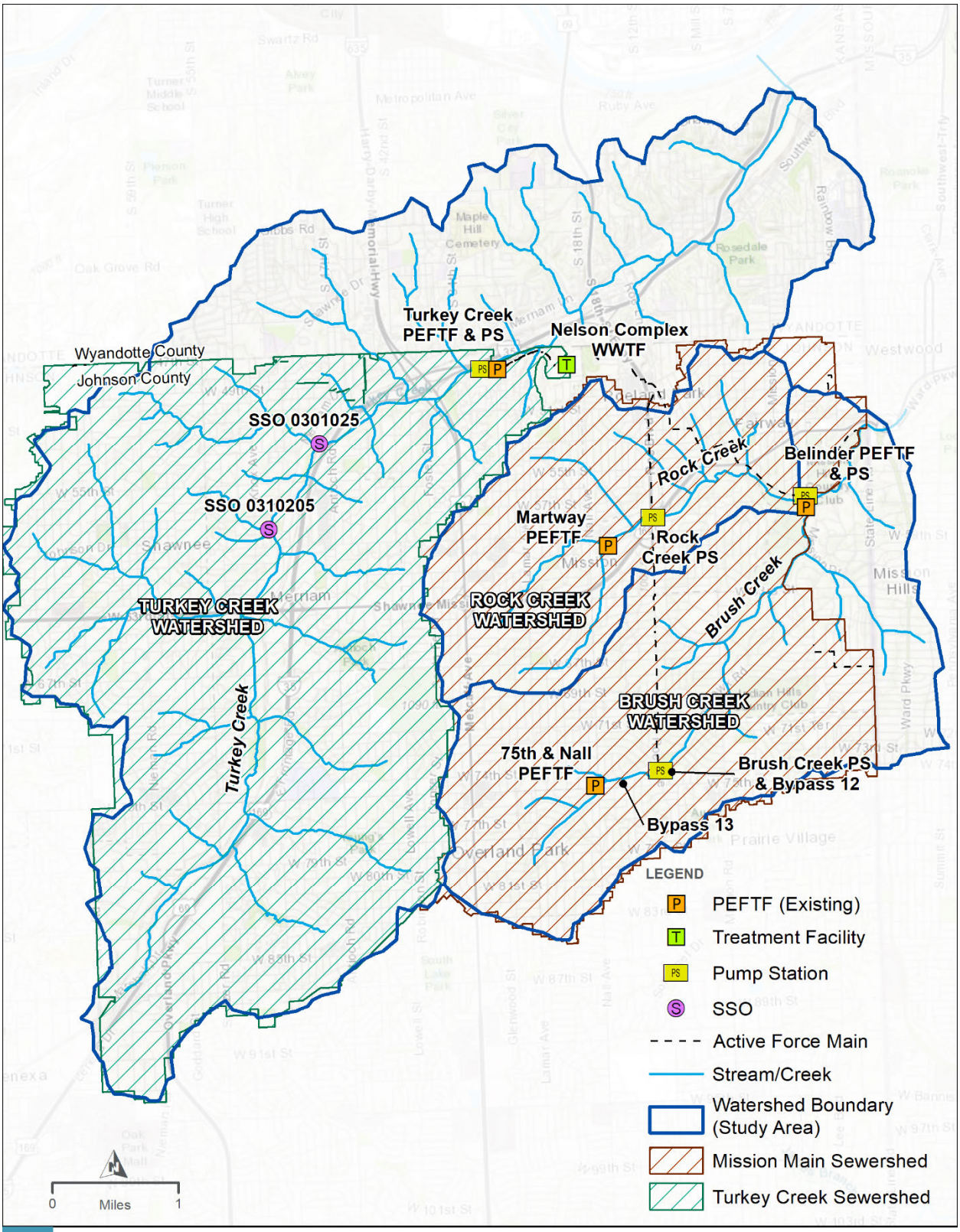


FIGURE 1
WATER QUALITY STUDY AREA
STUDY AREA WATERSHEDS
NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN

1.1 Purpose and Scope

The purpose of this technical memorandum is to characterize water quality impacts on receiving waters from various wet weather management alternatives associated with the Nelson Complex. Wet weather alternatives evaluated as part of this study include the following:

- *Baseline Conditions* – This alternative represents current conditions and includes the existing collection system and the Nelson Complex WWTF discharges.

- *Eliminating all PEFTFs* – This alternative includes capacity improvements to eliminate PEFTF discharges and address SSOs and in-system bypasses up to JCW's aggressive level of service criteria. This alternative also includes upgrades to the Nelson Complex WWTF, including replacing the existing trickling filter system with a biological nutrient removal (BNR) treatment facility.

- *Collection System Improvements and Facility Upgrades* – This alternative includes PEFTF enhancements to improve disinfection and reduce total residual chlorine (TRC). It also includes capacity improvements to address SSOs and in-system bypasses and upgrades to the Nelson Complex WWTF. Upgrades to the Nelson Complex WWTF include replacing the existing trickling filter system with a BNR treatment facility.

The scope of this study is limited to water quality impacts associated with the aforementioned alternatives on those portions of the Turkey and Brush Creek watersheds within the State of Kansas. Characterization of water quality impacts is also limited to the following parameters: *Escherichia coli* (*E. coli*), total residual chlorine (TRC), ammonia as nitrogen (ammonia-N), total phosphorus (TP), and total nitrogen (TN).

1.2 Approach

Water quality impacts associated with each of the alternatives were simulated using the Storm Water Management Model (SWMM) version 5 watershed model. SWMM is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time-steps (USEPA 2015).

Point source discharges from PEFTFs, SSOs, in-system bypasses, and the Nelson Complex WWTF were simulated with hydraulic models previously developed for the Mission Main and Turkey Creek sewersheds using the InfoWorks ICM (Integrated Catchment Modeling) hydraulic modeling platform by Innovyze. The models were subsequently updated in 2011 and 2016, and most recently again in 2018 for use in long-term simulations. Documentation is provided for in TM 2 (*Hydraulic Model Updates, Section 5*). Output from the updated continuous simulation InfoWorks hydraulic models was directly input into the SWMM model to simulate point source discharges.

The water quality model was calibrated based on historical water quality and flow data collected within the study area by Johnson County Wastewater (JCW), the U.S. Geological Survey (USGS),

and the U.S. Environmental Protection Agency (USEPA). Additional information on model setup and calibration is included in Section 5 of this TM.

2 Description of Study Area

The study area is located in the southwestern corner of the Kansas City metropolitan area covering 36.6 square miles of land (Figure 1). The area roughly parallels the boundaries of the Turkey Creek and Mission Main sewersheds, but also includes the Wyandotte County portion of the Turkey Creek watershed. The major streams in the study area include Turkey, Brush and Rock Creek. All three creeks are classified in the Kansas Surface Water Register as general purpose waters with the following common designated uses: aquatic life (expected), domestic water supply, food procurement, ground water discharge, industrial water supply and irrigation use. Turkey and Brush Creek are also designated for primary contact recreation (category B). Rock Creek is designated for secondary contact recreation (category a). Information on land use, water quality issues, and pollutant sources within the study are described below.

2.1 Land Use

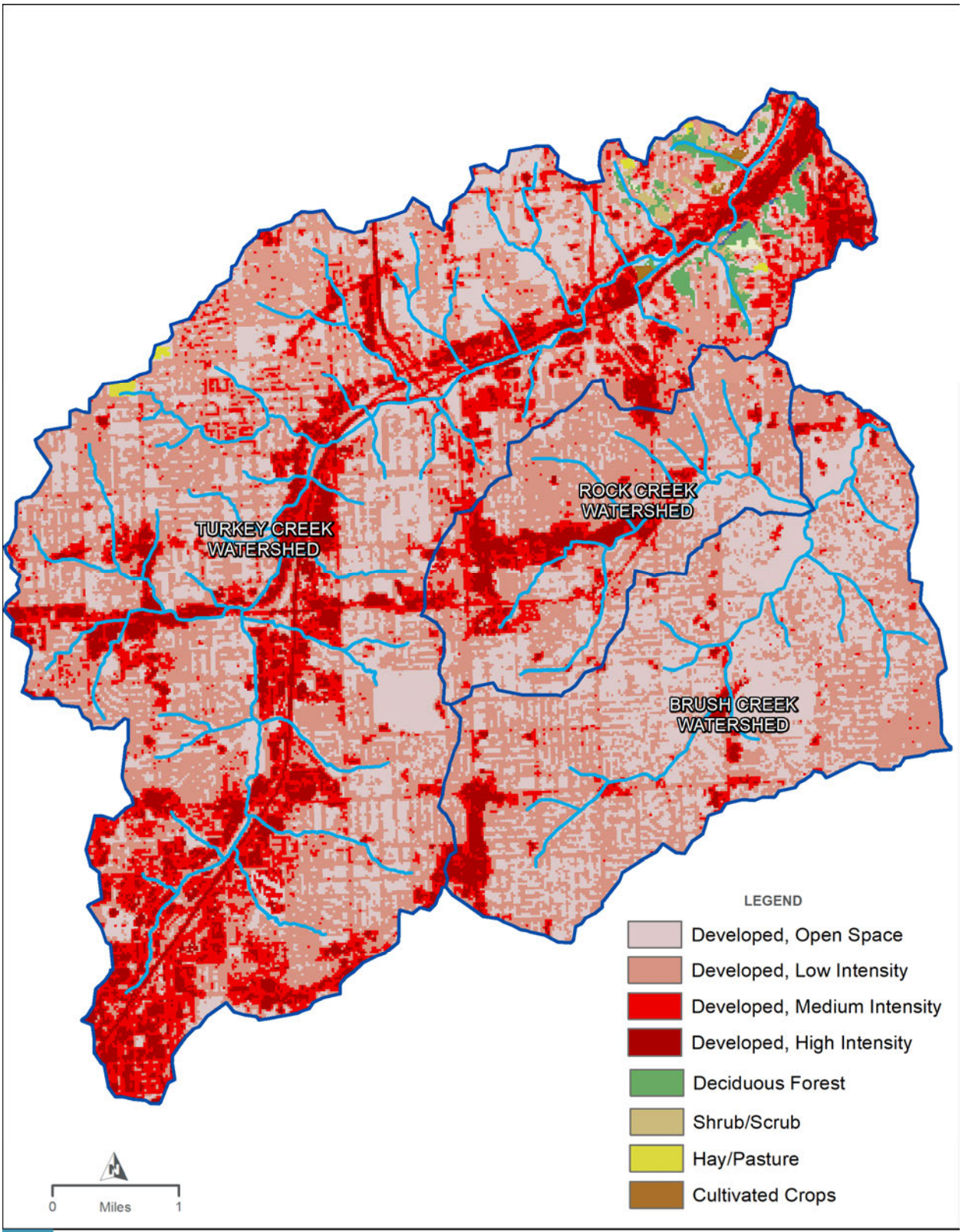
Based on analysis of the National Land Cover Database 2011 (NLCD 2011), approximately 99 percent of the study area has been developed (Table 1 and Figure 2). The majority of this area (45.1 percent) is classified as low intensity development, largely consisting of residential neighborhoods and some commercial development. Twenty-nine and one-half (29.5) percent of the area is developed open space, which primarily includes parks and golf courses. The highest intensity land use is located along the Highway 35 corridor, which parallels Turkey Creek, and along other major thoroughfares, including Shawnee Mission Parkway and Metcalf Avenue. Medium and high intensity land use account for 23.9% of the study area, which is comprised of commercial and some light industrial development.

Table 1. Study Area Land Uses

Land Use	Percent
Developed, Open Space	29.5%
Developed, Low Intensity	45.1%
Developed, Medium Intensity	15.5%
Developed, High Intensity	8.4%
Deciduous Forest	0.8%
Shrub/Scrub	0.2%
Hay/Pasture	0.2%
Cultivated Crops	0.1%
Other	0.2%

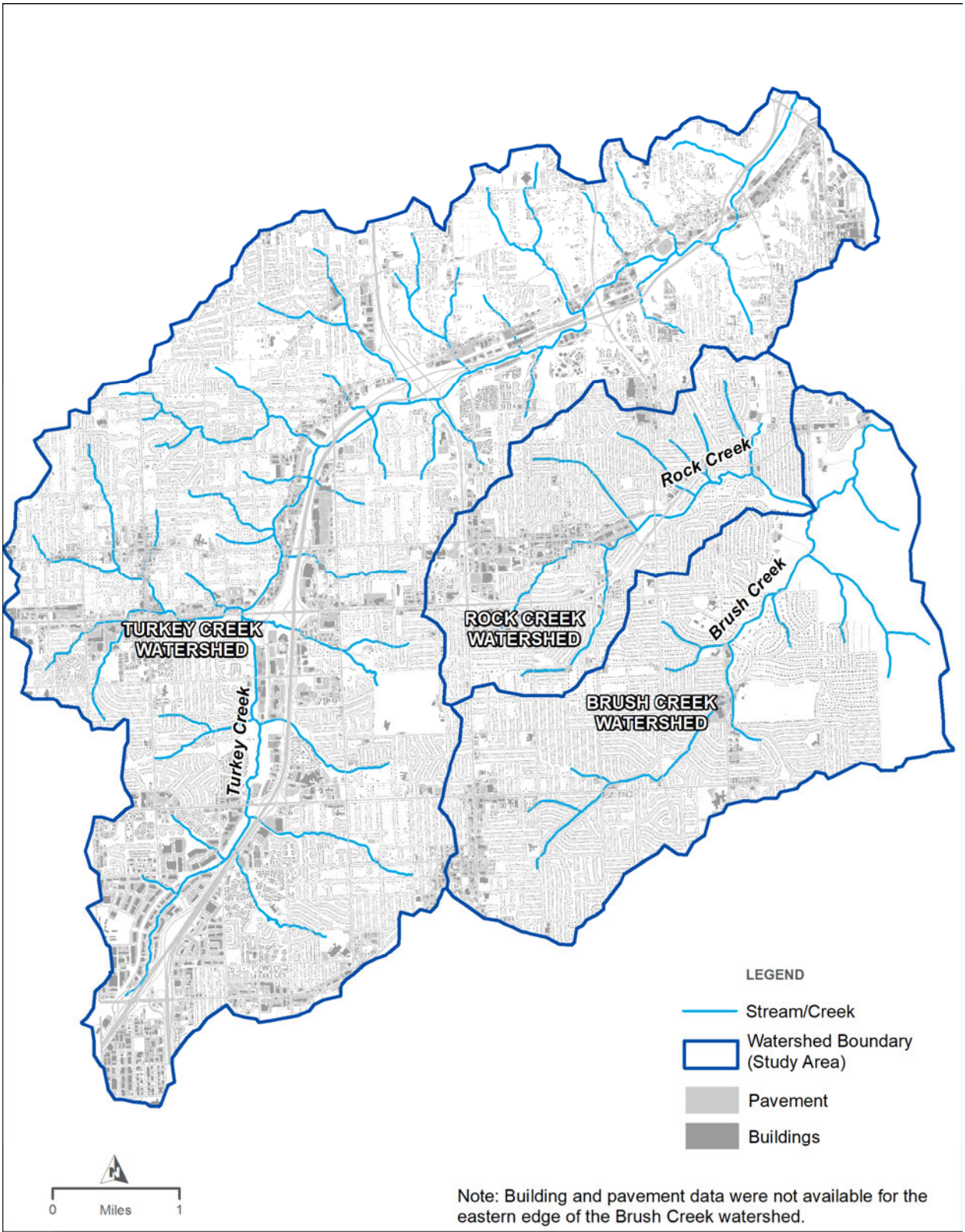
*Source: NLCD 2011

As with most urban areas, a significant fraction of the land surface is impervious. Based on data obtained from JCW and Wyandotte County, approximately 31% of the study area is covered with impervious surfaces including buildings, driveways, roads, and parking lots (Figure 3). The percentage of impervious surface area is considered a fundamental factor in stream quality and has been negatively correlated with biological conditions. Some studies suggest that when impervious area exceeds about 10 percent, biological conditions start to decline (e.g., Rasmussen et al. 2012).



HDR JOHNSON COUNTY KANSAS

FIGURE 2
LAND USES
STUDY AREA WATERSHEDS
NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN



HDR JOHNSON COUNTY KANSAS

FIGURE 3

IMPERVIOUS AREA

STUDY AREA WATERSHEDS

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN

2.2 Water Quality Impairments

Per Section 303(d) of the Clean Water Act, the Kansas Department of Health and Environment (KDHE) identifies waterbodies where existing water quality is impaired because it does not support designated uses. A Total Maximum Daily Load (TMDL) must typically be developed for waterbodies considered impaired. Currently, the only 303(d) impaired water within the study area is Turkey Creek, which does not meet its aquatic life use due to ammonia (Table 2). Turkey Creek is also included within the 2017 Lower Kansas River TMDL for phosphorus. No other TMDLs have been completed within the study area.

Table 2. Clean Water Act Impaired Streams within the Study Area

Stream	303(d) Impairment	TMDL
Turkey Creek	Ammonia	Phosphorus*
Brush Creek	None	None
Rock Creek	None	None

Source: KDHE 2018 303(d) List
*Turkey Creek is within the Lower Kansas River watershed, which was issued a phosphorus TMDL in 2017.

2.3 Pollutant Sources

A number of pollutant sources exist within the study area that have the potential to impact stream water quality. Included among these are discharges from the JCW Nelson Complex WWTF, PEFTFs, SSOs, urban stormwater runoff, failing septic systems, resuspension, and other watershed sources.

2.3.1 JCW Nelson Complex WWTF, PEFTFs and SSOs

The primary point source within the study area is wastewater discharge from the Nelson Complex WWTF, which discharges to Turkey Creek with an average daily dry weather (ADDF) flow of 15 million gallons per day (mgd). However, during peak flow events, wastewater can potentially discharge from a number of locations within the Turkey Creek or Mission Main sewersheds. These include the Turkey Creek PEFTF, Belinder PEFTF, Martway PEFTF, 75th & Nall PEFTF, SSOs on Turkey Creek (manholes 0301025 and 0310205), Bypass 12, and Bypass 13 (Figure 1). The PEFTFs serve to either store wet weather flow and return it to the collection system after the storm passes, or discharge directly to the receiving streams after providing screening, primary treatment and disinfection. Wet weather discharges from the Turkey Creek SSOs, Bypass 12, and Bypass 13 receive no treatment.

2.3.2 Urban Stormwater Runoff

As with most urban areas, pollutant loadings from stormwater runoff are likely significant within the study area. The study area has a high percentage of impervious area (31%) and is comprised of both residential and commercial land uses. During wet weather, runoff from streets, lawns, parking lots, and other urban surfaces can drain into nearby creeks carrying with it a variety of pollutants. Common pollutants from urban stormwater runoff include sediment, heavy metals, toxic organics, salts, nutrients, bacteria, herbicides, pesticides, trash, and pet waste. Nutrients in urban runoff are frequently attributed to fertilizers, pet waste, and yard waste. Bacteria in urban runoff can also be attributed to pet waste and different wildlife sources.

2.3.3 Septic Systems

Contamination from failing septic systems can contribute to bacteria, nutrient, and other pollutant loadings in nearby creeks. A previous study evaluated possible septic system locations within Johnson County based on county estimates of households and businesses not connected to sewage lines (Lee et al. 2005). While the majority of septic systems are located in watersheds with predominantly nonurban uses, a number of potential septic systems were identified within the Turkey and Brush Creek watersheds. Lee et al. (2005) estimated the density of septic systems within the study area are as follows:

- Brush Creek – 3.7 septic systems per square mile
- Rock Creek – 0.4 septic systems per square mile
- Turkey Creek – 4.7 septic systems per square mile

Pollutant loadings from septic systems within the study area are not well characterized. Therefore, pollutant loadings from septic systems were not directly simulated within the project SWMM model. However, baseflow pollutant concentrations were calibrated to existing data and should reflect existing pollutant sources, including septic systems.

2.3.4 Instream Resuspension

Bacteria that enter streams can exist both freely suspended in the water column and attached to particles and other solid substrates. Once attached to particles, bacteria can survive and persist in stream sediment for an extended period of time. Studies have shown that sediment helps shelter bacteria from sunlight and predation and, in some cases, promotes growth by providing a source of nutrients (Garzio-Hadzick et al. 2010). Bacteria in the sediment bed can resuspend during periods of increased flow from stormwater runoff, causing levels to increase within the water column. Complex process such as bacterial regrowth and resuspension are not well characterized within the study area and were not directly simulated within the study model.

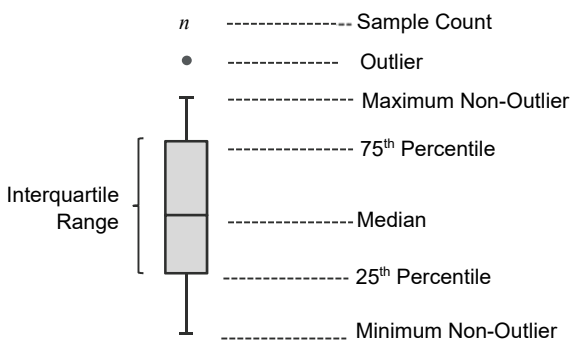
2.3.5 Other Watershed Sources

In addition to known and suspected sources identified above, there could be a number of other sources of contamination. An exhaustive understanding of all pollutant sources within the study area is not possible, but these could include bank erosion, illicit discharges, and undetected leaks from aging and disrepaired sewer lines. Pets and wildlife could also contribute to pollutant loadings during non-stormwater runoff conditions. Other watershed sources of pollutants are not explicitly included in the study model.

3 Water Quality Data Compilation and Analysis

The impacts of the Nelson Complex WWTF and wet weather discharges on receiving water quality is a major focus of this study. To better understand these impacts and to support development of the water quality model, effluent and instream water quality data were assessed for the following parameters: *E. coli*, TRC, TP, TN, and ammonia-N. Box and whisker plots were used to assess the data since these provide a visual representation of central tendencies, variability, and spatial trends.

A box and whisker plot is a method of graphically depicting groups of numerical data through their quartiles. It consists of a central rectangle that spans from the 25th to 75th percentile (interquartile range or IQR), a line though the 50th percentile (median), and lines extending vertically from the boxes indicating the furthest points that are not outliers. By default, values below the 25th percentile minus 1.5 times the IQR or above the 75th percentile plus 1.5 times the IQR are considered to be outliers. The level of overlap between the interquartile ranges (25th to 75th percentile) may be used as general guidance for assessing the similarity of different data groups (e.g., between different monitoring locations).



Note: Data are depicted with dots if sample size is less than 5.

3.1 Data Sources

Water quality data collected within the study area were obtained from multiple sources. Data sources include: Johnson County Wastewater, the U.S. Geological Survey, and the U.S. Environmental Protection Agency.

- Johnson County Wastewater (JCW) – JCW routinely collects effluent and instream water quality samples as part of National Pollutant Discharge Elimination System (NPDES) permitting requirements for the Nelson Complex WWTF. In addition to routine sampling, from 2012 to 2013, JCW has collected dry and wet weather water quality data within Turkey, Rock, and Brush Creeks.

- U.S. Geological Survey (USGS) – In recent years, the USGS has monitored 2 locations on the upper portion of Turkey Creek to satisfy municipal separated storm sewer system (MS4) permitting requirements for the Johnson County Stormwater Management Program. In addition to these sites, USGS has previously collected water quality samples from a number of different locations throughout the study area at different times since about 1998. Most

notably, USGS routinely collected water quality data at Brush Creek at Ward Parkway (06893557) from 1998 to 2010. USGS data were obtained from the USGS National Water Information System (NWIS) website.

- U.S. Environmental Protection Agency (USEPA) – Since 2006, USEPA has intermittently collected water quality data from 2 locations on Brush Creek and 3 locations on Turkey Creek. These data collection efforts do not appear to be ongoing and resulted in 3 to 10 samples per site. USEPA data were obtained from the Water Quality Portal (WQP).

3.2 Data Compilation

Effluent and instream water quality data obtained from JCW, USGS, and USEPA were compiled into a Microsoft Access™ database. The compiled database included data from a total of 3,455 effluent samples and 869 instream samples (Tables 3 and 4). Instream sampling locations were well distributed throughout the study area (Figure 4).

For purposes of analysis, instream water quality data were attributed as either dry or wet weather data. Methods used for attributing samples as either dry or wet are shown below in order of preference:

- Explicit - USGS and JCW data explicitly collected for purposes of characterizing storm water conditions were attributed as wet weather data. Similarly, JCW data collected explicitly for purposes of characterizing dry weather conditions were attributed as dry weather.

- Precipitation – Data not explicitly attributed as wet or dry, were attributed based on antecedent precipitation. Samples collected within 24 hours of a half-inch rain event were attributed as wet weather. If there was less than 0.1 inch of rain in the previous 7 days, samples were attributed as dry weather.

- Flow – For remaining samples that were neither explicitly attributed or did not fit the precipitation criteria shown above, attribution was based on flow conditions at the USGS gage 06893557 (Brush Creek at Ward Parkway). If daily flow was more than the 60th percentile flow exceedance value, samples collected on that day were attributed as a wet weather event. Otherwise samples were attributed as a dry weather event.

Table 3. Summary of Compiled Effluent Water Quality Data

Source	Outfall	Begin Date	End Date	Sample Count	*E. coli*	TP	TN*	Ammonia-N	TRC
JCW	Nelson Complex WWTF Outfall 001	Jul-08	Apr-18	2,979	X	X	X	X	X
JCW	75th & Nall PEFTF	Jul-08	Mar-18	138	X			X	X
JCW	Belinder PEFTF	Jul-08	Mar-18	158	X			X	X
JCW	Martway PEFTF	Sep-08	Aug-17	69	X			X	X
JCW	Turkey PEFTF	Jul-08	Oct-17	111	X			X	X

*Calculated as nitrate plus TKN (Total Kjeldahl Nitrogen)

Table 4. Summary of Compiled Instream Water Quality Data

Common Site Code	Source	Source Site Code	Waterbody	Begin Date	End Date	Dry Weather Events	Wet Weather Events	*E. coli*	TP	TN	Ammonia-N	TRC
BC1	JCW	B6	Brush Creek	Feb-12	Jun-13	3	21	X			X	X
BC2	JCW	B5	Brush Creek	Feb-12	Jun-13	3	21	X			X	X
BC3	USEPA	EPA_R7_WQX-Brush3	Brush Creek	Aug-06	Aug-15	6	4	X	X	X	X	
BC4	USGS	390056094371600	Brush Creek	Nov-02	Jul-03	2	2	X	X	X	X	
BC5	USGS	390109094370301	Brush Creek	Aug-04	Aug-05	3	0	X	X	X	X	
BC6	JCW	B2	Brush Creek	Sep-08	Sep-08	4	48	X			X	X
BC7	USEPA	EPA_R7_WQX-Brush2	Brush Creek	Aug-06	Aug-15	6	4	X	X	X	X	
BC7	USGS	390127094365800	Brush Creek	Nov-02	Apr-10	3	8	X	X	X	X	
BC8	JCW	B4	Brush Creek	Jul-08	Mar-18	4	185	X			X	X
BC9	USGS	6893557	Brush Creek	Aug-98	Jun-10	29	79	X	X	X	X	
RC1	JCW	R1	Rock Creek	Feb-12	Jun-13	4	35	X			X	X
RC2	JCW	R4	Rock Creek	Feb-12	Jun-13	4	21	X			X	X
RC3	JCW	R3	Rock Creek	Feb-12	Jun-13	4	46	X			X	X
TC1	USEPA	EPA_R7_WQX-Turkey3	Turkey Creek	Aug-06	Sep-15	4	4	X	X	X	X	
TC1	USGS	385937094420300*	Turkey Creek	Mar-15	Aug-17	2	17	X	X	X	X	
TC2	USGS	390027094415600	Turkey Creek	Nov-02	Apr-10	2	12	X	X	X	X	
TC3	USEPA	EPA_R7_WQX-E2A0A0EC	Turkey Creek	May-11	Jun-11	1	2	X				
TC4	USGS	390201094411500†	Turkey Creek	Mar-15	Aug-17	2	15	X	X	X	X	
TC5	USGS	390219094402000	Turkey Creek	Nov-02	Jul-03	2	3	X	X	X	X	
TC6	JCW	T1	Turkey Creek	Sep-12	Oct-17	4	39	X			X	X
TC7	JCW	T3	Turkey Creek	Feb-12	Jun-13	4	32	X			X	X
TC8	USEPA	EPA_R7_WQX-Turkey2	Turkey Creek	Aug-06	Sep-15	4	4	X	X	X	X	
TC9	JCW	T4	Turkey Creek	Jul-08	Oct-17	4	130	X			X	X
TC10	JCW	T5	Turkey Creek	Feb-12	Jun-13	4	29	X			X	X

*Johnson County Stormwater Management Program MS4 sampling site

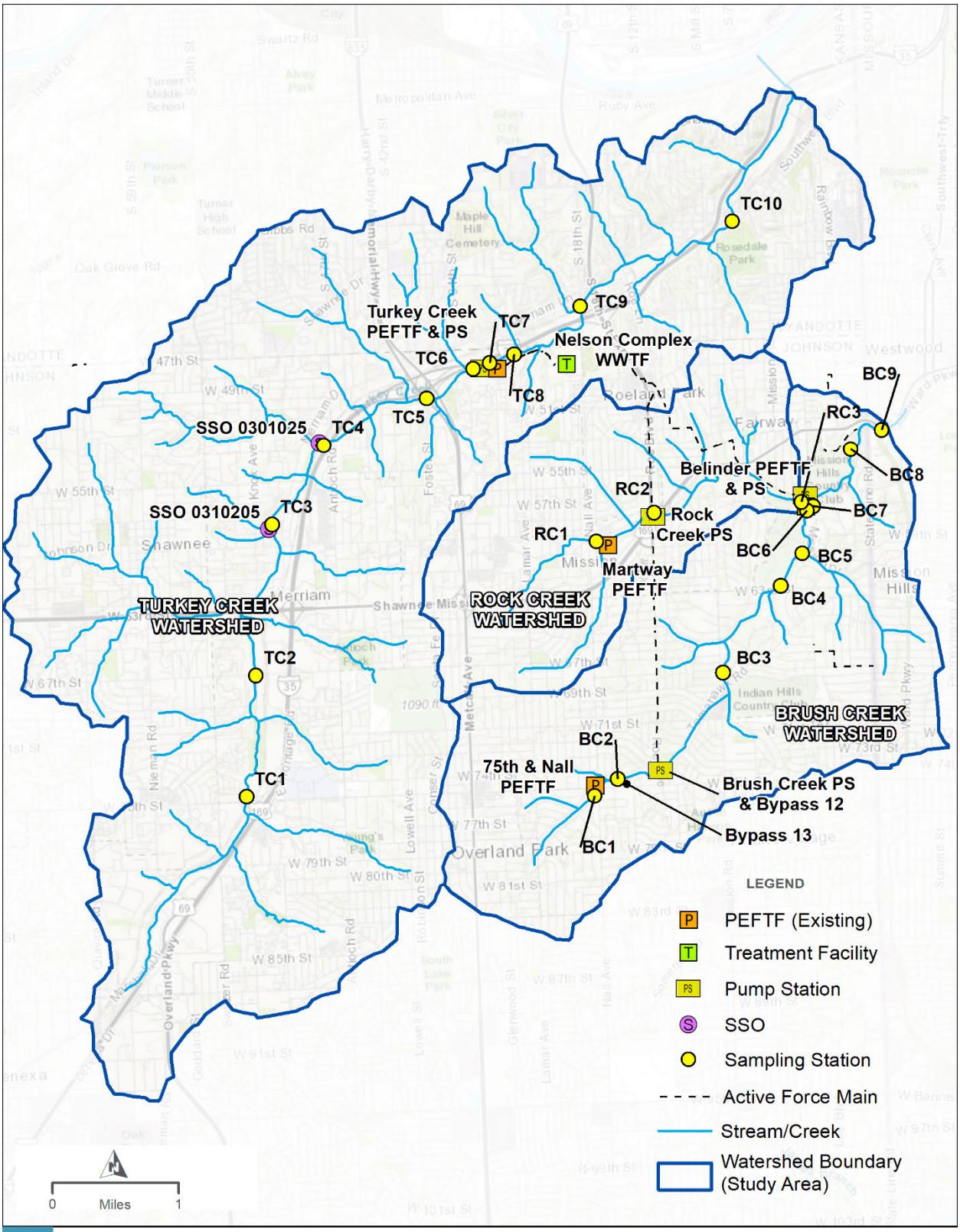


FIGURE 4
WATER QUALITY SAMPLING LOCATIONS
STUDY AREA WATERSHEDS
NELSON COMPLEX COLLECTION SYSTEM WET WEATHER PLAN

3.3 Effluent Water Quality Data

3.3.1 *E. coli*

E. coli levels significantly vary at and between the different discharge locations. In ascending order, the median concentrations of *E. coli* were 10 cfu/100 mL (Belinder PEFTF), 82 cfu/100 mL (Nelson Complex WWTF), 717 cfu/100 mL (Turkey Creek PEFTF), 828 cfu/100 mL (75th & Nall PEFTF), and 2,125 cfu/100 mL (Martway PEFTF) (Figure 5). The interquartile range of *E. coli* levels also varied by several thousand cfu/100 mL at the Turkey Creek, 75th & Nall, Martway PEFTFs. JCW disinfects effluent at all PEFTFs by chlorination; however, current chlorine feed and control systems likely contribute to variable disinfection efficacy. Further study of this issue is needed, but improved controls and operations are needed to reduce *E. coli* variability.

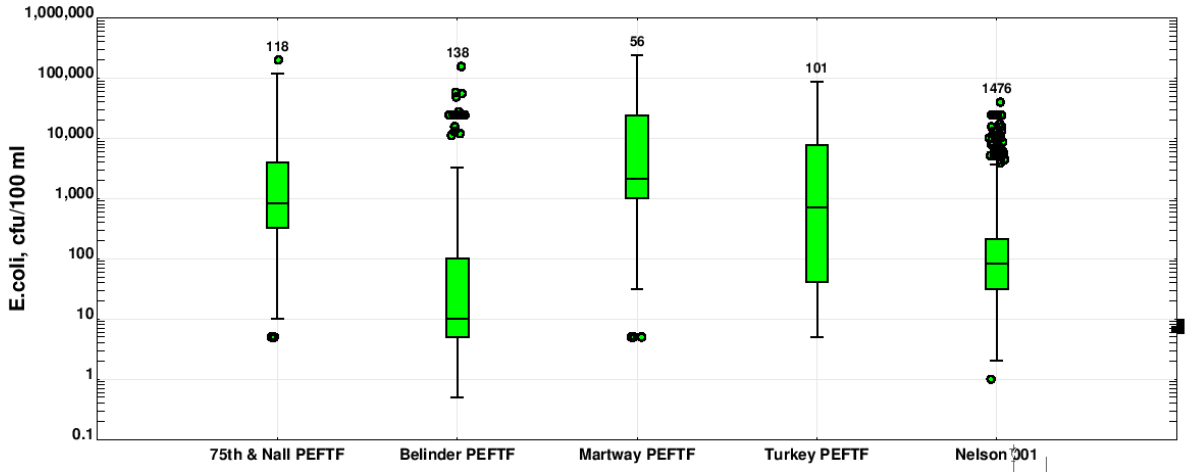


Figure 5. *E. coli* Box and Whisker Plot for Study Area Dischargers

3.3.2 Total Phosphorus

TP is routinely sampled for at the Nelson Complex WWTF, but was not available for any of the PEFTFs. TP concentrations at the Nelson Complex WWTF ranged from 0.7 to 8.7 mg/L, but had a median concentration of 3.0 mg/L (Table 5). The interquartile range of TP concentrations at the Nelson Complex WWTF was 2.2 mg/L (25th percentile) to 3.6 mg/L (75th percentile).

Table 5. Total Phosphorus Effluent Data for the Nelson Complex WWTF

	Total Phosphorus, mg/L
Count	477
Minimum	0.7
25th Percentile	2.2
Median	3.0
75th Percentile	3.6
Maximum	8.7

3.3.3 Total Nitrogen

TN, as measured by summing nitrate and total Kjeldahl nitrogen (TKN), is routinely sampled for at the Nelson Complex WWTF, but was not available for any of the PEFTFs. TN concentrations at the Nelson Complex WWTF ranged from 6.3 to 49 mg/L with a median concentration of 19 mg/L (Table 6). The interquartile range of TN concentrations at the Nelson Complex WWTF was 14.9 mg/L (25th percentile) to 22.8 mg/L (75th percentile).

Table 6. Nitrogen Effluent Data for the Nelson Complex WWTF

	Total Nitrogen, mg/L
Count	473
Minimum	6.3
25th Percentile	14.9
Median	19.0
75th Percentile	22.8
Maximum	49.0

Note: TN calculated as the sum of nitrate nitrogen and total Kjeldahl nitrogen (TKN).

3.3.4 Ammonia

Median ammonia concentrations were relatively low at all the PEFTFs ranging from 1.0 to 2.6 mg/L (Figure 6). Per TM 1 (*Basis of Analysis*), the average influent ammonia concentrations in the Mission Main and Turkey Creek sewersheds are 16 and 18 mg/L, respectively. As the PEFTFs are not designed to remove ammonia, dilution due to inflow and infiltration may partially account for the observed levels. However, observed levels of ammonia are generally below what would be expected based on dilution alone. The relatively low levels of ammonia may also be due to local oxidation from the chlorine used for disinfection. This process, referred to as local breakpoint chlorination, occurs when localized ratios near the point of injection are above the breakpoint for ammonia. As a result, observed levels of ammonia may be lower than what would be expected based on homogenous chlorine and ammonia concentrations.

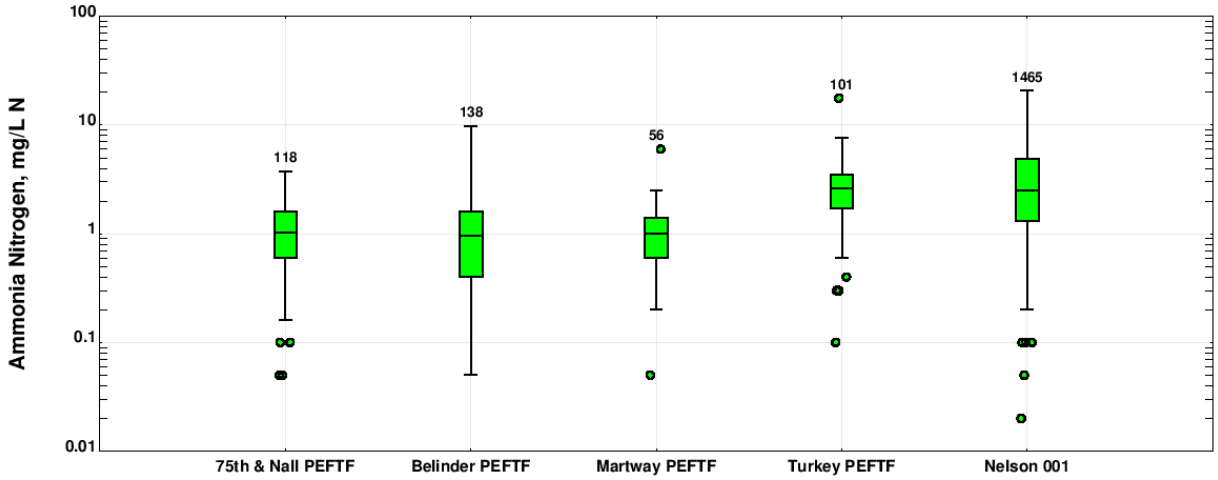


Figure 6. Ammonia Box and Whisker Plot for Study Area Dischargers

3.3.5 Total Residual Chlorine

Facilities with dechlorination had significantly lower levels of TRC than those without dechlorination capabilities. TRC levels at these locations, which includes the Nelson Complex WWTF, 75th & Nall

PEFTF, and the Martway PEFTF, were typically below detection limits. Detection limits varied but were most frequently reported as 0.05 mg/L, which are displayed at half this value for purposes of this analysis (Figure 7). In contrast, median TRC levels at the Belinder and Turkey PEFTFs, where there is no dechlorination, ranged from 2.3 to 2.7 mg/L.

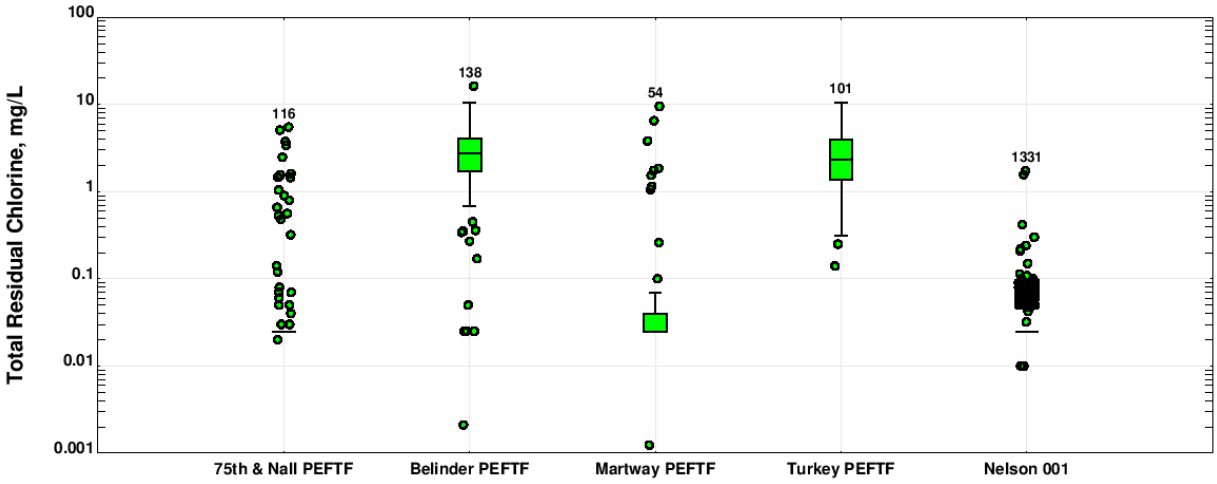


Figure 7. Total Residual Chlorine Box and Whisker Plot for Study Area Dischargers

3.4 Instream Water Quality Data

3.4.1 *E. coli*

Dry weather *E. coli* data generally ranged from below 100 cfu/100 mL to upwards of several hundred or more cfu/100 mL at most monitoring stations (Figure 8). However, relatively few dry weather samples were available from most monitoring stations, making it difficult to characterize baseflow conditions throughout the study area with much certainty. Additionally, it is unclear whether sampling methods could have biased any of the results. Monitoring station BC9 (Brush Creek at Ward Parkway) was the best characterized site with 29 dry weather samples and had a median dry weather *E. coli* concentration of 100 cfu/100 mL.

Wet weather *E. coli* data were elevated relative to dry weather data at all locations, with median values ranging from 525 to 26,000 cfu/100 mL (Figure 8). The most notably elevated concentrations of *E. coli* were in the upper portion of Turkey Creek at sites TC1 and TC4, which had median values ranging from 24,000 to 26,000 cfu/100 mL. Sites TC1 and TC4 also have elevated levels of total suspended solids (TSS), suggesting *E. coli* results are not comparable to other sites (Figure 9). As shown in Figure 10, *E. coli* is strongly correlated with TSS. USGS specifically targeted sample collection during the rising limb of storms at sites TC1 and TC4 to satisfy the requirements of the Johnson County Public Works MS4 program, which likely explains the elevated levels of TSS and *E. coli* at these locations (Rasmussen et al. 2017).

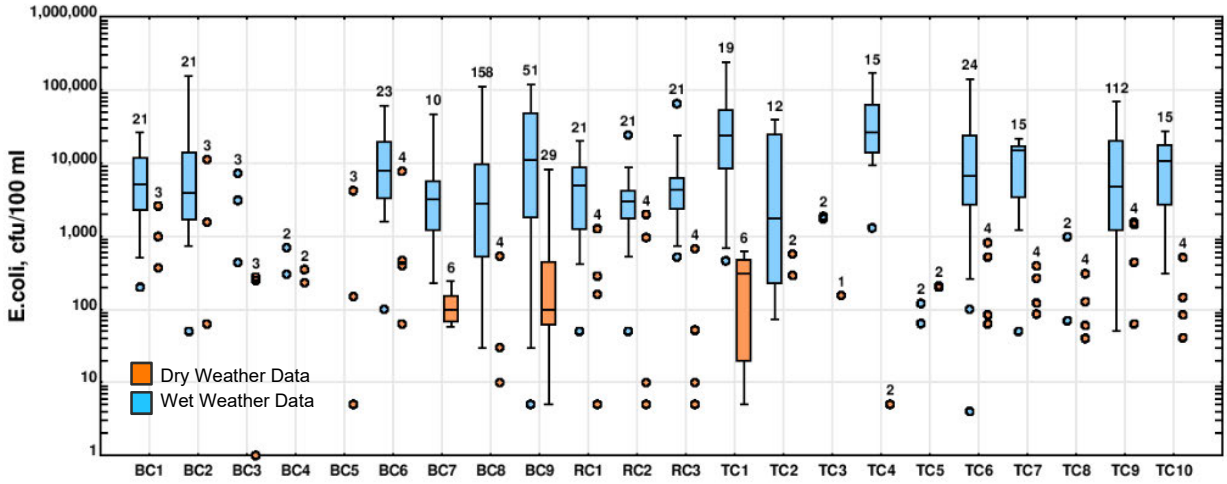


Figure 8. *E. coli* Box and Whisker Plot for Study Area Streams

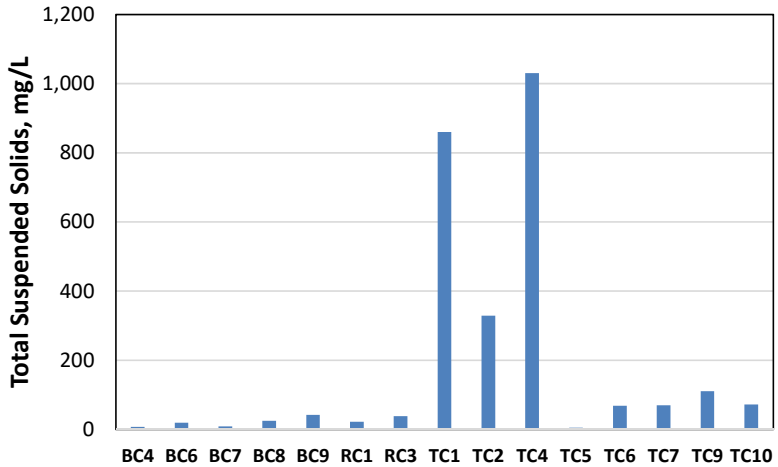


Figure 9. Median Wet Weather TSS Concentrations for Study Area Streams

Figure 10. Relationship between *E. coli* and TSS for Study Area Streams

3.4.2 Total Phosphorus

The median of dry weather TP data ranged from 0.05 to 0.20 mg/L at sites with available data (Figure 11). However, relatively few dry weather samples were available from most monitoring stations, making it difficult to characterize baseflow conditions with much certainty. Monitoring site BC9 (Brush Creek at Ward Parkway) was the best characterized site with 29 dry weather samples and had a median dry weather TP concentration of 0.07 mg/L.

Median wet weather TP levels ranged from 0.03 to 0.56 mg/L (Figure 11). The most elevated concentrations of TP were measured at sites TC1, TC2, and TC4, which have median values ranging from 0.19 to 0.84 mg/L. As shown in Figure 9, these sites have elevated levels of TSS relative to other locations and there is a positive correlation between TSS and TP (Figure 12). Sampling methods that targeted first flush conditions may account for elevated levels of TSS and TP at these locations.

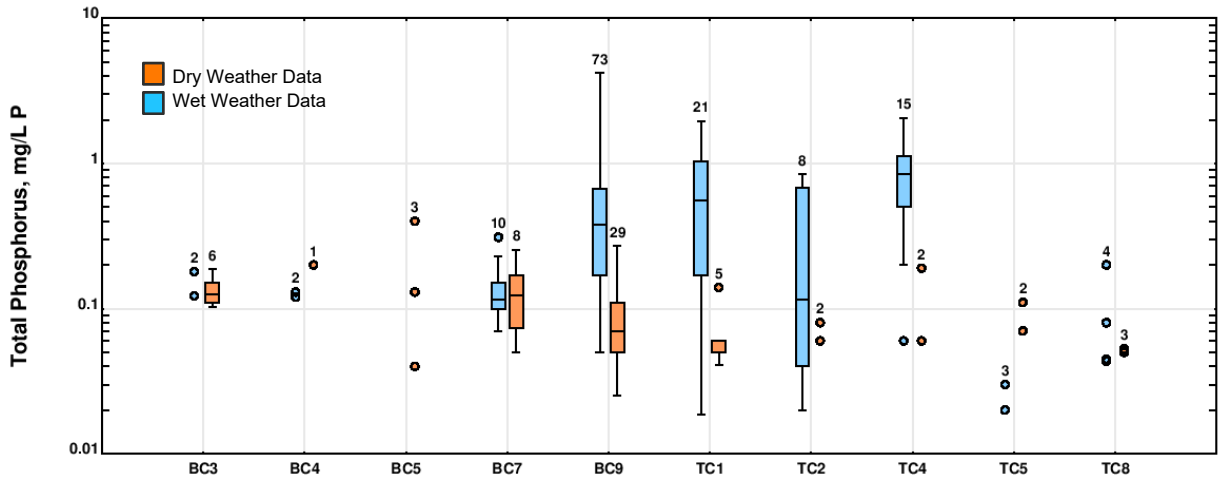


Figure 11. Total Phosphorus Box and Whisker Plot for Study Area Streams

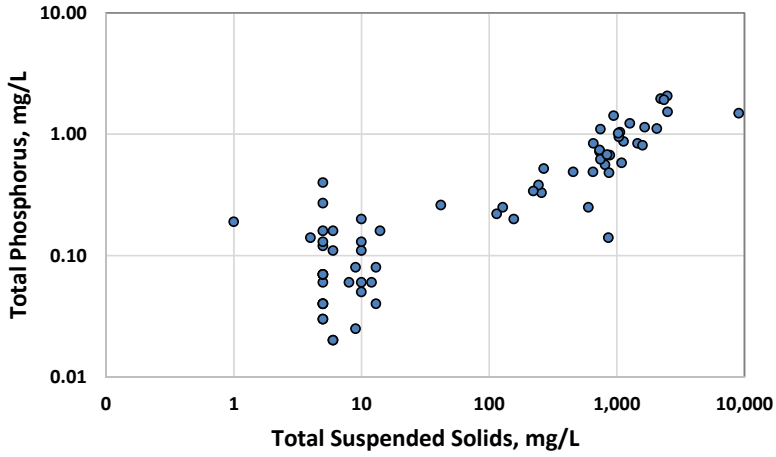


Figure 12. Relationship between TP and TSS for Study Area Streams

3.4.3 Total Nitrogen

Median dry weather TN levels range from 0.22 to 2.20 mg/L throughout the study area (Figure 13). However, relatively few dry weather samples were available from most monitoring stations, making it difficult to characterize baseflow conditions with much certainty. Monitoring site BC9 (Brush Creek at Ward Parkway) was the best characterized site with 29 dry weather samples and had a median dry weather TN concentration of 0.79 mg/L.

Median wet weather TN levels were elevated relative to dry weather data, with values ranging from 0.72 to 3.70 mg/L (Figure 13). Sites TC1 and TC4 had the most elevated levels of TN with wet weather median concentrations of 3.45 and 3.70 mg/L, respectively. However, as previously discussed, wet weather data from TC1 and TC4 may not be representative of average conditions due to sampling methods that targeted first flush conditions.

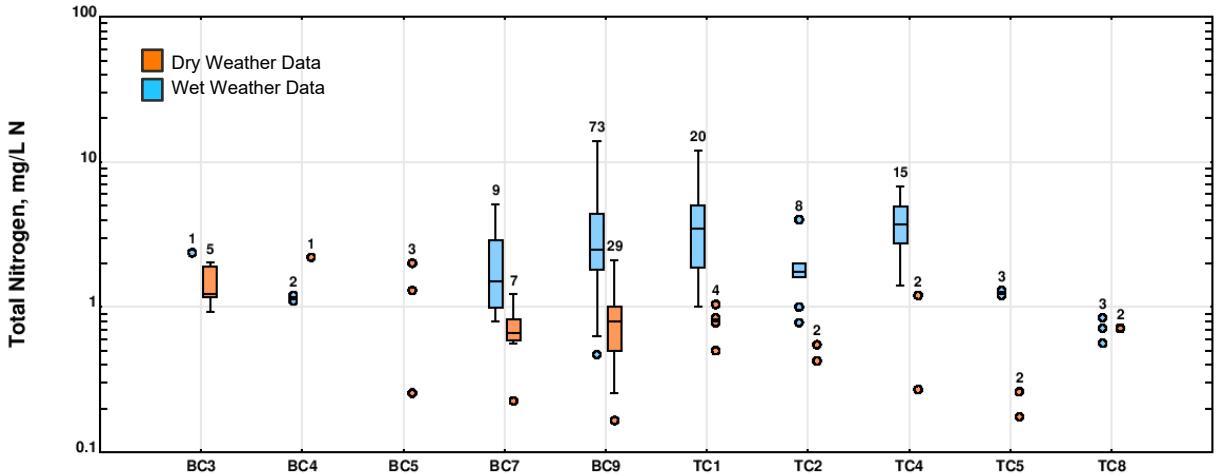


Figure 13. Total Nitrogen Box and Whisker Plot for Study Area Streams

3.4.4 Ammonia-N

During dry weather conditions, ammonia levels are relatively low at all locations other than downstream of the Nelson Complex WWTF (i.e., TC9 and TC10). Outside the influence of the Nelson Complex WWTF, median dry weather ammonia levels ranged from 0.02 to 0.15 mg/L at all but site BC4 (Figure 14). Site BC4 had a dry weather median ammonia concentration of 0.93 mg/L, however, this was based on only 2 samples, and there are no known dry weather sources of ammonia upstream of BC4. Downstream of the Nelson Complex WWTF, median dry weather ammonia concentrations ranged from approximately 3.5 to 3.9 mg/L, with maximum concentrations are as high as 8.6 mg/L.

Relative to dry weather data, instream concentrations of ammonia appear to slightly increase during wet weather conditions at most locations outside the influence of the Nelson Complex WWTF. Median wet weather ammonia levels at these locations ranged from 0.02 to 0.63 mg/L (Figure 14). Downstream of the Nelson Complex WWTF, instream concentrations of ammonia appear to slightly decrease relative to the dry weather data. Reduced levels of ammonia downstream of the Nelson Complex WWTF are likely due to dilution with stormwater runoff.

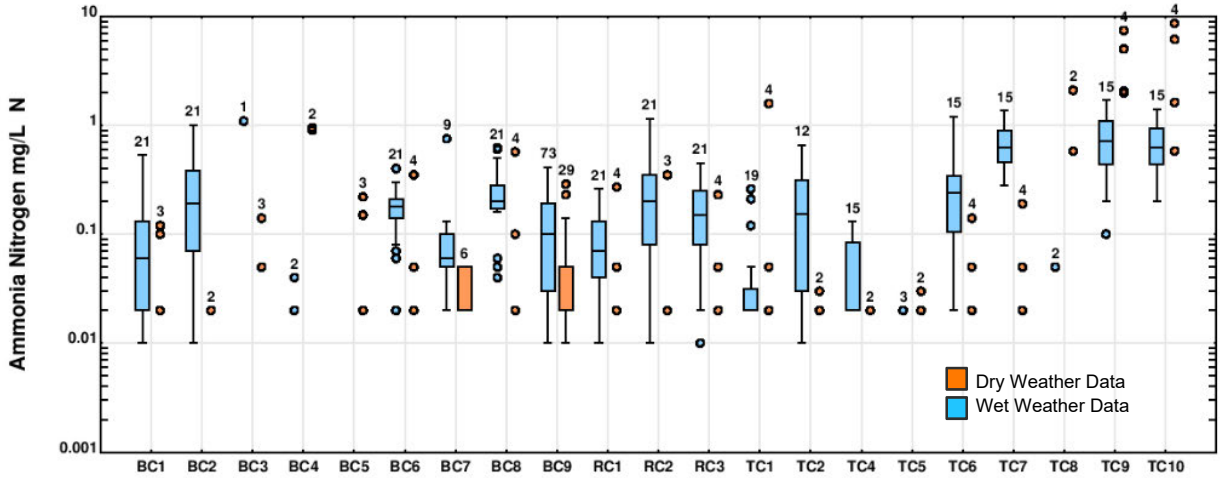


Figure 14. Ammonia Nitrogen Box and Whisker Plot for Study Area Streams

3.4.5 Total Residual Chlorine Data

Instream concentrations of dry weather TRC were typically above KDHE's chronic and acute criteria of 0.011 and 0.019 mg/L, respectively. Median dry weather values ranged from 0.01 to 0.18 mg/L and maximum values ranged from 0.05 to 1.14 mg/L (Figure 15). The source of dry weather TRC is unclear.

During wet weather conditions, PEFTF discharge appears to increase instream levels of TRC downstream of the Belinder and Turkey Creek PEFTFs. The median wet weather instream concentration of TRC increases from 0.01 to 0.07 mg/L from upstream (BC6) to downstream (BC8) of the Belinder PEFTF (Figure 15). Similarly, the median wet weather instream concentration of TRC increases from 0.09 mg/L at site TC6 (upstream of Turkey PEFTF) to 0.38 mg/L at site TC7 (downstream of Turkey PEFTF). Neither the Belinder nor Turkey PEFTF have dechlorination. There are no significant observable impacts on instream levels of TRC from the 75th & Nall (BC1 to BC2) and Martway PEFTFs (RC1 to RC2), which include dechlorination.

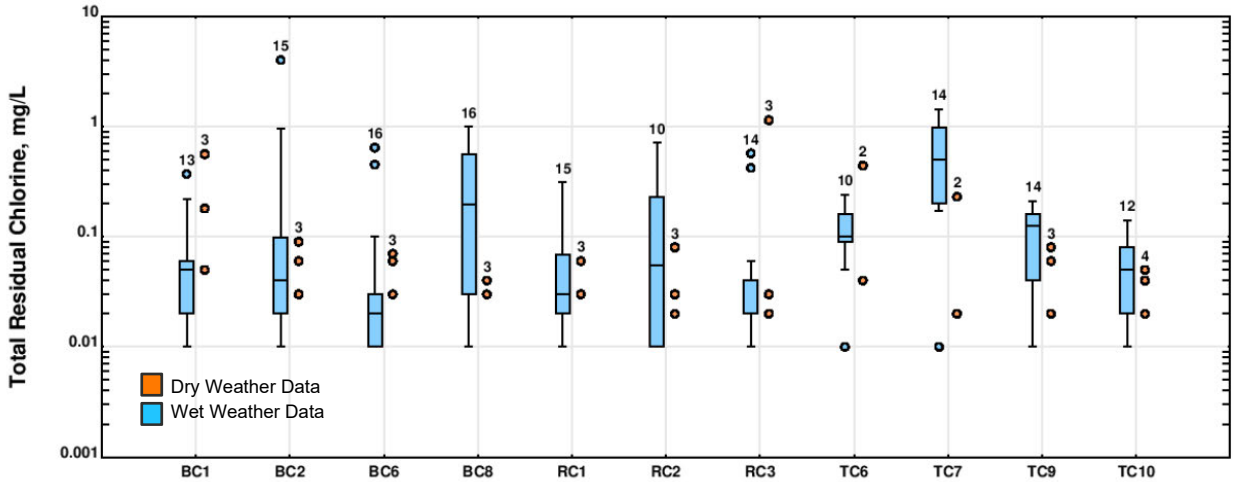


Figure 15. Total Residual Chlorine Box and Whisker Plot for Study Area Streams

4 Model Year Selection

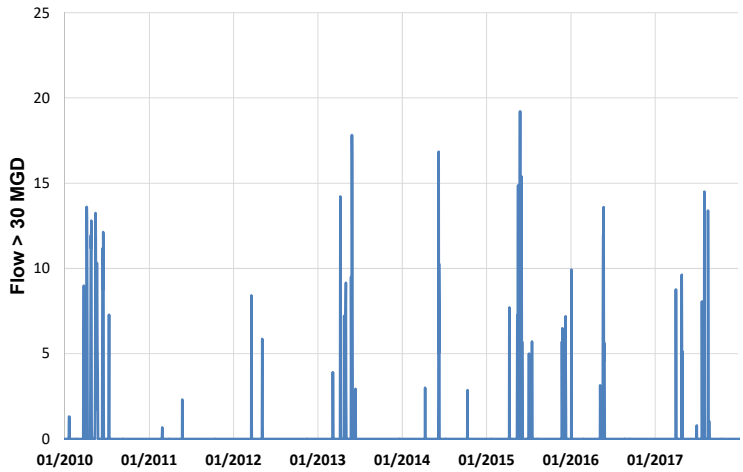
The objective of this study was to evaluate the impacts of wet weather discharges on receiving water quality using a long-term continuous simulation model. These impacts vary depending on the intensity and frequency of precipitation in the study area. Therefore, selection of the historical rainfall record used to drive the model is critical to this study's findings. In order to meet the overall purpose of the study, two separate years were selected from which to base the SWMM model. The year 2010 was selected to represent reasonable worst case conditions in terms of frequency and intensity of storm events. The year 2016 was selected as representative of more typical conditions. The basis for this decision was made on number of days PEFTFs discharge, peak flows at the Nelson Complex WWTF, and precipitation data as discussed below.

JCW's PEFTF data were assessed to determine the number of discharge events on an annual basis for the 2010-2017 period of record (Table 7). The number of events were typically higher than average at most PEFTFs during the years 2010, 2015, and 2017. Alternatively, the year 2016 most closely aligns with the average number of discharge events making it a candidate for the typical year.

Table 7. Annual PEFTF Discharge Events for the 2010-2017 Period of Record

Year	Turkey Creek	Belinder	Martway	75th & Nall
2010	7	12	7	15
2011	1	3	1	2
2012	3	3	2	3
2013	3	7	2	10
2014	4	8	3	4
2015	14	14	8	10
2016	10	8	1	7
2017	17	16	11	11
Average	7	9	4	8

Peak wet weather flows, as defined here in excess of 30 mgd or twice the ADDF at the Nelson Complex WWTF, were also evaluated for the 2010-2017 period of record. On an average annual basis, the Nelson Complex WWTF discharged flows above 30 mgd for 14 days over this time period (Figure 16). The greatest number of days with flow above 30 mgd occurred in 2010 (36 days) and 2015 (24 days), making these years candidates for a worst case year. Alternatively, those years most representative of average days with peak wet weather flow were 2013 (15 days), 2016 (13 days), and 2017 (13 days).



Year	Days >30 MGD
2010	36
2011	2
2012	4
2013	15
2014	7
2015	24
2016	13
2017	13
Average	14

Figure 16. Peak Flow Greater than 30 MGD at the Nelson Complex WWTF

In addition to wet weather discharge data, precipitation data from StormWatch rain gage BR06 (Martway at Rock Creek) were also evaluated. Rain gage BR06 was selected due to its relatively central location within the study area and its relatively long period of record. Precipitation totals were summed by month and year for the 2000-2017 period of record to assess rainfall patterns (Table 8). Based on total annual rainfall, the years 2015 and 2010 were ranked 1 and 2, respectively. However, much of the 2015 rainfall total occurred in the month of May; whereas, rainfall appears to be more equally distributed in 2010. This pattern is also apparent in precipitation hydrographs, which show a more uniform distribution of rain throughout the year during 2010 relative to 2015 (Figure 17). For this reason, 2010 was selected over 2015 as the model year representative of worst case conditions.

The precipitation data also support the selection of 2016 as the typical year. In terms of total annual rainfall, the year 2016 ranks 11 out of 18. In 2016 there was a total of 35.6 inches of rain, which is relatively close to the long-term average of 39 inches. The year 2016 also exhibited a mixture of different types of storm events. There was one notably large storm event August of approximately 5 inches and about 6 other medium size events in excess of 1 inch from April through July. Additionally, in 2016 there were a number of smaller events less than 1 inch distributed throughout the year. Based on these precipitation patterns and the wet weather discharge data, 2016 was selected as the model year representative of typical conditions.

Table 8. Precipitation Totals at StormWatch Rain Gage BR06 (Martway at Rock Creek)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Rank
2000	0.24	2.47	2	0.6	3.15	7.26	4.06	2.45	3.24	5.33	2.35	0.28	33.4	16
2001	2.19	3.04	2.16	4.33	6.01	10.63	3.61	4.21	3.79	3.28	1.35	0.84	45.4	3
2002	0.68	2.04	0.88	5.64	6.24	1.91	1.35	2.62	1.00	3.76	0.48	0	26.6	17
2003	0.24	1.16	1.55	4.03	2.64	7.51	0.16	10.54	2.8	0.88	1.27	3.48	36.3	10
2004	0.6	1.04	5.04	1.84	8.18	5.81	8.03	6.72	0.91	2.60	3.00	0.72	44.5	7
2005	2.72	2.72	1.16	2.08	3.40	7.30	2.32	11.63	4.62	2.43	0.96	1.08	42.4	9
2006	0.88	0.04	1.88	3.72	2.23	5.07	2.72	7.40	1.72	4.4	1.24	2.52	33.8	15
2007	0.68	3.59	2.48	4.65	8.00	4.67	1.35	3.76	4.69	7.86	0.20	2.56	44.5	6
2008	1.36	3.16	3.16	4.08	3.70	4.51	6.78	0.92	9.07	3.88	1.80	1.96	44.4	8
2009	0.08	1.32	4.36	6.88	2.95	7.60	5.04	6.42	2.16	5.84	1.36	1.36	45.4	4
2010	0.48	2.08	2.32	6.82	5.92	8.82	7.73	2.51	5.5	0.92	1.96	0.40	45.5	2
2011	0.60	2.40	2.16	3.00	4.24	3.36	2.62	5.16	2.77	0.08	5.12	2.80	34.3	14
2012	0.16	2.44	3.28	1.59	4.14	2.37	0.56	2.84	4.47	1.51	1.56	0.92	25.8	18
2013	1.76	1.60	1.72	4.67	7.11	3.50	1.40	2.93	4.37	4.72	1.24	0.48	35.5	12
2014	0.2	0.68	1.16	5.43	1.12	8.58	1.58	5.85	2.04	5.64	0.48	2.32	35.1	13
2015	1.00	1.00	0.92	4.07	10.09	6.98	7.41	3.07	3.15	1.52	6.40	3.80	49.4	1
2016	0.92	0.48	2.04	4.57	9.48	1.28	4.51	8.32	2.76	0.12	0	1.12	35.6	11
2017	1.32	0	2.72	6.4	3.4	5.64	8.59	13.51	2.70	0	0	0.24	44.5	5
Average	*0.9*	*1.7*	*2.3*	*4.1*	*5.1*	*5.7*	*3.9*	*5.6*	*3.4*	*3.0*	*1.7*	*1.5*	*39.0*	

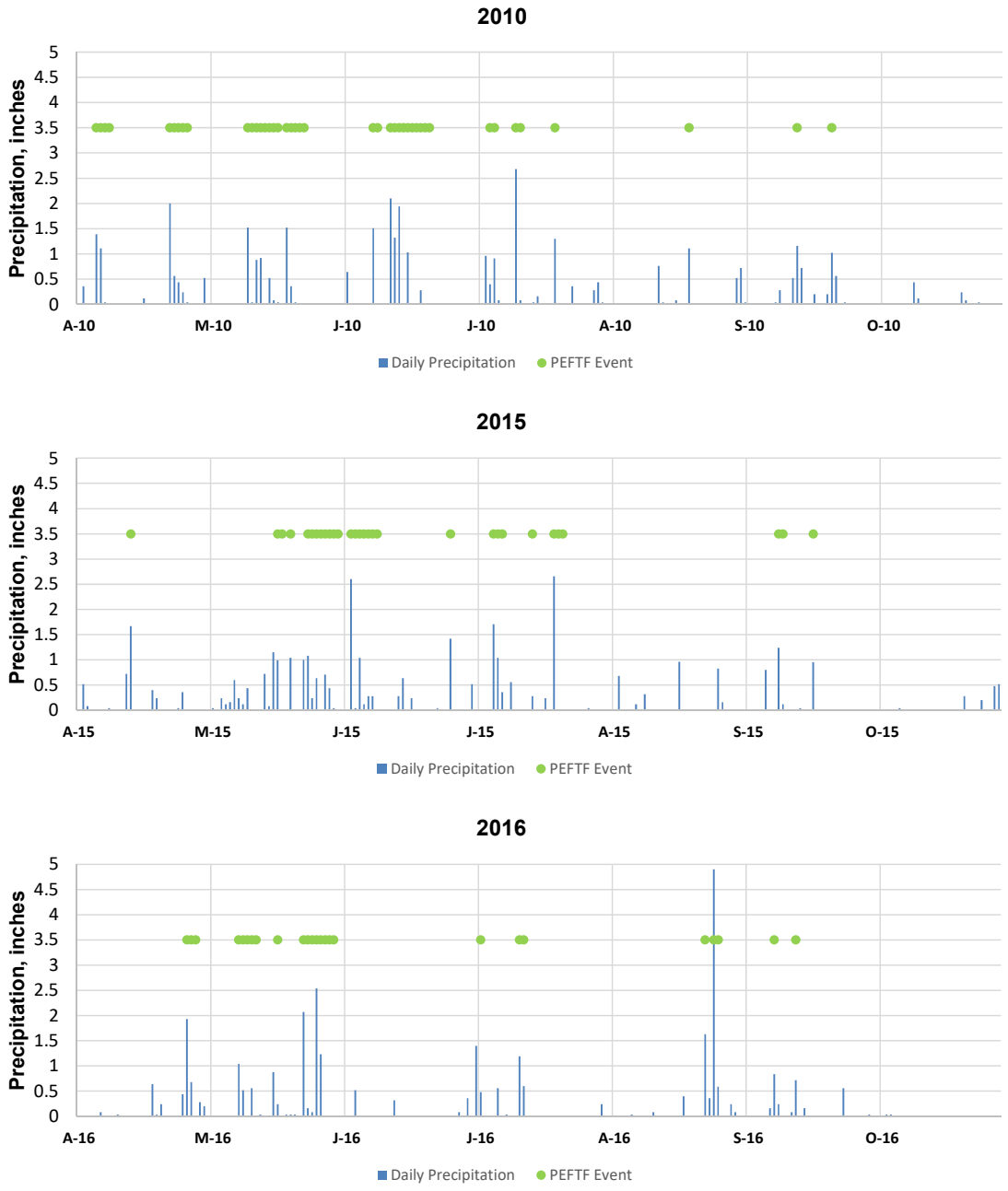


Figure 17. Daily Rainfall at Storm Watch Gage BR06 in 2010, 2015 and 2016

5 Water Quality Model Setup and Calibration

The long-term quantity and quality of rain-driven surface runoff and instream flow within the study area was computed using USEPA's Storm Water Management Model version 5 (SWMM 5) with the PCSWMM software package. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion transports this runoff through a system of channels, which were developed for this study from the USGS National Hydrography Dataset (NHD). These processes are governed within the SWMM model by the principles of conservation of mass, energy, and momentum.

The SWMM model was set up and validated based on readily available environmental and physical data. This process is described below in Section 5.1 for the hydrology and hydraulics portion of the model. Section 5.2 describes the water quality pollutant portion of the model.

5.1 Hydrology and Hydraulics

Hydrology is generally related to those processes that produce runoff, such as precipitation and land surfaces, whereas hydraulics generally refers to the physics that govern the routing of flow. Model setup and parameterization with respect to hydrologic and hydraulic processes that drive flow and flow routing are described below.

5.1.1 Precipitation

Precipitation within the SWMM model was based on continuous 15-minute rainfall data from StormWatch rain gage BR06 (Martway at Rock Creek). Rain gage BR06 was considered representative of the study area due to its relatively central location. Additionally, an analysis of other StormWatch rain gages suggests there is minimal variability with respect to monthly average rainfall within the study area.

5.1.2 Surface runoff

The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The subcatchments were created in GIS based on a pre-existing layer developed from previous JCW stormwater modeling efforts (Figure 18). The subcatchment layer was modified to include the entirety of the Turkey Creek watershed and the entirety Brush Creek watershed upstream of the Missouri border. Slight modifications were also made to the subcatchment boundaries where necessary based on topographic data. Parameterization of the model subcatchments is described below for both physical and hydrologic parameters.

5.1.2.1 PHYSICAL PARAMETERS

Physical model parameters estimated for each catchment include area, width, and slope. These were estimated as follows:

- Area - Subcatchment area was calculated in GIS from the delineated layer described above.
- Width – Subcatchment width is defined as the area divided by the runoff length. Initial estimates of width were modified to hydraulically calibrate the model to match observed flows at USGS gage 06893557 (Brush Creek at Ward).
- Slope – Subcatchment slope was calculated in GIS based on elevation data.

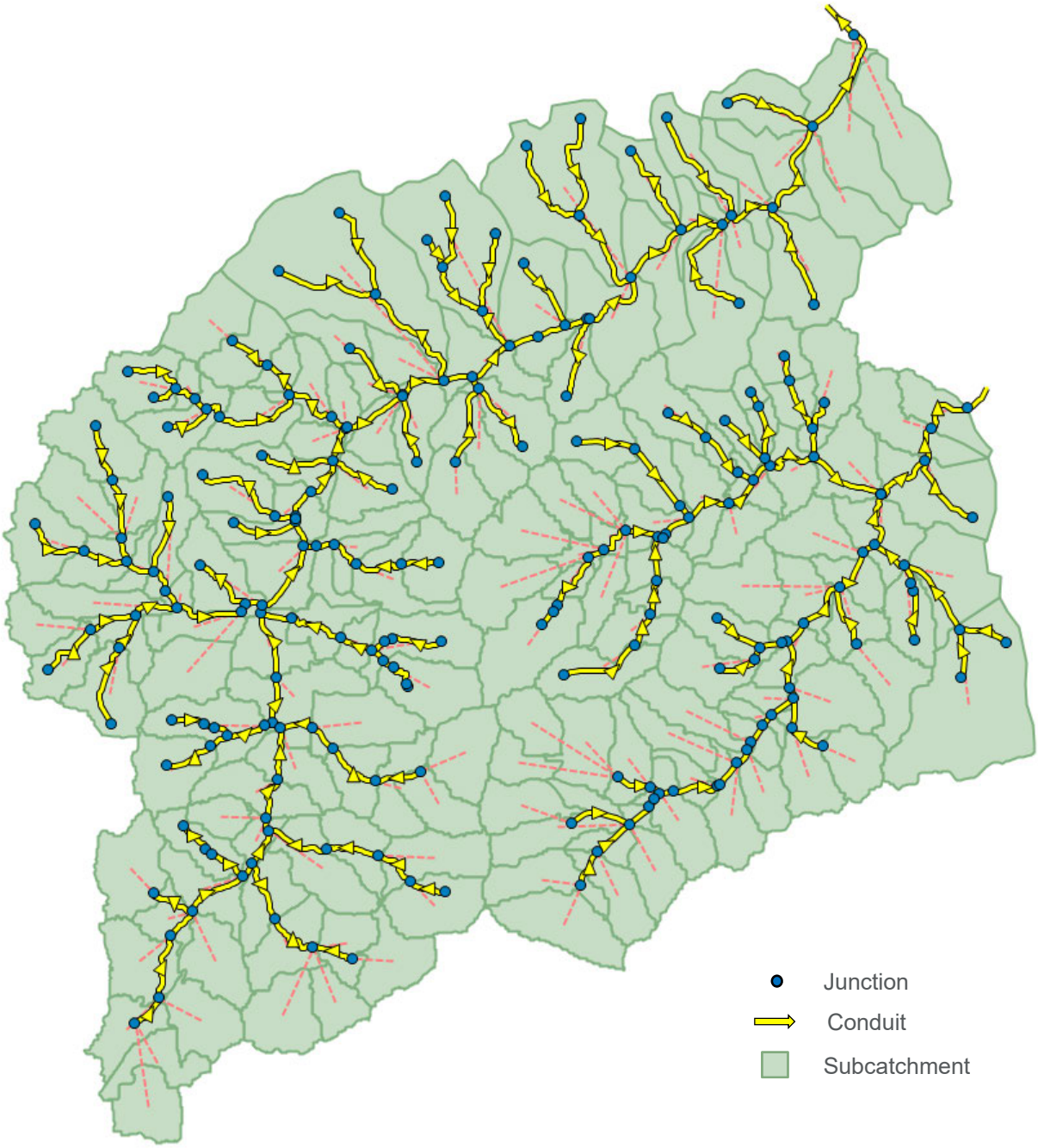


Figure 18. SWMM Model Subcatchments, Conduits and Junctions

5.1.2.2 HYDROLOGIC PARAMETERS

Hydrologic model parameters estimated for each catchment include imperviousness, impervious and pervious Manning, impervious and pervious depression storage, and infiltration. These were estimated as follows:

- Imperviousness – Imperviousness is represented by the percentage of area that is covered by impervious surfaces in the subcatchment. This was calculated in GIS based on the impervious layer depicted in Figure 3. On average, the study area was estimated to be 31 percent impervious.
- Impervious and Pervious Manning – The Manning's roughness coefficient for the impervious and pervious fraction of all subcatchment were estimated based on literature values at 0.02 and 0.2, respectively.
- Impervious and Pervious Depression Storage – This represents the maximum volume of water that can be stored in the natural depression for the impervious and pervious fraction of the subcatchment. This was estimated at 0.08 and 0.2 inches for the impervious and pervious fraction of all subcatchment, respectively.
- Infiltration - Infiltration of precipitation into the unsaturated soil was modeled within SWMM using the Green-Ampt method. The Green-Ampt method assumes a sharp wetting front exists in the soil column, separating soil with some initial moisture content below from saturated soil above. Input parameters required for the Green-Ampt method are described below:
    - Initial moisture deficit – Estimated at 0.391 (expressed as a fraction) based on local soil conditions and literature values.
    - Hydraulic conductivity – Estimated at 0.256 inches per hour based on local soil conditions and literature values.
    - Suction head – Estimated at 6.567 inches based on local soil conditions and literature values.

5.1.3 Stream Flow

The routing portion of SWMM transports flow from surface runoff, baseflow, and direct discharges through stream channels. The stream channels were imported into SWMM from the USGS National Hydrography Dataset (NHD) stream layer. Physical and hydrologic parameters of the model reaches along with direct inputs of flow are described below.

5.1.3.1 PHYSICAL PARAMETERS

Physical model parameters estimated for each stream channel reach include cross-sectional shape and reach slope. These were estimated as follows:

- Cross-sectional shape – Stream reaches were modeled as a user-defined irregular cross-sectional shape based on a combination of data. Where available, the cross-section shape was imported from HEC-RAS data. Otherwise, the cross-sectional area was delineated within PCSWMM from digital elevation model (DEM) data. The DEM layer for the Wyandotte County portion of the study area was generated from high resolution LiDAR data. The DEM layer for the Johnson County portion of the study area was generated from 2 foot contour data.
- Reach slope – Stream reach slopes were automatically generated in PCSWMM based on inlet and outlet node elevations. Node elevations were based on DEM data.

5.1.3.2 HYDROLOGIC PARAMETERS

Hydrologic model parameters estimated for each stream reach include Manning's roughness and flow routing method.

- Manning's Roughness – Manning's roughness was estimated at 0.025 for all stream reaches based on literature values.
- Flow Routing – Flow routing within a conduit link (channel) in SWMM is governed by the conservation of mass and momentum equations from gradually varied, unsteady flow (i.e., the Saint-Venant flow equations). The Saint-Venant flow equation was solved within SWMM using the dynamic wave routing method.

5.1.3.3 DIRECT INPUTS OF FLOW

In addition to surface runoff, two other sources of stream flow were included within the model as direct inputs. These other sources included baseflow and direct discharges.

5.1.3.3.1 Baseflow

Baseflow represents that portion of streamflow maintained by groundwater discharge. Also called low-water flow, it is distinct from direct surface runoff and is usually simulated separately in computer models. Baseflows within the Turkey and Brush Creek watersheds were calculated from USGS gage 06893557 (Brush Creek at Ward) daily[1] streamflow data using the following two parameter digital filter separation method proposed by Eckhardt (2005):

$$\text{Equation 1:}\quad b_t = \frac{(1-BFI_{max})\times\alpha + b_{t-1} + (1-\alpha)\times BFI_{max}\times Q_t}{1-\alpha\times BFI_{max}}$$

where BFI_{max} is the maximum long term ratio of baseflow to total streamflow, α is the filter parameter, and Q_t is the total streamflow at the t time step. Default values of 0.5 and 0.98 were used for BFI_{max} and α, respectively. Calculated baseflows and total measured streamflow for the Brush Creek at Ward station are presented below in Figure 19. Baseflows calculated using this method were distributed in the model as inflows throughout the study area based on catchment area. Using this method, total baseflow in the Turkey Creek watershed was determined to be approximately 1.8 times baseflow at Brush Creek at Ward based on contributing drainage area.

[1] Although 15-minute streamflow data were available, baseflows were calculated using daily average flows due to significant data gaps in the 15-minute dataset.

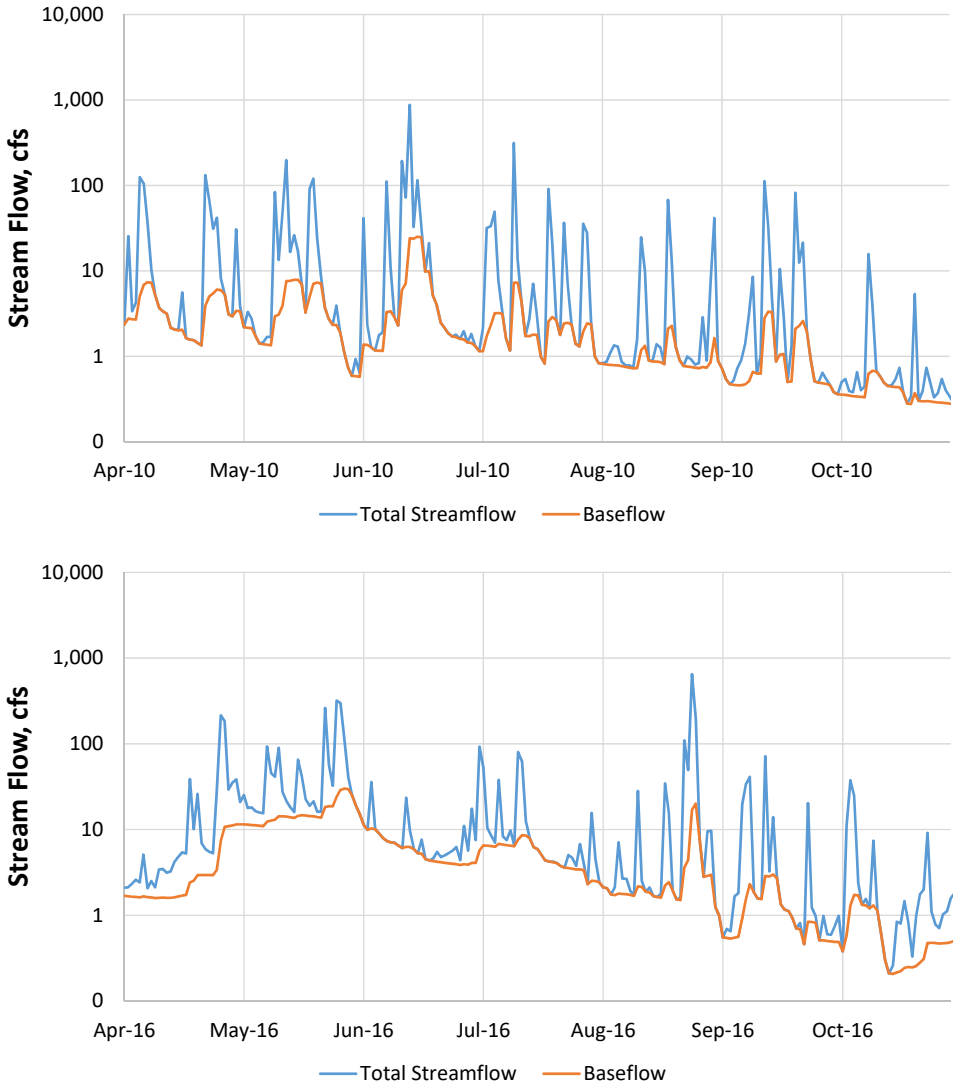


Figure 19. Daily Average Baseflow at USGS Gage 06893557 (Brush Creek at Ward) for Model Years 2010 and 2016

5.1.3.3.2 Direct Dischargers

Direct discharges from the Nelson Complex, PEFTFs, SSOs, and in-system bypasses were modeled for the 2010 and 2016 recreational seasons using the InfoWorks ICM hydraulic modeling platform by Innovyze. Model results, summarized in Table 9 and in Appendix A, were exported from the InfoWorks ICM model as time series and imported for use as the boundary inflow in the SWMM model. The InfoWorks ICM model was originally calibrated to represent peak flow and for capacity analysis. Although the model was partially calibrated for use in long-term simulations, modeled flows may be over or under representative in some instances and do not necessarily reflect actual flows. Additional model documentation of the InfoWorks ICM model is provided for in TM 2 (*Hydraulic Model Updates, Section 5*).

Table 9. Recreational Season System Discharge Flows Modeled by InfoWorks

Discharge	Receiving Stream	*Baseline Conditions (MG)*		*Eliminating all PEFTFs (MG)*		*Collection System Improvements and Facility Upgrades (MG)*	
		2010	**2016**	**2010**	**2016**	**2010**	**2016**
Nelson Complex WWTF	Turkey Creek	4,554	4,165	4,888	4,503	4,554	4,172
Turkey PEFTF	Turkey Creek	194	152	0	0	206	167
Belinder PEFTF	Brush Creek	82.0	102.3	0	0	82.0	102.3
75th & Nall PEFTF	Brush Creek	27.1	32.3	0	0	27.1	32.3
Martway PEFTF	Rock Creek	19.6	29.6	0	0	19.6	29.6
SSO 0310205	Turkey Creek	6.3	7.4	0	0	0	0
SSO 0301025	Turkey Creek	5.1	7.2	0	0	0	0
Bypass 12	Brush Creek	0.2	6.7	0	0	0	0
Bypass 13	Brush Creek	0	0.04	0	0	0	0
	Total Flow	4,888	4,503	4,888	4,503	4,888	4,503

Note: Recreational season is from April through October.

5.1.4 Flow Calibration

Flow calibration was performed using USGS gage 06893557 (Brush Creek at Ward Parkway), which is located at the downstream extent of the Brush Creek watershed within the study area. No other flow gages are located within the study area. Hydraulic calibration efforts were based on flow data for the 2015 recreational season (April – October), due to the availability of 15-minute flow data. The USGS Ward station was frequently down during other years, including model years 2010 and 2016, making those datasets unsuitable for hydraulic calibration.

Subcatchment widths and Green-Ampt infiltration parameters were considered for adjustment to achieve a better comparison at the Ward location. The predicted flows were assessed to correlate well with monitored flows overall. Calibration metrics are described below.

- Graphical Time-Series Plot – A hydrograph of observed and predicted flows was plotted to assess similarity in terms of time-to-peak, peak flow patterns, and recession curves (Figure 20). Predicted flows patterns appear to closely mimic observed flows throughout most of the model period.
- Peak Flows – Peak flows were evaluated based on the average percent difference between predicted and observed peak flows. On average, peak flows in excess of 100 cfs were overpredicted by approximately 13%.
- Volume – Excluding periods when the Ward station was inoperable, total predicted and observed flow volumes were compared for the 2015 recreational season. There was good agreement between the modeled and observed flow volume with only a 6% difference (2,342 MG (observed) versus 2,487 MG (predicted)).
- Relative Error – The Nash-Sutcliffe efficiency coefficient was used to evaluate the relative error between model predictions and observations. With the Nash-Sutcliffe measure, an R2 coefficient is calculated using Equation 2:

$$\text{Equation 2: } R^2 = 1 - \frac{\sum(Q_o - Q_p)^2}{\sum(Q_o - Q_a)^2}$$

where: Q_o is the observed value, Q_p is the predicted value, and Q_a is the average of the observed values. Coefficient (R^2) values equal to 0 suggest the model is no better than the average of the observed data. The closer the model efficiency is to 1, the more accurate is the model. The Nash-Sutcliffe R^2 value was estimated to be 0.55 for this calibrated dataset.

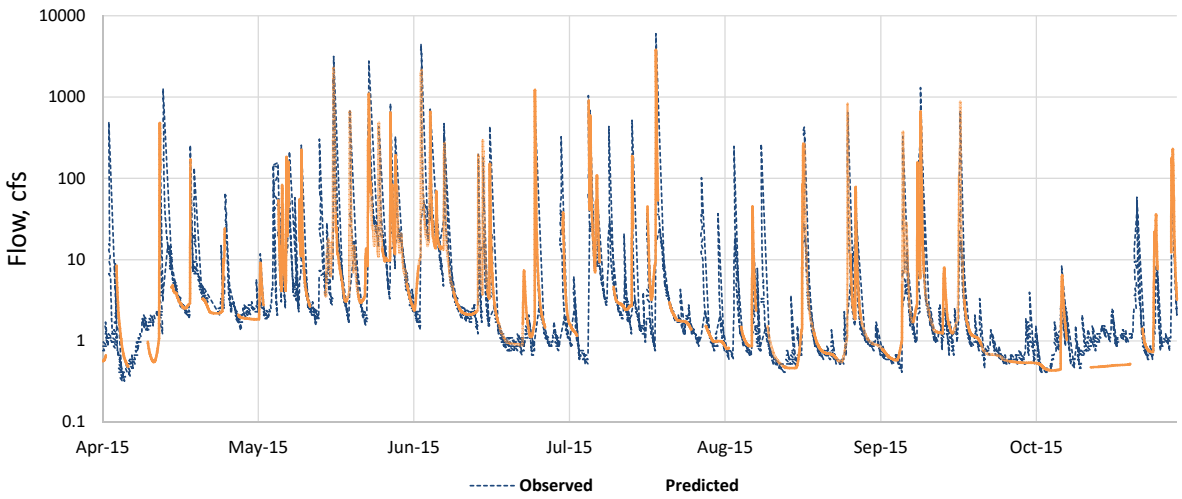


Figure 20. Observed versus Predicted Flow at Brush Creek at Ward Parkway

5.2 Water Quality

SWMM can simulate the generation, inflow, and transport of any number of user-defined pollutants. Setting up the water quality portion of the SWMM model includes assigning pollutant concentrations to direct flow inputs (e.g., baseflow, WWTF, PEFTFs, bypasses and SSOs) and defining the buildup and washoff functions used to simulate pollutant runoff. The steps required for simulating pollutant runoff loading consists of defining land use categories, assigning a mixture of land uses to each subcatchment area, and parameterizing the buildup and washoff functions.

For purposes of this study, modeled pollutants included *E. coli*, TP, TN, ammonia-N, and TRC. Although some level of decay may occur for some or all of these pollutants, the assumption was that it does not occur. Therefore, the decay coefficient was set to 0 for all pollutants. This is likely a reasonable assumption during peak flow events when travel time within the study area is minimal. Additionally, assuming zero decay during baseflow conditions serves as a measure of conservatism with respect to assessing impacts of the Nelson Complex WWTF on instream water quality in Turkey Creek.

Methods for assigning pollutant concentrations to known discharges, baseflow, and surface runoff are discussed below. Although other watershed sources of pollutants may exist within the study area, these sources are not explicitly accounted for in the SWMM model (e.g., illicit discharges). Model pollutant assumptions are summarized in Appendix B.

5.2.1 Discharge Pollutant Concentrations

5.2.1.1 E. COLI

Discharge concentrations of *E. coli* in the SWMM model were set based on existing data or literature values where data were not available, as discussed below.

5.2.1.1.1 Nelson Complex WWTF Outfall 001

The Nelson Complex WWTF currently disinfects its effluent using chlorine as part of the treatment process to eliminate bacteria and viruses. *E. coli* effluent quality in the Nelson Complex WWTF is

relatively stable with a median concentration of 80 cfu/100 mL (Figure 5). Therefore, an effluent quality of 80 cfu/100 mL was assumed in the SWMM model for all model alternatives.

5.2.1.1.2 PEFTFs

All PEFTF discharges are currently disinfected by chlorination. However, analysis of the PEFTF effluent data suggests efficacy rates significantly vary between locations and storm events. Median *E. coli* levels range between 10 cfu/100 mL at Belinder to 2,125 cfu/100 mL at Martway (Table 10). *E. coli* effluent quality also varies by approximately an order of magnitude within the interquartile range (25th to 75th percentile) at each PEFTF.

Table 10. PEFTF E. coli Statistics

	***E. coli*, cfu/100 mL**			
PEFTF	**25th Percentile**	**Median**	**75th Percentile**	**Maximum**
Belinder	5	10	95	155,000
Martway	1,005	2,125	23,725	241,000
75th & Nall	330	828	3,945	199,000
Turkey Creek	41	717	7,840	86,600

In order to capture the observed variability of the PEFTF *E. coli* effluent quality within the SWMM model, an *E. coli* time series dataset was developed for each PEFTF. Where data were available, the time series dataset was populated with measured *E. coli* levels for the respective PEFTF location and date. Where there was no measured data for a modeled PEFTF event, the *E. coli* concentration was set to the observed long-term median value (Table 10). The *E. coli* time series used as model inputs for baseline conditions is included in Appendix C.

For purposes of simulating the collection system improvements and facility upgrades scenario, the *E. coli* effluent concentration was modeled at 100 cfu/100 mL at the Martway, 75th & Nall, and Turkey PEFTFs. The Belinder PEFTF was modeled at the existing median concentration of 10 cfu/100 mL for the same scenario. This scenario presumes upgrades or operational changes will be made at the PEFTFs to improve disinfection efficacy.

5.2.1.1.3 SSOs and In-System Bypasses

Water quality samples were not available for discharges from SSOs or in-system bypasses within the study area. However, USEPA's 2004 *Report to Congress - Impacts and Controls of CSOs and SSOs* reports that wet weather SSOs have a median fecal coliform concentration of 500,000 cfu/100 mL. This finding was based on a 2001 study conducted by the Wisconsin Department of Natural Resources, which supported USEPA's data collected on wet weather SSOs for their 2004 Report to Congress. For purposes of this study, *E. coli* concentrations for modeled SSOs and in-system bypasses were set equal to USEPA's reported median fecal coliform concentration of 500,000 cfu/100 mL.

5.2.1.2 NUTRIENTS AND AMMONIA

Discharge concentrations of TP, TN, and ammonia-N were set based on existing data as discussed below.

5.2.1.2.1 Nelson Complex WWTF Outfall 001

Modeled discharge concentrations of TP, TN and ammonia-N for the Nelson Complex WWTF baseline conditions were set equal to the observed median values (Table 11). For the other model alternatives, effluent quality was presumed to be equivalent to biological nutrient removal (BNR) with

a TP and TN concentration of 1 and 10 mg/L, respectively, and effluent ammonia-N was assumed to be 0.3 mg/L.

Table 11. Modeled Nutrient and Ammonia Discharge Concentrations for Nelson Complex WWTF

Parameter	Baseline	Other Model Alternatives*
TP, mg/L	3.0	1
TN, mg/L	19	10
Ammonia-N, mg/L	2.5	0.3

*Other model alternatives include 1) eliminating all PEFTFS, and 2) collection system improvements and facility upgrades.

5.2.1.2.2 PEFTFs, SSOs, and In-System Bypasses

In order to characterize effluent concentrations of nutrients and ammonia within the Turkey Creek and Mission Main collection systems, a mass-balance model was utilized based on average loadings and flows within the different service areas of the collection systems. Results of the mass-balance model were used to develop a time series dataset for inclusion in the SWMM model.

The mass-balance model used to develop the time series dataset was based on following equation:

$$\text{Equation 3: } Concentration, mg/L = \frac{Pollutant\ Load, lbs/day}{Flow, MGD \times 8.34}$$

where the pollutant load was assumed constant for the three pump station service areas within Mission Main (i.e., Brush Creek Pump Station Service Area, Rock Creek Pump Station Service Area and Belinder Pump Station Service Area) and the Turkey Creek Service Area. Pollutant loads for the respective service areas were based on annual average loads presented in TM 1 (*Nelson Complex WWTF Improvements Facility Plan – Basis of Analysis*, August 2018) of the Nelson Complex WWTF Improvements Facility Plan (Table 12).

Table 12. Design Flows and Loads for the Nelson Complex

Collection System	Mission Main			Turkey Creek
Service Area[1]	Brush Creek	Rock Creek	Belinder	Turkey Creek
ADDF, mgd[2]	2.0	2.1	2.9	8.0
Average Ammonia-N Influent, mg/L[3]	16	16	16	18
Average Ammonia-N Load, lbs/day	267	285	382	1,201
Average TN Influent, mg/L	30	30	30	26
Average TN Load, lbs/day	500	535	716	1,735
Average TP Influent, mg/L	3.4	3.4	3.4	2.9
Average TP Load, lbs/day	57	61	81	193

Notes:
1. Brush Creek Service Area is representative of the 75th & Nall PEFTF, Bypass 12, and Bypass 13. Rock Creek Service Area is representative of the Martway PEFTF. Turkey Creek Service Area is representative of SSOs 0310205 and 0301025 and the Turkey PEFTF.
2. Mission Main ADDF of 7 mgd split between the different service areas based on flow analysis presented in the April 2013 draft report entitled "Nelson Wastewater Treatment Complex Sanitary Sewer Service Area – Scope Task 2.1 – Flow and Rainfall Data Analysis and Update Previous Flow Analysis with New Acres".
3. Average influent concentration obtained from TM 1 (Basis of Analysis) of the Nelson Complex WWTF Improvements Facility Plan. TKN assumed equivalent to TN for purposes of this study.

Flows within the collection system were assumed to exceed system capacity during modeled wet weather discharge events. Therefore, flows for Equation 3 were set equal to the stated firm capacity

of the respective pump stations (Table 13) plus the respective PEFTF discharge flows as modeled by InfoWorks.

Table 13. Pump Station Firm Capacity

	Pump Station Firm Capacity, mgd
75th & Nall Pump Station	5.5
Rock Creek Pump Station[1]	12
Belinder Pump Station	10.6
Turkey Creek Pump Station[2]	21

Source: TM 1 (Basis of Analysis) of the Nelson Complex WWTF Improvements Facility Plan.
[1.] Rock Creek Pump Station is representative of the Martway PEFTF.
[2.] Turkey Creek Pump Station has a stated firm capacity of 27 mgd. However, it is currently limited to approximately 21 mgd due to hydraulic restrictions at the Nelson Complex.

Based on the method and assumptions presented above, the simulated concentrations reflect the expected variability in effluent quality. TN levels range from approximately 1.4 to 11 mg/L, TP levels range from approximately 0.2 to 1.2 mg/L, and ammonia levels range from approximately 0.8 to 6.9 mg/L (Figure 21). Although simulated ammonia concentrations generally exceed observed values previously depicted in Figure 3, the simulated values are considered a reasonable, conservative assumption for purposes of this study. As discussed in Section 3.3.4, the relatively low levels of observed ammonia may be due to local breakpoint chlorination resulting in ammonia oxidation. The PEFTFs were not intentionally designed to remove ammonia; therefore, the model conservatively assumes no ammonia removal.

Simulated PEFTF concentrations of ammonia and nutrients were assumed to apply to SSOs and in-system bypasses located within the same service area. Accordingly, simulated effluent quality at the Turkey PEFTF was applied to the SSOs and effluent quality at the 75th & Nall PEFTF was applied to Bypass 12 and 13.

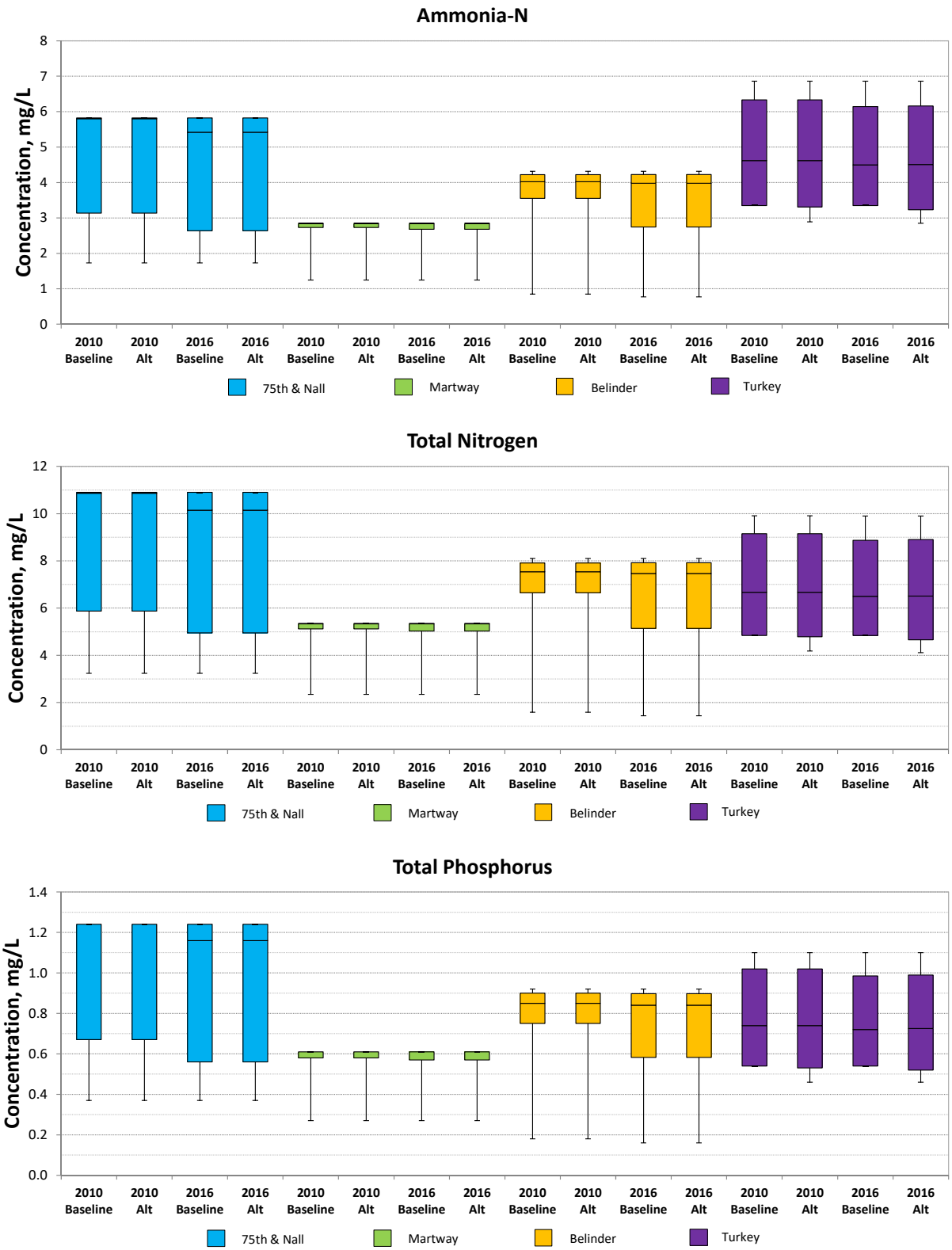


Figure 21. Box and Whisker Plot of Simulated PEFTF Effluent Quality
(Note: "Alt" is the collection system improvements and facility upgrades alternative.)

5.2.1.3 TOTAL RESIDUAL CHLORINE

For purposes of modeling, existing baseline effluent TRC concentrations were set equal to median values presented in Section 3.3.5 (Figure 7). SSOs and Bypasses 12 and 13 were assumed to have no TRC, since there is no chlorination at these locations. TRC assumptions for the collection system improvements and facility upgrades alternative was set equal to 25 ug/L. This is equal to half the detection limit since at least half the samples were below the limits of detection at 75th & Nall, Martway and the Nelson Complex WWTF.

Table 14. Modeled Effluent Total Residual Chlorine Concentrations

Outfall	Total Residual Chlorine, ug/L	
	Baseline	Collection System Improvements and Facility Upgrades
Nelson WWTF	25	25
75th & Nall PEFTF	25	25
Belinder PEFTF	2,400	25
Martway PEFTF	25	25
Turkey PEFTF	2,300	25
SSO 0301025	0	--
SSO 0310205	0	--
Bypass 12	0	--
Bypass 13	0	--

5.2.2 Baseflow Pollutant Concentrations

Baseflow pollutant concentrations were calculated for the entire study area based on dry weather data summarized in Section 3. Data collected below the Nelson Complex WWTF were excluded from consideration. Baseline concentrations were calculated as the median of the compiled dry weather dataset for *E. coli* (151 cfu/100 mL), TP (0.07 mg/L), TN (0.78 mg/L), and ammonia-N (0.03 mg/L). No baseflow pollutant concentration was calculated for TRC, which was considered negligible.

5.2.3 Surface Runoff Concentrations

The event mean concentration (EMC) approach, which was utilized for this study, assumes an equal concentration of pollutant in all precipitation driven surface runoff. This approach is achieved within the SWMM model by turning off the buildup function and setting the washoff function to “EMC”.

EMCs are intended to represent the average concentration for a single monitored event and are typically based on flow-weighted composite sampling or calculated from discrete samples collected throughout a storm event (NRC 2008). However, data from the study area were generally insufficient for fully characterizing the entire duration of individual storm events. Although the JCW data included some composite sampling, composite sampling data were not available for any of the parameters of interest (*E. coli*, TN, TP, or ammonia-N) and flow data were also lacking. Therefore, EMCs were estimated from existing wet weather data and compared to literature values for verification.

For purposes of this study, a single EMC was applied to the entire study area for each parameter of interest. Although EMCs are frequently associated with land uses, calculating EMCs by land use was impractical for purposes of this study. The existing monitoring stations each drain a relatively homogenous mixture of different land uses including commercial, residential, industrial, roadways,

and developed open space (e.g., parks and golf courses). Additionally, given the relatively homogenous makeup of land uses, it was reasonable to assume an average EMC for the entire watershed.

In calculating EMCs, preference was given to monitoring stations located upstream of the WWTF, PEFTFs, and SSOs. Additionally, data from stations TC1, TC2, and TC4 were excluded from consideration based on elevated TSS levels and sampling methods that targeted “first flush” capture. Median TSS levels from these locations ranged from 607 to 1,035 mg/L, which is outside the range of typical values for most land use types based on the National Stormwater Quality Database (NSQD) (Maestre and Pitt, 2015 for version 4.02). EMCs were calculated as the median concentration of the remaining wet weather dataset (Table 15). Final calculated EMCs were within the range of values in the NSQD, which includes individual EMCs from about 8,700 separate events (Table 15).

5.2.4 Water Quality Validation

To help validate model assumptions, the 2010 and 2016 model results were compared to instream water quality data at two locations: 1) Brush Creek below the Belinder PEFTF, and 2) Turkey Creek above the Nelson Complex. Due to relatively small sample sizes and a lack of information on sample times, model results were paired with observed data based on flow conditions rather than sample time. Load duration curves developed for *E. coli*, TP and TN show relatively good agreement between model results and the observed data. Model results, as represented by the median value, generally match the central tendency of the observed data (Figure 22).

5.3 Data and Model Uncertainty

As with any model used to simulate environmental phenomena, simplifications of conditions and processes are required and results are inherently inexact and uncertain. Model simplifications and the quality of the data can impose limitations on the interpretation of model results. This is no less true for the model described herein, which was used for extrapolating conditions over a large urban area and wide range of hydrologic conditions. Model limitations arise from a number of sources including data quality and system simplifications. Examples of model limitations include:

- Water quality data used to characterize SSOs were unavailable and limited to a few parameters at the PEFTFs.
- The SWMM model utilized EMCs rather than more complex buildup and washoff functions.
- Not all pollutant sources were explicitly accounted for in the model. Example pollutant sources not explicitly modeled include failing septic systems, bank erosion, and resuspension.

The limitations above can be significant, with results that lend themselves to qualitative insights and guidance rather than precise quantification.

Table 15. Model versus National Stormwater Quality Database Event Mean Concentrations

	Land Use	*E. coli*, cfu/100 mL	TP, mg/L	TN, mg/L	Ammonia-N, mg/L	TSS, mg/L
Model EMCs	Study Area (Mixed Land Use)	5,205	0.26	2.30	0.10	--
NSQD EMCs	Commercial	1,726 (113 - 20,531)	0.19 (0.07 - 0.68)	2.06 (0.70 - 5.57)	0.43 (0.10 - 1.41)	51 (11 - 264)
	Highways/Freeways	1,900 (698 – 7,940)	0.25 (0.11 - 0.68)	1.58 (0.97 - 5.45)	0.86 (0.20 - 2.71)	75 (17 - 250)
	Industrial	2,750 (547 – 4,050)	0.22 (0.06 - 0.90)	1.71 (0.46 - 3.96)	0.38 (0.10 - 1.23)	71 (15 - 347)
	Institutional	NA	0.14 (0.05 - 0.43)	2.51 (1.42 - 4.95)	0.18 (0.10 - 0.67)	67 (15 - 241)
	Open Space	1,100 (372 – 3,260)	0.13 (0.05 - 0.51)	2.02 (0.59 - 4.35)	0.10 (0.10 - 0.50)	38 (5 - 549)
	Residential	800 (146 – 19,800)	0.30 (0.10 - 0.83)	2.91 (0.93 - 6.78)	0.31 (0.10 - 1.27)	57 (10 - 285)
	Unknown	4,150 (2,445 – 6,125)	0.16 (0.04 - 0.51)	NA	0.37 (0.12 - 1.24)	35 (12 - 124)

Note: Values outside parentheses are 50th percentile. Value ranges inside parentheses are the 10th and 90th percentile.

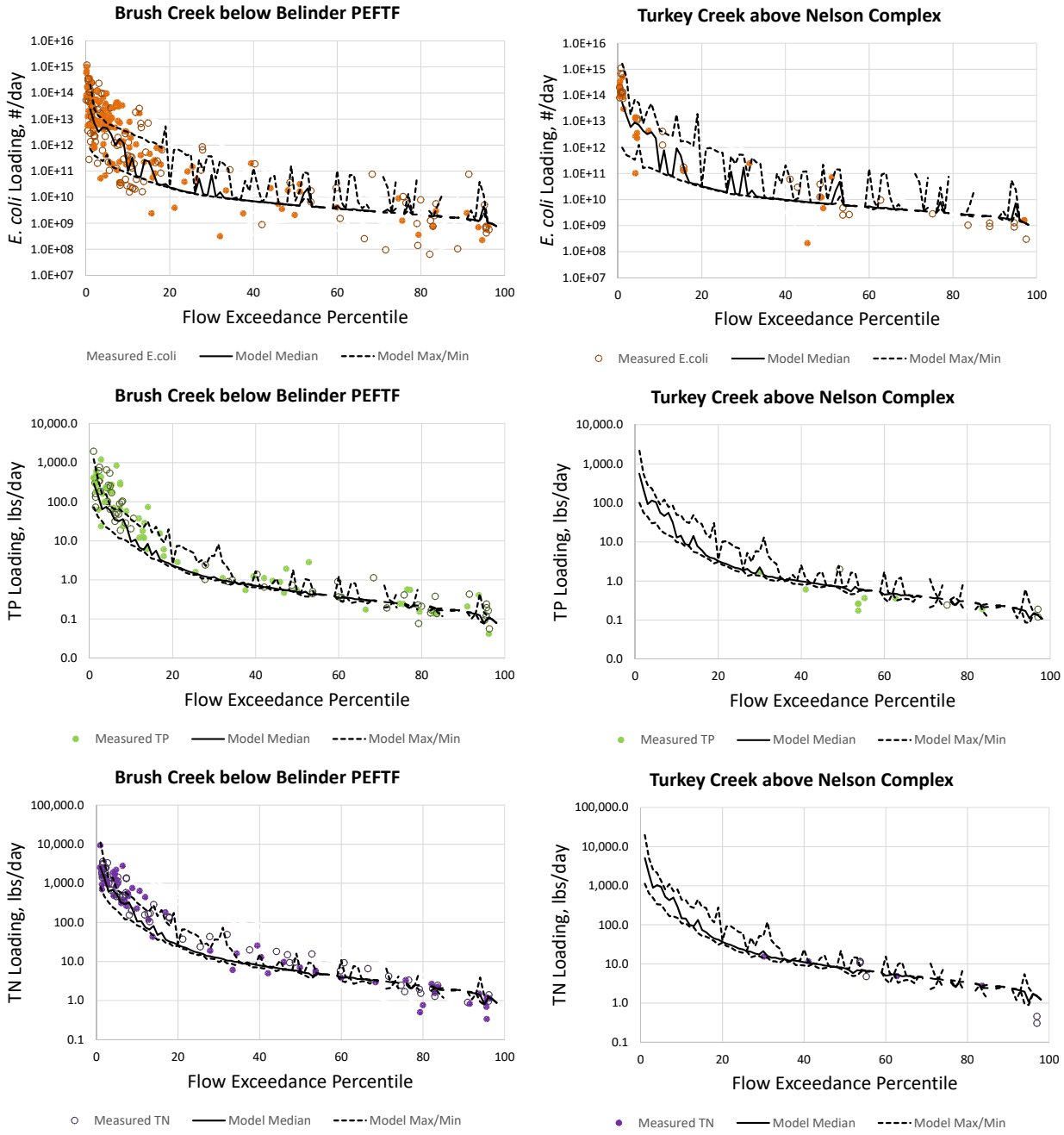


Figure 22. Comparison of Model Results and Observed Data Using Load Duration Curves

6 Water Quality Model Results

The SWMM model described in Section 5 was used to approximate water quality conditions in Brush and Turkey Creek under existing baseline conditions and for two alternatives: 1) eliminating all PEFTFs and 2) collection system improvements and facility upgrades. The second alternative includes PEFTF enhancements to improve disinfection and reduce TRC, plus capacity improvements to address SSOs and in-system bypasses. Both alternatives include upgrades to the Nelson Complex WWTF to address ammonia and nutrient discharge requirements. The SWMM model was run under all three scenarios in continuous simulation mode for the 2010 and 2016 recreational seasons (April through October).

Model results suggest that PEFTFs, SSOs, and in-system bypasses likely pose the greatest human health and aquatic life toxicity risks during wet weather conditions, but may be addressed through collection system improvements and facility upgrades. The model also demonstrates that the Nelson Complex WWTF represents the largest source of nutrient and ammonia loading within the study area. Further model findings are discussed below with respect to *E. coli*, TP, TN, ammonia-N, and TRC. Although discussion of pollutant sources is generally limited to those explicitly characterized within the model (i.e., Nelson Complex WWTF, PEFTFs, SSOs, in-system bypasses, stormwater runoff, and baseflow), this is not meant to imply that other pollutant sources do not exist within the study area. As previously discussed in Section 2, other watershed sources (e.g., illicit discharges and bank erosion) likely exist but were difficult to directly characterize within the model.

6.1 *E. coli*

E. coli model results presented below are in terms of both loading and concentration. Discussion of bacteria loadings have no direct bearing on attainment of water quality criteria, but help with understanding of the relative contribution of different sources. In contrast, modeled instream bacteria concentrations can be directly compared to water quality criteria. However, comparisons of model results to the Kansas *E. coli* criterion of 262 cfu/100 mL are only intended to provide a relative understanding of water quality conditions. The Kansas *E. coli* criterion of 262 cfu/100 mL is expressed as a recreational season geometric mean; therefore, discussion of instantaneous or monthly average model results are not directly comparable to the criterion.

6.1.1 Loading Sources during Baseline Conditions

The model results show that the majority of bacteria loading, as represented by *E. coli*, is from stormwater runoff or other watershed sources not explicitly modeled. Loadings from stormwater runoff account for approximately 83% and 70% of the entire bacteria loading during baseline conditions for the 2010 and 2016 recreational seasons, respectively (Figure 23).

Untreated discharges from SSOs and bypasses constitute the second highest loading source of bacteria within the study area during baseline conditions. The Turkey Creek SSOs collectively represent approximately 14% and 15% of the total bacteria loading for the 2010 and 2016 recreational seasons, respectively (Figure 23). Bacteria loadings from Bypass 12 appear minimal for the 2010 model year, but represent approximately 7% of the loading for the 2016 recreational season.

Comparatively, the Nelson Complex WWTF and Brush Creek PEFTFs (75th and Nall, Martway, and Belinder PEFTFs) account for less than 2% of the bacteria loading within the study area during

baseline conditions. However, bacteria loadings from the Turkey PEFTF are approximately 1.9% and 5.5% for the 2010 and 2016 recreational seasons, respectively (Figure 23). Bacteria loadings from the Turkey PEFTF reflect its relatively large discharge volume (see Table 9) and relatively high levels of *E. coli* (i.e., 717 cfu/100 mL as a median).

During PEFTF events (i.e., while PEFTFs are discharging), the contribution from stormwater runoff decreases relative to other wet weather sources. However, stormwater runoff still represents the majority of bacteria loading during PEFTF events. During these periods, stormwater runoff represents approximately 67% and 54% of the entire bacteria loading within the study area, respectively (Figure 23). The collective loading from SSOs and bypasses during PEFTF events increases to approximately 28% for 2010 and 36% for 2016.

6.1.2 Instream Concentrations during Baseline Conditions

Modeled instream concentrations of *E. coli* exceed the Kansas criterion value of 262 cfu/100 mL for most months during baseline conditions in both Brush Creek and Turkey Creek for both 2010 and 2016 (Figure 24). For the 2010 and 2016 model years, monthly geometric means range from 197 to 515 cfu/100 mL in Brush Creek near Stateline. Similarly, monthly geometric means range from 194 to 582 cfu/100 mL in Turkey Creek above the Nelson Complex WWTF for the same model years. However, *E. coli* concentrations modeled below the Nelson Complex WWTF were typically below the criterion due to dilution provided by the Nelson Complex WWTF discharge.

The instantaneous model results indicate that instream *E. coli* concentrations are most elevated downstream of SSOs and Bypass 12 during major storm events. During the week of August 21, 2016 storm, which had over 7 inches of precipitation, modeled *E. coli* levels exceeded 100,000 cfu/100 mL downstream of the Turkey Creek SSOs and in Brush Creek below Bypass 12 (Figure 25).

6.1.3 Comparison of Alternative Scenarios

Relative to baseline conditions, the alternative scenarios will have minimal impact on instream *E. coli* levels when measured as a monthly geometric mean. Considering July 2010, which conservatively represents one of the worst months with respect to elevated levels of *E. coli*, the monthly geometric mean will decrease less than 10% if all discharges from PEFTFs, SSOs, and in-stream bypasses are eliminated (e.g., 582 to 543 cfu/100mL at Turkey Creek above the Nelson Complex WWTF) (Figure 26). This suggests that eliminating wet weather discharges from the Nelson Complex WWTF collection system will not have an appreciable impact with respect to meeting the recreational season *E. coli* criterion.

Although collection system improvements and facility upgrades to address PEFTF and SSO discharges may not appreciably impact *E. coli* levels as a monthly geometric mean, reductions in instantaneous levels of *E. coli* would be significant during wet weather events. Eliminating untreated discharges from SSOs and in-system bypasses would also significantly reduce loadings of fecal pathogens, thereby reducing the risk of infection. Providing improved disinfection at the PEFTFs would provide additional benefits with respect to reducing levels of fecal pathogens.

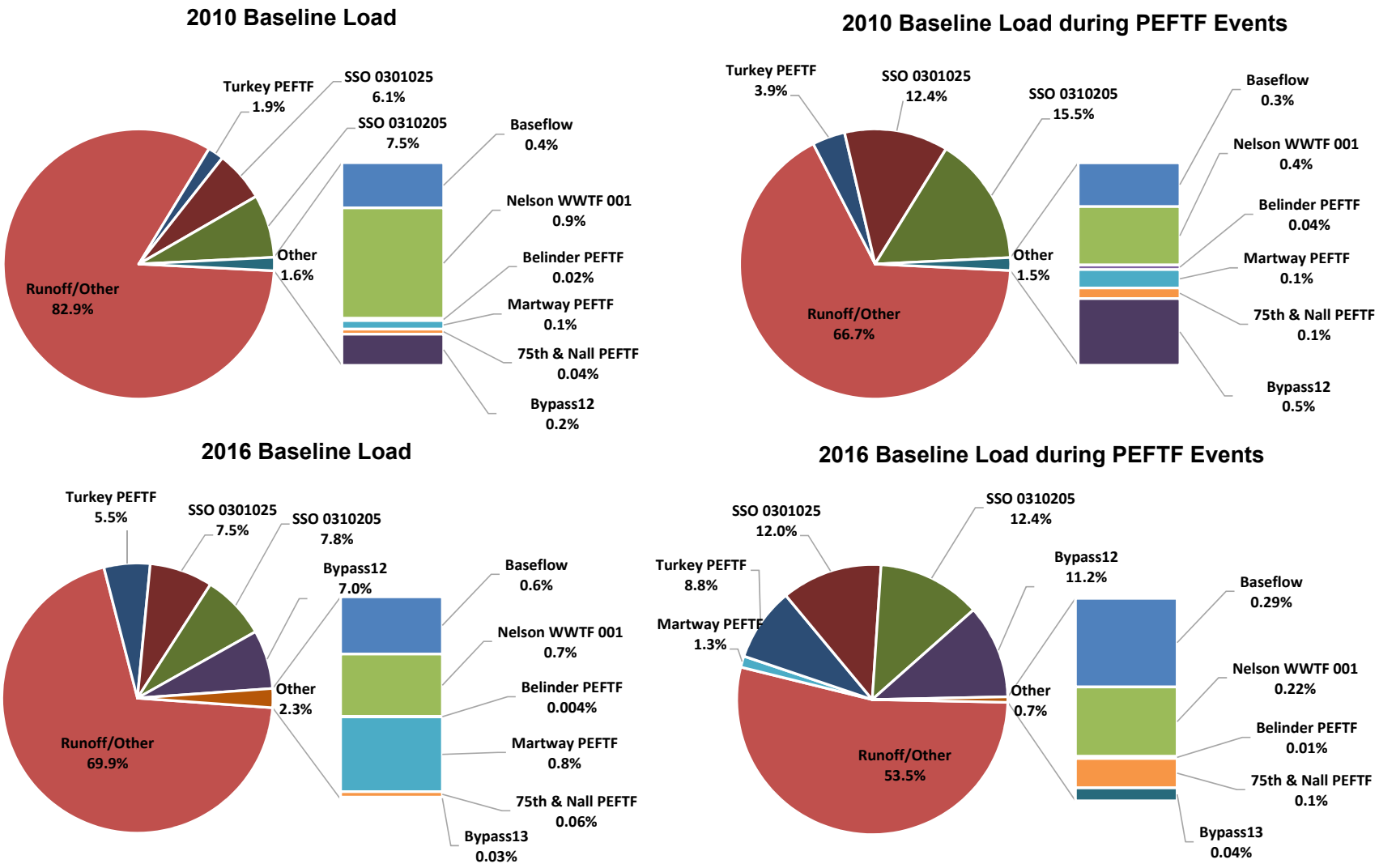


Figure 23. *E. coli* Loading Sources for Baseline Conditions in the Project Study Area

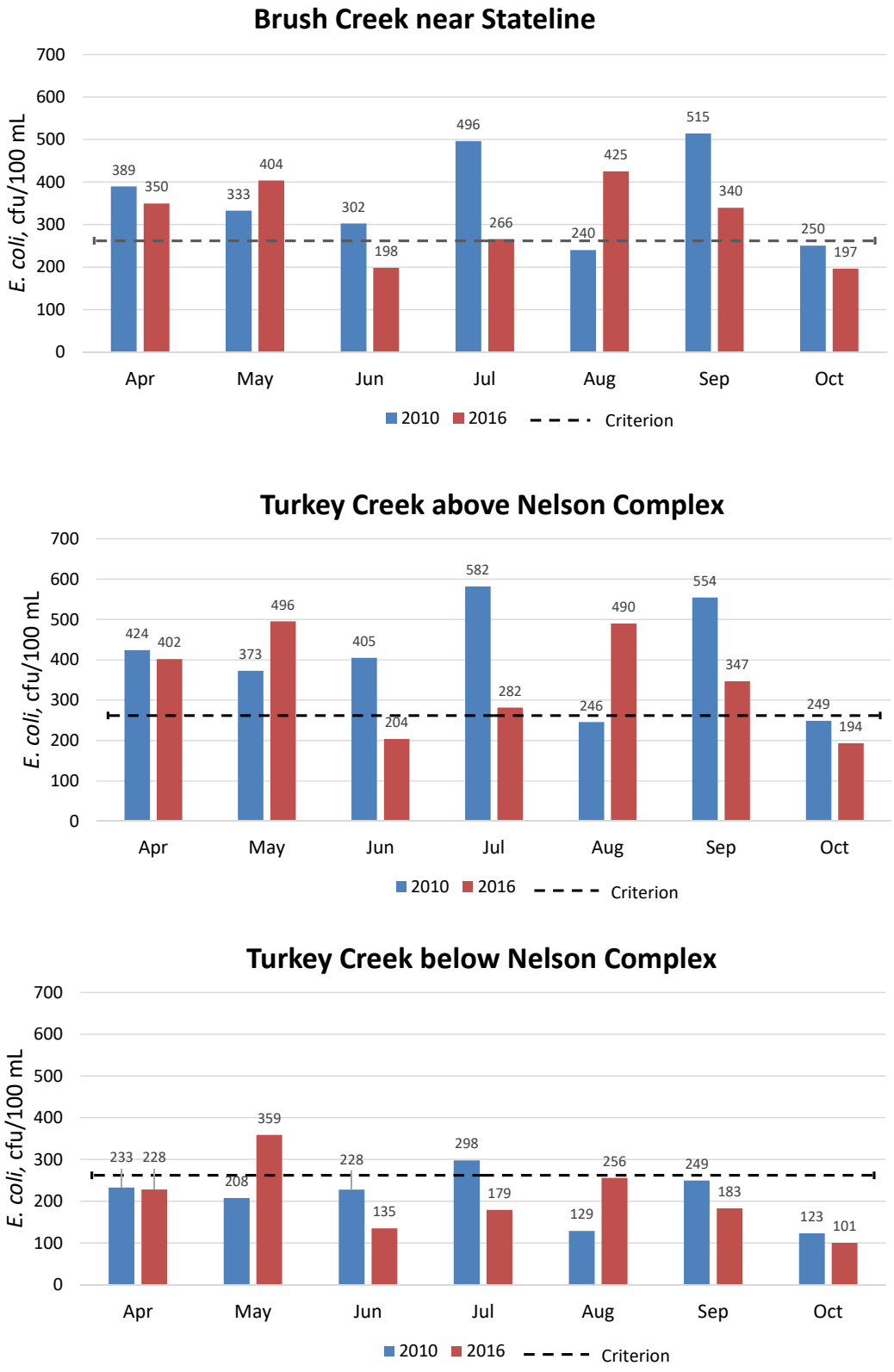


Figure 24. Modeled Monthly *E. coli* Geometric Means for Baseline Conditions

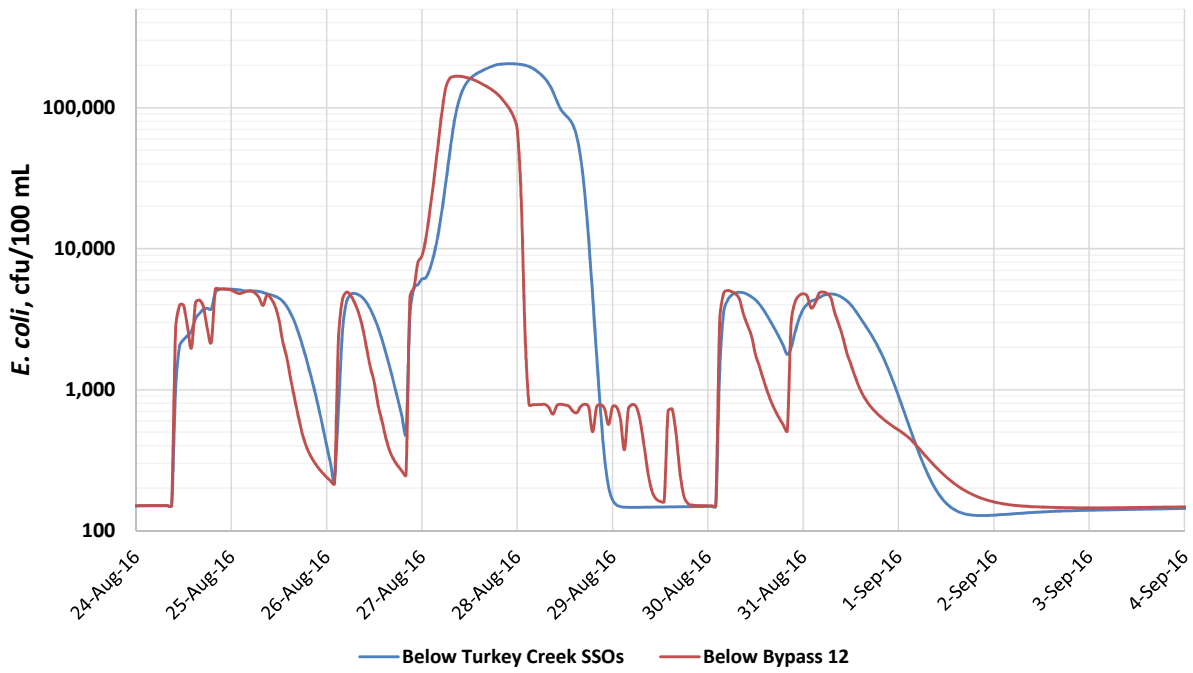


Figure 25. Modeled Response of *E. coli* to SSOs and Bypass 12 during Major Storm Event

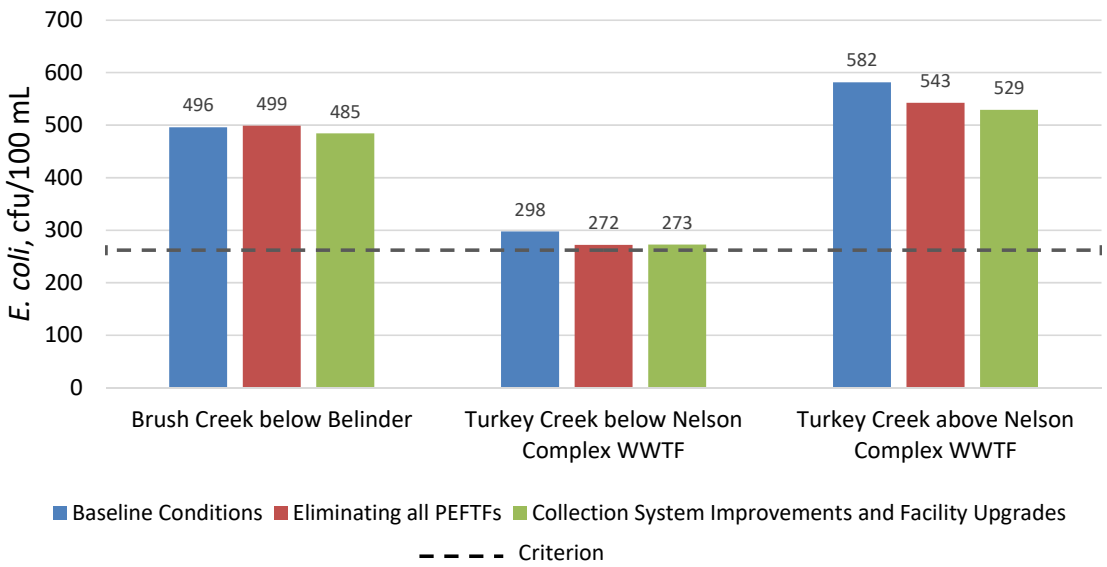


Figure 26. July 2010 Modeled Geometric Means for Alternative Scenarios
(Note: July 2010 conservatively represents one of the worst modeled months with respect to elevated levels of *E. coli*)

6.2 Total Phosphorus

The model results show that the majority of TP loading is from the Nelson Complex WWTF. TP loadings from the Nelson Complex WWTF account for approximately 87% and 86% of the entire TP loading within the study area during baseline conditions for the 2010 and 2016 recreational seasons, respectively (Figure 27). Stormwater runoff and other watershed sources not explicitly modeled represent the second leading source of TP within the study area during baseline conditions at approximately 11-12% of the total load. Comparatively, baseflow, PEFTFs, SSOs, and in-system bypasses collectively represent approximately 2% of the total TP loading within the study area.

Relative to baseline conditions, the most significant reductions to TP loading can be achieved through nutrient removal at the Nelson Complex WWTF. Based on the 2010 model results, TP loading within the entire study area would be reduced approximately 58% with collection system improvements and facility upgrades (i.e., 130,403 lbs/year versus 54,411 lbs/year). Nearly 100% of the reduction in TP would be associated with nutrient removal at the Nelson Complex WWTF (Figure 28). The model also shows there is little to no benefit with respect to TP by eliminating the PEFTFs. This is largely due to the fact that eliminating PEFTFs would only serve to transfer the TP loading to the Nelson Complex WWTF.

6.3 Total Nitrogen

The model results show that the majority of TN loading is from the Nelson Complex WWTF. TN loadings from the Nelson Complex WWTF account for approximately 83% and 82% of the entire TN loading within the study area during baseline conditions for the 2010 and 2016 recreational seasons, respectively (Figure 29). Stormwater runoff and other watershed sources not explicitly modeled represent the second leading source of TN within the study area during baseline conditions at approximately 15% of the total load. Comparatively, baseflow, PEFTFs, SSOs, and in-system bypasses collectively represent approximately 2-3% of the total TN loading within the study area.

Relative to baseline conditions, the most significant reductions to TN loading can be achieved through nutrient removal at the Nelson Complex WWTF. Based on the 2010 model results, TN loading within the entire study area would be reduced approximately 39% with collection system improvements and facility upgrades (i.e., 868,771 lbs/year versus 526,602 lbs/year). Nearly 100% of the reduction in TN would be associated with nutrient removal at the Nelson Complex WWTF (Figure 30). The model also shows there is little to no benefit with respect to TN by eliminating the PEFTFs. This is largely due to the fact that eliminating PEFTFs would only serve to transfer the TN loading to the Nelson Complex WWTF.

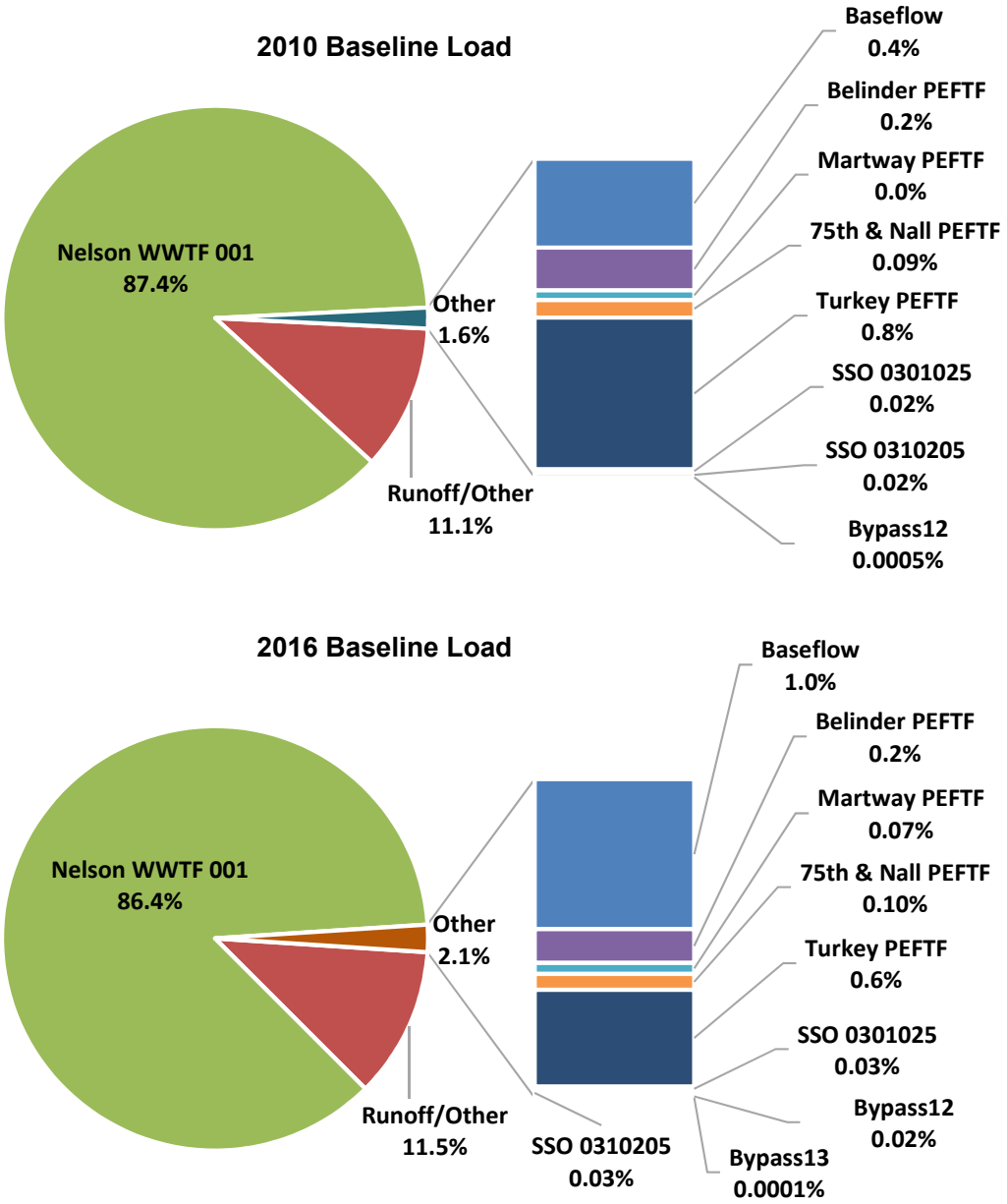
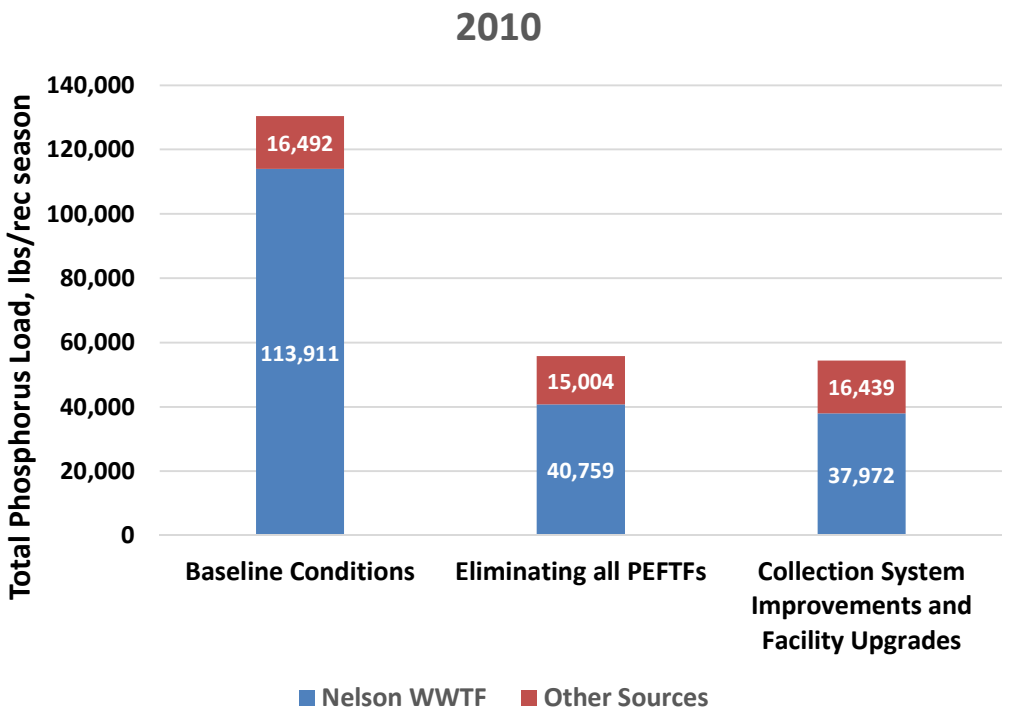


Figure 27. Total Phosphorus Loading Sources for Baseline Conditions in the Project Study Area



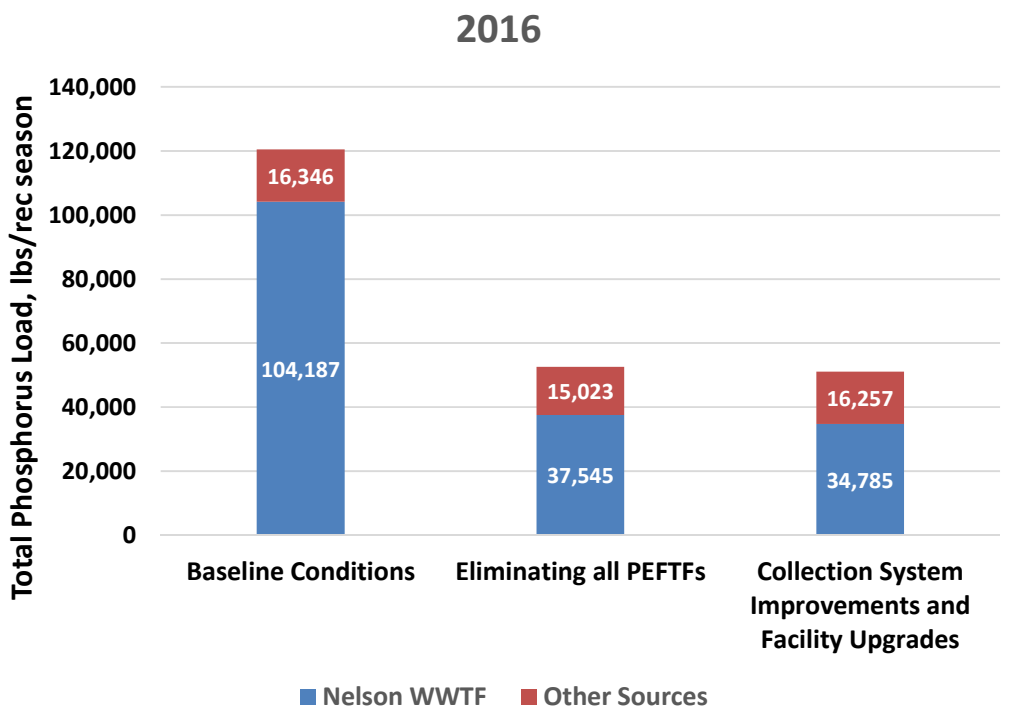


Figure 28. Total Phosphorus Loadings within the Study Area for Alternative Scenarios

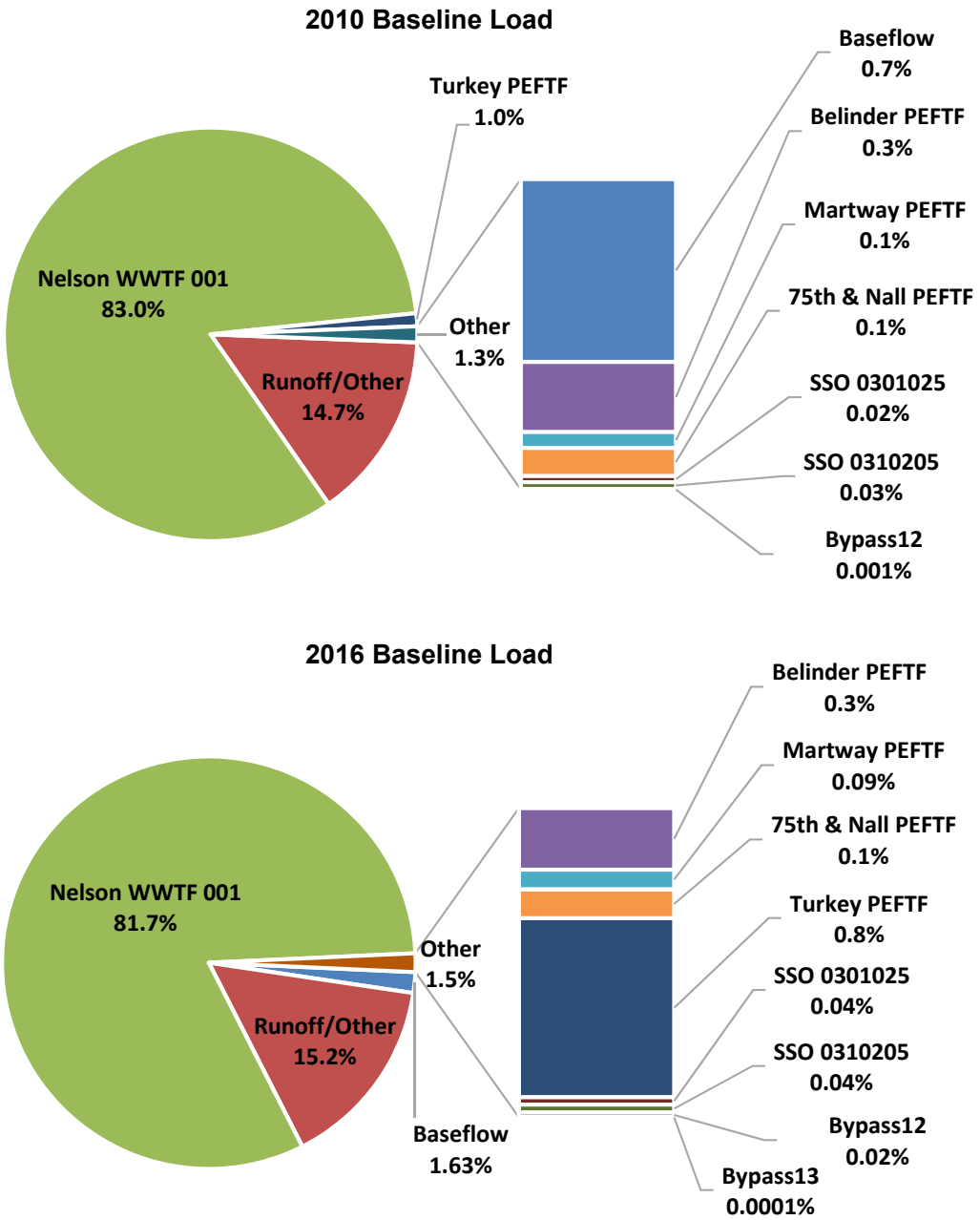


Figure 29. Total Nitrogen Loading Sources for Baseline Conditions in the Project Study Area

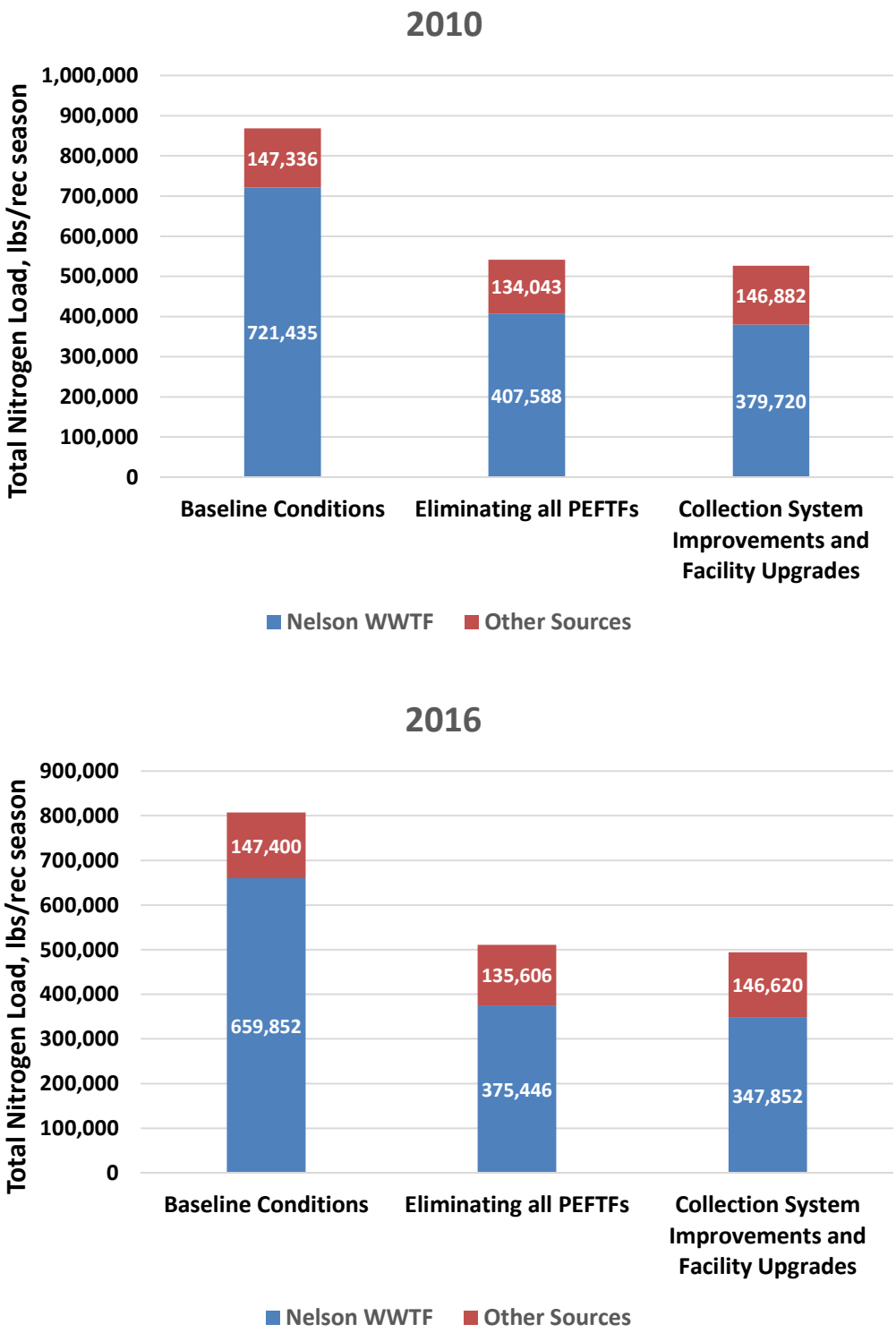


Figure 30. Total Nitrogen Loadings within the Study Area for Alternative Scenarios

6.4 Ammonia Nitrogen

Ammonia-N levels modeled below each of the PEFTFs and the Nelson Complex WWTF were compared against ammonia-N criteria to identify potential toxicity issues. For purposes of this analysis, ammonia-N criteria were based on pH and temperature assumptions from representative stations presented in TM 2 (*Hydraulic Model Updates, Section 5*). Per TM 2, pH was assumed to be 7.8 for the months of June through September and 7.7 for the remaining months. Based on these assumptions, the 30-day chronic criteria range from approximately 0.8 to 1.9 mg/L and acute criteria range from 4.5 to 12.9 mg/L.

Model results for the 2010 and 2016 recreational seasons for baseline conditions never exceeded either the chronic or acute ammonia-N criteria immediately below any of the PEFTFs. In addition, the 30-day running average ammonia-N concentration was typically well below the chronic criteria below the PEFTFs (Figures 31-34). However, the 1-hour model results approached the acute criteria below the 75th & Nall and Turkey PEFTFs during the July 2010 and August 2016 storm events (Figures 31 and 34). Meeting acute criteria was less of an issue at the Martway or Belinder PEFTFs due to greater available dilution. Potential issues with meeting acute criteria at Turkey and 75th & Nall are based on conservative assumptions regarding ammonia effluent quality. As previously discussed in Section 3.3.4, simulated concentrations of effluent ammonia-N were higher than actually observed.

While the model demonstrates that the PEFTFs do not contribute to ammonia toxicity issues, it does indicate that Turkey Creek is impaired for ammonia downstream of the Nelson Complex WWTF for existing baseline conditions. Based on model results, the 30-day running average ammonia-N concentration consistently exceeds the chronic criteria for baseline conditions (Figure 35). However, there appear to be no ammonia toxicity issues in Turkey Creek based on model scenarios that include additional ammonia removal at the Nelson Complex WWTF (Figure 36).

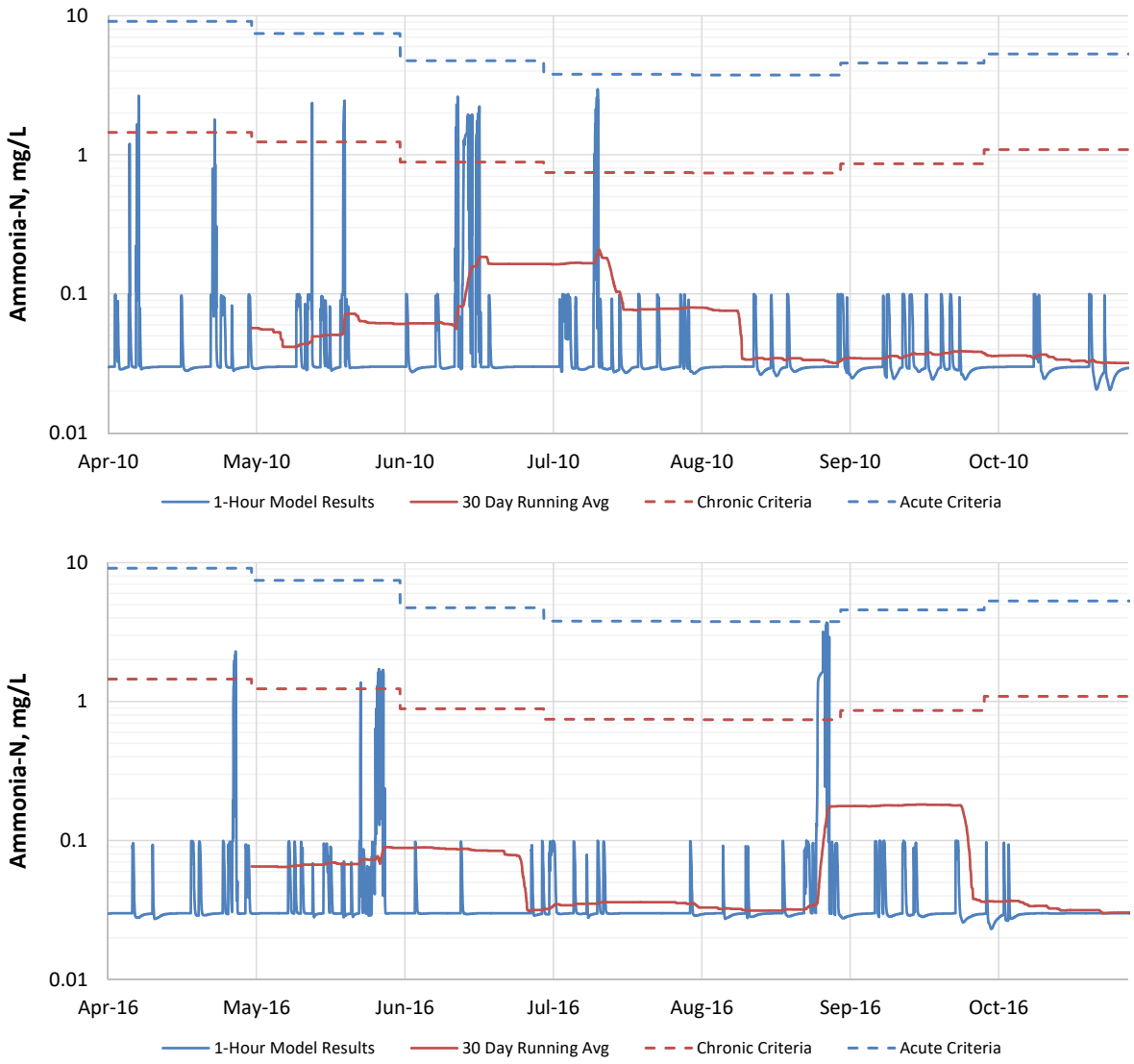


Figure 31. Modeled Ammonia Concentrations in Brush Creek below the 75th & Nall PEFTF for Baseline Conditions

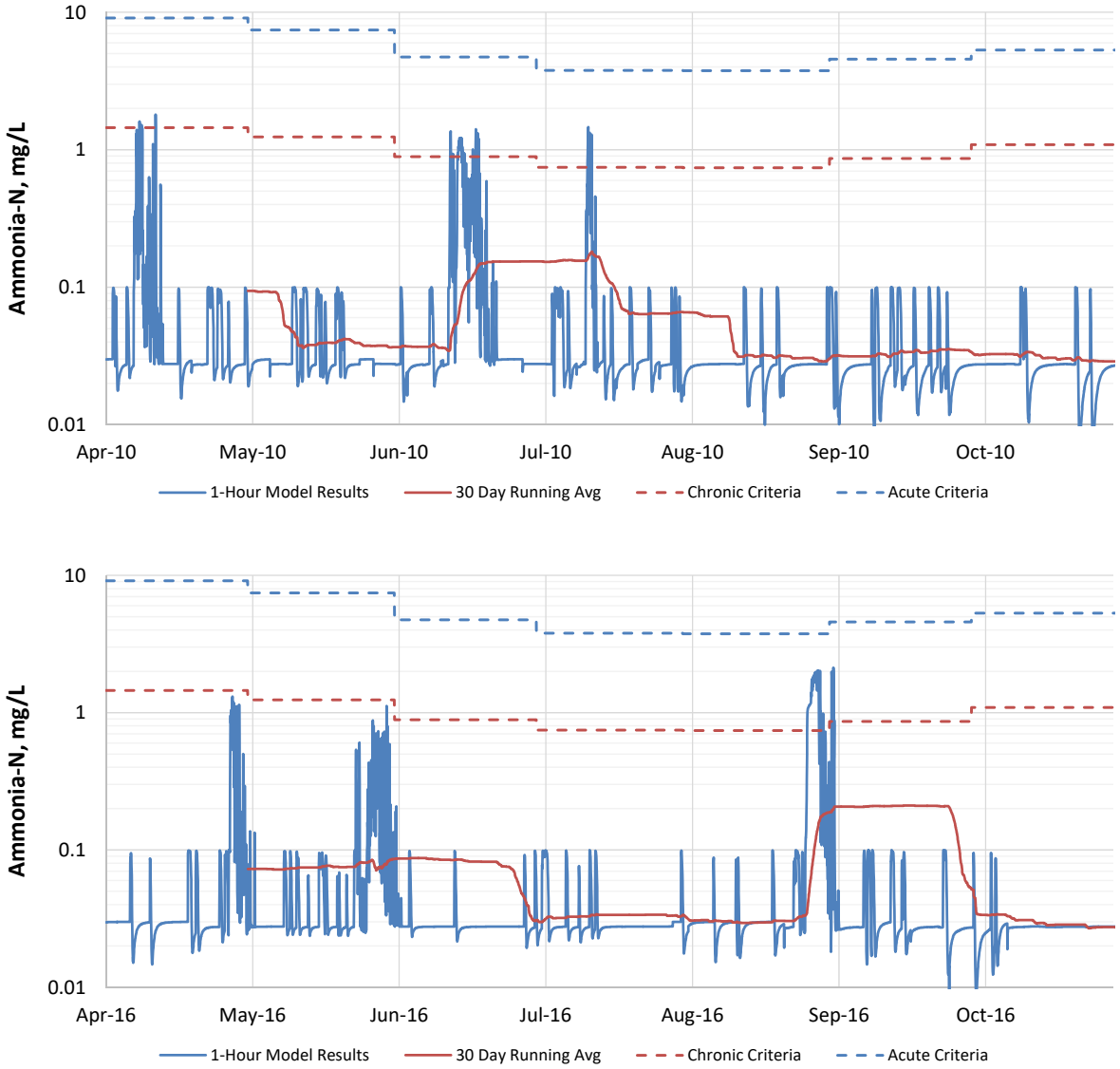


Figure 32. Modeled Ammonia Concentrations in Rock Creek below the Martway PEFTF for Baseline Conditions

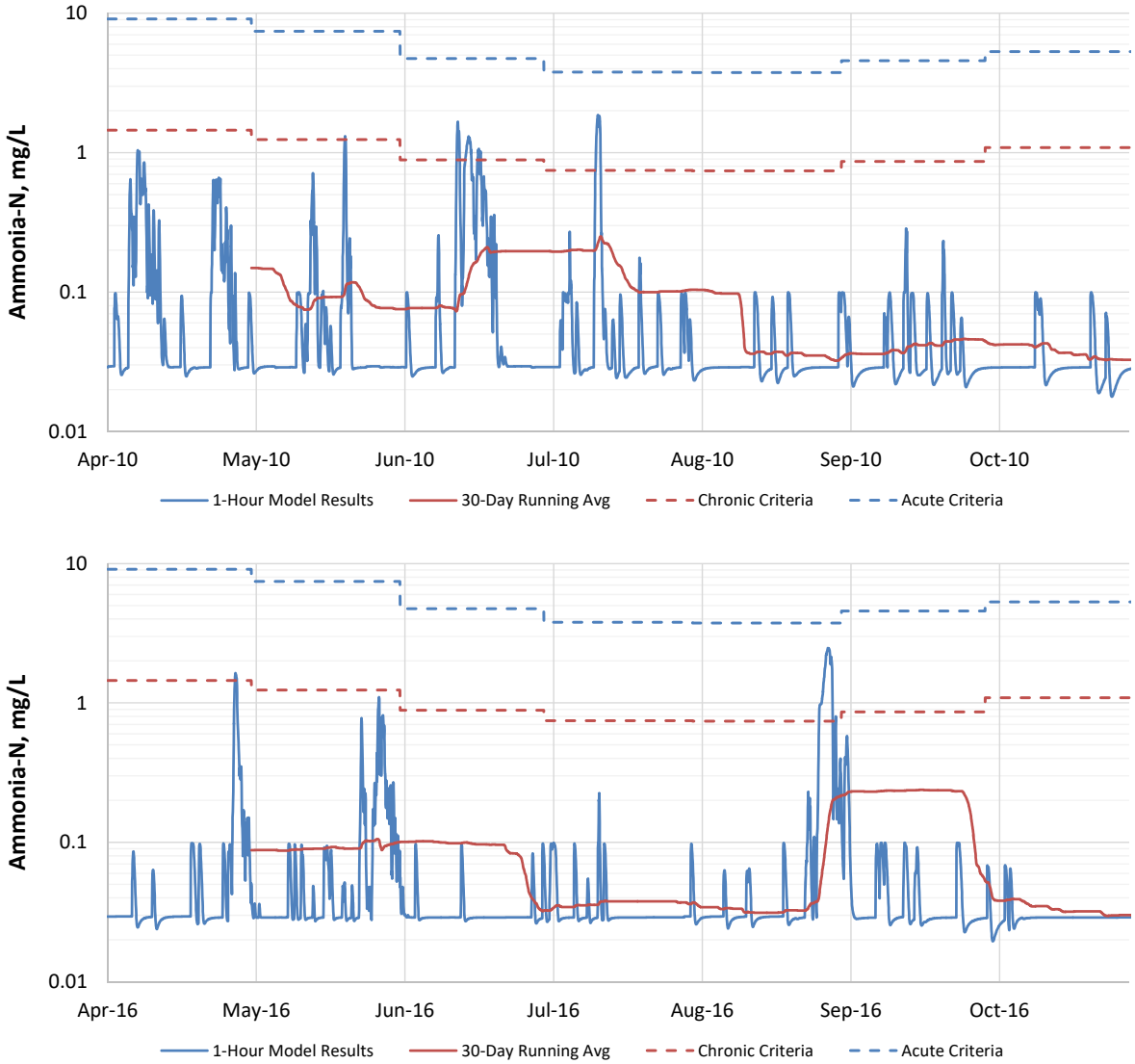


Figure 33. Modeled Ammonia Concentrations in Brush Creek below the Belinder PEFTF for Baseline Conditions

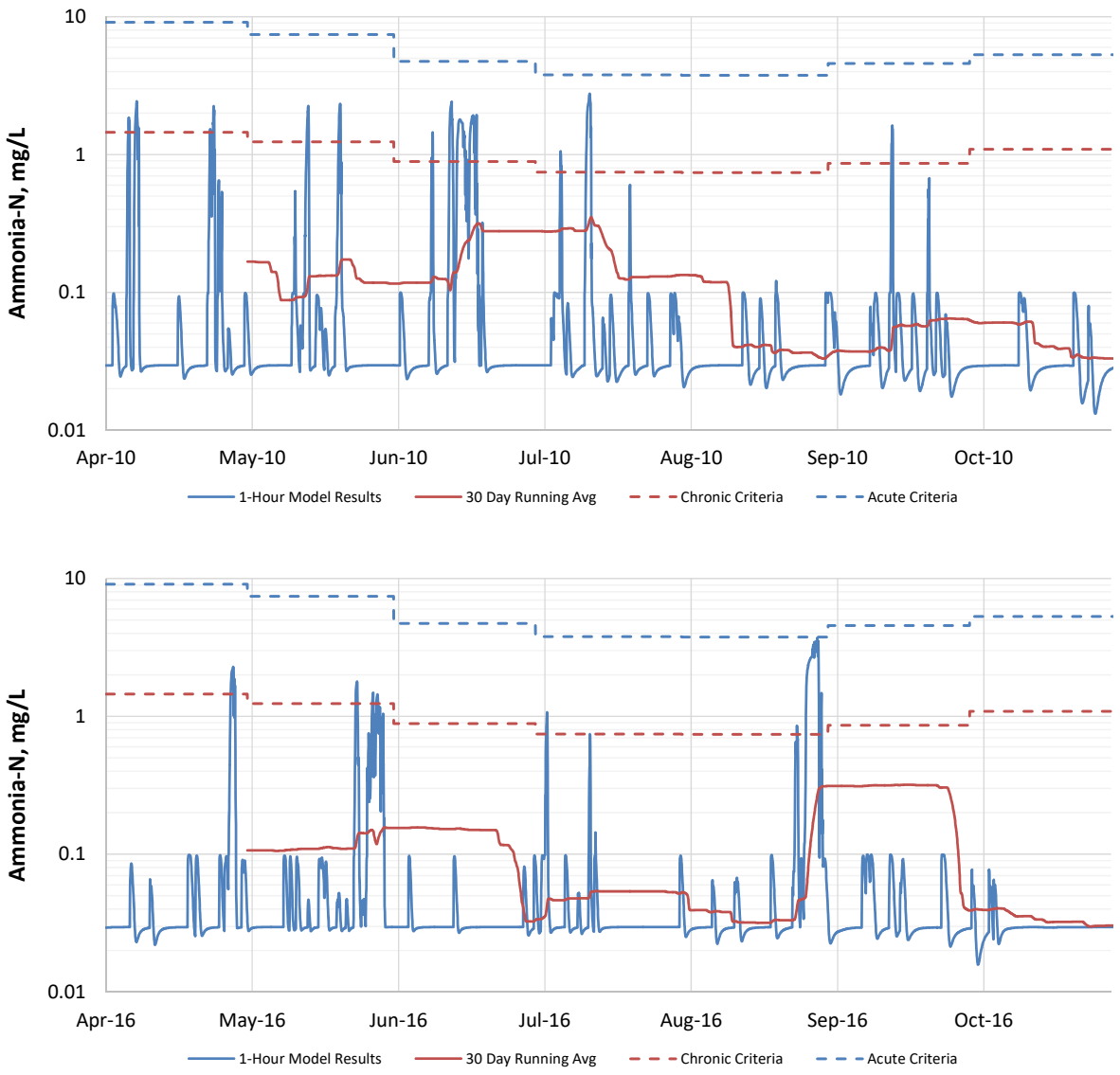


Figure 34. Modeled Ammonia Concentrations in Turkey Creek below the Turkey PEFTF and above the Nelson Complex WWTF for Baseline Conditions

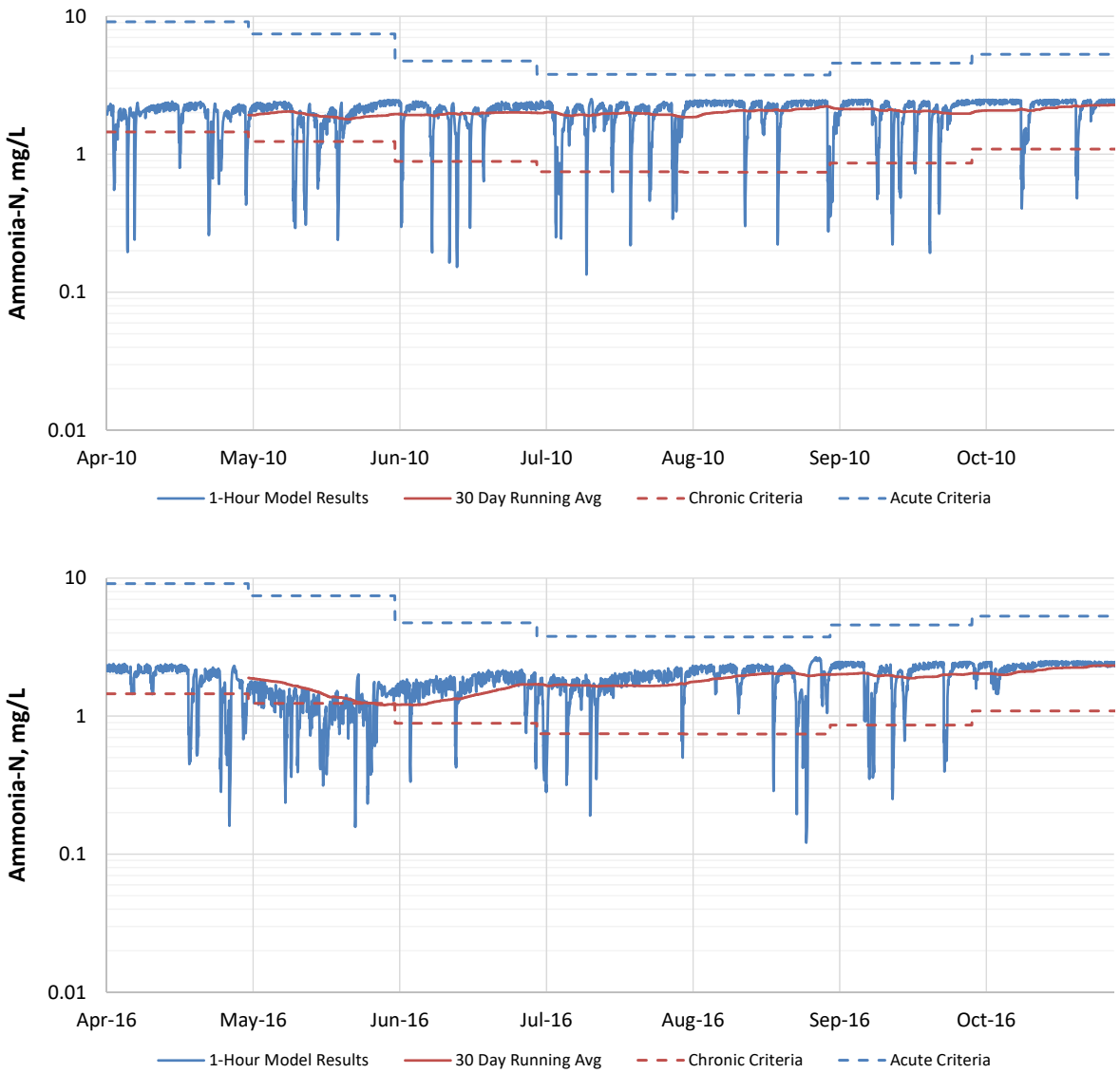


Figure 35. Modeled Ammonia Concentrations in Turkey Creek below the Nelson Complex WWTF for Baseline Conditions

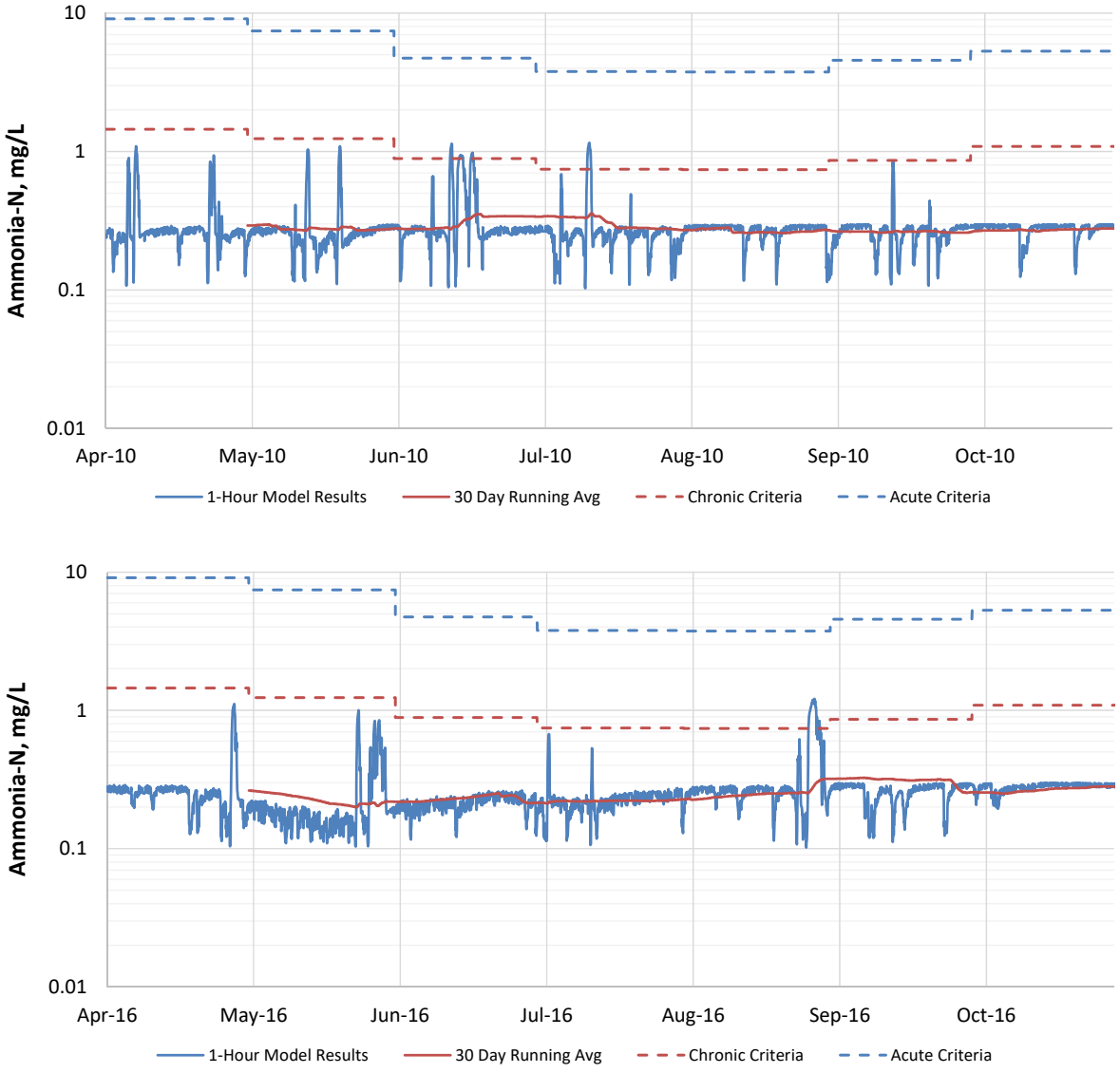


Figure 36. Modeled Ammonia Concentrations in Turkey Creek below the Nelson Complex WWTF for Collection System Improvements and Facility Upgrades

6.5 Total Residual Chlorine

The Nelson Complex WWTF and the four PEFTFs were the only sources of total residual chlorine (TRC) included within the SWMM model. However, the Nelson Complex WWTF and the Martway and 75th & Nall PEFTFs are not considered significant sources since these facilities dechlorinate . The two PEFTFs that do not currently dechlorinate (Turkey Creek and Belinder) had an assumed effluent concentration of 2,300 ug/L and 2,400 ug/L, respectively. The model indicates that TRC levels downstream of these PEFTFs periodically exceed both the 1-hour acute and 4-day chronic criteria of 19 ug/L and 11 ug/L, respectively (Figures 37 and 38).

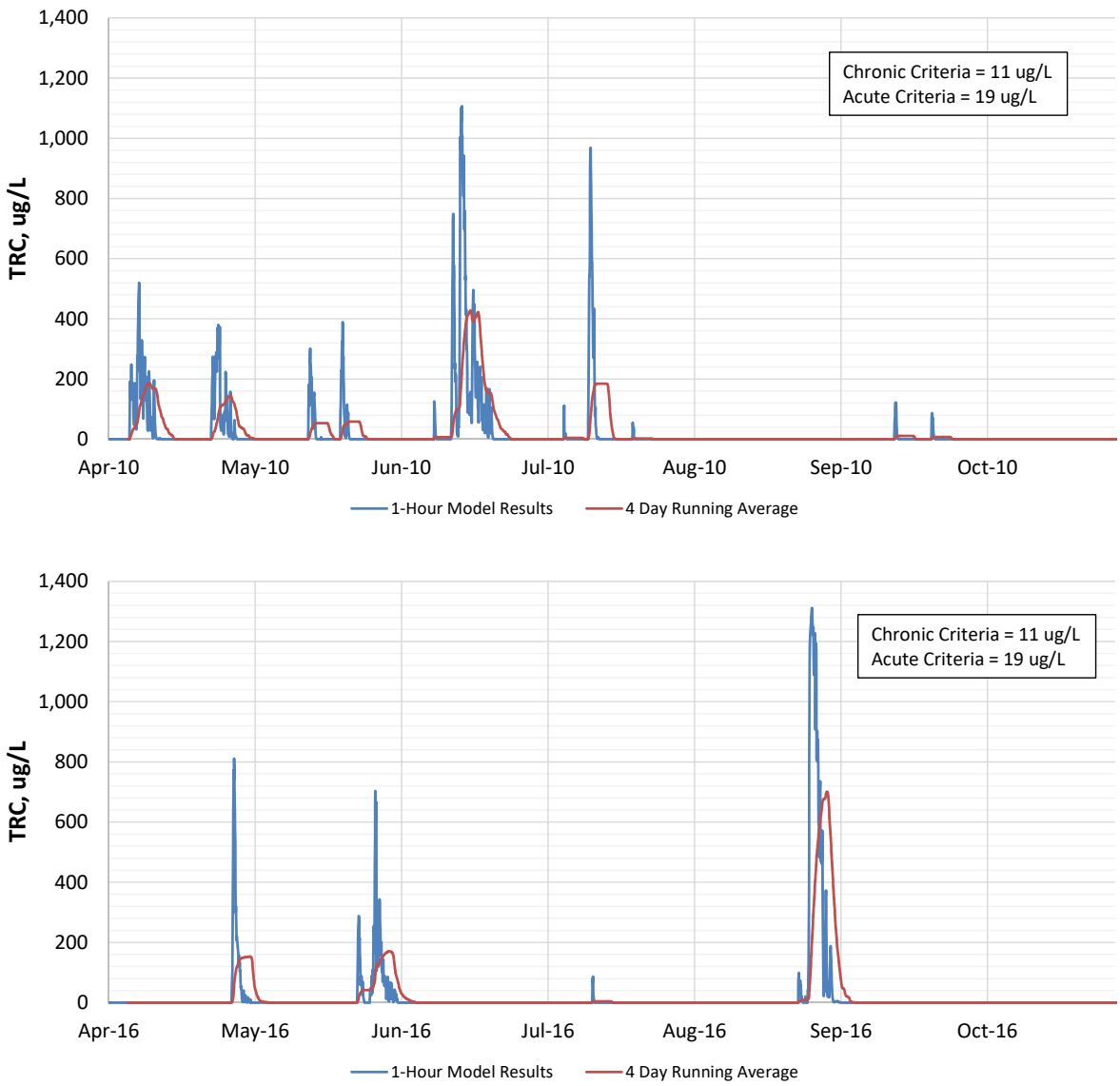


Figure 37. Modeled Total Residual Chlorine Concentrations in Brush Creek below the Belinder PEFTF for Baseline Conditions

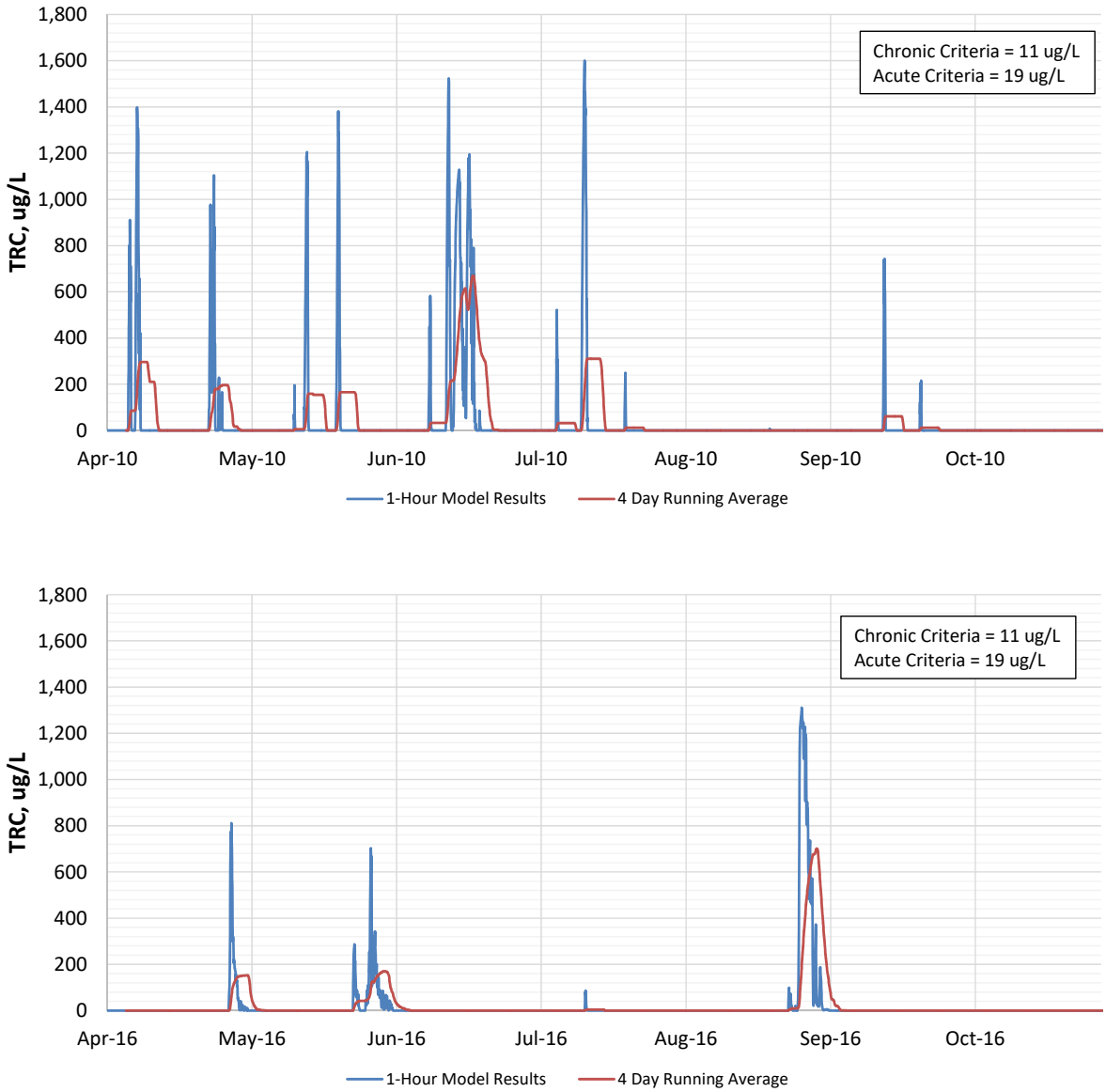


Figure 38. Modeled TRC Concentrations in Turkey Creek below the Turkey PEFTF and above the Nelson Complex WWTF for Baseline Conditions

7 Conclusions

The SWMM model and existing data assessments were used to evaluate water quality impacts of wet weather discharges from the Nelson Complex and associated facilities in the Brush and Turkey Creek watersheds. The water quality impacts were assessed for the 2010 and 2016 recreational seasons (April through October) for existing baseline conditions and two alternatives: 1) eliminating all PEFTFs, and 2) collection system improvements and facility upgrades. The second alternative includes PEFTF enhancements to improve disinfection and reduce TRC, plus capacity improvements to address SSOs and in-system bypasses. Both alternatives include upgrades at the Nelson Complex WWTF to address ammonia and nutrient discharge requirements. Study findings are summarized below with respect to bacteria, nutrients, and toxics, followed by a discussion of water quality priorities.

Bacteria

- Stormwater runoff and other watershed sources not explicitly modeled (e.g., instream resuspension) dominate bacteria loading within the study area.
- Eliminating all PEFTFs, SSOs and in-system bypasses would have minimal impacts on monthly instream *E. coli* geometric means.
- Bacteria treatment efficacy varies between the different PEFTFs. Based on existing data, the Belinder PEFTF discharges the lowest average level of *E. coli* (10 cfu/100 mL) and the Martway PEFTF discharges the highest average level of *E. coli* (2,125 cfu/100 mL).
- Relative to PEFTFs, SSOs, and in-system bypasses have a larger impact on instream *E. coli* both in terms of loading and in-stream wet weather concentration.

Nutrients

- Stormwater runoff and other watershed sources not explicitly modeled (e.g., bank erosion) dominate nutrient loading in the Brush Creek watershed.
- The Nelson Complex WWTF dominates nutrient loading within the combined Turkey and Brush Creek watershed area.
- Nutrient removal at the Nelson Complex WWTF commensurate with BNR technology will reduce the overall nutrient loading to the study area by approximately 60% for total phosphorus (TP) and 40% for total nitrogen (TN).
- Nutrient loadings from the PEFTFs, SSOs, and in-system bypasses are negligible relative to other sources, including the Nelson Complex WWTF and stormwater runoff.

Toxics

- Total residual chlorine (TRC) and ammonia levels peak downstream of PEFTFs after stormwater runoff recedes.
- TRC levels significantly exceed the criterion downstream of the Belinder and Turkey Creek PEFTFs following wet weather events. Currently, neither of these PEFTFs dechlorinate before discharge.

- Instream ammonia concentrations may approach acute criteria below the 75th & Nall and Turkey Creek PEFTFs during isolated summer wet weather events, based on conservative model assumptions that do not account for local breakpoint chlorination.
- Improved ammonia removal is required at the Nelson Complex WWTF to attain recently updated ammonia criteria downstream of the discharge.

Water Quality Priorities

Results of this study are ultimately intended to help JCW prioritize capital improvement decisions. To support this effort, water quality issues were prioritized based on threat to aquatic life and human health. Priority considerations included types of pollutants, nature of discharges, impacts to receiving streams, and JCW's ability to address the issue. For example, the study results indicate stormwater runoff and other nonpoint sources are the largest contributor of bacteria loading, but stormwater management falls outside JCW's area of responsibility. Therefore, stormwater runoff is not prioritized here. From these considerations, water quality priorities are discussed below in descending order of importance.

- ***Ammonia toxicity and nutrient impacts from the Nelson Complex WWTF*** – With an average daily dry weather flow (ADDF) of 15 mgd, the Nelson Complex WWTF exerts significant influence over water quality in Turkey Creek. Because the facility is not designed to meet KDHE's revised ammonia criteria for the protection of freshwater mussels, Turkey Creek is currently impaired for ammonia per KDHE's 2018 303(d) List and as demonstrated by the SWMM model. Additionally, the Nelson Complex WWTF is the largest contributor of nutrient loading in the study area and is identified as a contributing source in KDHE's 2017 Lower Kansas River Phosphorus TMDL.

- ***TRC toxicity and bacteria impacts from current PEFTF operations*** – Modeled TRC levels significantly exceed the criterion downstream of the Turkey Creek and Belinder PEFTFs following wet weather events. Exceedances of the TRC criterion are due to the fact that neither of these facilities currently dechlorinate. Additionally, modeled bacteria levels periodically spike downstream of all four PEFTFs due to variable disinfection quality. However, variable disinfection performance appears to have little impact on the *E. coli* recreational season geomean, which is used by KDHE to assess recreation use attainment.

- ***Bacteria impacts from the Turkey Creek SSOs and Bypass 12*** – The model suggests that bacteria levels increase several orders of magnitude downstream of the Turkey Creek SSOs and Bypass 12 following large wet weather events. However, discharges from the Turkey Creek SSOs and Bypass 12 are relatively infrequent and have little impact on the *E. coli* recreational season geomean, which is used by KDHE to assess recreation use attainment.

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Rasmussen, T.J., and Paxson, C.R. 2017. Preliminary assessment of a water-quality monitoring program for total maximum daily loads in Johnson County, Kansas, January 2015 through June 2016: U.S. Geological Survey Scientific Investigations Report 2017-5089, 20 p.

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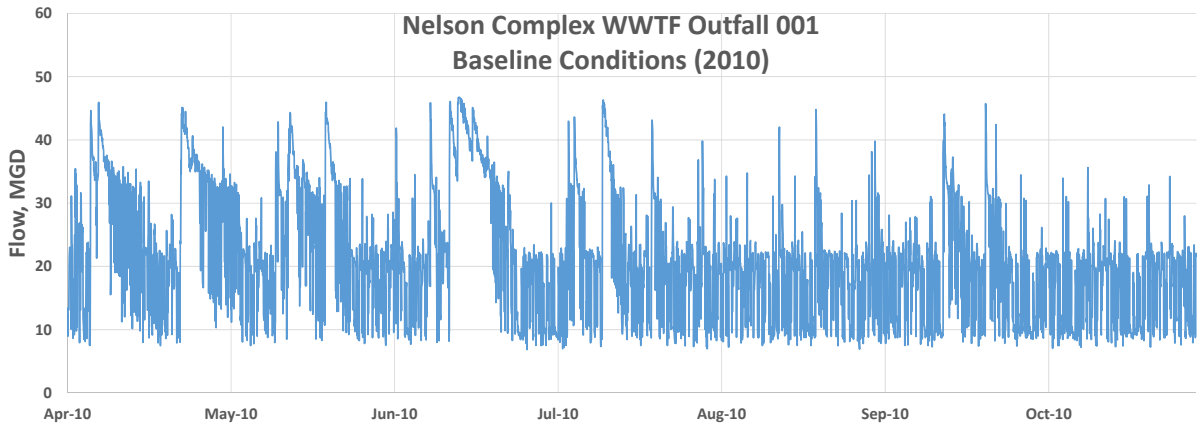
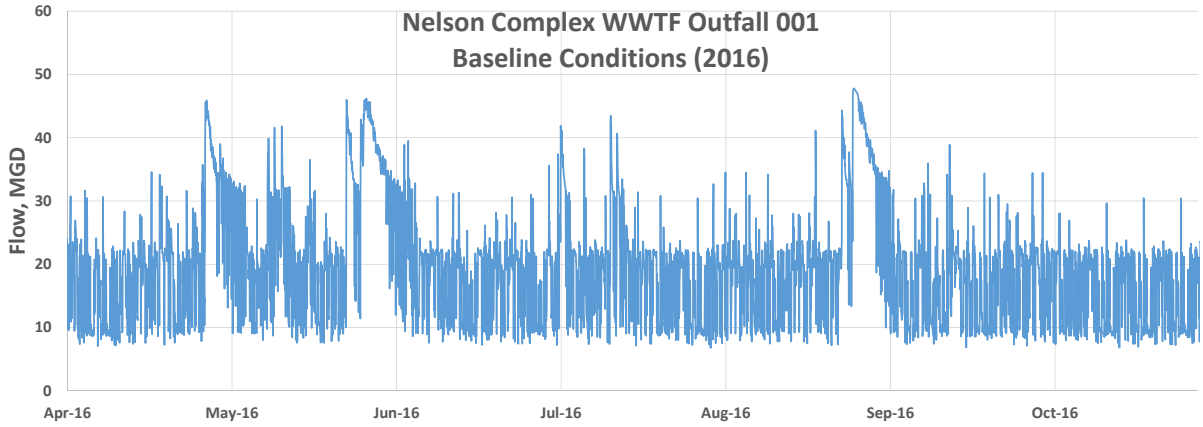
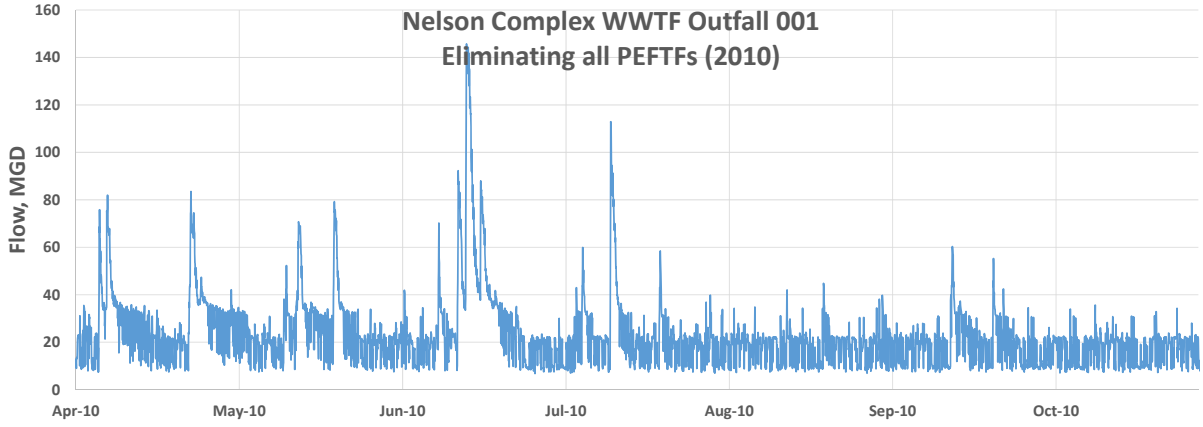
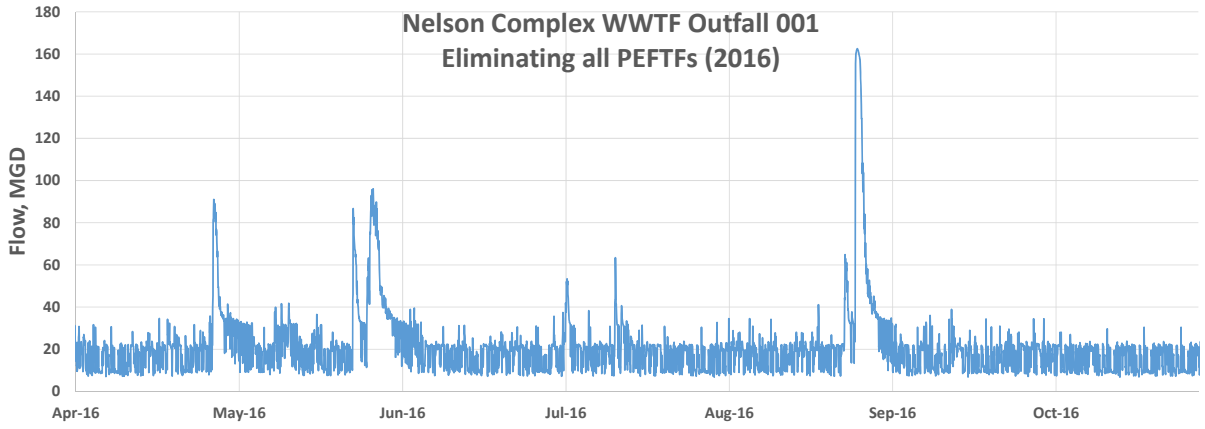
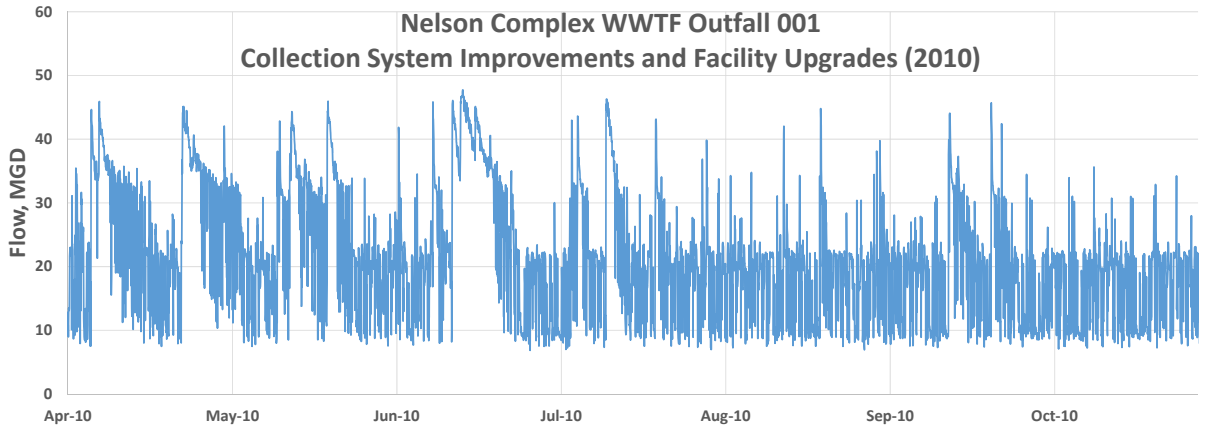
Appendix A – InfoWorks Hydrographs

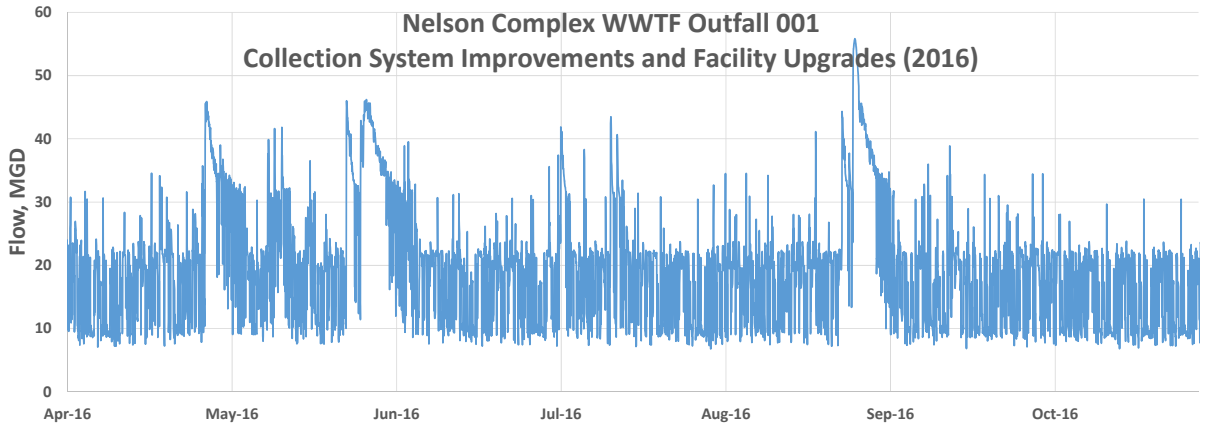


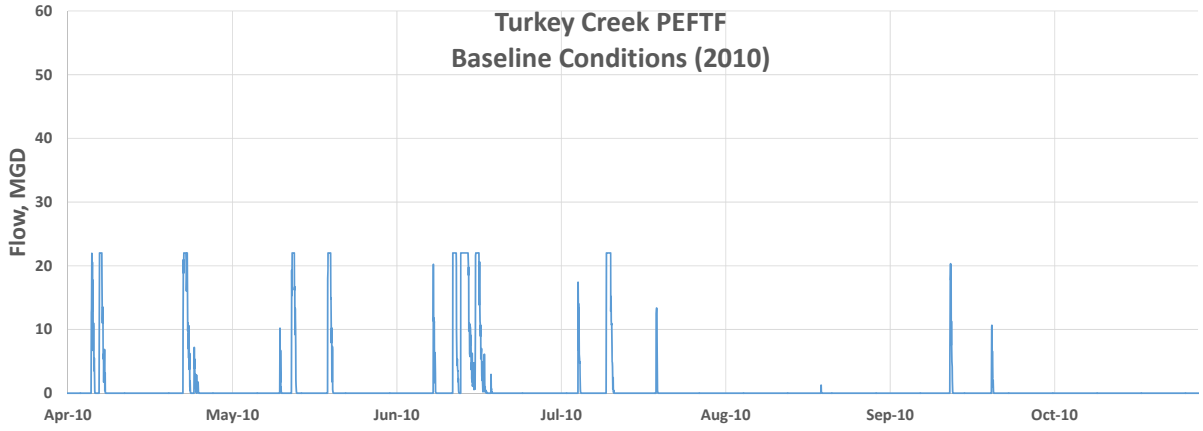


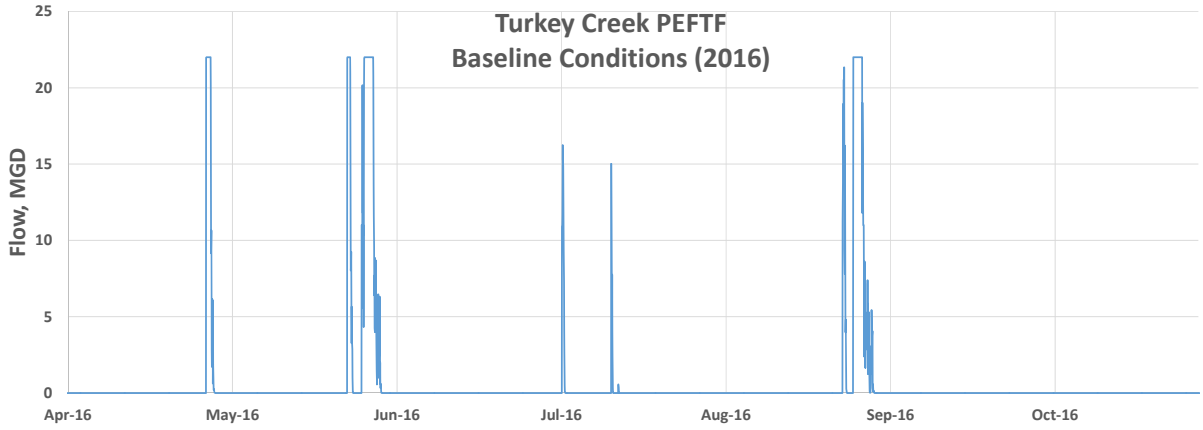


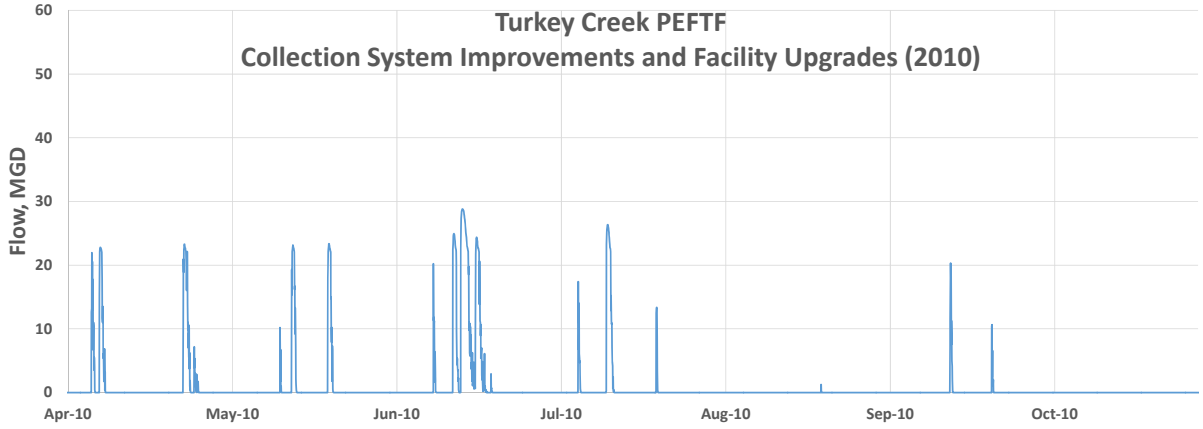

Nelson Complex WWTF Outfall 001
Eliminating all PEFTFs (2016)
Flow, MGD
180
160
140
120
100
80
60
40
20
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

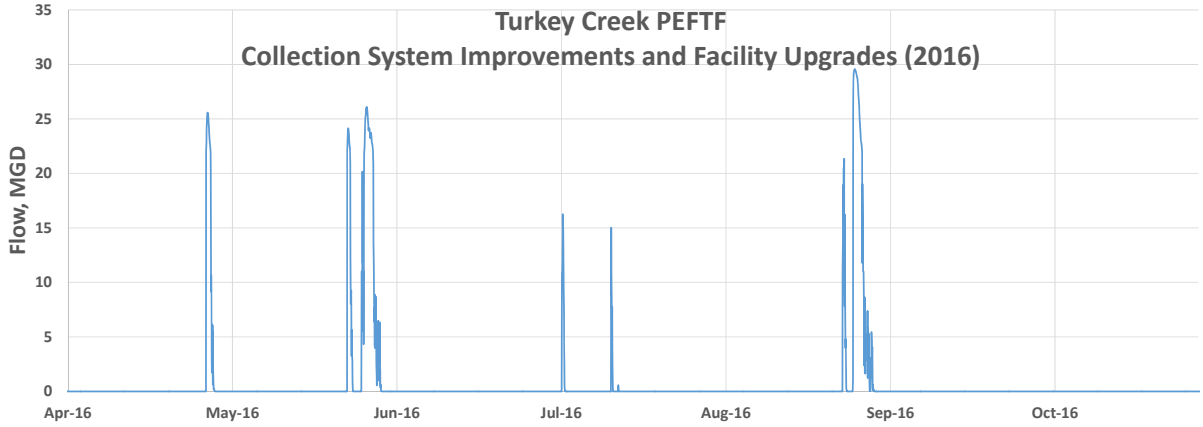

Nelson Complex WWTF Outfall 001
Collection System Improvements and Facility Upgrades (2010)
Flow, MGD
60
50
40
30
20
10
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

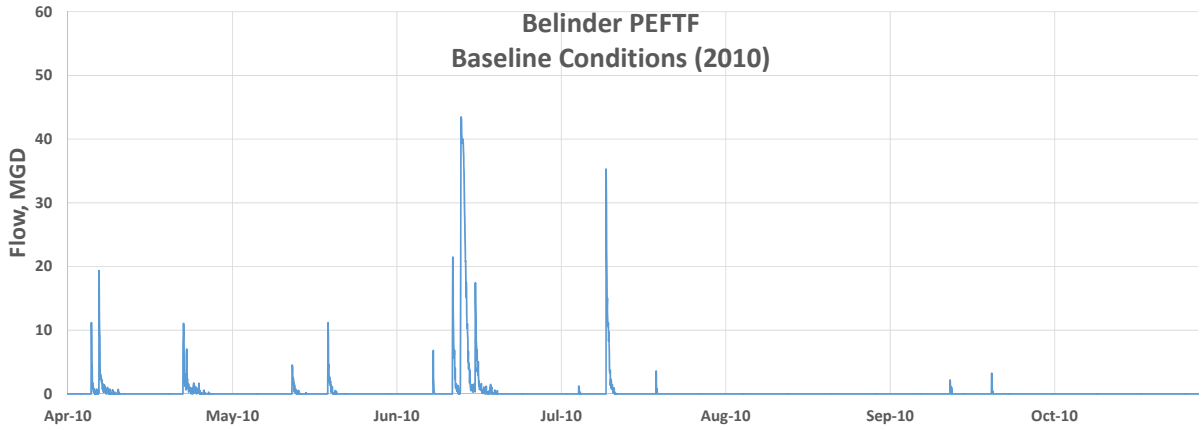

Nelson Complex WWTF Outfall 001
Collection System Improvements and Facility Upgrades (2016)
Flow, MGD
60
50
40
30
20
10
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

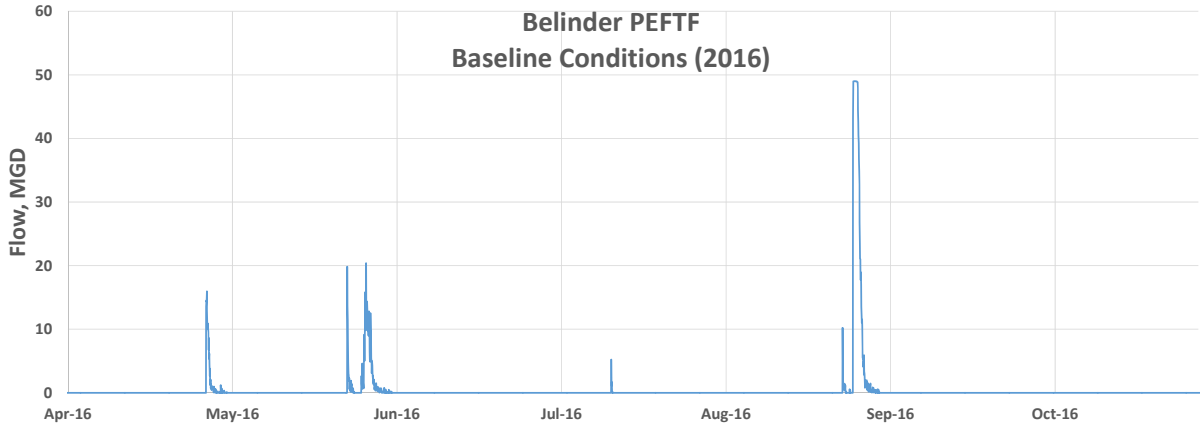

Turkey Creek PEFTF
Baseline Conditions (2010)
Flow, MGD
60
50
40
30
20
10
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

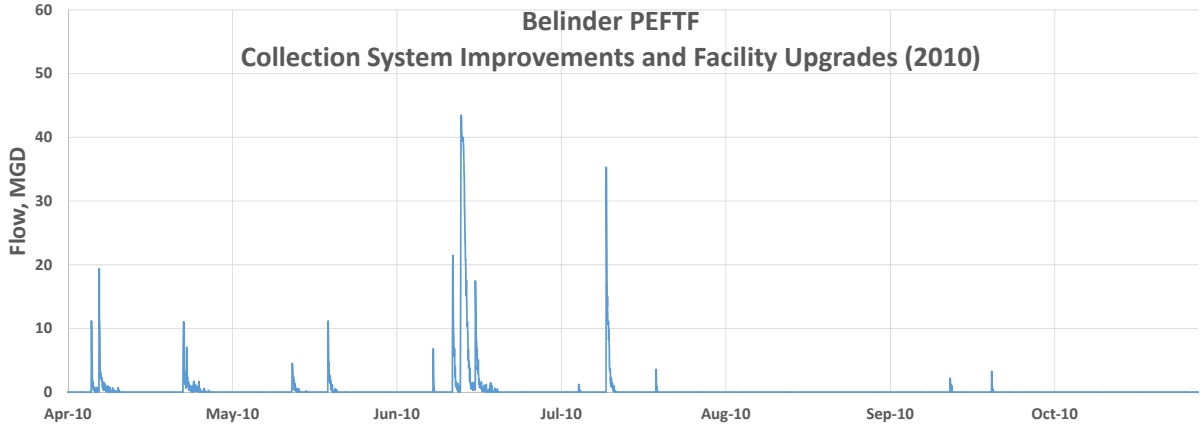

Turkey Creek PEFTF
Baseline Conditions (2016)
Flow, MGD
25
20
15
10
5
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

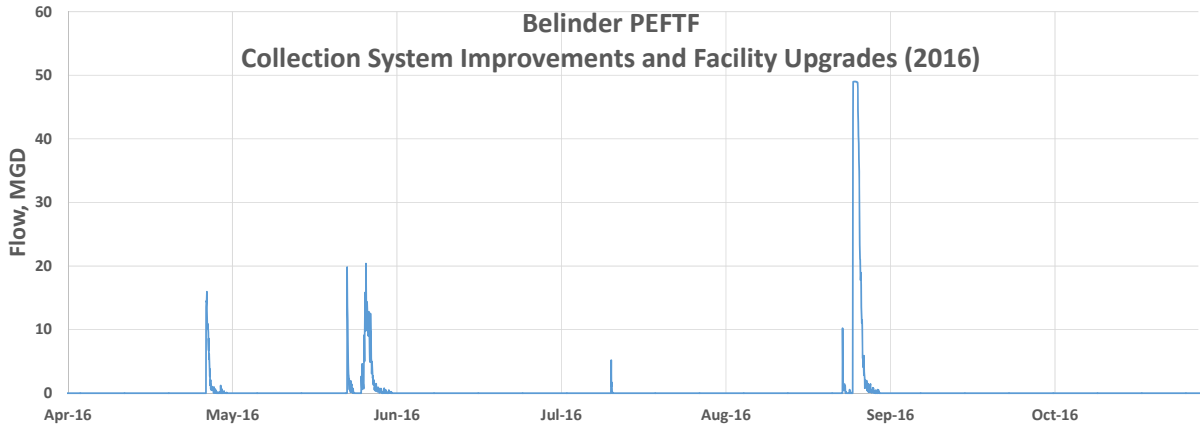

Turkey Creek PEFTF
Collection System Improvements and Facility Upgrades (2010)
Flow, MGD
60
50
40
30
20
10
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

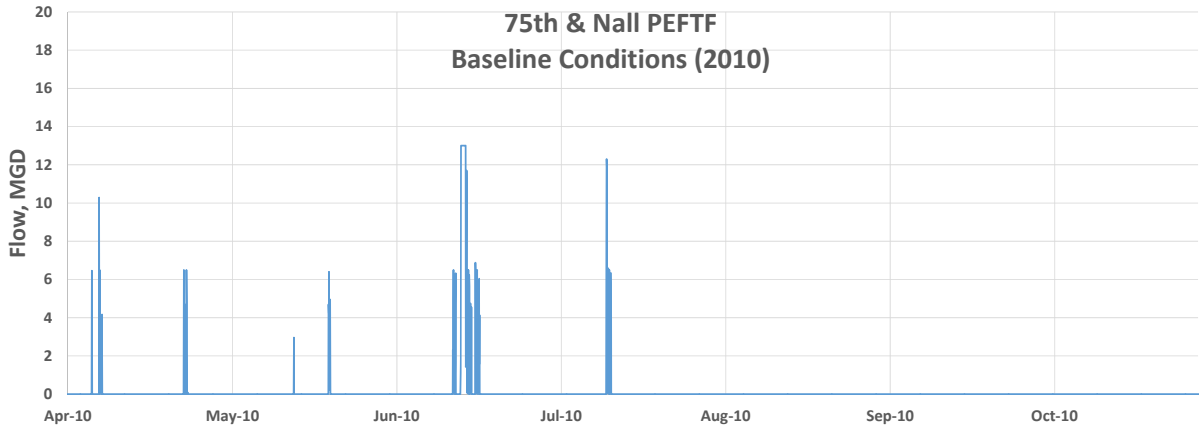

Turkey Creek PEFTF
Collection System Improvements and Facility Upgrades (2016)
Flow, MGD
35
30
25
20
15
10
5
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

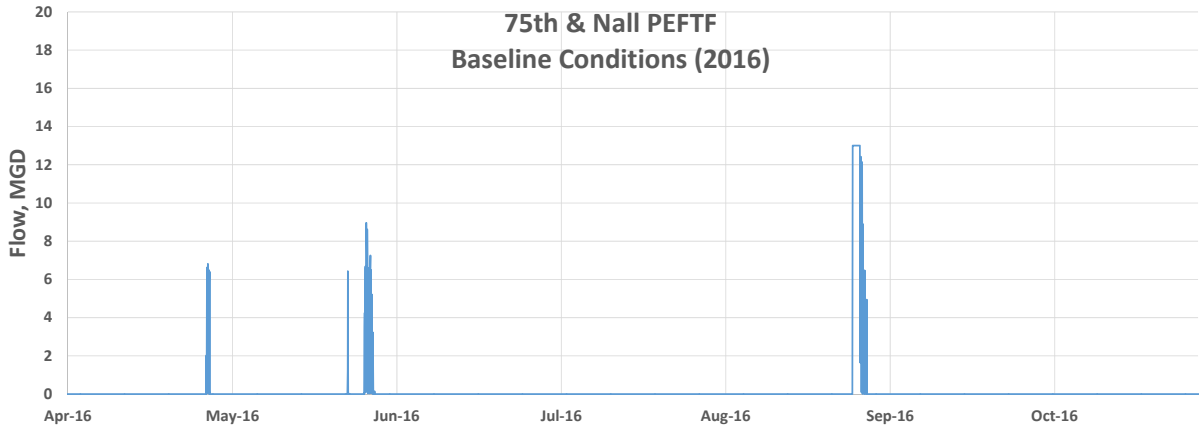

Belinder PEFTF
Baseline Conditions (2010)
Flow, MGD
60
50
40
30
20
10
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

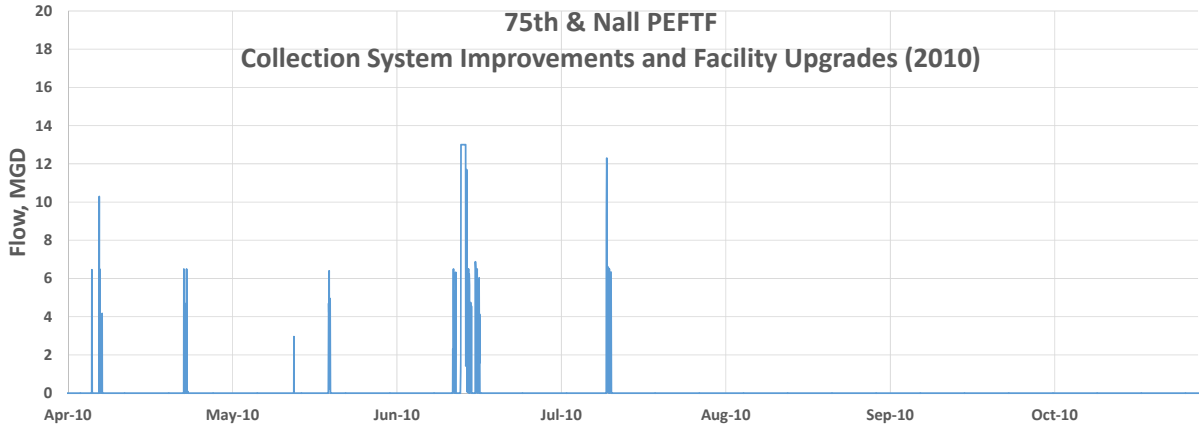

Belinder PEFTF
Baseline Conditions (2016)
Flow, MGD
60
50
40
30
20
10
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

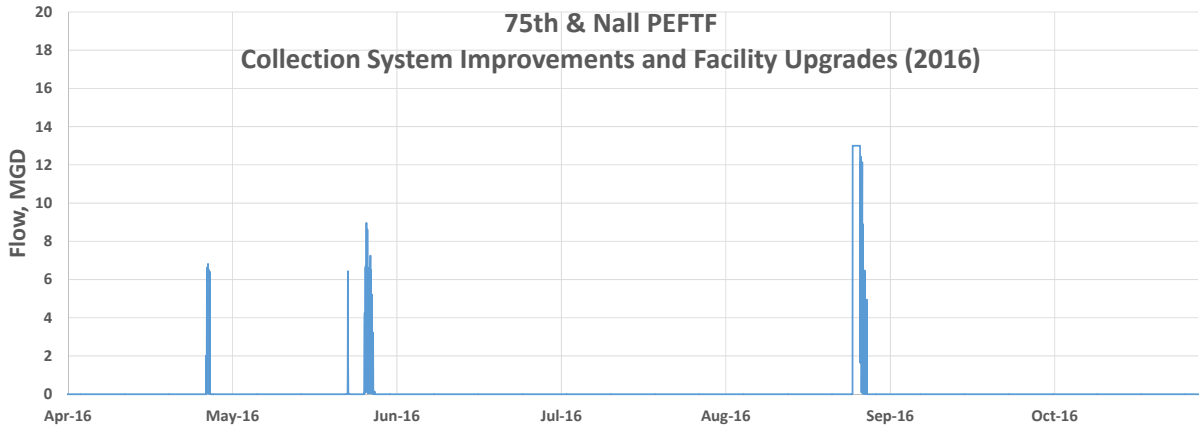

Belinder PEFTF
Collection System Improvements and Facility Upgrades (2010)
Flow, MGD
60
50
40
30
20
10
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

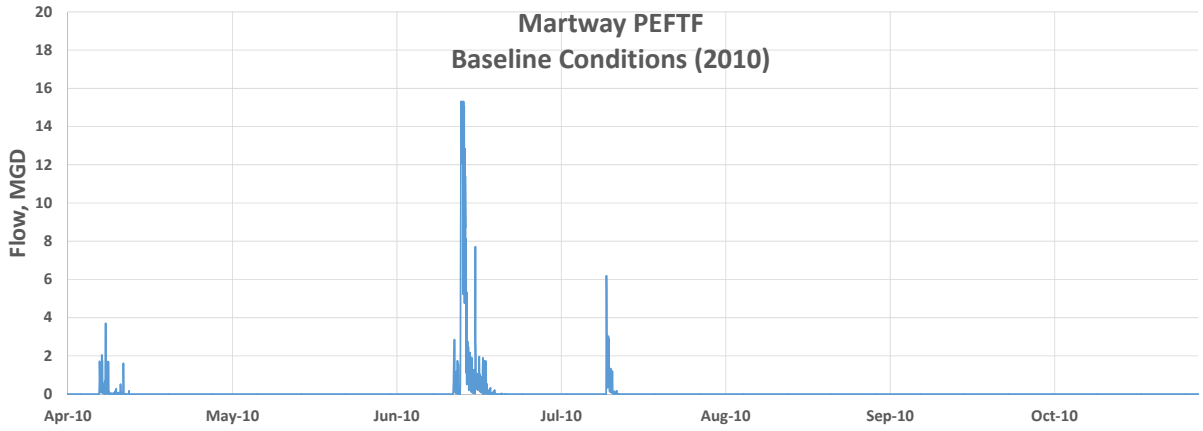

Belinder PEFTF
Collection System Improvements and Facility Upgrades (2016)
Flow, MGD
60
50
40
30
20
10
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

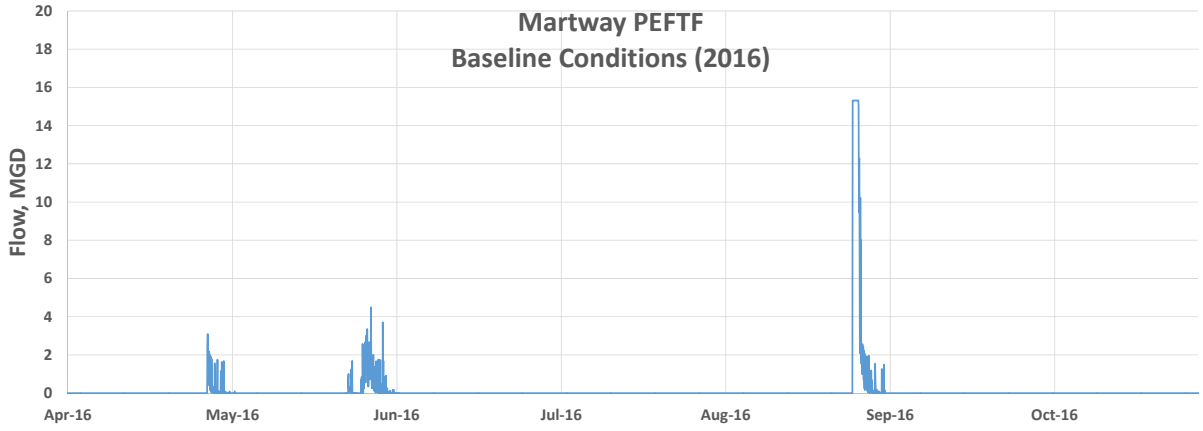

75th & Nall PEFTF
Baseline Conditions (2010)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

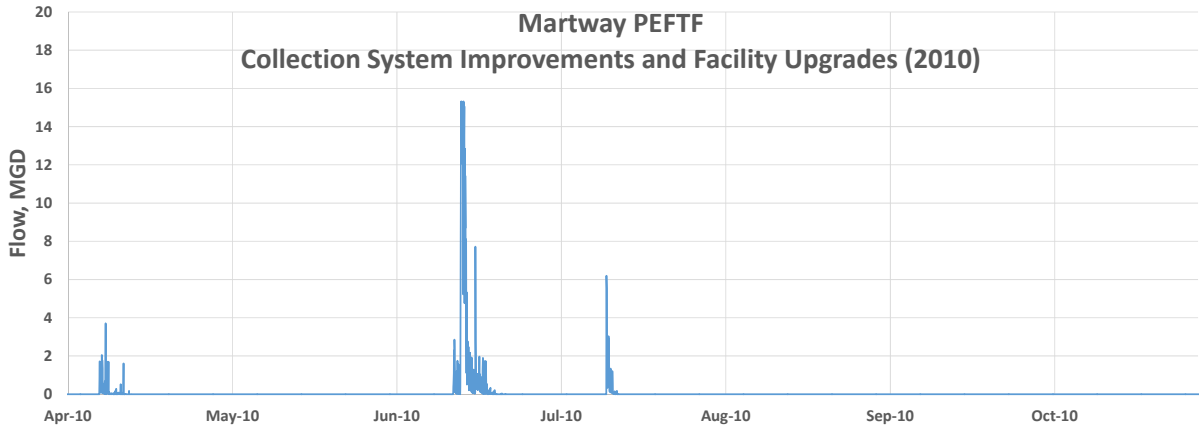

75th & Nall PEFTF
Baseline Conditions (2016)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

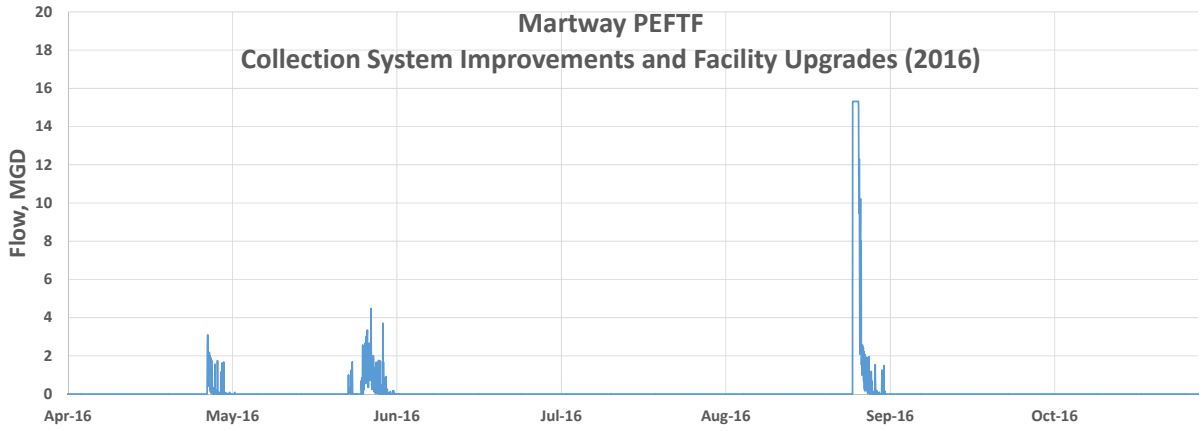

75th & Nall PEFTF
Collection System Improvements and Facility Upgrades (2010)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

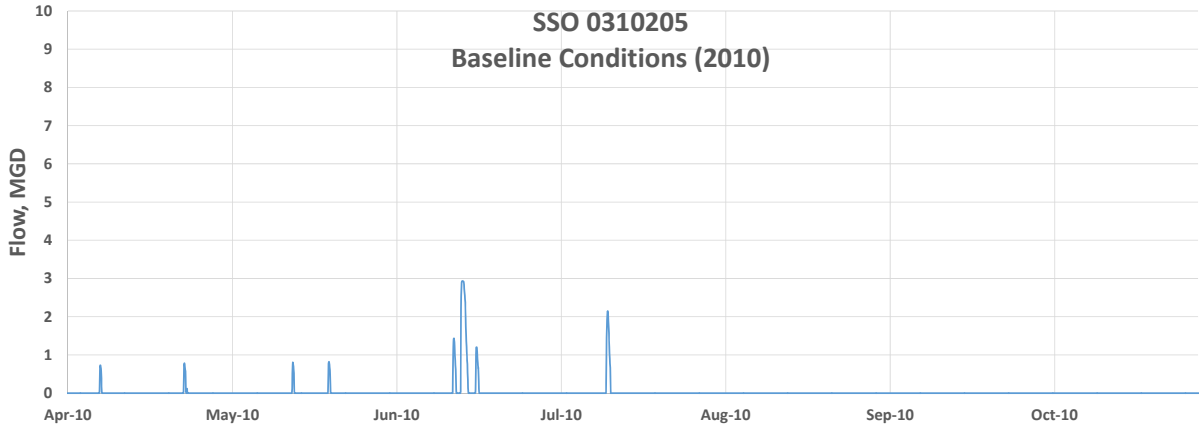

75th & Nall PEFTF
Collection System Improvements and Facility Upgrades (2016)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

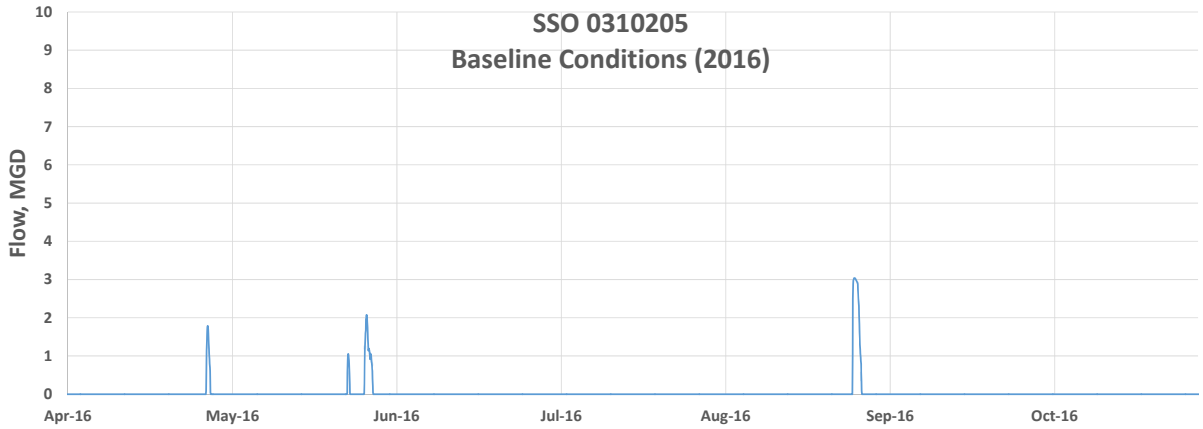

Martway PEFTF
Baseline Conditions (2010)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

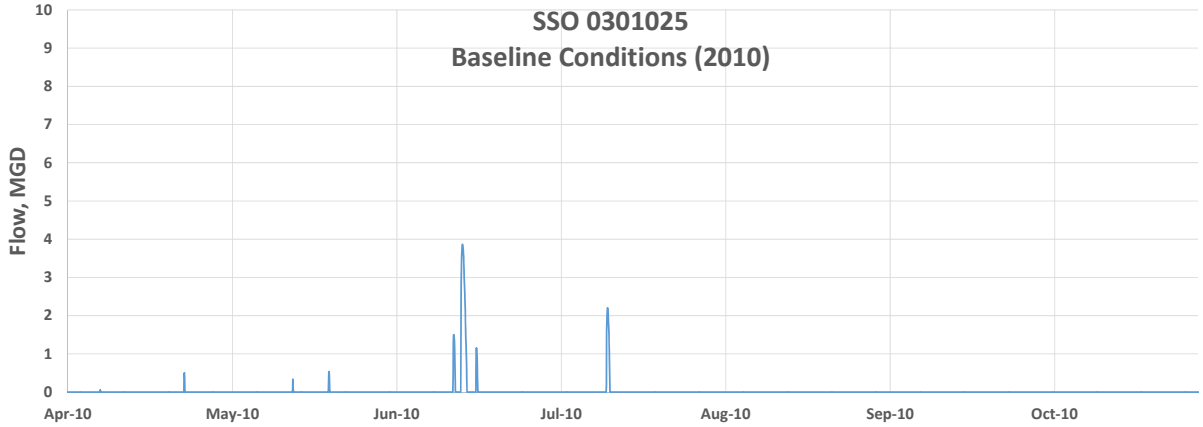

Martway PEFTF
Baseline Conditions (2016)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

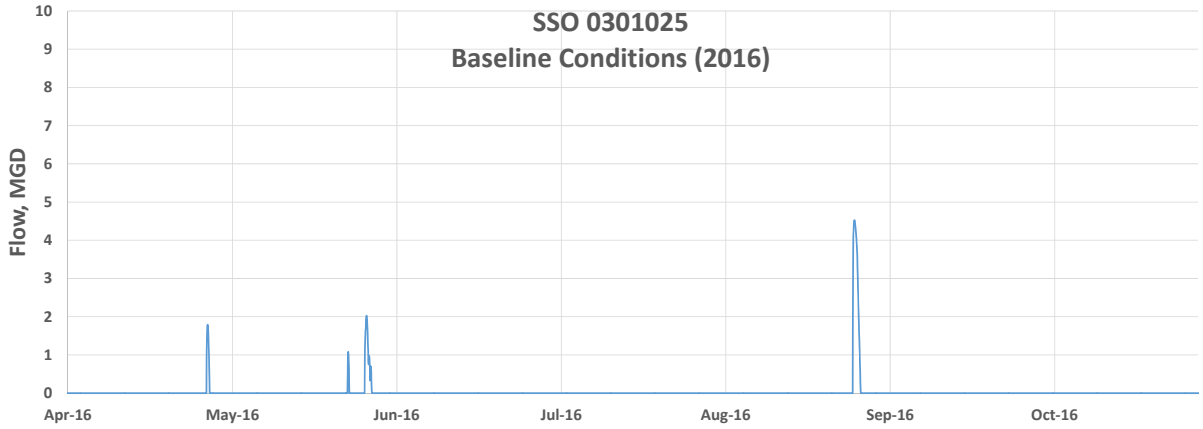

Martway PEFTF
Collection System Improvements and Facility Upgrades (2010)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10

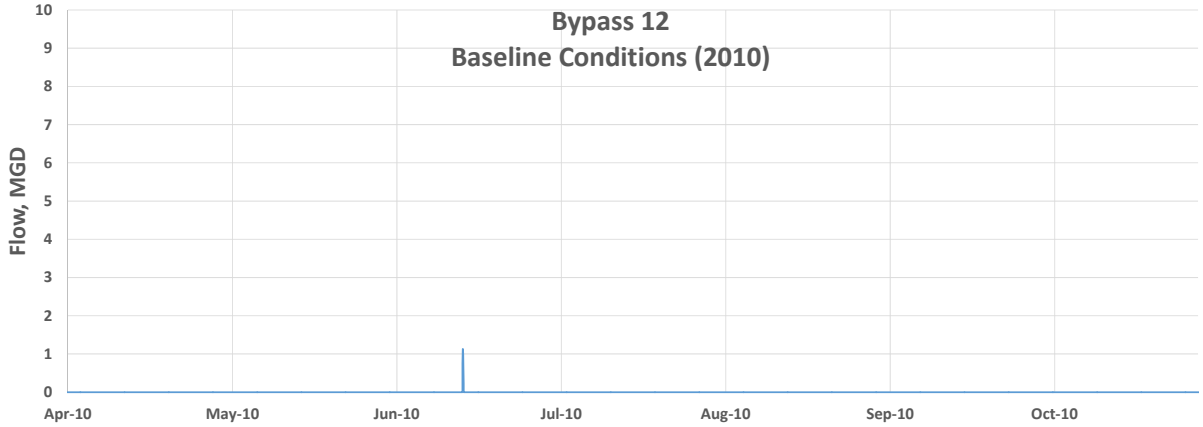

Martway PEFTF
Collection System Improvements and Facility Upgrades (2016)
Flow, MGD
20
18
16
14
12
10
8
6
4
2
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

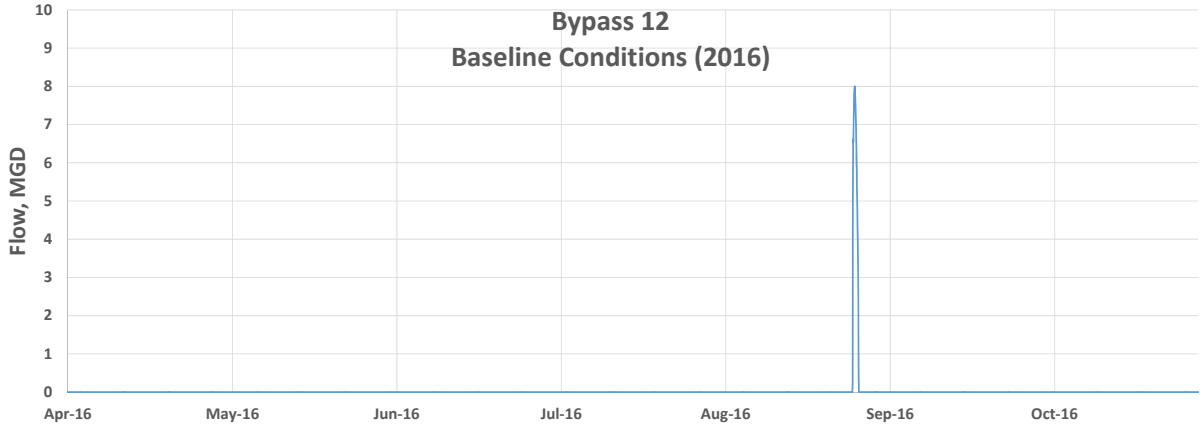

SSO 0310205
Baseline Conditions (2010)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10


SSO 0310205
Baseline Conditions (2016)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16


SSO 0301025
Baseline Conditions (2010)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10


SSO 0301025
Baseline Conditions (2016)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16


Bypass 12
Baseline Conditions (2010)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10


Bypass 12
Baseline Conditions (2016)
Flow, MGD
10
9
8
7
6
5
4
3
2
1
0
Apr-16
May-16
Jun-16
Jul-16
Aug-16
Sep-16
Oct-16

Appendix B – Summary of Model Pollutant Assumptions

Table B1. Pollutant Model Assumptions for Baseline Conditions

	E. coli, cfu/100 mL	Ammonia-N, mg/L	Total Nitrogen, mg/L	Total Phosphorus, mg/L	Total Residual Chlorine, mg/L
Baseflow	151	0.03	0.78	0.07	0
Runoff EMCs	5,250	0.1	2.3	0.26	0
Nelson WWTF	80	2.5	19	3.0	25
75th & Nall PEFTF	time series[1]	time series[1]	time series[1]	time series[1]	25
Martway PEFTF	time series[1]	time series[1]	time series[1]	time series[1]	25
Belinder PEFTF	time series[1]	time series[1]	time series[1]	time series[1]	2,400
Turkey PEFTF	time series[1]	time series[1]	time series[1]	time series[1]	2,300
SSOs	500,000	time series[2]	time series[2]	time series[2]	0
Bypasses	500,000	time series[2]	time series[2]	time series[2]	0

1. Time series described in Section 5.2.1. The complete *E. coli* time series included in Appendix C.
2. Turkey PEFTF time series applied to SSOs. 75th & Nall PEFTF time series applied to bypasses.

Table B2. Pollutant Model Assumptions for Eliminating all PEFTFs Scenario

	E. coli, cfu/100 mL	Ammonia-N, mg/L	Total Nitrogen, mg/L	Total Phosphorus, mg/L	Total Residual Chlorine, mg/L
Baseflow	151	0.03	0.78	0.07	0
Runoff EMCs	5,250	0.1	2.3	0.26	0
Nelson WWTF	80	2.5	19	3.0	25
75th & Nall PEFTF	--	--	--	--	--
Martway PEFTF	--	--	--	--	--
Belinder PEFTF	--	--	--	--	--
Turkey PEFTF	--	--	--	--	--
SSOs	--	--	--	--	--
Bypasses	--	--	--	--	--

Table B3. Pollutant Model Assumptions for Collection System Improvements and Facility Upgrades Scenario

	E. coli, cfu/100 mL	Ammonia-N, mg/L	Total Nitrogen, mg/L	Total Phosphorus, mg/L	Total Residual Chlorine, mg/L
Baseflow	151	0.03	0.78	0.07	0
Runoff EMCs	5,250	0.1	2.3	0.26	0
Nelson WWTF	80	0.3	10	1.0	25
75th & Nall PEFTF	100	time series[1]	time series[1]	time series[1]	25
Martway PEFTF	100	time series[1]	time series[1]	time series[1]	25
Belinder PEFTF	10	time series[1]	time series[1]	time series[1]	25
Turkey PEFTF	100	time series[1]	time series[1]	time series[1]	25
SSOs	--	--	--	--	--
Bypasses	--	--	--	--	--

1. Time series described in Section 5.2.1.

Appendix C – PEFTF *E. coli* Time Series Model Input

Date	*E. coli* Model Assumptions, cfu/100 mL							
	Turkey Creek		Belinder		Martway		75th & Nall	
	2010	2016	2010	2016	2010	2016	2010	2016
1-Apr	717	717	10	10	2,125	2,125	828	828
2-Apr	717	717	10	10	2,125	2,125	828	828
3-Apr	717	717	10	10	2,125	2,125	828	828
4-Apr	717	717	10	10	2,125	2,125	828	828
5-Apr	52	717	5	10	24,200	2,125	368	828
6-Apr	717	717	5	10	2,125	2,125	828	828
7-Apr	19,900	717	5	10	2,125	2,125	2,010	828
8-Apr	717	717	5	10	2,125	2,125	828	828
9-Apr	717	717	10	10	2,125	2,125	828	828
10-Apr	717	717	10	10	2,125	2,125	828	828
11-Apr	717	717	10	10	2,125	2,125	828	828
12-Apr	717	717	10	10	2,125	2,125	828	828
13-Apr	717	717	10	10	2,125	2,125	828	828
14-Apr	717	717	10	10	2,125	2,125	828	828
15-Apr	717	717	10	10	2,125	2,125	828	828
16-Apr	717	717	10	10	2,125	2,125	828	828
17-Apr	717	717	10	10	2,125	2,125	828	828
18-Apr	717	717	10	10	2,125	2,125	828	828
19-Apr	717	717	10	10	2,125	2,125	828	828
20-Apr	717	717	10	10	2,125	2,125	828	828
21-Apr	717	717	10	10	2,125	2,125	828	828
22-Apr	717	717	10	10	2,125	2,125	828	828
23-Apr	676	717	5	10	2,125	2,125	1,840	828
24-Apr	717	717	5	10	2,125	2,125	828	828
25-Apr	10	717	5	10	2,125	2,125	1,400	828
26-Apr	717	717	5	10	2,125	2,125	828	828
27-Apr	717	86,600	10	20	2,125	2,125	828	4,352
28-Apr	717	717	10	81	2,125	2,125	828	828
29-Apr	717	717	10	10	2,125	2,125	828	828
30-Apr	717	717	10	10	2,125	2,125	828	828
1-May	717	717	10	10	2,125	2,125	828	828
2-May	717	717	10	10	2,125	2,125	828	828
3-May	717	717	10	10	2,125	2,125	828	828
4-May	717	717	10	10	2,125	2,125	828	828
5-May	717	717	10	10	2,125	2,125	828	828
6-May	717	717	10	10	2,125	2,125	828	828
7-May	717	717	10	10	2,125	2,125	828	828
8-May	717	717	10	10	2,125	2,125	828	828
9-May	717	717	10	265	2,125	2,125	828	392
10-May	717	717	10	24,100	2,125	2,125	828	605
11-May	717	24,100	10	630	2,125	2,125	828	4,390
12-May	717	717	10	10	2,125	2,125	828	828
13-May	30	717	5	10	24,100	2,125	1,590	828
14-May	31	717	5	10	2,125	2,125	934	828
15-May	717	717	10	10	2,125	2,125	828	828
16-May	717	717	5	10	2,125	2,125	1,050	828
17-May	717	717	10	10	2,125	2,125	828	828
18-May	717	717	10	10	2,125	2,125	828	828
19-May	717	717	10	10	2,125	2,125	828	828
20-May	24,200	717	5	10	988	2,125	1,590	828
21-May	13,700	717	30	10	8,500	2,125	934	828
22-May	160	717	10	10	2,125	2,125	4,240	828
23-May	717	1,850	10	310	2,125	2,125	828	410

Date	*E. coli* Model Assumptions, cfu/100 mL							
	Turkey Creek		Belinder		Martway		75th & Nall	
	2010	2016	2010	2016	2010	2016	2010	2016
24-May	717	24,100	10	10	2,125	2,125	828	317
25-May	717	717	10	10	2,125	2,125	828	828
26-May	717	5	10	20	2,125	2,125	828	291
27-May	717	3,650	10	41	2,125	2,125	828	697
28-May	717	84	10	10	2,125	2,125	828	281
29-May	717	5	10	5	2,125	2,125	828	1,695
30-May	717	717	10	10	2,125	2,125	828	5,960
31-May	717	717	10	10	2,125	2,125	828	828
1-Jun	717	717	10	10	2,125	2,125	828	828
2-Jun	717	717	10	10	2,125	2,125	828	828
3-Jun	717	717	10	10	2,125	2,125	828	828
4-Jun	717	717	10	10	2,125	2,125	828	828
5-Jun	717	717	10	10	2,125	2,125	828	828
6-Jun	717	717	10	10	2,125	2,125	828	828
7-Jun	717	717	10	10	2,125	2,125	828	828
8-Jun	717	717	10	10	2,125	2,125	828	828
9-Jun	717	717	10	10	2,125	2,125	828	828
10-Jun	717	717	10	10	2,125	2,125	828	828
11-Jun	717	717	10	10	2,125	2,125	828	828
12-Jun	30	717	10	10	2,125	2,125	828	828
13-Jun	717	717	10	10	2,125	2,125	828	828
14-Jun	2,600	717	201	10	413	2,125	328	828
15-Jun	3,650	717	10	10	5,790	2,125	481	828
16-Jun	41	717	10	10	2,125	2,125	336	828
17-Jun	371	717	10	10	2,125	2,125	985	828
18-Jun	717	717	10	10	2,125	2,125	36,500	828
19-Jun	717	717	10	10	2,125	2,125	828	828
20-Jun	717	717	10	10	2,125	2,125	828	828
21-Jun	717	717	10	10	2,125	2,125	5,480	828
22-Jun	717	717	10	10	2,125	2,125	828	828
23-Jun	717	717	10	10	2,125	2,125	828	828
24-Jun	717	717	10	10	2,125	2,125	828	828
25-Jun	717	717	10	10	2,125	2,125	828	828
26-Jun	717	717	10	10	2,125	2,125	828	828
27-Jun	717	717	10	10	2,125	2,125	828	828
28-Jun	717	717	10	10	2,125	2,125	828	828
29-Jun	717	717	10	10	2,125	2,125	828	828
30-Jun	717	717	10	10	2,125	2,125	828	828
1-Jul	717	717	10	10	2,125	2,125	828	828
2-Jul	717	717	10	10	2,125	2,125	828	828
3-Jul	717	384	10	10	2,125	2,125	828	828
4-Jul	717	717	10	10	2,125	2,125	828	828
5-Jul	717	717	10	10	2,125	2,125	828	828
6-Jul	717	717	10	10	2,125	2,125	828	828
7-Jul	717	717	10	10	2,125	2,125	828	828
8-Jul	717	717	10	10	2,125	2,125	828	828
9-Jul	717	717	10	10	2,125	2,125	828	828
10-Jul	717	717	10	10	2,125	2,125	828	828
11-Jul	132	717	5	10	1,980	2,125	480	828
12-Jul	717	717	10	10	2,125	2,125	828	828
13-Jul	717	717	10	10	2,125	2,125	828	828
14-Jul	717	717	10	10	2,125	2,125	828	828
15-Jul	717	717	10	10	2,125	2,125	828	828
16-Jul	717	717	10	10	2,125	2,125	828	828
17-Jul	717	717	10	10	2,125	2,125	828	828
18-Jul	717	717	10	10	2,125	2,125	828	828
19-Jul	717	717	10	10	2,125	2,125	828	828
20-Jul	717	717	10	10	2,125	2,125	828	828

Date	*E. coli* Model Assumptions, cfu/100 mL							
	Turkey Creek		Belinder		Martway		75th & Nall	
	2010	2016	2010	2016	2010	2016	2010	2016
21-Jul	717	717	10	10	2,125	2,125	828	828
22-Jul	717	717	10	10	2,125	2,125	828	828
23-Jul	717	717	10	10	2,125	2,125	828	828
24-Jul	717	717	10	10	2,125	2,125	828	828
25-Jul	717	717	10	10	2,125	2,125	828	828
26-Jul	717	717	10	10	2,125	2,125	828	828
27-Jul	717	717	10	10	2,125	2,125	828	828
28-Jul	717	717	10	10	2,125	2,125	828	828
29-Jul	717	717	10	10	2,125	2,125	828	828
30-Jul	717	717	10	10	2,125	2,125	828	828
31-Jul	717	717	10	10	2,125	2,125	828	828
1-Aug	717	717	10	10	2,125	2,125	828	828
2-Aug	717	717	10	10	2,125	2,125	828	828
3-Aug	717	717	10	10	2,125	2,125	828	828
4-Aug	717	717	10	10	2,125	2,125	828	828
5-Aug	717	717	10	10	2,125	2,125	828	828
6-Aug	717	717	10	10	2,125	2,125	828	828
7-Aug	717	717	10	10	2,125	2,125	828	828
8-Aug	717	717	10	10	2,125	2,125	828	828
9-Aug	717	717	10	10	2,125	2,125	828	828
10-Aug	717	717	10	10	2,125	2,125	828	828
11-Aug	717	717	10	10	2,125	2,125	828	828
12-Aug	717	717	10	10	2,125	2,125	828	828
13-Aug	717	717	10	10	2,125	2,125	828	828
14-Aug	717	717	10	10	2,125	2,125	828	828
15-Aug	717	717	10	10	2,125	2,125	828	828
16-Aug	717	717	10	10	2,125	2,125	828	828
17-Aug	717	717	10	10	2,125	2,125	828	828
18-Aug	717	717	10	10	2,125	2,125	828	828
19-Aug	717	717	10	10	2,125	2,125	828	828
20-Aug	717	717	10	10	2,125	2,125	828	828
21-Aug	717	717	10	10	2,125	2,125	828	828
22-Aug	717	717	10	10	2,125	2,125	828	828
23-Aug	717	717	10	10	2,125	2,125	828	828
24-Aug	717	717	10	10	2,125	2,125	828	828
25-Aug	717	717	10	10	2,125	2,125	828	828
26-Aug	717	717	10	10	2,125	2,125	828	828
27-Aug	717	24,100	10	5	2,125	24,100	828	318
28-Aug	717	717	10	10	2,125	2,125	828	828
29-Aug	717	717	10	10	2,125	2,125	828	828
30-Aug	717	717	10	10	2,125	2,125	828	828
31-Aug	717	717	10	10	2,125	2,125	828	828
1-Sep	717	717	10	10	2,125	2,125	828	828
2-Sep	717	717	10	10	2,125	2,125	828	828
3-Sep	717	717	10	10	2,125	2,125	828	828
4-Sep	717	717	10	10	2,125	2,125	828	828
5-Sep	717	717	10	10	2,125	2,125	828	828
6-Sep	717	717	10	10	2,125	2,125	828	828
7-Sep	717	717	10	10	2,125	2,125	828	828
8-Sep	717	717	10	10	2,125	2,125	828	828
9-Sep	717	717	10	10	2,125	2,125	828	828
10-Sep	717	717	10	10	2,125	2,125	828	828
11-Sep	717	717	10	10	2,125	2,125	828	828
12-Sep	717	717	10	10	2,125	2,125	828	828
13-Sep	717	717	10	10	2,125	2,125	828	828
14-Sep	717	5	10	10	2,125	2,125	828	828
15-Sep	717	717	10	10	2,125	2,125	828	828
16-Sep	717	717	10	10	2,125	2,125	828	828

Date	*E. coli* Model Assumptions, cfu/100 mL							
	Turkey Creek		Belinder		Martway		75th & Nall	
	2010	2016	2010	2016	2010	2016	2010	2016
17-Sep	717	717	10	10	2,125	2,125	828	828
18-Sep	717	717	10	10	2,125	2,125	828	828
19-Sep	717	717	10	10	2,125	2,125	828	828
20-Sep	717	717	10	10	2,125	2,125	828	828
21-Sep	717	717	10	10	2,125	2,125	828	828
22-Sep	717	717	10	10	2,125	2,125	828	828
23-Sep	717	717	10	10	2,125	2,125	828	828
24-Sep	717	717	10	10	2,125	2,125	828	828
25-Sep	717	717	10	10	2,125	2,125	828	828
26-Sep	717	717	10	10	2,125	2,125	828	828
27-Sep	717	717	10	10	2,125	2,125	828	828
28-Sep	717	717	10	10	2,125	2,125	828	828
29-Sep	717	717	10	10	2,125	2,125	828	828
30-Sep	717	717	10	10	2,125	2,125	828	828
1-Oct	717	717	10	10	2,125	2,125	828	828
2-Oct	717	717	10	10	2,125	2,125	828	828
3-Oct	717	717	10	10	2,125	2,125	828	828
4-Oct	717	717	10	10	2,125	2,125	828	828
5-Oct	717	717	10	10	2,125	2,125	828	828
6-Oct	717	717	10	10	2,125	2,125	828	828
7-Oct	717	717	10	10	2,125	2,125	828	828
8-Oct	717	717	10	10	2,125	2,125	828	828
9-Oct	717	717	10	10	2,125	2,125	828	828
10-Oct	717	717	10	10	2,125	2,125	828	828
11-Oct	717	717	10	10	2,125	2,125	828	828
12-Oct	717	717	10	10	2,125	2,125	828	828
13-Oct	717	717	10	10	2,125	2,125	828	828
14-Oct	717	717	10	10	2,125	2,125	828	828
15-Oct	717	717	10	10	2,125	2,125	828	828
16-Oct	717	717	10	10	2,125	2,125	828	828
17-Oct	717	717	10	10	2,125	2,125	828	828
18-Oct	717	717	10	10	2,125	2,125	828	828
19-Oct	717	717	10	10	2,125	2,125	828	828
20-Oct	717	717	10	10	2,125	2,125	828	828
21-Oct	717	717	10	10	2,125	2,125	828	828
22-Oct	717	717	10	10	2,125	2,125	828	828
23-Oct	717	717	10	10	2,125	2,125	828	828
24-Oct	717	717	10	10	2,125	2,125	828	828
25-Oct	717	717	10	10	2,125	2,125	828	828
26-Oct	717	717	10	10	2,125	2,125	828	828
27-Oct	717	717	10	10	2,125	2,125	828	828
28-Oct	717	717	10	10	2,125	2,125	828	828
29-Oct	717	717	10	10	2,125	2,125	828	828
30-Oct	717	717	10	10	2,125	2,125	828	828
31-Oct	717	717	10	10	2,125	2,125	828	828

Nelson Complex Collection System Wet Weather Plan Technical Memorandum #6 Alternatives Development

April 2019

JOHNSON COUNTY KANSAS

Wastewater

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ACRONYMS AND ABBREVIATIONS

AADF	Annual Average Daily Flow
ADDF	Average Daily Dry Weather Flow
BOD_5	Five Day Biological Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EFHB	Excess Flow Holding Basin
EPA	Environmental Protection Agency
GPD	Gallons per Day
GPM	Gallons per Minute
I/I	Inflow and Infiltration
JCW	Johnson County Wastewater
KCPL	Kansas City Power and Light
KDHE	Kansas Department of Health and Environment
L	Liter
LF	Linear Feet (Foot)
MGAL	Million Gallons
MGD	Million Gallons per Day
$M	Million Dollars
MH	Manhole
mg/l	Milligrams/liter
MMADF	Maximum Month Average Daily Flow
MTM1	Mission Township Main Sewer District No. 1
NC	Nelson WWTF Complex
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NH3-N	Ammonia Nitrogen
O&M	Operation and Maintenance
PEFTF	Peak Excess Flow Treatment Facility
PHF	Peak Hour Flow
PC	Primary Clarifier
$Pro2D^2$	Professional Process Design and Dynamics Whole Plant Simulator by CH2M

PS	Pump Station
SCADA	Supervisory Control and Data Acquisition
SMTC	Shawnee Mission Turkey Creek
SSO	Sanitary Sewer Overflow
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultra Violet
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

1 Introduction

1.1 Background & Purpose

The tributary area to the Nelson Complex consists of two watersheds with names corresponding to the two Wastewater Treatment Facility (WWTF) trains, Mission Main and Turkey Creek. Flows from these watersheds are pumped to the WWTF via multiple pump stations. The watersheds also contain Peak Excess Flow Treatment Facilities (PEFTFs) which either store wet weather flow and return it to the collection system after the storm passes, or discharge directly from the collection system to the creek after providing primary treatment and disinfection.

JCW is developing a long term plan to address wet weather flows within the Turkey Creek and Mission Main watersheds. Several upgrade alternatives are being considered for both watersheds including:

- Conveyance Upgrades
  - Gravity
  - Pump Station/Forcemain
- Storage
  - Shallow Underground
  - Linear/Tunnel
- I/I Reduction
- PEFTF Upgrades
- Auxiliary Treatment Facility (ATF) at the Nelson Complex.

Optimization was used as a tool in the planning process to identify the most cost-effective combination of these alternatives that will meet JCW's desired level of service (LOS). Two primary optimized solutions were developed, *Alternative 1: Eliminate PEFTFs through Wet Weather Management* (referred to in TM 4 as the Preferred No PEFTF solution) and *Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment* (referred to in TM 4 as the Preferred With PEFTF solution). Each optimized solution provides a comprehensive list of capital projects and associated expenditures necessary to achieve the LOS requirements.

1.2 Alternatives Development Approach

In order to further increase confidence in the major CIP expenditures recommended in the optimization, detailed planning level costs were developed for the underground storage alternatives, major gravity interceptor projects, pump stations and associated forcemains, and PEFTF treatment upgrades (in that scenario). Additional factors, including construction feasibility, operational and maintenance needs, and water quality, were also evaluated in order to conduct a triple bottom line analysis and provide the most practical set of recommendations.

This technical memorandum (TM 6) serves to document the alternatives development process, present updated alternatives and their associated costs, and summarize the triple bottom line evaluation. The Collection System Wet Weather Plan has been progressing concurrently with the MK Nelson WWTF Improvements Facility Plan, and the two plans are highly interdependent. To avoid duplicating detailed alternatives development information between studies, the detailed planning level design information regarding pump stations, PEFTFs, and ATF have been included in the *Nelson Complex WWTP and Collection System Technical Memorandum #5, Project Development* (May

2019). However, a brief summary of each of these alternatives is included in TM 6 (this TM) for ease of reference. Detailed planning level design information regarding underground storage facilities and the major gravity interceptor projects are included in this TM.

1.3 TM Organization

The contents of this TM are organized into six sections. Section 2 describes the review and further refinement of the refined optimization modeling results using the InfoWorks ICM model. The next sections summarize the development of major capital projects for *Alternative 1: Eliminate PEFTFs through Wet Weather Management* (Section 3) and *Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment* (Section 4). Section 5 describes the process and results of the triple bottom line evaluation. Section 6 summarizes the alternatives development and provides recommendations and next steps in the long-term planning process.

2 Alternative Review and Refinement Modeling

2.1 Preferred Solutions from Refined Optimization

Several scenarios and sensitivities were evaluated through the refined optimization process and are documented in TM 4 (*Refined Optimization Findings,* January 2019). Two solutions were selected for further development and continued inclusion in the long-term planning process, one in which all PEFTFs are eliminated through wet weather management (PEFTF Elimination) and one in which all PEFTFs are retained with enhanced high rate treatment (PEFTF Retention). The following costs are shown in 2018 dollars.

The optimized cost summary for Alternative 1 – PEFTF Elimination is presented in Table 2-1.

Table 2-1: Cost Summary for Alternative 1 – PEFTF Elimination

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) (1)	Turkey Creek 20-yr PV Total Cost ($M) (1)	Mission Main 20-yr PV Total Cost ($M) (1)	20-yr PV Total Cost ($M) (1)
Gravity Sewers	28.80	-	9.52	19.27	**28.80**
Pumping Station Upgrades	37.77	6.71	13.23	31.24	**44.48**
Force Mains	18.06	-	3.21	14.85	**18.06**
Underground Storage Facilities	40.38	0.11	19.48	21.02	**40.49**
Linear Storages	-	-	-	-	**-**
PEFTF Upgrades	-	-	-	-	**-**
Baseline I/I Reduction	30.00	-	17.19	12.81	**30.00**
Additional I/I Reduction	13.89	-	3.18	10.71	**13.89**
Auxiliary Treatment Facility	40.76	4.50	6.21	39.05	**45.26**
TOTAL	**209.65**	**11.32**	**72.02**	**148.95**	**220.97**

(1) Costs do not include operation and maintenance costs that are common among alternatives.

In Turkey Creek, the PEFTF Elimination scenario is characterized by:

- Approximately 6,650 LF of parallel gravity main and 2,300 LF of replace/upsize gravity main
- Upgrade of the Turkey Creek PS to 43.2 MGD with a parallel 36” forcemain (3,800 LF)
- Two underground storage facilities:
  - Turkey Creek South – 2.1 MG
  - Turkey Creek North – 1.0 MG
- A selected overall I/I reduction in Turkey Creek of 17%

In Mission Main, the PEFTF Elimination scenario is characterized by:

- Approximately 7,600 LF of parallel gravity main and 30,800 LF of replace/upsize gravity main
- Upgrade of the Belinder PS to 53.5 MGD with a parallel 48” forcemain (14,000 LF)

- Upgrade of the Rock Creek PS to 24.3 MGD with a parallel 24" forcemain (10,100 LF)
- Brush Creek underground storage facility – 4.4 MG
- A selected overall I/I reduction in Mission Main of 15%

The optimized cost summary for Alternative 2 - PEFTF Retention is presented in Table 2-2.

Table 2-2: Cost Summary for Alternative 2 – PEFTF Retention

Cost Item	Initial Capital Cost ($M)	20-yr O&M Cost ($M) (1)	Turkey Creek 20-yr PV Total Cost ($M) (1)	Mission Main 20-yr PV Total Cost ($M) (1)	20-yr PV Total Cost ($M) (1)
Gravity Sewers	27.12	-	9.69	17.43	**27.12**
Pumping Station Upgrades	-	-	-	-	**-**
Force Mains	-	-	-	-	**-**
Underground Storage Facilities	20.91	0.05	20.96	0.00	**20.96**
Linear Storages	-	-	-	7.42	**7.42**
PEFTF Upgrades	55.21	6.61	11.95	49.87	**61.82**
Baseline I/I Reduction	30.00	-	17.19	12.81	**30.00**
Additional I/I Reduction	9.49	-	2.13	7.35	**9.49**
Auxiliary Treatment Facility	-	-	-	-	**-**
TOTAL	**142.72**	**6.66**	**61.92**	**94.88**	**156.80**

(1) Costs do not include operation and maintenance costs that are common among alternatives.

The optimized solutions eliminating or retaining PEFTFs have very similar overall strategies. The only significant differences occur at the major facilities. In the solution with PEFTF upgrades allowed:

- The Turkey Creek PS upgrade is exchanged for a PEFTF upgrade;
- The Belinder PS upgrade is exchanged for a PEFTF upgrade;
- The Rock Creek PS upgrade is exchanged for linear storage;
- The Brush Creek storage is exchanged for a PEFTF upgrade at 75th/Nall; and
- The ATF upgrade is not required, as peak excess flows are treated at the upgraded PEFTFs.

The optimized solutions are presented graphically in Figure 2-1 and Figure 2-2, for Alternative 1 and Alternative 2, respectively.

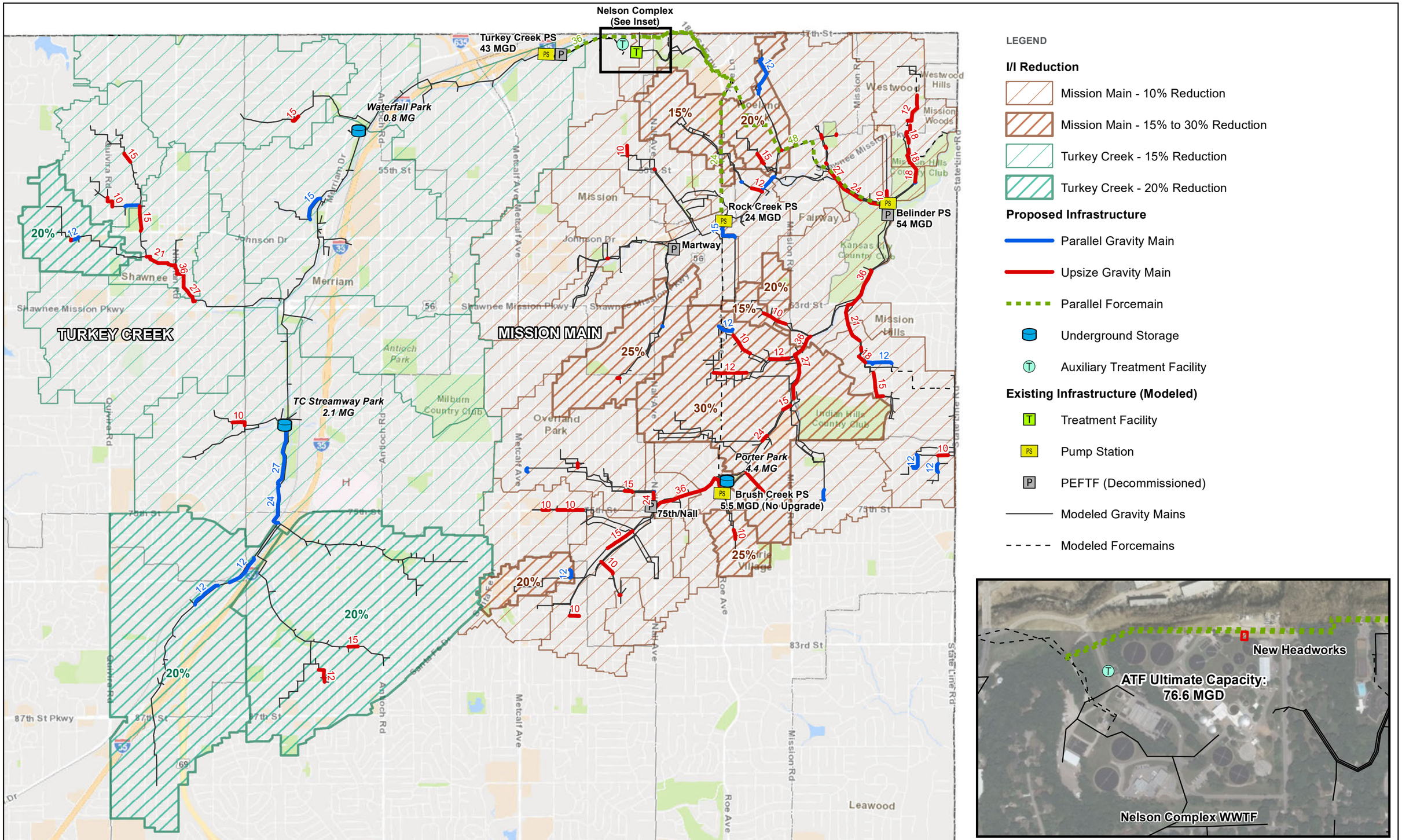

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FIGURE 2-1

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 1: ELIMINATE PEFTFS THROUGH WET WEATHER MANAGEMENT

OPTIMIZED SOLUTION

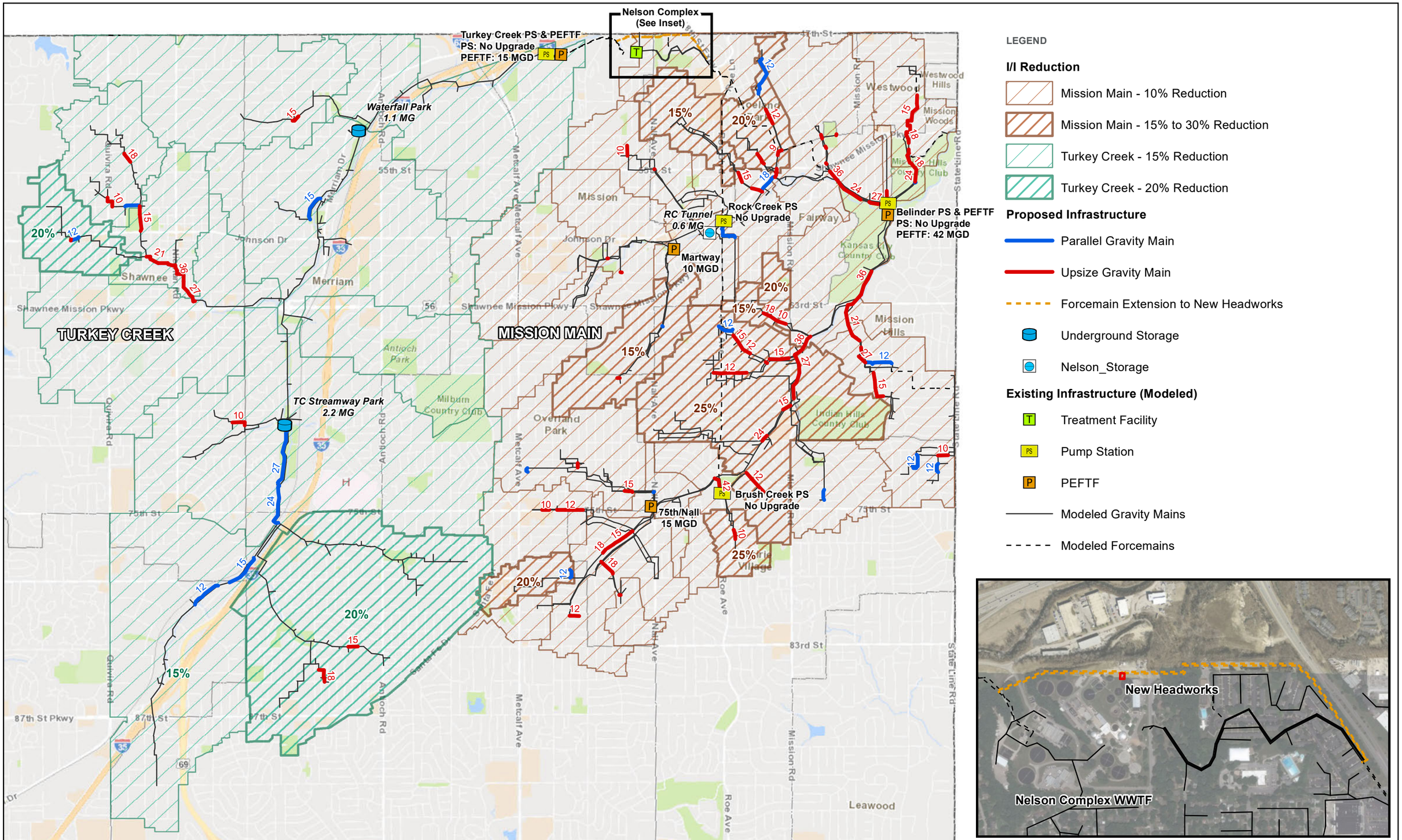

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FIGURE 2-2

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 2: RETAIN PEFTFS WITH ENHANCED HIGH RATE TREATMENT

OPTIMIZED SOLUTION

2.2 Modeling Differences and Refinements

JCW's InfoWorks ICM model was converted to SWMM for use in the optimization process. The identified optimized solutions were replicated in the ICM model to confirm system performance and facility sizing. During the validation of solutions, the difference between the two models were identified and are presented in the following sections.

2.2.1 Modeling Differences

- The ICM model runs the full hydrologic calculations to determine runoff to the system. ICM uses variable timesteps for this calculation to account for flow and peaks. The SWMM model does not perform the hydrologic calculations; only hydraulic (pipe routing) calculations are run. Runoff hydrographs generated by ICM on a 15-minute timestep are used to load the SWMM pipe network. Because of this arrangement, some flow peaks that occurred in different timesteps were not fully captured in the SWMM model, resulting in a slightly lower peak flow at some points in the system.
- Reduction in I/I was accounted for in two different ways between the two models. Since the full hydrologic calculations were run in the ICM model, I/I reduction was modeled by reducing the contributing area by the selected I/I reduction amount. In the SWMM model, the I/I reduction was applied to the input hydrograph.

Overall, these differences resulted in only minor differences in system performance results between the two models. No sizing modifications were necessary to major pump stations or underground storage facilities.

2.2.2 Modeling Refinements

Due to the differences in models, the peak flows in the ICM model were generally slightly higher than in SWMM. Consequently, some of the optimized gravity main diameters were slightly undersized when validated in ICM.

The optimization software looks for the most inexpensive solution that will meet the given criteria. For gravity mains, this means the optimization may choose unrealistic solutions including:

- Upsize of a short segment of pipe at a larger diameter to act as storage rather than upsizing the entire line to a more modest diameter to alleviate surcharge
- Inconsistent pipe diameters due to changes in slope or other variations.

During alternative refinement in ICM, the alignments and sizes of selected parallel relief sewers and upsize-in-place sewers were reviewed in detail and modifications were made to the modeled solution.

During this review, a discrepancy in network configuration was noted between the SWMM model and the ICM model upstream of Martway PEFTF. A modeled pipe upstream of Martway was confirmed to be abandoned (or may never have existed) through review of as-builts and photo inspections previously in the study. This pipe was removed from the ICM model, but this change was not translated to the SWMM model during optimization. This pipe allowed flow to bypass Martway and continue to Rock Creek PS. Due to this discrepancy, it was determined that Martway PEFTF should be sized for a capacity of 12 MGD, instead of the 10 MGD selected in Alternative 2, the PEFTF Retention optimized solution. This refinement had negligible impact on Alternative 1.

Modifications to the gravity main improvements are presented in Figure 2-3 and Figure 2-4, for Alternative 1 and Alternative 2, respectively. Updated costs associated with these refinements are reflected in Section 3 (gravity refinements) and Section 4 (PEFTF capacity refinement) of this TM.

2.3 Turkey Creek Storage Evaluation

In both the PEFTF Elimination and PEFTF Retention optimized solutions, two storage facilities were selected along the Turkey Creek interceptor, a larger facility at Turkey Creek Streamway Park (Turkey Creek South) and a smaller facility at Waterfall Park (Turkey Creek North). In the PEFTF Elimination solution, Turkey Creek Streamway Park was selected for approximately 2.1-2.2 MG and downstream Waterfall Park was selected for an additional 0.8-1.1 MG. Constructing, operating, and maintaining two wet weather facilities would be an extra burden on JCW O&M staff. Therefore, the possibility of consolidation into a single larger storage facility at Turkey Creek Streamway Park was evaluated in the refined ICM model.

Modeling results indicate that it is conceptually feasible to consolidate to a single 3.7 MG (peak flow 16.4 MGD) facility at Turkey Creek Streamway Park with minimal impact to the interceptor downstream. This single consolidated facility alternative was more fully evaluated for site feasibility and cost comparison to the two facility alternative and is documented in Section 3.1.

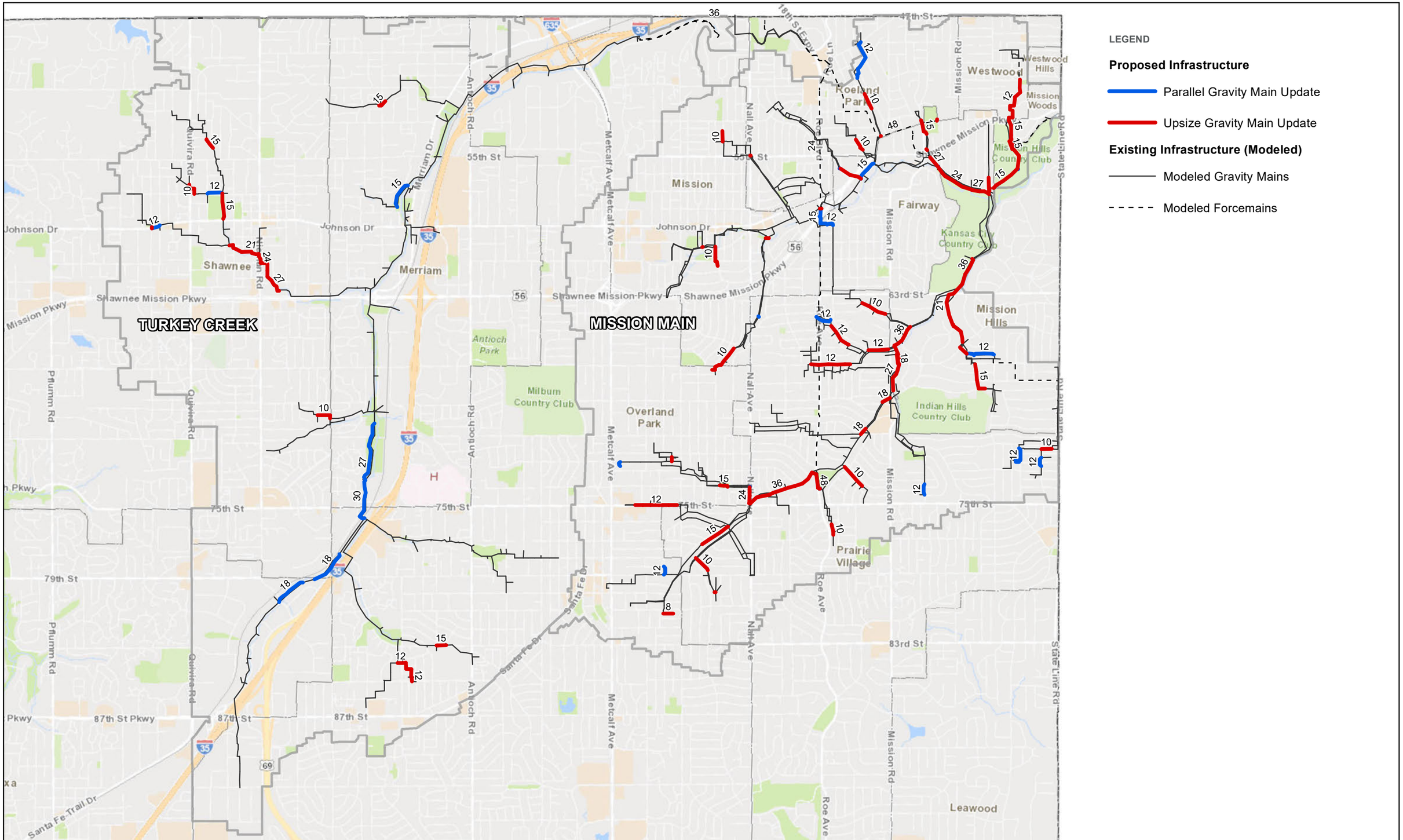

FIGURE 2-3

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 1: ELIMINATE PEFTFS THROUGH WET WEATHER MANAGEMENT

UPDATED GRAVITY MAIN IMPROVEMENTS

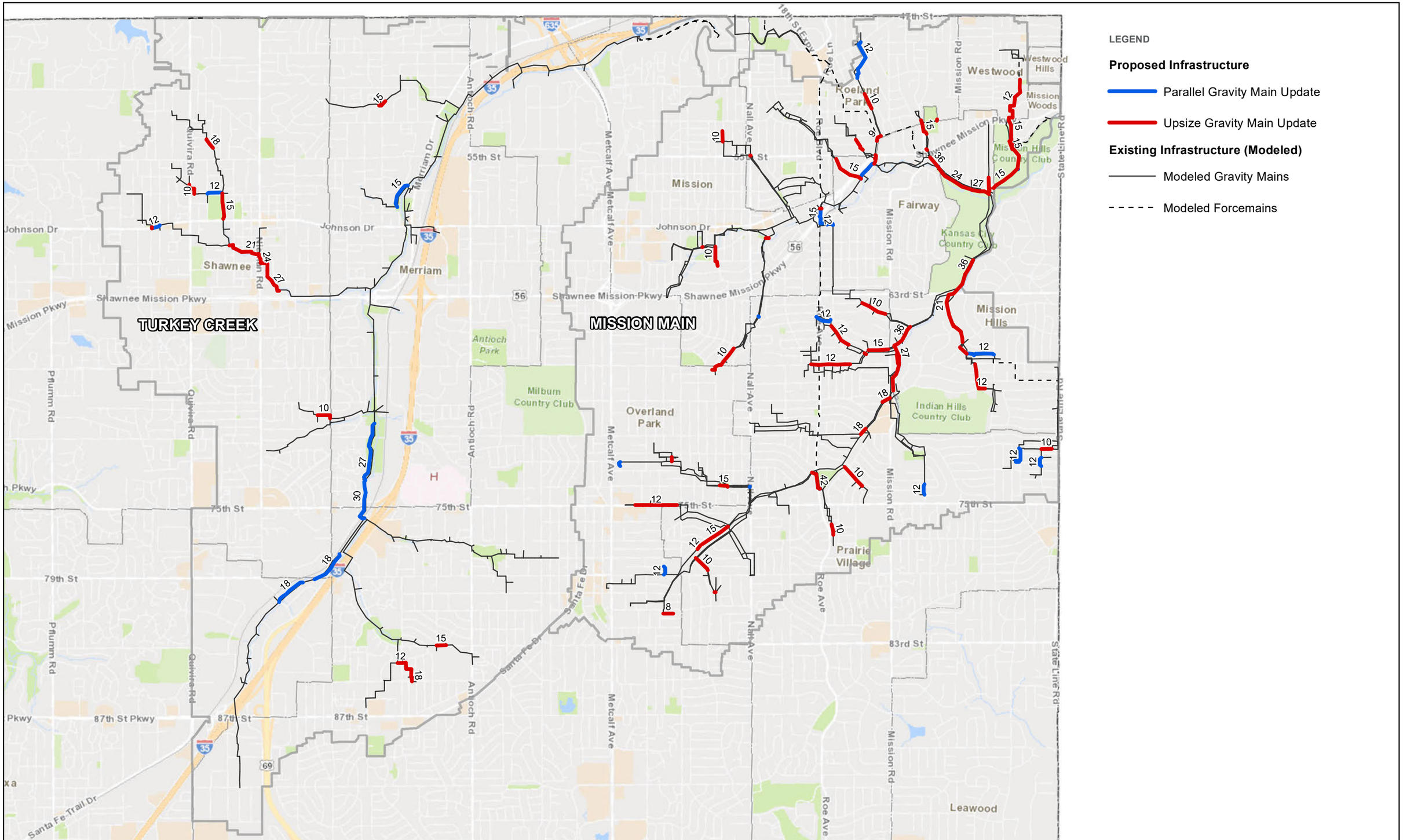

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FIGURE 2-4

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 2: RETAIN PEFTFS WITH ENHANCED HIGH RATE TREATMENT

UPDATED GRAVITY MAIN IMPROVEMENTS

3 Development of Major Capital Projects (Alternative 1)

Alternative 1: Eliminate PEFTFs through Wet Weather Management includes a variety of capital projects to manage peak flows including underground storage facilities, conveyance improvements, and an Auxiliary Treatment Facility (ATF) at the Nelson Complex. In order to further increase confidence in the major CIP expenditures recommended in this alternative, detailed planning level costs were developed for the underground storage alternatives, major gravity interceptor projects, pump stations and associated forcemains, and the ATF. All costs detailed in this section are shown in 2018 dollars.

3.1 Storage Facilities

As shown in Figure 2-1, three (3) underground storage facilities were selected during refined optimization, two smaller facilities along the Turkey Creek interceptor and one larger facility in the Mission Main basin near Brush Creek Pump Station.

Consolidation of the two facilities on the Turkey Creek interceptor into one larger facility would reduce both operational challenges and maintenance requirements. Based on feedback from JCW during the February 4, 2019 workshop, one larger facility would be the preferred alternative. Therefore, consolidation of storage at the upstream location was included and evaluated with the options herein.

Each of the three (3) base facilities as well as the consolidated Turkey Creek facility option were evaluated for both Gravity In-Pump Out and Pump In-Gravity Out configurations to determine the feasibility and associated cost to construct and operate each option. A Gravity In-Pump Out facility would require deeper excavation but has the advantage of needing a smaller dewatering pump station. A Pump In-Gravity Out facility has the advantage of being shallow, however the pump station must be sized to handle peak flows during wet weather events. The Pump In-Gravity Out option also presents a higher risk of customer impacts if the peak flow pump station were to fail during a wet weather event. The Gravity In-Pump Out option is less likely to have an operational equipment failure during a wet weather event, as the drain pump would not need to operate during the storm event. JCW provided feedback at the February 4, 2019 workshop that Gravity In-Pump Out was preferred at all sites for operational and risk reasons, but all evaluated options will be presented for reference.

<u>Diversion Structure Design Parameters</u>

These facilities were designed to reduce peak flows through the interceptors by diverting and storing a portion of the peak flow during the 10-year storm event, thereby avoiding extensive and disruptive interceptor capacity upgrades. A control structure would be constructed on the existing gravity line upstream of the storage facility. During normal flow conditions, flow would bypass the storage facility and continue downstream. During wet weather events, the control structure would divert a portion of the peak flows into the storage facility which would be held until the existing interceptor could handle the additional flow. The release rates could be controlled automatically or operated manually based on local flow conditions or the total wet weather flow in the entire Nelson watershed system.

<u>Pump Station Design Parameters</u>

Storage pump stations were sized according to the following guidelines:

- Gravity in-pump out options: Sized to dewater the storage facility within 24 hours
- Pump-in gravity out options: Sized to convey the peak flow into the storage facility.

Storage Tank Design Parameters

The concrete storage facilities were designed to minimize solids and debris from becoming trapped in the structure. These facilities are rectangular in shape with 4.0% side slopes, a 0.5% running slope, and a central channel to the outfall. All structural columns were circular to minimize solids being trapped behind them. An internal wall with reverse risers, an automated control gate, and an overflow weir was added to contain approximately 20% of the storage capacity. This compartment would act as a forebay, keeping most of the solids near the entrance/exit point. A sprayer system was included to further minimize the maintenance at these facilities. The footprint of the facility was based on the available land and the depth to rock. Conceptual storage facility details are presented in Appendix B.

Construction Considerations

Earthwork was a large cost driver for the facilities. The assumed excavation included a 4-ft clearance to all exterior walls. The excavation in soil assumed a 1:1 slope.

The rock depth at each site was estimated based on the rock depth shown on nearby existing sanitary sewer main as-builts. Rock excavation was assumed to be vertical, with major excavations completed through blasting. A higher unit cost for rock removal was used for deeper excavations to account for the challenges associated with increased depths. All excavated rock and excess soil was considered haul off material. Only soil was used for backfill.

Other underground storage facility components included:

- Access manholes for any required maintenance
- Air release and odor control
- Rock anchors for some of the shallower facilities
- Replacement and/or rehabilitation of existing park features and surface restoration
- SCADA
- Redundant power/generator

3.1.1 Turkey Creek

Two underground storage facilities were proposed in the Turkey Creek Basin – 2.1 MG at the southern location, and 0.8 MG at the northern location. One consolidated 3.7 MG storage facility was also considered at the southern location at or near Turkey Creek Streamway Park, based on the conceptual ICM modeling results described in Section 2.3. Each facility is strategically located along the Turkey Creek interceptor to store peak wet weather flows and avoid significant gravity upgrades that would otherwise be necessary.

3.1.1.1 TURKEY CREEK STREAMWAY PARK (TURKEY CREEK SOUTH)

Turkey Creek Streamway Park is owned by the City of Merriam, located east of cross streets W 69th Street and Farley Street. The property is just west of Merriam City Public Works. There are two high voltage power transmission lines under which the proposed storage facility would be constructed. A major gas transmission line also runs diagonally southwest to northeast through the center of the park separating it into two areas. Both the North and South sites were evaluated, individually and together.

The required storage volume and the peak flow rate are 2.1 MG and 11.1 MGD (3.7 MG and 16.4 MGD for consolidated), respectively.

Site-specific considerations for this facility include:

- Construction in the vicinity of two high voltage overhead power lines
    - Relocation of power lines considered to increase the storage footprint
- Upgrade of existing trail to improve site access
- Evaluation of the use of two sites split by gas transmission main
    - North of the gas transmission – In the floodway
    - South of the gas transmission – In the side of a cliff
- Site in the FEMA floodway – Would require no-rise

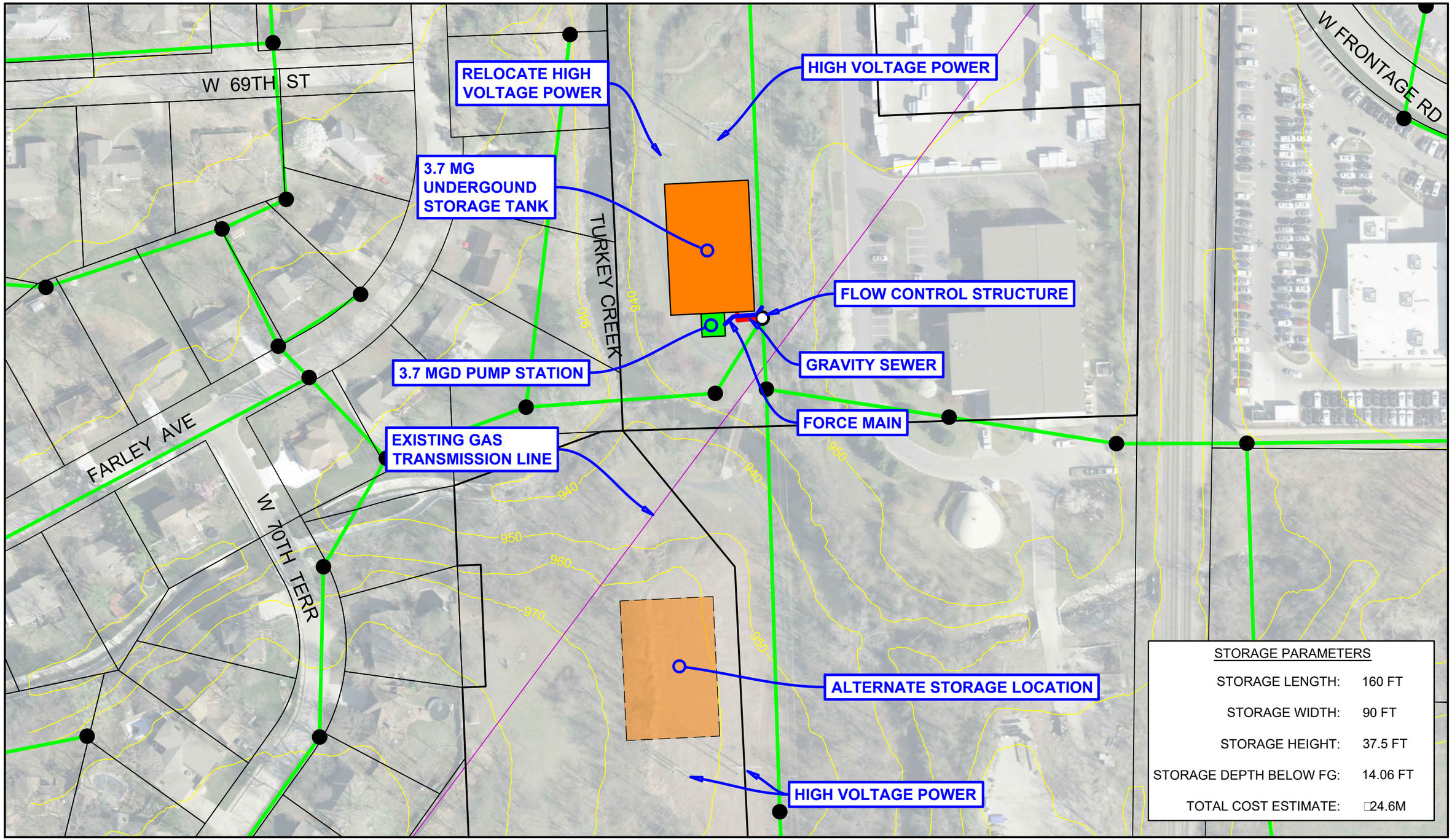
All storage options considered at Turkey Creek Streamway Park were:

- South Site Gravity In-Pump Out (2.1 MG)
- South Site Pump In-Gravity Out (2.1 MG)
- North Site Gravity In-Pump Out (2.1 MG)
- North Site Pump In-Gravity Out (2.1 MG)
- North Site Gravity In-Pump Out – Power Relocation (2.1 MG)
    - Two power transmission lines would be relocated to increase the storage footprint and decrease the depth in rock (reduced rock excavation)
- North Site Pump In-Gravity Out – Power Relocation (2.1 MG)
    - Two power transmission lines would be relocated to increase the storage footprint and decrease the depth in rock (reduced rock excavation)
- Combined North & South Gravity In-Pump Out (2.1 MG)
    - Both sites utilized with piping connecting the facilities
- Consolidated North Site Gravity In-Pump Out (3.7 MG)
    - This would eliminate the need for additional storage at Waterfall Park
- Consolidated North Site Gravity In-Pump Out – Power Relocation (3.7 MG)
    - This would eliminate the need for additional storage at Waterfall Park

The North Site Gravity In-Pump Out was initially selected at Turkey Creek Streamway Park. The conceptual site plan is shown in Figure 3-1. The drain pump was sized to dewater the facility within 24 hours following the 10-year design event (2.1 MGD). This was the least expensive option and would require the least amount of operational costs. The total estimated capital cost for this facility is $12.65M. Cost estimate details for this and all other storage options are included in Appendix C.

The Consolidated North Site Gravity In-Pump Out configuration was estimated to have a higher capital cost than the two separate storage facilities but would simplify system operations during wet weather events and reduce long term maintenance costs and is JCW's preferred alternative. The total estimated capital cost for this facility is $24.6M as compared to $20.55M for storage at both the Streamway and Waterfall Park sites. During design of this facility, it is recommend to consider alternate construction methods including an above ground storage tanks at the south site (with enhanced site screening) or tunneling options.

Cost estimate details for this and all other storage options are included in Appendix C.



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TURKEY CREEK STORAGE
CONSOLIDATED □ STREAMWAY
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03□08□2019

FIGURE
FIGURE 3-1

3.1.1.2 WATERFALL PARK (TURKEY CREEK NORTH)

Waterfall Park is owned by the City of Merriam, located east of cross streets W 52nd Street and Merriam Drive. The property is just west of I-35. The park is currently used as a small soccer facility with a trail at the south end. The optimization selected a minimum storage volume of 0.8 MG at Waterfall Park, with a peak flow to the facility of 6.8 MGD. A storage volume of 1 MG was evaluated in this analysis.

Site-specific considerations for this facility include:

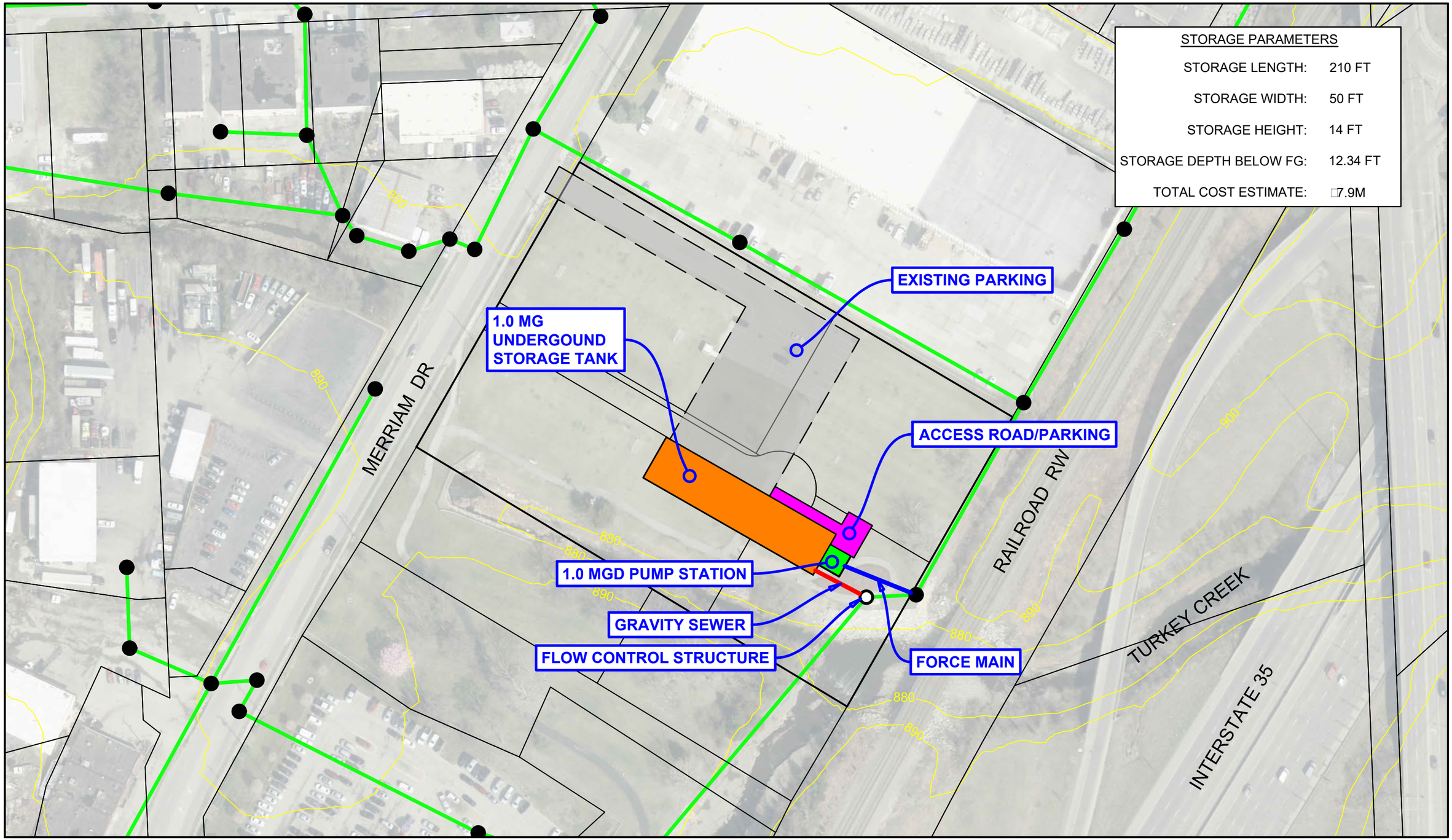
- Site is in the FEMA floodplain and would require a floodplain development permit
- Minor trail and parking lot replacement would be required

All storage options considered at Waterfall Park were:

- Gravity In-Pump Out (1.0 MG)
- Pump In-Gravity Out (1.0 MG)
- No Storage – No storage required at Waterfall Park if the consolidated storage is selected at Turkey Creek Streamway Park

The Pump In-Gravity Out option was found to be the least costly alternative at Waterfall Park by a small margin, but the Gravity In-Pump Out option was preferred as previously noted. The conceptual site plan is shown in Figure 3-2. The drain pump was sized to dewater the facility within 24 hours following the 10-year design event (1.0 MGD). The total estimated capital cost for this facility is $7.9M.

Cost estimate details for this and all other storage options are included in Appendix C.



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TURKEY CREEK STORAGE
WATERFALL PARK
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03 08 2019

FIGURE
FIGURE 3-2

3.1.2 Mission Main

One underground storage facility was proposed in the Mission Main Basin with a volume of 4.4 MG (10.2 MGD peak flow) at Porter Park near Brush Creek Pump Station. Porter Park is owned by the City of Prairie Village, located on the southeast corner of Roe Avenue and Tomahawk Road. The facility will drain back to Brush Creek PS following wet weather events, when the downstream system has adequate capacity.

Site-specific considerations for this facility include:

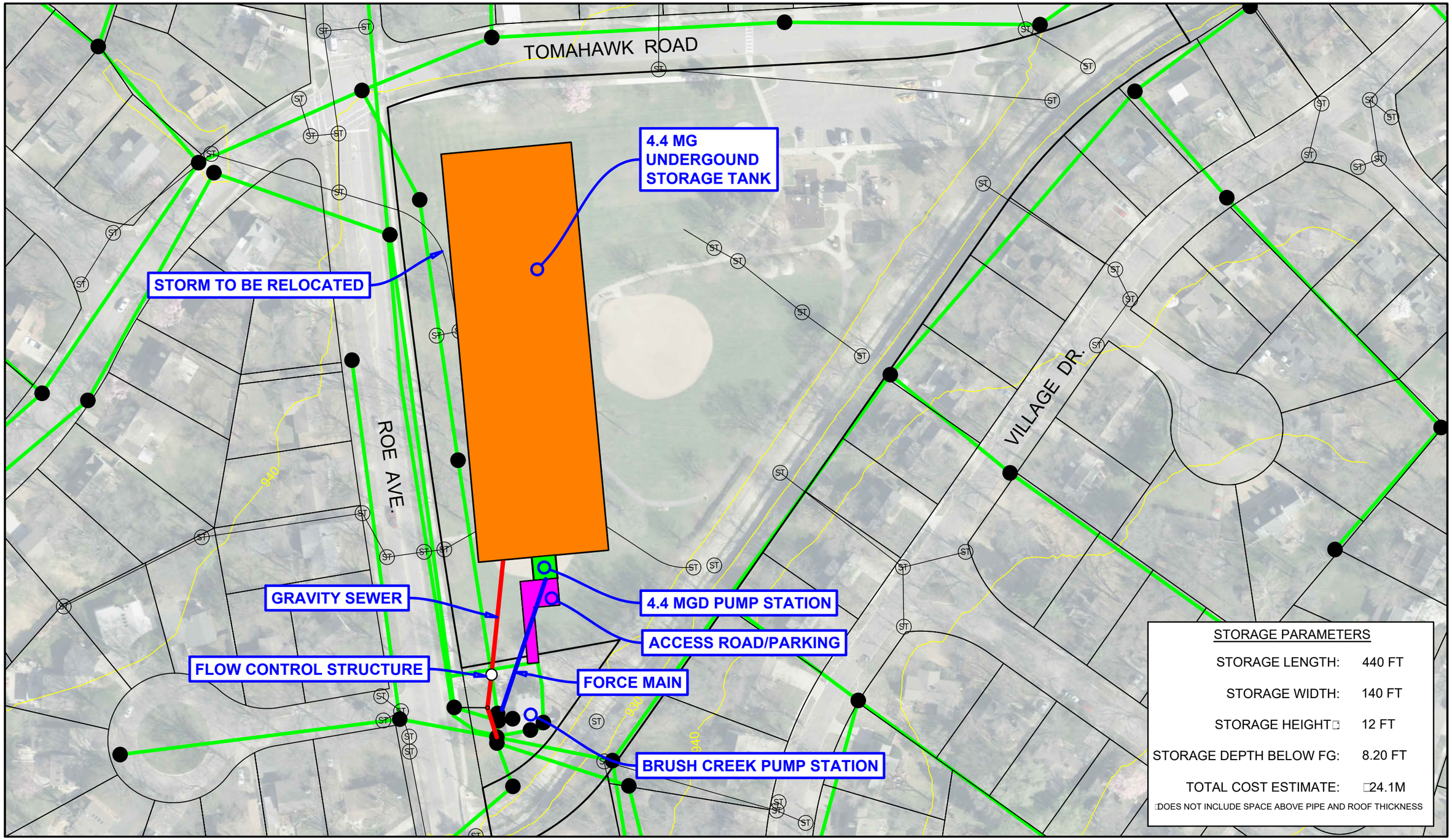
- Relocation of 60-inch RCP storm line
- Replacement of playground equipment and ball fields
- This site is not within the current (2018) FEMA floodplain and would not require floodplain permitting

All storage options considered at Porter Park were:

- Gravity In-Pump Out (4.4 MG)
- Pump In- Gravity Out (4.4 MG)

The Gravity Out-Pump In option at Porter Park was estimated to have a slightly lower capital costs, but the Gravity In-Pump Out option was the preferred alternative. The conceptual site plan is shown in Figure 3-3. The drain pump was sized to dewater the facility within 24 hours following the 10-year design event (4.4 MGD). The total estimated capital cost for this facility is $24.1M.

Cost estimate details for this and all other storage options are included in Appendix C.



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MISSION MAIN STORAGE
PORTER PARK
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE 03□08□2019

FIGURE

FIGURE 3-3

3.1.3 Summary of Selected Storage Facilities

A summary of selected underground storage facilities for Alternative 1 is presented in Table 3-1. Alternative 2 would require only storage at Turkey Creek Streamway Park. Storage at, or near, Porter Park would be exchanged for the upgraded 75th/Nall PEFTF.

Table 3-1: Summary of Selected Storage Facilities

Facility	Storage Volume (MG)	Pump Station Capacity (MGD)	Capital Cost ($M)
Turkey Creek Streamway Park (Turkey Creek South) (1)	3.7	3.7	24.6
Waterfall Park (Turkey Creek North) (1)	-	-	-
Porter Park (Brush Creek)	4.4	4.4	24.1
TOTAL			**48.7**

(1) The Turkey Creek required storage was consolidated to one location at Streamway Park removing the need at Waterfall Park.

3.2 Gravity Interceptors

Both localized gravity capacity improvements and major interceptor projects were selected in the optimization. Four (4) major interceptor projects were further evaluated for construction feasibility and refined cost estimating, two (2) in Turkey Creek and two (2) in Mission Main. Field visits were conducted to evaluate each existing alignment in greater detail and site specific details were incorporated to further refine costs. All costs are shown in 2018 dollars.

3.2.1 Turkey Creek – Interceptor Improvements

The optimization analysis indicated improvements were necessary on the Turkey Creek interceptor west of I-35 between 70th Street and 81st Street. During alternatives screening, parallel mains were determined to be feasible along this stretch of the interceptor. The conceptual alignment is shown in Figure 3-4.

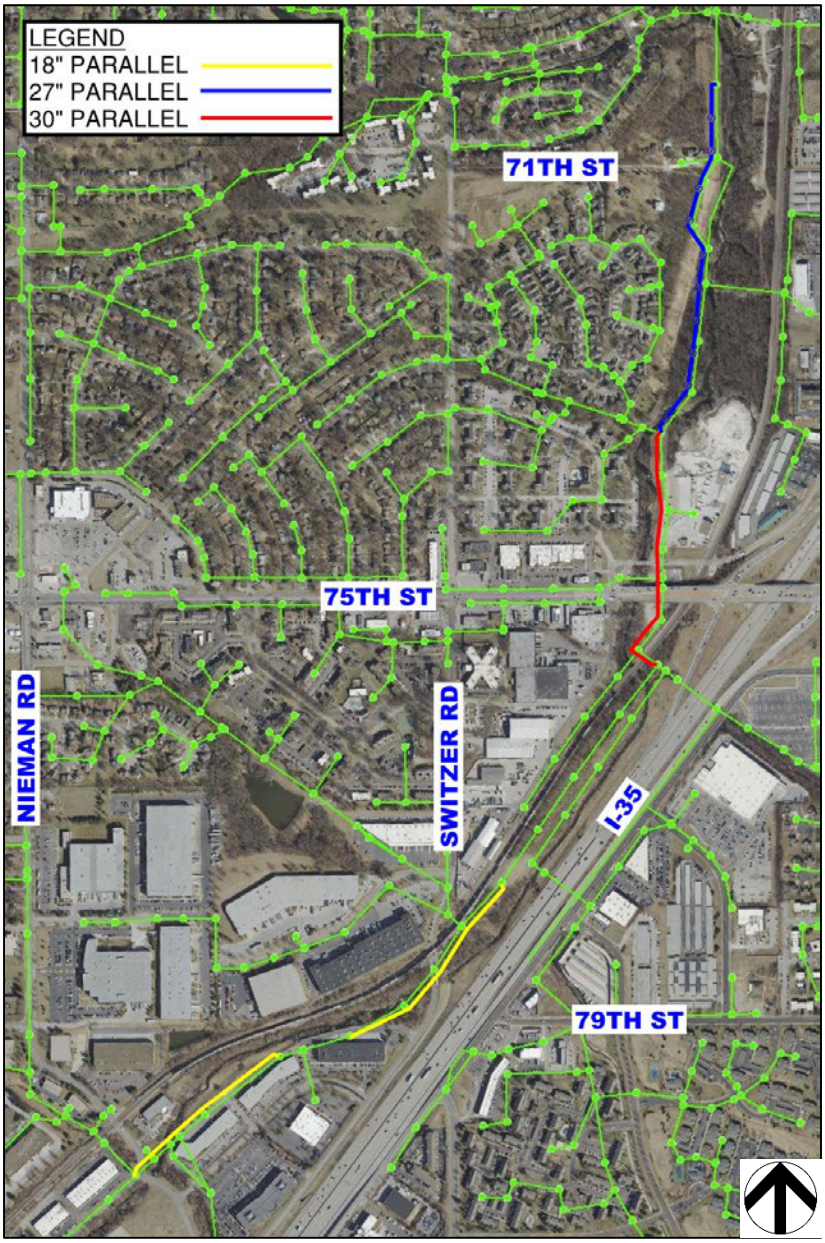

Figure 3-4: Turkey Creek Interceptor Improvements

Site-specific considerations for this improvement include:

- Arterial Crossings
- Line under existing business loading dock
- Stream crossings
- Railroad crossing
- Construction beneath 75th Street bridge
- Construction beneath high and low voltage overhead power
- Minimum to no bypass pumping would be required

Line improvements include approximately:

- 2,600 LF of parallel 18-inch main
- 2,300 LF of parallel 27-inch main
- 1,750 LF of parallel 30-inch main

The total estimated capital cost for the 6,650 LF of parallel main improvement is $5.1M. Cost estimate details for this are included in Appendix D.

3.2.2 Turkey Creek – Nieman Road Trunk Improvements

The optimization analysis indicated improvements were necessary on the Turkey Creek Nieman Road Trunk main between 60th Street and Shawnee Mission Parkway. The optimization designated an upsize-in-place of the existing gravity sewer.

During review, it was found that some of the proposed upgrades were recently replaced and in some cases upsized as part of a JCW street/storm program project coinciding with a stormwater channel improvements that included channel modifications and armoring. This recent project reduced the extents of the capacity improvements; however it was determined that some additional trenchless construction would be required at crossings of the improved concrete lined stream channel. The conceptual alignment is shown in Figure 3-5.

Site-specific considerations for this improvement include:

- Arterial Crossings
- Concrete channel crossings
- Construction near existing concrete wall/building
- Bypass pumping would be required

Line improvements include approximately:

- 1,100 LF of 21-inch main
- 1,200 LF of 27-inch main

The total estimated capital cost for the 2,300 LF of upsize main improvement is $2.3M. Cost estimate details for this are included in Appendix D.

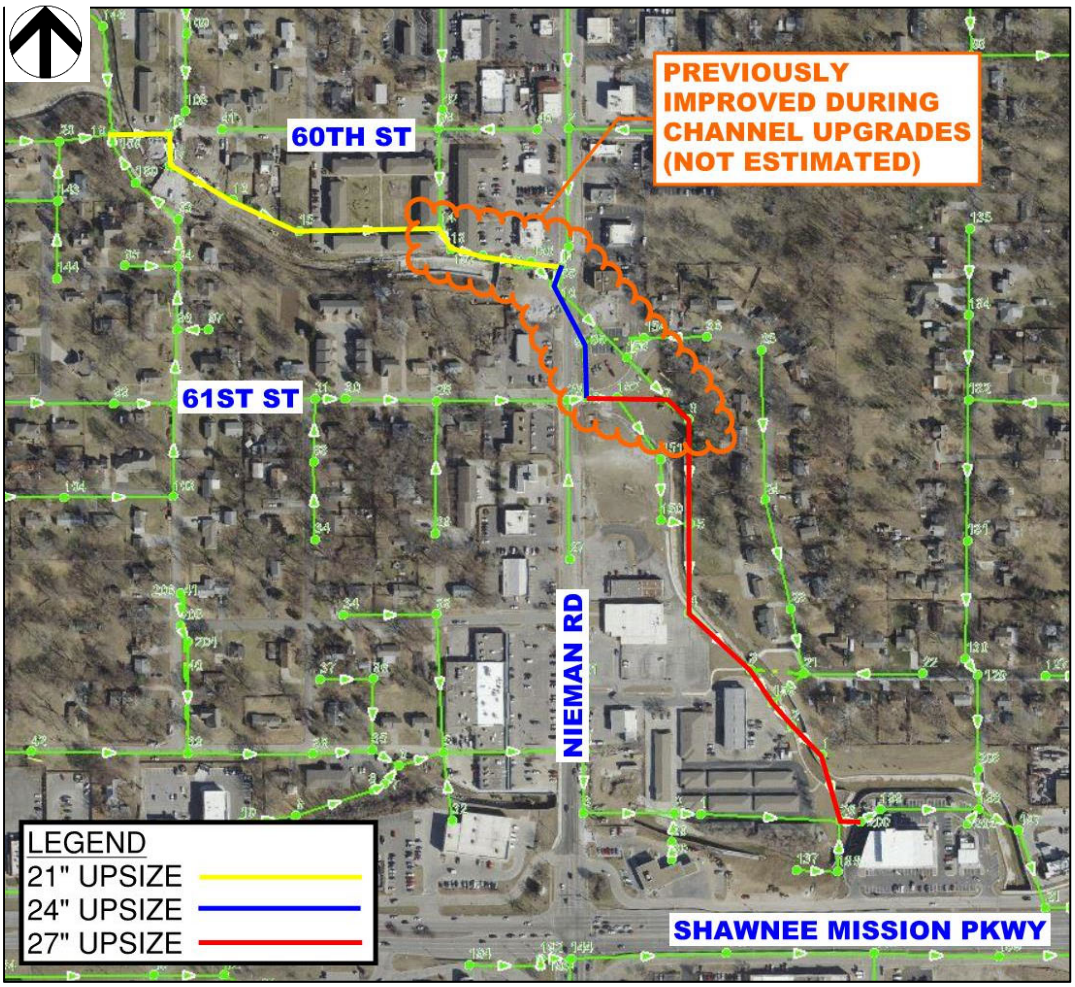

Figure 3-5: Turkey Creek – Nieman Road Trunk Improvements

3.2.3 Mission Main – Brush Creek Interceptor Improvements

The optimization analysis indicated that once the 75th and Nall PEFTF is decommissioned, improvements will be necessary on the Brush Creek interceptor to convey flow to the Brush Creek Pump Station. The conceptual alignment is shown in Figure 3-6.

Site-specific considerations for this improvement include:

- Arterial Crossings
- Construction in the street
- Construction near concrete/gabion channel
- Bypass pumping would be required

Line improvements include approximately:

- 2,800 LF of 36-inch main
- 800 LF of 48-inch main

The total estimated capital cost for the 3,600 LF of upsize main improvement is $3.75M. Cost estimate details for this are included in Appendix D.

Figure 3-6: Mission Main – Brush Creek Interceptor Improvements

3.2.4 Mission Main – Belinder Interceptor Improvements

The optimization analysis indicated improvements were necessary on the Belinder interceptor between Mission Road and North of 63rd Street. The conceptual alignment is shown in Figure 3-7.

Site-specific considerations for this improvement include:

- Arterial Crossings
- Stream crossings
- Construction on narrow streets with limited shoulders in Mission Hills
- Bypass pumping would be required

Line improvements include approximately:

- 1,800 LF of 27-inch main
- 2,650 LF of 36-inch main

The total estimated capital cost for the 4,450 LF of upsize main improvement is $4.9M. Cost estimate details for this are included in Appendix D.

Figure 3-7: Mission Main – Belinder Interceptor Improvements

3.2.5 Summary of Selected Gravity Main Improvements

A summary of selected gravity main improvements for Alternative 1 is presented in Table 3-2. Improvements are similar for Alternative 2, however that alternative does not require an upgrade of the Brush Creek Interceptor.

Table 3-2: Summary of Gravity Main Improvements

Project	Improvement Length (LF)	Diameter Range (in)	Capital Cost ($M)
Turkey Creek Interceptor	6,650	18-30	5.1
Turkey Creek – Nieman Road Trunk	2,300	21-27	2.3
Brush Creek Interceptor	3,600	36-48	3.75
Belinder Interceptor	4,450	27-36	4.9
TOTAL	**17,000**	**18-48**	**16.05**

3.3 Pump Stations

Three (3) major pump stations were selected for upgrade during the refined optimization process, Turkey Creek, Rock Creek, and Belinder Pump Stations (PS). Brush Creek PS was not selected for upgrade due to the recommendation to store peak flows at an underground storage facility, which resulted in no increase in peak flow to Brush Creek PS. As part of the alternative refinement process, more detailed screening and pumping improvements at each pump station site were evaluated to develop more refined upgrade costs. All costs are shown in 2018 dollars.

Conceptual design details for each pump station site can be found in Section 6.2 of *Nelson Complex WWTP and Collection System Technical Memorandum #5 – Project Development*, March 2019.

Due to the current condition and rehabilitation needs at Rock Creek PS, it has been proposed to completely replace the pump station as a part of the long term plan. In the PEFTF Elimination alternative, construction could be phased to delay a portion of the expenditures (wet weather pumps and piping) until such time that the Martway PEFTF is eliminated and additional capacity is needed at the pump station. In this arrangement, the entire pump station structure and associated site work would be completed during the initial phase with wet weather pumps and piping being added in the follow on phase.

A summary of selected pump station capacity upgrades for Alternative 1 is presented in Table 3-3. Note that all of the capital costs required to fully replace the Rock Creek PS are shown in the table; however, only the costs attributed to wet weather conveyance will be carried forward in the rest of this TM. Alternative 2 does not require any major pump station capacity upgrades, as upgraded PEFTFs would handle excess flows.

Table 3-3: Summary of Selected Pump Station Upgrades

Facility	Pump Station Total Capacity (MGD)	Capital Cost ($M)
Turkey Creek PS	43	8.02
Rock Creek PS	24	16.98
• DW Conveyance (Phase 1)	12	11.44
• Initial WW Conveyance (Phase 1)	0	4.00
• Future WW Conveyance (Phase 2)	12	1.54
Belinder PS	54	25.66
TOTAL	**121**	**50.66**

3.4 Forcemains

Corresponding with the major pump station upgrades, three (3) parallel forcemains were selected during refined optimization:

- Turkey Creek PS: New 36-inch main, abandon existing 24-inch main
- Rock Creek PS: Parallel 24-inch main
- Belinder PS: Parallel 48-inch main

Field visits were conducted to evaluate each forcemain alignment in greater detail during alternatives development. Site specific details were incorporated to further refine costs (all costs are shown in 2018 dollars). Minimum depths were assumed for the forcemain installation. The conceptual alignments were set to avoid existing utilities and maintain appropriate separations where possible.

3.4.1 Turkey Creek

There are two existing forcemains from Turkey Creek PS to the Nelson Complex, 24-inches and 30-inches in diameter. The length used for the Turkey Creek forcemain in the optimization was 3,500 LF, roughly corresponding to the existing alignment length. Both forcemains will be extended, at their existing diameters, to the proposed Headworks Building location on the north side of the Nelson Complex as a part of the WWTF project. The extension alignment length is estimated to be 600 LF.

The optimization selected a parallel 36-inch main to replace the existing 24-inch main. The length used during alternatives development to refine costs for the new main is inclusive of the existing alignment length and the extension length for a total of 4,100 LF. The conceptual alignment is shown in Appendix E.

Site-specific considerations for this improvement include:

- Arterial Crossing
- Construction in the road
- Limited access on Foxridge Drive
- Avoid new administration building near Nelson plant entrance

The total estimated project costs for the new wet weather forcemain and initial optimization estimate are as follows:

- Optimization: 3,500 LF at $3.2M
- Alternatives Development: 4,100 LF at $3.6M

3.4.2 Rock Creek

There is one existing 24-inch diameter forcemain from Rock Creek PS to the Nelson Complex. The length used for the Rock Creek forcemain in the optimization was 7,047 LF, roughly corresponding to the existing alignment length. This forcemain will be extended at the existing diameter to the proposed Headworks Building as a part of the WWTF project. The extension alignment length is estimated to be 2,553 LF.

The optimization selected a parallel 24-inch main. The conceptual alignment is shown in Appendix E.

Site-specific considerations for this improvement include:

- Arterial Crossings

- Working in Roe Avenue
- Highly congested alignment with existing utilities
- Bore under Roe at the north end

The total estimated project costs for the new wet weather forcemain and initial optimization estimate are as follows:

- Optimization: 7,047 LF at $5.7M
- Alternatives Development: 9,600 LF at $5.8M

3.4.3 Belinder

There are two existing forcemains from Belinder PS to the Nelson Complex, 24-inches (State Park Rd) and 16-inches (Belinder Rd) in diameter. Only the 24-inch forcemain is in operation at this time. The length used for the Belinder forcemain in the optimization was 10,604 LF, roughly corresponding to the existing 24-inch forcemain alignment length. This forcemain will be extended at the existing diameter to the proposed Headworks Building as a part of the WWTF project. The extension alignment length is estimated to be 3,196 LF.

The optimization selected a parallel 48-inch main. The conceptual alignment is shown in Appendix E.

Dual 36-inch forcemains were also considered instead of the single 48-inch, which would provide a redundant system that could alternate between the three forcemains. After the initial evaluation it was determined that two parallel lines would not fit in the already congested alignment. The second 36-inch forcemain was evaluated in the alignment of the existing out of service 16-inch main. This alternate alignment is approximately 16,600 LF (2,800 LF longer than the other forcemain).

Site-specific considerations for this improvement include:

- Arterial Crossings
- Construction in the road
- Bore under Roe Ave at the north end

The total estimated project costs for the new wet weather forcemain and initial optimization estimate are as follows:

- Optimization: 10,604 LF at $9.2M (single 48-inch FM)
- Alternatives Development: 13,800 LF at $16.8M (single 48-inch FM)
- Alternatives Development: 30,400 LF at $27.4M (dual 36-inch FMs)

3.4.4 Summary of Selected Forcemain Upgrades

A summary of selected forcemain upgrades for Alternative 1 is presented in Table 3-4. Alternative 2 does not require any major forcemain upgrades. Detailed cost estimates can be found in Appendix E.

Table 3-4: Summary of Selected Forcemain Upgrades

Facility	Total Alignment Length (LF)	Diameter (in)	Capital Cost ($M)
Turkey Creek Forcemain	4,100	36	3.64
Rock Creek Forcemain	9,600	24	5.82
Belinder Forcemain	13,800	48	16.80
TOTAL	**27,500**	**24-48**	**26.26**

3.5 Auxiliary Treatment Facility

Conceptual design details for the ATF can be found in Section 6.2 of *Nelson Complex WWTP and Collection System Technical Memorandum #5 – Project Development*, March 2019. Detailed cost estimates can be found in Appendix A of the same document. A summarized cost estimate (in 2018 dollars) for the ATF is presented below in Table 3-5.

Table 3-5: Summary of Updated Estimated ATF Costs

Cost Item	Capital Costs ($M)
Initial ATF Constructed with WWTF (Phase 1)	10.32
Future ATF Phases (Phases 2-4)	27.20
TOTAL	**37.52**

3.6 Updated Alternative Cost

Total updated costs (in 2018 dollars) for Alternative 1 are presented in Table 3-6. The increase in cost was driven largely by the increased forcemain length for the Rock Creek and Belinder parallel mains and construction challenges, particularly along the Belinder forcemain alignment.

Table 3-6: Alternative 1 - Updated Cost Estimate Comparison

Cost Item	Total Nelson - Optimization Costs ($M)	Total Nelson - Updated Costs ($M)
Gravity Sewers	28.80	31.87
Pumping Station Upgrades [1]	37.77	39.21
Force Mains	18.06	26.26
Underground Storage Facilities	40.38	48.69
Linear Storage	-	-
PEFTF Upgrades	-	-
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	13.89	13.89
ATF Phases 1 - 3	40.76	37.52
Total, Capital Costs	**209.65**	**227.44**
Comparative O&M Increase	11.32	11.32
Total, with Incremental O&M Life Cycle Costs	**220.97**	**238.76**

[1] Includes portion of new Rock Creek pump station (constructed with treatment plant) attributable to wet weather conveyance.

4 Development of Major Capital Projects (Alternative 2)

In Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment, the PEFTFs would be retained and upgraded to include enhanced high rate treatment, in lieu of wet weather pump station/forcemain upgrades and storage near Brush Creek PS. In order to further increase confidence in the major CIP expenditures recommended in this alternative, detailed planning level costs were developed for the PEFTF upgrades. All costs detailed in this section are shown in 2018 dollars.

The storage facility and gravity sewer capacity projects included in Alternative 2 are identical or very similar to the capital projects proposed for Alternative 1. Therefore, development details for these projects are not included in this section. Refer to Section 3 for details on the underground storage and gravity sewer projects included in Alternative 2.

4.1 PEFTFs

Four (4) PEFTFs were selected for upgrade during the refined optimization process, Turkey Creek, Martway, 75th/Nall, and Belinder PEFTFs. As part of the alternative refinement process, more detailed improvements at each PEFTF site were evaluated to develop a more refined upgrade costs.

Conceptual design details for each PEFTF site can be found in Section 6.3 of *Nelson Complex WWTP and Collection System Technical Memorandum #5 – Project Development*, March 2019. Detailed cost estimates can be found in Appendix A of the same document. A summary of updated costs for each PEFTF is also presented in Table 4-1.

Table 4-1: Summary of Updated Estimated PEFTF Costs

Facility	Firm Capacity (MGD)	Capital Cost ($M)
Turkey Creek PEFTF	15.2	17.01
Martway PEFTF	12	15.03
75th/Nall PEFTF	15	17.58
Belinder PEFTF	42	37.44
TOTAL	**84**	**87.06**

4.2 Updated Alternative Cost

Total refined costs for Alternative 2 are presented in Table 4-2. The increase in costs was driven primarily by increased capital cost to upgrade the Belinder PEFTF.

Table 4-2: Preferred PEFTF Upgrade Alternative - Updated Cost Estimate Comparison

Cost Item	Total Nelson - Optimization Costs ($M)	Total Nelson - Updated Costs ($M)
Gravity Sewers	27.12	29.76
Pumping Station Upgrades [1]	-	-
Force Mains	-	-
Underground Storage Facilities	27.51	24.59
Linear Storage	-	-
PEFTF Upgrades	55.21	87.05
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	9.49	9.49
ATF Phases 1 - 3	-	-
Total, Capital Costs	**149.33**	**187.49**
Comparative O&M Increase	6.67	6.67
Total, with Incremental O&M Life Cycle Costs	**156.00**	**194.16**

[1] Includes portion of new Rock Creek pump station (constructed with treatment plant) attributable to wet weather conveyance.

5 Triple Bottom Line Evaluation

5.1 Qualitative Criteria

A triple bottom line evaluation was performed to evaluate non-quantitative characteristics of the PEFTF Elimination and PEFTF Upgrade alternatives. Six (6) qualitative criteria were included in the evaluation: operational complexity/performance risk, adaptability/phasing, land requirements, short term social impacts, long term social impacts, and environmental impacts. These criteria were reviewed with JCW staff during the workshop on February 6, 2019 and updated to reflect JCW input.

5.1.1 Operational Complexity/Performance Risk

This criterion encompasses how well the alternative is able to manage fluctuations of flow, reliability and redundancy, how proven the technology is, and the complexity of required oversight and maintenance. Key notes on the advantages and disadvantages of each alternative are provided below.

<u>Alternative 1 - Eliminate PEFTFs through Wet Weather Management</u>

- Pumping and coarse screening are straight forward and reliable processes
- Additional collection system storage facilities require additional maintenance
- Management of swing from high wet weather to low dry weather flows, primarily in terms of forcemain detention times
- Wet weather pump stations/forcemains increase overall system vulnerability as forcemain breaks would stop the conveyance of flow (unlike PEFTFs which convey flow out of the system onsite)

<u>Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment</u>

- More processes and more operational complexity/performance risk
- Disk filtration is generally less proven than pumping and storage, particularly in remote locations that only operate during wet weather
- Unattended equipment startup when storms begin at night
- Maintaining filters “wetted” during periods of dry weather
- Maintaining proper chemical feed rates with varying flows and chlorine demands

5.1.2 Adaptability/Phasing

This criterion encompasses how easily the alternative can be upgraded for future conditions or requirements and whether the alternative can be phased to meet changing needs over time in a cost effective manner.

<u>Alternative 1 - Eliminate PEFTFs through Wet Weather Management</u>

- The ATF can be expanded in modules as PEFTFs are eliminated and wet weather pump stations/forcemains are constructed

<u>Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment</u>

- Potentially flexible CIP scheduling as each PEFTF upgrade could be constructed separately
- MOPOs more complex at PEFTFs than for pump stations and storage

5.1.3 Land Requirements

This criterion encompasses land acquisition, easements, and right-of-way permits required to construct and maintain the alternative.

Alternative 1 - Eliminate PEFTFs through Wet Weather Management

- No land acquisition required for pump station capacity upgrades
- Easements and right-of-way permits required along wet weather forcemain alignments
- Land acquisition required for underground storage sites

Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment

- Martway PEFTF requires land acquisition for disk filter building

5.1.4 Short Term Social Impacts

This criterion encompasses social impacts relating to conditions present during construction.

Alternative 1 - Eliminate PEFTFs through Wet Weather Management

- Disruption at pump stations and storage sites during construction
- Disruption along forcemain alignments during construction

Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment

- Disruption at PEFTF sites during construction

5.1.5 Long Term Social Impacts

This criterion encompasses social impacts relating to long term conditions including how well the alternative performs in terms of traffic, noise, odors, and aesthetics.

Alternative 1 - Eliminate PEFTFs through Wet Weather Management

- Odor potential due to long forcemain/detention times, removal/hauling of screenings from pump stations, retention of wastewater at storage facilities

Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment

- Odor potential due to retention of wastewater at PEFTFs, removal/hauling of screenings
- Concerns related to hauling of chemicals
- Impact on neighborhood aesthetics due to larger facility footprints for disk filter building at each PEFTF

5.1.6 Environmental Impacts

This criterion encompasses environmental impacts and regulatory considerations of the alternative including expected water quality and regulatory support.

Alternative 1 - Eliminate PEFTFs through Wet Weather Management

- Better wet weather treatment expected since the treatment process is consolidated in one centralized, manned facility

Alternative 2 - Retain PEFTFs with Enhanced Wet Weather Treatment

- Higher risk of long term regulatory exposure

5.2 Qualitative Criteria Benefit Scoring

The criteria were assigned weightings to quantify the relative importance of each criterion to JCW. Established criteria weightings are presented in Table 5-1. Environmental impacts and operational complexity/performance risk were weighted as most important.

Table 5-1: Qualitative Criteria Weighting

Criteria	Weighting Percentages	Relative Weights
Operational Complexity/Performance Risk	25	2.5
Adaptability/Phasing	5	0.5
Land Requirements	10	1.0
Short Term Social	10	1.0
Long Term Social	20	2.0
Environmental	30	3.0
Total	**100**	**10**

A relative benefit score was then assigned to each criterion for each of the two alternatives to quantify (on a scale of 1 to 10) the ability of the alternative to meet each criterion. The benefit scoring for each alternative is presented in Table 5-2.

Table 5-2: Alternative Benefit Scoring

Criteria	Alternative 1 PEFTF Elimination	Alternative 2 PEFTF Retention
Operational Complexity/Performance Risk	7	3
Adaptability/Phasing	6	4
Land Requirements	5	5
Short Term Social	3	7
Long Term Social	6	4
Environmental	7	3
Total	**34**	**26**

The criteria weighting multiplied by the alternative benefit scoring gives the alternative weighted benefit scoring, presented in Table 5-3 and graphically in Figure 5-1. Excluding cost, Alternative 1 (PEFTF Elimination) has a higher weighted benefit score, meaning it provides the most qualitative value to JCW.

Table 5-3: Alternative Weighted Benefit Scoring

Criteria	Alternative 1 PEFTF Elimination	Alternative 2 PEFTF Retention
Operational Complexity/Performance Risk	17.5	7.5
Adaptability/Phasing	3.0	2.0
Land Requirements	5.0	5.0
Short Term Social	3.0	7.0
Long Term Social	12.0	8.0
Environmental	21.0	9.0
Total	**61.5**	**38.5**
Weighted Rank	**1**	**2**

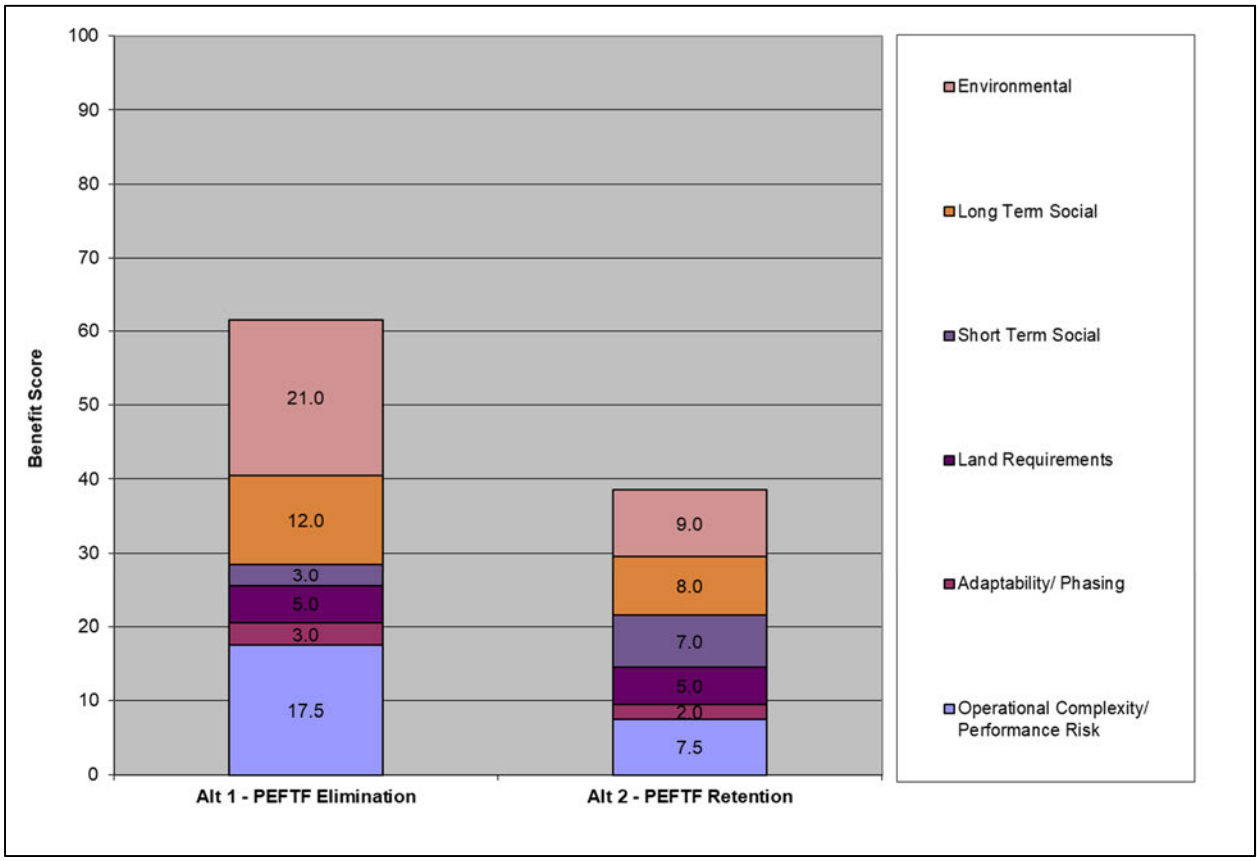

Figure 5-1: Alternative Weighted Benefit Scoring

5.3 Cost to Benefit Ratio

Utilizing the non-economic criteria to weight the cost alternatives allows for the determination of the alternative that provides the best value option for the Nelson watersheds. Figure 5-2 shows the projected 20-year net present value cost per weighted benefit score for each alternative. This analysis shows that Alternative 1 (PEFTF Elimination) has a lower cost to non-economic benefit ratio. Although the NPV of Alternative 1 is higher than Alternative 2, Alternative 1 provides better overall value to JCW when non-economic factors are taken into consideration.

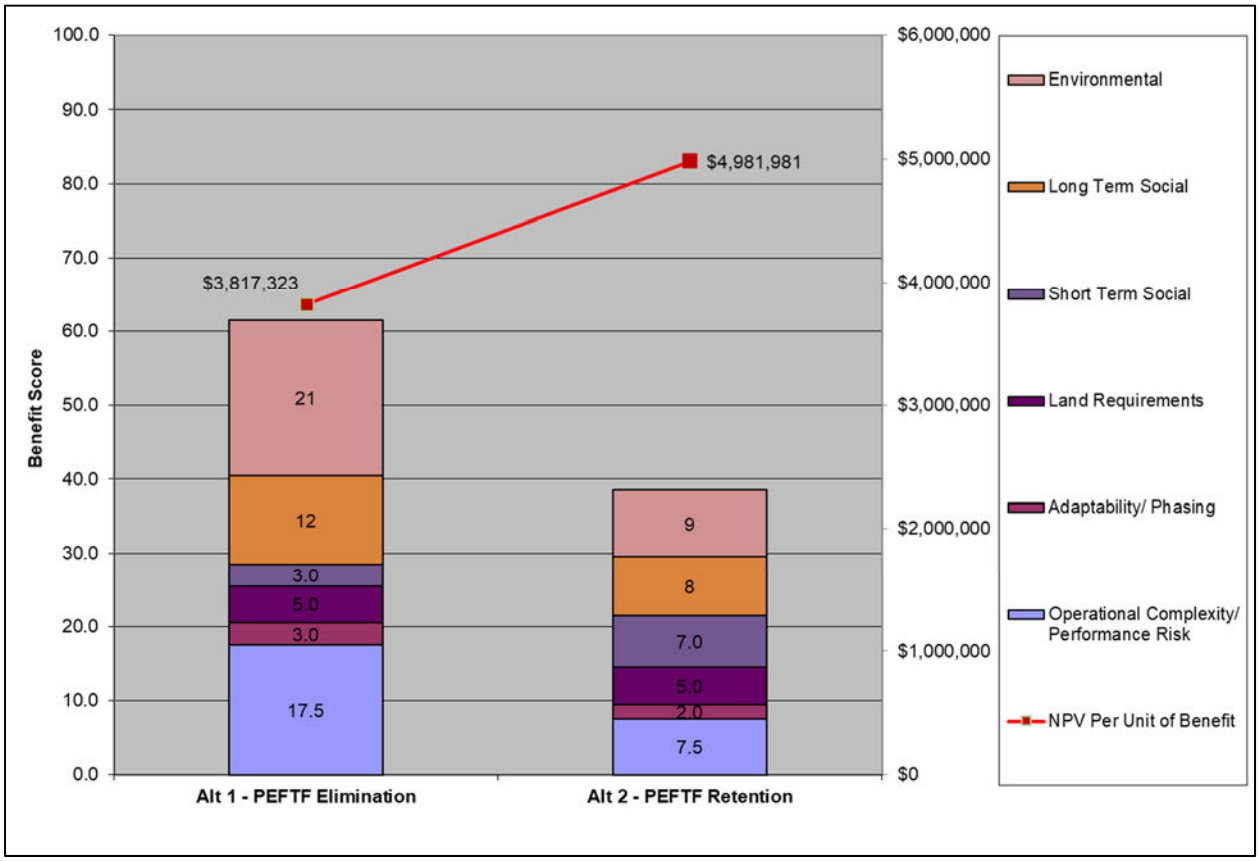

Figure 5-2: Alternative Weighted Cost Benefit Scoring

6 Summary and Next Steps

6.1 Alternative Costs

Two alternatives, *Alternative 1: Eliminate PEFTFs through Wet Weather Management* and *Alternative 2: Retain PEFTFs with Enhanced High Rate Treatment*, were more fully developed in terms of level of design detail and cost estimating.

A comparison of updated costs (in 2018 dollars) is presented in Table 6-1. The updated solutions are presented in Figure 6-1 and Figure 6-2, for Alternative 1 and Alternative 2, respectively.

Table 6-1: Alternative 1 and 2 - Comparison of Updated Costs

Cost Item	Alternative 1	Alternative 2
Gravity Sewers	31.87	29.76
Pumping Station Upgrades (1)	39.21	-
Force Mains	26.26	-
Underground Storage Facilities	48.69	24.59
Linear Storages	-	-
PEFTF Upgrades	-	87.05
Baseline I/I Reduction	30.00	30.00
Additional I/I Reduction	13.89	9.49
ATF Phases 1 - 3	37.52	-
Total, Capital Costs	**227.44**	**187.49**
Comparative O&M Increase	11.32	6.67
Total, with Incremental O&M Life Cycle Costs	**238.76**	**194.16**

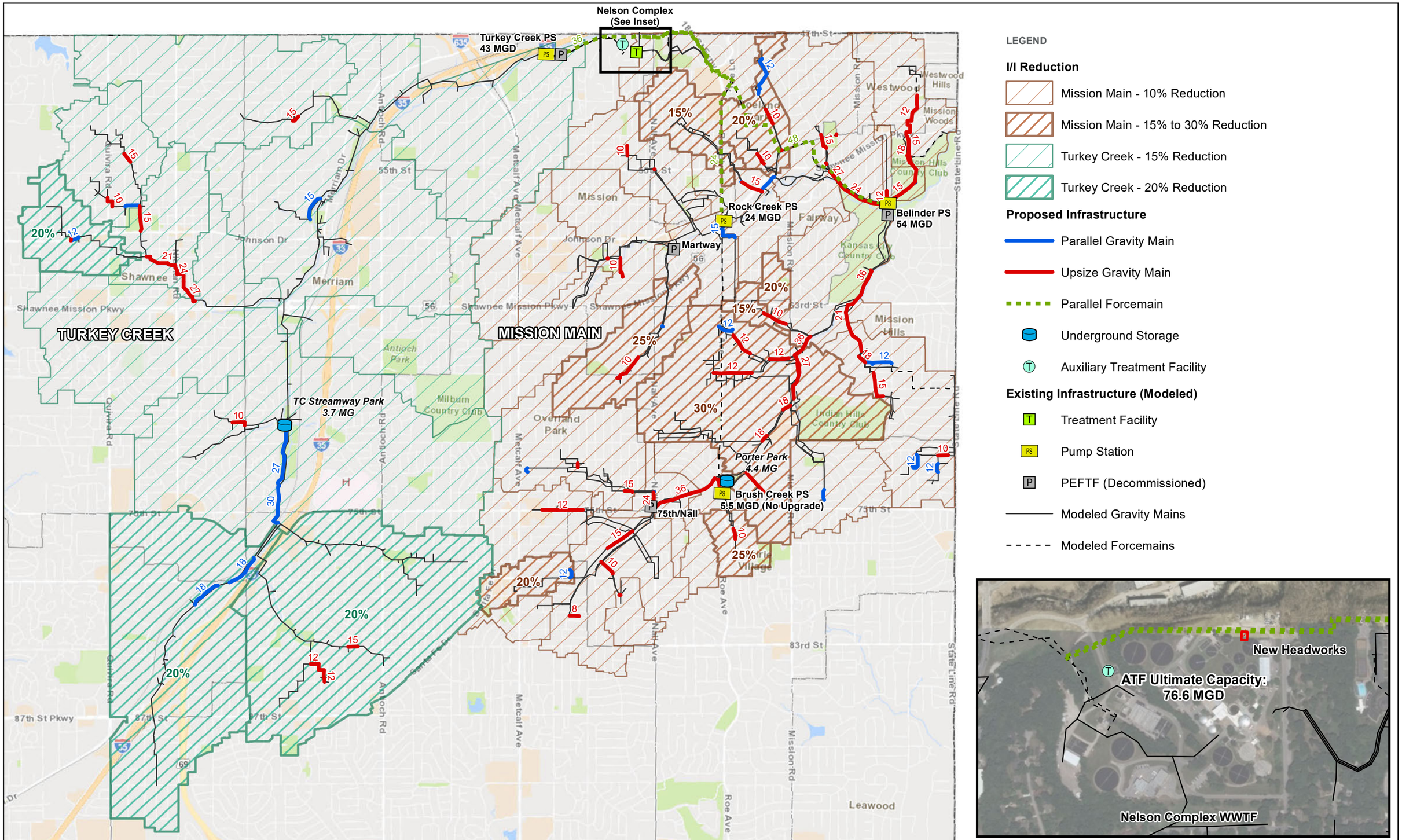

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FIGURE 6-1

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 1: ELIMINATE PEFTFS THROUGH WET WEATHER MANAGEMENT

UPDATED SOLUTION

Nelson Complex (See Inset)

Turkey Creek PS & PEFTF
PS: No Upgrade
PEFTF: 15 MGD

Rock Creek PS
No Upgrade

RC Tunnel
0.6 MG

Martway
12 MGD

Belinder PS & PEFTF
PS: No Upgrade
PEFTF: 42 MGD

TC Streamway Park
3.7 MG

Brush Creek PS
No Upgrade

75th/Nall
15 MGD

TURKEY CREEK

MISSION MAIN

LEGEND

I/I Reduction

- Mission Main - 10% Reduction
- Mission Main - 15% to 30% Reduction
- Turkey Creek - 15% Reduction
- Turkey Creek - 20% Reduction

Proposed Infrastructure

- Parallel Gravity Main
- Upsize Gravity Main
- Forcemain Extension to New Headworks
- Underground Storage
- Nelson_Storage

Existing Infrastructure (Modeled)

- Treatment Facility
- Pump Station
- PEFTF
- Modeled Gravity Mains
- Modeled Forcemains

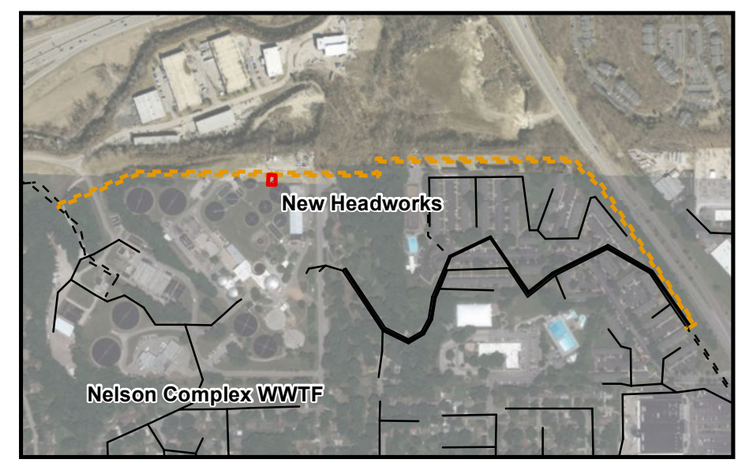

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FIGURE 6-2

NELSON COMPLEX COLLECTION SYSTEM WET WEATHER SOLUTIONS

ALTERNATIVE 2: RETAIN PEFTFS WITH ENHANCED HIGH RATE TREATMENT

UPDATED SOLUTION

6.2 Triple Bottom Line

A triple bottom line evaluation was performed to evaluate non-quantitative characteristics of the PEFTF Elimination and PEFTF Upgrade alternatives. Six (6) qualitative criteria were included in the evaluation: operational complexity/performance risk, adaptability/phasing, land requirements, short term social impacts, long term social impacts, and environmental impacts. These criteria were reviewed with JCW staff during the workshop on February 6, 2019 and updated to reflect JCW input.

The Alternative Weighted Benefit Scoring and Alternative Weighted Cost per Benefit scoring are shown below in Figures 6-3 and 6-4, respectively.

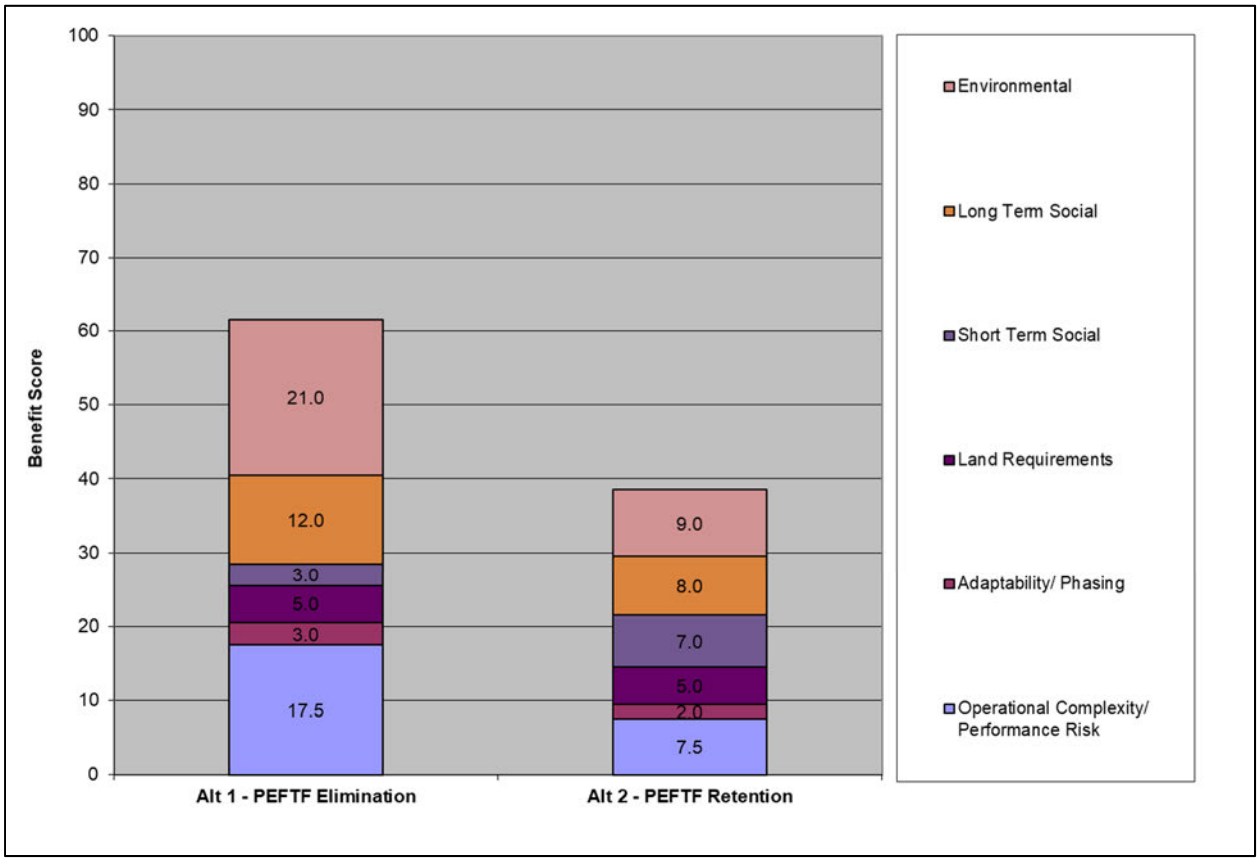


Figure 6-3: Alternative Weighted Benefit Scoring

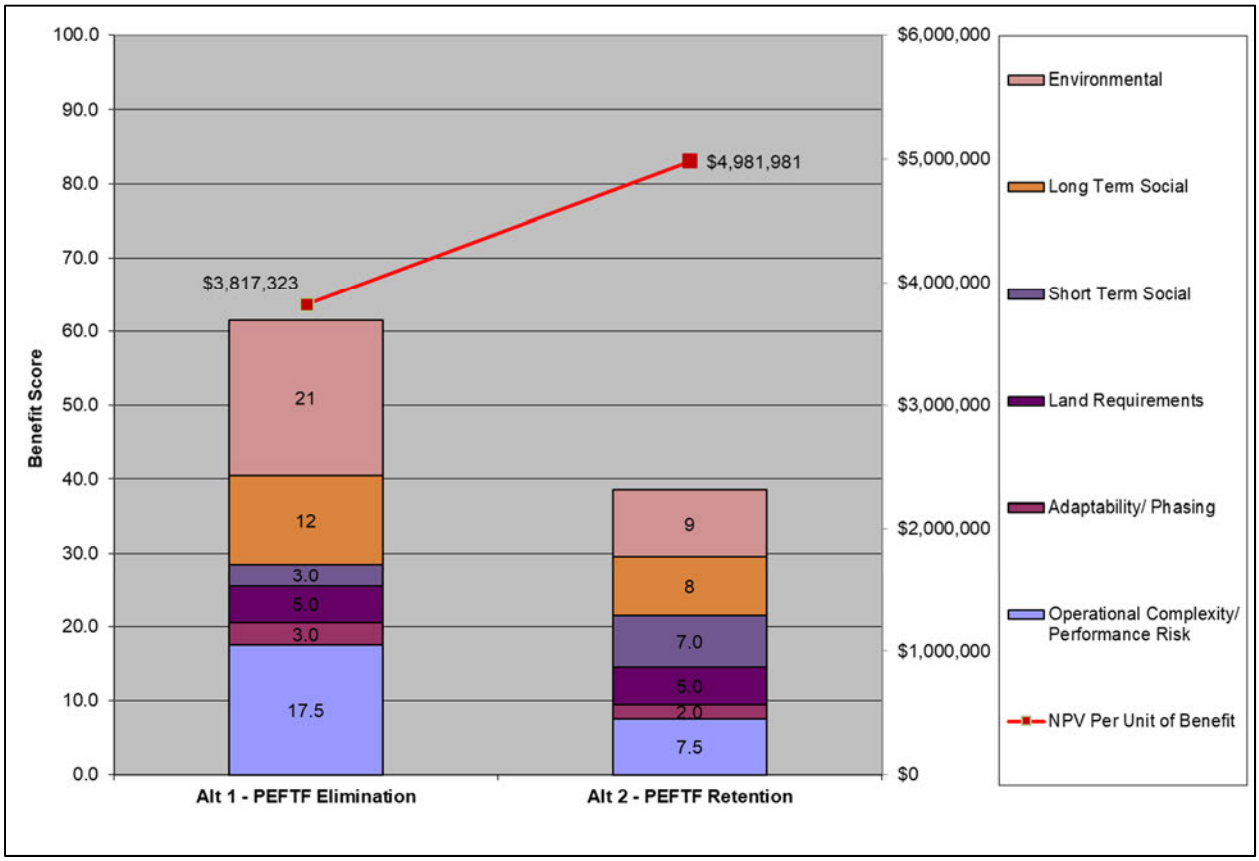


Figure 6-4: Alternative Weighted Cost Benefit Scoring

The Triple Bottom Line evaluation determined that Alternative 1 (PEFTF Elimination) has a lower cost to non-economic benefit ratio. Although the NPV of Alternative 1 is higher than Alternative 2, Alternative 1 provides better overall value to JCW when non-economic factors are taken into consideration.

6.3 Recommendations and Next Steps

In conjunction with the WWTF Plan, the key findings and recommendations include the following:

- An optimized layout was determined for the Nelson Complex BNR upgrades. A schedule, sequencing plan, and interim operations plan were developed. The project is tentatively scheduled for construction in 2024-2028, with mid-point in year 2026.
- The treatment plant total project cost is estimated to be $328 million in 2018 dollars ($416 million in 2026 dollars). With the necessary improvements to the pump stations that pump to the plant, the total cost is estimated to be $353 million in 2018 dollars ($447 million in 2026 dollars).
- A detailed optimization process and comparative analysis concluded that Alternative 1 (removal of the PEFTFs and conveyance of wet weather flows to the WWTF for auxiliary treatment) is the best long term plan for the Nelson Watershed.

- In support of the wet weather analysis, wet weather pumping upgrades were estimated to cost $39 million, while PEFTF upgrades, should the PEFTFs be retained, were estimated at $87 million (both figures in 2018 dollars). The overall watershed cost, including collection system improvements, was less for Alternative 2 (PEFTF Retention) - $187 million vs $227 million capital, $194 million vs $239 million Net Present Value (all in 2018 dollars). However, the triple Bottom Line analysis strongly favored conveyance and centralized auxiliary treatment (Alternative 1).
- Over $42 million (2018 dollars) in near term asset renewal projects were identified. Of these $26 million are already in the five-year CIP. However, there remains up to $16 million in assorted projects at the WWTF, pump stations, and PEFTFs that are not currently scheduled, but are needed to keep these facilities operating reliably until they can be upgraded or replaced beginning in 2024 or later.

Although the timing of the major upgrades to the WWTF and its tributary pump stations has been defined, that is not the case with the wet weather upgrades associated with PEFTF removal or the near term asset renewal needs. JCW has identified over $2 billion in system wide capital needs that must be addressed over the next 25-30 years. Thus, the Nelson Watershed improvement, other than the WWTF project must be incorporated into a comprehensive system wide prioritization process so they, along with other system needs, are scheduled, in order of priority based on the benefits afforded to water quality and JCW's customers.

Therefore, the next step for the improvements identified in this Collection System Study and the WWTF Facility Plan is to incorporate them, along with other known needs, into a system wide Integrated Management Plan. Phase 1 of the integrated planning process is underway and will continue to be carefully coordinated with the results of the Nelson collection system and WWTF studies.

Appendix A - Relevant Past Studies & Documents

Following is a list of relevant past studies and documents, from most current to least current.

HDR. *Johnson County Wastewater Facilities Asset Management Program Implementation Plan.* April 2018

HDR. *Johnson County Wastewater Collection System Asset Management Program. Implementation Plan and other Program Documents.* January 2014 to Date.

Black and Veatch/HDR. *Johnson County Wastewater Tomahawk Creek WWTF Project Definition Study.* June 2016.

CH2M HILL. *Nelson Wastewater Treatment Complex Sanitary Sewer Service Area, EPA 308(a) Response Document: Executive Plan*. March 2015.

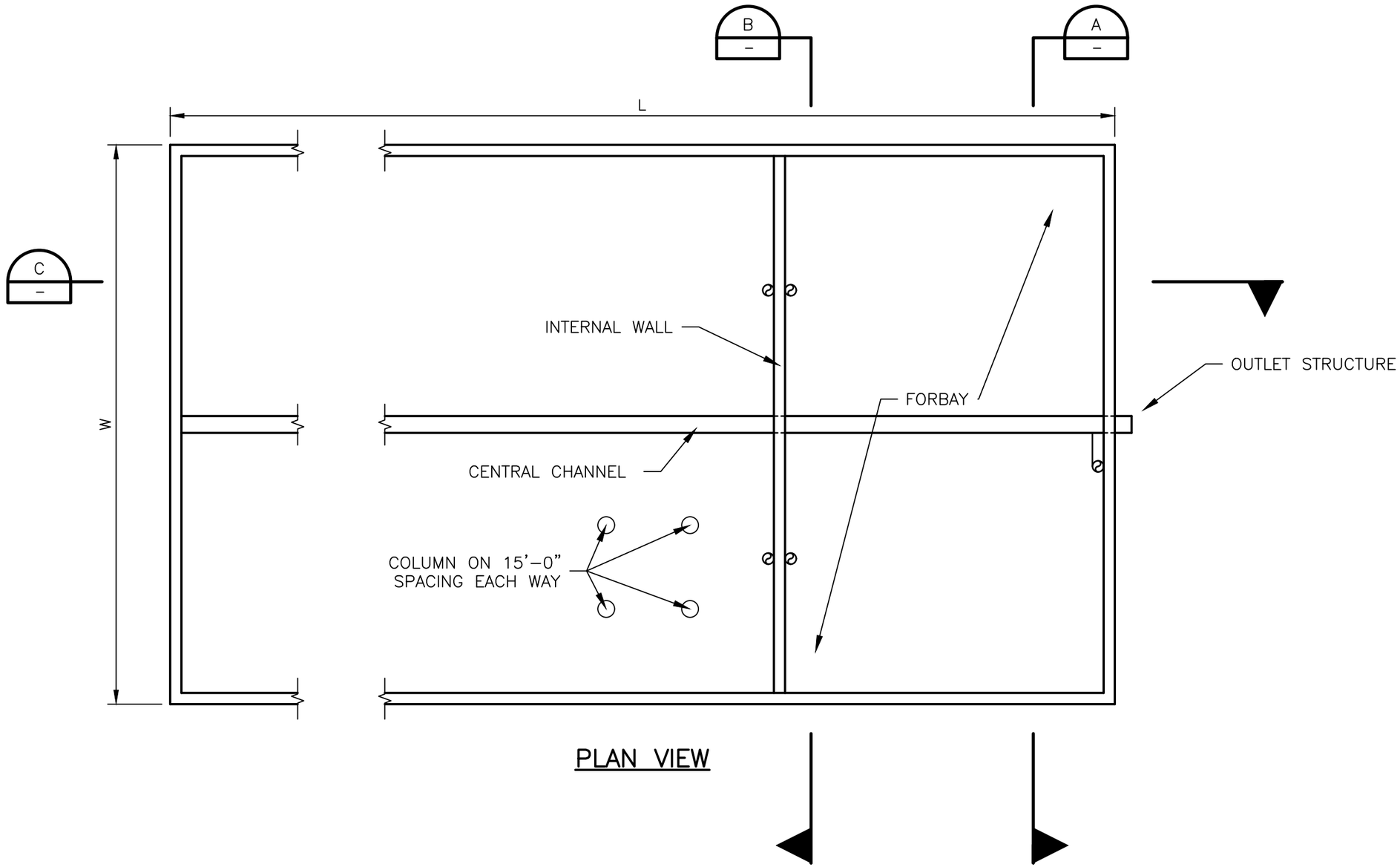
CH2M HILL. *Collection System Analysis for Peak Excess Flow Treatment Facilities: Mission Township Main Sewer District No. 1 and Shawnee Mission Turkey Creek Watersheds, Supplement to January 2009 Technical Response to EPA 308(a) Request*. December 2014.

CH2M HILL. *Draft Technical Memorandum #2 and #3: Data Characterization, Quantification, and Costing I/I Curve Development, Repair Prioritization, and Application of Results to other Basins*. June 2011.

CH2M HILL*. Draft Technical Memorandum #2: Inventory Verification, Hydraulic Model Development and Model Calibration*. March 2010.

Johnson County Wastewater. *Response to: EPA Request for Information Pursuant to Section 308(a) of the Clean Water Act Items A.2, A.4, A.5 and A.6*. January 2009.

Appendix B – Underground Storage Details



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HORIZ. SCALE: NTS

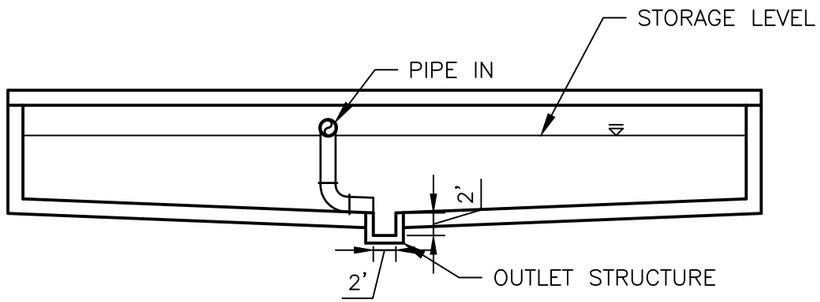
STORAGE FACILITIES
TYPICAL PLAN VIEW

HDR

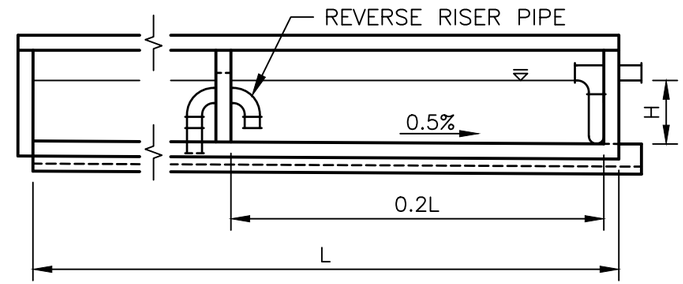
JOHNSON COUNTY KANSAS
Wastewater

DATE
3-08-19

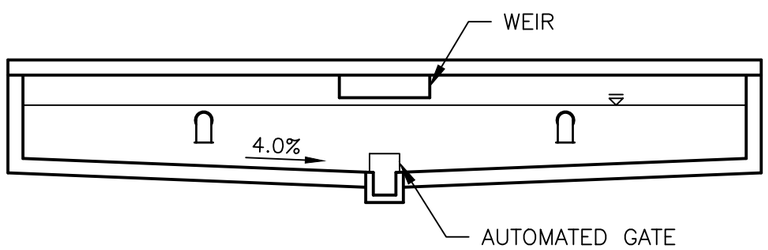
FIGURE
B-1



SECTION A



SECTION C



SECTION B

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HORIZ. SCALE: NTS

STORAGE FACILITIES
TYPICAL SECTIONS

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
B-2

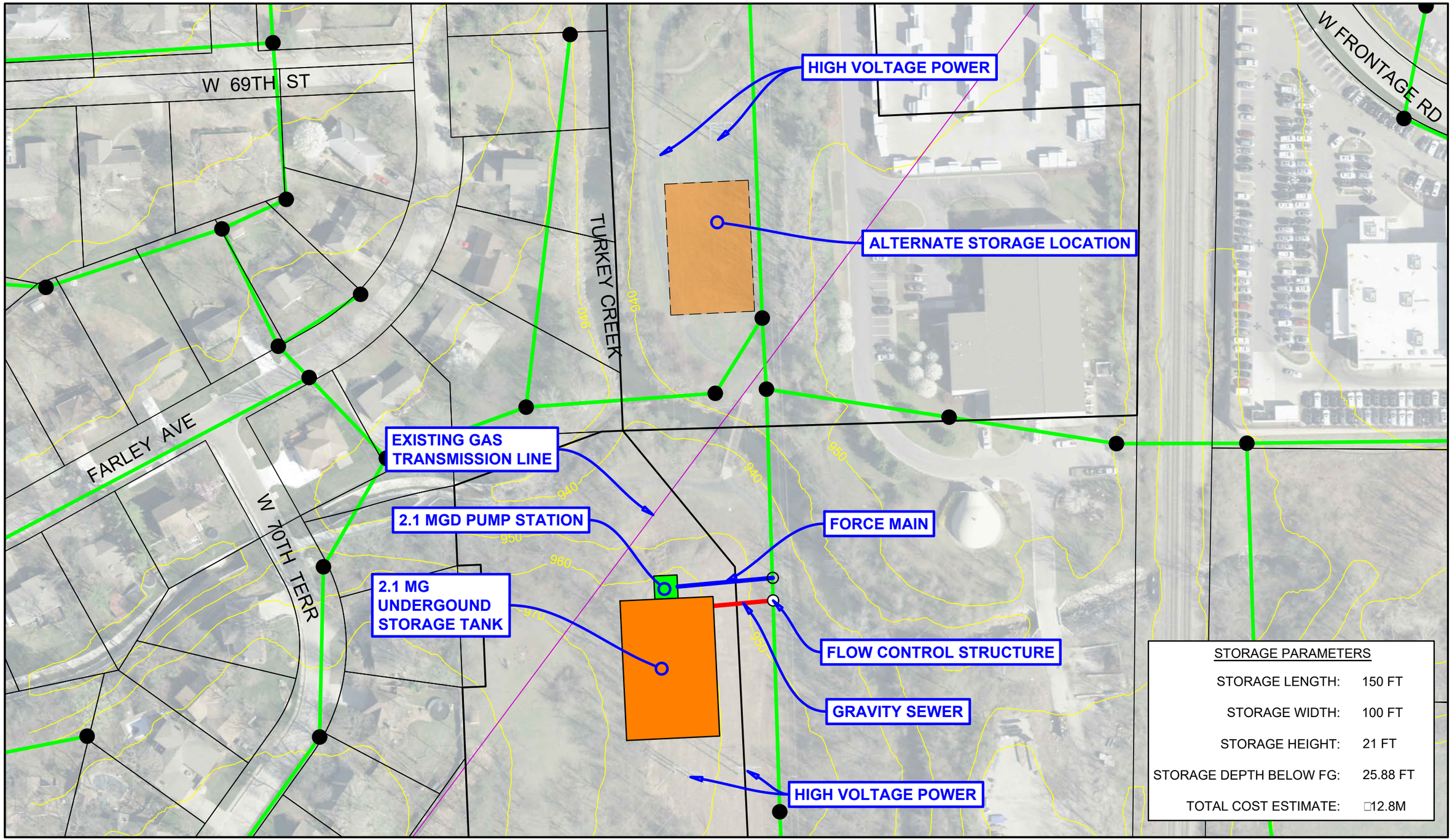
Appendix C – Underground Storage Exhibits and Cost Estimates

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

SOUTH SITE GRAVITY IN-PUMP OUT (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	12,300	$61,500
Rock Excavation	CY	$50	27,900	$1,395,000
Back Fill and Compaction	CY	$10	18,400	$184,000
Haul off	CY	$10	27,900	$279,000
Haul in	CY	$15	6,100	$91,500
Reinforced Concrete - Storage	CY	$900	5,300	$4,770,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	125	$31,250
Pipe Out	LF	$250	125	$31,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Seeding, Fertilize, & Mulch	SY	$2	3,000	$6,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$7,434,500
			20% Contingency:	$1,486,900
			Subtotal:	$8,921,400
			25% ELA:	$2,230,350
			Pump Station(1):	$1,668,922
			Grand Total:	**$12,821,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
STREAMWAY PARK
SOUTH-GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03 08 2019

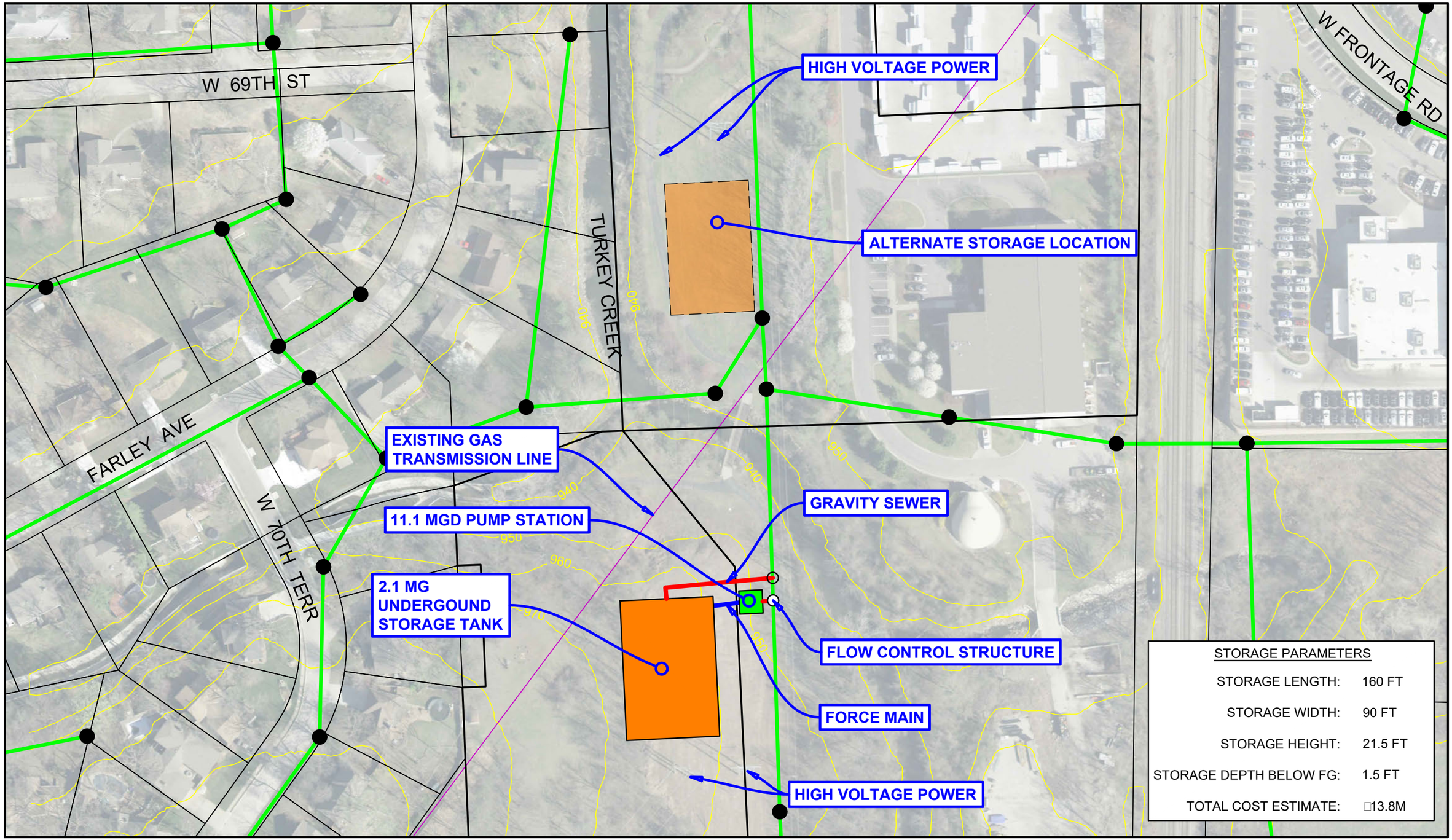
FIGURE
C-2

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

SOUTH SITE PUMP IN-GRAVITY OUT (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	12,000	$60,000
Rock Excavation	CY	$50	9,100	$455,000
Back Fill and Compaction	CY	$10	4,800	$48,000
Haul off	CY	$10	16,300	$163,000
Reinforced Concrete - Storage	CY	$900	4,210	$3,789,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	125	$31,250
Pipe Out	LF	$250	125	$31,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	210	$420,000
Seeding, Fertilize, & Mulch	SY	$2	3,000	$6,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$5,588,500
			20% Contingency:	$1,117,700
			Subtotal:	$6,706,200
			25% ELA:	$1,676,550
			Pump Station(1):	$5,401,582
			Grand Total:	**$13,784,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
STREAMWAY PARK
SOUTH-PUMP IN-GRAVITY OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03/08/2019

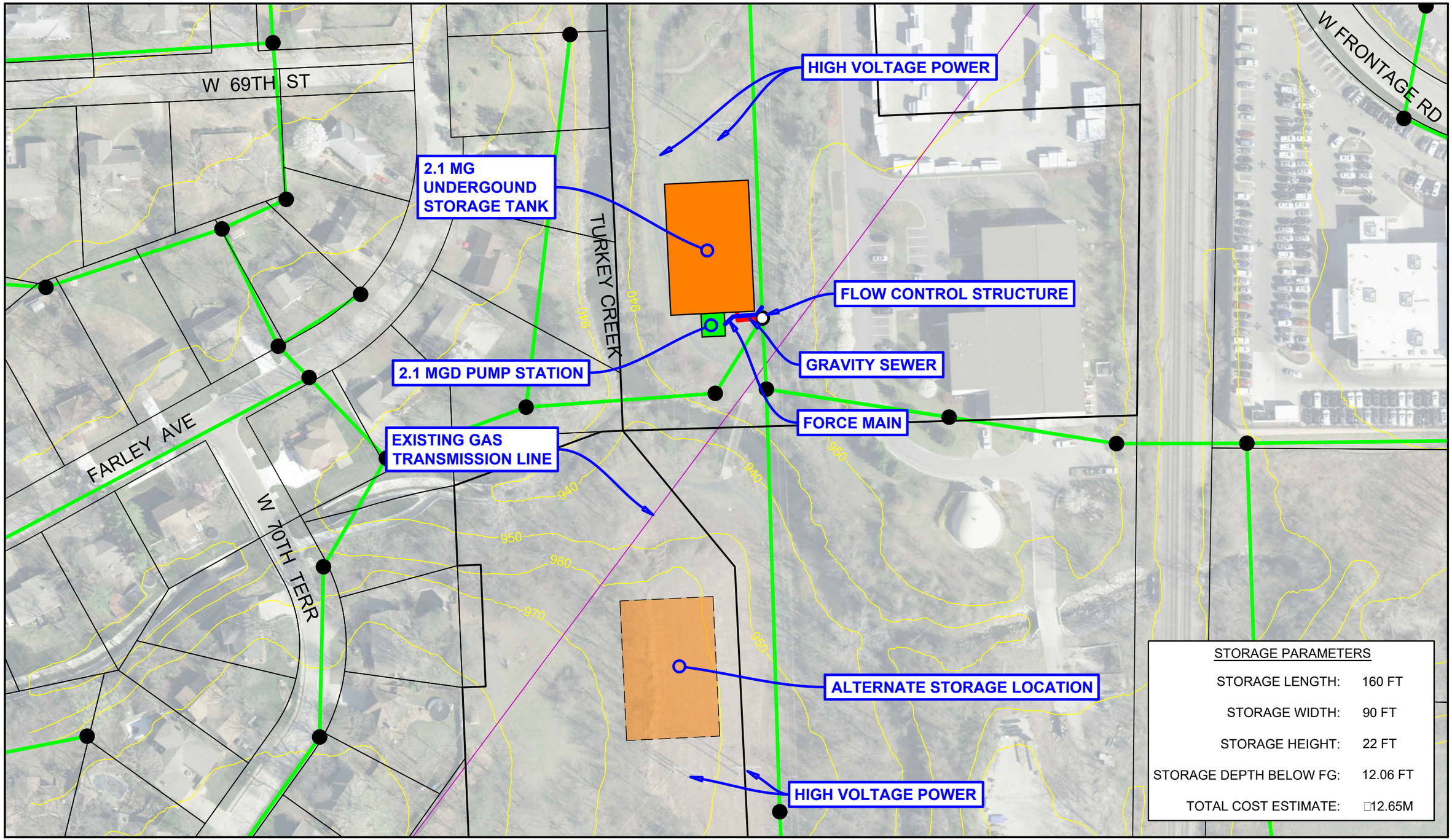
FIGURE
C-4

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

NORTH SITE GRAVITY IN-PUMP OUT (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	7,900	$39,500
Rock Excavation	CY	$50	22,800	$1,140,000
Back Fill and Compaction	CY	$10	9,000	$90,000
Haul off	CY	$10	22,800	$228,000
Haul in	CY	$15	1,100	$16,500
Reinforced Concrete - Storage	CY	$900	5,750	$5,175,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	65	$16,250
Pipe Out	LF	$250	65	$16,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Seeding, Fertilize, & Mulch	SY	$2	3,600	$7,200
Asphalt Trail Replacement	SY	$20	200	$4,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$7,317,700
			20% Contingency:	$1,463,540
			Subtotal:	$8,781,240
			25% ELA:	$2,195,310
			Pump Station(1):	$1,668,922
			Grand Total:	**$12,645,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
STREAMWAY PARK
NORTH-GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03/08/2019

FIGURE
C-6

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

NORTH SITE PUMP IN-GRAVITY OUT (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	7,200	$36,000
Rock Excavation	CY	$50	9,600	$480,000
Back Fill and Compaction	CY	$10	2,700	$27,000
Haul off	CY	$10	14,100	$141,000
Reinforced Concrete - Storage	CY	$900	1,760	$1,584,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	65	$16,250
Pipe Out	LF	$250	65	$16,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	50	$100,000
Seeding, Fertilize, & Mulch	SY	$2	3,600	$7,200
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$2,996,700
			20% Contingency:	$599,340
			Subtotal:	$3,596,040
			25% ELA:	$899,010
			Pump Station(1):	$5,401,582
			Grand Total:	**$9,897,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.

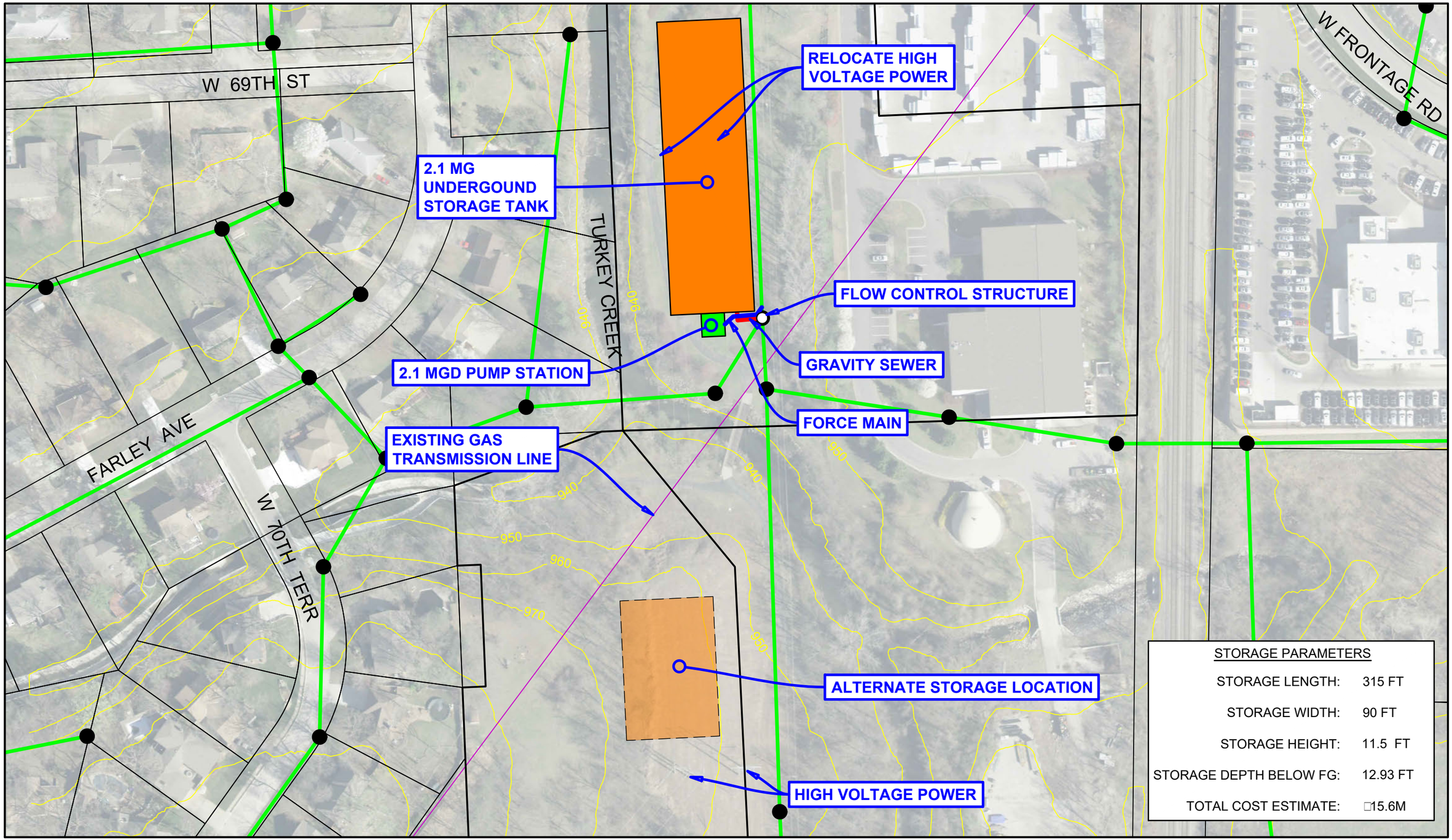
(2) **This configuration will not work due the depth to attain the required volume is below the existing downstream gravity sewer main.**

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

NORTH SITE GRAVITY IN-PUMP OUT – POWER RELOCATION (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	13,500	$67,500
Rock Excavation	CY	$50	6,300	$315,000
Back Fill and Compaction	CY	$10	4,600	$46,000
Haul off	CY	$10	15,200	$152,000
Reinforced Concrete - Storage	CY	$900	2,680	$2,412,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	65	$16,250
Pipe Out	LF	$250	65	$16,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	100	$200,000
Seeding, Fertilize, & Mulch	SY	$2	7,200	$14,400
Asphalt Trail Replacement	SY	$20	400	$8,000
Relocated Electrical Transmission	LS	$2,000,000	1(2)	$2,000,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$5,832,400
			20% Contingency:	$1,166,480
			Subtotal:	$6,998,880
			25% ELA:	$1,749,720
			Pump Station(1):	$5,401,582
			Grand Total:	**$14,150,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.
(2) Assumed one transmission main tower would require to be relocated.



N

0 1" 2"

HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
STREAMWAY PARK
NORTH-GRAVITY IN-PUMP OUT
POWER RELOCATION

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03/08/2019

FIGURE
C-9

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

NORTH SITE PUMP IN-GRAVITY OUT – POWER RELOCATION (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	12,300	$61,500
Rock Excavation	CY	$50	27,900	$1,395,000
Back Fill and Compaction	CY	$10	18,400	$184,000
Haul off	CY	$10	27,900	$279,000
Haul in	CY	$15	6,100	$91,500
Reinforced Concrete - Storage	CY	$900	5,300	$4,770,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	125	$31,250
Pipe Out	LF	$250	125	$31,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Seeding, Fertilize, & Mulch	SY	$2	3,000	$6,000
Relocated Electrical Transmission	LS	$2,000,000.00	1(3)	$2,000,000.00
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$5,832,400
			20% Contingency:	$1,166,480
			Subtotal:	$6,998,880
			25% ELA:	$1,749,720
			Pump Station(1):	$5,401,582
			Grand Total:	**$14,150,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.

(2) This configuration will not work due the depth to attain the required volume is below the existing downstream gravity sewer main.

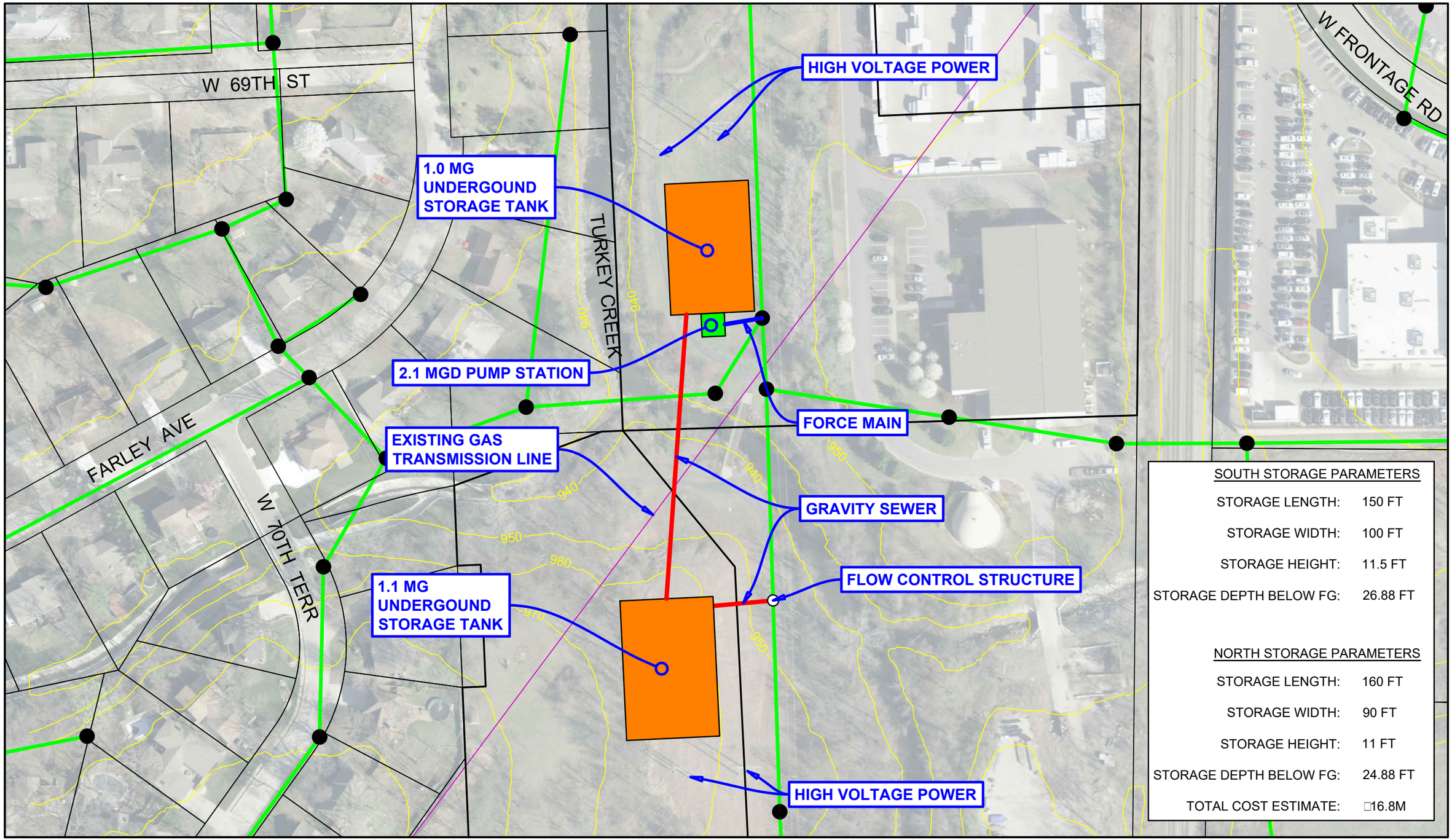
(3) Assumed two transmission main towers would require to be relocated.

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

COMBINED NORTH & SOUTH SITES GRAVITY IN-PUMP OUT (2.1 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	19,400	97,000
Rock Excavation	CY	$75	41,300	2,065,000
Back Fill and Compaction	CY	$10	34,000	340,000
Haul off	CY	$10	41,300	413,000
Haul in	CY	$15	14,600	219,000
Reinforced Concrete - Storage	CY	$900	6,160	5,544,000
Holding Bay Gate and Reverse Risers	LS	$20,000	2	40,000
Air Release	LS	$20,000	2	40,000
Access MH 5 Dia	EA	$7,500	4	30,000
Oder Control	LS	$20,000	2	40,000
Pipe IN	LF	$250	425	106,250
Pipe Out	LF	$250	425	106,250
Sewer Manhole	EA	$10,000	2	20,000
Flow Control Structure	EA	$100,000	2	200,000
Sprinklers	LS	$100,000	2	200,000
Seeding, Fertilize, & Mulch	SY	$2	6,000	12,000
Electrical/Control/SCADA	LS	$100,000	2	200,000
Redundant Power/Generator	LS	$200,000	2	400,000
			Subtotal:	$10,072,500
			20% Contingency:	$2,014,500
			Subtotal:	$12,087,000
			25% ELA:	$3,021,750
			Pump Station(1):	$1,668,922
			Grand Total:	**$16,778,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
STREAMWAY PARK
COMBINED-GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03□08□2019

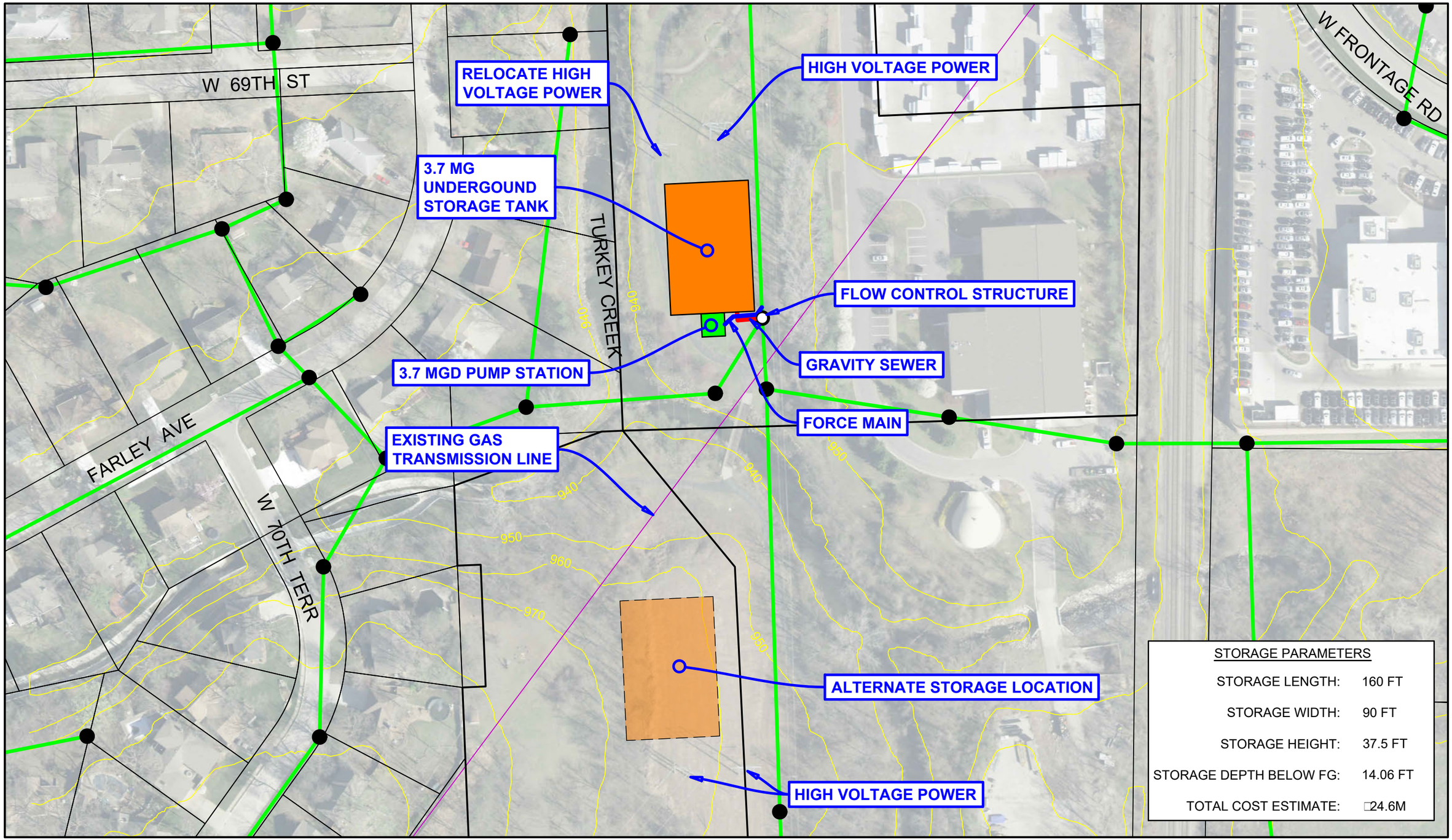
FIGURE
C-12

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

CONSOLIDATED NORTH SITE GRAVITY IN-PUMP OUT (3.7 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	8,400	$42,000
Rock Excavation	CY	$75(2)	38,200	$2,865,000
Back Fill and Compaction	CY	$10	10,600	$106,000
Haul off	CY	$10	38,200	$382,000
Haul in	CY	$15	2,200	$33,000
Reinforced Concrete - Storage	CY	$900	10,400	$9,360,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	65	$16,250
Pipe Out	LF	$250	65	$16,250
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	200	$400,000
Seeding, Fertilize, & Mulch	SY	$2	3,600	$7,200
Asphalt Trail Replacement	SY	$20	200	$4,000
Relocated Electrical Transmission	LS	$1,000,000	1(3)	$1,000,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$14,816,700
			20% Contingency:	$2,963,340
			Subtotal:	$17,780,040
			25% ELA:	$4,445,010
			Pump Station(1):	$2,365,658
			Grand Total:	**$24,591,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.
(2) Higher Rock excavation was assumed to account for challenges associated with increased depths.
(3) Assumed one transmission main tower would require to be relocated.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
CONSOLIDATED STREAMWAY
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03 08 2019

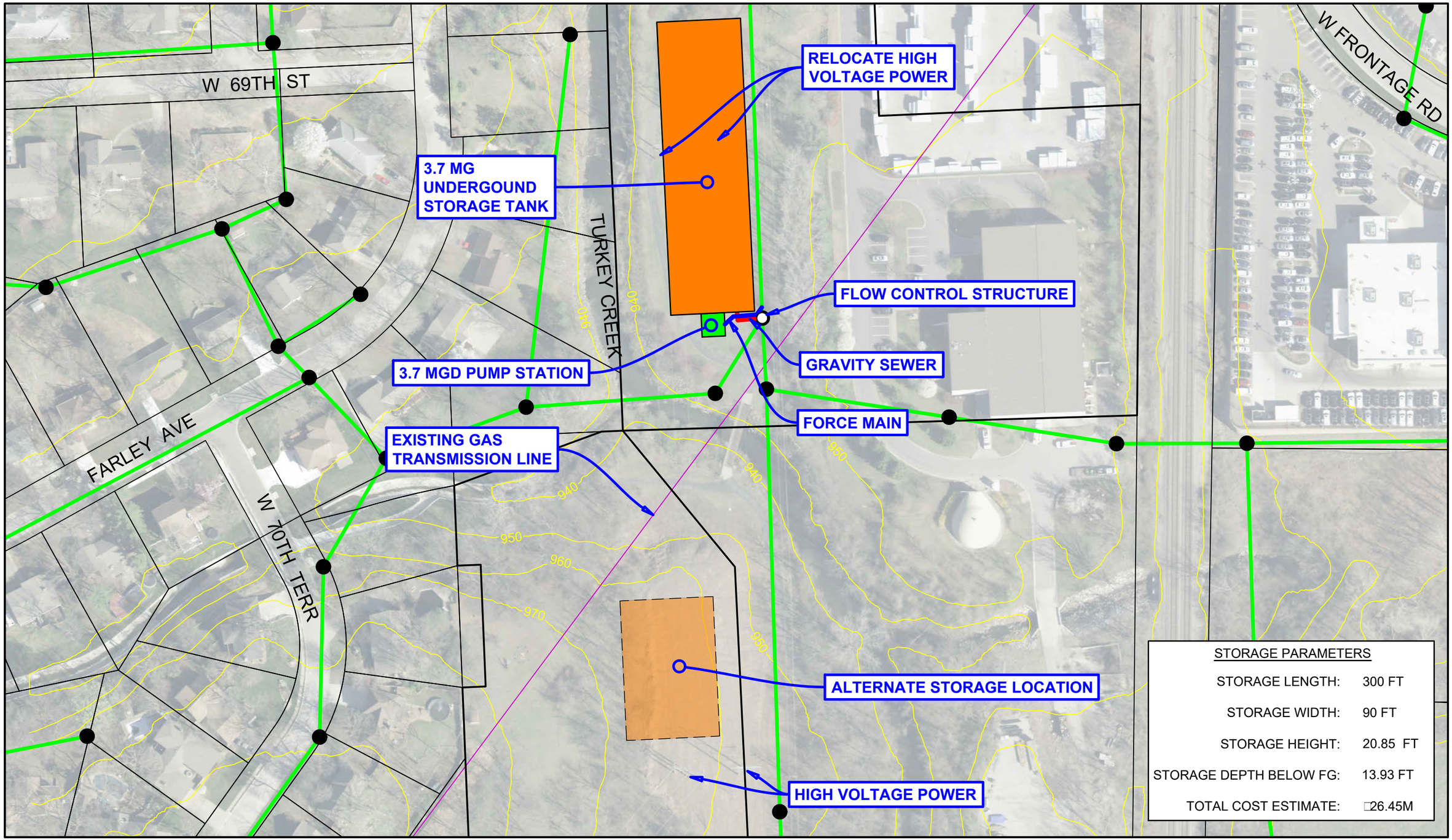
FIGURE
C-14

STREAMWAY PARK STORAGE DETAILED COST ESTIMATE

CONSOLIDATED NORTH SITE GRAVITY IN-PUMP OUT – POWER RELOCATION (3.7 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	14,000	$70,000
Rock Excavation	CY	$75(2)	40,800	$3,060,000
Back Fill and Compaction	CY	$10	17,900	$179,000
Haul off	CY	$10	40,800	$408,000
Haul in	CY	$15	3,900	$58,500
Reinforced Concrete - Storage	CY	$900	9,810	$8,829,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	65	$16,250
Pipe Out	LF	$250	65	$16,250
Connection to Existing MH	EA	$2,000	1	$2,000
Sewer Manhole	EA	$10,000	2	$20,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	400	$800,000
Seeding, Fertilize, & Mulch	SY	$2	7,200	$14,400
Asphalt Trail Replacement	SY	$20	400	$8,000
Relocated Electrical Transmission	LS	$2,000,000	1(3)	$2,000,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$16,056,400
			20% Contingency:	$3,211,280
			Subtotal:	$19,267,680
			25% ELA:	$4,816,920
			Pump Station(1):	$2,365,658
			Grand Total:	**$26,450,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.
(2) Higher Rock excavation was assumed to account for challenges associated with increased depths
(3) Assumed two transmission main towers would require to be relocated.



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HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
CONSOLIDATED □ STREAMWAY
GRAVITY IN-PUMP OUT
POWER RELOCATION

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03□08□2019

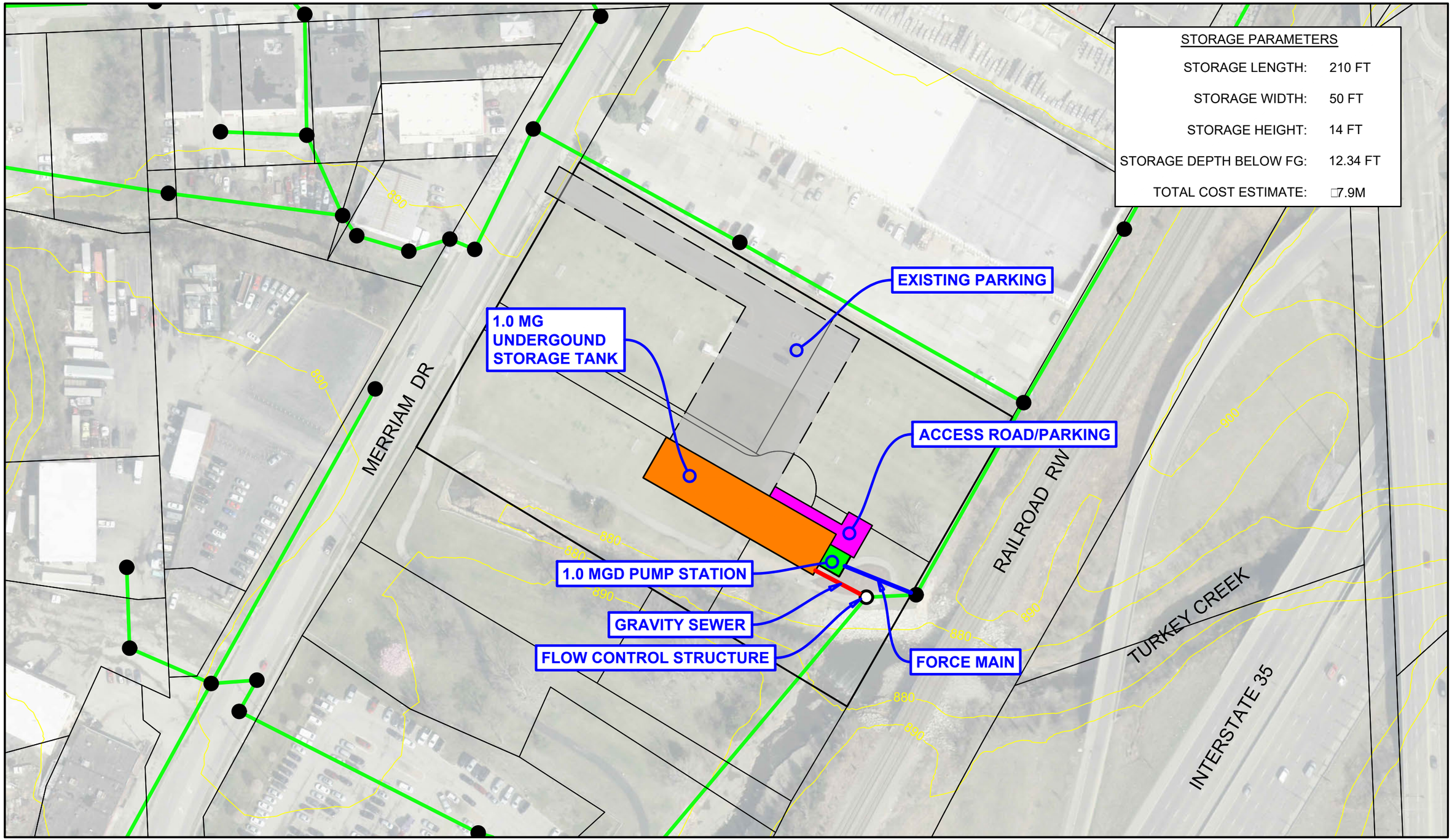
FIGURE
C-16

WATERFALL PARK STORAGE DETAILED COST ESTIMATE

GRAVITY IN-PUMP OUT (1.0 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	10,100	$50,500
Rock Excavation	CY	$50	11,000	$550,000
Back Fill and Compaction	CY	$10	9,100	$91,000
Haul off	CY	$10	12,000	$120,000
Reinforced Concrete - Storage	CY	$900	3,320	$2,988,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$500	100	$50,000
Pipe Out	LF	$250	100	$25,000
Connection to Existing MH	EA	$2,000	2	$4,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Seeding, Fertilize, & Mulch	SY	$2	3,600	$7,200
Asphalt Parking Lot Replacement	SY	$35	530	$18,550
Asphalt Trail Replacement	SY	$20	120	$2,400
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$4,481,650
			20% Contingency:	$896,330
			Subtotal:	$5,377,980
			25% ELA:	$1,344,495
			Pump Station(1):	$1,181,600
			Grand Total:	**$7,904,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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0 1" 2"

HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
WATERFALL PARK
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03 08 2019

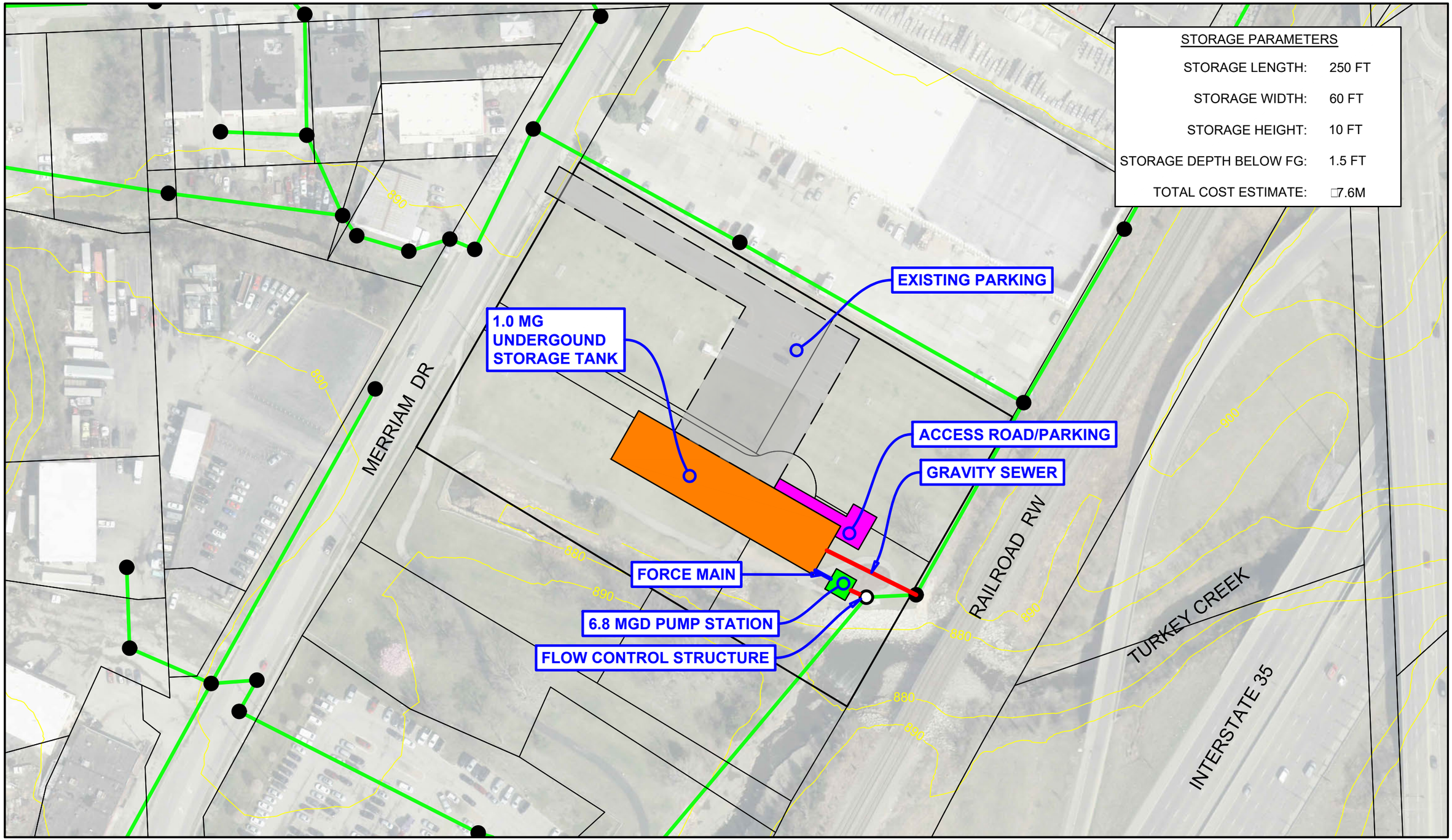
FIGURE
C-18

WATERFALL PARK STORAGE DETAILED COST ESTIMATE

PUMP IN-GRAVITY OUT

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	11,800	$59,000
Rock Excavation	CY	$50	100	$5,000
Back Fill and Compaction	CY	$10	4,800	$48,000
Haul off	CY	$10	7,100	$71,000
Reinforced Concrete - Storage	CY	$900	1,480	$1,332,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	100	$25,000
Pipe Out	LF	$250	100	$25,000
Connection to Existing MH	EA	$2,000	2	$4,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	210	$420,000
Seeding, Fertilize, & Mulch	SY	$2	3,600	$7,200
Asphalt Parking Lot Replacement	SY	$35	530	$18,550
Asphalt Trail Replacement	SY	$20	120	$2,400
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$2,592,150
			20% Contingency:	$518,430
			Subtotal:	$3,110,580
			25% ELA:	$777,645
			Pump Station(1):	$3,674,788
			Grand Total:	**$7,563,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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0 1" 2"

HORIZ. SCALE: 1"=100'

TURKEY CREEK STORAGE
WATERFALL PARK
PUMP IN-GRAVITY OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03 08 2019

FIGURE
C-20

PORTER PARK STORAGE DETAILED COST ESTIMATE

GRAVITY IN-PUMP OUT (4.4 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	27,500	$137,500
Rock Excavation	CY	$50	39,000	$1,950,000
Back Fill and Compaction	CY	$10	23,400	$234,000
Haul off	CY	$10	43,100	$431,000
Reinforced Concrete - Storage	CY	$900	11,790	$10,611,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$400	190	$76,000
Pipe Out	LF	$250	190	$47,500
Connection to Existing MH	EA	$2,000	2	$4,000
Sewer Manhole	EA	$10,000	2	$20,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Seeding, Fertilize, & Mulch	SY	$2	7,500	$15,000
Asphalt Trail Replacement	SY	$20	150	$3,000
Storm 60" RCP Relocation	LF	$400	300	$120,000
35'x20' Metal Roof Shelter	EA	$20,000	1	$20,000
Miscellaneous Playground Equipment	LS	$7,500	3	$22,500
Ball Field	EA	$10,000	2	$20,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$14,286,500
			20% Contingency:	$2,857,300
			Subtotal:	$17,143,800
			25% ELA:	$4,285,950
			Pump Station(1):	$2,665,972
			Grand Total:	**$24,096,000**

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.

TOMAHAWK ROAD

ROE AVE.

VILLAGE DR.

4.4 MG UNDERGOUND STORAGE TANK

STORM TO BE RELOCATED

GRAVITY SEWER

FLOW CONTROL STRUCTURE

4.4 MGD PUMP STATION

ACCESS ROAD/PARKING

FORCE MAIN

BRUSH CREEK PUMP STATION

STORAGE PARAMETERS

STORAGE LENGTH:	440 FT
STORAGE WIDTH:	140 FT
STORAGE HEIGHT□	12 FT
STORAGE DEPTH BELOW FG:	8.20 FT
TOTAL COST ESTIMATE:	□24.1M

□DOES NOT INCLUDE SPACE ABOVE PIPE AND ROOF THICKNESS

N

0 1" 2"

HORIZ. SCALE: 1"=100'

MISSION MAIN STORAGE
PORTER PARK
GRAVITY IN-PUMP OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE 03□08□2019

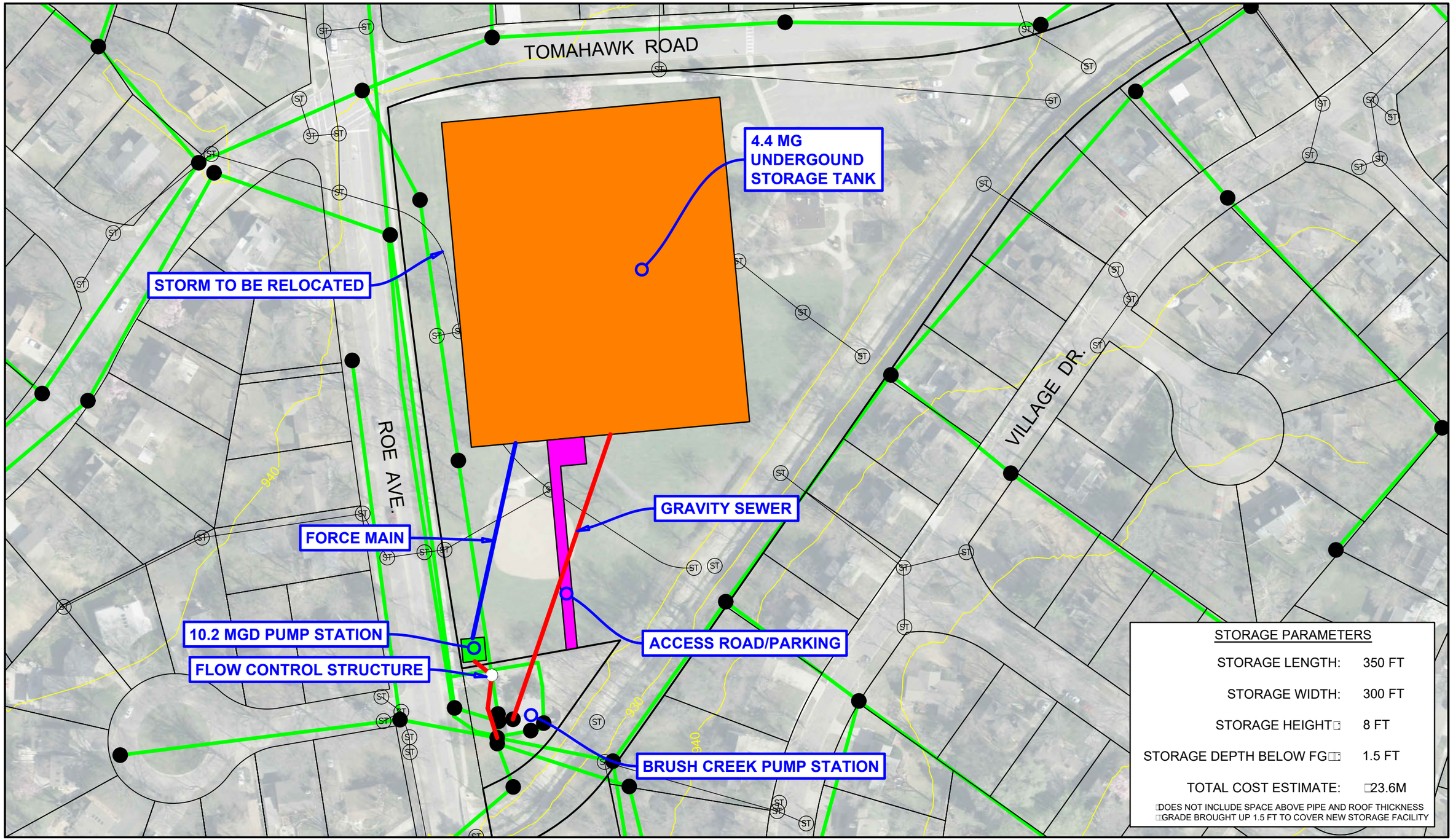
FIGURE C-22

PORTER PARK STORAGE DETAILED COST ESTIMATE

PUMP IN-GRAVITY OUT (4.4 MG)

Description	Unit	Unit Price	Quantity	Total Price
Soil Excavation	CY	$5	39,600	$198,000
Rock Excavation	CY	$50	1,400	$70,000
Back Fill and Compaction	CY	$10	4,800	$48,000
Haul off	CY	$10	36,200	$362,000
Reinforced Concrete - Storage	CY	$900	8,630	$7,767,000
Holding Bay Gate and Reverse Risers	LS	$20,000	1	$20,000
Air Release	LS	$20,000	1	$20,000
Access MH 5 Dia	EA	$7,500	2	$15,000
Oder Control	LS	$20,000	1	$20,000
Pipe IN	LF	$250	200	$50,000
Pipe Out	LF	$250	200	$50,000
Sewer Manhole	EA	$10,000	1	$10,000
Flow Control Structure	EA	$100,000	1	$100,000
Sprinklers	LS	$100,000	1	$100,000
Rock Anchors	EA	$2,000	1,500	$3,000,000
Seeding, Fertilize, & Mulch	SY	$2	12,000	$24,000
Asphalt Trail Replacement	SY	$20	300	$6,000
Storm 60" RCP Relocation	LF	$400	300	$120,000
35'x20' Metal Roof Shelter	EA	$20,000	1	$20,000
Miscellaneous Playground Equipment	LS	$7,500	3	$22,500
Ball Field	EA	$10,000	2	$20,000
Electrical/Control/SCADA	LS	$100,000	1	$100,000
Redundant Power/Generator	LS	$200,000	1	$200,000
			Subtotal:	$12,342,500
			20% Contingency:	$2,468,500
			Subtotal:	$14,811,000
			25% ELA:	$3,702,750
			Pump Station(1):	$5,048,728
			Grand Total:	$23,562,000

(1) Pump station costs were taken from generated cost curves which include 30% Contingency and 25% ELA.



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HORIZ. SCALE: 1"=100'

MISSION MAIN STORAGE
PORTER PARK
PUMP IN-GRAVITY OUT

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE 03/08/2019

FIGURE C-24

Appendix D – Gravity Interceptor Cost Estimates

TURKEY CREEK INTERCEPTOR

6,650 LF OF 18”-30” PARALLEL MAIN IMPROVEMENTS

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	3,820	$1,890,000
Arterial Crossing/Working in the Road	200	$110,000
Stream Crossing	155	$240,000
Railroad Crossing	50	$260,000
Under/Near High Voltage Power	2,310	$2,370,000
Under Overpass	115	$110,000
Retaining Wall and Other Pavement Restoration	N/A	$140,000
Total	**6,650**	**$5.1M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

TURKEY CREEK NEEMAIN ROAD TRUNK IMPROVEMENTS

2,300 LF OF 21”-27” UPSIZE MAIN IMPROVEMENTS

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	770	$390,000
Arterial Crossing/Working in the Road	30	$20,000
Bore Under Concrete Channel	310	$920,000
Under Overpass	1,190	$1,020,000
Total	**2,300**	**$2.3M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

MISSION MAIN BRUSH CREEK INTERCEPTOR IMPROVEMENTS

3,600 LF OF 36”-48” UPSIZE MAIN IMPROVEMENTS

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	2,225	$2,150,000
Arterial Crossing/Working in the Road	825	$860,000
Construction near concrete/gabion channel	550	$720,000
Other Pavement Restoration	N/A	$10,000
Total	**3,600**	**$3.75M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

MISSION MAIN BELINDER INTERCEPTOR IMPROVEMENTS

4,450 LF OF 27”-36” UPSIZE MAIN IMPROVEMENTS

Limited Construction Type	Length (ft)	Total Price
Arterial Crossing/Working in the Road	1,085	$1,060,000
Stream Crossing	485	$950,000
Working in an Isolated Area near a Stream	1,465	$1,390,000
Culvert Crossing	75	$70,000
Working on Narrow Road with Narrow Shoulders	1,340	$1,390,000
Total	**4,500**	**$3.75M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

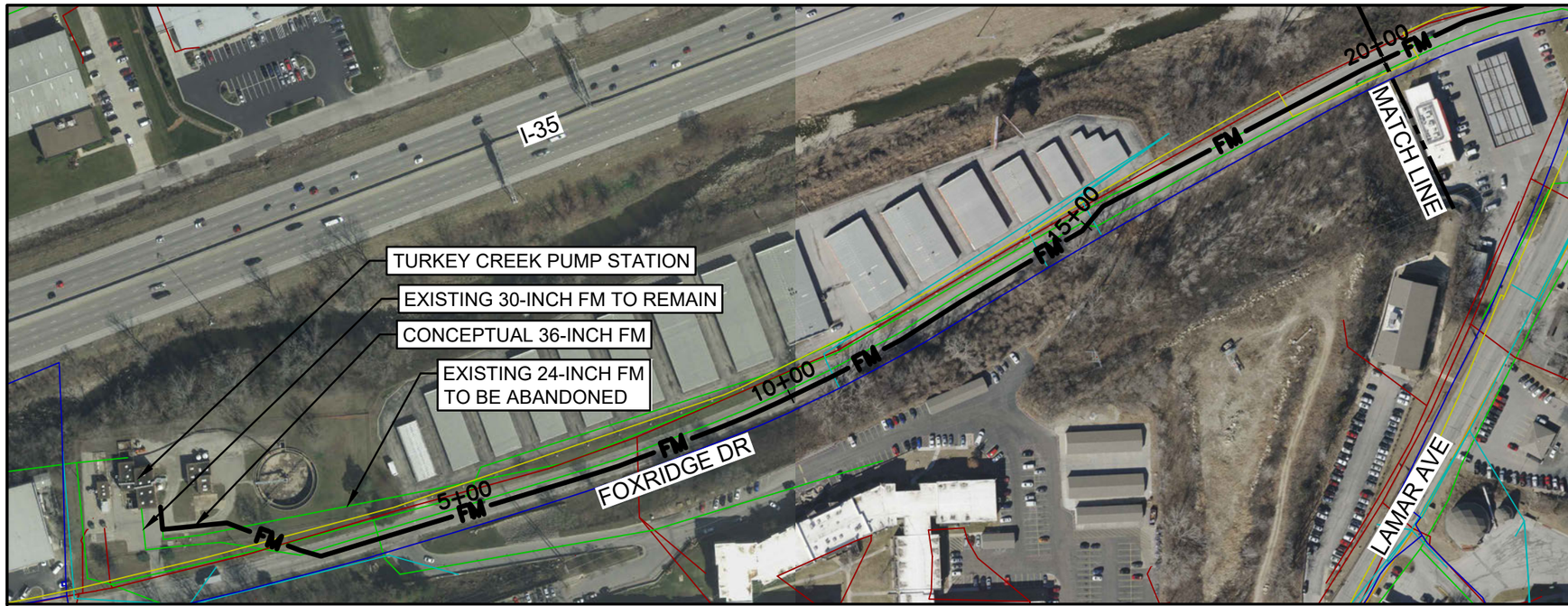
Appendix E – Forcemain Alignment Exhibits and Cost Estimates

TURKEY CREEK

4,100 LF OF 36" UPSIZE FORCEMAIN

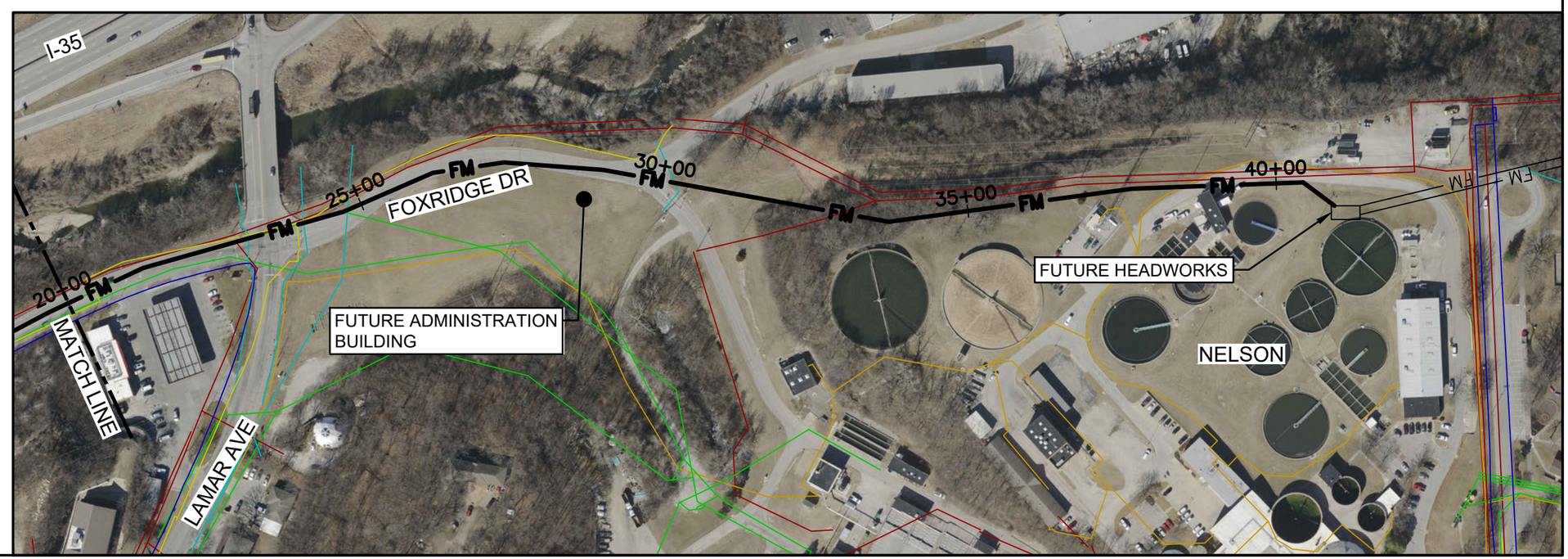
Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	960	$760,000
Arterial Crossing/Working in the Road	2,790	$2,540,000
Construction on a Steep/Wooded Hill	350	$330,000
Other Pavement Restoration	N/A	$10,000
Total	**4,100**	**$3.6M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.



LEGEND

- EXISTING SEWER LINE
- EXISTING WATER MAIN
- EXISTING STORM LINE
- EXISTING COMMUNICATION LINE
- EXISTING ELECTRICAL LINE
- EXISTING GAS MAIN
- EXISTING GAS TRANSMISSION
- CONCEPTUAL FORCE MAIN — FM



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HORIZ. SCALE: 1"=200'

FORCE MAIN CONCEPTUAL PLAN
TURKEY CREEK
UPSIZE EXISTING 24-INCH TO 36-INCH

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-2

ROCK CREEK

9,600 LF OF 24" PARALLEL FORCEMAIN

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	2,400	$1,200,000
Arterial Crossing/Working in the Road	6,200	$3,760,000
Bore Under Road	100	$260,000
Working in Isolated area on a Steep Hill	900	$590,000
Other Pavement Restoration	N/A	$10,000
Total	**9,600**	**$5.8M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

N

0 1" 2"

HORIZ. SCALE: 1"=200'

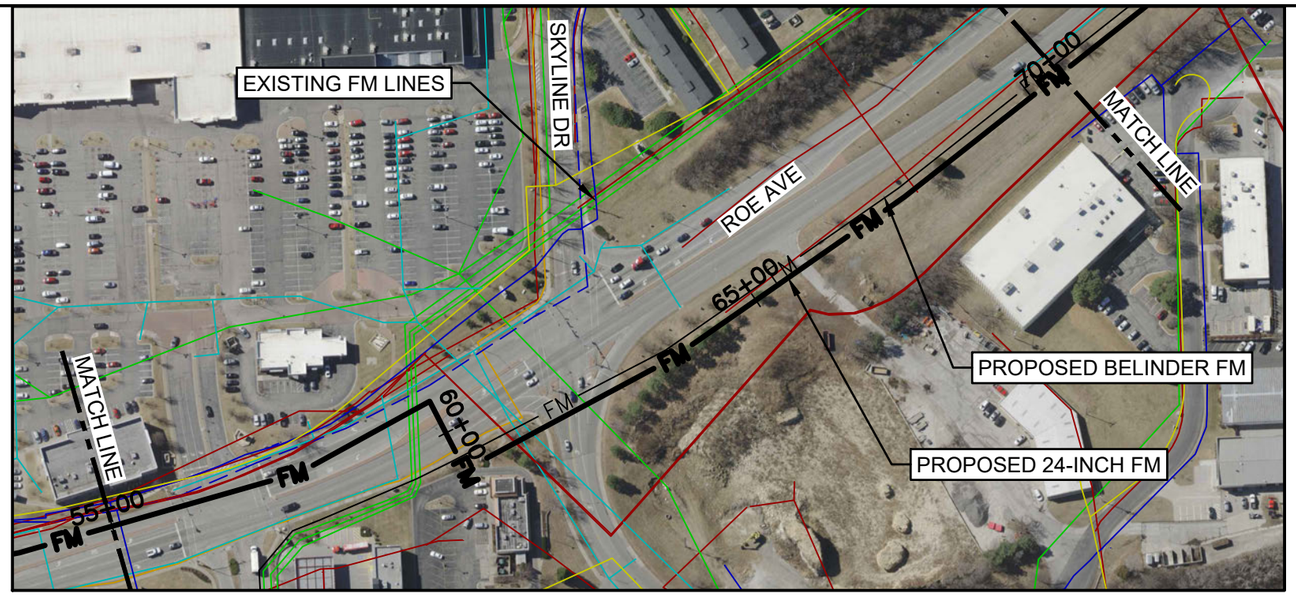
FORCE MAIN CONCEPTUAL PLAN
ROCK CREEK
24-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

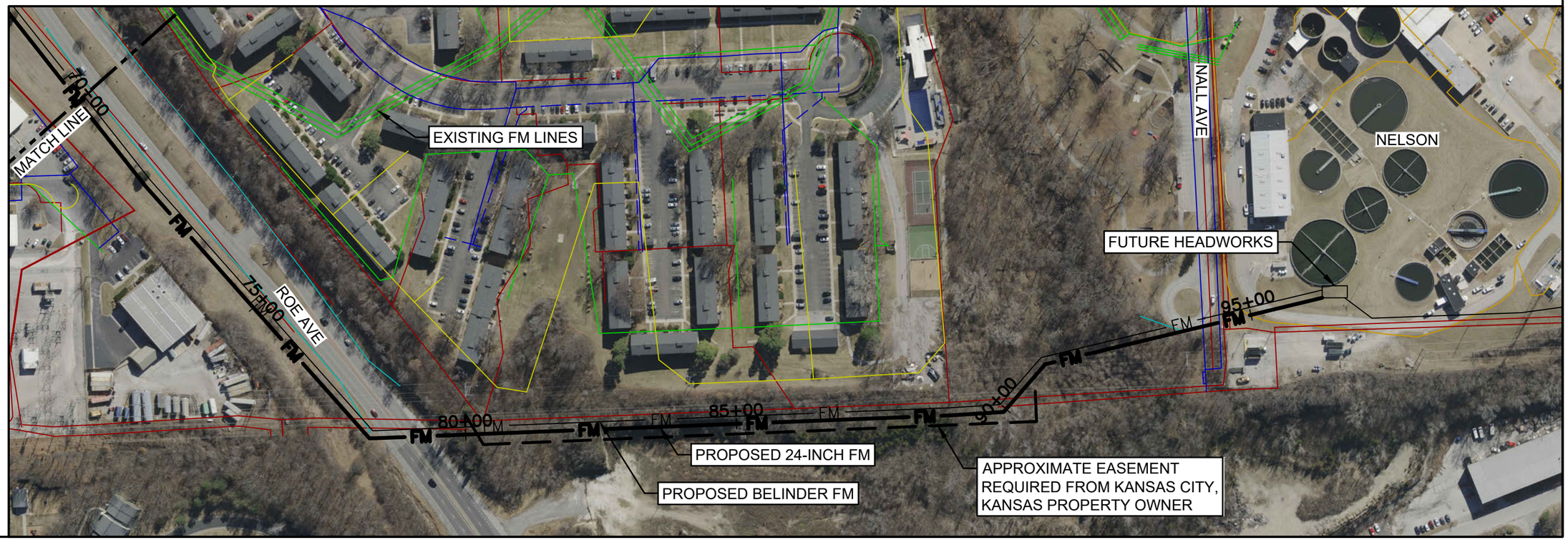
FIGURE
E-4



N

LEGEND

- EXISTING SEWER LINE
- EXISTING WATER MAIN
- EXISTING STORM LINE
- EXISTING COMMUNICATION LINE
- EXISTING ELECTRICAL LINE
- EXISTING GAS MAIN
- EXISTING GAS TRANSMISSION
- CONCEPTUAL FORCE MAIN — FM —



N

0 1" 2"

HORIZ. SCALE: 1"=200'

FORCE MAIN CONCEPTUAL PLAN
ROCK CREEK
24-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-5

BELINDER

13,800 LF OF 48" PARALLEL FORCEMAIN

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	2,730	$2,880,000
Arterial Crossing/Working in the Road	10,070	$12,200,000
Bore Under Road	100	$530,000
Working in Isolated area on a Steep Hill	900	$1,190,000
Other Pavement Restoration	N/A	$10,000
Total	**13,800**	**$16.8M**

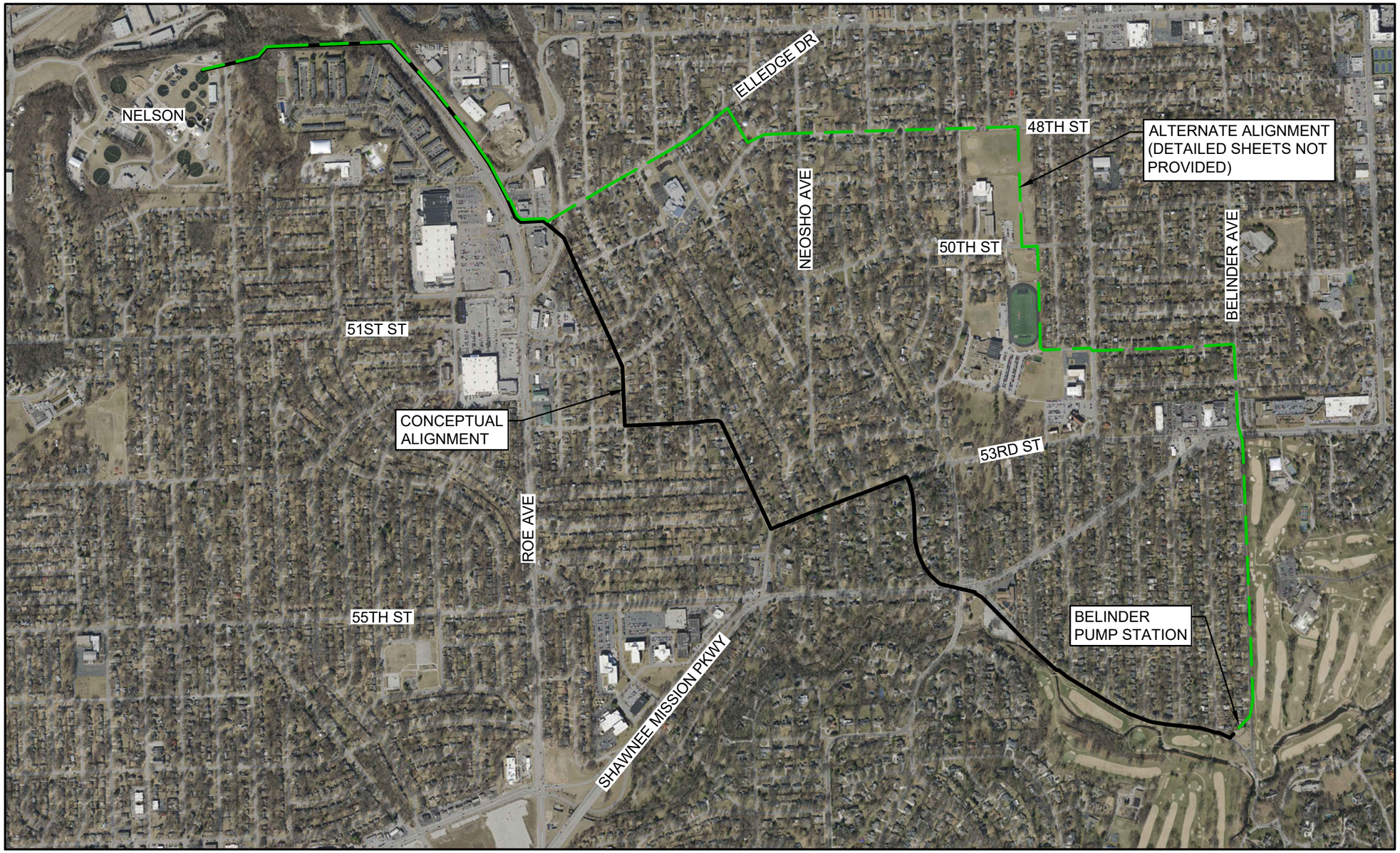
(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.

BELINDER – ALTERNATE

30,400 LF OF DUAL 36" PARALLEL FORCEMAIN

Limited Construction Type	Length (ft)	Total Price
Residential/Unobstructed	7,895	$6,210,000
Arterial Crossing/Working in the Road	18,105	$16,450,000
Bore Under Road	200	$790,000
Working On/Near the Golf course	2,400	$2,090,000
Working in Isolated area on a Steep Hill	1,800	$1,780,000
Rock Wall/Other Pavement Restoration	N/A	$60,000
Total	**30,400**	**$27.4M**

(1) Costs include overhead, profit, bonds, insurance, 30% Contingency, and 25% ELA.



N

0 1" 2"

HORIZ. SCALE: 1"=1,000'

FORCE MAIN CONCEPTUAL PLAN
BELINDER
ALIGNMENT ALTERNATIVES

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-7

N

0 1" 2"

HORIZ. SCALE: 1"=200'

FORCE MAIN CONCEPTUAL PLAN
BELINDER
48-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-8

N

0 1" 2"

HORIZ. SCALE: 1"=200'

FORCE MAIN CONCEPTUAL PLAN
BELINDER
48-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-9

N

0 1" 2"

HORIZ. SCALE: 1"=200'

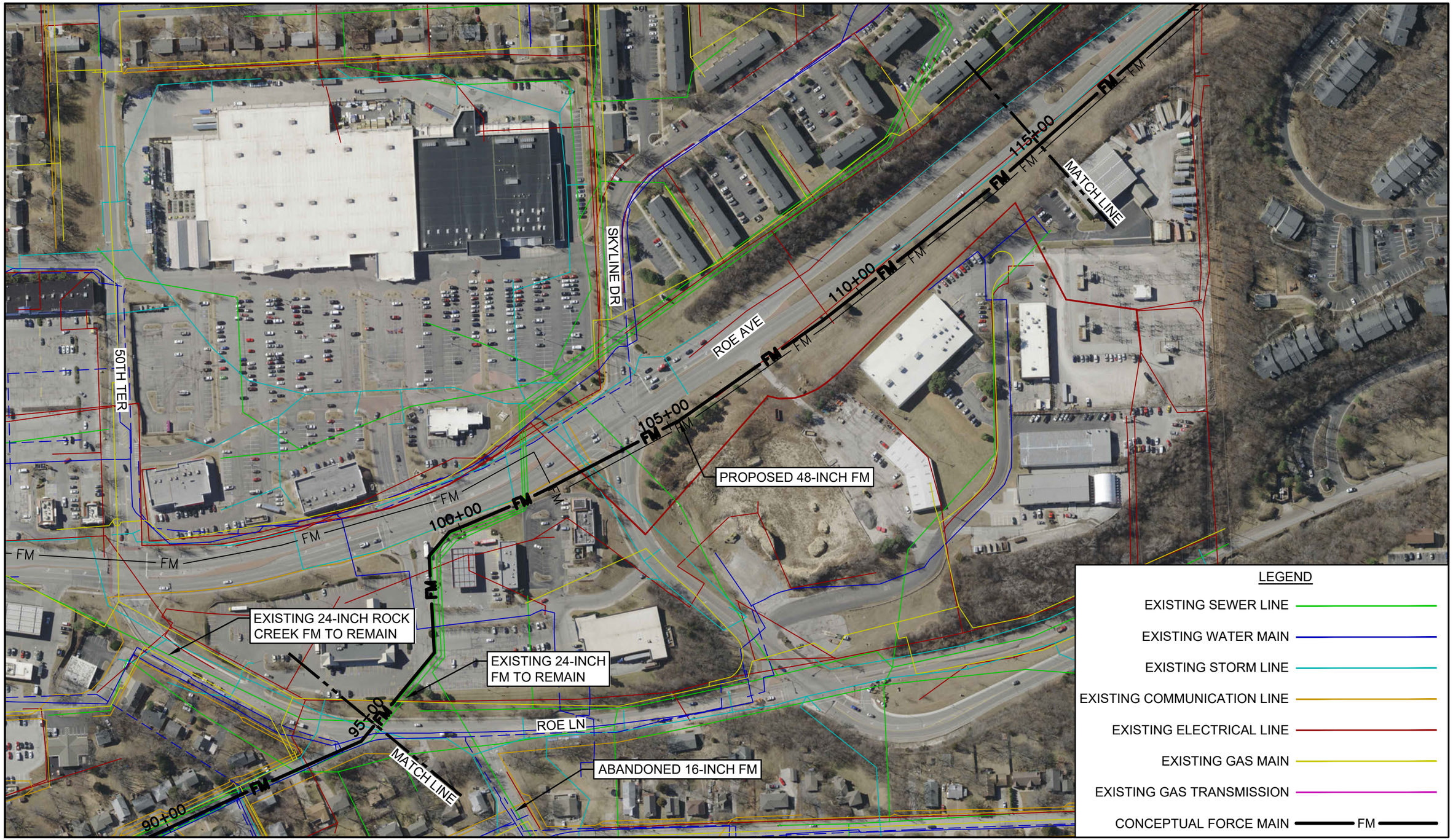
FORCE MAIN CONCEPTUAL PLAN
BELINDER
48-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-10



N

0 1" 2"

HORIZ. SCALE: 1"=200'

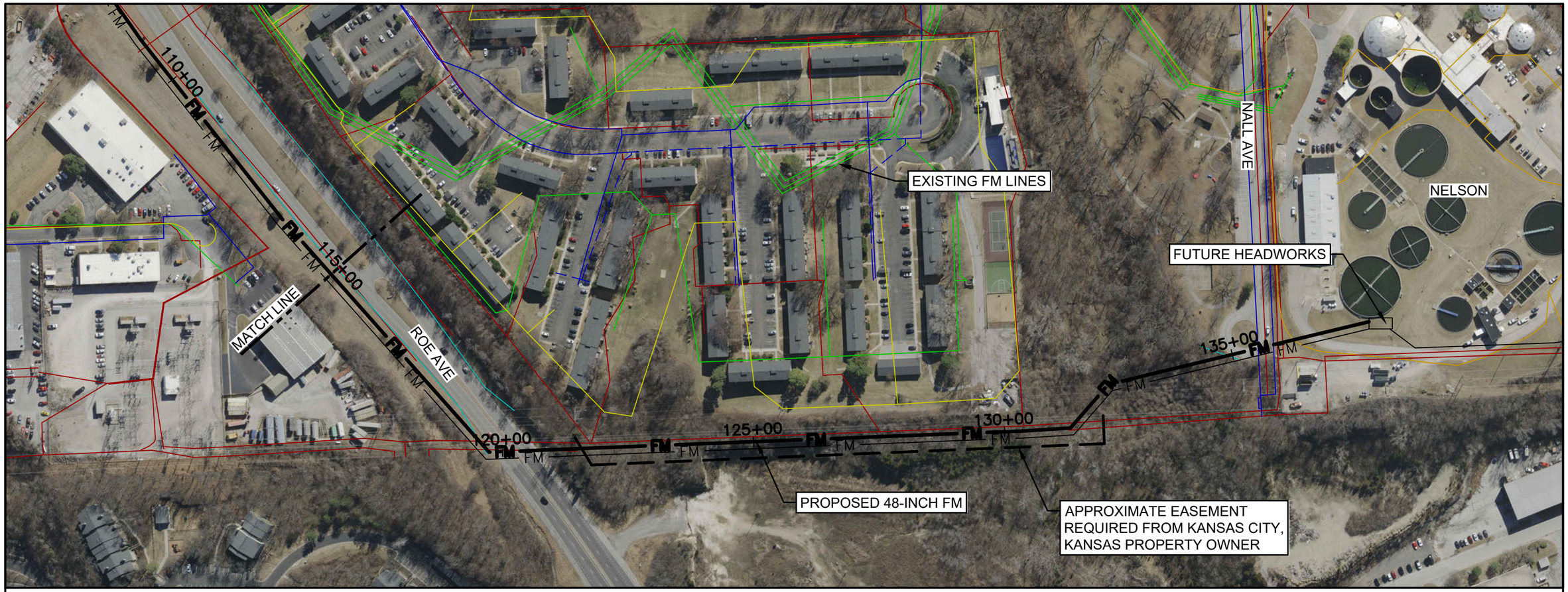
FORCE MAIN CONCEPTUAL PLAN
BELINDER
48-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS
Wastewater

DATE
03-08-19

FIGURE
E-11



LEGEND

- EXISTING SEWER LINE
- EXISTING WATER MAIN
- EXISTING STORM LINE
- EXISTING COMMUNICATION LINE
- EXISTING ELECTRICAL LINE
- EXISTING GAS MAIN
- EXISTING GAS TRANSMISSION
- CONCEPTUAL FORCE MAIN — FM

N

0 1" 2"

HORIZ. SCALE: 1"=200'

FORCE MAIN CONCEPTUAL PLAN
BELINDER
48-INCH PARALLEL

HDR

JOHNSON COUNTY KANSAS Wastewater

DATE 03-08-19

FIGURE E-12