175368

GROUNDWATER MIGRATION CONTROL SYSTEM SAUGET AREA 2 SUPERFUND SITE

Volume 1
Prefinal Design Submittal

Prepared for
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URS

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Section 1

SECTIONONE Introduction

On October 3, 2002, an Administrative Order for Remedial Design and Interim Remedial Action (the Order) associated with the Sauget Area 2 groundwater operable unit (the OU) was sent by the United States Environmental Protection Agency (USEPA) to a list of potentially responsible parties (PRPs) for the Sauget Area 2 Superfund Site (the Site). The Order (Docket No. V-W-'02-C-716) directed respondents to perform a remedial design for the Interim Groundwater Remedy described in the associated Statement of Work (SOW) and the Record of Decision (ROD) dated September 30, 2002, and to implement the design by performing an interim remedial action. This document represents the Prefinal Design submittal required by the Order. At the time of submission of this Prefinal Design, Solutia does not know whether any other recipients of the Order intend to comply with the terms of that Order.

1.1 OVERVIEW OF DESIGN

This Prefinal Design submittal has been developed in accordance with the previously submitted Remedial Design/Remedial Action Workplan (RD/RA Workplan) as required by the Order, and is consistent with the design criteria and assumptions established in the Order as well as within the Statement of Work and the Record of Decision associated with the Order.

The remedial action objectives for this work, as stated in the RD/RA Workplan, include:

- Prevent or abate actual or potential exposure to nearby human populations (including workers), animals or the food chain from hazardous substances, pollutants or contaminants
- Prevent or abate actual or potential contamination of drinking water supplies and ecosystems
- Achieve acceptable chemical-specific contaminant levels, or range of levels, for all applicable exposure routes
- Mitigate or abate other situations or factors that may pose threats to public health, welfare or the environment
- Mitigate or abate the discharge of groundwater to the Mississippi River so that the impact is insignificant or acceptable.

To accomplish these objectives, the selected remedy is a Groundwater Migration Control System (GMCS) that is the subject of this Prefinal Design submittal. Key elements of the GMCS include:

- Institutional controls
- Groundwater recovery wells
- Treatment and discharge of extracted groundwater
- Groundwater quality monitoring, groundwater level monitoring, and sediment and surface water monitoring.
- Installation of a 3,300-ft long U-shaped, jet grout barrier wall to be installed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River

Detailed descriptions of the elements of the selected remedy (i.e., extraction wells, monitoring program, barrier wall, etc.) can be found in Section 2 of the RD/RA Workplan.

1.1.1 Cleanup Objectives

Mass loading, gradient control, and reduction in fish tissue bioaccumulation will be used as performance measures for the Groundwater OU remedial action. Specific descriptions of the cleanup verification methods (Monitoring Programs) to be employed for this Remedial Action are described in detail in Section 2 of the RD/RA Workplan. Groundwater quality monitoring will be conducted on a quarterly basis during the first year of operations of the system; sediment and surface water quality monitoring will be conducted twice a year, during the summer low flow period and the winter low flow period during the first year. These monitoring programs are discussed in greater detail in the Field Sampling Plan which is an element of Volume 3 – Performance Standard Verification Plan, and will be conducted until the final groundwater remedy and associated groundwater monitoring program for the Sauget Area 2 sites is in place.

Extracted groundwater will be discharged to the American Bottoms Regional Treatment Facility for treatment and eventual discharge to the Mississippi River through American Bottoms' diffuser located at the north end of Site R. As such, the treated groundwater will be in compliance with all Applicable or Relevant and Appropriate Requirements (ARARs).

1.1.2 Design Flow Rates

The design criteria and assumptions utilized to determine the flow rates from the groundwater extraction wells were developed and previously submitted in the Focused Feasibility Study developed for the Sauget Area 2 groundwater operable unit. Sections 3, 4, 5, and 6 of this document present additional details concerning the extraction wells, the barrier wall, conveyance system, and control systems, respectively.

1.2 SITING CRITERIA

The various elements of the remedial action have been located based on a variety of factors, including minimization of groundwater flow to the river, subsurface obstructions, access to utilities, and site topography. Several of the key aspects of the project are discussed below. Section 2 presents a more detailed discussion of the design specifics associated with site development for each of these elements.

1.2.1 Extraction Wells

The primary control mechanism for the Groundwater Migration Control System will be the extraction wells. These wells have been sized and located to minimize groundwater discharge to the Mississippi River and to maintain a near zero gradient across the barrier wall.

1.2.2 Barrier Wall

As stated above, the primary control mechanism for this system will be the extraction wells. The role of the barrier wall will be to minimize the flow of groundwater from the west, in the vicinity of the Mississippi River towards the extraction wells. The barrier wall alignment has been selected to optimize performance of the extraction wells within the physical constraints in the vicinity of Site R. Specifically, these constraints include the capped landfill area, the presence of numerous subsurface obstructions in the northwest corner of the site (pipes, tank foundations, etc.) and significant buried utilities along the northern end of the site. The temporary stockpile area, for the temporary storage of spoils generated during wall construction, was selected based upon access to the barrier wall construction activities, as well as the utilization of the clay cap material and topographic features of Site R.

1.2.3 Effluent Lines

The location of effluent discharge lines that will be used to convey extracted groundwater from the site to an access point in the American Bottoms system has been selected based upon proximity to the American Bottoms system as well as proximity to an existing conduit beneath the U.S Army Corps of Engineers levee immediately east of Site Q.

1.3 REAL ESTATE, EASEMENT, AND PERMIT REQUIREMENTS

All activities associated with the remedial action will be conducted in accordance with specific property access agreements and easements where appropriate (i.e., where Solutia does not own the property). Such agreements and/or easements will be secured prior to initiation of activity on the affected property.

As stated in the Order, no permit is required for any portion of the work conducted entirely on-site, except as provided in 121(e) of CERCLA and the NCP. Where any portion of the work requires a Federal or State permit, timely applications will be made to obtain such permits. A listing of all such permits, if applicable, will be generated following approval of the Final Design submittal.

1.4 SURFACE WATER AND EROSION CONTROL

Prior to construction, the selected contractor will be required to develop and submit to Solutia a Stormwater Management Plan, documenting all measures to be taken to control erosion and collect and manage stormwater during the remedial action. The Construction Manager and contractor Site Superintendent will monitor adherence to this plan on a daily basis.

1.5 PRELIMINARY CONSTRUCTION SCHEDULE

A preliminary construction schedule was previously included in the RD/RA Workplan. This schedule will be periodically updated throughout the duration of the remedial action process.

1.6 CONTRACTING STRATEGY

Solutia, or the PRP Group that includes Solutia, will manage all aspects of the RD/RA process for the Groundwater OU at the Site. An overall Project Manager will be identified who will be responsible for the execution of the RD/RA work in accordance with the Order, the SOW, and

the ROD. Additionally, a Construction Manager will be identified and assigned to the RD/RA project to assist the Project Manager and to oversee all aspects of the construction program.

A list of pre-qualified bidders will be solicited to prepare bids for the remedial action portion of the project. Based on the submittals received, one or more contractors will be selected to undertake the required remedial actions. This work will then be conducted under the direction of the Construction Manager and in accordance with the Order, the SOW, and the ROD. A Contractor pre-qualification package has been distributed to about ten potential contractors. The responses to that Request for Qualifications will be used to prepare a short list of qualified contractors who can be invited to submit construction bids on short notice.

1.7 ORGANIZATION OF THIS VOLUME

This volume includes a narrative of the design of the GMCS along with supporting drawings, specifications, and calculations. Additional components of the Prefinal Design Package include the Construction Quality Assurance Plan, the Performance Standard Verification Plan, and the Contingency Plan, each of which are presented in additional volumes.

Section 2

SECTIONTWO Site Development

This section discusses the issues that determine the horizontal locations of the barrier wall and the temporary spoil stockpile. Other sections discuss the locations of the extraction wells and the discharge pipeline.

The entire site is located within the 100-year floodplain of the Mississippi River. The approximate 100-year flood elevation is 426. In the area of the barrier wall, the ground elevation varies from 420 to 426. However, the crest elevation of the existing Site R landfill area is above the 100-year flood level.

2.1 BARRIER WALL

The barrier wall will be an approximately 3,300-ft long U-shaped wall between the downgradient boundary of Site R and the Mississippi River. Approximately 2,000 ft of this wall runs parallel to the river bank and two arms (approximately 650-ft long) extend on the north and south sides of the Site R (refer to drawings).

Historical documents, including photographs and site plans, were used to augment a current site plan. Several site visits were conducted to investigate the physical constraints affecting the location of the wall. These constraints included the location of existing fences, pavement, utilities, buildings, and remains of old tank foundations, an abandoned Ranney well, an old sheet pile wall and other subsurface features that would adversely affect wall construction.

The final location of the wall was selected to avoid as many of the surface and subsurface obstacles as possible and provide adequate room to move equipment, materials, and personnel during construction of the wall. The location is outside of the known boundaries of the Site R landfill area.

On the west side, the wall will be located approximately 25 to 30 ft from an existing fence that forms the boundary of the site at the top of the riverbank. This location allows for construction-related equipment to move between the wall and the fence. It also provides for an area on the east side of the wall for excavation of slurry pits to handle spoils that will be generated during wall construction.

The north arm of the wall will be located in the pavement of Riverview Avenue. A fence separates the south side of the road from the north edge of the landfill. North of the road are

several utilities including a buried water line, buried chemical lines, several sewer lines, and aboveground electrical power lines. A large drainage ditch also lies just north of the road. An overhead line on the south side of the road appears to be a telephone line. Electrical power lines cross the road at several points. The south half of the pavement was selected for the location of the wall because: 1) this location limits the number of overhead electrical power and phone lines that have to be relocated; 2) it is away from the buried utilities; and 3) presents a shorter distance with fewer obstructions for supply of the barrier wall material from a centrally located batch plant. The wall will extend eastward to the existing gate that defines the eastern extent of the landfill.

The south arm of the wall will be located 10 ft south of the fence that defines the south side of the landfill. This property is not under the direct ownership and control of Solutia, and is currently used for the movement of large trucks in and around an existing industrial building. This location was selected to minimize the impact of the wall on the off-site commercial operations. The wall will extend eastward to the end of the fence that defines the eastern extent of the landfill.

Construction of both the north and south arms of the barrier wall will be conducted in areas that do not have room for excavation of slurry pits to contain the spoils. In these areas, the contractor will be required to propose a method of drying and transporting the excavated spoils before placement into the temporary stockpile.

Construction of the barrier wall will require a batch plant for mixing of the wall grout. One of the most likely locations for the batch plant is near the west center of the existing site west of the landfill. The area required is estimated to be approximately 50 by 150 ft. Deliveries to the batch plant will be by tractor-trailers and is expected to be in the range of six to ten trucks per day.

2.1.1 Temporary Stockpile

A temporary spoil stockpile will be constructed on the existing landfill to manage the spoils generated during construction. The stockpile will be located at a distance from the top of the slope that defines the landfill so that equipment and delivery trucks will have adequate room to maneuver. Section 3 of this volume provides more information on spoils handling.

2.1.2 Chain Link Fences

Portions of existing chain link fences will need to be removed to allow wall construction. They may or may not be replaced in the same location. Additional fencing may be required to protect certain new construction such as the extraction wells.

2.1.3 Site Access

The only current access to the site is via the vacated Riverview Avenue on the north side of the landfill. During construction of the wall in this location, this access will be blocked. Therefore, an access agreement with the adjacent landowner on the south side will be obtained. In order to construct the south arm of the barrier wall, an easement for the wall and a temporary construction agreement will also be obtained.

Upon completion of all construction activities, access to the site will be required for purposes of monitoring the operation of the extraction pumping system. Riverview Avenue will provide the access.

2.1.4 Roads On-Site

During construction, the contractor will provide temporary gravel construction roads on-site. These roads are expected to be necessary for the barrier wall batch plant, access roads and parking for workers and material storage, transfer of spoils from the construction area to the temporary spoils stockpile, and general movement of equipment around the site.

New permanent roads will not be required.

2.1.5 Stormwater

Current regulations specify that construction sites of this size provide stormwater pollution prevention plans. Due to the nature of the materials being handled on-site, special provisions for managing stormwater will be required. A Stormwater Pollution Prevention Plan (SWPPP) that meets the requirements of the National Pollutant Discharge Elimination System (NPDES) and State of Illinois regulations will be prepared by the contractor and submitted to Solutia for approval prior to starting any activities. This process will involve implementing best management practices (BMPs) for stormwater runoff that does not contact construction spoils.

Stormwater runoff that comes into contact with construction spoils will be captured and treated by a temporary water treatment system before being released. This system will be provided by the contractor as part of the SWPPP. Run-on of stormwater from off-site will be prevented. Upon completion of the project, natural drainage will be restored.

2.1.6 Agreements for Construction on Public and Private Property

Solutia is in the process of negotiating acquisition of suitable agreements for construction activities on public and private property.

2.2 ELECTRICAL POWER AND TELEPHONE

Primary electrical power (480 volt, 3 phase) and telephone service is available to the site on overhead lines at Riverview Avenue.

As part of construction, electrical power will be provided to the various pumps and other equipment. Permanent facilities will be located on poles or platforms above the 100-year flood level.

2.3 UTILITIES

Since the site will generally be unmanned, no permanent sanitary facilities for workers will be provided.

Section 3

SECTIONTHREE Extraction Wells

The primary control mechanism for the overall Groundwater Mitigation Control System will be the extraction wells. The extraction system consists of three extraction wells located east of the barrier wall. These wells will be drilled in accordance with the Technical Specifications (Numbers 02525, 02526, 16500, and 16600) presented in this volume. Well locations and details are shown in the Drawings.

3.1 DESIGN ASSUMPTIONS AND PARAMETERS

The Specifications were produced based on the following assumptions and parameters:

- The extraction system is to consist of three, 10-in. diameter wells.
- The wells are to be screened with 65 ft of screen at depths from 40 to 105 ft below ground surface (bgs).
- Each well is to have a nominal pumping capacity of 333 gallons per minute (gpm). Therefore, the total nominal system capacity will be 1,000 gpm. Actual extraction rates will be determined after the system is installed.
- The overall hydraulic conductivity of the formation is assumed to be 0.1 centimeters per second (cm/sec).
- Extracted groundwater is to be conveyed from the wells via buried underground lines consisting of high density polyethylene (HDPE) pipe.
- It is anticipated that an existing pipe with a diameter of 30 in. can be used as a casing pipe for the effluent pipeline which will convey the extracted groundwater through certain features and facilities, including a levee and railroad tracks. The remainder of the pipeline will likely be installed adjacent to the existing 30 in. pipeline, but not pass through it. However, this information is pending final design of the conveyance system.
- The well controls will be placed at each well head.
- Instantaneous flow will be measured at each well (no remote data transmission).
- Total and instantaneous flow will be measured at the discharge point.
- A double-valved sample port will be added to each wellhead.
- All electrical power will be run underground.

- The piping system will be over-designed in the event that additional flow is required subsequently, using higher capacity pumps.
- The well head will be capable of surviving a 100-year flood event (see below).
- Assume that the system will operate for 30 years.
- Supplied electrical service will be 480 volt, 280 amp service located near the pole-barn.
- The preferred drilling method is to drive 10-in. diameter casing using a cable tool-drilling rig and install a telescoping screen beneath the casing.

Sieve analyses and boring logs were provided for a number of wells located in the vicinity of the planned extraction wells. Results of the sieve analyses for two of the wells, which are located near the planned extractions wells, are included in Attachment 4-1 of this report. These sieve analyses were used as the design basis for the extraction wells. Sieve analysis depth intervals generally correspond to the depth range of the proposed wells, but do not correspond to the uppermost and lowermost depths.

The extraction wells will be designed to withstand a 100-year flood event to the extent possible and the control panels will be sealed to restrict the influx of floodwater. The control panels will be installed at an elevation above the 100-year flood event.

The extraction system discussed herein has been designed to operate for a 30 year period of time. However, this assumes that periodic maintenance will be conducted. The required maintenance program will be documented in the Operation and Maintenance Plan to be developed for this project.

3.2 TECHNICAL SPECIFICATIONS

Specific design parameters for the wells are discussed in the specifications. The specifications discuss the construction methods, design materials, and design restrictions. Means of handling drill cuttings and fluids and are also discussed in the specifications. The extraction system is illustrated through the use of five technical drawings that are included in the specifications. Well performance criteria are discussed in the Construction Quality Assurance Plan.

Attachment 3-1 Calculations

Golder Associates CONSULTING ENGINEERS	SUBJECT SITE R WELLS		
	Job No. 013-9665	Made by JRS	Date 3/26/02
	Ref. SCREEN DESIGN	Checked MSA	Sheet 1 of 5
		Reviewed	

WELL DESIGN

BASIS OF DESIGN:

CONVERSATIONS WITH SOLUTIA - 3/24/02 TO 3/26/02 + A FAX MESSAGE DATED 3/24/02

WELLS TO BE SCREENED FROM 355' TO 315'
(SURFACE IS APPROXIMATELY 420')

WELL ASSUMED TO HAVE 40' OF SCREEN

IN TERMS OF DEPTH BELOW GROUND SURFACE →
SCREEN INTERVAL 65' BGS - 105' BGS
(SCREEN MIDPOINT = 85' BGS)

CAPACITY:

300 GPM WITH 20% OVER DESIGN CAPACITY
FOR A PER WELL CAPACITY OF 360 GPM
(1 GPM = 5.45 m^3/DAY)

WELL DIAMETER: 10" WELL WITH 10" DIA
TELESCOPING SCREEN

HYDRAULIC CONDUCTIVITY: ASSUMED TO BE
0.1 CM/SEC

Golder Associates CONSULTING ENGINEERS	SUBJECT SITER WELLS		
	Job No. 013-9665	Made by JRS	Date 3/20/02
	Ref. SCREEN DESIGN	Checked MSL	Sheet 2 of 5
		Reviewed MLS	

CONVERSIONS 0.1 CM/SEC = 86 M/DAY
284 FT/DAY

SCREEN ENTRANCE VELOCITY CRITERIA

SOURCE: "THE HANDBOOK OF GROUNDWATER ENGINEERING", JACQUES DELLEUR, 1999, CRC PRESS LLC

RECOMMENDED SCREEN ENTRANCE VELOCITY PER TABLE 9.8:

0.02 M/SEC

ASSUMING HYDRAULIC CONDUCTIVITY OF 86 M/DAY

FORMULA:

A_0 = EFFECTIVE OPEN AREA PER METER OF SCREEN LENGTH

A_0 = 3.14 X WELL DIAMETER (M) X CLOG FACTOR X OPEN AREA

L_m = MINIMUM PERMISSIBLE SCREEN LENGTH

$$L_m = \frac{\text{PUMP RATE } (m^3/\text{DAY})}{86400 \times \text{SCREEN ENTRANCE VELOCITY} \times A_0}$$

(1M = 3.28')

Golder Associates CONSULTING ENGINEERS	SUBJECT SITE R WELLS		
	Job No. 013-9605	Made by TRS	Date 3/26/02
	Ref. SCREEN DESIGN	Checked MSL	Sheet 3 of 5
		Reviewed MKJ	

FORMULA INPUT: WELL DIAMETER = 10" = 0.25 M

CLOG FACTOR = 0.5 (ASSUMED)

SCREEN ENTRANCE CRITERIA = 0.02 M/S

SCREEN OPEN AREAS FOR VARIOUS SLOT SIZES

SOURCE: TECHNICAL SPECIFICATIONS – JOHNSON SCREENS, TYPE 304 STAINLESS STEEL SCREENS, TELESCOPING SCREEN, 10" DIAMETER.

$$\text{OPEN AREA} = \frac{\text{SLOT}}{\text{SLOT} + \text{WIRE WIDTH}}$$

30 SLOT — 0.21

40 SLOT — 0.26

50 SLOT — 0.30

FORMULA APPLICATION — MINIMUM SCREEN LENGTH

30 SLOT = 44' 13.6 M

40 SLOT = 36' 11.0 M

50 SLOT = 31' 9.5 M

RESULTS: 40 SLOT AND HIGHER ARE PERMISSIBLE ACCORDING TO ENTRANCE VELOCITIES

Golder Associates CONSULTING ENGINEERS	SUBJECT		
	Job No. 013-9665	Made by JRS	Date 3/26/02
	Ref. SCREEN DESIGN	Checked MSL	Sheet 4 of 5
		Reviewed MAS	

SLOT SIZE BASED ON FORMATION DATA

SOURCES:

1) CRITERIA LISTED IN "GROUNDWATER MANUAL", US DEPARTMENT OF THE INTERIOR, 1985

2) SIEVE ANALYSES PROVIDED IN "KRUMMRICH GROUNDWATER MIGRATION CONTROL PRE-DESIGN INVESTIGATION", URS, OCTOBER 4, 2001

SIEVE ANALYSIS CURVES FOR SB-2 84'-86'

(CHOSEN TO CORRESPOND TO MID-POINT ON THE PROPOSED SCREEN AT 85' BGS.)

UNIFORMITY - DEPARTMENT OF INTERIOR METHOD

PERCENT PASSING - UNIFORMITY = D60/D10

D60 = 2.6 mm
D10 = 0.3 mm

UNIFORMITY = 8.67

FOR UNIFORMITY OF 8.67 - RECOMMENDED SLOT SIZE TO RETAIN 30 TO 50% OF AQUIFER

IN OTHER WORDS - ALLOW TO PASS 70% TO 50% OF AQUIFER

Golder Associates CONSULTING ENGINEERS	SUBJECT SITE R WELLS		
	Job No. 013-9665	Made by JRS	Date 3/26/02
	Ref. SCREEN DESIGN	Checked MSL	Sheet 5 of 5
		Reviewed MRG	

BASED ON PARTICLE SIZE CURVES

50 % PASS = 1.3 MM = 0.05 INCH OR

50 SLOT OR HIGHER IS OK

RESULT:

BASED ON SCREEN VELOCITIES, 40 SLOT IS OK

BASED ON SIEVE ANALYSIS, 50 SLOT OR HIGER IS OK
HOWEVER, INSPECTION OF OTHER INTERVALS AND BORING SIEVE ANALYSES, FINER STRATA DO OCCUR.

THEREFORE USE 40 SLOT SCREEN (0.040 INCH) FOR WELLS.

11/6/02 NOTE:

SOLUTIA REQUESTS 25 FEET OF ADDITIONAL SCREEN BEGINNING AT 40 FEET BELOW GROUND SURFACE, IN ORDER TO SCREEN MORE OF THE AQUIFER. ADDITIONAL SCREEN LENGTH WILL REQUIRE THAT THE PUMP BE PLACED BELOW TOP OF SCREEN, BUT NOT SIGNIFICANTLY CHANGE OTHER DESIGN PARAMETERS. JRS.

WELL SCREEN DATA SHEET — TYPE 304 S.S.

LARGE DIAMETER
SHALLOW DEPTH
STANDARD CONSTRUCTION

Nominal Size	100 Ft							250 Ft						
	OD	Clear ID	Wire Wd	Wire Ht.	Co	Rod Area	Wt/Ft*	OD	Clear ID	Wire Wd	Wire Ht.	Co	Rod Area	Wt/Ft*
6P **	6.57	6.02	0.089	0.075	31	0.338	3.70	6.66	6.02	0.116	0.144	200	0.338	4.78
8T	7.53	6.76	0.116	0.144	139	0.432	5.53	7.53	6.76	0.116	0.144	139	0.432	5.53
8P	8.66	7.87	0.116	0.144	91	0.475	6.29	8.66	7.87	0.116	0.144	91	0.475	6.29
10T	9.57	8.66	0.116	0.144	68	0.562	7.07	9.57	8.66	0.116	0.144	68	0.562	7.07
10P	10.69	9.87	0.116	0.144	48	0.605	7.83	10.75	9.87	0.148	0.200	181	0.605	10.61
12T	11.21	10.37	0.116	0.144	42	0.691	8.40	11.27	10.37	0.148	0.200	157	0.691	11.31
12P	12.75	11.84	0.148	0.200	102	0.691	12.49	12.75	11.84	0.148	0.200	102	0.691	12.49
14T	12.45	11.57	0.148	0.200	116	0.562	11.82	12.45	11.57	0.148	0.200	116	0.562	11.82
14P/16T	13.99	13.03	0.148	0.200	82	0.670	13.41	13.99	13.03	0.148	0.200	82	0.670	13.41
16P/18T	16.00	15.05	0.148	0.200	55	0.756	15.30	16.04	15.05	0.150	0.220	71	1.512	25.34
18P/20T	17.80	16.74	0.148	0.200	40	0.778	16.81	17.84	16.74	0.150	0.220	51	1.555	27.76
20P	19.84	18.77	0.148	0.200	29	0.907	18.87	19.88	18.77	0.150	0.220	37	1.814	31.21
24T	21.86	20.66	0.150	0.220	28	1.037	31.10	21.92	20.66	0.158	0.240	40	2.074	42.16
24P/26T	24.03	22.78	0.158	0.240	30	1.964	45.35	24.26	22.78	0.142	0.295	50	1.964	47.75
26P	25.75	24.39	0.158	0.240	25	2.111	48.62	25.90	24.39	0.142	0.295	41	2.111	51.03
30T	27.10	25.73	0.158	0.240	21	2.111	50.79	27.25	25.73	0.142	0.295	35	2.111	53.31
30P/36T	29.70	28.27	0.158	0.240	16	2.455	56.15	29.85	28.27	0.142	0.295	27	2.455	58.88
36P	35.70	34.26	0.142	0.295	16	2.480	70.12	35.85	34.26	0.142	0.295	27	5.696	70.37

To Calculate:
Open area (OA) percent OA = slot/(slot + wire width)
Inlet area (IA) in sq. in./ft. of screen: IA = 37.7 x OD x OA
Transmitting Capacity (TC) in gpm/ft. of screen: TC = IA x 0.31
Tensile Strength (TS) in lbs: TS = Rod Area x 30,000 x SF
Hang Weight (HW) in lbs: HW = TS/2
Collapse Strength (ClpS) in psi: ClpS = Co x (wire width/wire width + design slot) x SF

SF = Safety Factor
Co = Collapse strength at zero slot
Slot openings greater than 0.050" may necessitate deviation from standard construction
*WT/FT based on 30 slot construction – no fittings included
**Max. depth – 50 ft.

USF Filtration & Separation

Johnson Screens
P.O. Box 64118
St. Paul, MN 55164
800.VEE WIRE (833-9473) phone
651-636-3900 phone
1-800-328-9891 fax
http://www.johnsonscreens.usfilter.com

Wesco Screens
14909 Sommermeyer Road
Houston, TX 77041
1-800.231-0419 phone
713-939-8567 fax

5204 LgDiam/SS
Shallow/Std-1199

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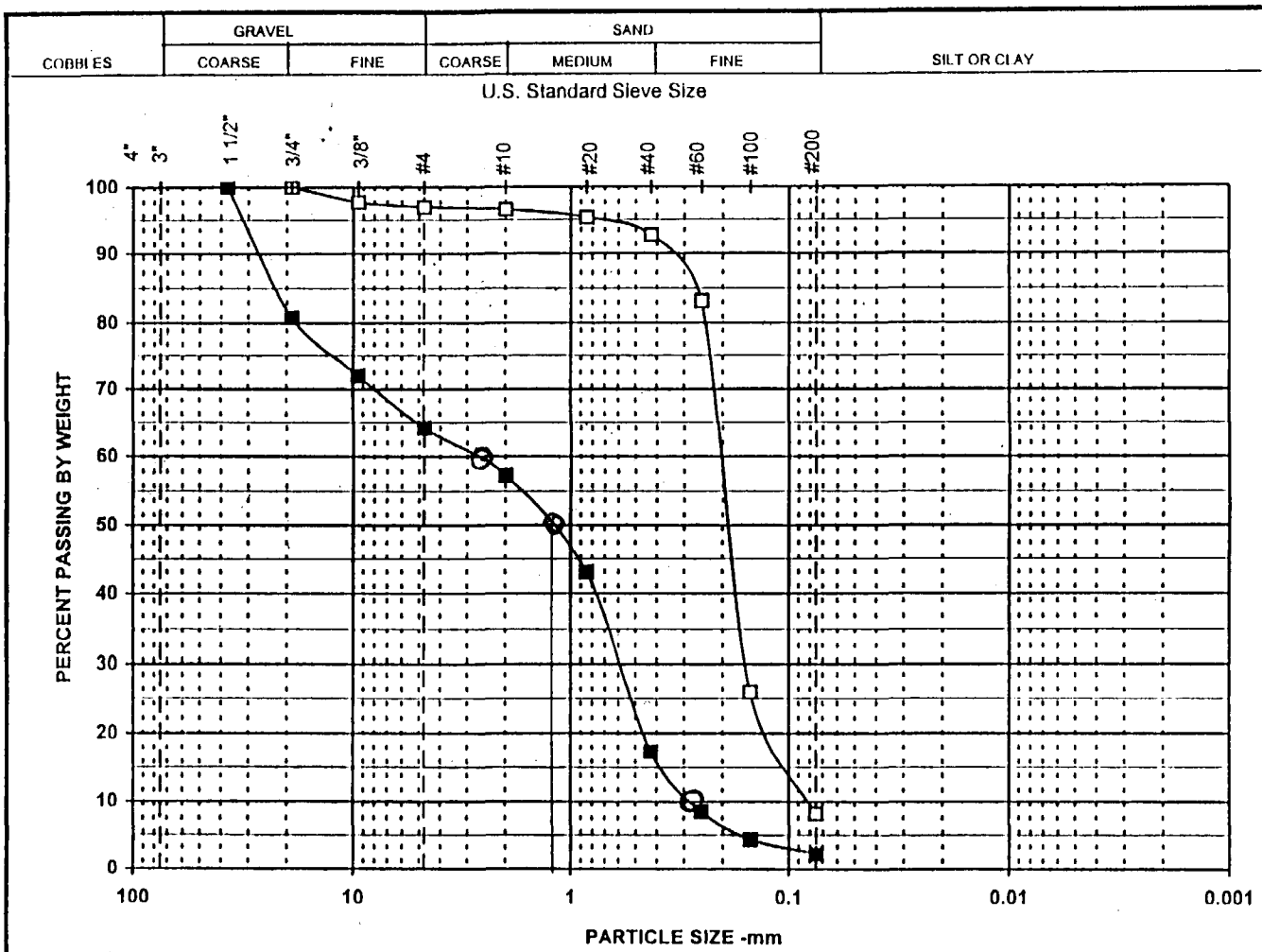


Symbol	□	■	○
Boring	SB-2	SB-2	
Sample			
Spec			
Depth	79-81	84-86	
% +3"			
% Gravel	3.0	35.7	
% SAND	88.8	62.0	
% FINES	8.2	2.3	
% -2μ			
Cc	1.4	0.5	
Cu	2.5	11.0	
LL			
PL			
PI			
USCS	SP-SM	SP	
w (%)	26.3	7.2	

Particle Size	PERCENT FINER		
(Sieve #)	□	■	○
4"			
3"			
1 1/2"		100.0	
3/4"	100.0	80.9	
3/8"	97.7	72.1	
4	97.0	64.3	
10	96.6	57.3	
20	95.4	43.1	
40	92.8	17.4	
60	83.2	8.5	
100	26.1	4.4	
200	8.2	2.3	

SYMBOL	DESCRIPTION AND REMARKS
□	light gray f. SAND, trace f. gravel, m. sand, silt.
■	light gray gravelly c-f SAND, trace silt.
○	

PARTICLE SIZE DISTRIBUTION

Solutia Site R

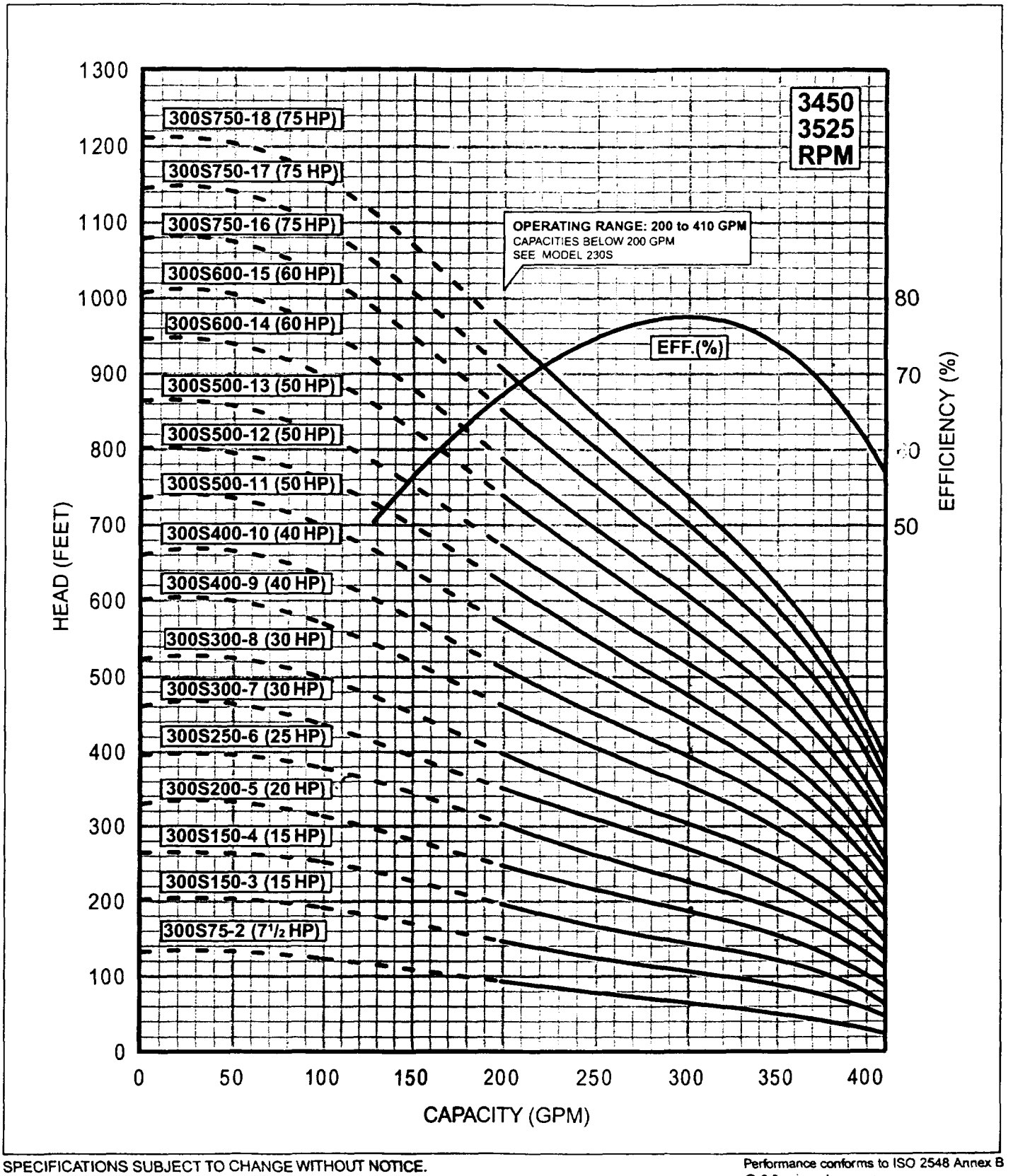
Project No.		
23-20010085	August 2001	Figure

URS

slev1d.xls 08/29/2001

Model 300S 300 GPM Performance Curves

FLOW RANGE: 200 -410 GPM **OUTLET SIZE: 3"& 4" NPT*** **NOMINAL DIA. 6"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 7.5 HP/3450 RPM.
6" MOTOR STANDARD,15-50 HP/3450 RPM.
8" MOTOR STANDARD, 60-75 HP/3525 RPM.
* 3" NPT 2-7 STAGES, 4" NPT 8-18 STAGES.

Performance conforms to ISO 2548 Annex B
@ 8 ft. min. submergence.

GRUNDFOS

The purpose of the barrier wall is to reduce the volume of groundwater flow into the GMCS from the Mississippi River during operation of the groundwater extraction pumps. The pumps are intended to be the principal groundwater control measure for this project. The barrier wall is intended to reduce operation and maintenance (O&M) costs by reducing the volume of water treated. Higher pumping rates will increase O&M costs but will not reduce the ability to abate the impact of groundwater discharge to the Mississippi River from Site R and other nearby sources.

Portions of the design of the barrier wall can not be completed until a contractor has been selected. Once selected, the contractor will construct a test section, and the contractor's means and methods established during this testing phase will influence design elements such as mix design, injection hole spacing, injection pressure, panel lengths, and extraction rates. Therefore, once the pre-production testing is complete, the design elements for the barrier wall can be finalized.

4.1 SUBSURFACE CONDITIONS

4.1.1 Geology

This site is located in the American Bottoms physiographic province. The subsurface materials consist of unconsolidated, recent alluvium known as the Cahokia Alluvium, overlying glacio-alluvial outwash known as the Henry Formation. The Cahokia Alluvium is approximately 40-ft thick and consists of unconsolidated, poorly-sorted, fine-grained material with some local sand lenses. These alluvial deposits unconformably overlie the Henry Formation, which is composed of medium to coarse sand and gravel that increases in grain size with depth. This unit is approximately 100-ft thick at the site and generally becomes thinner with increasing distance from the Mississippi River.

The alluvial soils are underlain by Mississippian and Pennsylvanian age bedrock consisting primarily of limestone and dolomite with some sandstone and shale. The bedrock is older in the central and western sections of the American Bottoms.

4.1.2 Hydrogeology

Sauget Area 2 is located in the southwestern section of the American Bottoms floodplain. More specifically, it is situated south of East St. Louis, and extends approximately three-quarters to

one mile east of the eastern bank of the Mississippi River. The stratigraphy beneath the site is much like that of the rest of the floodplain. The Cahokia Alluvium is about 30 to 40-ft thick consisting of clay and silt with sand zones. Below this, the unconsolidated deposits of the Henry Formation are present. Locally, the Henry Formation is characterized by medium-to-coarse sand that becomes coarser and more permeable with depth. Bedrock is located approximately 130 to 140 ft below ground surface. Cross-sections showing site-specific geology are provided in the Drawings.

Three hydrogeologic units can be identified: 1) a shallow hydrogeologic unit (SHU); 2) a middle hydrogeologic unit (MHU); and 3) a deep hydrogeologic unit (DHU). The SHU is 30 to 40-ft thick and includes the Cahokia Alluvium (recent deposits) and the uppermost portion of the Henry Formation. This unit is primarily an unconsolidated, fine-grained, stratum with low to moderate permeability. The MHU is 40-ft thick and formed by the upper to middle, medium to coarse sand of the Henry Formation. It contains a higher permeability sand than found in the overlying SHU, and these sands become coarser with depth. At the bottom of the aquifer is the DHU, which includes the high permeability, coarse-grained deposits of the lower Henry Formation. This zone is estimated to be about 30 to 40-ft thick.

Recharge to the aquifer occurs through four sources: 1) precipitation; 2) infiltration from the Mississippi River; 3) inflow from the buried valley channel of the Mississippi River; and 4) subsurface flow from the bluffs that border the floodplain on the east.

During normal and low river stage conditions, groundwater at Sauget Area 2 flows from east to west and discharges to the Mississippi River, the natural discharge point for groundwater in the American Bottoms aquifer. When flood stage occurs in the Mississippi River, flow reverses.

4.1.2.1 Results of Recent Field Sampling

From October to December 2002, ten additional borings were drilled along the planned barrier wall alignment. The primary objective of the exploration program was to obtain data from a depth of approximately 70 ft to bedrock, specifically focusing on the attributes of a clay interval that has previously been identified in the area (at depths of approximately 115 to 125 ft below ground surface). Boring logs and other geotechnical data are included in Attachment 4-1 of this volume.

In addition to the drilling program mentioned above, one of the three permanent wells to be used for groundwater extraction has been completed.

4.1.3 Geometry, Plan and Elevation

A 3,300-ft long, U-shaped, fully penetrating, barrier wall installed using jet-grouting techniques will be constructed between the downgradient boundary of Sauget Area 2 Site R and the Mississippi River. Plans and details are shown in the Drawings. The barrier wall is designed to reduce recharge from the Mississippi River in the MHU and DHU. It will extend vertically from nominally about 40 ft below grade to the top of bedrock, nominally 130 to 140 ft below grade. The injection holes will be drilled a few feet into the bedrock to ensure that the injection ports are approximately at the elevation of the top of the bedrock. The jet grout wall will be designed to produce a continuous barrier with minimal gaps. Minor discontinuities may occur because of localized geologic variations, utilities, or other obstructions. These discontinuities, if they exist, are expected to be minor and should not materially affect the performance of the system.

4.1.4 Permeability and Strength

The average design permeability of the in-place wall will be specified to be less than 1×10^{-5} cm/sec based on pump test results from a test cell installed prior to wall construction, and in the two test cells to be constructed along the wall during construction. The design strength of the grout mix will be specified to be a minimum of 30 psi at 28 days. These design parameters were chosen as performance criteria, but are not critical design parameters. If the permeability of the wall is greater or the strength of the wall less than indicated above, the system should not be compromised. Because the extraction wells are the primary control mechanisms for this system, additional recharge from the river through the wall would simply result in additional quantities of groundwater to be extracted, but will not influence the objective of the overall control system which is to minimize groundwater discharge to the Mississippi River from the area east of the extraction wells.

4.1.5 Materials

Materials for the barrier wall may include Portland Cement, bentonite, pozzolanic material, water, and the insitu soils along the wall alignment, primarily sand and gravel. Non-toxic and biodegradable admixtures such as fluidifiers and retarders may also be used. The actual grout

mix will be determined by the barrier wall contractor based on laboratory trial mixes, and the pre-production test cells.

4.2 BASIS OF BARRIER DESIGN

Design restrictions of the wall alignment are noted in Section 2. Elements of the design of the barrier wall can not be completed until a contractor has been selected. As noted previously, the barrier wall will be constructed by jet-grouting, which involves injecting grout into the soils at high pressures. The ability to construct a continuous barrier with a minimum of discontinuities depends on a number of factors, including:

- The soil type(s)
- The type of injection system
- The spacing and verticality of the injection holes
- The grout mix
- The injection pressure
- The withdrawal rate of the grout string.

With the exception of the soil type(s), all of these parameters are dependent on the type of injection system selected to construct the wall and, hence, on the contractor.

Jet grout panels can be constructed using one of several injection systems:

- Single fluid systems which utilize a single injection port in the drill stem to inject high pressure grout to fluidize the soil, while mixing with it at the same time.
- Double fluid systems that utilize an air curtain around the grout stream to keep the stream more coherent and, hence, provide better control of the geometry and effective radius of the jet stream.
- Triple fluid systems that use an air and water stream to erode and fluidize the soil, which is pumped to the ground surface. Grout is injected beneath the water jet and forms a grout panel as the drill string is withdrawn. The triple fluid system is a total replacement system, in that the soil is completely replaced by the grout.

An advanced technique for use with these systems has been developed in Japan and is used by one contractor in this country. This technique, known as superjet grouting, uses a very high velocity stream of cement slurry and air to fluidize and mix the soil. The advantage of this technique is that it allows larger grout injection hole spacings and, hence, larger panel sizes. However, as noted, the technology has only been licensed to one contractor in the United States.

Each method has its advantages and disadvantages. For example, single jet grouting will generally produce the minimum amount of spoils, but allows the least control of the geometry and continuity of the wall. Triple fluid systems, on the other hand, are more expensive, since they totally replace the soil with grout and will produce the largest volume of spoils. However, they provide strong continuous structures and are generally used for structural walls.

Because of the wide variability in techniques and equipment, the key wall construction parameters cannot be specified until a contractor is selected. Once that selection is made, the contractor will be required to develop and implement a pre-construction test program designed to determine the critical parameters to be used during construction at this site, including mix design, injection hole spacing, injection pressure, panel lengths, extraction rates, and wall thickness. Therefore, the pre-production testing will need to be completed prior to a finalized design of the barrier wall is made.

4.3 CONSTRUCTION METHODS AND SEQUENCE

The barrier wall will be constructed using jet-grouting techniques by a specialty contractor on a design-build basis.

4.3.1 Construction Methods

Jet grouting involves injecting a grout mixture at very high pressures (up to 5,000 to 6,000 psi) and velocities as great as 1,000 ft/s into the pore spaces of the surrounding soil formation. Drilling is performed using rotary or percussion drilling techniques and an external water flush with special drill rods and bits. Following the advance of the drill rods to the design depth, the jet-grouting process commences. The jetted grout cuts, replaces, and mixes the soil with cementing material to form a low permeability soil-cement admixture. The soil structure is destroyed as grout and soil are mixed, forming a homogenous mass. Many structures and geometries can be achieved by altering the parameters of the grouting process. A panel is

formed by extracting the drill rod without rotation. The barrier wall will be a series of overlapping panels to form a continuous wall.

4.3.2 Construction Sequence

The actual construction sequence will be determined by the selected design-build contractor. Key elements of the construction sequence will include the following:

- Preparation of trial grout mixes and selection of an optimum mix that is compatible with site groundwater. An initial study of compatibility of grouts with the site groundwater has been performed and is included as Attachment 4-2.
- Mobilization.
- Construction of a pre-production test cell to verify the adequacy of the design and construction techniques to create a barrier wall with an average permeability of 1×10^{-5} cm/sec or less. Once the pre-production testing is complete, the site-specific details of the design, including mix composition, injection hole spacing, injection pressure, panel lengths, panel thickness, and extraction rates will be finalized.
- It is anticipated that EPA will be on site during the installation and testing performed for the pre-production test cells. Upon completion of the pre-production test results, it is assumed that the EPA representative on site will approve the pre-production test procedures which yielded a satisfactory product for the barrier wall construction. It is anticipated that this approval will be made in the field and that an additional submittal will not be required.
- Barrier wall installation with overlapping panels constructed from the bottom up along the wall alignment. Drill holes will be surveyed prior to grouting to verify verticality and that adequate overlap is achieved.
- Installation of two test cells along the wall during production to verify continuity and permeability of the barrier wall.
- Demobilization.

4.4 SPOILS HANDLING AND STORAGE

Barrier wall construction will generate spoils that will be collected and transferred to the temporary spoil stockpile. The stockpile is intended to be a temporary facility, and the final disposition of the stockpile will be addressed as part of a future Record Of Decision for Sauget Area 2. The actual method of spoil handling will be determined by the barrier wall contractor; however, spoil will likely be handled by different methods for different portions of the barrier wall. It has been assumed that spoils will be contained in temporary pits for sections of the barrier wall that are parallel to the river where space permits. Due to the pozzolanic material in the spoils, they are expected set up or strengthen to the consistency of a stiff clay. After the spoil sets up, it will be removed from the pits using a backhoe and trucked to the temporary stockpile where it will be placed and compacted. Once hardened, the spoils will not contain free water. Each open spoil pit will then be backfilled with soil excavated from the adjacent pit or imported clean fill as barrier wall construction proceeds.

It is anticipated that spoil disposal along the north and south legs of the "U" will be handled in a different manner because these sections of the wall will be built on non-Solutia property or through the pavement of Riverview Avenue. In these areas, spoil pits are not practical and the contractor will likely collect the spoil in a container as it is generated. The fluid spoils will be hauled to temporary drying pits to allow the spoil to set up, after which the spoils will be removed and trucked to the temporary stockpile where it will be placed and compacted. Drying pits will be restricted to areas outside of the existing Site R landfill, but within the Site R property boundaries.

4.4.1 Volume and Type of Spoils

The volume and type of spoils will depend on the contractor's selected means and methods. There are a variety of types of spoils that could be generated during the construction of the barrier wall. Material from the following sources are expected to comprise the spoils: 1) spoils from the boreholes to be used for the injection pipes; 2) cuttings from construction of the jet grouted elements; and 3) excess or spilled grout. Therefore, the spoils could be any combination of clay, sand, gravel, and grout.

For the purpose of this design, it has been estimated that approximately 30,000 cubic yards of material will be placed into the temporary stockpile. This volume was determined based on

discussions with a specialty contractor. Only solidified spoils will be placed in the temporary stockpile.

4.4.2 Temporary Spoil Stockpile

A temporary spoil stockpile will be constructed on top of the existing landfill to manage the spoils from the wall construction and other excavations. Once placed into the stockpile area, the spoils will be graded and compacted using a front-end loader or bulldozer.

The stockpile is designed to contain soil or dry, hardened material from the slurry pits. If the slurry is not dry, temporary drying pits may be required prior to placement in the stockpile.

The perimeter of the stockpile will be constructed of clean soil material imported from off site. A daily cover of polyethylene sheeting will be placed over the spoils. A clean soil layer, if needed, will serve to provide a leveling layer between the spoils and a interim HDPE cover as shown in the drawings. Rip rap will be placed on the exterior side slopes of the stockpile to protect it from scour and erosion. A vegetative layer will be placed on top of the HDPE cover. The top of the vegetative layer will be at a minimum elevation of 431.8 ft, which is nearly 5 ft above the 100-year flood level, 3 ft above the 500-year flood level, and half a foot above the top of the levee. Therefore, it is not necessary to place riprap on the top of the temporary spoil stockpile.

If the volume of generated spoils is greater than 30,000 cubic yards, the stockpile could be extended in a northerly direction as shown in the Drawings.

4.4.2.1 Stormwater Control

During construction, the contractor will be required to implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP will include the design, construction, operations, and maintenance of a run-off management system to collect and control impacted water resulting from a 24-hour, 25-year storm. The contractor must also design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the temporary stockpile during the peak discharge from the 25-year storm.

4.4.2.2 Daily Cover/Cap

The spoils material will be covered daily by a polyethylene sheet to minimize wind dispersal, and to minimize the amount of rainfall runoff that contacts the spoils.

4.4.2.3 Interim Cover

The filled temporary spoils stockpile will be covered with a clean soil leveling layer, if needed, which will then be covered with a HDPE geomembrane cover. An additional clean soil layer will be placed on top of the HDPE material and will be seeded to form a vegetative layer. Details of the cover are shown on the construction drawings.

4.5 EXPECTED LONG-TERM MONITORING

Long-term monitoring is discussed in detail in Volume 3.

4.6 CALCULATIONS

Hydraulic calculations regarding the anticipated flow rates into the wells, with and without the barrier wall, are provided in the Focused Feasibility Study.

Section 5

5.1 DESIGN ASSUMPTIONS AND PARAMETERS

5.1.1 Flows

The effluent pipeline has been conservatively designed for a maximum flow of 667 gpm per well for the three Site R extraction wells, or a total flow of 2,000 gpm, as opposed to the 1,000 gpm flow expected based on the previous hydrogeologic modeling. It may be necessary to increase the sizes of the pumps and drop pipes in the wells if such higher flows are required from the wells, but the pipeline itself will be sufficient for such higher flows.

5.1.2 Flood Level

The maximum Mississippi River flood stage at the site has been (conservatively) assumed for the purpose of computing external pressure as El 431.5 ft, NGVD, which is the approximate top of the concrete floodwall where the pipeline crosses under the levee. This level corresponds to a flood about 2.7 ft above the 500-year flood level at Mile 178 (above Ohio River) on a Corps of Engineers drawing dated 1979 entitled "Standard River Profiles, Mississippi River, St Louis District." This is the approximate location of the site on the river profile.

5.1.3 Size of Pump Drop Pipe and Head Loss Characteristics

The size of the stainless steel pump drop pipe has been assumed as 4.5 in. O.D. and 4.026 in. I.D. (Sch 40 pipe). A Hazen and Williams coefficient of 140 has been used to calculate friction head losses through the stainless steel drop pipe.

5.1.4 Lift

The lift has been computed to be 61 ft from El 363 (3 ft above the pump setting at El 360, about 60 ft below the existing ground surface) to a high point in the discharge line at El 424.

5.1.5 Pipeline Size and Head Loss Characteristics

(See Drawings 2-14 through 2-18.) The pipeline will be 12.75-in. OD SDR 21 HDPE pipe on the river side of the levee. A combination air/vacuum valve will be installed in a manhole at the high point of the pipeline on the river side of the levee. Because the pipeline will be slipped into the existing 30-in. diameter concrete pipe under the levee and the impracticality of ever changing the pipeline diameter there in the future, the pipeline will be increased under the levee to 24-in. OD SDR 21 HDPE and will be that diameter to the eastern side of Mobile St, where it will be

reduced again to 12.75 in. OD SDR 21 HDPE. From the eastern side of Mobile St. to a point north of the manholes east of the P-Chem Plant, the pipeline will be 12.75 in. OD SDR 21 HDPE. At that point, the pipeline material will change to 12-in. ID ductile iron pipe, and all pipe and fittings from that point to the discharge end will be ductile iron. The friction loss in the HDPE pipeline has been computed using a Hazen and Williams coefficient of 155. The friction losses in the ductile iron pipe have been computed using a Hazen and Williams coefficient of 130. A safety factor of 44 ft of head was added to the total head to account for increasing roughness of the pipe with increasing age.

5.1.6 Discharge Point

The discharge point will be into one of the two open-top manholes east of the P-Chem Plant. The design will include valves to direct the flow into either manhole. The fittings and instruments at the end of the pipeline will be enclosed in a heated shelter on a concrete slab. The pipe will elbow over the tops of the manhole walls and terminate inside of the manholes 5 ft below the top of the manhole.

5.1.6.1 Flow Measurement

The flow will be measured at the eastern end of the discharge line using an electromagnetic flow meter. The signal from the flow meter will be transmitted by spread spectrum radio or through hard wire to the American Bottoms Regional Wastewater Treatment Facility (ABRTF).

5.1.6.2 Water Sampling

Samples of the effluent for ABRTF will be taken continuously using an American Sigma 900MAX sampler.

5.1.6.3 Check Valve and Plug Valves

There will be a check valve and two plug valves downstream of the flow meter. The check valve will be a rubber flap-type swing check valve with a small closing arc to minimize water hammer. The head loss characteristics of a Valmatic Swing-Flex valve have been used to compute the head loss through the valve. Two iron plug valves will be installed in the two lines downstream of the check valve to permit diversion of the flow into the selected manhole.

5.1.7 Pipe Route from Wells to Discharge Point

The location of the pipeline is shown on the Drawings. The pipeline will be laid from Well EW-3 north approximately parallel to the proposed barrier wall to the Solutia easement south of the fence on the south side of the Ameren Power Plant property and north of Riverview Avenue, then east to the levee. On the west side of Pitzman Road, an existing abandoned 30-in. diameter reinforced concrete water line will be exposed and the effluent pipe will be slipped into it to the eastern side of Mobile Avenue. It may not be possible to slip the pipeline into the 30-in. RCP for the entire length between Pitzman Road and Mobile Avenue. As a minimum, the pipeline will extend from the riverside of the levee to the landside east of the first set of railroad tracks. Under the levee, the annulus between the pipeline and the ID of the 30-in. RCP will be grouted full length as indicated on the drawings to prevent piping through the annulus during a flood. East of the railroad tracks, the pipeline may be slipped into the existing 30-in. RCP or laid in its own trench alongside of the 30-in. RCP. Just north of Existing Manhole C east of the levee, the pipeline will turn up through the proposed slab on grade, where the discharge will be metered and samples will be obtained for testing by the American Bottoms Regional Wastewater Treatment Facility. The two pipelines will be supported on pipe supports to Manholes B and C, where they will discharge over the walls and into the manholes 5 ft below the tops of the manholes.

5.1.7.1 Sliplining within Existing 30-in. Concrete Waterline

The current plan is to remove the 6-in. diameter steel sulfuric acid line and its 12-in. diameter steel carrier pipe now within the 30-in. line and slip the new 24-in. OD HDPE line through the 30-in. diameter line. The annulus between the OD of the new 24-in. diameter HDPE pipe and the ID of the existing 30-in. diameter concrete pipe will be grouted full length under the levee to prevent water from flowing through the annulus during a flood.

5.1.8 Air Release/Vacuum Relief Valves

A combination air valve will be installed in a manhole at the high point of the pipeline on the western side of the levee and an air release valve will be installed at the discharge point.

5.2 DESIGN RESTRICTIONS

5.2.1 Capacity of Well Pumps

The pumps will be 15-20 HP pumps with limited head capacity. When final selection of the pumps is made, system curves will be developed and these curves will define the flow for a given pumping water level in the wells and the particular pumps being used.

5.2.2 Status and Condition of Existing 30-in. RCP Water Line Under Levee

The pipeline has been designed based on the assumption that the pipeline can be slipped through this pipe under the levee. Should this prove to be impossible, the line will be routed over rather than under the levee. In this case, the head on the pumps will be increased, requiring acceptance of lower flow or redesigning with pumps with higher head capacity.

5.3 CALCULATIONS

5.3.1 Total Dynamic Head (Maximum Flow)

The total dynamic head for a flow of 333 gpm per well is about 125 ft, calculated as shown in Attachment 5-1a. A safety factor of 44 ft of head has been added to the total head account for increasing roughness in the pipeline with age. The friction losses were computed based on the Hazen and Williams formula with the coefficients given above and detailed in Attachment 5-1a. The total head was also computed for a flow of 667 gpm per well. With the 44-ft allowance for increased roughness in the pipe, the total computed head is 178 ft, or 53 ft more than the total head computed for the 333-gpm per well flow. This increase in head will be reduced considerably should larger pumps be required by using larger diameter drop pipe and fittings (5-in. or 6-in. nominal diameter) in the wells and larger pipe and fittings between the well and the effluent pipeline.

5.3.2 Internal Pressure

The maximum normal internal pressure in the pipe line will be the sum of head losses between Well EW-1 and the high point in the pipeline farthest from Well EW-1 plus the difference in the pipe elevation between Well EW-1 (El 416) and the high point in the line (El 423). This total head (for a well flow of 333 gpm) is about 49 + 7 = 56 ft, or about 24 psi. Transient pressures caused by check valves closing could increase the pressure within the pipeline. No calculations

have been made to estimate the magnitude of the water hammer pressures. Based on experience, SDR 21 pipe was selected for the pipeline. SDR 21 pipe has a pressure rating of 80 psi at a temperature of 73.48 F. The groundwater at the site will have a constant temperature of around 55.8 F, which would increase the pressure rating to about 88 psi. The minimum internal pressure will be 0 psi (gage) because of the combination air valve at the high point in the line.

5.3.3 External Pressure

External pressures will be exerted on the pipeline by water, earth, and vehicle loads. The maximum water pressures will occur during floods at the low point in the line on the river side of the levee. Assuming the maximum river stage at the top of the flood wall (El 431.5) and the lowest point in the line is at Well EW-3 (El 416), the maximum external water pressure is 15.5 ft of water, or about 7 psi. The maximum earth loading is the submerged weight of soil above the pipeline at its deepest cover, about 6 ft at Riverview Drive. At this point the maximum earth load would be about 3 psi. Based on a design chart published by Driscopipe, an H20 highway loading would add 6.3 psi of external pressure to a pipeline with a minimum cover of 3 ft. There would be no vehicular loads during a flood, so the maximum external pressure would be the dry weight of 6 ft of earth (5.2 psi) plus a vehicular load of 6.3 psi = 11.5 psi. This compares to a lesser load of 7 + 3 = 10 psi during a flood. The design burial calculations by Driscopipe[1] indicate that if SDR 21 Driscopipe 1000 Series HDPE pipe is bedded in clean sand compacted to at least 85% of standard Proctor density with a minimum cover of 3 ft, the ring deflection is acceptable, the crushing design safety factor is 16.9, and the wall buckling design safety factor is 8.5.

5.4 MATERIALS, VALVES, INSTRUMENTATION, AND FITTINGS

5.4.1 HDPE Pipe and Fittings

SDR 21 pipe ranging from 12.75 in. OD to 24 in. OD will be used for the pipeline.

5.4.2 Ductile Iron Pipe and Fittings

Ductile iron pipe will be pressure class 350 pipe (0.28-in. wall thickness for 12-in. nominal diameter pipe) with mechanical joints where buried and flanged joints where the pipe is above ground. Thrust blocks will be cast to restrain joints at elbows with mechanical joints. The

[1] DriscopipeDesign CD, Version 1.4, July 1999, Phillips Petroleum Company

aboveground pipe and fittings will be supported on steel supports anchored to the slab on grade. Outside of the concrete slab, the pipe will be supported on reinforced concrete pipe supports.

5.4.3 Bedding Material

The pipeline will be bedded in clean sand extending from 6 in. below the pipe to 6 in. above the crown, and the sand will be compacted to at least 85% of Standard Proctor maximum dry density.

5.4.4 Valves

The two valves at the discharge end of the pipeline will be flanged-end, gear-operated Milliken Millcentric Fig. 601 eccentric plug valves or equivalent. The check valve will be a flanged-end rubber flapper swing check valve equal to Apco Series 100 or Valmatic Swing-Flex, equipped with a hold-open device for backflushing. The combination air valve will be an Apco single body double orifice valve or a Valmatic single housing style combination air valve. (The exact size of this valve has not been selected yet.) An air release valve (Valmatic Model No. 22 simple lever type, 1-in. NPT inlet size) will be installed upstream of the flow meter to release small amounts of entrained air that may be in the effluent at that point.

5.4.5 Flow Meter

The flow meter will be a 12-in. Krohne Aquaflux or equal magnetic flow meter with flanged ends, IP67 rated, integral signal converter, 115AC powered, NEMA 4X rated, and digital display of rate and total. The signal from the flow meter will be transmitted to ABRTF via spread spectrum radio telemetry (Elpro).

5.4.6 Continuous Sampler

The water sampler will be an American Sigma 900 MAX all-weather refrigerated sampler, 115 VAC, with a 6-ft power cord and pump tube insert. It shall be equipped with a set of four 3-gallon polyethylene bottles, a distributor with arm (2/4 bottle, AWRS), and a 10-ft long multi-purpose half cable.

5.4.7 Foundation

As a minimum, the foundation will consist of a 12-in. thick reinforced concrete slab on grade extending 3 in. above the surrounding grade. This slab may be eliminated and individual pipe supports installed with a separate concrete slab on grade to support the sampler.

Attachment 5-1 Calculations

By:G.R. Bird January 17, 2003

Attachment 5-1a. Design Calculations: Total Dynamic Head
Well Pumps at Site R Only (333 gpm/well), 4" Drop Pipe, 12" Header (24" Under Levee and RR Tracks)

Well EW-3 (farthest south)

High point in discharge line (Ft, NGVD)	424.0	Total Head Loss (Ft)	63.4
Pumping Water Level (Ft, NGVD)	363.0	Lift	61.0
Pump Setting (Ft, NGVD)	360.0	**Total Dynamic Head (Ft)**	**124.4**
Drop Pipe Dia (In.)	4	**Minimum Size Grundfos Pump: 385S150-2, 15 HP, 350 gpm @ 125 ft, Eff = 77%**	

Head loss (K) factors are from *Engineering Data Book*, 2nd Edition (1990), Hydraulic Institute
Friction loss data for HDPE pipe from Driscopipe Systems Design (1991)
Friction losses computed using Hazen-Williams formula

Run	Dia. (In.)	ID (in.)	Flow (gpm)	h_f (ft/100 ft)	Length (ft)	K	v (ft/sec)	$v^2/2g$ (ft)	Head Loss (ft)	Remarks
Pump discharge loss	3	3	333				15.12	3.55	2.5	would be no loss if use 385S pump with 4" discharge
Well EW-3 SS Drop Pipe (360 to 418)	4	4.026	333	5.95	58		8.40	1.09	3.4	new Sch 40 steel pipe (Hazen & Williams C = 140)
Pitless adapter 90° elbow)	4	4.026	333			0.65	8.40	1.09	0.7	
4" SDR 11 HDPE pipe (horizontal; allow 20 ft)	4	3.682	333	7.60	10		10.04	1.57	0.8	Hazen & Williams C = 155; assume magnetic flow meter in pit; no additional head loss
4" ball valve	4	4.026	333						0.4	C_v = 815 (Victaulic ball valve, fully open)
4" x 2" tee (run)	4	4.026	333							(negligible)
4" check valve (Valmatic dual disc)	4	4.026	333						2.5	from Valmatic catalog
4" SDR 11 HDPE pipe	4	3.682	333	7.60	10		10.04	1.57	0.8	Hazen & Williams C = 155
4" x 12" tee, branch flow	4	4.026	333			0.53	8.40	1.09	0.6	
12.75" OD SDR 21 HDPE to Well EW- 2	12	11.536	333	0.03	580		1.02	0.02	0.2	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-2 to Well EW-1	12	11.536	666	0.11	760		2.05	0.06	0.8	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-1 to E/W discharge line	12	11.536	999	0.23	330		3.07	0.15	0.7	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE western end to west side of Pitzman Ave	12	11.536	999	0.23	1310		3.07	0.15	3.0	Hazen & Williams C = 155
12" x 24" enlargement	24	21.174	999	0.01			0.91	0.01	0.1	Hazen & Williams C = 155
24" OD SDR 21 HDPE to landside	24	21.174	999	0.01	600		0.91	0.01	0.1	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Landside to P Chem Manhole	12	11.536	999	0.23	900		3.07	0.15	2.0	Hazen & Williams C = 155
24 x 12 reducer	12	11.536	999				3.07	0.15	0.1	
12.75" OD tee	12	11.536	999			0.5	3.07	0.15	0.1	
12.75" OD 90-degr elbow	12	11.536	999			0.5	3.07	0.15	0.1	
12.75" OD 90-degr elbow	12	11.536	999			0.5	3.07	0.15	0.1	
12.75" OD 90-degr elbow	12	11.536	999			0.5	3.07	0.15	0.1	
12.75" OD pipe	12	11.536	999	0.23	54		3.07	0.15	0.1	Hazen & Williams C = 130
Valmatic Swingflex check valve	12	11.536	999						0.2	From manufacturer's curve
Exit loss	12	11.536	999			1.0	3.07	0.15	0.1	
Subtotal pipeline head loss									19.4	
Safety Factor					4480				44.0	safety factor for decreased C factor with age
Total head loss									**63.4**	

By:G.R. Bird January 17, 2003

Attachment 5-1b. Design Calculations: Total Dynamic Head
Well Pumps at Site R Only (666 gpm/well), 4" Drop Pipe, 12" Header (24" Under Levee and RR Tracks)

Well EW-3 (farthest south)

High point in discharge line (Ft, NGVD)	424.0	Total Head Loss (Ft)	116.8
Pumping Water Level (Ft, NGVD)	363.0	Lift	61.0
Pump Setting (Ft, NGVD)	360 0	**Total Dynamic Head (Ft)**	**177.8**
Drop Pipe Dia (In.)	4	**Minimum Size Grundfos Pump: 625S400-2-2 (40 HP) 667 gpm at 185 ft**	

Head loss (K) factors are from *Engineering Data Book*, 2nd Edition (1990), Hydraulic Institute
Friction loss data for HDPE pipe from Driscopipe Systems Design (1991)
Friction losses computed using Hazen-Williams formula

Run	Dia. (In.)	ID (in.)	Flow (gpm)	h_f (ft/100 ft)	Length (ft)	K	v (ft/sec)	$v^2/2g$ (ft)	Head Loss (ft)	Remarks
Pump discharge loss	3	3	667				30.29	14.25	9.9	would be no loss if use 385S pump with 4" discharge
Well EW-3 SS Drop Pipe (360 to 418)	4	4.026	667	21.50	58		16.82	4.39	12.5	new Sch 40 steel pipe (Hazen & Williams C = 140)
Pitless adapter 90° elbow)	4	4.026	667			0.65	16.82	4.39	2.9	
4" SDR 11 HDPE pipe (horizontal; allow 20 ft)	4	3.682	667	27.49	10		20.11	6.28	2.7	Hazen & Williams C = 155; assume magnetic flow meter in pit; no additional head loss
4" ball valve	4	4.026	667						1.5	C_v = 815 (Victaulic ball valve, fully open)
4" x 2" tee (run)	4	4.026	667							(negligible)
4" check valve (Valmatic dual disc)	4	4.026	667						10.0	from Valmatic catalog
4" SDR 11 HDPE pipe	4	3.682	667	27.49	10		20.11	6.28	2.7	Hazen & Williams C = 155
4" x 12" tee, branch flow	4	4.026	667			0.53	16.82	4.39	2.3	
12.75" OD SDR 21 HDPE to Well EW- 2	12	11.536	667	0.11	580		2.05	0.07	0.6	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-2 to Well EW-1	12	11.536	1333	0.38	760		4.09	0.26	2.9	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Well EW-1 to E/W discharge line	12	11.536	2000	0.81	330		6.14	0.59	2.7	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE western end to west side of Pitzman Ave	12	11.536	2000	0.81	1310		6.14	0.59	10.7	Hazen & Williams C = 155
12" x 24" enlargement	24	21.174	2000	0.04			1.82	0.05	0.5	Hazen & Williams C = 155
24" OD SDR 21 HDPE to landside	24	21.174	2000	0.04	600		1.82	0.05	0.3	Hazen & Williams C = 155
12.75" OD SDR 21 HDPE Landside to P Chem Manhole	12	11.536	2000	0.81	900		6.14	0.59	[illegible]	Hazen & Williams C = 155
24 x 12 reducer	12	11.536	2000				6.14	0.59	0.5	
12.75" OD tee	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD 90-degr elbow	12	11.536	2000			0.5	6.14	0.59	0.3	
12.75" OD pipe	12	11.536	2000	0.81	54		6.14	0.59	0.4	Hazen & Williams C = 130
Valmatic Swingflex check valve	12	11.536	2000						0.5	From manufacturer's curve
Exit loss	12	11.536	2000			1.0	6.14	0.59	0.5	
Subtotal pipeline head loss									72.8	
Safety Factor					4480				44.0	safety factor for decreased C factor with age
Total head loss									**116.8**	

Section 6

SECTIONSIX Automated Control and Monitoring System

The Automated Control and Monitoring System (ACMS) is a primary component of the Groundwater Migration Control System (GMCS). The primary function of the ACMS will be to automatically monitor stage level of the Mississippi River and adjust pumping rates of the three extraction wells. A secondary function of the ACMS will be to monitor the water level in four pairs of piezometers, which will be equally spaced along the west-side of the U-shaped barrier wall. One piezometer of each pair will be located inside the barrier wall and one will be located outside the wall. These piezometer readings will be used by the ACMS to further adjust pumping rates to minimize groundwater gradients across the barrier wall.

6.1 DESIGN PARAMETERS

The ACMS will be designed using the following parameters:

- Automatically monitor water level and flow rate of three, 10-in. diameter extraction wells. Each well will have a nominal pumping capacity of 333 gpm with a total system capacity of 1000 gpm. Extraction well pumps will use 15 - 20 HP motors.
- Automatically monitor water level in four pairs of piezometers along the west wall of the proposed barrier wall.
- Automatically read and record Mississippi River stage elevations.
- Automatically adjust pump flow rates based upon calculated combined pump flow rates for specific river stages as shown on Table 6-1.
- Maintain "zero" gradient condition across the barrier wall based upon average water levels measured at piezometer pairs along the west wall of barrier wall.
- Provide the ability to remotely monitor and adjust pump flow rates, monitor river stage, automated piezometer levels, and extraction well water levels.
- Provide capability for remote alarm annunciation in the event of system operational problems.
- Maintain instrument readings database for archiving purposes.

6.2 DESIGN CONSTRAINTS

The ACMS will be designed to accommodate the following site constraints:

- ACMS components will be selected and located to minimize potential effects of a 100-year flood event, approximate elevation 426 ft at Site R.
- AC power will not be available at the automated piezometer locations
- AC power will not be available at the river stage level transmitter

6.3 THEORY OF OPERATION

The three extraction well pumping rates will primarily be a function of river stage. Table 6-1 shows the calculated combined pumping rates for the three wells based on river stage. As shown on Table 6-1 the calculated combined pump flow rates range from 0 to about 1,000 gpm for corresponding river elevations of 413 to 374. For reference purposes, the 100-year flood stage at Site R is about elevation 426.

When the Mississippi River stage reaches elevation 413 the pumping system will automatically shutdown. The system will automatically restart pumping once the river level falls below elevation 413.

Occasionally it may be necessary to temporarily increase extraction well pumping rates to maintain a "zero" gradient across the barrier wall. As mentioned above, water levels in the four pairs of piezometers, along the west wall of the proposed barrier wall, will be read automatically. If the average water level inside the barrier wall is greater than the average water level outside the barrier wall for a period of one to two days, the extraction well pumping rates will be increased until a "zero" gradient condition is reestablished across the wall.

The ACMS will employ variable frequency drives (VFDs) on each of the extraction well pump motors. The VFDs will provide the ability to optimize overall performance of the GMCS resulting in reduced energy and extracted groundwater treatment costs.

6.4 OVERVIEW OF ACMS

The ACMS will consist of the following key components:

- Measurement and Control Unit (MCU)
- River stage gauge
- Power distribution panel
- Pump control panels with variable frequency drives
- Magnetic flow meters at each extraction well
- Automated piezometer pairs along west barrier wall
- Host/Remote Access PC

6.4.1 Measurement and Control Unit (MCU)

The measurement and control unit (MCU) will receive river stage readings from a river stage gage located at the northwest corner of Site R. The MCU will send signals to a variable frequency drive at each of the extraction wells. The variable frequency drives will maintain the appropriate pump motor speed to produce the necessary pump flow rate based upon the current river stage. The system design incorporates magnetic flow meters at each extraction well. The flow meters will provide closed-loop feedback to the VFDs and relay current flow rates for each of the extraction wells to the MCU. A secondary system control protocol employs automated readings of four pairs of piezometers along the west wall of the proposed barrier. If the water level differential inside the barrier wall is greater than "zero" gradient for a period of one to two days, the extraction wells pumping rate will be increased. The increased pumping rate will be maintained until the "zero" gradient condition is reestablished. The frequency of readings and necessary pumping rate adjustments will be made on an hourly basis. The river stage, individual pump flow and automated piezometer readings will be stored and time stamped each hour.

The MCU will have a conventional phone modem for remote access via the host computer. The host computer will serve as a gateway to the on-site MCU. Host computer software will include vendor-supplied applications to interface with the MCU. Users will be able to view current water level information, flow rates and river stage levels. It will also be possible to make changes to the control application software to adjust reading frequencies, threshold levels and to perform remote system diagnostics. The vendor-supplied software will include a database to store automated readings.

If the pumps stop for some reason, the VFD will instantly generate an alarm and the received fault signal at the MCU will result in the MCU logging the event and dialing, via the phone line, to notify appropriate personnel.

A system block diagram is provided in Drawings. Manufacturer's cut-sheets and technical specifications are given in this volume.

6.4.2 River Stage Transmitter

The river stage gauge (RS-1) is an existing bubbler-type water level indicator owned and operated by the American Bottoms Regional Wastewater Treatment Facility (ABRWTF). Arrangements are being made to share the river stage signal for use by the ACMS. This gauge will be connected to the MCU via direct buried cable. The MCU will convert the raw data to river stage elevation.

6.4.3 Power Distribution Panel

There will be a power distribution panel located in the existing pole barn on Site R. The power distribution panel will be sized to accommodate power connections for the three extraction well pumps and disconnects. There will also be disconnects at each well location.

All of the wiring from the power distribution panel to the three extraction wells will be in buried conduit. All power for the VFDs and the pump motors will be 480vac, 60hz, 3 phase. There will also be a separate breaker and a separate 120vac circuit installed at each well location area.

6.4.4 Pump Control Panels with Variable Frequency Drives

A pump control panel will be located above grade at each of the extraction wells. The individual pump control panel will be housed in an enclosure that will also include the variable frequency drive and flow meter readout unit. The pump control enclosure will be set at an elevation 1 ft above the 100-year flood event (approximately 5 ft above existing grade).

A Reliance Electric SP600 variable frequency AC drive (VFD) will operate each pump motor. The VFD will allow variable speed operation of the pump motor and allow a variable pumping flow rate to be achieved by each pump motor. By using a flow meter at each well, the flow meter's 4-20ma output will provide a feedback signal to the MCU to allow closed loop operation of the pumps. This will allow the VFD to maintain the flow set point provided by the MCU for a

given river stage elevation. Each VFD will provide switch closure signals to the MCU to indicate fault conditions. As previously described, the MCU will then generate an alarm annunciation.

A small manual pump control panel will be located at each extraction well. The pump control panel will be mounted in the same enclosure as the VFD and flow meter readout unit. The VFD will incorporate an automatic control bypass mode to allow manual starting and stopping of the pump motor.

6.4.5 Magnetic Flow Meters

Magnetic flow meters will be installed at each extraction well location. The magnetic flow meters will measure pump flow rate and work in conjunction with the VFDs to maintain optimum pump speed to achieve required pumping rate. The magnetic flow meters will be 4-in. diameter and will be mounted in the flow meter vault at each extraction well. The flow meters will output a 4-20ma signal to the MCU. Manufacturer literature and specifications are attached.

6.5 ANTICIPATED LONG-TERM MONITORING AND OPERATIONAL REQUIREMENTS

The ACMS is designed for unattended operation. The system will incorporate necessary alarm annunciation in the event of fault conditions during system operation. The system design includes the ability to remotely perform system diagnostics from the host PC.

In the event of a major flood event, pump disconnects will be located near the pole barn. Since it isn't necessary to operate the extraction pumping system during high river stages it will be possible to completely shut power off to the entire pumping system until flood waters recede.

Detailed ACMS operations and maintenance procedures will be prepared as part of the overall O&M plan for the project.

TABLE 6-1

Pumping Rate Lookup Table		
River Stage (ft)	Combined Pumping Rate (gpm)	River Elevation Comments
430	0	Highest Recorded River Elevation
413	0	
412	25	
411	50	
410	75	
409	100	
408	125	
407	150	
406	175	
405	200	
404	225	
403	250	
402	275	
401	300	High Monthly Average Flow
400	325	
399	350	
398	375	
397	400	
396	425	
395	450	
394	475	
393	500	
392	525	
391	535	Average Monthly Average Flow
390	550	
389	575	
388	600	
387	625	
386	650	
385	675	
384	700	
383	725	Low Monthly Average Flow
382	750	
381	775	
380	800	
379	825	
378	850	
377	875	
376	900	
375	925	
374	950	Lowest Recorded River Elevation

Drawings

Drawings

SITE R
SAUGET, ILLINOIS

GROUNDWATER MIGRATION CONTROL SYSTEM

SOLUTIA™
Applied Chemistry, Creative Solutions

INDEX

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2-04	OVERALL SITE PLAN
2-05	BORING LOCATION PLAN
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6-02	AUTOMATED CONTROL AND MONITORING SYSTEM DETAILS (SHEET 1)
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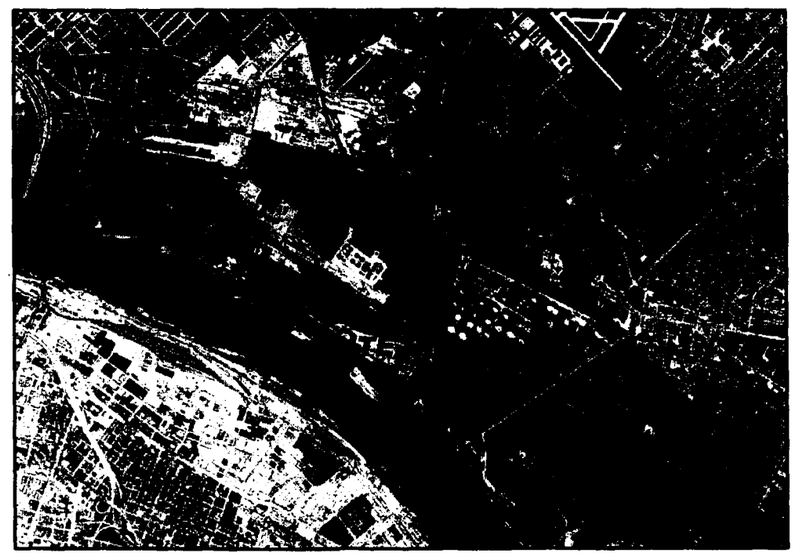

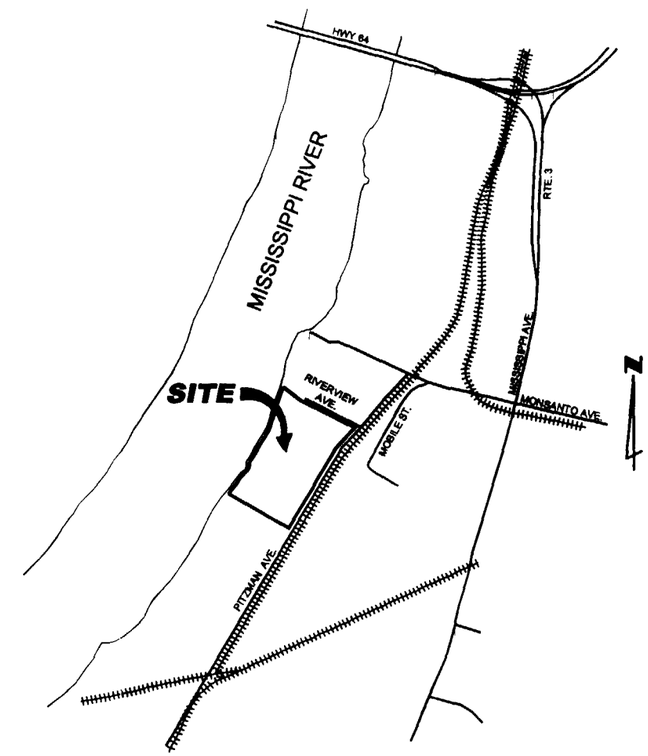

LOCATION MAP

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

NO.	DATE	REVISION DESCRIPTION	APPROVED

SEAL

DATE: 1/21/03
SCALE: AS SHOWN
DESIGNED: DJD/WDL
DRAWN: DJD/WDL
CHECKED: MJB
SUBMITTED:

PREPARED BY:
URS
2316 Millpark Drive St. Louis, MO. 63043 Tel: 314-429-0100 Fax: 314-429-0462

PROJECT NO. 21561192.00001

SHEET NO. 2-01

SITE ACCESS NOTES:

THE CONTRACTOR SHALL SUBMIT A CONSTRUCTION AND TRAFFIC ACCESS CONTROL PLAN FOR APPROVAL BY SOLUTIA. THIS PLAN SHALL INDICATE ALL ROUTES FOR ACCESS TO THE SITE AND FOR TEMPORARY ROADS WITHIN THE SITE. THE CONTRACTOR SHALL LIMIT HIS ACTIVITIES TO THE AREAS DESIGNATED BY SOLUTIA AS SOLUTIA PROPERTY, EASEMENTS AND CONSTRUCTION WORKING ROOM. DURING ALL TIMES WHEN ACCESS TO THE SITE OR WALL CONSTRUCTION IS THROUGH OR ON PRIVATE PROPERTY NOT OWNED BY SOLUTIA, THE CONTRACTOR SHALL PROVIDE BARRICADES, SIGNS, LIGHTS AND FLAGMEN AS NECESSARY TO CONTROL AND DIRECT TRAFFIC TO THE APPROVED ROUTE.

ACCESS TO THE SITE FOR CONSTRUCTION OF THE NEW BARRIER WALL, RELATED FACILITIES AND SPOIL STOCKPILE IS LIMITED TO RIVERVIEW AVENUE EXCEPT FOR THE TIMES WHEN THE NORTH AND SOUTH ARMS OF THE BARRIER WALL ARE BEING CONSTRUCTED. CONSTRUCTION OF THE NORTH AND SOUTH ARMS OF THE BARRIER WALL SHALL NOT BE PERFORMED SIMULTANEOUSLY.

CONSTRUCTION OF THE SOUTH ARM OF THE BARRIER WALL WILL HAVE TO BE SCHEDULED TO AVOID INTERFERENCE WITH ON GOING OPERATIONS AT THE ADJACENT FACILITY. CONSTRUCTION OF THIS ARM CANNOT BE SCHEDULED FOR SPRING OR FALL MONTHS.

DURING THE TIME THAT THE CONTRACTOR IS CONSTRUCTING THE SOUTH ARM OF THE NEW BARRIER WALL FROM THE VICINITY OF P4-W TO THE EAST, HE SHALL LIMIT HIS OPERATIONS ADJACENT TO THE WALL TO ONLY THOSE ABSOLUTELY NECESSARY TO CONSTRUCT THE WALL.

DURING THE TIME THAT THE CONTRACTOR IS CONSTRUCTING THE NORTH ARM OF THE NEW BARRIER WALL FROM THE VICINITY OF P1-W TO THE EAST, HE WILL BE ALLOWED TO ACCESS THE SITE FROM THE PRIVATE PROPERTY ON THE SOUTH. ACCESS AT THIS TIME WILL BE LIMITED TO VEHICULAR TRAFFIC.

TRAFFIC ON TOP OF THE EXISTING LANDFILL SHALL BE LIMITED TO THAT NECESSARY FOR CONSTRUCTION OF THE TEMPORARY STOCKPILE AND DEPOSITION OF SPOILS. SHOULD DRYING PITS BE NECESSARY FOR THE SPOILS, THEY MAY BE CONSTRUCTED ABOVE GRADE IN THIS AREA WITH THE USE OF A POLYETHELENE SHEET ON BOTTOM AND TEMPORARY BERMS. NO EXCAVATION FOR DRYING PITS WILL BE ALLOWED IN THIS AREA. NO EQUIPMENT OR MATERIAL DELIVERIES WILL BE PERMITTED TO CROSS THIS AREA.

STORM WATER AND SEDIMENT CONTROL NOTES:

A STORMWATER POLLUTION PREVENTION PLAN (SWPPP) THAT MEETS THE REQUIREMENTS OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) AND STATE OF ILLINOIS REGULATIONS SHALL BE PREPARED BY THE CONTRACTOR AND SUBMITTED TO SOLUTIA FOR APPROVAL PRIOR TO STARTING ANY ACTIVITIES. THIS WILL INVOLVE IMPLEMENTING BEST MANAGEMENT PRACTICES (BMPS) FOR STORMWATER RUN-OFF AND RUN-ON, SEDIMENT CONTROL AND WIND BLOWN DUST.

EXISTING DITCHES DRAINING TO THE MISSISSIPPI RIVER SHALL BE FILLED AND TEMPORARY CULVERTS INSTALLED DURING CONSTRUCTION OF THE BARRIER WALL. UPON COMPLETION OF THE PROJECT, NATURAL DRAINAGE SHALL BE RESTORED.

THE SWPPP SHALL INCLUDE THE DESIGN, CONSTRUCTION, OPERATIONS AND MAINTENANCE OF A RUN-OFF MANAGEMENT SYSTEM TO COLLECT, CONTROL AND TREAT THE WATER VOLUME RESULTING FROM A 24-HOUR, 25-YEAR STORM. THE CONTRACTOR MUST ALSO DESIGN, CONSTRUCT, OPERATE AND MAINTAIN A RUN-ON CONTROL SYSTEM CAPABLE OF PREVENTING FLOW ONTO THE ACTIVE PORTION OF THE STOCKPILE DURING THE PEAK DISCHARGE FROM AT LEAST A 25-YEAR STORM.

THE SPOILS IN THE TEMPORARY STOCKPILE SHALL BE COVERED WHEN NOT IN USE IN ORDER TO MINIMIZE THE WIND DISPERSAL OF THE MATERIAL. THIS COVER WILL ALSO SERVE TO MINIMIZE THE AMOUNT OF RAINFALL RUNOFF THAT HAS BEEN IN CONTACT WITH THE SPOILS.

ABBREVIATIONS

A	Amp
AMSL	Above Mean Sea Level
C.I.	Cast Iron
	Center Line
DIA.	Diameter
EA.	Each
EL.	Elevation
EW	Extraction Well
FT	Foot or Feet
GND	Ground
GPM	Gallons Per Minute
HDPE	High Density Polyethylene
I.D.	Inside Diameter
I/O	Input/Output
Ma	Milliamp
MCU	Measurement Control Unit
Min.	Minimum
Mils.	Measurement of Length = .001 inches
NTS	Not to Scale
O.C.	On Center
O.D.	Outside Diameter
P	Piezometer
PVC	Polyvinyl Chloride
Req'd	Required
RS	River Stage Gauge
SCH	Schedule
SDR	Standard Dimension Ratio
S.S.	Stainless Steel
SQ	Square
TYP.	Typical
V	Voltage
VAC	Voltage Alternative Current
VDC	Voltage Direct Current
VFD	Variable Frequency Drive
VW	Vibrating wire
W	With

Legend

☒ EW-1 – Extraction Well for GMCS

▲ P1-W – Piezometer for GMCS

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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DRAWN: DJB/WDL
CHECKED: MJB
SUBMITTED:

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Applied Chemistry, Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM

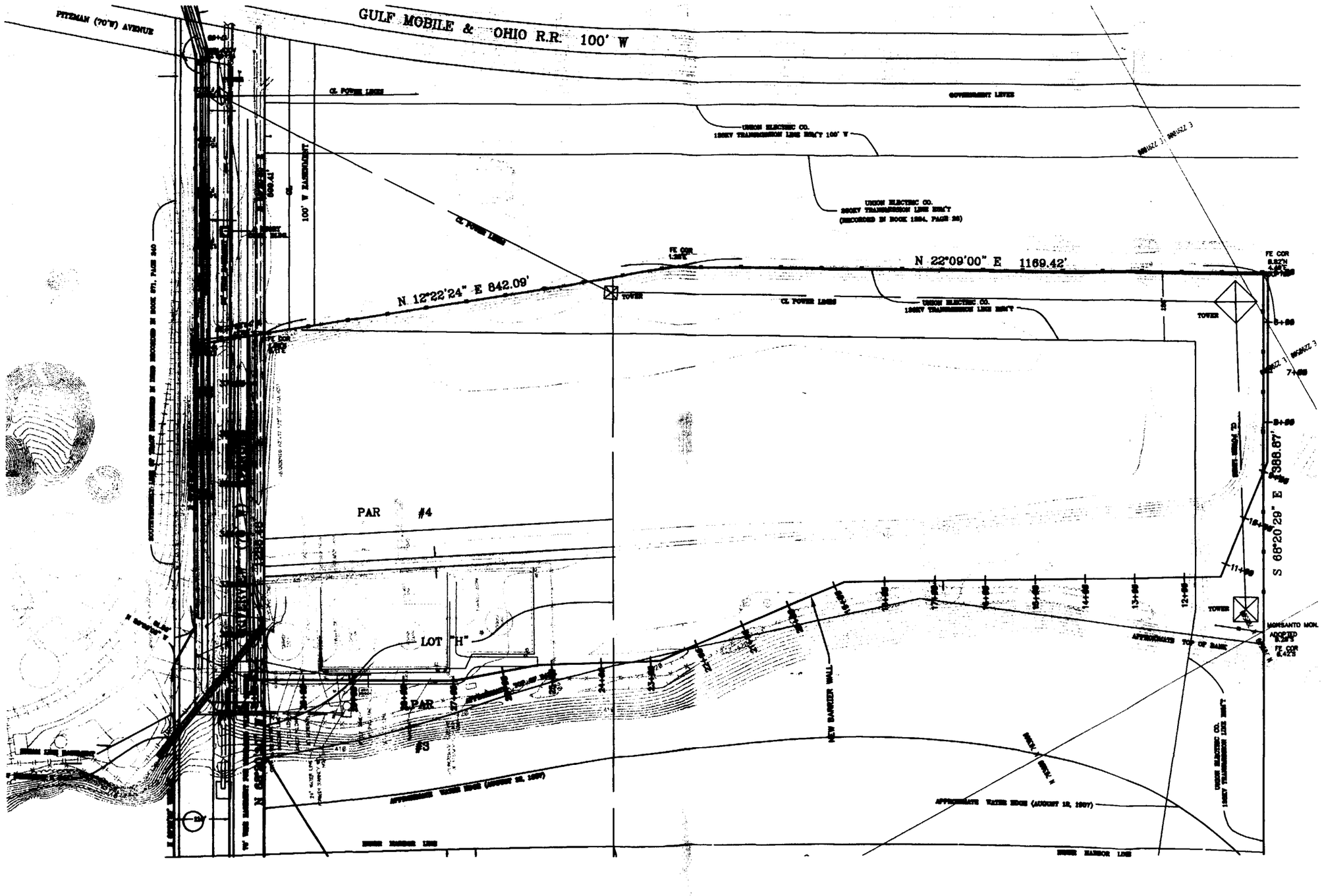
PACKAGE 2 – BARRIER WALL

GENERAL NOTES & ABBREVIATIONS

URS PROJECT NO. 21561192.00001

SHEET NO. 2-02

File: E:\21561192.00001\12-16-03 FINAL\SHEET 2-02.DWG Last edited JAN. 21, 03 @ 08:35 a.m. by: DJBCOLIO



NOTE:

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2585 METRO BLVD. SUITE J
MARYLAND HEIGHTS, MO. 63043
314-432-6469 FAX: 314-432-6461

SEAL

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CHECKED: MJB
SUBMITTED:

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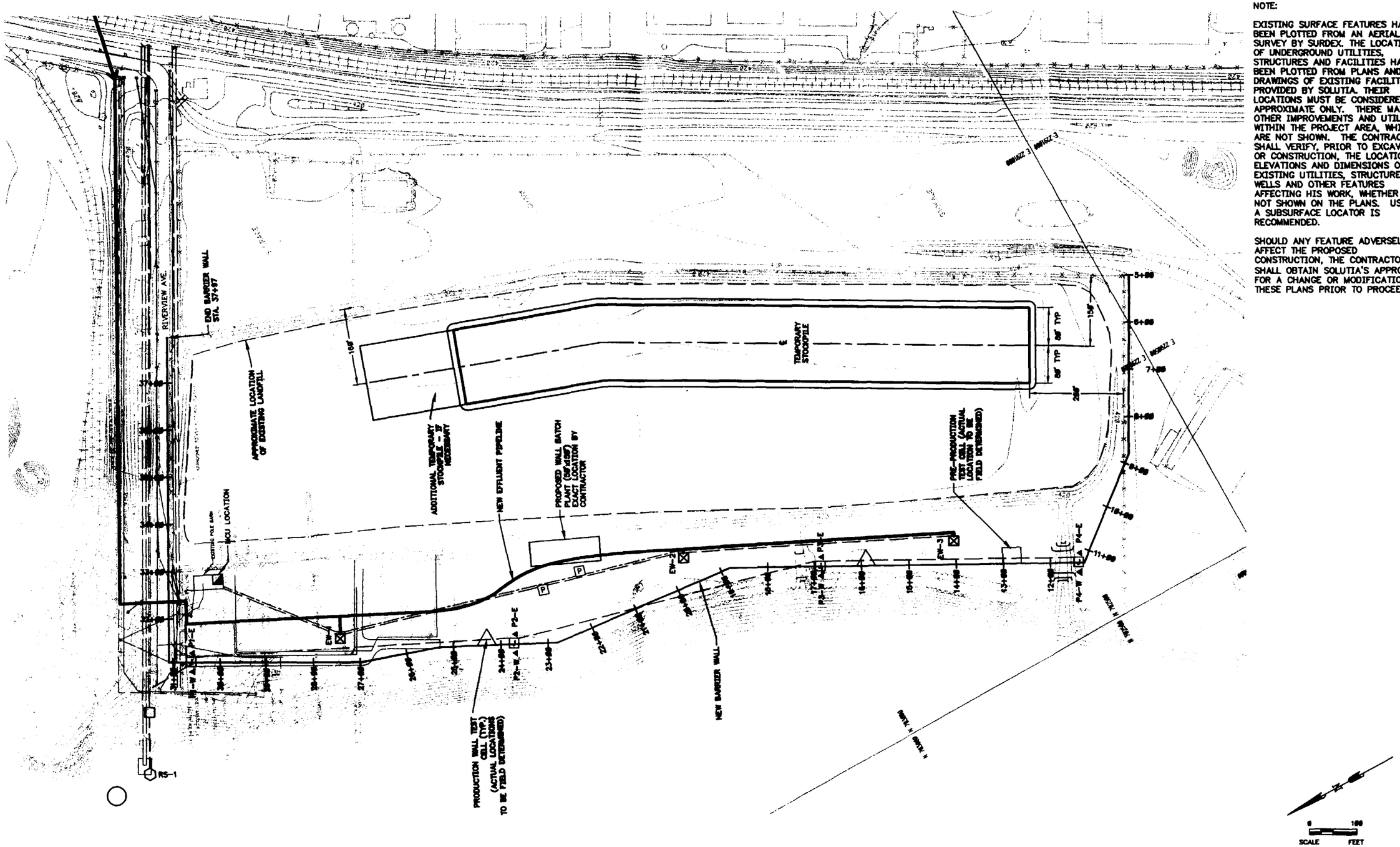
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

EXISTING PROPERTY AND TOPOGRAPHY PLAN

PROJECT NO. 21561192.00001

SHEET NO. 2-03



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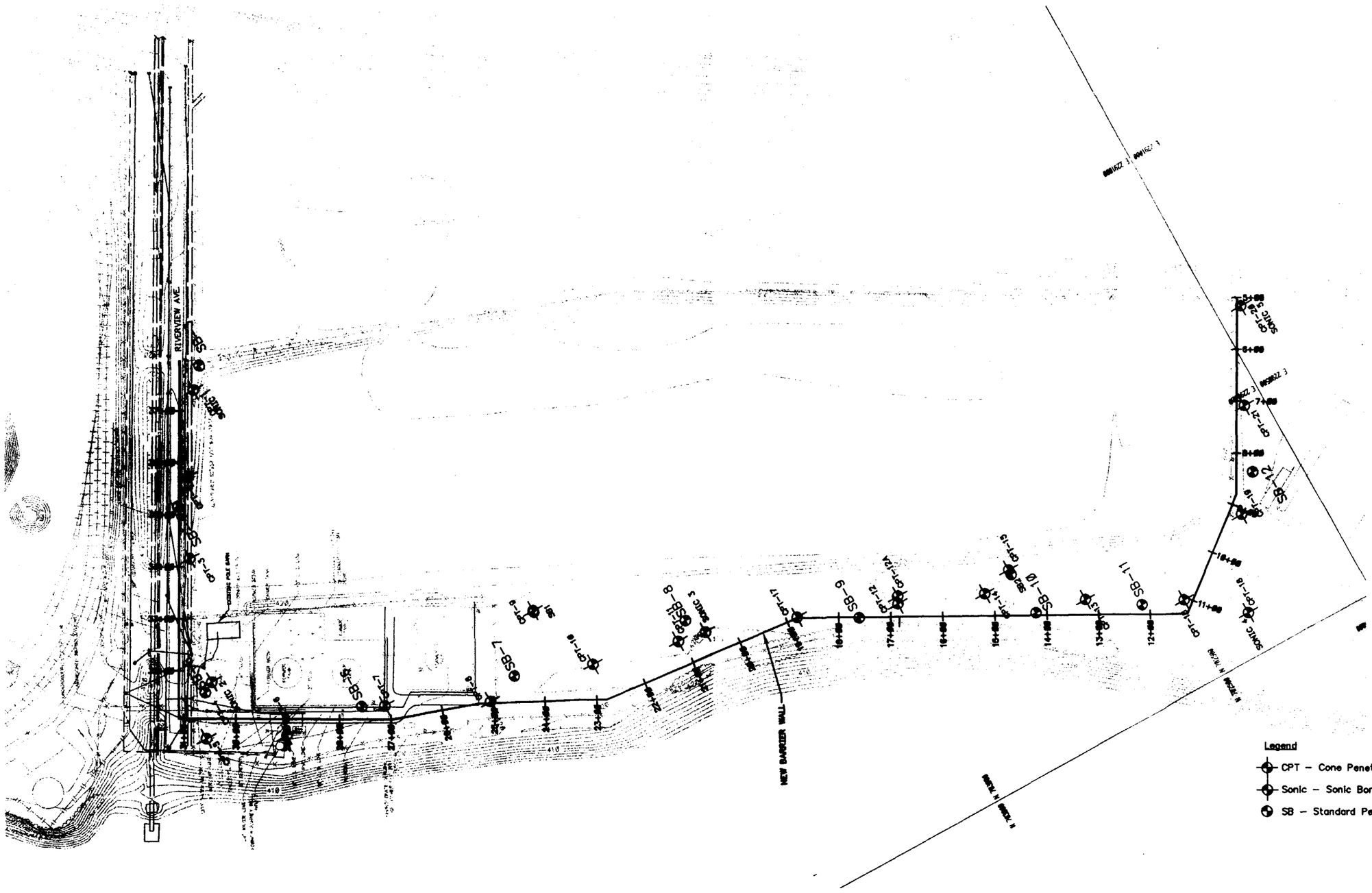
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

OVERALL SITE PLAN

PROJECT NO. 21561192.00001

SHEET NO. 2-04



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GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

BORING LOCATION PLAN

PROJECT NO. 21561192.00001

SHEET NO. 2-05

NOTE:

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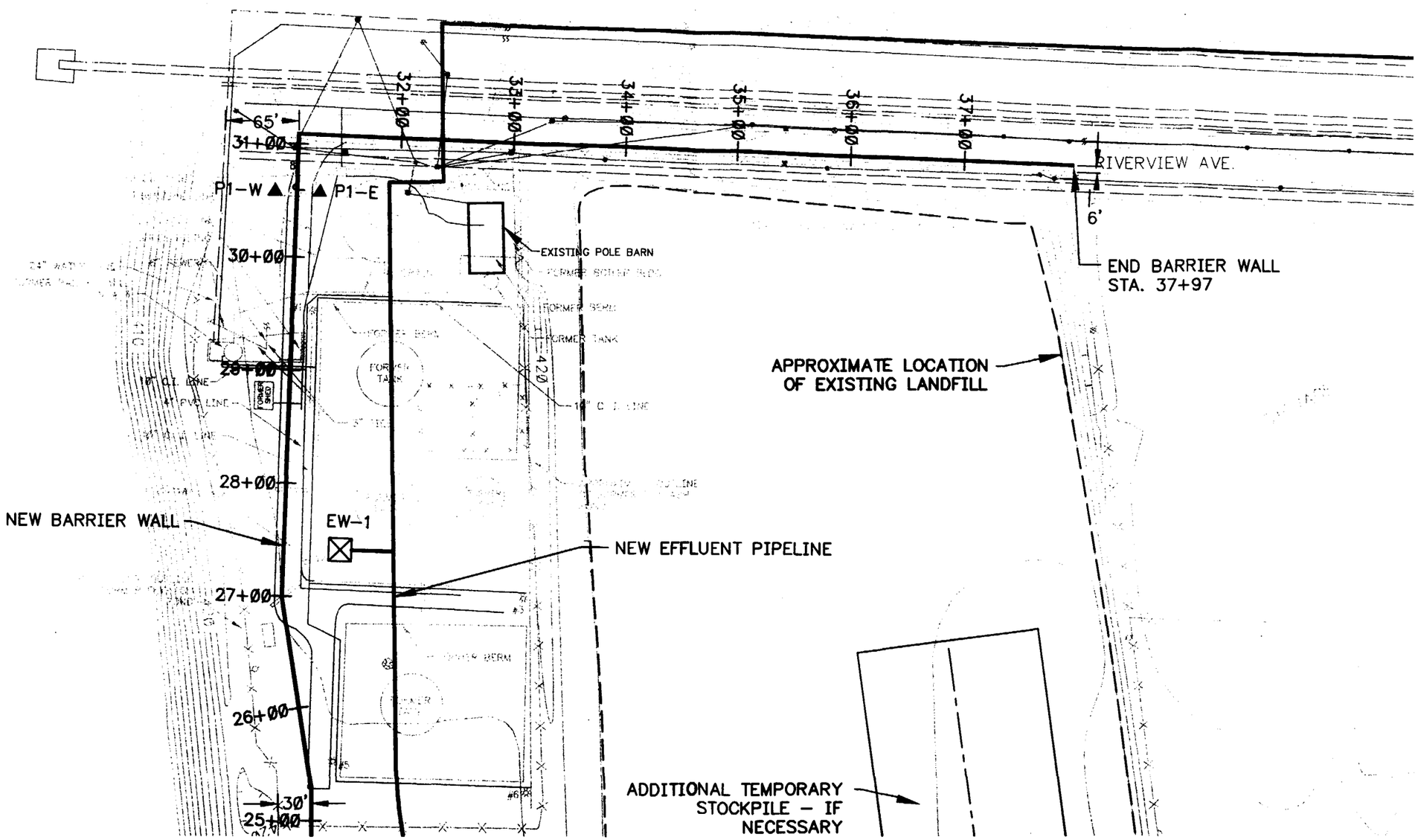

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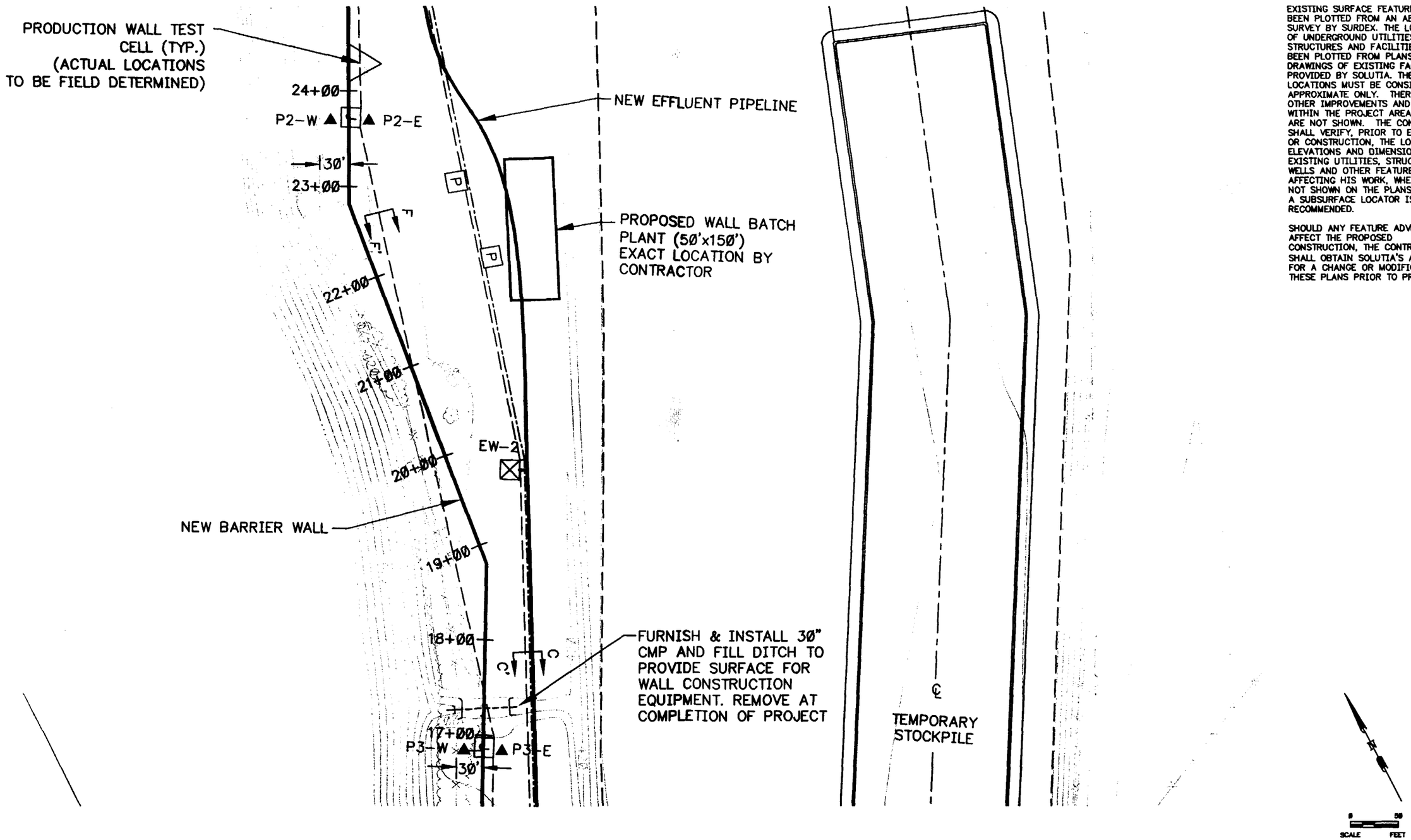
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

SITE PLAN - NORTH

PROJECT NO. 21561192.00001

SHEET NO. 2-06



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GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

SITE PLAN – MIDDLE

PROJECT NO. 21561192.00001

SHEET NO. 2-07

NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

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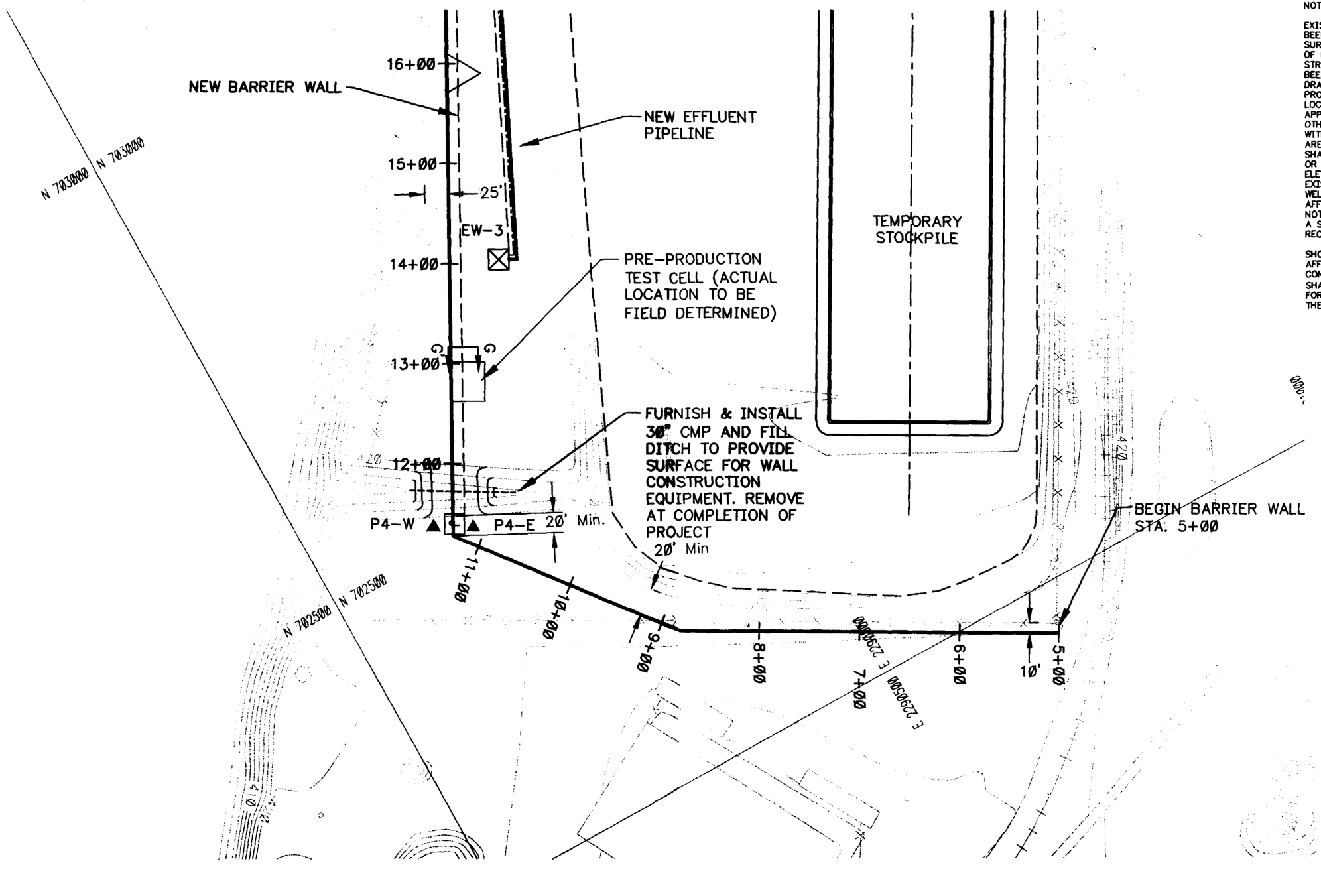

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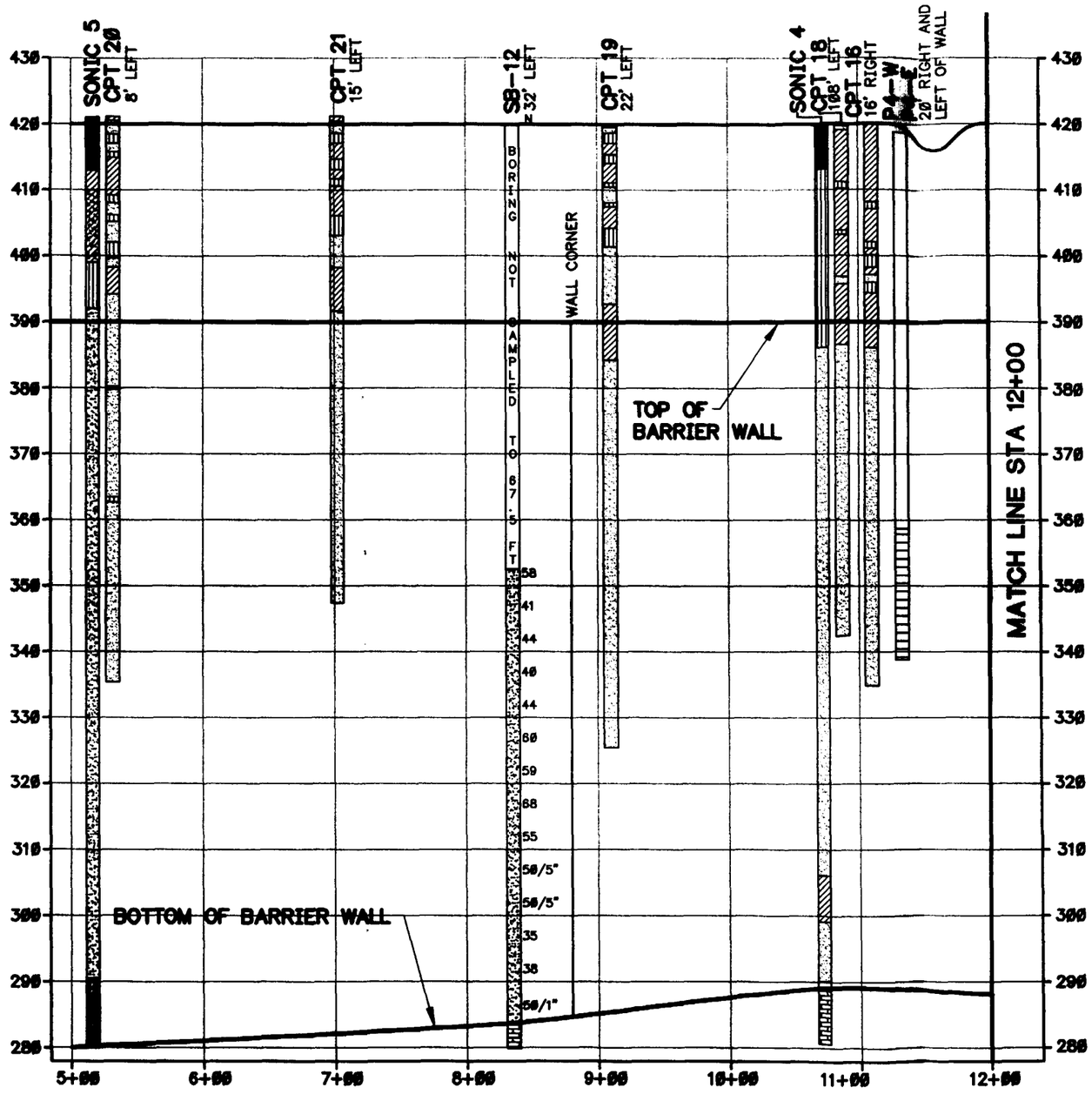
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

SITE PLAN - SOUTH

PROJECT NO. 21561192.00001

SHEET NO. 2-08



LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
- LIMESTONE
- PROPOSED SCREENED INTERVAL OF EXTRACTION WELL OR PIEZOMETER
- 10+00 — WALL STATION AT CENTERLINE OF BARRIER WALL
- CPT-1 — CONE PENETROMETER TEST NUMBER (2001)
- SONIC 1 — SONIC BORING NUMBER (2002)
- SB-1 — SOIL BORING NUMBER (2002)
- 62 — STANDARD PENETRATION TEST BLOW COUNT (N). BLOWS /12" PENETRATION OF SAMPLER UNLESS INDICATED OTHERWISE
- P — HYDRAULICALLY PUSHED SAMPLE

NOTES:

1) THESE GRAPHIC LOGS DEPICT GENERALIZED SOIL CONDITIONS. REFER TO INDIVIDUAL LOGS FOR DETAILS.

2) TOP AND BOTTOM OF BARRIER WALL AS SHOWN ARE APPROXIMATE. ACTUAL LOCATIONS ARE SUBJECT TO CHANGE DUE TO DESIGN AND CONSTRUCTION ISSUES. LOCATIONS AS SHOWN ARE FOR PREFINAL DESIGN.

VERTICAL SCALE 0 10 FEET

HORIZONTAL SCALE 0 50 FEET

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CHECKED: KMB
SUBMITTER:

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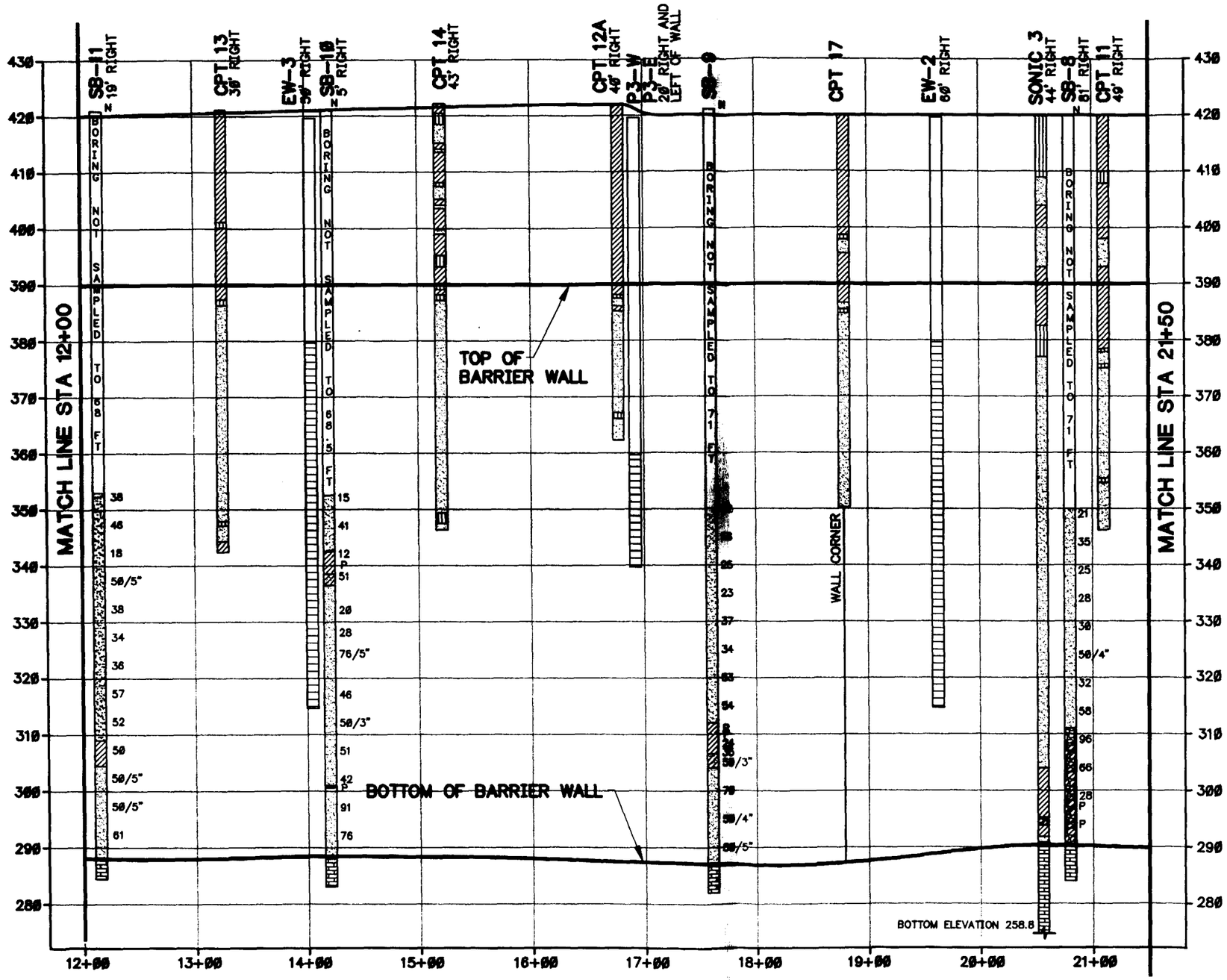
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

BARRIER WALL - PROFILE
STA 5+00 TO 12+00

URS PROJECT NO.
21561192.00001

SHEET NO.
2-09



LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
- LIMESTONE
- PROPOSED SCREENED INTERVAL OF EXTRACTION WELL OR PIEZOMETER
- 10+00 WALL STATION AT CENTERLINE OF BARRIER WALL
- CPT-1 CONE PENETROMETER TEST NUMBER (2001)
- SONIC 1 SONIC BORING NUMBER (2002)
- SB-1 SOIL BORING NUMBER (2002)
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0 10 VERTICAL SCALE FEET

0 50 HORIZONTAL SCALE FEET

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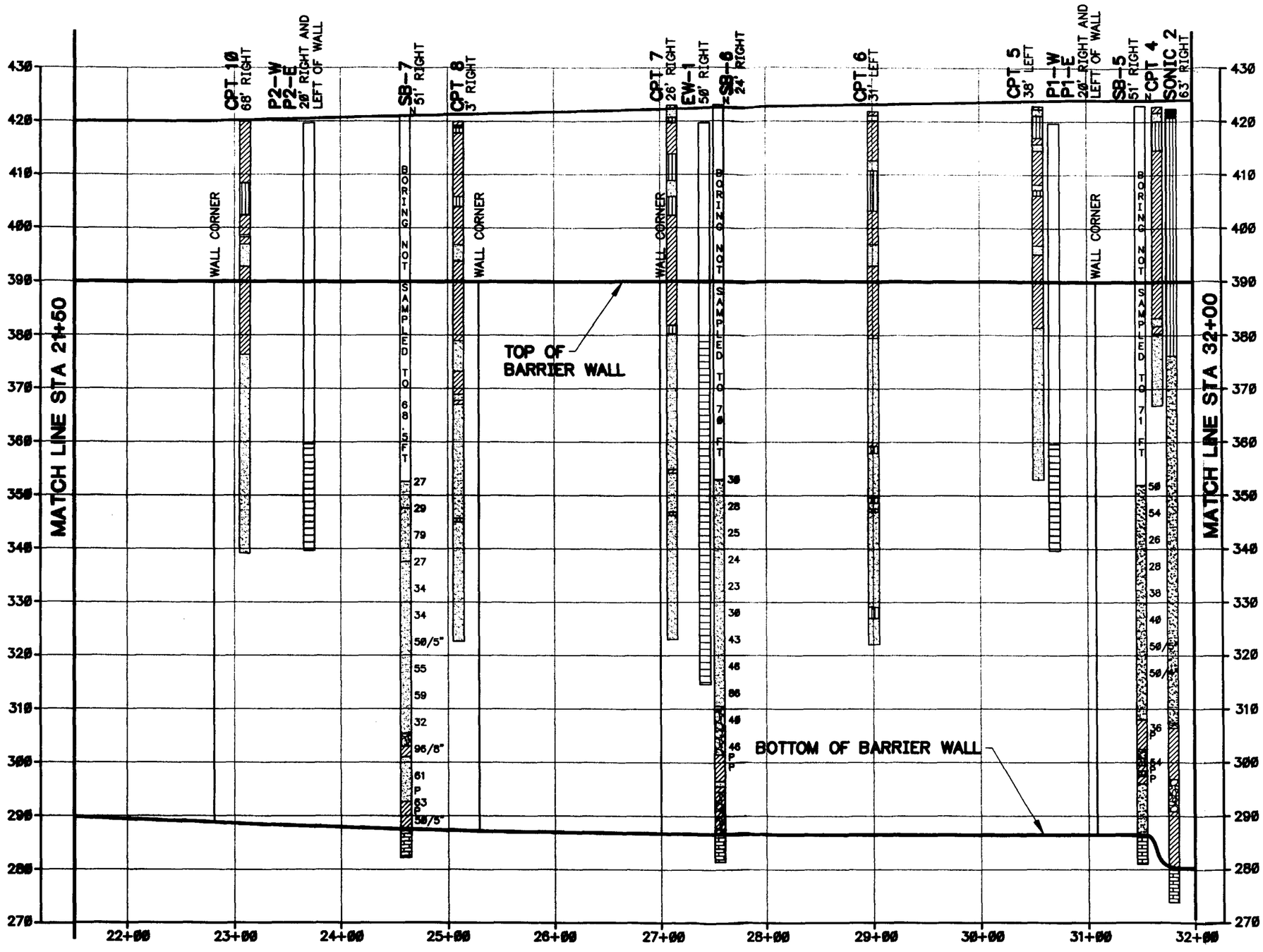
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

BARRIER WALL - PROFILE
STA 12+00 TO 21+50

URS PROJECT NO.
21561192.00001

SHEET NO.
2-10



LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
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VERTICAL SCALE 0 10 FEET

HORIZONTAL SCALE 0 50 FEET

NO.	DATE	REVISION DESCRIPTION	APPROVED

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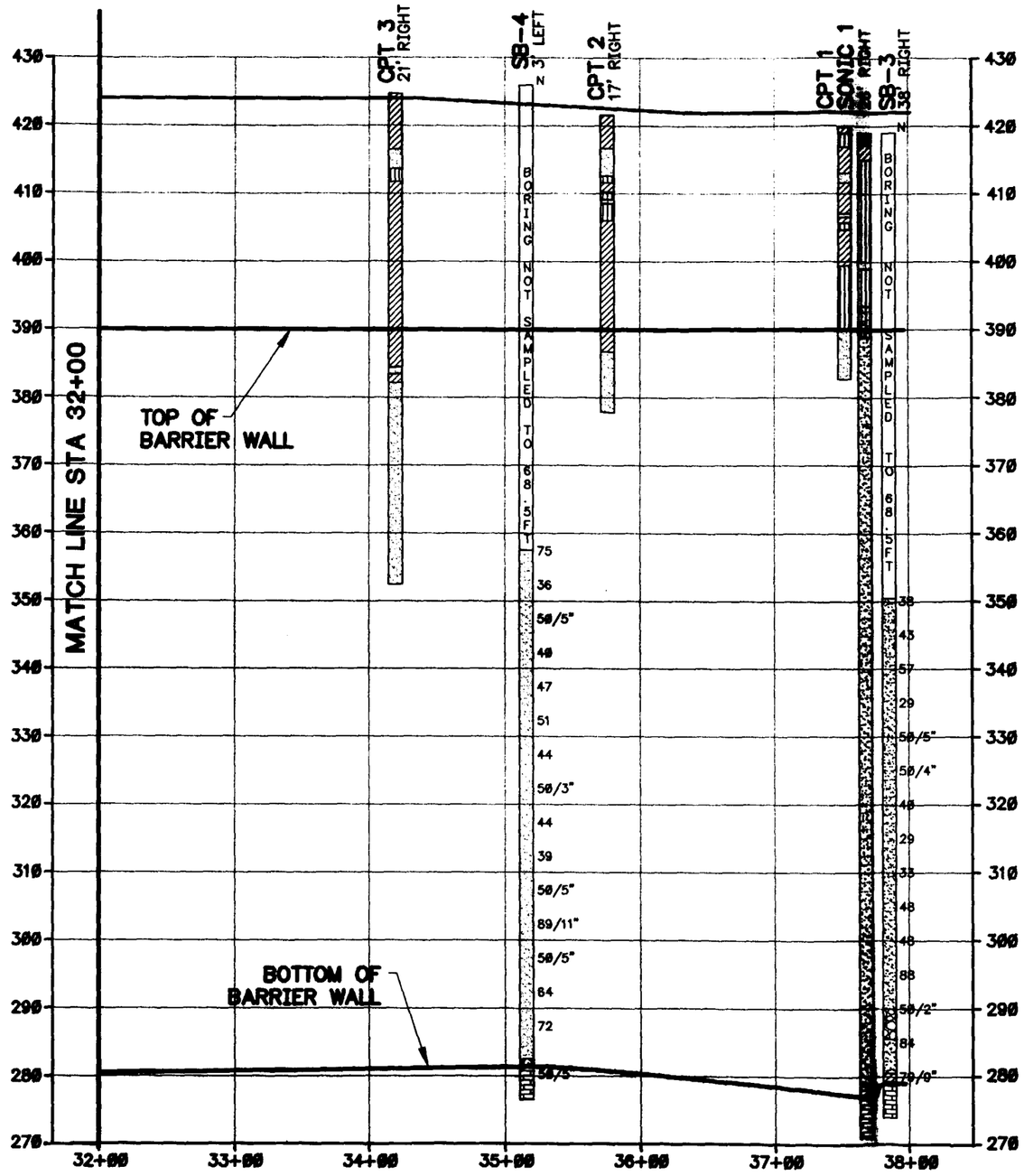
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

BARRIER WALL - PROFILE
STA 21+50 TO 32+00

URS PROJECT NO. 21561192.00001

SHEET NO. 2-11



LEGEND

- CLAY (CL OR CH)
- SILT (ML)
- CLAYEY SAND (SC)
- SAND (SP OR SW)
- GRAVEL AND/OR COBBLES
- LIMESTONE
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- 10+00 — WALL STATION AT CENTERLINE OF BARRIER WALL
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0 10 VERTICAL SCALE FEET

0 50 HORIZONTAL SCALE FEET

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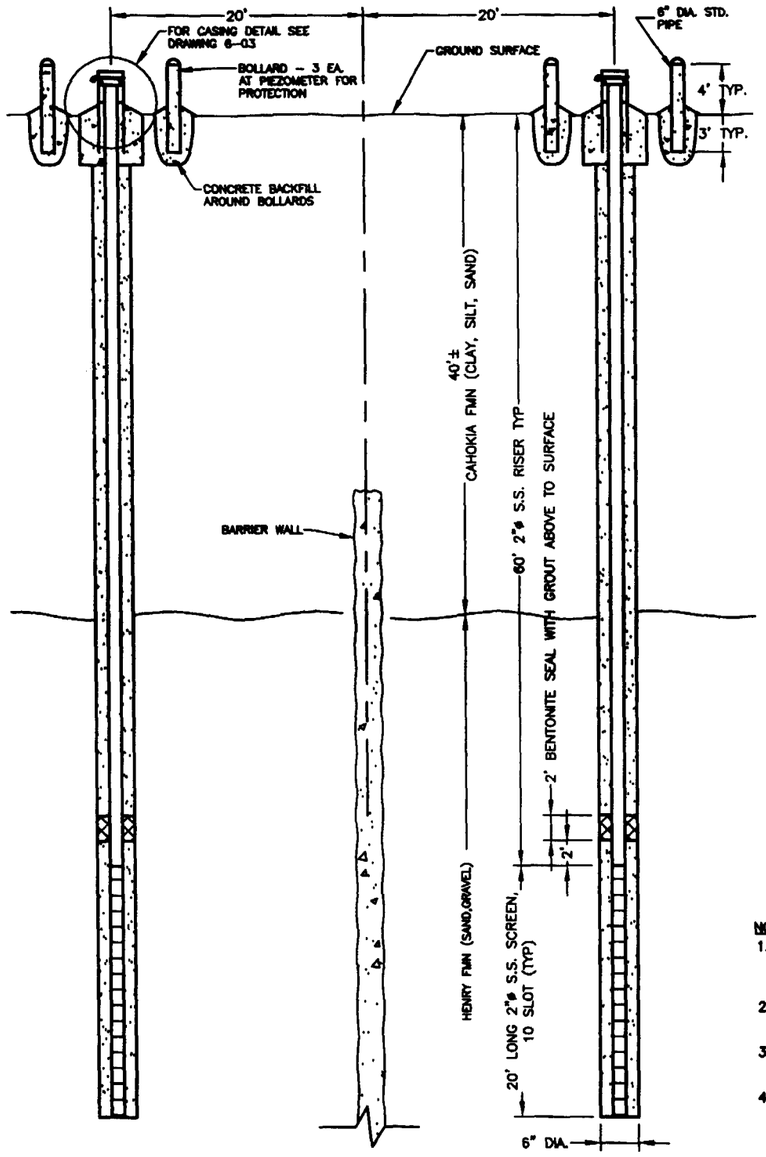
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

BARRIER WALL - PROFILE
STA 32+00 TP 37+97

URS PROJECT NO.
21561192.00001

SHEET NO.
2-12



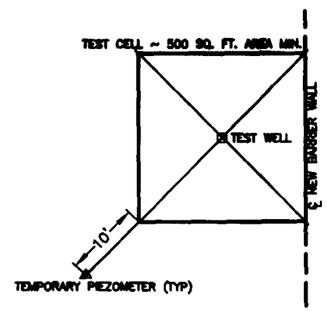
TYPICAL PERMANENT PIEZOMETER ARRANGEMENT
FOR PIEZOMETER PAIRS AT BARRIER WALL

NOT TO SCALE

Barrier Wall Layout Table						
Station	Northing	Easting	Ground Elevation	Top of Wall	Bottom of Wall*	Top of Rock*
	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)
5+00	702134.45	2280657.77	420	390	280	280
8+80	702321.24	2280326.81	420	390	285	285
11+28	702514.78	2280172.6	420	390	286	286
18+79	703176.38	2280529.57	420	390	287	287
22+81	703575.91	2280573.45	420	390	289	289
25+29	703797.03	2280685.51	421	390	287	287
27+00	703962.00	2280740.07	422	390	287	287
31+06	704315.56	2280939.85	423	390	287	287
37+97	703979.41	2281539.83	422	390	279	279

* ELEVATION IS ESTIMATED. ACTUAL ELEVATIONS TO BE FIELD DETERMINED

Permanent Piezometer Layout Table					
Piezometer	Northing	Easting	Ground Elevation	Tip Elevation	Top of Screen
	(ft.)	(ft.)	(ft.)	(ft.)	(ft.)
P1-W	704281.97	2290898.03	423	343	363
P1-E	704263.00	2290933.33	423	343	363
P2-W	703664.78	2290597.35	420	340	360
P2-E	703645.81	2290632.65	420	340	360
P3-W	703015.78	2290419.97	423	343	363
P3-E	702996.78	2290455.27	423	343	363
P4-W	702533.45	2290160.17	420	340	360
P4-E	702514.47	2290195.47	420	340	360

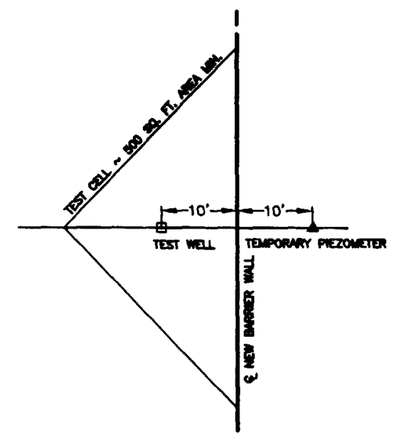


NOTES:

1. INSTALL TEST CELL USING SAME MIX DESIGN AND CONSTRUCTION PROCEDURES AS PROPOSED FOR PRODUCTION BARRIER WALL.
2. INSTALL TEST CELL PRIOR TO INSTALLATION OF PRODUCTION BARRIER WALL.
3. PIEZOMETER EXTENDS TO 80 FEET BELOW GRADE, SCREENED IN BOTTOM 20 FEET.
4. TEST WELL DESIGN PER CONTRACTOR.

TYPICAL TEST ARRANGEMENT AT
BARRIER WALL
PRE PRODUCTION TEST CELL

SCALE 1"=10'

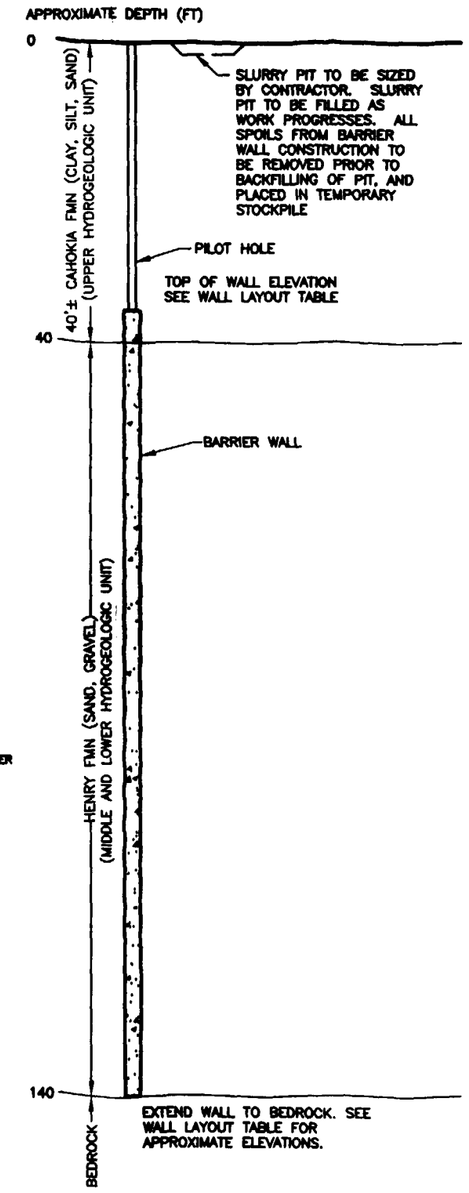


NOTES:

1. INSTALL TEST CELL USING SAME MIX DESIGN AND CONSTRUCTION PROCEDURES AS PRODUCTION BARRIER WALL.
2. PIEZOMETER EXTEND TO 80 FEET BELOW GRADE, SCREENED IN BOTTOM 20 FEET.
3. TEST WELL DESIGN PER CONTRACTOR.

TYPICAL TEST ARRANGEMENT AT
BARRIER WALL
PRODUCTION TEST CELL

SCALE 1"=10'



BARRIER WALL DETAIL

NOT TO SCALE

0 5 10
SCALE FEET

0 10 20
SCALE FEET

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

URS

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DATE: 1/21/03
SCALE: AS SHOWN
DESIGNED: KMB
DRAWN: DJD
CHECKED: KMB
SUBMITTED:

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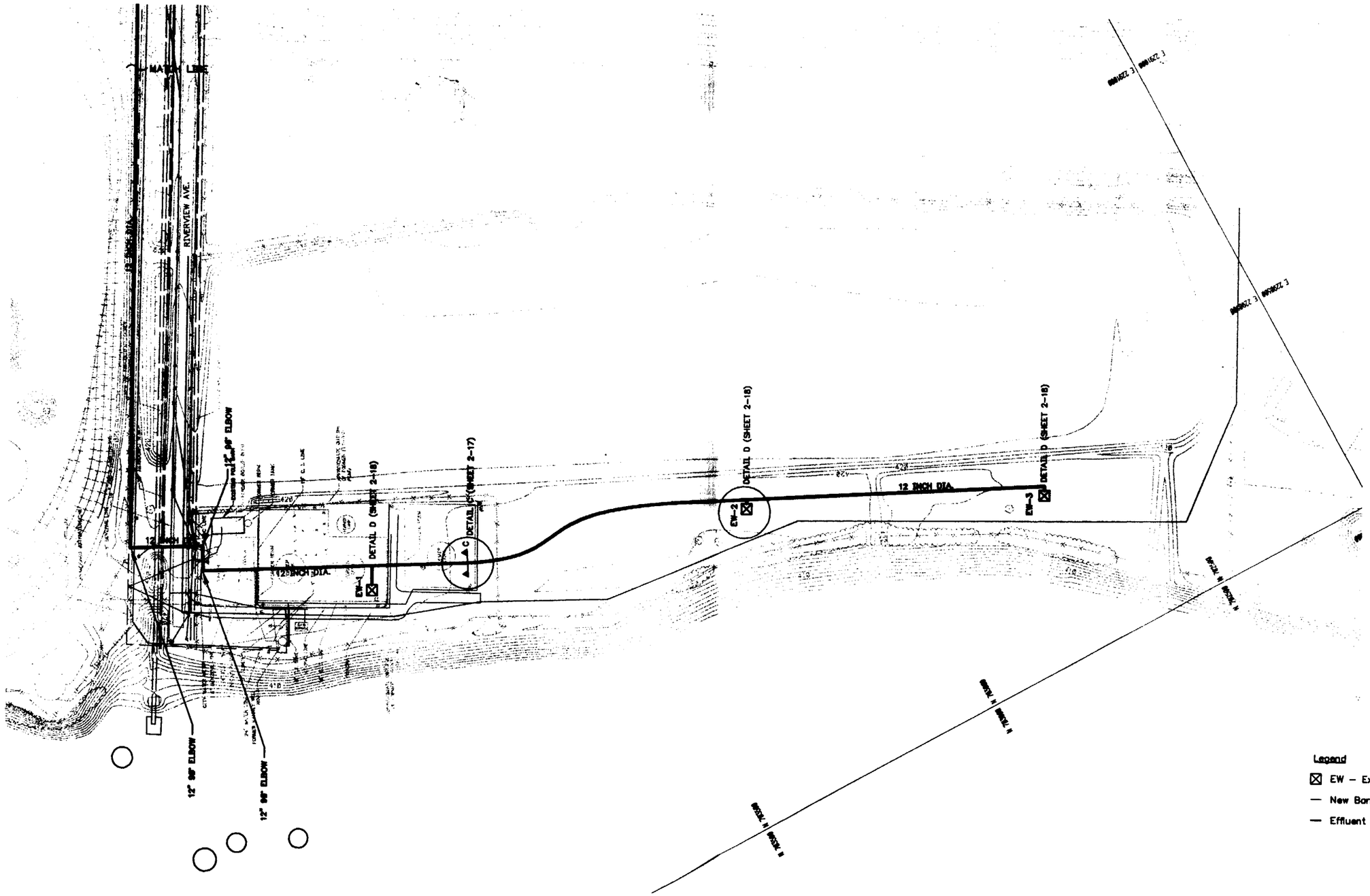
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

BARRIER WALL DETAILS

URS PROJECT NO. 21561192.00001

SHEET NO. 2-13



NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

FOR PIPE ELEVATION SEE DWG 2-16.

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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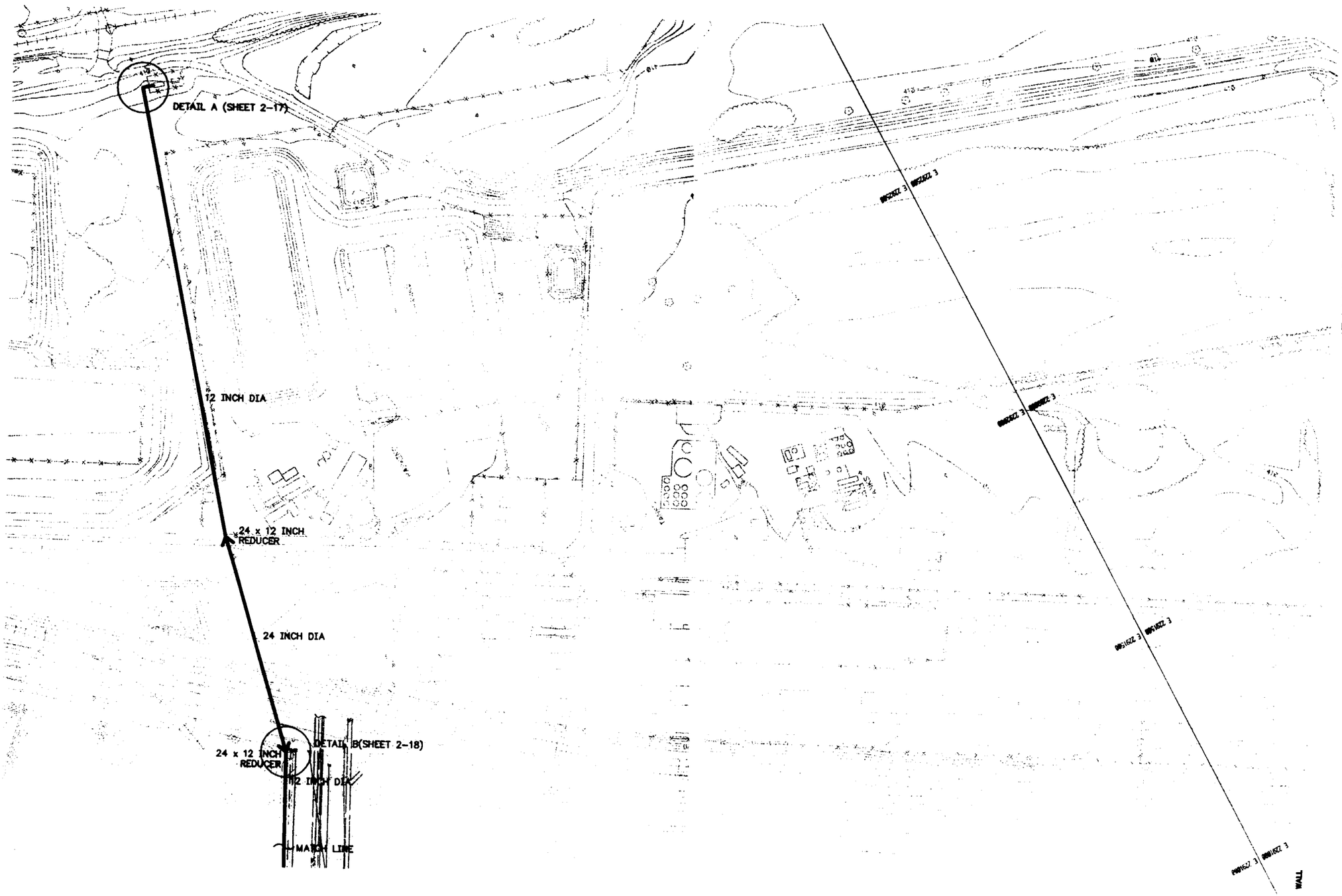
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

PLAN OF EFFLUENT PIPELINE (WEST)

PROJECT NO. 21561192.00001

SHEET NO. 2-14



NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

Legend

— Effluent Pipeline

Reducer

N

0 100
SCALE FEET

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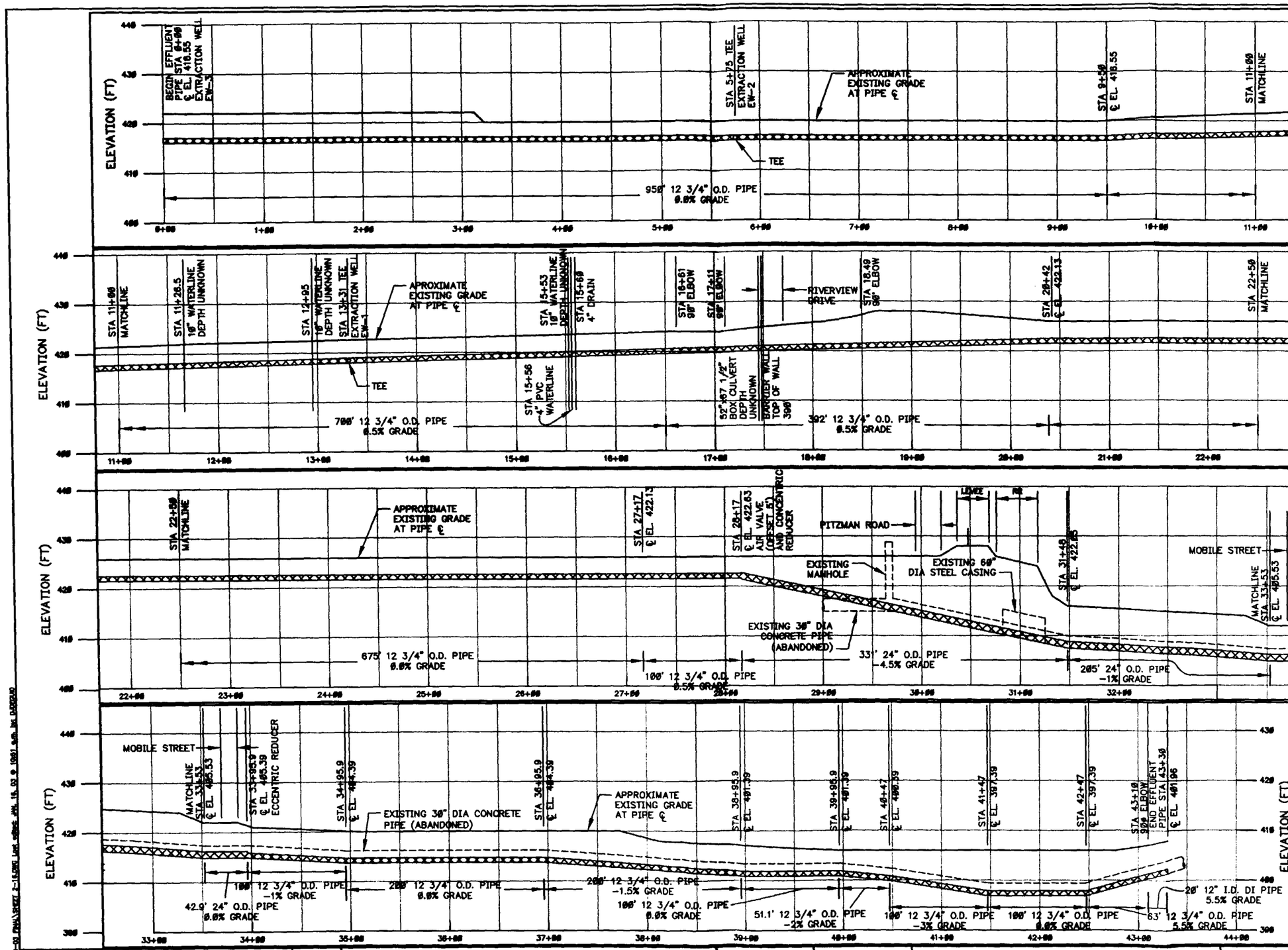
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

PLAN OF GROUNDWATER DISCHARGE LINE (EAST)

PROJECT NO. 21561192.00001

SHEET NO. 2-15



NOTES:

1) REMOVE EXISTING 6-IN DIA. SULFURIC ACID CARRIER PIPE AND 12-IN DIA. STEEL CASING PIPE AND SLIP 24-IN. OD HDPE PIPE INTO EXISTING 30-IN. ID ABANDONED REINFORCED CONCRETE WATER PIPE AT ABOUT STA 29+60 AND EXTEND TO STA 43+10. IT MAY BE NECESSARY TO EXCAVATE AT INTERMEDIATE LOCATIONS TO ACCOMPLISH THE SLIPLINING. (SEE REFERENCE DRAWINGS).

2) GROUT ANNULUS BETWEEN 24-IN. DIAMETER HDPE PIPE AND ID OF 30-IN. DIAMETER RCP FROM AT LEAST STA 29+60± TO STA 31+48. INSTALL SUFFICIENT CENTERING GUIDES TO ASSURE UNIFORM ANNULAR GROUT THICKNESS IN THIS REACH. DEVELOP AND SUBMIT DESIGN OF PACKER TO CONTAIN GROUT AT STA 31+48.

3) DEMOLISH EXISTING 30-IN. VALVE MANHOLE AND 30-IN. PIPE AT SUCH LOCATIONS NECESSARY TO INSTALL HDPE LINE. LOAD AND HAUL DEMOLITION DEBRIS TO TEMPORARY STOCKPILE.

4) GRADES OF THE EXISTING ABANDONED 30-IN. DIAMETER REINFORCED CONCRETE PIPE ARE BASED ON THE FOLLOWING REFERENCE DRAWINGS AND ADDING 312.36 FT TO THE ELEVATIONS SHOWN ON THE REFERENCE DRAWINGS TO CONVERT THEM TO FT, NGVD:

A. MONSANTO CHEMICAL CO. DWG D-13054, REV. 4, 4/19/54
B. MONSANTO CHEMICAL CO. DWG D-13055, REV. 4, 4/19/54
C. MONSANTO CHEMICAL CO. DWG D-13056, REV. 4, 4/19/54
D. MONSANTO CHEMICAL CO. DWG D-13057, REV. 6, 5/7/54
E. MONSANTO CHEMICAL CO. DWG D-13059, REV. 4, 5/19/54
F. MONSANTO CHEMICAL CO. DWG D-13060, REV. 2, 1/21/54

5) OTHER REFERENCE DRAWINGS
A. MONSANTO COMPANY DRAWING TS-B-15062, REV. 2, 9/10/79
B. MONSANTO COMPANY DRAWING TS-D-15071, REV. 0, 9/6/79

6) THE DRAWINGS SHOW THE PIPELINE WITHIN THE EXISTING 30-IN. DIA RCP FROM ABOUT STA 29+60 TO STA 43+10. THE PIPELINE SHALL BE WITHIN THE RCP AS A MINIMUM UNDER THE LEVEE AND RAILROAD TRACKS (APPROXIMATELY STA 29+60 TO STA 31+48). AT OTHER LOCATIONS, THE PIPELINE MAY BE INSTALLED EITHER IN THE 30-IN. RCP OR IN ITS OWN TRENCH ALONGSIDE THE 30-IN. RCP. CONTRACTOR SHALL FURNISH AND INSTALL THE NECESSARY HDPE FITTINGS TO ACCOMPLISH TRANSITIONS IN THE LOCATION OF THE PIPELINE EITHER WITHIN OR OUTSIDE OF THE 30-IN. RCP.

NO.	DATE	REVISION DESCRIPTION	APPROVED

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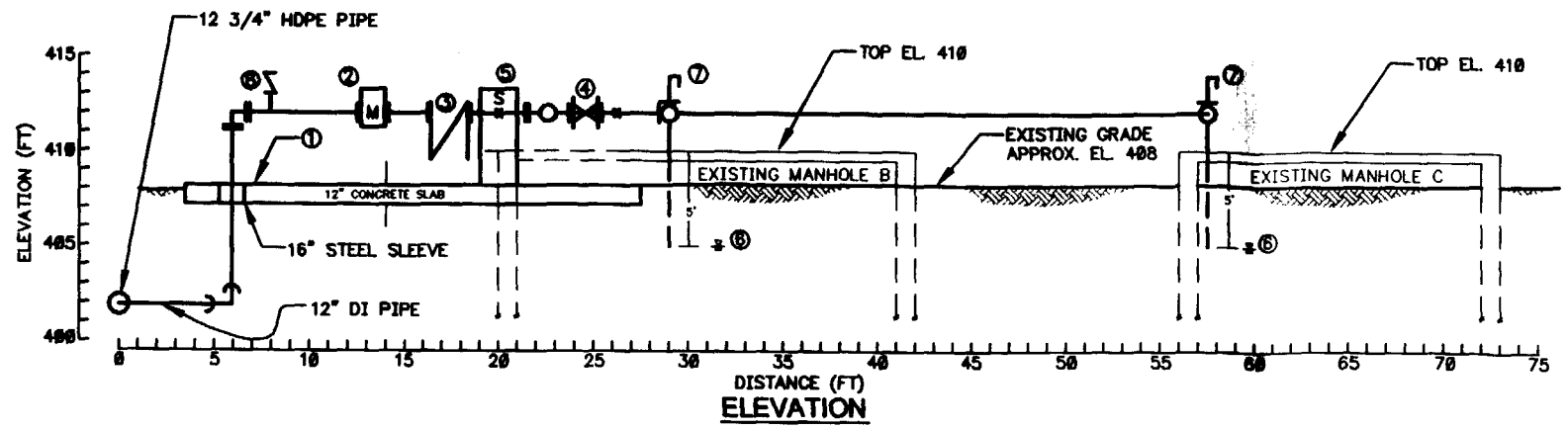
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

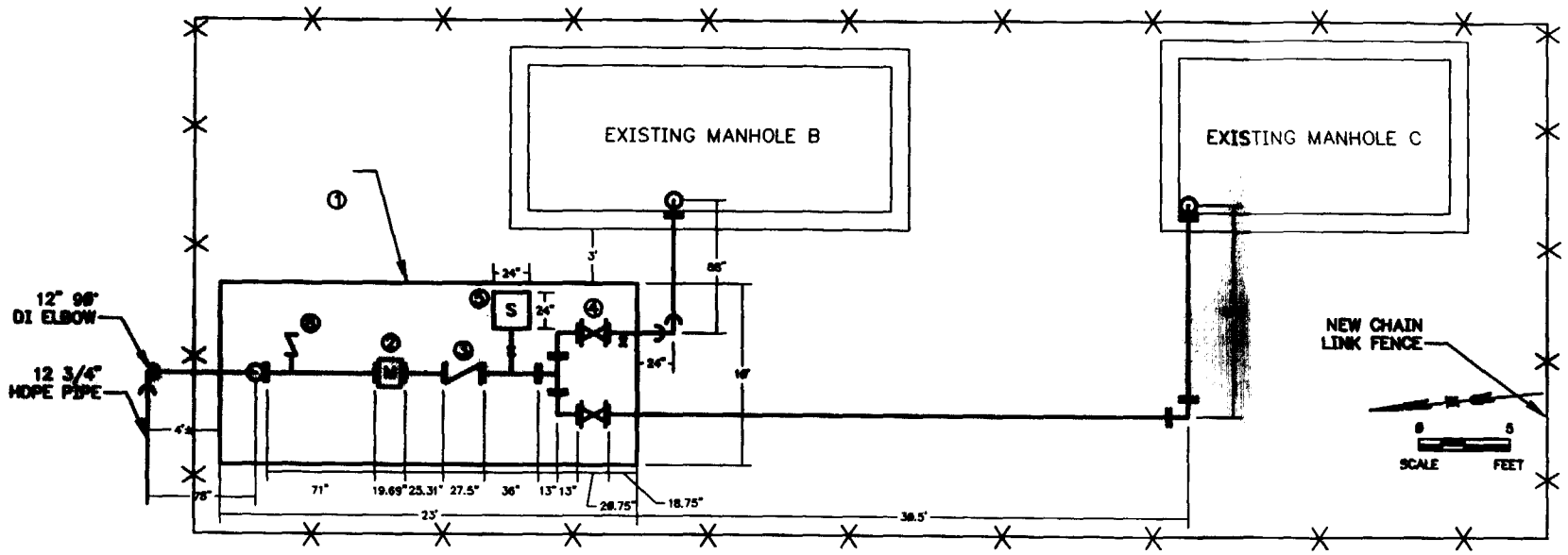
PROFILE OF EFFLUENT PIPELINE

PROJECT NO. 21561192.00001

SHEET NO. 2-16



ELEVATION



PLAN

	FLANGED	SCREWED	BELL & SPIG
JOINT			
ELBOW 90 DEG.			
ELBOW 45 DEG			
ELBOW TURNED UP			
ELBOW TURNED DOWN			
TEE			
TEE-OUTLET UP			
TEE-OUTLET DOWN			
GATE VALVE			
CHECK VALVE			
REDUCER			

NOTES:

1. CONCRETE SLAB ON GRADE
2. 12" MAGNETIC FLOW METER
3. 12" CHECK VALVE
4. 12" GATE OR PLUG VALVE
5. SIGMA 900 MAX SAMPLER
6. LOWEST WATER LEVEL
7. 2" VENT
8. AIR RELEASE VALVE (1")

NOTES:

1) REMOVE EXISTING CHAIN-LINK FENCE AROUND MANHOLES B AND C AND INSTALL NEW FENCE AROUND THE MANHOLES AND THE NEW ABOVEGROUND PIPING (MATCHING THE EXISTING FENCE). FURNISH AND INSTALL ONE 36-IN. WIDE GATE WITH REPLACEMENT PADLOCK KEYED FOR AMERICAN BOTTOMS REGIONAL WASTEWATER TREATMENT FACILITY PERSONNEL.

2) DESIGN, FURNISH, AND INSTALL INSULATION AND HEAT TRACING ON ALL ABOVEGROUND PIPING.

3) DESIGN, FURNISH AND INSTALL AREA LIGHTING WITH DUSK-TO-DAWN CELLS.

4) DESIGN AND INSTALL POWER SERVICE AND ELECTRICAL DISTRIBUTION FOR HEAT TRACING, INSTRUMENTS, AND AREA LIGHTING.

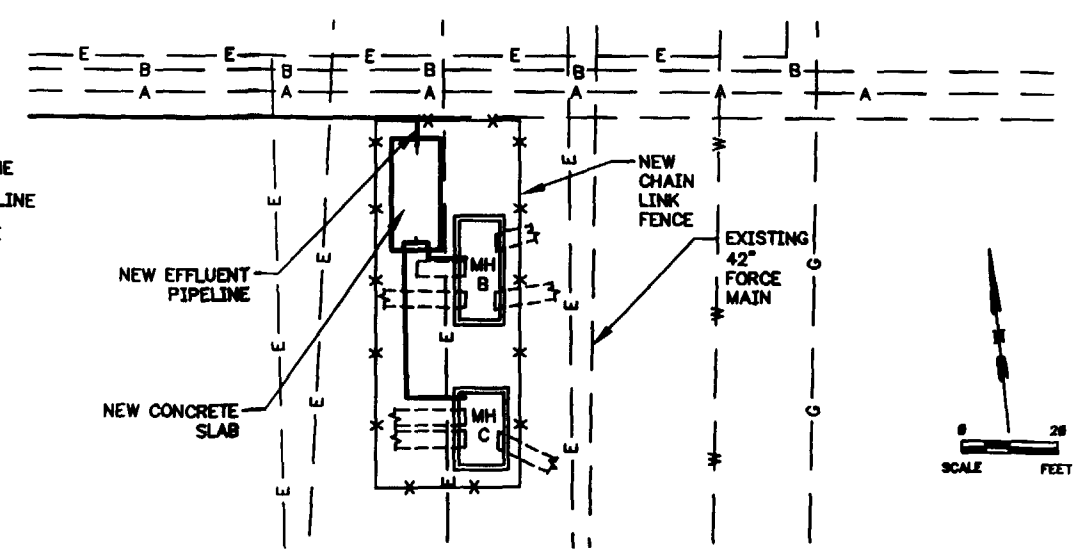
REFERENCE DRAWINGS:

MANHOLES C AND I, VILLAGE OF SAUGET, ILLINOIS SEWER REHABILITATION, SHEET 1, AS-BUILT 1/24/91, P.H. WEIS & ASSOCIATES INCORPORATED

T.R.R.A., VILLAGE OF SAUGET, ILLINOIS SEWER REHABILITATION, SHEET 1, AS-BUILT 1/24/91, P.H. WEIS & ASSOCIATES INCORPORATED

LEGEND

—W—	EXISTING 16" WATERLINE
—B—	EXISTING 6" BENZENE LINE
—A—	EXISTING 6" ACID LINE
—G—	EXISTING GAS LINE



SITE PLAN

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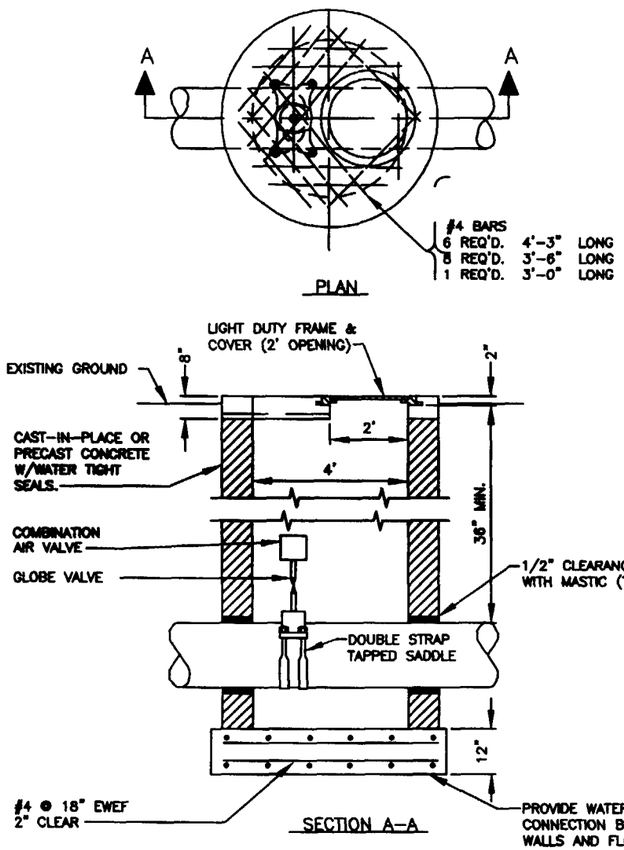
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

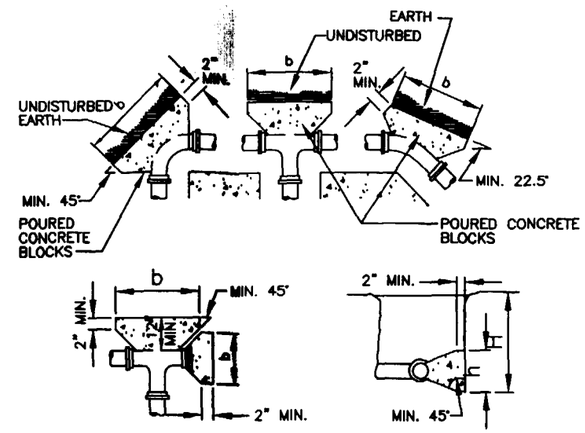
PIPING PLAN & DETAILS AT DISCHARGE POINT

URS PROJECT NO. 21561192.00001

SHEET NO. 2-17



DETAIL B
VACUUM AND AIR RELIEF VALVE MANHOLE
NOT TO SCALE



NOTES:
1. PLACE 4 MIL. POLYETHYLENE BETWEEN CONCRETE AND FITTING (CONCRETE SHALL NOT INTERFERE WITH JOINT.)
2. MINIMUM CONCRETE THICKNESS SHALL BE 12 INCHES.
3. THE HORIZONTAL DIMENSION (b) OF THE BEARING AREA SHALL BE BETWEEN 1.0 AND 2.0 TIMES THE VERTICAL DIMENSION (h). (h <= b <= 2h)
4. THE VERTICAL DIMENSION (h) OF THE BEARING AREA SHALL BE EQUAL TO ONE-HALF THE TOTAL DEPTH (H) TO THE BOTTOM OF THE THRUST BLOCK BUT NOT LESS THAN THE OUTSIDE DIAMETER (Do) OF THE FITTING (Do < h <= H/2).
5. THRUST BLOCK ORIENTATION SHALL BE SUCH THAT THE CENTER OF THE FITTING CORRESPONDS WITH THE CENTER OF THE THRUST BLOCK.
6. THE MINIMUM ALLOWABLE ANGLE (EITHER VERTICAL OR HORIZONTAL) SHALL BE 45 DEGREES.

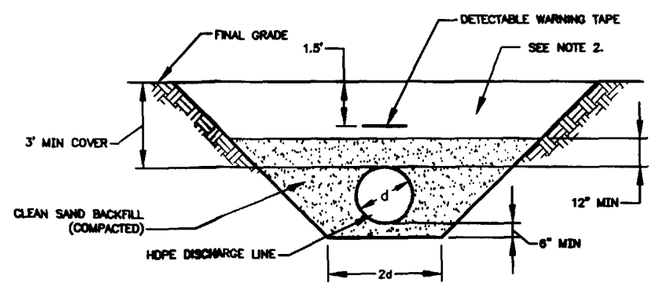
BEARING AREA OF BLOCK IN SQ. FT. (b x h)

FITTING SIZES	TEE & END	90° BEND	45° BEND	22 1/2° BEND	11 1/4° BEND
12"	4.0	4.0	4.0	2.0	2.0

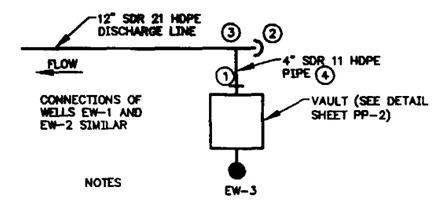
(FIGURES TO BE ENTERED IN TABLE WHEN RANGE OF PIPE SIZES IS DETERMINED)

TYPICAL THRUST BLOCKING DETAILS
NOT TO SCALE

NOTES:
1) SLOPE SIDES OF TRENCH AS REQUIRED BY SOIL CONDITIONS AND OSHA REGULATIONS.
2) FINAL BACKFILL SHALL BE IMPORTED UNCONTAMINATED EARTH, EXCEPT WITHIN LIMITS OF BARRIER WALL, WHERE SOIL EXCAVATED FROM TRENCH MAY BE USED.
3) HAUL EXCAVATED SOIL TO TEMPORARY STOCKPILE (EXCEPT WITHIN LIMITS OF BARRIER WALL).



DETAIL C
PIPELINE TRENCH DETAIL
NOT TO SCALE



NOTES
1. FLANGE OR OTHER APPROVED CONNECTION
2. MOLDED SDR 11 HDPE CAP
3. 12"X4" SDR 11 HDPE BRANCH SADDLE
4. BED HDPE PIPE IN SAND SIMILAR TO DETAIL C

DETAIL D
WELL-TO-DISCHARGE CONNECTION
NOT TO SCALE

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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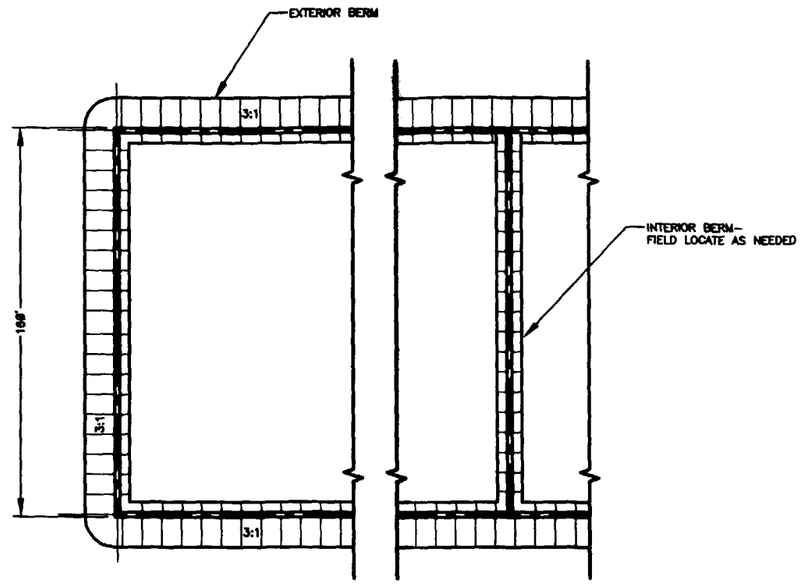
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

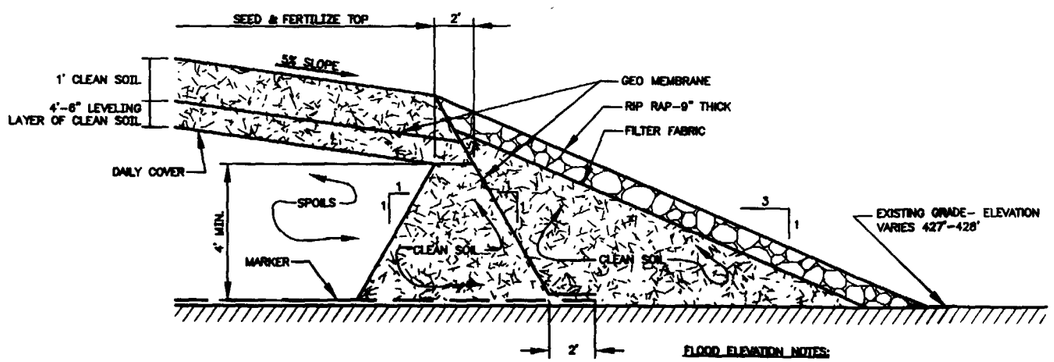
PIPING DETAILS

URS PROJECT NO. 21561192.00001

SHEET NO. 2-18

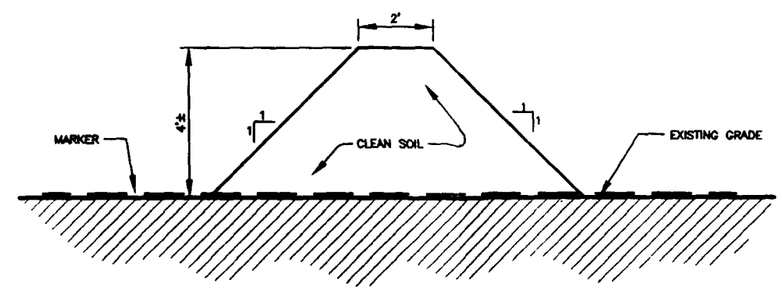


TEMPORARY STOCKPILE
N.T.S.



TYPICAL EXTERIOR BERM
N.T.S.

FLOOD ELEVATION NOTES:
-500 YR FLOOD - 428.8
-100 YR FLOOD - 427.0
-EXISTING LEVEE - 431.5



TYPICAL INTERIOR BERM
N.T.S.

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DRAWN: BJB/VDL
CHECKED: MJB
SUBMITTED:

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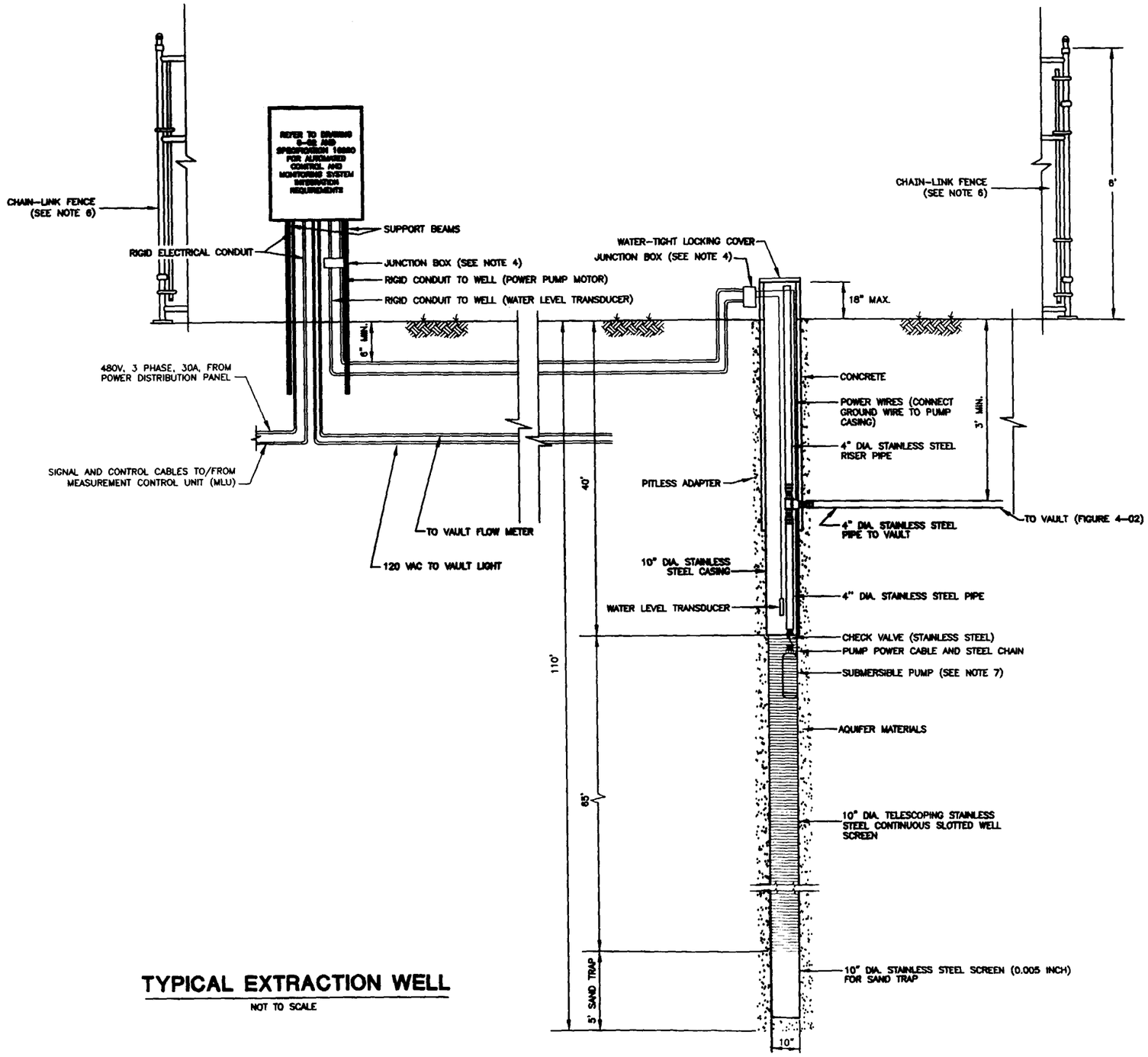
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

TEMPORARY STOCKPILE DETAILS

URS PROJECT NO. 21561192.00001

SHEET NO. 2-19



TYPICAL EXTRACTION WELL

NOT TO SCALE

NOTES

1.) TYPICAL WELL CONSTRUCTION. ACTUAL PLACEMENT OF WELL SCREEN AND CASING TO BE MODIFIED BY REMEDIAL DESIGNER BASED ON FIELD CONDITIONS.

2.) COMPLETION OF EXTRACTION WELLS SHALL BE UNDER THE DIRECT SUPERVISION OF THE REMEDIAL DESIGNER OR OTHER QUALIFIED PROFESSIONAL DESIGNATED BY SOLUTIA. THE FINAL COMPLETION OF EXTRACTION WELLS WILL BE BASED ON ACTUAL CONDITIONS ENCOUNTERED DURING WELL CONSTRUCTION.

3.) SUPPORT PUMP AND DISCHARGE PIPING FROM TOP. DO NOT ALLOW PITLESS ADAPTER TO SUPPORT PUMP UNLESS PITLESS ADAPTER IS CONCRETED IN PLACE. PROVIDE STAINLESS STEEL CHAIN TO ATTACH TO PUMP.

4.) ALL WIRING BETWEEN THE EXTRACTION WELLS AND CONTROL PANEL SHALL BE SUBMERSIBLE. CONNECT WIRES TO WELL CONDUIT USING SEAL TIGHT CONNECTORS. PROVIDE ELECTRICAL BOX (NEMA 6)AT GROUND SURFACE SIZED TO STORE A MINIMUM OF 5 FEET OF EXCESS WIRES (SLACK) COILED NEATLY IN JUNCTION BOX FOR ADJUSTING DEPTH IN WELLS.

5.) PRESSURE TRANSDUCER TO BE INSTALLED IN EACH WELL IN ORDER TO GAUGE DRAWDOWN, 5 FEET ABOVE TOP OF PUMP.

6.) CONTRACTOR SHALL INSTALL A CHAIN LINK FENCE ENCLOSURE AROUND THE PERIMETER OF EACH WELL AS SPECIFIED IN FIGURE 3-02.

7.) SUBMERSIBLE PUMP TO BE PLACED WITHIN SCREEN AT DEPTH OF 60 FEET BELOW GROUND SURFACE.

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

APPROVED

Golder Associates
St. Louis, Missouri

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DATE:	1/21/03
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CHECKED:	JH
SUBMITTED:	

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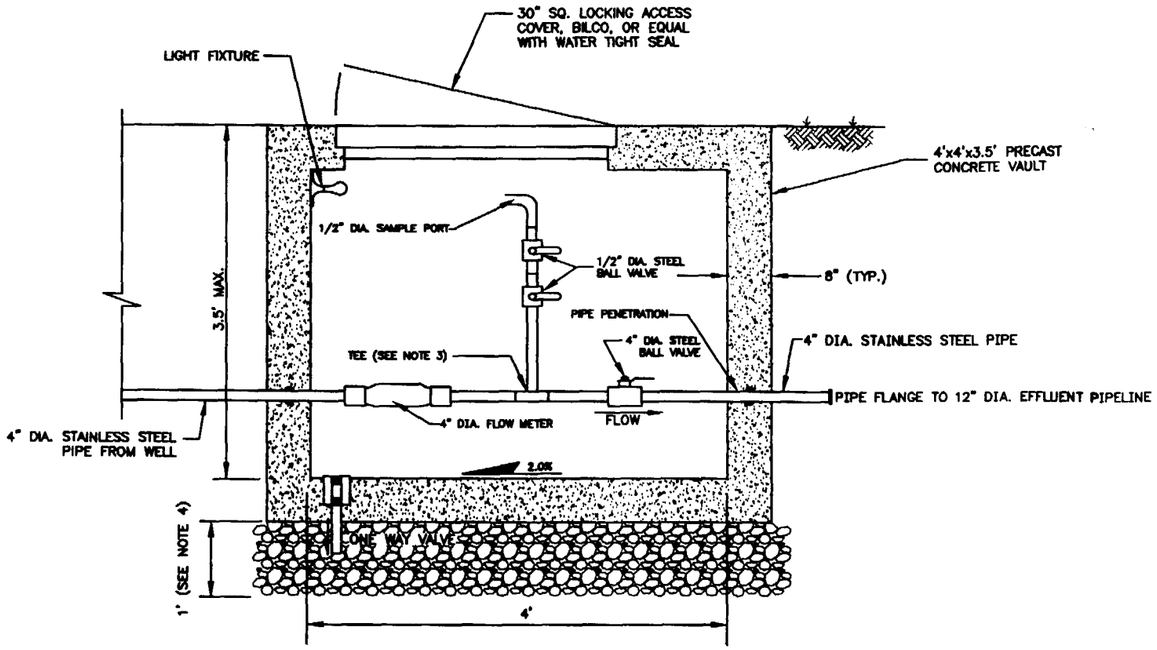
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

TYPICAL EXTRACTION WELL

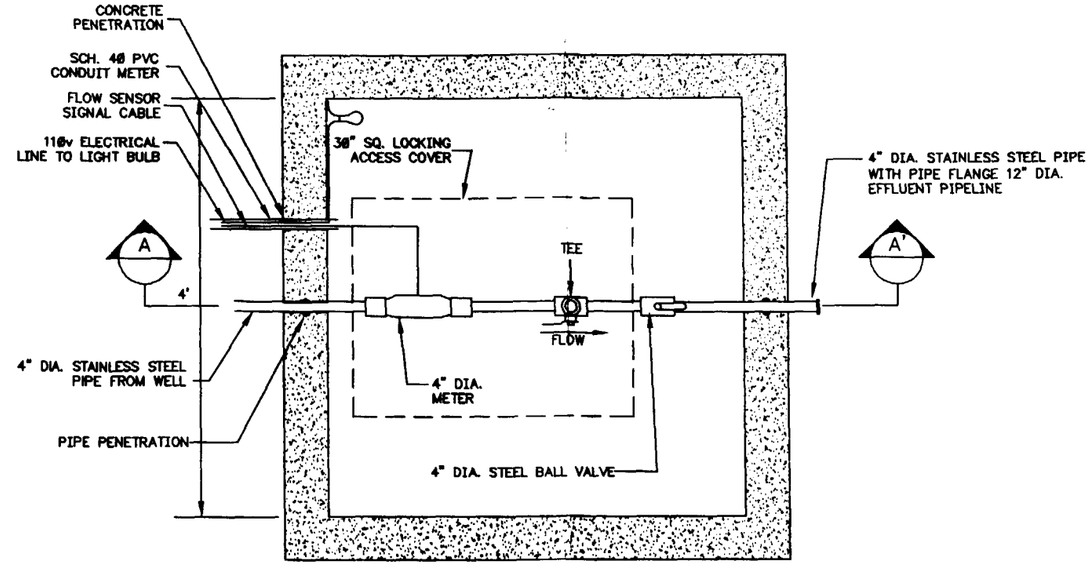
URS PROJECT NO. 21561192.00001

SHEET NO. 3-01



FLOW METER AND SAMPLING VAULT - PROFILE VIEW A-A' (TYP.)

NOT TO SCALE



FLOW METER AND SAMPLING VAULT - PLAN VIEW (TYP.)

NOT TO SCALE

NOTES

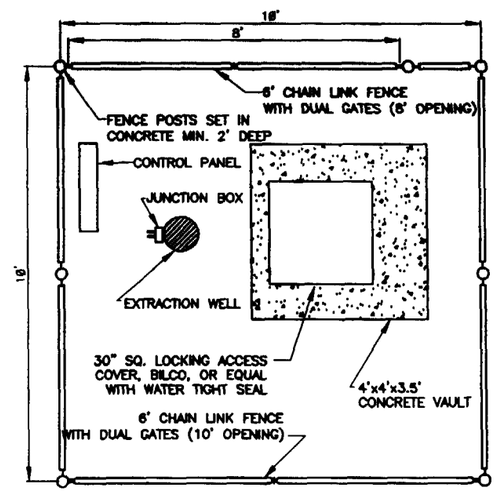
1.) ALL WIRING BETWEEN THE FLOW METER AND CONTROL PANEL SHALL BE SUBMERSIBLE.

2.) FOR PRE-CAST CONCRETE, CONTRACTOR SHALL FOLLOW THE INSTRUCTIONS OF THE MANUFACTURER WHICH HAVE ALREADY BEEN FAVORABLY REVIEWED BY THE REMEDIAL DESIGNER.

3.) TEE JOINT TO BE AT LEAST TWO PIPE DIAMETERS FROM FLOW METER.

4.) GRAVEL LAYER AT LEAST ONE FOOT THICK TO FACILITATE DRAINAGE.

TYPICAL WELL ENCLOSURE
PLAN VIEW



NOTE:
CONTRACTOR SHALL INSTALL A CHAIN LINK FENCE ENCLOSURE AROUND THE PERIMETER OF EACH WELL. CONTRACTOR SHALL SUPPLY DUAL GATES WITH PADLOCKING LATCH FOR EACH ENCLOSURE AND POSITIONED TO ALLOW DIRECT ACCESS TO THE VAULT AND INTERNAL COMPONENTS. CHAIN LINK FENCE NOT SHOWN ON ALL DETAILS FOR CLARITY.

TYPICAL WELL ENCLOSURE -PLAN VIEW (TYP.)

NOT TO SCALE

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

Golder Associates
St. Louis, Missouri

SEAL

DATE:	1/21/03
SCALE:	AS SHOWN
DESIGNED:	DNB,FMB,JH
DRAWN:	MRM,DJD,JAC
CHECKED:	JH
SUBMITTED:	

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141
Applied Chemistry, Creative Solutions

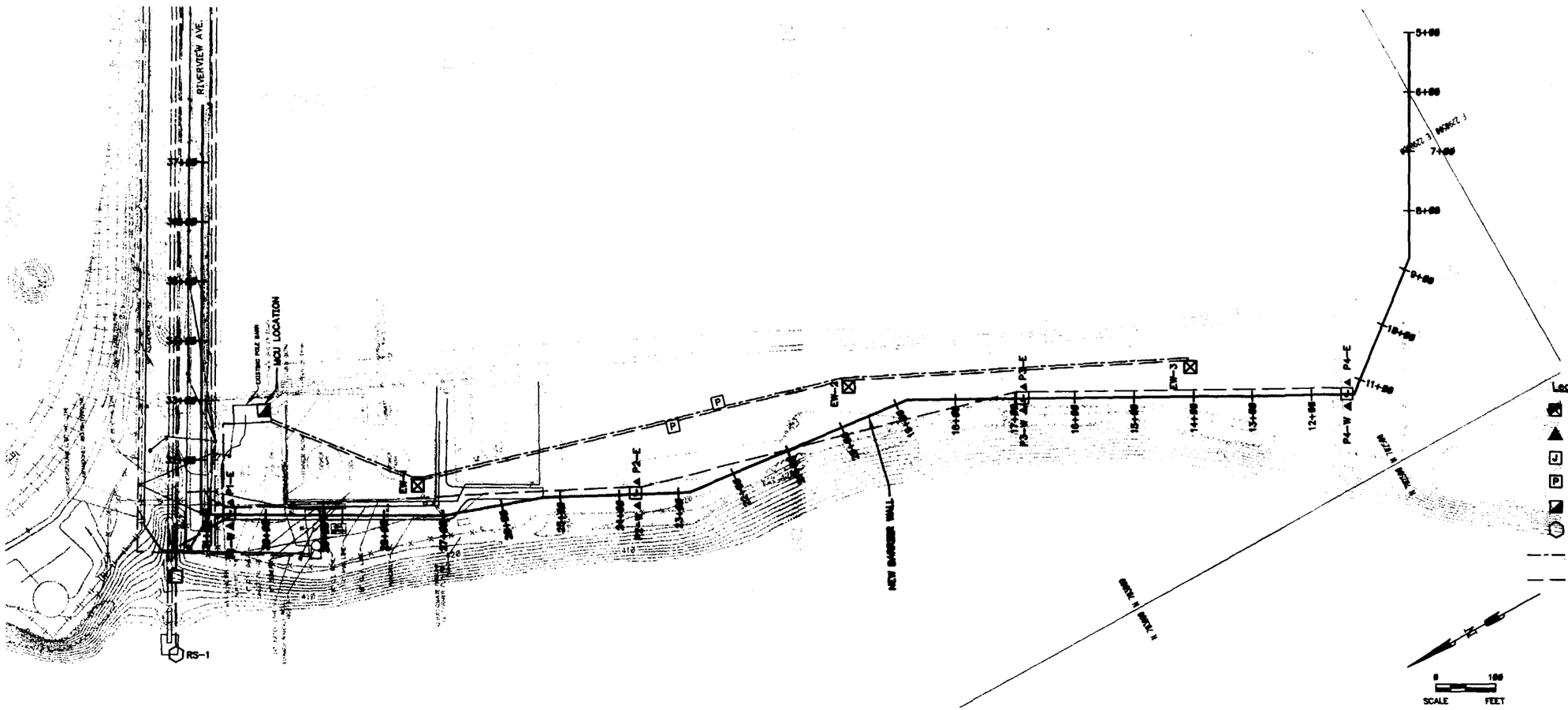
GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 – BARRIER WALL

FLOWMETER AND SAMPLING VAULT DETAILS

URS PROJECT NO. 21561192.00001

SHEET NO. 3-02



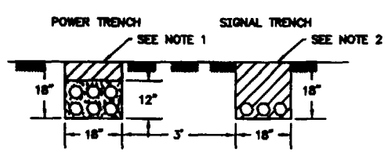
NOTE:

EXISTING SURFACE FEATURES HAVE BEEN PLOTTED FROM AN AERIAL SURVEY BY SURDEX. THE LOCATIONS OF UNDERGROUND UTILITIES, STRUCTURES AND FACILITIES HAVE BEEN PLOTTED FROM PLANS AND DRAWINGS OF EXISTING FACILITIES PROVIDED BY SOLUTIA. THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHER IMPROVEMENTS AND UTILITIES WITHIN THE PROJECT AREA, WHICH ARE NOT SHOWN. THE CONTRACTOR SHALL VERIFY, PRIOR TO EXCAVATION OR CONSTRUCTION, THE LOCATIONS, ELEVATIONS AND DIMENSIONS OF ALL EXISTING UTILITIES, STRUCTURES, WELLS AND OTHER FEATURES AFFECTING HIS WORK, WHETHER OR NOT SHOWN ON THE PLANS. USE OF A SUBSURFACE LOCATOR IS RECOMMENDED.

SHOULD ANY FEATURE ADVERSELY AFFECT THE PROPOSED CONSTRUCTION, THE CONTRACTOR SHALL OBTAIN SOLUTIA'S APPROVAL FOR A CHANGE OR MODIFICATION TO THESE PLANS PRIOR TO PROCEEDING.

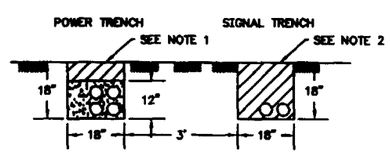
Legend

- EW – Extraction Well for GMCS
- P – Piezometer for GMCS
- J – JUNCTION BOX
- P – PULL BOX
- MEASUREMENT CONTROL UNIT (MCU)
- RS – RIVER STAGE GAUGE
- POWER CABLE/CONDUIT TRENCH
- SIGNAL CABLE/CONDUIT TRENCH



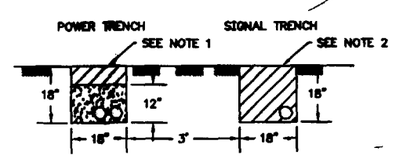
POWER: (6) 2" SDR 11 HDPE ELECTRICAL CONDUITS
3 – BELDEN #18 (480 VAC)
3 – BELDEN #18 (120 VAC)
SIGNAL: (3) 2" SDR 11 HDPE ELECTRICAL CONDUITS
3 – BELDEN #9524

SECTION A–A'



POWER: (4) 2" SDR 11 HDPE ELECTRICAL CONDUITS
2 – BELDEN #18 (480 VAC)
2 – BELDEN #18 (120 VAC)
SIGNAL: (2) 2" SDR 11 HDPE ELECTRICAL CONDUITS
2 – BELDEN #9524

SECTION B–B'



POWER: (2) 2" SDR 11 HDPE ELECTRICAL CONDUITS
1 – BELDEN #18 (480 VAC)
1 – BELDEN #18 (120 VAC)
SIGNAL: (1) 2" SDR 11 HDPE ELECTRICAL CONDUITS
1 – BELDEN #9524

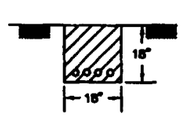
SECTION C–C'

TRENCH NOTES:

1. BACKFILL POWER TRENCH WITH 12 INCHES RED–DYE CONCRETE THEN NATIVE BACKFILL THE UPPER 6 INCHES.
2. BACKFILL SIGNAL TRENCH WITH NATIVE BACKFILL FREE OF ROCKS AND DEBRIS.

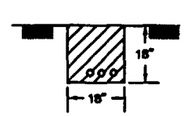
ELECTRICAL NOTES:

1. SPLICES ARE NOT PERMITTED IN ANY FIELD SIGNAL CABLE.
2. ALL JUNCTION BOXES AND PULL BOXES SHALL BE NEMA 6.
3. MAINTAIN CONTINUITY OF SIGNAL CABLE ACROSS ALL JUNCTION BOXES FOR SIGNAL CABLE.



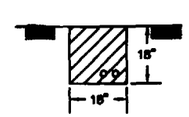
(4) 1" SDR 11 HDPE ELECTRICAL CONDUITS
4 – BELDEN #9666

SECTION D–D'



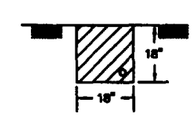
(3) 1" SDR 11 HDPE ELECTRICAL CONDUITS
3 – BELDEN #9666

SECTION E–E'



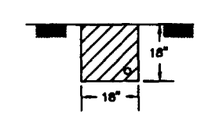
(2) 1" SDR 11 HDPE ELECTRICAL CONDUITS
2 – BELDEN #9666

SECTION F–F'



(1) 1" SDR 11 HDPE ELECTRICAL CONDUIT
1 – BELDEN #9666

SECTION G–G'



(1) 1" SDR 11 HDPE ELECTRICAL CONDUIT
1 – BELDEN #9666

SECTION H–H'

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

URS

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Louis, MO. 63043 Tel:
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314-429-0462

SEAL

DATE: 1/21/03
SCALE: AS SHOWN
DESIGNED: JH
DRAWN: DJD/WDL
CHECKED: JH
SUBMITTED:

SOLUTIA™
Applied Chemistry, Creative Solutions

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141

GROUNDWATER MIGRATION CONTROL SYSTEM

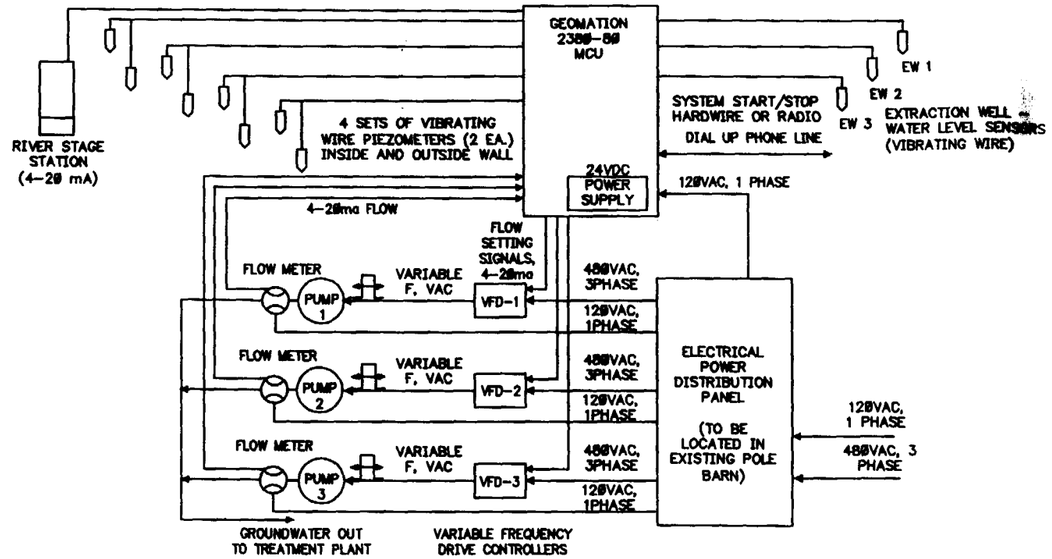
PACKAGE 2 – BARRIER WALL

AUTOMATED CONTROL AND MONITORING SYSTEM SITE PLAN

PROJECT NO. 21561192.00001

SHEET NO. 6–01

File: G:\21561192.00001\15-16-03 PAW\SITE PLAN2.DWG Last edited: JAN. 22, 03 @ 3:23 p.m. by: WDLOWZO

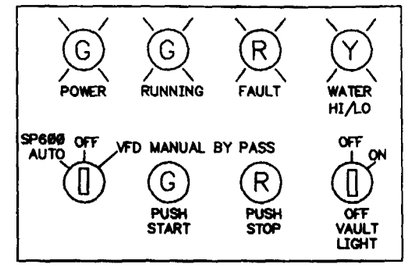


PUMP CONTROL SYSTEM BLOCK DIAGRAM

NOT TO SCALE

INPUT				OUTPUT		
INPUT	TYPE	RANGE		OUTPUT	TYPE	RANGE
PZ-1W OUTSIDE	VW	50 PSI		P-1 PUMP 1-FLOW	CURRENT	4-20 ma
PZ-2W OUTSIDE	VW	50 PSI		P-2 PUMP 2-FLOW	CURRENT	4-20 ma
PZ-3W OUTSIDE	VW	50 PSI		P-3 PUMP 3-FLOW	CURRENT	4-20 ma
PZ-4W OUTSIDE	VW	50 PSI		ON 1 PUMP 1 START	DIGITAL	24 V
PZ-1E INSIDE	VW	50 PSI		OFF 1 PUMP 1 STOP	DIGITAL	24 V
PZ-2E INSIDE	VW	50 PSI		ON 2 PUMP 2 START	DIGITAL	24 V
PZ-3E INSIDE	VW	50 PSI		OFF 2 PUMP 2 STOP	DIGITAL	24 V
PZ-4E INSIDE	VW	50 PSI		ON 3 PUMP 3 START	DIGITAL	24 V
PZ-EW1 WELL1	VW	50 PSI		OFF 3 PUMP 3 STOP	DIGITAL	24 V
PZ-EW2 WELL 2	VW	50 PSI		W-1 WATER HI/LO	DIGITAL	24 V
PZ-EW3 WELL 3	VW	50 PSI		W-2 WATER HI/LO	DIGITAL	24 V
FL-EW1 FLOW1	CURRENT	4-20 ma		W-3 WATER HI/LO	DIGITAL	24 V
FL-EW2 FLOW 2	CURRENT	4-20 ma		FAULT-1 PUMP FAULT	DIGITAL	24 V
FL-EW3 FLOW 3	CURRENT	4-20 ma		FAULT-2 PUMP FAULT	DIGITAL	24 V
RIVER STAGE	CURRENT	4-20 ma		FAULT-3 PUMP FAULT	DIGITAL	24 V
				DIALER -1 PUMP 1 FAULT	DIGITAL	24 V
				DIALER -2 PUMP 2 FAULT	DIGITAL	24 V
				DIALER -3 PUMP 3 FAULT	DIGITAL	24 V
				DIALER -4		

INPUT/OUTPUT TABLE FOR MCU

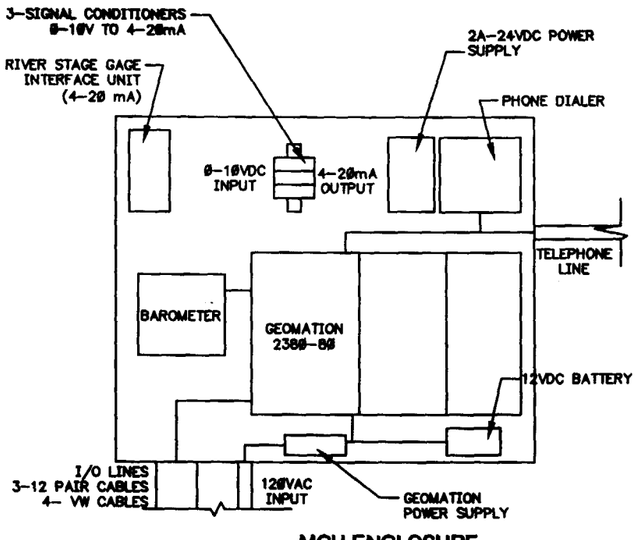


DETAIL OF PUMP CONTROL PANEL

NOT TO SCALE

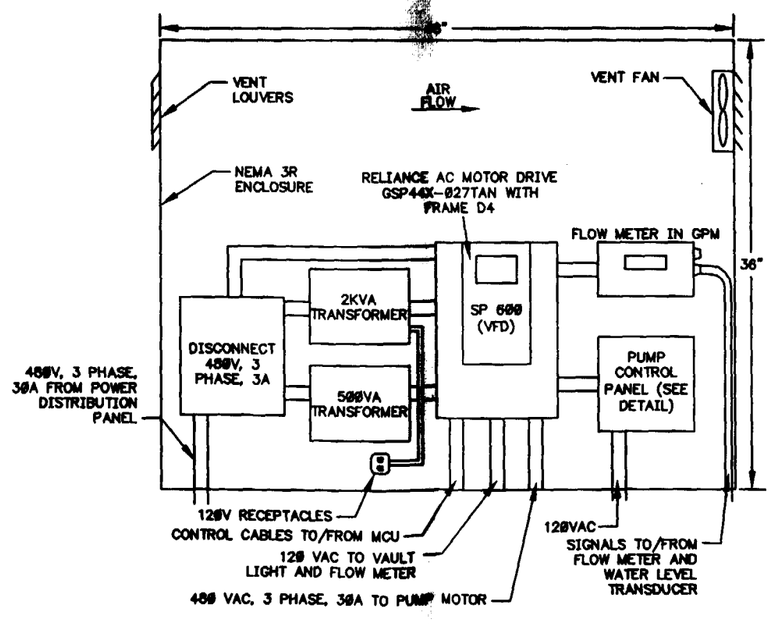
RIVER STAGE (FT, AMSL)	PUMPING RATE (GPM)	RIVER ELEVATION COMMENTS
430	0	HIGHEST RECORDED RIVER ELEVATION
413	0	
412	25	
411	50	
410	75	
409	100	
408	125	
407	150	
406	175	
405	200	
404	225	
403	250	
402	275	
401	300	HIGH MONTHLY AVERAGE FLOW
400	325	
399	350	
398	375	
397	400	
396	425	
395	450	
394	475	
393	500	
392	525	
391	535	AVERAGE MONTHLY AVERAGE FLOW
390	550	
389	575	
388	600	
387	625	
386	650	
385	675	
384	700	
383	725	LOW MONTHLY AVERAGE FLOW
382	750	
381	775	
380	800	
379	825	
378	850	
377	875	
376	900	
375	925	
374	950	LOWEST RECORDED RIVER ELEVATION

PUMPING RATE LOOKUP TABLE



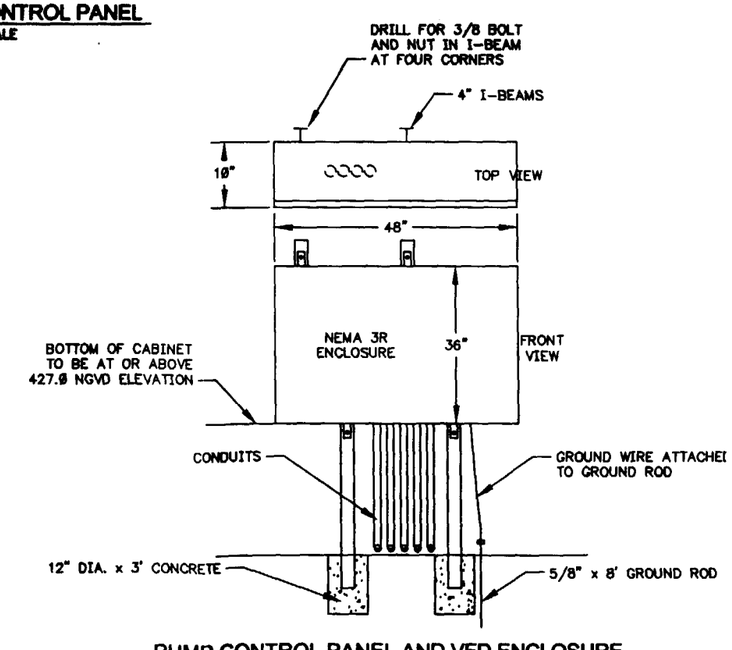
MCU ENCLOSURE

NOT TO SCALE



PUMP CONTROL PANEL/VFD ENCLOSURE
(TYPICAL EACH EXTRACTION WELL)

NOT TO SCALE



PUMP CONTROL PANEL AND VFD ENCLOSURE

NOT TO SCALE

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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DESIGNED: JH
DRAWN: DJB
CHECKED: JH
SUBMITTED:

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Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM

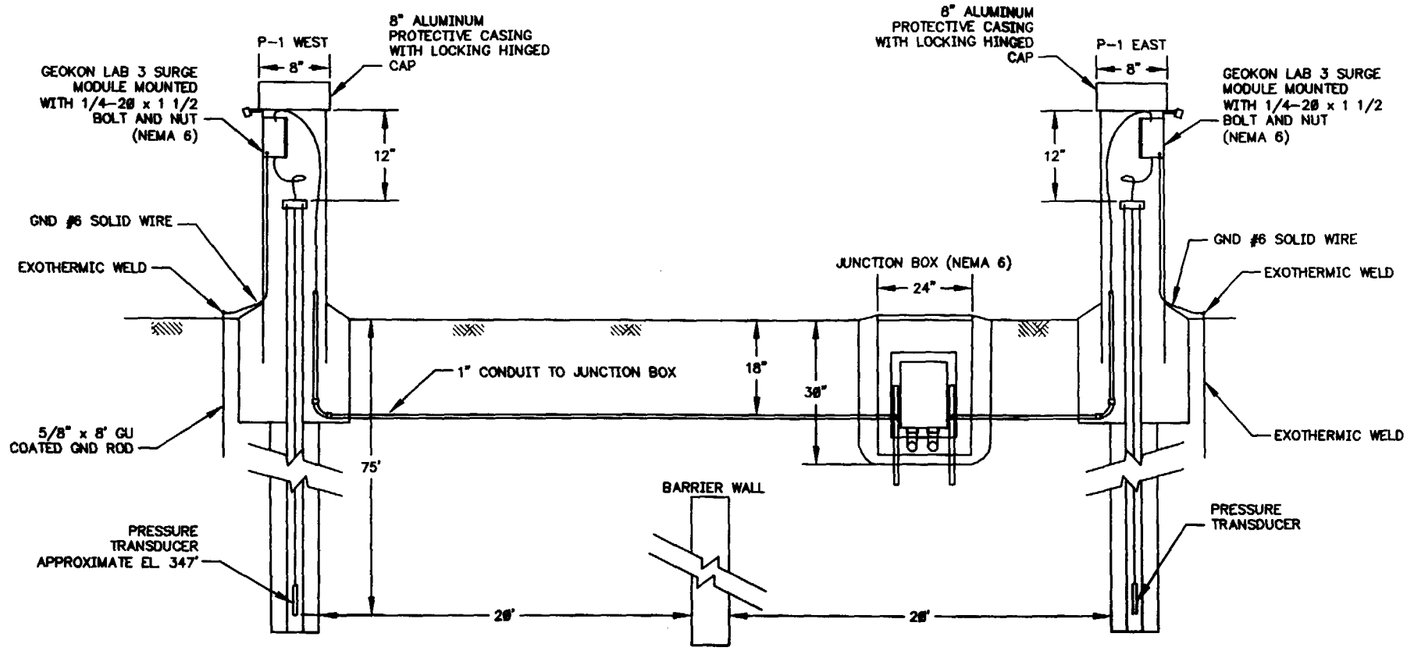
PACKAGE 2 - BARRIER WALL

AUTOMATED CONTROL AND MONITORING SYSTEM DETAILS (SHEET 1)

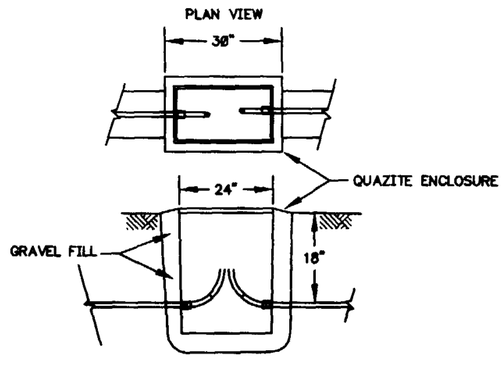
URS PROJECT NO. 21561192.00001

SHEET NO. 6-02

NOTES



AUTOMATED PIEZOMETER PAIR WITH SIGNAL CABLE JUNCTION BOX
NOT TO SCALE



PULL BOX
NOT TO SCALE

NO.	DATE	REVISION DESCRIPTION	APPROVED

PREPARED BY:

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SEAL

DATE: 1/21/03
SCALE: AS SHOWN
DESIGNED: JH
DRAWN: DJB
CHECKED: JH
SUBMITTED:

SOLUTIA INC.
575 MARYVILLE CENTRE DRIVE
ST. LOUIS, MO. 63141
Applied Chemistry, Creative Solutions

GROUNDWATER MIGRATION CONTROL SYSTEM

PACKAGE 2 - BARRIER WALL

AUTOMATED CONTROL AND MONITORING SYSTEM DETAILS (SHEET 2)

URS PROJECT NO. 21561192.00001

SHEET NO. 6-03

Section No.	Title
	Division 1 – General Requirements
01010	Summary of Work
01500	Mobilization & Temporary Facilities
01550	Site Preparation
01700	Demobilization & Project Closeout
	Division 2 – Site Work
02100	Erosion and Stormwater Control During Construction
02150	Clearing and Grubbing
02190	Temporary Haul Roads
02260	Trenching and Backfilling (not included)
02310	Jet Grouted Groundwater Barrier
02320	Construction Spoils Handling
02325	Geomembrane
02525	Extraction Wells
02526	Submersible Well Pump and Motor
02550	Effluent Pipeline and Appurtenances
02900	Site Restoration
02920	Chain Link Fences and Gates
	Division 3 – Concrete
03300	Cast-in-Place Concrete
	Division 13 – Special Construction
13500	Piezometers
	Division 16 – Electrical
16500	Basic Electrical Power Materials and Methods
16900	Controls and Instrumentation

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.0 SECTION INCLUDES

A. Background Information

B. General Requirements

C. Summary of Work

1.1 BACKGROUND INFORMATION

A. Solutia Inc. (Owner) plans to construct a Groundwater Mitigation Control System (GMCS) at their property in Sauget, Illinois. The purpose of the GMCS is to mitigate or abate the discharge of environmentally impacted groundwater to the Mississippi River. The project consists of installation of 3 wells and well pumps, discharge piping and appurtenances and a 3,300 feet long jet grouted barrier wall. The wall consists of two 650 feet long sections at the north and south ends and a 2,000 feet long section running parallel to the Mississippi River. Bedrock depth is about 120 to 140 feet below the existing ground surface. The barrier wall will extend from approximately 30 feet below ground surface to the top of the bedrock.

B. The site is designated as Solutia Area 2-Site R. Subsurface information and geotechnical data are presented on the drawings. Access to the work site is by paved roads. A locked gate controls entry to the site.

1.2 GENERAL REQUIREMENTS

A. Authority of Construction Manager

1. The work will be reviewed, observed and inspected by the on-site Construction Manager in accordance with the contract, Plans, Specifications and the Construction Quality Assurance Manual for the GMCS. The Construction Manager will decide all questions which may arise as to the quality or acceptability of materials furnished and work performed, the manner of performance and rate of progress of the work, the interpretations of the Drawings and Specifications and the acceptable

fulfillment of the contract on the part of the Contractor. Construction Manager's decisions will be final and binding.

B. Conformity with Drawings and Specifications

1. All work performed and all materials furnished shall be in conformity with the lines, grades, cross sections, dimensions, details, gradations, physical, and chemical characteristics of materials in accordance with tolerances shown on the Drawings and as required by the Specifications. Construction tolerances and accuracy limits will be as defined in the respective items of the contract or if not defined, as determined by the Construction Manager.

2. It is the responsibility of the Contractor to verify all quantities of materials shown on the Drawings before ordering same. The Contractor will not be paid for material rejected due to improper processing, excess quantity or for any other reasons within his control.

3. In the event the Construction Manager finds that the work performed or the materials used are not within conformity with the Drawings and Specifications, the affected material or product shall be removed and replaced or otherwise satisfactorily corrected by and at the expense of the Contractor.

4. Any deviations from the Plans, Specifications and approved Shop Drawings will be made only with the approval of the Construction Manager with the concurrence of the Designer. All requests for variance or modification shall be by written communication from the Contractor to the Construction Manager.

5. The Specifications accompanying the Drawings are essential parts of the contract and a requirement occurring in one is as binding as though occurring in all. They are intended to be cooperative and to describe and provide for a complete work. In cases of disagreement, dimensions provided on figures shall govern over scaled dimensions, Drawings shall govern over Specifications, and Instructions to Bidders. Addenda shall govern over all.

C. Cooperation of Contractor

1. The Contractor shall designate, to the Construction Manager in writing, the name of a Superintendent, employed by the firm, regardless of how much of the work may be sublet. The Superintendent shall be cooperative,

responsible and competent, English speaking, authorized to receive orders and to act for the Contractor. The Superintendent will be on-site and available at all times during site preparation, construction of the vertical barrier wall and all appurtenant work. In the event a competent superintendent is not available, the Construction Manager may suspend work at no additional cost to the Owner until one is available.

D. Removal of Defective and Unauthorized Work

1. All work which has been rejected as being in nonconformance with the Drawings and Specifications shall be remedied or removed and replaced in an acceptable manner by the Contractor at his expense. Work done without written authority will be considered as unauthorized and done at the expense of the Contractor and will not be paid for. Work so done may be ordered removed at the Contractor's expense. Upon failure on the part of the Contractor to comply with any order of the Construction Manager made under the provisions of this paragraph, the Construction Manager will have authority to cause defective work to be remedied or removed and replaced and unauthorized work to be removed and the cost thereof may be deducted from any moneys due or to become due to the contractor.

E. Protection of Adjoining Property

1. The Contractor shall take proper measures to protect the adjacent or adjoining property which might be injured by any process of construction, and, in case of any injury or damage resulting from any act or omission on the part of or on behalf of the Contractor, he shall restore at his own expense the damaged property to a condition similar or equal to that existing before such injury or damage was done, or he shall make good such injury or damage in an acceptable manner.

F. Contractor's Responsibility for Work

1. Until final written acceptance of the project by the Construction Manager, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the nonexecution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof which are a portion of the work, not damaged by the Contractor or his operations, except for damage to the work due to

Acts of God (force majeure) such as earthquake, flood, tornado, or other cataclysmic phenomena of nature or acts of governmental authorities. In case of suspension of work for any cause, the Contractor shall be responsible for the preservation of all materials. He shall provide suitable drainage and shall erect temporary structures where required.

G. Work Near Electrical Power Lines

1. Any operations by the Contractor that are located near any electrical power lines shall be accomplished using established industry and utility safety practices. The Contractor shall consult with the appropriate utility company prior to beginning any such work. All consultation and compliance will be the responsibility of the Contractor.

H. Workers and Equipment

1. The Contractor shall furnish such suitable machinery, equipment, and construction forces as may be necessary, in the opinion of the Construction Manager, for the proper prosecution of the work. Construction Manager may require the Contractor to provide additional resources to maintain the project schedule. Construction Manager may suspend the work until his requests are complied with.

2. All workers employed by the Contractor shall have such skill and experience as will enable them to properly perform the duties assigned. Any person employed by the Contractor or a subcontractor who, in the opinion of the Construction Manager, does not perform his work in a proper and skillful manner, or who is disrespectful, intemperate, disorderly or otherwise objectionable, shall at a written request of the Construction Manager be forthwith discharged and shall not be employed again on any of the work without written consent of the Construction Manager.

3. Contractor and all employees, subcontractors, supporting firms and incidental labor shall meet the minimum safety requirements for the Owner's facilities.

I. Final Clean Up

1. Upon completion of the work and before acceptance and final payment is made, the Contractor shall clean, remove rubbish and temporary structures from the site, restore in an acceptable manner all property which has been

damaged during the prosecution of the work and leave the site of the work in a neat and presentable condition throughout.

J. Final Inspection

1. Whenever the work provided for in, and contemplated under, the contract has been satisfactorily completed (with the exception of any performance periods) and the final clean up performed, the Contractor shall notify in writing to the Construction Manager to make the "Final Inspection". Such inspection will be made as soon as possible, but not longer than (10) days after such notification. After such final inspection, if the work is found to be satisfactory (with the exception of any performance periods), the Contractor will be notified in writing of the acceptance of same. The "Final Acceptance" will not release the Contractor from responsibility for all items, materials, or equipment requiring performance test periods or final measurements unless otherwise shown in the contract.

1.3 SUMMARY OF WORK

A. General

1. The Contractor shall work closely and communicate regularly with the Owner in order to minimize conflicts and expedite the completion of the work. The Construction Manager serves as the Owner's representative.

2. All equipment and materials on-site during the work will be the responsibility of the Contractor. The Owner shall not be responsible for theft, vandalism or damage to any of the equipment or materials.

3. Contractor shall be required to prepare and adhere to a Quality Control Plan for field installation, as approved by the Construction Manager.

4. Contractor shall select and pay for an independent laboratory(ies) as required for testing materials and product.

5. Contractor shall adhere to all health and safety requirements as identified in the Site Health and Safety Plan and as required by Plant and Solutia corporate safety requirements.

6. Contractor shall prepare and submit for approval by the Construction Manager all Work Plans, Safety Plans, and Construction Plans as required by these Specifications.

B. Work Covered by Contract Documents

- Mobilization to site
- Site preparation to include clear and grub (if necessary), installation of temporary facilities, erosion control, access road development and stormwater management measures
- Construction of wells and piezometers
- Installation of well pumps, piping and appurtenances
- Installation of the vertical barrier wall
- Handling construction spoils, construction of a temporary spoil stockpile
- Chain link fencing and gates
- Management of stormwater and construction water
- Electrical power and controls
- Site restoration, including grading and reseeding as required
- Demobilization from the site

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION

SECTION 01500

MOBILIZATION AND TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mobilization

B. Temporary Facilities

1.2 WORK INCLUDED

A. The work to be performed under this section, includes the mobilization of all equipment, material, temporary facilities and personnel required to perform the work detailed in this contract.

B. Administrative expenses required to meet the contract conditions, such as insurance, permits, etc. are included in this task.

1.3 SUBMITTALS

A. Prior to beginning work, Contractor shall submit a plan for the Construction Manager's approval, showing the proposed locations of haul roads and access roads.

B. Contractor shall submit a plan to the Construction Manager, for approval, showing all proposed laydown areas, storage areas, construction support facilities (trailers) and equipment and vehicle parking areas.

PART 2 – PRODUCTS

Not used

PART 3 – EXECUTION

3.1 MOBILIZATION

A. Contractor shall commence mobilization within fourteen (14) days following receipt of Notice to Proceed, and shall complete mobilization within the time allocation shown on the Contractor's construction schedule.

B. Contractor shall provide traffic controls, including flaggers as necessary, for safe and efficient use of the access and haul roads. Contractor shall provide flaggers and

controls as necessary to prevent construction traffic from interfering with public and private traffic.

3.2 TEMPORARY FACILITIES

A. Contractor shall provide for onsite trash dumpster to centralize collection and removal of incidental construction debris, rubbish and other trash.

B. Contractor shall coordinate and maintain all utilities that he deems are necessary to conduct the work. Telephone service, electrical power and potable water are not available at the construction area.

C. Contractor shall provide all necessary sanitary facilities in accordance with applicable laws and requirements. This may include portable toilet units or temporary sanitary sewage holding tanks. Transport and disposal of sanitary sewage from the construction site will be included in the Contractor requirements.

D. All temporary buildings (trailers, sheds etc.) shall be properly secured in accordance state and local ordinance requirements.

E. Contractor will maintain the site in a clean, uncluttered and safe condition during all phases of the work.

F. Site security for all construction equipment, facilities and personnel shall be the responsibility of the Contractor.

G. Contractor shall provide for a centralized fueling station(s), approved by the Construction Manager, for all construction and auxiliary equipment. This location shall be no closer that 25 feet from inhabited buildings. Fuel storage tanks shall be properly grounded, with spill prevention and containment as required by state and local ordinance. Fueling of equipment outside of the designated fuel station areas is not permitted.

H. Contractor shall coordinate through the Construction Manager all deliveries, service providers and/or approved visiting personnel required to conduct the work. Access to the site will be denied to all persons not in compliance the Solutia Plant Access Procedures.

END OF SECTION

SECTION 01550

SITE PREPARATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Surveying Services
B. Utilities Relocation
C. Utilities Installation
D. Access Roads
E. Construction Staging and Work Areas

1.2 DEFINITIONS

A. Land Surveyor: Surveyor shall be a registered land surveyor in the State of Illinois and acceptable to the Construction Manager.

B. Record Documents: All information collected by Surveyor.

C. Utilities: Water, electrical power and telephone services.

1.3 SUBMITTALS

A. Contractor shall submit name, address, and telephone number of Surveyor to the Construction Manager before starting survey work.

B. On request of the Construction Manager, Contractor shall submit documentation verifying accuracy of survey work.

C. Contractor shall submit certificate signed by Surveyor certifying that elevations and locations of site constructed features are in conformance, or non-conformance, with the Contract Documents.

D. Contractor shall be responsible for coordinating the location, relocation and restoration of all site utilities, required by the work. All such activities require approval by the Construction Manager. Contractor shall secure the usage of onsite utilities and shall be billed directly by the service provider.

E. Contractor shall prepare and submit a Site Preparation Plan clearly showing all proposed locations for staging and storage areas, temporary access roads, temporary

structures, temporary utilities, vehicle parking and any modifications to the existing site conditions. Only contractor owned vehicles, required to conduct the work, will be allowed past the project vehicle parking area(s).

F. All disturbed surface areas shall be managed in such fashion as to prevent erosion and control water and sediment transport. Such measures may include silt fencing, straw bales, rock check dams, and/or erosion control mats.

G. All construction permits, building permits or work notifications required by state or local government agencies shall be obtained or conducted by the Contractor. All regulatory and environmental permits will be secured and maintained by the Owner.

H. The Owner will provide a fenced, locked-gate site. Contractor shall be responsible for security and protection of all elements of the work at the site.

I. Contractor shall coordinate and prepare the site in a manner that promotes efficient and safe delivery of materials with no disruption to existing businesses or site conditions.

1.4 PROJECT RECORD DOCUMENTS

A. Contractor shall maintain [redacted] site a complete, accurate log of control and survey work as it progresses.

B. Upon completion of the work or as requested by the Construction Manager, Contractor shall submit Record (as-built) Documents to the Construction Manager.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 INSPECTION

A. Contractor shall verify locations of site reference and survey control points prior to starting work. Contractor shall promptly notify the Construction Manager of any discrepancies discovered.

B. All modifications to the site, either temporary or permanent, require written approval by the Construction Manager.

3.2 SURVEY REFERENCE POINTS

A. Contractor shall protect survey control points prior to starting sitework and preserve permanent reference points during construction. Contractor shall not relocate site reference points without prior written approval by the Construction Manager.

B. Contractor shall promptly report to the Construction Manager the loss, damage, or destruction of any reference point or relocation required because of changes in grades or other reasons. Contractor shall replace dislocated survey control points based on original survey control at no cost to the Owner.

3.3 SITE REQUIREMENTS

A. Contractor shall maintain the site in a clean and safe condition for the duration of the work.

B. Unauthorized persons will not be allowed access to the site. Contractor shall provide the Construction Manager with a list of all personnel, suppliers, and vendors that will regularly enter and leave the site. Contractor shall notify the Construction Manager of visitors or any change in site personnel.

C. Contractor shall install and maintain all sanitary facilities required for the work. Fuel transport, delivery and storage shall be in conformance with all applicable state, federal and Solutia Inc. requirements.

D. Contactor shall provide and maintain dumpsters, roll off boxes or other trash and debris containers needed to conduct the work.

3.4 SURVEYS FOR CONTRACTOR QUALITY CONTROL

A. Contractor shall perform surveys to determine as-built elevations of all components of the project as required by the Specifications and the Contractor's Quality Control Plan and shall notify the Construction Manager prior to starting the work.

END OF SECTION

SECTION 01700

DEMOBILIZATION & PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work to be performed under this section includes the decontamination and removal of all Contractor's equipment, materials, temporary facilities and personnel from the project site and the restoration of all areas used for offices, parking, staging and storage.

B. Project Closeout will follow notification to the Construction Manager, by Contractor, that the work is substantially complete.

1.2 SUBMITTALS

A. Contractor shall submit the following to the Construction Manager prior to demobilization:

- Warrantees / Guarantees
- Certificates of Inspection
- Operating Manuals and Instructions (if applicable)
- Record (as-built) Drawings
- Inspection/Compliance Certificates and Permits issued by local agencies
- Final Waivers of Liens
- Documentation and/or Verification as may be requested by the Construction Manager
- Equipment Decontamination Records

B. Contractor shall submit a schedule at least three (3) weeks in advance of anticipated demobilization and project closeout. This schedule is to include the sequence and timing of all activities associated with moving equipment, facilities and materials. It is to include all preparation and coordination required to remove Contractors facilities from the Solutia property.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 DEMOBILIZATION

A. Contractor shall remove all temporary facilities, equipment, and materials used to conduct the work. The site shall be graded to required elevations, cleaned, and restored to the original conditions.

B. Contractor shall remove and dispose of any collected sediment from erosion control devices.

C. All temporary utilities installed by the Contractor shall be disconnected and removed.

D. Contractor shall replace or repair existing plant facilities that were temporarily relocated, closed, or otherwise impacted during the work.

E. Contractor shall restore all decontamination areas to original site conditions.

3.2 CLOSEOUT PROCEDURES

A. Contractor shall notify the Construction Manager that the Contract is substantially complete and is ready for inspection a minimum of five (5) working days prior to the desired date of the final inspection. Following completion of the site inspection, by the Construction Manager, notification will be given to the Contractor, in the form of a Punchlist, of items to be completed or corrected. Contractor shall remedy deficiencies and send a notice of final completion, as detailed in Subsection 3.3.

3.3 FINAL COMPLETION

When Contractor considers the work to be complete, written certification will be submitted to the Construction Manager that:

A. The Contract Documents have been reviewed.

B. The work has been inspected by the Construction Manager for compliance with the Contract Documents.

C. Deficiencies identified in the Punchlist have been inspected and corrected.

D. The work is complete and ready for final walk-through.

After a final walk-through by the Owner, Engineer, and Construction Manager, Contractor will be notified in writing of any incomplete or defective work.

Contractor shall remedy deficiencies and send a second notice of completion, and the work will be re-examined. This procedure shall continue until Owner, Engineer, and Construction Manager approvals are obtained.

3.4 FINAL PAYMENT

A. Contractor shall submit his invoice for final payment in accordance with the contract procedures.

END OF SECTION

SECTION 02100

EROSION AND STORMWATER CONTROL DURING CONSTRUCTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP).
2. Implementation of Best Management Practices (BMPs) for storm water run-on and run-off.
3. Control of wind blown dust.
4. Design, construction, operation and maintenance of a storm water collection system.

B. Contractor shall schedule and conduct its operations to minimize erosion of soils. The area of bare soil exposed at any one time by construction operations shall be kept to a minimum.

C. The Owner will provide a storm water treatment system.

1.2 SUBMITTALS

A. A site specific SWPPP.

B. A plan to control storm water run-on from off site.

C. A plan to control wind blown dust.

D. A design for a storm water collection system, including an operations and maintenance manual.

E. Location and specifications for any borrow materials.

PART 2 - PRODUCTS

2.1 SWPPP

A. A SWPPP shall be prepared that meets the requirements of the National Pollutant Discharge Elimination System (NPDES) and the State of Illinois.

B. The SWPPP must address all areas disturbed by the construction including, but not limited to the barrier wall, temporary stockpile, extraction wells and related well head equipment, and effluent pipeline.

2.2 RUN-ON CONTROL PLAN

A. The Plan shall be prepared to prevent run-on of storm water from off site during the peak discharge from a 25-year storm.

B. The Plan must include the area of the barrier wall, temporary stockpile, extraction wells and related well head equipment, and effluent pipeline.

C. The Plan must segregate the stormwater run-on from rain that comes in contact with spoils from the excavated areas, from areas that are not impacted by excavated materials.

D. Run-on stormwater may be diverted directly to the drainage facilities that drain into the Mississippi River.

2.3 WIND BLOWN DUST PLAN

A. The plan shall address how wind blown dust will be controlled.

B. The Plan must include the area of the barrier wall, temporary stockpile, extraction wells and related well head equipment, and effluent pipeline.

2.4 STORM WATER COLLECTION SYSTEM

A. The collection system must be capable of collecting the water volume resulting from a 24-hour 25-year storm and delivering the runoff to a treatment system provided by the Owner on site. Rainfall from areas that are not impacted by excavated materials are not included.

B. The Plan must include the area of the barrier wall, temporary stockpile, extraction wells and related well head equipment, and effluent pipeline.

C. The Owner will provide, operate and maintain the storm water treatment system.

2.5 EARTH FILL

A. The borrow material shall be a clean low plastic clay, CL classification per ASTM D2487. In addition, a plasticity index of 7 or greater is required.

PART 3 - EXECUTION

3.1 EXECUTION - GENERAL

A. Construct the systems described herein in accordance with the approved plan submittals.

B. Implement the systems described herein accordance with the approved operations and maintenance manuals.

C. Should conditions warrant revisions to the approved plans and manuals, obtain the Owner's approval for modifications before making changes.

D. Be prepared to respond to emergencies and have a plan to address unusual conditions.

3.2 EROSION AND STORM WATER CONTROL DEVICES REMOVAL

A. At the completion of the work, and once the permanent vegetation has been established, remove all erosion and storm water control measures from the site, and re-vegetate all areas disturbed during construction.

END OF SECTION

SECTION 02150

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, equipment and materials as required to clear and grub existing vegetation from the site.

B. Removal and disposal of vegetation generated by the clearing and grubbing activities.

1.2 MATERIAL OWNERSHIP

A. Cleared materials shall become Contractor's property and shall be removed from project site.

1.3 SUBMITTALS

A. Contractor shall submit a Clearing and Grubbing Plan that is consistent with the selected locations for the construction areas and temporary haul road(s).

1.4 PROJECT CONDITIONS

A. Authority for performing site clearing indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract. Do not proceed with work on adjoining property until directed by the Owner.

B. Notify utility locator service for area where Project is located before site clearing.

C. Do not commence site-clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain.

C. Protect existing site improvements to remain from damage during construction. Restore damaged improvements to their original condition, as acceptable to the Owner.

3.2 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.3 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.4 DISPOSAL

A. Remove unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.

B. Burning on site is not permitted.

END OF SECTION

SECTION 02190

TEMPORARY HAUL ROADS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, equipment and materials as specified herein to develop, utilize and maintain temporary haul roads.

B. Contractor shall be responsible for survey layout, site preparation, excavation, material transfer and maintenance of the haul road(s).

C. Contractor shall be responsible for constructing temporary haul roads that adequately serve all construction and spoils placement needs throughout the project duration. All road maintenance shall be the responsibility of the Contractor.

1.2 SUBMITTALS

A. Layout drawings of the proposed locations of temporary haul roads that conform to the requirements of the drawings.

B. Site access traffic control plan.

PART 2 - PRODUCTS

2.1 HAUL ROADS

A. Materials used for temporary haul roads is at Contractor's discretion.

B. All materials must be from sources approved by the Owner.

PART 3 - EXECUTION

3.1 EXECUTION - GENERAL

A. Construct and maintain the systems described herein in accordance with the approved plan submittals.

B. Should conditions warrant revisions to the approved plans and manuals, obtain the Owner's approval for modifications before making changes.

C. Be prepared to respond to emergencies and have a plan to address unusual conditions.

D. Temporary cut slopes shall not be steeper than 1 horizontal to 1 vertical. Finished slopes, left for final grading and long- term maintenance, shall not be steeper than 3:1 horizontal to vertical distance.

E. Contractor shall provide all Traffic and Safety controls as required. This includes, but is not limited to barricades, signs, lights and flagmen and necessary to control and direct traffic to the approve routes.

F. Effective Dust Control Measures must be employed at all times, in all areas of the work. Contractor shall include any and all dust suppression measures that are necessary for workers health and safety and for the health and safety of persons on or adjacent to the Owner's property. Dust Control Measures may include, but are not limited to: watering spray trucks, approved chemical dust suppressants, road grading, or surface treatments, such as gravel. The Owner will approve all proposed dust control methods and may request additional control measures if site conditions begin to effect visibility, traffic safety or workers breathing areas.

G. Authority for site access indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract. Do not proceed with work on adjoining property until directed by the Owner.

3.2 REMOVAL

A. At the completion of the work, remove all temporary haul roads, fill depressions to restore original grades and re-vegetate all areas disturbed during construction.

END OF SECTION

SECTION 2310

JET GROUTED GROUNDWATER BARRIER

PART 1 GENERAL

1.1 SUMMARY

A. This section includes requirements for constructing a groundwater control barrier. The barrier shall consist of elements (panels) comprised of soil mixed with bentonite/cement grout, constructed by the jet grouting method using a double or triple fluid system. Alternate injection techniques may be proposed by the Contractor, but will be subject to approval by the Owner. The work includes:

1. Designing the barrier wall to meet performance requirements of these specifications.
2. Mobilizing equipment for jet grouting.
3. Determining suitable grouting procedures and grout mixes.
4. Installing a test cell for pre-production installation and performing a pumping test.
5. Installing production jet grout elements as required by the Contractor's design and testing to produce a continuous, relatively impermeable barrier.
6. Construction of test cells during production installation of the barrier wall to verify that performance of barrier conforms with design requirements.
7. Performing additional work as required to assure that the barrier is performing as designed.
8. Control, clean up, and disposal of waste materials resulting from jet grouting.

B. Subsurface Conditions

1. Subsurface conditions were explored by electronic cone soundings, sonic borings, and conventional borings. Observation wells and piezometers were installed to evaluate groundwater conditions. Laboratory tests were performed on selected soil samples. Subsurface data are shown on the plans. Detailed data including exploratory logs, groundwater data, and laboratory test data are included in the Geotechnical Data volume – Attachment 4-1 of the Prefinal Design Report.
2. The general conditions along the barrier wall include fine-grained soils (clay, and silt, with sandy zones) extending from grade to a depth of about 40 feet below grade. Sand underlies the fine-grained soils and extends to

limestone bedrock about 120 to 140 feet beneath site grade. The sand grades coarser and denser with depth and includes gravel, cobbles, and boulders from about 20 feet above bedrock. In some areas a clay stratum up to 10 ft thick with sand and gravel exists above the cobble and boulder zone above bedrock.

C. All work shall be performed in accordance with all Owner, local, state, and federal safety regulations required for the project.

1.2 REFERENCES

A. Commercial Standards:

1. American Petroleum Institute (API):

a. API 13A, Specification for Drilling Fluid Materials.

b. API 13B, Standard Procedure for Testing Drilling Fluids.

2. American Society for Testing and Materials (ASTM):

a. C-39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

b. C-150, Specification for Portland Cement.

c. C-109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 in. or 50 mm Cube Specimens).

d. C-494, Specification for Chemical Admixtures for Concrete.

e. C-939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).

f. D-2850, Standard Test Method for Unconsolidated Undrained Compressive Strength of Cohesive Soils in Triaxial Compression.

g. D-4832, Standard Test Method for Preparation and Testing of Soil-Cement Slurry Test Cylinders.

h. D-5084, Standard Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using the Flexible Walled Permeameter.

B. U.S. Army Corps of Engineers

1. Handbook for Concrete and Cement, CRD-C400, Requirements for Water for Use in Mixing or Curing Concrete

1.3 DEFINITIONS

A. Jet Grouting: The process of creating stabilized elements in place utilizing a grout mix delivered at high pressure through a special drill bit that has high velocity horizontal jets. This process produces elements by pumping a grout slurry through horizontal jets located above the drill bit such that the slurry cuts and mixes in-situ with the surrounding soil materials as the drill bit is slowly withdrawn. Air and water may also be injected depending on the double or triple fluid systems installation technique.

B. Primary Elements: Jet grout panels constructed from the maximum elevation shown on the drawings down to the surface of the bedrock.

C. Secondary Elements: Jet grout panels constructed between and overlapping with the primary elements to tie into the adjacent primary elements and providing a continuous relatively impermeable barrier to seepage.

D. Bedrock: Naturally occurring bedded limestone or dolomite.

1.4 PROJECT REQUIREMENTS

A. Clean up any discharge of grout immediately.

B. All panels shall be oriented vertically.

C. Perform jet grouting so that the stabilized grout element produced meets the following requirement:

1. Minimum unconfined compressive strength at 28 days is 30 psi based on laboratory tests on the selected grout mix during mix design testing.
2. Maximum average hydraulic conductivity of in-place barrier based on production cell pumping tests is $1x10^{-5}$ cm/sec.

3. The barrier wall extends from the top elevation shown in the plans to the top of bedrock. The alignment of the barrier wall shall be similar to that shown on the plans. The minimum wall thickness shall be 4 inches.

D. Hole spacing, jet grout injection, and extraction rates shall be sufficient to produce grout elements meeting the depth, overlap, and material property requirements specified herein and in the Contractor's design.

E. Drill bit shall be capable of advancing through logs, boulders, cobbles, and into the limestone bedrock.

1.5 SUBMITTALS

A. Submit the following with sufficient detail to allow the Owner to judge whether or not the proposed equipment, material, procedures and qualifications will meet the Contract requirements.

B. At least two weeks prior to mobilization to the site, the Contractor shall provide a preliminary design. At a minimum, the drawings shall indicate the panel locations, panel thickness, panel numbers, injection hole diameter, injection hole spacing, injection grout rates and pressure, and withdrawal rates of the steel. Along with the design, provide calculations, laboratory test results substantiating mix design, and other relevant information supporting the barrier wall design. Calculations should verify that the wall meets the performance requirements within these specifications. Upon completion of the test cell, the Contractor shall submit signed and sealed drawings by a Professional Engineer currently registered in the State of Illinois of the final barrier wall design to the Owner for approval with the final installation criteria.

C. Qualifications:

1. Submit written documentation summarizing the qualifications of the firm and references for five similar projects. Provide qualifications detailing the experience of the jet grouting superintendent in the supervision of jet grouting work of the type required for this project.

2. Submit the name of the independent testing laboratory that will be performing laboratory testing of test specimens.

D. Work Plan and Grouting Methods:

1. Submit a detailed work plan describing the proposed grouting methods and equipment to be used including the following:

2. Jet grouting procedures for constructing the barrier.

3. Provisions to prevent discharge of slurry grout and provisions to contain any discharge should it occur.

4. Description of grout plant and equipment.

5. Arrangement of grout mixing, recording, and injection equipment, layout of grout elements, and other details.

6. Schedule and sequence for completing jet grouting test cell and production jet grouting work.

7. Layout and designation of jet grout elements.

8. Grout mix design, sources of mix materials, and admixtures. Grout mix design shall include target range for unit weight, Marsh Viscosity, and bleed that will produce desired grout strength and hydraulic conductivity. Provide design hydraulic conductivity and design compressive strengths at 7, 14, and 28 days for the grout mix. Perform strength and hydraulic conductivity tests on grout samples using both tap water and groundwater obtained from the site at locations approved by the Owner to verify compatibility of the mix design for the site conditions. Submit MSDS sheets for admixtures that may be used.

9. Proposed methods for measuring and documenting hole verticality.

10. Proposed methods for correcting the work if injection holes are found to deviate from vertical.

11. Quality control procedures including record keeping, field testing, sampling, and laboratory testing of completed elements.

E. Test Cell: At the beginning of the work, the contractor shall submit a design for constructing and testing a closed cell barrier as specified herein.

F. Jet Grouting Reports: Prepare and submit daily shift reports for the jet grouting test program and the production jet grouting. The forms shall be submitted to the Owner for approval prior to commencement of jet grouting work. As a minimum the reports shall include:

1. Jet grout element identification including element number, diameter, length, location, orientation, and plumbness.

2. Time and date of beginning and completion of each element.

3. Grout flow rates and total grout quantity used to construct each element.

4. Water and air pressures used to construct each element.

5. Rate of withdrawal of jet rods for each element.

6. As-built drawings indicating the locations, top and bottom elevations, and orientations of jet grout elements.

1.6 QUALITY ASSURANCE

A. Due to the specialized nature of the jet grouting work, the Contractor shall either be a specialty contractor or shall engage a specialty subcontractor who will furnish the materials and perform the work. The specialty subcontractor shall have satisfactorily completed at least five projects of similar scope and magnitude. The jet grouting superintendent shall be assigned full time to the project and shall be present at the work site at all times during jet grouting operations

PART 2 PRODUCTS

2.1 MATERIALS

A. Grout: Grout shall be a mixture of Portland cement, fly ash, pozzolans, water and bentonite or other non-toxic, biodegradable admixtures if required. The grout shall be mixed in a grout plant that combines dry cement and water in predetermined proportions. Grout mixes shall have a consistency that is fluid and pumpable. It shall be proportioned to provide the required strength and mixing consistency. The grout mix utilized shall have a maximum water/cement ratio of 1:1 by weight.

B. Cement: Portland cement, ASTM C 150, Type II.

C. Bentonite: Premium grade Wyoming sodium Montmorillonite, or equal, manufactured in accordance with API Standard 13A.

D. Water: Fresh and potable water meeting the requirements of Corps of Engineers CRD-C400 shall be used.

E. Admixtures: Admixtures may be used as necessary to improve pumpability, to control set time, and to prevent segregation and bleeding. Admixtures shall be non-toxic and conform to ASTM C 494.

2.2 EQUIPMENT

A. Drilling Equipment: All jet grouting equipment used for drilling boreholes; lowering and raising grout tubes; mixing grout; and injecting grout shall have proven performance for use in performing jet grouting work.

B. Mixers: Grout mixers, holding tanks, and associated equipment shall be of a type and capacity for producing uniform grout mixtures at all times, and in the quantities required for the timely prosecution of the work.

C. Jet Pumps: Pumps shall be high-pressure pumps capable of delivering the grout at the flow rates and pressures required.

D. Recording Equipment: Provide automatic recording equipment with a totalizing meter to determine the volume of grout injected. The meter shall be calibrated in liters and shall be accurate to the nearest liter.

E. Spare parts and/or equipment shall be available on site to maintain the jet grouting equipment in satisfactorily operating conditions at all times during execution of the grouting work.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Jet grouting shall utilize a double or triple fluid system to construct the panel elements. Alternate injection techniques may be proposed by the Contractor, but will be subject to approval by the Owner.

B. The general procedure for constructing each individual jet grouted element shall be as follows:

1. Checks of injection hole locations and verticality shall be performed.

2. The jet grout element shall be constructed from the top of the bedrock up to the elevation shown on the Drawings.

3. The grout and other fluids shall be pumped through the nozzles. The rods shall be withdrawn in prescribed increments and at prescribed rates creating the jet-grouted element.

4. Excess grout and soil from jet grouting operations shall be contained in mud tanks or by other approved methods to facilitate rapid cleanup at the end of each shift.

5. Equipment for mixing, holding, and pumping grout shall be in a secure location and shall be operated to prevent spillage of material.

6. At the completion of each jet grouting shift, thoroughly clean site and dispose of all debris, water, waste grout, and spilled material on site in the designated spoil pits or the spoil stockpile. No liquids are allowed in the stockpile.

3.2 CONSTRUCTION

A. Pre-Production Test Cell

1. At the beginning of the work and prior to production wall installation, the Contractor shall construct a closed cell barrier, full depth, using a portion of the production wall for one side at a location designated by the Owner. The closed cell shall contain an area of at least 500 square feet. Construction of the cell shall be by the same methods as those used for the final barrier wall and those methods shall be fully and accurately described in an as-built report. An as-built drawing shall also be submitted showing the cell and each primary and secondary element accurately in plan and elevation.

2. At the center of the test cell a dewatering well extending at least 30 ft into the sand aquifer shall be installed and developed before the cell is closed. One piezometer shall be installed as shown in the plans 10 ft outside of the wall of the cell at a location approved by the Owner. See drawings for additional details.

3. A pumping test shall then be performed for a duration of 3 days or until the groundwater level inside of the cell has been lowered to a level 30 ft below the pre-pumping level, whichever occurs first as noted in the test well. Flow from the well and water levels in the test well and piezometer outside the test cell shall be monitored during the test at the following approximate elapsed pumping times: 1, 2, 5, 10,

15, 20, 25, 30, 35, 40, 45, 50, and 55 minutes. 1, 2, 4, 8, and 24 hours, then daily thereafter. The flow shall be measured at the same elapsed pumping times using a new or factory-calibrated flow meter with totalizing and instantaneous flow indication with an accuracy within 1% of the actual flow. All water levels shall be measured with an automatic data reorder at intervals on 30 sec or less. All depth measurements shall be recorded to the nearest 0.01-ft. The well shall be pumped at a rate that ensures that the pump does not break suction within the first 24 hours of pumping. Water levels shall also be recorded 12 hours before pumping begins and then at the same time interval listed above for a duration of 3 days after the pump is shut off.

4. When the specified test drawdown level has been reached, as measured in the test well, the pumping shall be stopped and recovery readings shall be made in the test well and piezometer outside the test cell on the same schedule as the readings after the start of pumping except that the zero time shall be the time that pumping was stopped.

5. The drawdown data shall be plotted versus elapsed time for both pumping and recovery and submitted to the Owner, along with the records of the flow. The groundwater elevations (Ft, NGVD) at zero drawdown shall be indicated on the plots.

6. Mississippi River stage data at the Market Street gage shall be plotted (elevation in ft, NGVD vs. date/time) for the period beginning 7 days before the test through at least the final recovery reading. These data can be obtained at http://mvs-wc.mvs.usace.army.mil/gages.html#miss. Alternatively, river stage data from the American Bottoms gage may be plotted for the same period.

7. The data will be analyzed by the Owner to compute the flow into the cell for various time intervals assuming 0.15 for the specific yield of the sand formation within the cell. This assumption will be checked and modified, if appropriate, based on the storage coefficient. calculated from drawdown and recovery data. The test section will be considered acceptable if the analysis of the recovery data indicates that the maximum average hydraulic conductivity of the barrier is equal to or less than 1×10^{-5} cm/sec.

8. If the analysis shows that the hydraulic conductivity of the barrier exceeds the specified value, the contractor shall propose revisions to his installation procedures to achieve the required maximum permeability value and shall install and test another closed cell to

demonstrate the effectiveness of the proposed revised procedure, all at no additional cost to the Owner.

B. Production Test Cells: During production wall installation, two additional test cells shall be installed and tested as noted in section 3.2A at locations shown on the plans. Test data will be analyzed by the Owner as noted in 3.2A. If the analysis shows that the hydraulic conductivity of the barrier exceeds the specified value, the contractor shall propose revisions to his installation procedures to achieve the required maximum permeability value and shall install and test another closed cell to demonstrate the effectiveness of the proposed revised procedure, all at no additional cost to the Owner.

C. The jet grout elements shall be constructed from the top of bedrock up to the elevations shown on the Drawings. The thickness of the wall and overlap of elements shall be determined and demonstrated by the Contractor to meet the performance requirements in these specifications.

3.3 LOCATIONS OF ELEMENTS

A. The drill hole locations for the jet-grouted elements shall be surveyed and checked by the Contractor before the start of drilling. The hole layout shall be based on the minimum element dimensions shown on the Drawings provided by the Contractor prior to production panel installation. The location of each hole shall be noted and recorded on the daily shift report.

3.4 INCLINATIONS

A. Only vertical elements shall be installed.

B. The deviation of jet grouted elements from the theoretical axis is to be maintained at 1% (1H:100V horizontal to vertical) or less. Panel thickness and alignment shall be such that an overlap of the panels is maintained at the maximum allowable vertical offset.

3.5 ELEMENT DEPTH AND HEIGHT

A. Element depth shall be measured with respect to ground surface by observing the length of the rods inserted. Markings shall be located on the drill mast in one-foot increments to assist the drill operator in determining the exact depth. Drill holes shall extend a sufficient distance into bedrock to assure that the jet grout barrier will extend up from the top of bedrock.

B. Element depth shall also be measured by observing the length of the rods withdrawn while grouting.

C. The orientation, depth to the bottom, and depth to the top of each element shall be noted and recorded on the daily shift report.

3.6 GROUT MIXING

A. A mixing plant shall be used for the preparation of the grout. The mixing plant shall consist of high-speed grout mixer, grout agitator, grout pumps and control unit, as required. The plant shall be capable of supplying a uniform grout mixture in the quantities required for timely prosecution of the work.

B. Mix cement, water, and any admixtures in the proportions indicated in the approved submittals. If bentonite is used, add bentonite to water and mix thoroughly to fully hydrate prior to adding cement. Time of mixing shall be as required to fully hydrate the cement but not less than 5 minutes. Any grout not injected within 90 minutes of cement or pozzalan addition shall be wasted.

3.7 GROUT INJECTION RATE AND PRESSURE

A. The appropriate grout injection rate and pressure shall be determined during the test program and this injection rate and pressure shall be maintained during construction of the production elements.

B. The grout injection rate shall be monitored by using a flow meter and may be checked by counting the strokes of the piston pump in a fixed period of time.

C. Use automatic recording equipment to measure the volume of grout injected into each element.

D. The grout injection pressure shall be monitored with calibrated pressure gauges mounted on the injection lines. Prior to the start of each element, the pressure shall be checked to verify that there is no blockage in the jet grout rods.

E. The grout injection rate, volumes injected, and injection pressure for each element shall be noted and recorded on the daily shift reports. Depths of obstructions and/or changes in injection rates shall also be recorded.

3.8 WITHDRAWAL RATE

A. The withdrawal rate of the jet grout monitor shall be determined during the test program and maintained during construction of the production elements.

B. The rate of withdrawal shall be controlled by an electronic sensor mounted on the rig.

C. The withdrawal rate of the jet rods shall be noted and recorded for each element on the daily shift reports.

3.9 PREVENTION OF GROUND HEAVE

A. In order to prevent ground heave during jet grouting, the drilling shall be carried out with an oversize drill bit with respect to the drilling/grouting rods. Appropriate drilling procedures shall be determined during the test program and utilized during construction of the production elements.

B. The annulus between the rods and the borehole shall be kept open at all times during grouting.

3.10 CONTAINMENT OF GROUT DISCHARGE

A. All grout, water, and other drilling/grouting waste material shall be contained within the work areas with berms or other measures.

B. Clean up any grout discharges, spoils, or other unacceptable environmental impacts immediately and place in the spoil pits or temporary stockpile. No fluids are allowed in the stockpile.

3.11 QUALITY CONTROL

A. Grout Mix: Grout mix uniformity shall be verified by unit weight (density) measurements of the mixed grout by mud balance, Marsh Viscosity, and bleed from samples taken from grout return line. Testing frequency shall be at least one group of tests for every three hours that grout is mixed and pumped.

B. Verticality: verticality shall be reified at each injection hole prior to inclusion of grout.

3.12 CLEANUP

A. Cleanup of the work area after jet grouting operations shall be completed as soon as possible. Remove all grout spillage and residue from the work area.

END OF SECTION

SECTION 02320

CONSTRUCTION SPOILS HANDLING

PART 1 GENERAL

1.1 SUMMARY

A. This section describes general earthwork requirements for construction of the temporary stockpile, soil cover and related activities. This section also includes spoils handling and placement, and daily cover.

B. This Section does not include the interim cover material. This is covered in Section 02325 – Geomembrane.

1.2 REFERENCES

A. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

B. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).

C. ASTM D2216 - Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.

D. ASTM D2487 - Classification of Soils for Engineering Purposes.

E. ASTM D2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

F. ASTM D2937 - Test Method for Density of Soil in Place by the Drive Cylinder Method.

G. ASTM D3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

H. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

I. ASTM D1140 - Test Method for Amount of Material in Soils Finer than the No. 200 Sieve.

1.3 DEFINITIONS

A. Well-Graded: A mixture of particle sizes that has no specific concentration, or lack thereof, of one or more sizes. A material type that, when compacted, produces a strong and relatively incompressible soil mass.

B. Coverage: One coverage is defined as the requirement of successive trips of a piece of compaction equipment, which by means of sufficient overlap, will ensure that all areas of the layer being compacted have been subjected to one pass of the compaction equipment.

C. Optimum Moisture Content: The maximum moisture content that will result when plotted against the dry unit weight of a soil when subjected to the ASTM D698 compaction test.

D. Percent Compaction: The percent compaction in-place shall be calculated as the ratio (in percent) of the in-place dry density to the estimated maximum dry density, in accordance with ASTM D698, of the representative fill material at the location of the in-place density test.

E. Proof Rolling: Rolling a surface with a minimum of 3 passes with approved compaction equipment for the purpose of detecting soft or loose areas.

F. On-Site Soils: On-site soils are defined as the insitu material located within the footprint of the liner system and the perimeter berms.

G. Borrow Soils: borrow soils are defined as material transferred to the footprint area from a remote location.

H. Unsuitable Materials: All soil materials that contain waste, debris, roots, organic matter, frozen matter, stone or rock with any dimension greater than 1-inch, or any other material that are determined by the Owner to be unsuitable for stable, compacted backfill purposes. Approved on-site borrow soils are suitable fill.

I. Borrow Areas: Borrow areas are those locations approved by the Owner for procurement, excavation and use of materials for construction of the temporary spoil stockpile. Borrow areas do not include "on-site soils" as defined herein.

J. Fine-Grained Soils: Fined grained soils are defined as those materials which pass a 200 sieve in accordance with the guidelines established in ASTM C136.

1.4 TESTING

A. The Contractor shall retain the services of a QC testing laboratory that has been approved by the Owner to perform tests as specified herein. At a minimum, the Contractor shall be responsible for providing QC for the following:

1. Compliance testing for materials provided from onsite and offsite sources.

2. QC testing and inspection during construction.

B. The Contractor shall inspect and verify all earthwork operations are in conformance with this specification and the contract documents. Moisture/density relationships for the various fill materials will be established as part of the QC program. Field density tests, sample selection, and construction observations will be performed in sufficient numbers and in such locations to verify that the specified density is being achieved.

C. The Contractor shall inform the Owner prior to conducting all field tests to allow oversight. No additional fill placement shall be permitted in areas that have not met the specified fill placement criteria.

D. No testing of spoils placement is required.

1.5 SUBMITTALS

A. Construction Plan

The Contractor shall submit a construction plan identifying the procedures and methods to be used. The plan shall be approved by the Owner prior to any earthwork activities. The construction plan shall, at a minimum, include the following:

1. Proposed material source(s) and proposed method(s) of sampling.

2. Proposed soil processing, placement, compaction, and moisture control equipment, including equipment catalog with weight, dimensions, and operating data for all equipment.

3. Proposed locations of soil processing and moisture control.

4. Proposed methods for soil processing and moisture control.

5. Proposed work schedule.

6. Proposed method of protecting Work, to include temporary drainage measures.

7. Proposed QC Personnel. All QC personnel shall demonstrate specific experience of at least 2 years in the areas in which they will be performing QC inspections.

8. Proposed professional engineer registered in Illinois with no less than 5 years experience in the performance and evaluation of geotechnical laboratory tests on constructed materials.

9. Proposed land surveyor licensed in the State of Illinois.

10. Proposed excavation, stockpiling, regrading and staging plan describing handling and transport of borrow materials.

B. Contractor shall submit manufacturer's data and samples of daily cover material.

C. Contractor shall submit results of prequalification test data on each material source to the Owner for approval prior to procurement, excavation, transport, stockpiling or use.

D. Contractor shall submit results of all field and laboratory prequalification and quality control data to the Owner within 1 work day of receipt.

E. Contractor shall submit the results of all observations and documentation generated by its quality control personnel the next work day.

E. Contractor shall submit results of all field surveys and documentation to the Owner. Copies of surveyor field data, books and notes shall be submitted within 1 work day of generation. Copies of survey information signed and sealed by an Illinois licensed surveyor shall be submitted within 1 work day of receipt.

1.6 PROTECTION

A. All streets, roads, grading, structures, utilities and other improvements not specifically designated to be cleared, removed, stripped or altered as a part of the work shall be protected from damage throughout the construction period. Any damage caused by the Contractor, his employees, agents, or any lower tiered subcontractors shall be immediately repaired to the original condition and to the satisfaction of the Owner at no additional cost to the Owner.

B. Traffic Control

1. Keep all roads, sidewalks, and parking areas that are not part of this project usable at all times.

2. The Contractor shall provide all necessary barricades, lights, signs, signals, etc., for the protection of the workers and the public, as established by the Occupational Safety and Health Administration (OSHA) Construction Safety and Health Regulation 29 CFR, Part 1926, Subpart G, Signs, Signals and Barricades, and in Subpart P- Excavations, trenching and shoring, and IDOT Standard Specifications for Highway Construction, latest edition.

C. Existing Utilities

1. The Contractor is solely responsible for identification of all utilities, both known and unknown.

2. Any existing utility that is damaged by the Contractor shall be immediately repaired to its previous undamaged condition at no additional cost to the Owner.

2. Notify the Owner immediately of any encountered utilities not shown on the Drawings.

3 Obtain approval from the Owner before backfilling in areas of known utilities.

D. Monitoring Wells

1. Contractor shall be solely responsible for identification of all groundwater monitoring wells.

2. Known groundwater monitoring wells are indicated on the Plans. Contractor shall not operate machinery, excavate, mound soil or otherwise disturb the ground surface around a monitoring well without the concurrence of the Owner.

3. Contractor shall be solely responsible for the protection and usability of the monitoring wells during the work.

4. If the Contractor damages a monitoring well during the performance of the work, the Contractor shall immediately notify the Owner of the damage.

5. If the Owner subsequently determines that the damaged monitoring well no longer performs satisfactorily, the Owner will have the well repaired, replaced or

abandoned by a qualified well installer and will recover any resulting cost from the Contractor.

PART 2 PRODUCTS

2.1 ON-SITE SOILS

A. Soils in the vicinity of the stockpile contain a limited amount of organic and inorganic constituents. Excavation and removal of onsite or surrounding soils is not permitted unless approved by the Owner.

2.2 BORROW SOURCES

A. Borrow sources do not exist within the property boundary of the proposed site for use on this project.

B. Offsite Sources

1. Contractor shall be responsible for locating sources of borrow material from offsite sources sufficient to construct the perimeter berms and cover for the temporary stockpile. The Contractor shall obtain representative samples of the proposed source for laboratory testing. Results of the testing along with representative samples of the proposed material shall be submitted to the Owner for approval prior to procurement, excavation, transport stockpiling or use.

2. Use of other borrow sources shall only be with the written approval of the Owner. Unless otherwise directed by the Owner all material shall conform to the requirements of the Specifications.

3. Contractor shall be responsible for conducting TCL/TAL testing of borrow soils in accordance with the latest IEPA requirements. Off-site borrow shall be tested at a rate of one sample per 5,000 cubic yards of material excavated. Contractor shall compare the test results with TACO Tier I criteria for commercial / industrial area soils. The test results and the comparison to TACO criteria shall be submitted to the Owner for review and approval. Any borrow soils containing TCL/TAL contaminants above the Tier I levels shall not be acceptable for stockpile construction.

2.3 CLEAN SOIL

A. Compacted Fill

1. Compacted Fill shall consist of random cohesive materials obtained from approved off-site borrow areas. Compacted Fill shall be free of lenses, pockets or layers of material differing in texture, gradation, and moisture from surrounding material. Compacted Fill shall consist of soil types meeting the following classifications of ASTM D2487:

   For 4" leveling layer or 12" stockpile cover soil:

Silty to Clayey Sands	SC, SP-SM, SC-SM
Clayey Silts to Silty Clays	CL
Silty Sandy Clays	CL
Combinations of the above	

   For berms:

Clayey Silts to Silty Clays	CL
Silty Sandy Clays	CL
Gravely clay	CL
Combinations of the above	

   The plasticity index shall be 7 or greater.

2. The maximum clod size for Compacted Fill shall be 2 inches in any dimension. Oversize material shall be removed or reworked to conform to these requirements. Non-uniform material shall be removed or reworked to conform to these requirements.

3. Fill material placed in the cover that will be in contact with the Geomembrane liner shall not have any particle size greater than 1". Requirements for fill preparation for the cover are addressed in paragraph 3.5 below and Section 02325 Geomembrane.

2.4 EQUIPMENT

A. All equipment and tools used in the performance of this work are subject to the approval of the Owner before work is started.

B. Contractor shall provide compaction equipment appropriate for the material types to obtain the densities specified.

C. Contractor shall provide hand-operated compaction equipment in areas closer than 2 ft from pipes or other structures to obtain the densities specified.

D. Contractor shall operate and maintain compaction equipment in accordance with the manufacturer's instructions and recommendations. If inadequate densities are obtained, provide larger and/or different type equipment at no added cost to the Owner.

E. Contractor shall provide equipment for applying water of a type and quality adequate for the Work, free of leaks and equipped with a distributor bar or other approved device to ensure uniform application.

F Contractor shall provide equipment for mixing and drying out material, such as blades, discs, or other approved equipment.

G. Contractors mixing and blending equipment shall fully penetrate loose lifts during mixing to achieve a uniform material.

H. Contractor shall provide steel drum rollers to prepare the surface of placed or compacted fill prior to placement of geosynthetic materials.

2.5 SPOILS

A. Spoils are the excess grout and other materials generated by the construction of the barrier wall, materials excavated for the installation of the effluent pipeline and other materials generated that cannot be used as backfill in other areas of the project.

B. Spoils do not include materials that contain waste, debris, roots, organic matter, or any other material that are determined by the Owner to be unsuitable.

2.6 DAILY COVER

A. The cover shall consist of 6 mil thick polyethylene or equal.

2.7 MARKER & FILTER FABRIC

A. Marker and filter fabric shall consist of 8 oz non-woven polypropylene needle punched geotextile.

2.8 RIP-RAP

A. Rip-rap shall consist of crushed rock in gradation of 6" to 8" size.

PART 3 EXECUTION

3.1 SURFACE WATER CONTROL

A. Contractor shall furnish, install, maintain and operate all equipment and materials needed to prevent, control and remove surface water within or adjacent to the area of work in accordance these Specifications.

B. Contractor shall furnish, install, maintain, and operate all equipment and materials to prevent ground water from flowing into excavations or onto work areas or areas designated to receive fill as necessary or as required by the Owner.

3.2 CLEARING AND GRUBBING – TEMPORARY STOCKPILE

A. Contractor shall remove vegetation including snags, brush, and rubbish occurring in the areas of the work.

B. Roots, brush, rotten wood, and other refuse collected by the Contractor from the clearing and grubbing operations shall be disposed by the Contractor at a location designated by the Owner.

3.3 CONSTRUCTION OF TEMPORARY STOCKPILE

A. General

1. Construct as shown on the plans.

2. Contractor shall construct the soil components of the stockpile and cover system using suitable borrow materials as specified.

3. Contractor shall construct each layer in a continuous and nearly horizontal layer for the full width at the elevation of the layer unless otherwise required by the Specifications or Plans.

4. Contractor shall place and compact all materials to prevent constructed discontinuities in the fill or segregated areas of the work.

5. Special care shall be taken by the Contractor to ensure bonding of new fill to constructed segments previously placed by benching in 2 ft horizontally into the existing fill for each 1-ft vertical placement. This requirement shall not apply to construction interfaces between side slopes and bottom materials.

6. Contractor shall moisten or aerate, scarify, and work with harrows, discs, or other suitable equipment in such a manner to reduce the clod size of material being placed to the requirements given. Blend all material to be free from lenses, pockets, or layers of material differing in texture, gradation, and moisture from surrounding materials and to depths that provide a bonding surface with the new material.

7. Soils with excess moisture shall be sufficiently dried to meet the specified compaction requirements.

8. Contractor may at his option add moisture to the borrow area.

9. Soil shall be compacted to a minimum of 90% of the maximum dry density as determined by ASTM D698, at a moisture content +/- 4% of optimum.

3.4 PLACEMENT OF SPOIL

A. General

1. No spoils that exhibit free moisture may be placed in its final position within the stockpile. Contractor may construct drying pits to evaporate or remove free water or other liquids prior to placing in the spoil in its final position.

2. Contractor shall place the spoil components within the stockpile using suitable equipment.

3. Contractor shall construct spoil components to the lines and grades shown on the Plans.

4. The spoil material shall be placed by the Contractor in maximum 12-inch thick (loose) lifts.

5. Contractor shall construct each layer of each zone in a continuous and nearly horizontal layer for the full width at the elevation of the layer unless otherwise required by the Specifications or Plans.

B. Compaction of Spoils

1. Prior to placing any new fill, the Contractor shall compact the previous layer upon which new spoil is to be placed. Compaction may be accomplished by running tracked equipment over the spoils until all visible voids are filled.

2. No water may be added to the spoils.

C. Daily Cover

1. At the end of each work day or at any time when the spoils may be left exposed for more than four hours, a cover of polyethylene shall be placed over the spoils to prevent wind or water erosion.

2. The daily cover may be abandoned in place upon resumption of spoil placement.

3.5 PREPARATION FOR INTERIM COVER GEOMEMBRANE PLACEMENT

A. Contractor shall grade all surfaces and areas to receive geosynthetic materials to achieve a smooth uniform surface, free from sharp edges, ruts or discontinuities.

B. Contractor shall condition the upper six inches of surface soil in all areas to receive geosynthetic materials with water as necessary to achieve a moisture content of approximately optimum as determined by ASTM D 698.

C. Contractor shall smooth drum roll all areas after moisture conditioning is complete. Soft or spongy areas of fill shall be removed at the direction of the Owner and replaced in accordance with the requirements of these specifications at no cost to The Owner.

D. Contractor shall certify to the Owner that all areas to receive geosynthetic materials area free from sharp edges, ruts or discontinuities.

E. Prior to releasing an area for geosynthetic placement, the Owner will inspect the area for conformance to these specifications. Contractor shall rework areas that that are deemed not acceptable by the Owner until acceptance is achieved.

3.6 MAINTENANCE

A. During the course of the work and during work interruption(s) Contractor shall be solely responsible for protection of compacted materials.

B. Contractor shall remove and replace or recondition damaged materials.

3.7 CONSTRUCTION TOLERANCE

A. Survey Precision

1. Contractor shall provide survey control for all earthwork placement, compaction, excavation and grading and as otherwise directed by the Owner.

2. Contractor shall perform surveys of the work to ± 0.1 ft vertically and ± 0.25 ft horizontally.

B. Surface Tolerance

1. Contractor shall construct finished subgrades, compacted surfaces and drainage material layers from -0.0 to +0.1 ft.

2. Contractor shall provide constructed work with variations in final grade ≤ 0.25 ft above minimum thickness vertically between any two points located within 100 ft in any direction with the exception of designated changes in grade.

3.8 SURVEY CONTROL DATA

A. Survey data shall be collected as specified below or as otherwise directed by The Owner.

1. Contractor shall collect survey data at the center of the stockpile beneath the lining system footprint and at the top of the finished stockpile.

2. Contractor shall collect survey data for the outside toe and top of slope of the finished perimeter berm.

3.9 QUALITY CONTROL

A. General

1. Tests and analysis of fill materials will be performed by the Contractor's approved QC personnel and Testing Laboratory.

2. Field inspection and testing will be performed by the Contractor.

3. The test frequency option which results in the greatest number of tests shall be used by the Contractor.

4. If the Contractor's in-place density test fails due to moisture content or density, re-test in the same area. If the second test fails, remove or rework area defined by surrounding tests meeting the Specifications.

5. All perforations due to density test probe, sample tubes, or test pit excavation shall be backfilled by the Contractor. All perforations shall be backfilled with material similar to that of the layer. Backfill shall be recompacted using methods and procedures specified.

6. One point compaction tests shall be performed by the Contractor whenever a change in material is observed or suspected, as directed by the Owner, and no less than once per day per material type.

7. Contractor may use one point compaction data for calculation of maximum Standard Proctor dry density until a laboratory generated moisture density curve is developed. Contractor may continue placement at his own risk.

8. If placed and compacted material does not meet the requirements of these Specifications based on the laboratory generated moisture density curve, the Contractor shall remove or rework all such material to meet these requirements at no additional cost to the Owner.

9. Contractor shall submit all preconstruction and construction quality control data with a cover letter signed and sealed by a Illinois registered professional engineer indicating the requirements of the Specifications have been achieved and the data as presented is representative of the material tested.

B. Preconstruction Material Quality Evaluation

1. The Contractor shall perform material quality evaluations on all proposed borrow sources for approval by the Owner prior to procurement, excavating, transport, stockpiling or use.

2. Compacted Fill testing requirements:

• ASTM D 2216	1 per source
• ASTM D 4318	1 per source
• ASTM D 1140	1 per source
• ASTM D 698	1 per source

C. Construction Material Quality Evaluation

1. Laboratory testing shall be performed by the Contractor's QC personnel on each source throughout the performance of construction.

2. Compacted Fill testing requirements for each borrow source used:

• ASTM D 2216	1 per 15,000 yds^3
• ASTM D 4318	1 per 15,000 yds^3
• ASTM D 1140	1 per 15,000 yds^3
• ASTM D 698	1 per 15,000 yds^3

D. Post Constructed Quality Control

1. Compacted Fill

In-place density ASTM D2922 ASTM D3017	1 per 2,000 yd^3 placed and compacted
In-place density verification ASTM D2937 ASTM D2216	1 per 15,000 yd^3 placed and compacted

END OF SECTION

SECTION 02325

GEOMEMBRANE

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish all material, labor and equipment for the installation of the geomembrane interim cover as specified herein and as shown on the Drawings, and shall install the geomembrane and other geosynthetic components of the interim cover system in close coordination with the Owner.

1.2 REFERENCES

A.	ASTM D 638 -	Test Method for Tensile Properties of Plastics.
B.	ASTM D 792 -	Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement.
C.	ASTM D 1004 -	Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
D.	ASTM D 1204 -	Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature.
E.	ASTM D 1238, Condition E -	Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer.
F.	ASTM D 1505 -	Test Method for Density of Plastics by the Density - Gradient Technique.
G.	ASTM D 1603 -	Test Method for Carbon Black in Olefin Plastics.
H.	ASTM D 4437 -	Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
I.	ASTM D 4833 -	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
J.	ASTM D 5199 -	Test Method for Measuring Thickness of Plastics.

K. ASTM D 5397

O. ASTM D 5596

P. ASTM D 3895

Q. ASTM D 5885

R. ASTM D 5721

S. ASTM D 746

T. ASTM D 5321

U. NSF 54, Mod.

V. GM 11

W. GM12

1.3 DEFINITIONS

A. Batch: A quantity of resin. usually the capacity of one railcar, used in the fabrication of High Density Polyethylene (HDPE) geomembrane rolls. The finished rolls are identified by a roll number corresponding to the resin batch used.

B. Bridging: Condition existing when the geomembrane is not in contact with the underlying material.

C. Contractor: The party responsible for manufacturing, shipping, field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane. This responsibility includes the work performed by the Manufacturer and the Installer.

D. Manufacturer: The party responsible for production of any of the various geosynthetic components.

E. Installer: The part responsible for installation of the geosynthetics.

F. Extrudate: HDPE material produced in the form of a rod used by the Contractor to extrusion weld panels of geomembrane together.

G. Geomembrane: Very-low permeability synthetic flexible membrane liner (FML) barrier used to minimize fluid migration.

H. Geomembrane Subsurface: Material surface upon which geomembrane will be placed.

I. Quality Assurance Laboratory (Third Party Laboratory): Party, independent from the Owner, Manufacturer, and Contractor, responsible for conducting laboratory tests on samples of geomembrane obtained at the site.

J. Panel: The unit area of geomembrane, a roll or a portion of a roll, that will be seamed in the field.

K. Panel Layout Drawings: Drawings submitted by the Contractor indicating panel numbers, field seams, and details.

L. Subgrade: Soil material directly below the geomembrane.

1.4 TESTING

A. Contractor shall retain the services of a geosynthetics testing laboratory. At a minimum, Contractor shall be responsible for providing the following quality control information:

1. Compliance testing for installed geosynthetics.

2. Quality control testing during construction.

B. The Contractor shall inspect and ensure all work is in conformance with these Specifications.

C. Contractor shall inform the Owner prior to conducting all quality control testing to allow oversight.

D. Contractor shall submit all quality control data (both pre-construction and construction) with a cover letter signed and sealed by a Illinois registered professional Owner indicating the requirements of the Specifications were achieved and the data is representative of the material tested.

1.5 SUBMITTALS

A. General

1. Contractor shall submit qualification information on the Manufacturer, Installer and Geosynthetic Testing Laboratory.

2. Contractor shall submit the results of conformance testing of the geosynthetic materials selected for interface friction testing for approval within thirty (30) days of contract award.

3. Contractor shall submit prequalification data on each geosynthetic material to the Owner for approval prior to procurement transport, stockpiling or use.

4. Contractor shall submit results of all quality control data and information to the Owner within 1 work day of receipt.

5. Contractor shall submit all observations and documentation generated by its quality control personnel daily for the current day's activities.

6. Contractor shall submit results of all field surveys and documentation within 1 day of generation including copies of data, field books and notes. Copies of survey information signed and sealed by a Illinois licensed surveyor shall be submitted written 1 day of receipt.

B. Manufacturer

The Manufacturer shall submit the following prior to installing geosynthetics:

1. A list of material properties including certified test results attached to samples of the proposed geosynthetic material.

2. The origin and identification of the resin used to manufacture the products.

3. Submit all quality control documentation required by these Specifications prior to installation.

C. Installer

The Installer shall submit the following prior to installation:

1. Resume of Superintendent to be assigned to the project including dates/duration of employment.

2. Resume of Master Seamer including dates/duration of employment.

3. A list of personnel to be performing field seaming operations with pertinent experience information.

4. All geosynthetic quality control certificates .

5. Certification that the extrudate is comprised of the same resin as the geomembrane to be used.

6. Description of seaming techniques and apparatus to be used.

7. Properties of extrudate to be used.

D. Raw Materials

1. Copy of quality control certificates issued by resin suppliers.
2. Production date(s) of resin.

3. Reports on tests conducted to confirm quality of resin used to manufacture geomembrane rolls assigned to considered facility. Report shall indicate compliance with requirements in Part 2 – Products of this Specification.
4. Statement that no reclaimed polymer is added to resin during manufacture of actual geomembrane to be used in this project.

E. Geomembrane Roll Production: Copy of quality control certificates indicating compliance with requirements of Part 2 of this Specification.

F. Installation Panel Layout Drawing identifying placement patterns and seams, both fabricated (if applicable) and field seams, as well as any variance or additional details which deviate from the Drawings. Layout shall be drawn to scale and shall be adequate for use as the construction plan, and shall include information such as dimensions, panel numbering, and installation details. The Owner will review all Panel Layout Drawings prior to installation.

G. Installation Schedule.

H. During installation the Contractor shall submit:

1. Quality control documentation recorded during installation.

3. Daily subgrade acceptance for each area to be covered signed by the Installer.

I. Warranties:

1. Submit a material warranty signed by the geomembrane manufacturer. The material warranty shall be against manufacturing defects and workmanship, and against deterioration due to ozone, ultraviolet, and other exposure to the elements, for a period of one year from final acceptance. The material warranty shall be limited to replacement of material, and shall not cover installation of replacement geomembrane.

2. Submit workmanship warranty signed by the geomembrane installer. The installer shall warrant the geomembrane system to be installed to be free of defects in workmanship for a period of 2 years following the date of final acceptance of the work under this Contract. The workmanship warranty shall cover installation of replacement geomembrane.

J. Submittals Required for Project Closeout

1. Record Drawing: Submit reproducible drawings of record showing changes from the approved installation drawings. The record drawings shall include the identification and location of each repair, cap strip, penetration, boot, and sample taken from the installed geomembrane.

2. Quality Control Record: Submit copies of all material and seam test results. Each test shall be identified by date of sample, date of test, sample location, name of individual who performed the test, and standard test method used.

3. Weld Test Summary Report: Submit copies of report showing normal distribution of all test results, and individual test results identifying the high, low, and average of the five coupon samples in each test.

1.6 QUALIFICATIONS

A. Manufacturer

1. Manufacturer shall have at least 5 years continuous experience in the manufacturing of HDPE geomembrane rolls and experience totaling 2 million sq ft of manufactured HDPE for at least 10 completed facilities.

2. The Manufacturer shall have an internal quality control program that meets standard industry requirements.

B. Installer

1. The Installer shall have at least 5 years continuous experience in the installation of HDPE geomembrane and experience totaling 2 million sq ft of installed HDPE geomembrane for at least 10 completed facilities.

2. The Installer's Superintendent shall have previously managed at least two installation projects which entail at least 100,000 ft^2 of HDPE geomembrane.

3. Personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one "Master Seamer" shall have experience seaming a minimum of 1 million sq. ft. of HDPE geomembrane using same type of seaming apparatus in use on-site. The "Master Seamer" shall have experience seaming textured and non-textured material and shall provide direct supervision, as required, over less experienced seamers.

C. Quality Assurance Plan

Manufacturer/Contractor shall agree to participate in and conform to all items and requirements of these Specifications and the Construction Quality Assurance Plan for the Installation of Geosynthetic Components.

1.7 DELIVERY, STORAGE AND HANDLING

A. Deliver and store geomembrane in strict accordance with the manufacturer's recommendations.

B. Geomembrane delivered to the site shall be inspected for damage, unloaded, and stored with a minimum of handling. The storage area shall be such that materials are protected from mud, soil, dirt, and debris. Geomembrane may be stored directly on prepared level surface, but no more than three rolls in height.

C. The Contractor shall be responsible for coordination and payment of shipping, unloading, storing, handling and installing geomembrane.

D. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes slings, spreader bars or an equipment bucket which has been properly protected.

E. Damaged or unacceptable materials shall be replaced at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. GSE Lining Technology, Inc. (Gundle/SLT), Houston, Texas.

B. Approved Equal

2.2 GEOMEMBRANE

A. The geomembrane shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, as satisfactorily demonstrated by prior use.

B. The geomembrane shall be high-density polyethylene (HDPE) with a UV-stabilized surface and contain no plasticizers, fillers, chemical additives, reclaimed polymers, or extenders.

C. Approximately 2 percent carbon black shall be added to the resin for ultraviolet resistance.

D. The only other compound elements shall be anti-oxidants and heat stabilizers, of which up to 1.5 percent total, as required for manufacturing, may be added.

E. The geomembrane shall be supplied as a single-ply continuous sheet with no factory seams. Rolls shall have a minimum width of 22 feet.

F. The roll length shall be maximized to provide the largest manageable sheet for the fewest field seams.

G. All rolls shall be identified with a unique roll number printed on a label affixed to the inside and outside of the roll.

H. Each roll shall have a continuous identification printed on the membrane showing manufacturer, thickness, material, and date of manufacture.

I. HDPE geomembrane shall meet the following requirements:

HDPE GEOMEMBRANE - SMOOTH

Properties	Test Method	Requirements	Testing Frequency (minimum)
Liner Thickness, mils (nominal)	ASTM D5199	60	Per Roll
Density (g/cc)	ASTM D1505-A	0.94	200,00 lbs

Properties	Test Method	Requirements	Testing Frequency (minimum)
Tensile Properties (min. aveg.) 1. Tensile Strength @ Yield (ppi) 2. Tensile Strength @ Break (ppi) 3. Elongation @ Yield (%) 4. Elongation @ Break (%)	ASTM D638 Type IV Dumb-bell @ 2 ipm (2.0" Gauge Length) (NSF 54, Mod.)	 126 228 12 700	20,000 lbs
Tear Resistance (min. aveg.)	ASTM D1004 Die C	42 lbs	45,000 lbs
Dimensional Stability % Change Each direction	ASTM D1204 212 °F 1 hr	± 2	
Stress Crack Resistance (hrs)	ASTM D5397	200	Per Batch
Puncture Resistance (min. aveg.)	ASTM 4833	108 lbs	45,000 lbs
Carbon Black Content (%) Carbon Black Dispersion	ASTM D1603 ASTM D5596	2 A1, A2 and B1	20,000 lbs 45,000 lbs
Oxidative Induction Time (OIT) (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.)	 ASTM D3895 ASTM D5885	 100 minutes 400 minutes	200,000 lbs
Oven Aging at 85° (a) Standard OIT (min. aveg.) - % retained after 90 days -or- (b) High Pressure OIT (min. aveg.) - % retained after 90 days	ASTM D5721 ASTM D3895 ASTM D5885	55% 80%	Per Batch
UV Resistance (a) Standard OIT (min. aveg.) -or- (b) High Pressure OIT (min. aveg.) - % retained after 1600 hrs	GM 11 ASTM D3895 ASTM D5885	 Not Recommend 50%	Per Batch

J. Geomembrane shall not have striations, roughness, pinholes or bubbles on the surface

2.3 EXTRUDATE

A. Extrudate shall be made from the same resin as the geomembrane.

B. Additives shall be thoroughly dispersed in the extrudate.

C. Additives shall be free of contamination by moisture or foreign matter.

2.4 FIELD SEAMS

A. Approved processes for seaming are extrusion welding and fusion double seam welding. Fusion double seam welding is the preferred method for joining long, straight seams. Extrusion welding is the preferred seaming method in areas such as corners, sumps, pipe penetrations, tear repairs and cap strips where fusion double seam welding is not feasible.

B. Only apparatus which has been specifically approved by make and model shall be used.

C. Proposed alternate processes shall be documented and submitted by the Contractor for approval by the Owner.

D. Resin used for extrusion welding shall be produced from same resin type as geomembrane.

E. Physical properties of the welding resin shall be the same as those of the resin used in the geomembrane.

F. Geomembrane seams shall meet following requirements:

HDPE GEOMEMBRANE
SEAM PROPERTIES

Property	Qualifier	Unit	Specified Value	Test Method
Shear Strength (at yield point)	minimum	lb/in. width	120 and FTB[1]	ASTM D 4437
Peel Adhesion Fusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437
Peel Adhesion Extrusion	minimum	lb/in. width	100 and FTB[1]	ASTM D 4437

Note:

[1] = Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (i.e., sheet fails before the weld fails).

2.5 EQUIPMENT

A. Welding Equipment:

1. The Contractor shall provide welding equipment equipped with gauges showing temperatures at the nozzle (extrusion welder) or at the wedge (wedge welder), or have the equipment capable of measuring the temperature of the nozzle (hot air).

2. Equipment shall be maintained in adequate number to avoid delaying work, and shall be supplied by a power source capable of providing constant voltage under a combined-line load.

3. Electric generator shall not be placed on the membrane, unless otherwise approved by the Owner.

B. Field Tensiometer:

1. The Contractor shall provide a tensiometer for onsite shear and peel testing of geomembrane seams.

2. The tensiometer shall be motor driven and have jaws capable of traveling at a measured rate of two (2) inches per minute.

3. The tensiometer shall be in good working order, built to ASTM specifications, and accompanied by evidence of recent calibration.

4. It shall be equipped with a gauge that measures the force in unit pounds exerted between the jaws and have a digital readout.

C. Punch Press:

1. The Contractor shall provide a punch press for the onsite preparation of specimens for testing.

2. The press shall be capable of cutting specimens in accordance with ASTM D4437.

D. Vacuum Box:

1. The Contractor shall provide a vacuum box for onsite testing of geomembrane seams.

2. The vacuum box shall have a transparent viewing window on top and a soft, closed-cell neoprene gasket attached to the bottom.

3. The housing shall be rigid and equipped with a bleed valve and vacuum gauge.

4. A separate vacuum source shall be connected to the vacuum box.

5. The equipment shall be capable of inducing and holding a vacuum of 5 psi.

E. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of a manual or motor driven air pump equipped with a pressure gauge.

2. The equipped shall be capable of generating and sustaining pressure over 25 psi.

3. Equipment shall be mounted on a cushion to protect the geomembrane.

4. It shall be equipped with a rubber hose with fittings and connections along with a sharp hollow needle.

5. Other pressure feed devices with a gauge and an accuracy of one (1) psi may be used, as approved by the Owner.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

A. Additional requirements for preparation of the leveling soil which will become the subgrade are covered in paragraph 3.5 of Section 02320, Temporary Spoils Stockpile.

B. Contractor shall remove all gravel and other protrusions from geomembrane subgrade. Grade stakes or hubs shall also be removed from subgrade prior to geomembrane placement.

C. Special care must be taken to maintain prepared soil surface. Soil surface shall be observed daily to evaluate desiccation cracking. Damage to subgrade shall be repaired to the satisfaction of the Owner.

D. Do not place geomembrane in area which has become softened by precipitation.

E. Contractor shall certify to the Owner in writing daily that the surface on which the geomembrane will be placed is acceptable.

3.2 PREPARATIONS

A. Damage to geomembrane subsurface during geomembrane deployment or other activities shall be repaired prior to installation.

B. Subgrade shall be smooth and consist of clean fine graded material free of rocks, protrusions, sharp objects and deleterious material of any kind.

C. Edges of excavations and grade changes should be rounded to a minimum six (6) inch radius.

D. Geomembrane material may be placed when air temperature is greater than 35°F, and increasing or less than 100°F, unless other limits are approved, in writing, by The Owner.

E. Do not place during precipitation in presence of excessive moisture (e.g., fog, dew), in area of ponded water, or during excessive winds.

3.3 ANCHOR TRENCH

A. The anchor trench shall be excavated by the Contractor to the lines and grades shown on the Plans prior to geomembrane deployment.

B. Contractor shall remove all loose soil from the anchor trench prior to geomembrane deployment No loose soil shall be allowed to underlie the geomembrane.

C. Excavated surface of the anchor trench shall be protected by the Contractor from desiccation or excessive moisture.

D. Contractor shall not damage geomembrane during backfill placement in anchor trench.

3.4 DEPLOYMENT

A. Each panel deployed shall be assigned a simple and logical identifying code consistent with the submitted panel layout drawings.

B. No more panels shall be deployed in one day that can be welded during that same day.

C. Tack welding may be acceptable as a temporary measure; however, tack welded panels shall not be left overnight.

D. Panels shall be shingled on all slopes such that the upper panel of a cross-seam is overlapped above the lower panel.

E. Panels shall be oriented perpendicular to the line of the slope crest (i.e., down and not across slope) anchored securely and deployed down the slope in a controlled manner. Panels shall not be pulled up the slope.

F. Ballast, that will not damage the geomembrane, shall be used to prevent uplift due to wind. Methods used shall minimize wrinkles.

G. Contractor shall securely anchor the geomembrane on a daily basis to prevent "pull-out" from the anchor trench with materials and methods approved by the Owner. Special attention should be given to geomembrane shrinkage overnight.

H. Folds shall be immediately removed on all installations.

I. Personnel walking on the geomembrane shall not engage in activities or wear types of shoes, that could damage the geomembrane.

J. Smoking shall not be permitted while working on the geomembrane.

K. Vehicular traffic directly on the geomembrane shall not be permitted.

L. Equipment shall not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or any other means.

M. The geomembrane surface shall not be used as a work area, for preparing patches, storing tools and supplies, or other uses. If needed, a protective cover may be spread out as a work surface.

N. Material shall be placed in a manner to allow for geomembrane shrinkage, contraction and to avoid bridging.

3.5 SEAMING

A. Seam Layout

1. In general, orient end seams (traverse) parallel to line of maximum slope, i.e., oriented along, not across, slope. In corners and odd-shaped geometric locations, minimize numbers of field seams.
2. Seam coding system shall be compatible with panel coding system.

3. During welding operations, at least one Master Seamer shall be present and shall provide supervision over other welders.

4. The surface of the geomembrane shall be clean of grease, moisture, dust, dirt, debris, or other foreign material.

5. Solvents or adhesives shall not be used unless the product is approved in writing by the Owner.

6. Panels shall overlap by a minimum of four (4) inches for all welds.

7. Seams shall be welded to the outside edge of panels placed under anchor berms or in anchor trenches.

8. Fishmouths or wrinkles at seam overlaps shall be cut to achieve a flat overlap.

9. The cut fishmouths or wrinkles shall be extrusion welded or patched where the overlap is more than three (3) inches.

10. When there is less than three (3) inches overlap, an oval or round patch extending a minimum of six (6) inches beyond the cut in each direction shall be used.

11. Seams shall be welded only when ambient temperature is between 35°F and 100°F as measured 6 inches above the geomembrane surface unless other limits are approved in writing by the Owner.

B. Extrusion Seaming

1. Adjacent panels shall be tack bonded together using procedures that do not damage the geomembrane, allow required tests to be performed, and are not detrimental to final seaming.

2. Welding apparatus shall be free of heat-degraded extrudate before welding.

3. The geomembrane surface shall be abraded a maximum of 1/4 inch beyond the weld bead area, using a disc grinder, or equivalent, not more than one hour before extruding seam.

4. The ends of all seams, which are more than five (5) minutes old, shall be ground when restarting the weld.

5. Grinding depth shall not exceed ten (10) percent of the liner thickness.

6. Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.

7. Provide documentation of extrudate to the Owner and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.

8. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

9. Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from barrel.

10. Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.

C. Fusion Seaming

1. Welding apparatus shall be automated, vehicular-mounted, and equipped with gauges indicating applicable temperatures and pressures.

2. Edges of cross seams shall be ground smooth including top and bottom prior to welding.

3. Maintain one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.

D. Trial Welds

1. Trial welds shall be performed on geomembrane samples to verify welding equipment operations and performance of seaming methods and conditions.

2. Minimum of two (2) trial welds per day or shift per welding apparatus shall be made, one made prior to the start of work and one completed at mid shift.

3. Welds shall be made under the same surface and environmental conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature).

E. Trial Weld Testing

1. Sample shall be at least three (3) feet long and two (2) feet wide with the seam centered lengthwise.

2. Three (3), 1-inch wide test strips shall be cut from the trial weld.

3. Each of the specimens shall be tested in the field by the Contractor for peel and shear using a digital tensiometer.

4. Remaining sample shall be retained for future testing.

5. A trial weld specimen shall pass when the results are achieved for both peel and shear tests as shown herein. For double-wedge welding, both welds shall be individually tested and both shall be required to pass in peel.

6. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and two consecutive successful full trial seams are achieved

3.6 MATERIAL QUALTY EVALUATION

A. Contractor shall submit an affidavit and/or quality control certificate signed by the geomembrane manufacturer certifying that the geomembrane blankets and/or rolls meet or exceed specified requirements to the Owner for approval prior to geomembrane deployment.

B. Preinstallation material quality evaluation testing shall be performed as follows:

1. Raw material for geomembrane and extrudate rod or bead:

• ASTM D792	1 per batch
• ASTM D1238, Condition E	1 per batch
• ASTM D746	1 per batch

2. Geomembrane Roll:

• ASTM D5199	Continuous or 25 per sheet
• ASTM D638	1 per 50,000 ft^2
• ASTM D1505-A	1 per 50,000 ft^2
• ASTM D1004, Die C	1 per 50,000 ft^2
• ASTM D4833	1 per 50,000 ft^2
• ASTM D1603	1 per 100,000 ft^2

C. Conformance Testing

1. Samples shall be obtained at a frequency of one sample per 50,000 square feet.

2. The Contractor shall obtain samples and forward them to a laboratory designated by the Owner.

3. Tests shall be performed to determine geomembrane Density (ASTM D1505), Thickness (ASTM D5199) and Tensile Strength (ASTM D 638).

4. The sample shall be across the entire width of the roll excluding the first three (3) feet, and shall be cut three (3) feet long by width of roll.

5. Within 30 days of contract award. Contractor shall submit the results of the following interface shear tests:

   - Smooth HDPE - Compacted Soil
   - Smooth HDPE - Geonet
   - Textured HDPE - Geonet
   - Textured HDPE - Geosynthetic Clay Liner

   These tests shall be performed in accordance with ASTM D 5321.

3.7 CONSTRUCTION QUALTY EVALUATION

A. Contractor shall non-destructively test all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), or other approved methods. Non-destructive testing shall be carried out daily as the seaming progresses and not at completion of all seaming or at the completion of the day.

B. Vacuum testing shall conform to the following requirements:

1. The equipment shall consist of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.

2. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12" x 36"). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve, and ensure that a leak-

tight seal is created. Apply a vacuum of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section. If no bubble(s) appear after 15 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three (3) inches overlap, and repeat process.

C. Air Pressure Testing (for double seam with an enclosed space):

1. The equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure over twenty-five (25) psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of one (1) psi.

2. Testing shall conform to the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created by the double-wedge weld. Energize the air pump to a minimum pressure of twenty-five (25) psi, close the valve, and sustain the pressure for at least five (5) minutes. If pressure loss exceeds two (2) psi or does not stabilize, locate faulty area and repair as described in this Section. Puncture opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and seal penetration holes by extrusion welding.

D. Spark Testing: For those extrusion welded seams which are unable to be tested by a vacuum box, the spark test method shall be used with a 24-gauge copper wire placed 1/8" under the top sheet overlap and a Holiday detector operating at 20,000 volts.

E. Field seam locations that cannot be non-destructively tested by the Contractor as determined by the Owner will be cap-stripped using the same materials as the underlying geomembrane.

3.8 DESTRUCTIVE TESTING

A. Sample Location

1. Collect destructive test samples at a minimum frequency of one test per 1,000 feet of seam length or more frequent as directed by the Owner. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The Owner will be responsible for choosing the locations. The Owner will not

notify the Contractor in advance of selecting locations where seam samples will be taken.

2. The Contractor shall cut samples at locations designated by the Owner as the seaming progresses to obtain-laboratory test results before the geomembrane is covered. The Owner will number each sample and mark the sample number and location on the panel layout drawing.

3. The Contractor shall immediately repair all holes in the geomembrane resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this Section.

4. The destructive sample shall be eighteen (18) inches wide by forty-two (42) inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Contractor, the Laboratory and the Owner for archiving.

B. Laboratory Testing

1. Samples shall be tested in peel and shear (ASTM D4437).

2. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld.

3. At least five (5) coupons shall be tested by each test method.

4. Four (4) of the five (5) coupons shall meet the minimum requirements stated herein.

5. Test results shall be provided verbally within 24 hours after receiving samples, and within three (3) days in written form.

C. Destructive Test Failure

1. One of two options shall be followed:

a. Option 1: Reconstruct the seam between any two (2) passed test locations.

b. Option 2: Trace the weld to an intermediate location at least ten (10) feet minimum or to where the seam ends, in both directions from the location of the failed test to collect a destructive test sample at both locations. Check the next seam welded using the same welding device if required to obtain an additional sample (i.e., if one side of the seam is less than ten

(10) feet long). Bounding laboratory samples shall be taken, and destructive testing shall be performed per this Section. If the bounding samples pass, then the seam shall be reconstructed between the test sample locations. If any additional samples fail, then the process shall be repeated to establish the zone in which the seam shall be reconstructed.

2. Reconstruction methods shall include extrusion welding of previously wedge welded seams, cap stripping of seam, or replacing seam with a new one (1) foot wide panel and welding in place.

D. Acceptable seams shall be bounded by two locations from which samples have passed destructive tests. For reconstructed seams exceeding fifty (50) feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.

3.9 DEFECTS AND REPAIRS

A. The geomembrane shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

B. The geomembrane surface shall be clean at the time of the examination.

C. Each suspect location shall be repaired and non-destructively tested.

D. Geomembrane shall not be covered at locations which have been repaired until test results with passing values are available.

E. Damaged geomembrane shall be removed and replaced with acceptable geomembrane if damage cannot be satisfactorily repaired.

F. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test shall be repaired.

G. The Contractor shall be responsible for repair of damaged or defective areas. One of the procedures listed below shall be recommended by the Contractor and approved by the Owner:

1. Patching: Used to repair large and small holes, tears, undispersed raw materials, and contamination by foreign matter.

2. Abrading and Re-welding: Used to repair small seam sections (less than twelve (12) inches long).

3. Spot Welding: Spot welding is not allowed.

4. Capping: Used to repair large lengths of failed seams.

5. Removing unsatisfactory material and replacing with new material.

H. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

1. Patches or caps shall extend at least six (6) inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least four (4) inches.

2. The geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.

I. Repairs shall be verified using the following procedure:

1. Each patch repair shall be non-destructively tested using methods specified in this Section.

2. Destructive testing may be required at the discretion of the Owner.

3.10 GEOMEMBRANE ACCEPTANCE

A. Contractor shall retain all ownership and responsibility for the geomembrane until final acceptance by the Owner.

B. Owner will accept the geomembrane installation when the installation is finished and all required documentation from the Contractor has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

3.11 MATERIALS IN CONTACT WITH GEOMEMBRANE

A. General

1. Carefully install materials in contact with geomembrane surfaces to minimize damage potential.

2. Clamps, clips, bolts, nuts, or other fasteners used to secure geomembrane to each appurtenance shall have lifespan equal to or exceeding geomembrane's.

B. Pipes and Other Appurtenances

1. Install geomembrane around appurtenances, such as pipes, protruding through geomembrane as shown in Plans. Unless otherwise specified, initially install geomembrane sleeve or apron around each appurtenance prior to geomembrane installation.

2. After material is placed and seamed, complete final field seam connection between appurtenance sleeve or apron and geomembrane. Maintain sufficient initial overlap of appurtenance sleeve so shifts in location of geomembrane can be accommodated.

3. Extreme care shall be taken while seaming around appurtenances because both nondestructive and destructive seam testing might not be feasible. Do not damage geomembrane while making connections to appurtenances.

END OF SECTION

SECTION 02525

EXTRACTION WELLS

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing the extraction wells as shown on the Drawings.

B. The Contractor shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction. The Contractor is responsible for identifying and obtaining all appropriate licenses, approvals, and permits to complete the work of this Section. The Contractor shall provide a "Competent Person" to implement, supervise, and inspect the Work.

C. Prior to the installation of the extraction wells, the Contractor shall identify and perform any necessary utility mark-outs.

D. The Contractor shall coordinate the work of this Section with the work of other sections as required.

1.2 DESCRIPTION OF WORK

A. The approximate locations and depths of the extraction wells are shown on the Drawings. Exact locations shall be determined and field verified by the Contractor and Owner before the installation of the extraction wells is initiated.

1.3 SUBMITTALS

A. Drilling methods are described herein. The Contractor may propose alternative drilling method(s).

B. Submit a Statement of Qualifications for the Contractor who will perform the installation. Include resumes of drilling crews and the superintendent. Submit safety records (OSHA 200 logs and Experience Modification Ratings for the last 3 years) and insurance rating. The drilling personnel shall have Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operator (HAZWOPER) certification, along with required annual refresher training. The Statement of Qualifications shall include documentation of personnel

HAZWOPER certification as well as documentation that refresher training is current.

C. Submit a list of all equipment to be used for the Work described in this Section including proposed drill rigs and associated torque capacity. Submit an installation schedule and update it weekly during the Work.

D. No work shall be performed until the items discussed above have been favorably reviewed by the Owner.

E. During drilling of each well, the Contractor shall maintain a detailed daily driller's report and submit reports daily to the Owner. The report shall give a complete description of all formations or material encountered, number of feet drilled, number of hours on the job, shutdowns, feet of casing set, and all other pertinent data.

F. Upon completion of each well, the Contractor shall submit to the Owner a report including the following:

1. Total depth of the completed well;
2. Depth or location of any lost drilling materials or tools;
3. Nominal hole diameter of the well bore and total depth;
4. Volume and amount of materials (including number of bags) used to fill the annular space;
5. Depth and description of the well casing and screen;
6. Protective casing, plug, cap size, and materials used;
7. Concrete, bentonite, or grout materials used and depths;
8. Number and location of centralizers used;
9. Weather conditions during installation;
10. Name of individual who prepared the report and members of the drilling crew; and,
11. Other pertinent data requested by the Owner.

G. Following completion of drilling each well, the Contractor shall submit to the Owner signed copies of the driller's log book including the following information:

1. Reference point (i.e., top of casing) for all depth measurements;
2. Depth at which each change of material occurs;
3. Identification of the material of which each stratum is composed;
4. Depth interval from which sample was taken;
5. Name of individual who prepared log and members of drilling crew;
6. Water use during drilling;
7. Penetration resistance during split-spoon sampling (if any);
8. Water levels encountered during drilling;

9. Drill rig type, make, and torque capacity;
10. Split-spoon hammer weight and fall; (if appropriate) and,
11. Other pertinent data requested by the OWNER.

H. The Contractor shall submit the well coordinates and top-of-casing elevations certified by a Land Surveyor licensed in the State of Illinois.

I. The Contractor shall submit product data for the following:

1. Casing pipe;
2. Extraction well screen;
3. Drilling fluid materials and additives (if used);
4. Mix design of neat cement and cement grout; and,
5. Pitless adapter.

J. The Contractor shall submit a completed Well Construction Form for each extraction well constructed. Submit two (2) copies to the Owner upon completion of each extraction well.

1.4 QUALIFICATIONS

A. The Contractor responsible for the construction of the extraction wells shall be properly licensed and employ only competent workmen for the execution of this Work. All such Work shall be performed under the direct supervision of an experienced driller favorably reviewed by the Owner.

B. The driller shall be capable of identifying geologic formations, maintaining complete and current well logs and daily notes for the completion report.

C. The Contractor shall provide satisfactory evidence that all materials to be furnished in performing the Work are new and all equipment to be used is in good working order.

1.5 HANDLING OF MATERIALS

A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination will occur from the time of shipment until the Work described in this Section is complete.

B. If in the opinion of the Owner, parts and materials are damaged, deteriorated, or contaminated, the materials will be rejected and immediately removed from the Site. The Contractor shall replace the parts and materials at no additional cost to Owner.

1.6 SITE CONDITIONS

A. The Contractor shall coordinate access approvals with the Owner. Notify corporations, companies, individuals or authorities owning conduit wires or pipes running to property or encountered during construction. Protect, support, and maintain conduit, drains, sewers, pipes, and wires.

B. The Contractor shall not excavate within influence zone of existing footings or foundations without prior approval of the Owner.

C. The Contractor shall review with and obtain prior approval from the Owner for location of mud or water pits or other temporary excavations for construction purposes.

D. The Contractor shall perform site grading, filling, and surface stabilization, if necessary, to access the Site with drilling equipment.

PART 2 PRODUCTS

2.1 WELL CASING PIPE

A. 10.75-inch OD Type 304 Schedule 40 (0.365 in. wall thickness) seamless stainless steel pipe.

2.2 SCREEN

A. Manufacturers:

1. Howard Smith Screen Company.
2. Johnson Screen Company.
3. Or equal.

B. Type 304 stainless steel telescoping screen, with a nominal diameter of 10 inches. The weld ring wall thickness will vary depending on the manufacturer, but should be approximately 0.45 inch. A specially designed packer shall be used at the top of the screen to seal between the outside diameter of the screen and the inside diameter of the casing if the screen is to be telescoped into the 10-inch ID casing. Contractor shall submit details of the packer for approval.

C. Screen slot size: 0.040 inch, to be verified by the OWNER during construction.

D. Add five feet of 10-inch Type 304 stainless steel telescoping 0.005-inch slot screen below the primary screen to act as a sand trap. Close bottom of sand trap screen with factory-welded bottom plate of same material as the screen.

E. All fittings shall be welded by a certified welder.

F. Screen shall be continuous-slot, all welded design.

2.3 PITLESS UNIT

A. Manufacturers:

1. Standard Model Monitor PS Industrial Pitless Unit as manufactured by Baker Manufacturing Company.
2. Maass-Baski, Inc. heavy duty Pitless Unit.
3. Or equal.

B. Comply with recommended standards of Pitless Adapter Division - Water Systems Council, National Water Well Association.

C. Design Requirements:

1. Steel pitless case of same size as well casing, with epoxy corrosion resistant coating.
2. Drop pipe: 4-inch I.D. threaded connection.
3. Discharge connection: 4-inch threaded connection, 150 psi minimum working pressure.
4. Sealed conduit connection, with neoprene electrical cable seal and O-rings.
5. Lifting lugs.
6. Designed for stresses that may occur during installation, testing, and operation.
7. Stainless steel seating rings.
8. Pitless unit shall be encased in concrete.

2.4 STAINLESS STEEL DROP PIPE

A. Design Requirements:

1. 4.5-inch OD Schedule 40 (0.237 in. wall thickness) Type 304 stainless steel pipe, threaded and coupled, 21-ft maximum lengths.
2. Pipe shall not support weight of pump. Pump shall be supported by a stainless steel chain with a minimum working load of 3 times the weight of the pump and drop pipe and shall be attached to top of well or pitless adapter as appropriate.

PART 3 EXECUTION

The execution of the project shall be as follows:

3.1 EXAMINATION

A. The Contractor shall inspect all materials upon delivery and before placement to document that they are in the original packaging as supplied by the manufacturer or supplier and free of any deleterious material.

3.2 PREPARATION

The Contractor shall:

A. Protect existing structures from damage.

B. Prepare the area for staging of drill cuttings prior to transporting to the temporary spoil stockpile.

C. The Contractor shall provide access to all extraction wells. Proposed access locations shall be reviewed with the Owner.

3.3 GENERAL

A. A typical cross-section of proposed wells is included in the Drawings for reference purposes. The well cross-section shall not be interpreted to indicate exact formation, thickness, and material encountered. This information shall be verified during drilling and prior to installation of the screen.

B. The extraction wells shall be constructed using cable tool methods. However, in the event that drilling by cable tool is determined to be not feasible, another drilling method may be substituted. Drilling Methods shall be approved by the Owner and shall conform to all State and local standards for well construction.

1. Acceptable drilling fluids are potable water and air.
2. Extraction wells shall be drilled straight and plumb.

C. The Contractor shall provide water for drilling and grouting.

3.4 SCREENED WELL CONSTRUCTION

A. Drive a 10-inch nominal stainless steel casing 110 feet below ground surface (bgs) using cable tool methods, or another approved method. Cuttings shall be removed using the appropriate cable tool. The 10-inch diameter casing sections shall be welded in the field by a certified welder.

B. Following drilling and sampling of the 10-inch diameter boreholes, install 10-inch diameter telescoping screens concentrically within the 10-inch nominal diameter

casings, as casing is pulled back. Screen lengths specified to be 65 feet as shown on the Drawings. Actual screen lengths will be determined by the Owner based on the field conditions encountered. Place five feet of 10-inch diameter telescoping screen (0.005 inch slot) below each screen as a sand trap. The boreholes shall be sampled for stratigraphic classification purposes. Continuous sampling shall be accomplished by collecting small portions of the cable tool cuttings, for inspection and classification.

C. Terminate upper end of casings at height or depth relative to ground surface indicated on the Drawings.

D. The natural formation will comprise the filter pack for the well and no well grouting will be accomplished.

3.5 WELL DEVELOPMENT BY MECHANICAL SURGING AND PUMPING

A. Perform development by mechanical surging and pumping after completion of well construction.

B. Provide a surge block constructed of two rubber discs between three steel discs. The outside diameter of disc shall be not less than 0.5 in. smaller than the inside diameter of the end fittings (weld rings) of the well screen.

C. Prior to surging and pumping, clean out any fill from each well.

D. Provide necessary equipment for performing the well development.

E. Place the surge block in each well above the screen. Surge, then lower the surge block into each screen and develop intervals by slowly moving progressively downward.

F. Install a pump in each well and remove the water and sediment from the well. Continue development of each well until the turbidity of the pumped water is acceptable to the Owner or the discharge has a sand content of less than 2 ppm as measured with a Rossum centrifugal sand tester. The water level shall be monitored with a transducer and confirmed with manual measurements.

G. Collect, handle and dispose of well development water in accordance with the requirements of this section.

H. After development, conduct a short-duration performance test on each well, initially using a flow rate of approximately 50 gpm. Increase the flow rate in 100-gpm steps to 350 gpm. Each step shall be 30 minutes in duration. The water level shall be monitored with a transducer and confirmed with manual

measurements. The performance tests shall be conducted immediately after pump installation, if the discharge piping is connected to the American Bottoms Regional Wastewater Treatment Facility (ABRWTF). If the system is not connected to ABRWTF, performance tests shall not be performed until a connection has been made and a discharge permit has been obtained. The short-duration performance tests will be performed in order to verify that the system is functioning per design assumptions.

3.6 DECONTAMINATION

A. The drill rig and all drilling equipment shall be delivered clean and shall be steam-cleaned upon arrival on-site and prior to leaving the Site. Steam cleaning will not be required between boreholes. Potable water for steam cleaning shall be supplied by the Contractor. Between boreholes, all soil and wastes shall be removed from the drill rig and drilling equipment at the borehole location. Drill cuttings and other solid materials shall be disposed in the temporary spoils stockpile. Liquids are not to be disposed of in the stockpile.

3.7 SOLIDS, LIQUIDS AND PPE HANDLING

A. All solids, liquids, and personal protective equipment (PPE) used, collected, or encountered during the performance of this Work, including well development water and decontamination water, shall be collected in drums and be delivered to a consolidation area. These materials shall subsequently be transferred to an appropriate bulk container, e.g. a double walled-tank, contained single wall tank, roll-off box, or other appropriate container provided by Owner. Containerized solids and liquids shall be characterized to determine the proper disposal method and shall be disposed at a facility permitted to handle these materials in accordance with applicable rules and regulations, at Owner's expense.

3.8 WELL PROTECTION

During the progress of the Work, the Contractor shall protect all wells from tampering or the entrance of foreign material.

3.9 WELL ACCEPTANCE CRITERIA

A. The Contractor shall develop the extraction wells until, in the opinion of Owner, they are:

1. Producing minimum required flow rate;
2. Producing clear water with a turbidity index of less than 5 NTU (USEPA test Method 180.1); or a sand content of less than 2 ppm as measured with a Rossum centrifugal sand tester

3. Producing water completely free of drilling fluids; and,
4. No increase in well specific capacity is observed following successive development periods.

B. All boreholes shall be constructed and casing installed plumb and true to line.

C. All casing, screens, and caps shall be set to the depths directed by Owner.

D. All well identification numbers, dates of completion, and permit numbers shall be imprinted inside the well or sump cover.

E. All residual materials (bags, crates, containers, and miscellaneous debris) shall be removed from the Site, or placed into on-site solid waste dumpsters.

F. No payment will be due to the Contractor if he fails to meet all of the above requirements.

END OF SECTION

SECTION 02526

SUBMERSIBLE WELL PUMP AND MOTOR

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The Contractor shall provide all labor, equipment, materials, tools, and appurtenances required to complete the work of furnishing and installing submersible well pumps and motors as shown on the Drawings, as specified herein, and as otherwise required by the Owner.

B. The work of the Section includes furnishing and installing submersible pumps and motors in the extraction wells. The pumps shall be installed in a 10-inch well casing. The base of the pump shall be installed five feet above the top of the screen, or at another elevation directed by the Owner.

1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings:

1. Drawing of proposed surface plate and discharge head based on certified points.
2. Installation drawing of pump cross-section installed in well.
3. Parts list and descriptions including such items as manufacturer, make, model, style, type, weights, material, coatings, finishes, and references to appropriate standards.
4. Pump manufacturer's curve showing principal characteristics of proposed pump including:

    a. Relation between delivery and head.
    b. Relation between efficiency and delivery.

B. Miscellaneous:

1. Pump manufacturer's statement of overall efficiency guarantee for pumping unit, under the conditions specified in Section 3.2.2.
2. Pump schedule showing make and model number.

C. Submit documents to the Owner.

D. Provide record copies of the Shop Drawings as part of the Technical Manuals (O&M Manual).

1.3 QUALITY ASSURANCE

A. Pump installer shall be licensed in the State of Illinois.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prevent dirt, water, and chemicals from entering inside the discharge pipe and equipment.

B. Where possible, store materials and equipment inside to protect from weather. If it is necessary to store materials and equipment outside, store in a manner such that the materials and equipment are elevated above grade.

1.5 SITE CONDITIONS

A. Pump equipment specified in this Section is based on anticipated pumping conditions and is subject to change following well test results.

B. Modifications to pumping equipment, if necessary, will be made by written Change Orders.

C. Do not order pumping equipment until well has been tested and pump design conditions are verified by the Owner.

PART 2 PRODUCTS

2.1 GENERAL The pump and motor shall be designed for continuous submerged operation. The pump bowls, impellers, guide vanes, strainer, and check valve shall be 300 Series stainless steel. The shaft and coupling shall be 300 or 400 series stainless steel. The motor shall be an induction motor designed for continuous underwater operation in conformance with NEMA standards. The motor shall be water filled for cooling and lubrications and shall not utilize oils and greases.

A. Proposed equipment will not be considered if it has not demonstrated its reliability and efficiency on installations of similar units of approximately the same capacity and under conditions corresponding to this installation. Submit such information to the Owner.

B. Working parts shall be readily accessible for inspection and repairs, easily duplicated, and replaced.

C. Pump bearings shall be ample in size and water lubricated. Bearings and similar parts shall have temperature rise not to exceed limit of safety and good practice for such parts with water temperature of less than 68°F.

D. Apparatus shall be free from shock, vibration, and noise under conditions of load.

E. Proportion pump parts for stresses that may occur during continuous operation and for additional stresses that may occur during fabrication, erection, and intermittent or continuous operation.

F. Design for pumps, appurtenances, and cable to be capable of continuous submergence under water without loss of watertight integrity to depths as shown on the Drawings.

2.2 PUMPING EQUIPMENT

A. Manufacturers (see table below):

1. Grundfos Model 300S200-5; or
2. Grundfos Model 385S250-3;
3. Or equal.

Comparison of Pump Specifications:

		200 gpm		**300 gpm**		**400 gpm**	
	Range	**Total Dynamic Head**	**Efficiency**	**Total Dynamic Head**	**Efficiency**	**Total Dynamic Head**	**Efficiency**
	[gpm]	**[feet]**	**[%]**	**[feet]**	**[%]**	**[feet]**	**[%]**
300S200-5 (20 HP)	200 to 410	240	68	180	78	100	60
385S250-3 (25 HP)	260 to 550	250	60	210	74	177	77

The pump should be selected after final design of conveyance system and performance test of the well. For additional total dynamic head requirements, a motor with additional horsepower will be required. The 385S model is more efficient in the range of 350 to 450 gpm compared to model 300S which is most efficient in the range between 250 and 350 gpm.

B. Provide submersible well pumping equipment in accordance with the requirements shown on the Drawings, or as otherwise specified by the OWNER. Pumps will utilize variable frequency drives specified in another section, which are compatible with each pump, as recommended by the pump manufacturer.

C. Design to prevent damage to pumps and motors in the event that the units should be operated in the wrong direction.

D. Pumps shall be sized to provide at least 360 gallons per minute flow against a total head of at least 125 feet, depending on final design parameters for the conveyance system. The pump efficiency shall be above 70% for the projected pumping rate and total dynamic head.

E. Pumps provided shall be of the same manufacturer and of one model for ease of operation, maintenance, and repair.

2.3 CHECK VALVES

A. Manufacturers:

1. Lakewood.
2. Or equal.

B. Provide one (1) check valve of the same size as pump drop pipe.

C. Stainless steel construction, stainless steel spring, threaded ends, double disc type.

D. Neoprene tube around upper cross-bar to absorb seat opening shock.

2.4 FLOW CONTROL VALVES

A. Manufacturers:

1. Dole
2. Plast-O-Matic
3. Or Equal

B. Provide steel, 4-inch ball valves as depicted on Drawings, so that each well can be fully isolated from the system (for example, during repairs).

C. Provide one flow control valve per pump, located on conveyance pipe inside enclosure.

2.5 ELECTRIC MOTOR

A. Manufacturers:

1. Franklin.
2. Grundfos.
3. Or equal.

B. Provide submersible, 20 horsepower, 480V, 3-phase (60 Hz) electric motor. The electric motor shall draw approximately 31 amperes.

C. High thrust capacity with heavy thrust bearings.

D. Highest grade heavy-walled seamless steel motor housing.

E. Accurately machined shaft and rotor assembly, dynamically balanced to ensure vibration-less operation.

F. Capable of sustaining minimum of 3 starts/hr, 24 hrs/day, 365 days/yr.

2.6 PUMP CABLE

A. Provide submersible cable in accordance with AWWA E101 and this Section.

B. Design pump cable entry water seal to ensure watertight and submersible seal.

C. Do not use epoxies, silicones, or other secondary sealing systems.

D. Install suitable motor cable for submersible pump applications and indicate by code or legend permanently embossed on cable.

E. Provide four (4) or more separate conductors, including one (1) for ground.

1. Stranding in accordance with ASTM class designation standards.

2. Cable with four (4) or more conductors shall be jacketed with oil and water resistant material.

F. Cable shall extend from the motor to the junction box at pump head. Provide a minimum of 5-feet of extra cable.

G. Provide stainless steel clamps connected to the pump discharge pipe at not less than 10-foot intervals.

H. Provide stainless steel cable guard at pump assembly.

2.7 SOURCE QUALITY CONTROL

A. Factory test submersible pump and cable in accordance with AWWA E101 and perform insulation tests before and after testing.

B. Perform factory test with job motor driving pump.

C. Test points shall include shut-off head, rated head, and at least three (3) other points as required for accurate curve plotting.

D. Test data computations shall be made to provide field head-discharge curves, field wire to water efficiency curves, and field power consumption in kwh/1,000 gal at performance point.

1. Do not include velocity head, but include internal pump and screen losses, including built-in check valve, in performance curves.

2. Correct test results to show field performance at speed which unit will operate with 480V at motor terminals.

E. Pump motors shall be non-overloading throughout the entire operating range.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install pumping equipment complete and in accordance with the manufacturer's recommendations, approved submittals, and to the satisfaction of the Owner.

B. Install pump and discharge pipe in accordance with Section 2.0.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Supplier's or manufacturer's technician for the equipment specified herein shall be present at the Site for minimum of two (2) man days, travel time excluded, for start-up support and training of the OWNER'S personnel for the operation, maintenance, troubleshooting, and system-related areas.

B. Tests:

1. Conduct pumping test to demonstrate field performance of pumping equipment in accordance with Section 2.3.5 of this section.

2. Pump and motor shall operate without excessive vibration and shall operate at a pumping capacity and field efficiency which is consistent with the field total dynamic head conditions and approved performance curve data for the pumping equipment.

3. Tests will not be considered complete, nor will pumping equipment be accepted, if the requirements of this Section are not met.

END OF SECTION

SECTION 02550

EFFLUENT PIPELINE AND APPURTENANCES

1.0 GENERAL

1.1 SECTION INCLUDES:

1.1.1 Furnishing and installing HDPE pipe and fittings and connecting pipeline to well discharge lines.

1.1.2 Furnishing and installing ductile iron pipe and fittings and necessary pipe supports at discharge point.

1.1.3 Removing existing fence and furnishing and installing matching chain-link fence at discharge point

1.1.4 Furnishing and installing combination air valve and manhole

1.1.5 Furnishing and installing valves, flowmeter, sampling instrument, and wireless signal transmission equipment.

1.2 REFERENCES

ASTM D 638:	Test Method for Tensile Properties of Plastics.
ASTM D 790:	Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
ASTM D 1238:	Test Method for Flow Rates of Thermal Plastics Molding and Extrusion Materials.
ASTM D 1505:	Test Method for Density of Plastics by the Density Gradient Technique.
ASTM D 1599:	Test Method for Short Time Hydraulic Failure Pressure of Plastic Pipe Materials.
ASTM D 1693:	Test Method for Environmental Stress Cracking of Ethylene Plastics.
ASTM D 2122:	Method for Determining Dimensions of Thermal Plastic Pipe and Fittings.
ASTM D 2321	Recommended Practice for Underground Installation of Flexible Thermoplastic sewer Pipe

ASTM D 2837:	Method for Obtaining Hydrostatic Design Basis for Thermal Plastic Pipe Materials.
ASTM D 3350:	Polyethylene Plastics Pipe and Fitting Material.
ASTM F 714:	Polyethylene (PE) Plastic Pipe Based on Outside Diameter.
ASTM F 1248:	Determination of Environmental Stress Crack Resistance (ESCR) of Polyethylene Pipe.
ASTM D 4218:	Test Method for Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
ASTM D 1248:	Specification for Polyethylene Plastics Molding and Extrusion Material.
ASTM D 2240:	Test Method of Rubber Property - Durometer Hardness.
ASTM D 695:	Test Method for Compressive Strength of Rigid Plastics.
ASTM D 256:	Test Method for Impact Resistance of Plastics and Electrical Insulating Material.
ASTM D 696:	Test Method of Coefficient of Linear Thermal Expansion of Plastics.
ASTM C 177:	Test Method for Steady-State Heat Flux Measurement and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
ASTM D 746:	Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
ASTM D 152S:	Test Method for Vicat Softening Temperature of Plastics.
AWWA C104	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110	Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm through 1200 mm), for Water and Other Liquids
AWWA C111	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115	Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151	Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids
AWWA C153	Errata Nov 1996) Ductile-Iron Compact Fittings, 3 In. Through 24 In. and 54 In. through 64 In. for Water Service

1.3 SUBMITTALS

1.3.1 Submit certifications, manufacturer's data, shop drawings, test results, and records as necessary to show that materials, methods, and workmanship meet or exceed the requirements of these specifications.

1.3.2 Submit the following to the Owner for review and acceptance prior to shipment of the pipe:

1.3.2.1. Proposed profile drawing of pipeline. The pipeline shall be constructed at grades that maintain minimum 36-in. of cover over the pipe and that minimize the number of high points in the line from beginning to end. The profile shall be based on a ground elevation survey performed by Contractor along the proposed pipeline alignment. Ground elevations shall be obtained at all breaks in grade and at a minimum of every 50 ft.

1.3.2.2. A statement in writing from the pipe manufacturer that it is listed with the Plastic Pipe Institute as an extruder for polyethylene resin being used to manufacture the pipe for this project.

1.3.2.3. Catalog information confirming the pipe conforms to the requirements of these specifications.

1.3.3 Submit the following to the Owner for review and acceptance prior to shipment of the fittings and instruments:

1.3.3.1 Catalog data and all dimensions for HDPE, ductile iron, and stainless steel pipe fittings, if any.

1.3.3.2 Catalog data and dimensions for all valves and instruments to be furnished and installed as part of the discharge pipeline.

1.3.3.3 Large scale shop drawings (plan, elevation, and detail) showing the arrangement of the discharge line, elbows, flow meter, sampling instrument and tap, valves, drainage taps, and discharge piping to Existing Manholes B and C.

2.0 PRODUCTS

2.1 HDPE PIPE MATERIALS

2.1.1. Physical Properties for pipes and fittings:

Typical Physical Properties*

Property	Specification	Units	Nominal Values
Material Designation	PPI/ASTM	---	PE3408
Material Classification	ASTM D1248	---	III C 5 P34
Cell Classification	ASTM D3350	---	345434C
Density (3)	ASTM D1505	gm/cm^3	0.955
Melt Flow (4)	ASTM D1238	gm/10 min	0.11 @ 2.16 kg***
Flex Modulus (5)	ASTM D790	psi	135,000
Tensile Str. (4)	ASTM D638	psi	3,200
ESCR (3)	ASTM D1693	F_0, Hrs	F_0>5,000
HDB @ 73^0F (4)	ASTM D2837	psi	1,600
U-V Stabilizer (C)	ASTM D1603	% C	2.5
Hardness	ASTM D2240	Shore "D"	65
Compressive Strength (Yield)	ASTM D695	psi	1,600
Tensile Strength @ Yield(Type IV Spec)	ASTM D638(2"/min)	psi	3,200
Elongation @ Yield	ASTM D638	% minimum	8
Tensile Strength @ Break(Type IV Spec)	ASTM D638(2"/min)	psi	5000
Elongation @ Break	ASTM D638	% minimum	750
Modulus of Elasticity	ASTM D638	Psi	130,000
ESCR			
(Cond A, B, C: Mold. Slab)	ASTM D1693	F_0, Hrs	F_0>5,000**
Compressed Ring (Pipe)	ASTM F1248	F_{50}, Hrs	F_{50}>3,500**
Slow Crack Growth	Battelle Method	Days to Failure	F_0>64
Impact Strength (IZOD) (.125" THK)	ASTM D256(Method A)	in-lb/in Notch	42
Linear Thermal Expansion Coef.	ASTM D696	in/in/^{0}F	1.2×10^{-4}
Thermal Conductivity	ASTM C177	BTU-in/Ft^2/hrs/^{0}F	2.7
Brittleness Temp.	ASTM D746	^{0}F	<-180
Vicat Soft Temp.	ASTM D1525	^{0}F	+257
Heat Fusion Cond.	---	psi @ ^{0}F	75 @ 400

This list of Typical Physical Properties is intended for basic characterization of the pipe, and does not represent specific determinations or specifications.

**Tests were discontinued because no failures and no indication of stress crack initiation.

***Average Melt Index Value with a standard deviation of 0.01.

2.1.2 Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high density ethylene/hexane copolymer PE 3408 polyethylene resin meeting the above physical properties and pipe performance requirements. The material shall be listed by the Plastics Pipe Institute in PPI TR-4 with a 73^0F hydrostatic design basis rating of 1600 psi and a 140^0F hydrostatic design basis rating of 800 psi. The PPI Listing shall be based on ASTM D2837 and PPI TR-3 testing and validation of samples of the pipe manufacturer's production pipe.

2.2 PIPE

2.2.1. HDPE Pipe

2.2.1.1. HDPE pipe shall be produced with nominal physical properties outlined in Paragraph 2.1.1 and to the dimensions and tolerances specified in ASTM F714. Pipe shall be inspected per industry accepted manufacturer standards for:

Diameter
Wall Thickness
Concentricity
Joint Length
Ovality
Toe-In
Overall Workmanship
Inspection on ID & 0D
Print Line

Pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions or other deleterious defects, and shall be identical in color, density, melt index and other physical properties throughout.

2.2.1.2 Pipe shall be in compliance with the physical and performance requirements of Paragraph 2.1.1.

2.2.1.3. Pipe sizes and types:

a. 4.5-in. outside diameter, DR 11, Driscopipe, or approved equal.
b. 12.75-inch outside diameter, DR 21, Driscopipe, or approved equal.
c. 24-inch outside diameter, DR 21, Driscopipe, or approved equal.

2.3 FITTINGS

2.3.1 Furnish shop fabricated HDPE fittings as shown on the Drawings or required by the work. Fittings shall be molded or custom fabricated and shall have the same pressure ratings and wall thicknesses, or greater, than the pipe connected thereto.

2.3.2 Furnish valves as detailed on drawings.

2.4 DUCTILE IRON PIPE AND FITTINGS

Ductile-iron pipe and fittings shall conform to the following requirements. Thickness class of pipe and rated working pressure shall be as specified herein or as shown on the Drawings. All ductile iron pipe shall be Standard Thickness Class 350 or heavier. All ductile iron pipe fittings shall be mechanical joint or flanged fittings, pressure class 350 or heavier.

2.4.1 Pipe Ductile-iron pipe shall conform to the requirements of ANSI/AWWA C150/A21.50, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids, and ANSI/AWWA C110/A21.10, Flanged Ductile-Iron Pipe with Threaded Flanges.

2.4.2 Fittings Ductile-iron pipe fittings shall conform to the requirements of ANSI/AWWA C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3-inch through 48-inch, for Water and Other Liquids, and ANSI/AWWA C153/A21.53, Ductile-Iron Compact Fittings, 3-inch through 12-inch, for Water and Other Liquids.

2.4.3 Joints Rubber-gasket joints for ductile-iron pipe and fittings where either mechanical or push-on joints are used shall conform to the requirements of ANSI/AWWA C111/A21.11, Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings. Unless otherwise specified or indicated on the Drawings, all buried joints shall be mechanical joints and all other joints shall be flanged.

2.4.4 Lining Interior lining for ductile-iron pipe and fittings shall conform to the requirements of ANSI/AWWA C104/A21.4, Cement Mortar Lining for Ductile-Iron Pipe and Fittings for Water. Unless otherwise specified, special fittings and appurtenances shall be the same material as the pipe.

2.5 CHECK VALVE

The check valve at the end of the discharge pipeline shall be a 12-inch diameter Valmatic Model 518 Swing-Flex, Milliken Model 851, or equal full body flanged type with a domed access cover and only one moving part, the valve disc. The valve shall be equipped with a backflush device to enable flushing out the valve with backward flow. The straight pipe length downstream of the check valve shall be at least three pipe diameters. The valve body shall have full flow equal to the nominal pipe diameter at any point through the valve. The seating surface shall be on a 45-degree angle to minimize disc travel. The top access port shall be full size, allowing removal of the disc without removing the valve from the pipeline. The access cover shall be domed in shape. The disc shall be of one-piece construction, precision molded with an integral Oh-ring type sealing surface and contain steel and nylon reinforcements in both the Memory-Flex and central disc areas. The flex portion of the disc shall be warranted for twenty-five years.

Non-slam closing characteristics shall be provided through a short 35-degree disc stroke and a Memory-Flex return action. The valve body and cover shall be ASTM A126, Class B cast iron. The disc shall be Buna-N (NBR), ASTM D2000-BG. The interior and exterior of the valve shall be coated with a fusion bonded epoxy. The valve shall be cycle tested 1,000,000 times with no sign of wear or distortion of the valve disc or seat and shall remain drop tight at both high and low pressures. The test results shall be independently certified. Bolts and nuts for the flanges shall be Type 316 stainless steel.

2.6 FLOWMETER

The flowmeter shall be a 12-in. Krohne Aquaflux or equal magnetic flowmeter with hard rubber lining, Hastelloy C electrodes, 150-lb ANSI flanged ends, IP67 rated, 316SS grounding rings, IFC020F integral signal converter, 115AC powered, NEMA 4X rated, digital display of rate and total. Install with the minimum upstream and downstream lengths of straight pipe required for proper operation (60 in. and 24 in., respectively, measured from the centerline of the meter).

2.7 CONTINUOUS WATER SAMPLER

The water sampler shall be an all-weather American Sigma 900 MAX refrigerated sampler, 115 VAC, with a 6-ft power cord and pump tube insert. It shall be equipped with a set of four 3-gallon polyethylene bottles, a distributor with arm (2/4 bottle, AWRS), and a 10-ft long multi-purpose half cable.

2.8 WIRELESS SIGNAL TRANSMISSION EQUIPMENT

Radio Telemetry (Wireless I/O) Unit. The radio telemetry unit shall accept discrete, pulse and analog signals from process transducers, and transmit these signal values by radio to another radio telemetry unit which shall output the signals either as identical signals or via a RS232/485 serial data link to a host device. The radio telemetry unit shall provide both input and output signals.

2.8.1 General: Each unit shall be fully integrated with in-built radio transceiver, power supply and on-board I/O. Additional I/O must be able to be added by RS485 serial connection.

2.8.2 The unit shall include a radio transceiver, able to transmit and receive. Units shall have both signal input and output channels.

2.8.3 The telemetry unit shall provide LED indications when the unit transmits a message and when it receives a message. It shall also provide LED indication of power supply status, "normal operation" status and the status of each discrete input or output signal.

2.8.4 The radio telemetry unit shall be housed in a strong non-corrosive metal enclosure, capable of withstanding harsh industrial environments.

2.8.5 The unit shall have plug-in removable terminal strips for ease of replacement. Wiring terminals shall be able to take up to 12 gauge wire.

2.8.6 The radio telemetry units shall operate reliably in a temperature range of –40 to 140 degrees F, and humidity 0 to 99% RH non-condensing.

2.8.7 Operation

2.8.7.1 The radio telemetry system shall operate using peer-to-peer communications. Any unit shall be able to communicate directly to another unit, and any unit shall be able to communicate directly with all other units. The system shall not require a master unit to control communications.

2.8.7.2 The radio telemetry system shall use an exception-reporting protocol with a self checking update or poll function. The time period of the update or poll shall be able to be configured individually for each input channel.

2.8.7.3 It shall be possible to configure each unit such that any input channel can be linked to any output channel on any unit. It shall be possible to link any input channel to multiple output channels. Radio messages shall not be transmitted for input channels that are not configured.

2.8.7.4 Each telemetry unit shall have a system address and a unit address. The system address is a common address used by all units in the same system. Only units with the same system address shall act on messages received from other units. The system address shall be at least 12-bit value. Each radio telemetry unit shall have a different unit address, so that each transmitted message is acted on only by the correct receiving unit. The maximum number of radio telemetry units or sites including expanded I/O in one system shall be at least 100.

2.8.7.5 The radio telemetry unit shall transmit a data frame comprising addressing, input values and error-check. The radio telemetry unit shall transmit the value of the input signal whenever the signal changes. The input value shall also be transmitted if the signal has not changed within a pre-configured update time. The update time shall be individually configurable for each input.

2.8.7.6 Before the telemetry unit transmits a message, it shall monitor the radio channel to ensure that another unit is not already transmitting a message.

If there is, then the unit shall wait until the other message has been completed.

2.8.7.7 When a telemetry unit receives a message with a valid system address, unit address and error-check, it shall transmit back an acknowledgment message to the transmitting unit.

2.8.7.8 If a transmitting unit does not receive an acknowledgement within 100 msec, it shall re-transmit the message using a different radio frequency. The unit shall continue to re-try to send the message up to five times until it receives an acknowledgment. If an acknowledgement is still not received after the fifth attempt, then the transmitting telemetry unit shall provide an output signal as a "communications failure alarm". A communications failure alarm shall not stop the unit from transmitting other messages.

2.8.7.9 On start-up, the telemetry unit shall transmit the current values of input signals according to the configuration of the unit. It shall also send a start-up message to request immediate messages from remote units so that it can set its outputs to the correct values.

2.8.7.10 Each radio telemetry unit shall be able to act as a repeater unit for other units. If a unit receives a message with its unit address listed as a unit address, then it shall acknowledge the message, and re-transmit the message onto the next address in the data frame. It shall be possible to configure up to five (5) intermediate repeater addresses for any message. Configuration of repeater addresses shall be performed at the transmitting unit, such that radio routing may be reconfigured without having to visit or modify the repeater units.

2.8.7.11 Repeater units shall also be able act as normal radio telemetry units in every way.

2.8.8 Radio Transmitter

2.8.8.1 The radio telemetry unit shall have a 902 – 928 MHz, 1W Spread Spectrum Frequency Hopping integral transceiver.

2.8.8.2 Transmitter performance shall meet FCC Part 15 Class A and Part 15.247 such that the radio telemetry unit can be used under license-free conditions. A type test report to this specification must be available from an independent accredited test house.

2.8.8.3 Data shall be transmitted at a data rate of at least 19200 baud.

2.8.8.4 Discrete Inputs

2.8.8.4.1 The radio telemetry unit shall connect to at least four discrete inputs, which are voltage free contacts or NPN transistor signals. Additional I/O may be added to increase the number of discrete inputs to at least 256 inputs.

2.8.8.4.2 The telemetry unit shall provide a sensing voltage for the input circuits of at least 12VDC, with a contact wetting current of at least 5mA.

2.8.8.4.3 When the discrete signal changes, the radio telemetry unit shall immediately transmit the signal value. The discrete inputs shall have an input "debounce" delay to prevent multiple transmissions in the event of "contact bounce". The debounce time must be configurable between 0.1 second and 8 seconds.

2.8.8.4.4 Discrete inputs must have opto-isolation of at least 5000 volts.

2.8.8.4.5 The telemetry unit shall be able to be configured to transmit the inversion of any discrete input, such that an "off" input shall be output as "on" and vice-versa.

2.8.8.4.6 The telemetry unit shall provide a LED indication of the status of each input.

2.8.8.5 Discrete Outputs

2.8.8.5.1 The radio telemetry unit shall provide at least four discrete outputs, which are either relay contacts or transistor signals capable of driving external relays. Additional I/O may be added to increase the number of discrete outputs to at least 256 outputs.

2.8.8.5.2 Where outputs are transistor outputs, a voltage supply of at least 12VDC shall be provided to drive external relays.

2.8.8.5.3 Discrete outputs must be able to be configured to reset if the telemetry unit has not received a message within a certain time. The reset time must be able to be configured to at least twice the value of the update time of the input linked to the output. The output must be also able to be configured to not reset and remain in its last correct state.

2.8.8.5.4 The telemetry unit shall provide a LED indication of the status of each input.

2.8.8.6 Analog Inputs

2.8.8.6.1 The radio telemetry unit must provide at least two 4-20mA inputs, with expansion capability up to 128 analog inputs. Each analog input must be able to measure within the range 2 – 22 mA to provide over- and under-range indication.

2.8.8.6.2 The analog input must have at least 12 bit resolution and overall accuracy <0.1%.

2.8.8.6.3 The analog value shall be continuously measured and transmitted on change of input signal or time elapsed since last transmission. At each transmission, the telemetry unit shall transmit the last measured value to its best resolution and accuracy. The change sensitivity to initiate a "change" transmission shall be configurable from 0.8 to 50%.

2.8.8.6.4 At least one analog input shall have two configurable setpoint values which shall control an internal setpoint status. When the analog input is higher than the high setpoint, the setpoint status shall be active (on). When the analog value is less than the low setpoint, then the setpoint status shall reset (off).

2.8.8.6.5 The internal setpoint status shall be treated as another discrete input, with all of the properties of external discrete inputs. The telemetry unit shall be able to transmit the setpoint status as well as its corresponding analog input.

2.8.8.6.6 The telemetry unit shall provide a 24VDC regulated power supply to power analog loops. This power supply shall have sufficient capacity to drive all analog inputs and outputs at 20mA.

2.8.8.6.7 The telemetry unit shall be able to be configured to transmit the inversion of the analog input, such that an input of 0% shall be output as 100% and vice-versa.

2.8.8.7 Analog Outputs

2.8.8.7.1 The radio telemetry unit must provide at least two 4-20mA outputs, with output expansion capability up to 128 analog outputs. Each analog output must be within the range 2 – 22 mA to provide over- and under-range indication.

2.8.8.7.2 The analog output must have at least 12 bit resolution and overall accuracy <0.1%.

2.8.8.7.3 Analog outputs must be able to be configured to reset if the telemetry unit has not received a message within a certain time. The reset time

must be able to be configured to at least twice the value of the update time of the input linked to the output. The output must be also able to be configured to not reset and remain in its last correct state.

2.8.8.8 Pulse Signals

2.8.8.8.1 The radio telemetry unit must accept at least one pulse input and output signal, with I/O expansion possible up to at least 64 pulse inputs and outputs.

2.8.8.8.2 Pulse I/O must be capable of operating up to 100Hz with a 5 msec on-time. The pulse I/O must be capable of operating at any frequency less than 100 Hz, with a minimum 5msec on-time or off-time.

2.8.8.8.3 Pulse inputs shall be counted by the radio telemetry unit, and only the accumulated pulse count shall be transmitted to avoid loss of counts during periods of radio interference. The input count shall be transmitted at a regular period that shall be configurable. The pulse counter shall be at least a 16 bit value.

2.8.8.8.4 For pulse outputs, the telemetry unit shall retain two count values - a count of actual output pulses, and the count of input pulses received on the radio. When a new input count is received, the telemetry unit shall output pulses at a constant rate over a pre-configured time period. such that at the end of the period, the output count shall be the same as the input count.

2.8.8.8.5 The telemetry unit shall be able to handle counter "roll-over" situations.

2.8.8.8.6 For pulse inputs, the telemetry unit must be able to calculate the pulse rate as well as accumulate the pulse count. The pulse rate shall be treated as an internal analog value, with 100% (or 20mA) corresponding to a pre-configured pulse rate value. For example, if the calculated pulse rate is 1Hz, and the configured maximum pulse rate is 2Hz, then the pulse rate shall be deemed to have a analog value of 50% or 12mA in the 4-20mA range. The pulse rate must be able to be transmitted to a remote analog output in the same way as an external analog input.

2.8.8.9 Power Supply

2.8.8.9.1 The radio telemetry unit shall be able to be powered from a 12 – 30VDC supply or a 12 – 24VAC supply.

2.8.8.9.2 The radio telemetry unit shall provide an internal battery charger to float charge a 12 volt sealed lead acid battery of up to 12 amp-hours at the "10-hour" rate.

2.8.8.9.3 The radio telemetry unit shall provide an internal solar regulator that shall be capable of connecting directly to a 12V solar panel of up to 30W, and a battery of up to 100 amphours.

2.8.8.9.4 If the battery voltage drops to less than 11.0 volts, then the telemetry unit shall automatically shut-down all operations except for battery-charging operations. The telemetry unit shall not start-up again until the battery voltage increases above 12.0 volts.

2.8.8.9.5 The telemetry unit shall provide LED indications of main power supply health and normal unit operation.

2.8.8.9.6 The telemetry unit shall provide internal status of incoming main supply and low battery voltage. The telemetry unit shall treat the main supply status and the low battery voltage status as internal inputs, and shall be able to transmit them in the same manner as externally connected discrete inputs.

2.8.8.9.7 The telemetry unit shall provide a measurement of the battery voltage as an internal analog input, and shall treat this in the same way as an externally connected analog input. The battery voltage analog input shall be 4mA when the battery voltage is 8VDC, and 20mA for 16VDC.

2.8.8.10 Serial Ports. The radio telemetry unit must provide a RS232 port (9600 baud, full duplex) and a RS485 port (9600 baud, half-duplex) for connection to host devices or I/O expansion devices or for configuration and diagnostics.

2.8.8.11 I/O Provision

2.8.8.11.1 Each radio telemetry unit shall provide at least 12 I/O channels for economic pricing.

2.8.8.11.2 I/O expansion units must be available to extend I/O counts. The I/O expansion units shall connect to the radio telemetry unit via the serial ports. At least 15 expansion units must be able to connect to each radio telemetry unit.

2.8.8.11.3 The I/O expansion units and radio telemetry unit must be able to be interconnected by RS485 such that the units are separated over a 1mile multi-drop cable.

2.8.8.12 Configuration

2.8.8.12.1 Configuration shall be performed using a PC (or a laptop computer) connected to the unit via the RS232 port, or using on-board configuration switches or keypad. Configuration by PC shall be the normal method of configuration, however it shall also be possible to configure all functions without a PC.

2.8.8.12.2 Configuration software shall be able to operate under the latest version of Microsoft Windows operating system.

2.8.8.12.3 The PC configuration software shall allow the user to create a new configuration file; to upload the configuration from the radio telemetry unit to view or edit; and to download a configuration file into the radio telemetry unit.

2.8.8.12.4 Each input of the radio telemetry unit must be able to be mapped (or linked) to any output at any telemetry unit in the system, including its own unit. It shall be possible to map one input several times to different outputs. Each mapping shall be treated separately and transmitted as a separate message.

2.8.8.12.5 If an input is not configured, then the telemetry unit shall not transmit any messages for this input.

2.8.8.13 Interface to External Systems

2.8.8.13.1 A Modbus interface unit (MIU) shall be available to interface to external systems such as PLC's, DCS, SCADA computers etc.

2.8.8.13.2 The MIU shall have an integral radio transceiver and shall be able to communicate with at least 500 radio telemetry units.

2.8.8.13.3 The MIU shall communicate with external Modbus devices via RS232 and RS485. The serial ports shall be able to be configured for various standard data rates between 1200 and 19200 baud, and for various character types including 7 or 8 bit; even, odd or no parity; and 1 or 2 stop bits.

2.8.8.13.4 The MIU shall keep an internal process image of up to 4800 I/O points. The MIU shall be able to communicate in both directions.

Input signals at remote radio telemetry units shall be able to be transmitted to the MIU and be passed onto external Modbus devices. Output signals from external Modbus devices shall be able to be passed to the MIU, which shall transmit the output signals to remote telemetry units. The MIU shall transmit change messages and update messages for its configured I/O points in the same way as a radio telemetry unit.

2.8.8.13.5 The MIU shall keep a communications normal/fail status for each I/O point in its process image.

2.8.8.13.6 The MIU shall be able to act as a Modbus master unit and a Modbus slave unit. If configured as a Modbus master unit, the polling rate and command types for external Modbus slave devices shall be configurable.

2.8.8.13.7 Several MIU's shall be able to be configured into any one radio telemetry system. MIU's shall be able to communicate with each other by radio as well as radio telemetry units.

2.8.8.13.8 An MIU shall be able to act as a radio repeater between radio telemetry units.

2.8.8.14 Diagnostics

2.8.8.14.1 The telemetry unit shall provide diagnostic features to help identify problems.

2.8.8.14.2 The telemetry unit shall provide a display of the measured input signals in the radio telemetry unit. It shall also provide a facility to set discrete and analog outputs to any value for testing.

2.8.8.14.3 The telemetry unit shall provide a display of the actual telemetry messages being transmitted and received. It shall also indicate whether these messages are "OK" according to the error-check, or corrupted.

2.8.8.14.4 The telemetry unit shall provide a feature of continually transmitting a "one-zero" data string such that the radio transmitter may be tested.

2.8.8.14.5 The telemetry unit shall provide a display of the measured radio signal being received. This measurement shall be of the demodulated data signal. It shall be possible to take a measurement of both the noise on the radio channel and a transmitted message. The measurement shall be continually updated on the display.

3.0 EXECUTION

3.1 HDPE PIPE PREPARATION

3.1.1 Inspect pipe and fittings prior to assembly. Mark and remove from the job site all materials that are damaged or do not meet the specifications.

3.1.2 Sections of pipe with cuts or gouges in excess of ten percent of the wall thickness of the pipe shall be cut out and removed.

3.1.3 Confirm location of pipe, fittings and connections.

3.2 HDPE PIPE INSTALLATION - GENERAL

3.2.1 Install pipe to the lines indicated on the Drawings.

3.2.2 Handle and install pipe in accordance with the manufacturer's recommendations.

3.2.3 Joining

3.2.3.1 Butt heat fusion weld the joints in strict accordance with the manufacturer's instructions. The butt fusion equipment shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400^0F, alignment and 75 psi interfacial fusion pressure.

3.2.3.2 Joint weld strength shall be equal to or greater than the tensile strength of the pipe.

3.2.3.3 Socket fusion shall not be used.

3.3 LAYING AND BEDDING THE DUCTILE IRON PIPE

3.3.1 Pipe shall be installed to the lines and grades shown on the Drawings with bell socket ends aligned upstream unless otherwise specified. The pipe shall be installed in accordance with the manufacturer's recommendations, unless otherwise specified. Two copies of the Ductile Iron Pipe manufacturer's installation instructions shall be provided to The Owner before any pipe placement.

3.3.2 The pipe shall be firmly and uniformly bedded within the trench throughout the entire length of the pipe section to the depth and in the manner specified. Bell holes for flanged, push-on, or mechanical joint pipe shall be provided as necessary to allow space for joint assembly and to permit the pipe barrel to be uniformly supported on the bedding.

3.3.3 Joints and Connections: Pipe joints shall be mechanical joints and shall be sound and watertight at a pressure of 80 psi. The openings in the slab on grade base for the utility shelter shall be sleeved with a steel or PVC pipe between 2 and 4 inches larger than the outside diameter of the ductile iron pipe and the annulus filled with mastic or other approved material. Install underground piping with restrained joints at horizontal and vertical changes in direction. Where ductile iron pipe or fittings are connected to HDPE pipe, mechanical joint adapters shall be fused to the HDPE pipe (Driscopipe 4000 Series or equal).

3.3.4 Thrust Restraint - Plugs, caps, tees, wyes and bends deflecting 11.25 degrees or more, either vertically or horizontally shall be provided with thrust restraints. Valves shall be securely anchored or shall be provided with thrust restraints to prevent movement. Thrust restraints shall be restrained joints or concrete thrust blocks as detailed on the drawings..

3.4 HANDLING THE PIPE.

The contractor shall furnish all equipment and facilities needed to handle, store, and place the pipe without damaging the pipe, lining, or coating. Pipe coating or lining that is damaged shall be repaired using methods recommended by the manufacturer unless otherwise specified herein.

3.5 PRESSURE TESTING

Pressure testing of the conduit shall be conducted as follows:

3.5.1 Placement of backfill before pressure testing shall be as specified in the section on backfill.

3.5.2 Before pressure testing, the pipeline shall be flushed and free of all foreign material.

3.5.3 The pipeline shall not be pressure tested until concrete for anchor and thrust blocks has attained the minimum specified compressive strength unless other specified methods of thrust restraint are provided.

3.5.4 The total pipeline or continuous section of pipeline to be tested shall be filled wi. clean water at a rate not to exceed the maximum specified and tested at 80 psi.

3.5.5 The section of pipeline being tested shall be allowed to stand full of water for a minimum of 24 hours before the start of pressure and leakage tests. Test pressures shall be held constant for 2 hours. When the amount of water loss exceeds the maximum allowable loss specified, the leak(s) shall be repaired or otherwise corrected and the pipeline shall be re-tested. The testing procedure shall be repeated until the requirements of the Specifications are met.

3.5.6 Except for joint material setting or where concrete thrust blocks necessitate a 5-day delay, pipelines jointed with rubber gaskets, mechanical or push-on joints, or couplings may be subjected to hydrostatic pressure, inspected, and tested for leakage at any time after partial completion of backfill. Cement-mortar lined pipe may be filled with water as recommended by the manufacturer before being subjected to the pressure test and subsequent leakage test.

3.6 LEAKAGE TEST

3.6.1 The leakage test shall be conducted after the pressure tests have been satisfactorily completed. The duration of each leakage test shall be at least 2 hours, and during the test the water line shall be subjected to not less than 80 psi pressure. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved or approved section, necessary to maintain pressure within 1 psi of the specified leakage test pressure after the pipe has been filled with water and the air expelled. Piping installation will not be accepted if leakage exceeds the allowable leakage which is determined by the following formula:

$$L = 0.0001351(N)(D)P^{0.5}$$

L = Allowable leakage in gallons per hour

N = Number of joints in the length of pipeline tested

D = Nominal diameter of the pipe in inches

P = Average test pressure during the leakage test, in psi gauge

Should any test of pipe disclose leakage greater than that calculated by the above formula, the defective joints shall be located and repaired until the leakage is within the specified allowance, without additional cost to the Owner.

The contractor shall be fully responsible for any and all work required to correct any leakage when the leakage test results in water loss that exceeds the amount specified herein.

3.7 EXCAVATION AND BACKFILL

3.7.1 All earth excavated from the trench for the pipeline outside of the barrier wall shall be considered to be contaminated and shall be loaded and hauled to the the temporary spoil stockpile. Within the barrier wall, excavated earth may be used as backfill above the sand bedding.

3.7.2 Sand bedding shall be imported uncontaminated sand, shall be placed to the grades shown on the Drawings, and shall be compacted to at least 85% of the

maximum density sand bedding shall be sand with a maximum of 10% passing the U.S. Standard No. 200 sieve. Flooding may be used to compact the bedding layer if it can be demonstrated that the required degree of compaction is attained.

3.7.3 Initial backfilling shall be accomplished only in sufficient amount to hold the pipeline in place during testing, with the following exceptions:

3.7.3.1 Compacted backfill shall be placed to its final depth as shown on the Drawings at vertical and horizontal deflection points, road crossings, and thrust blocks. Backfill shall be placed such that pipe and joint displacement does not occur.

3.7.3.2 All joints and connections shall be completely exposed for visual observation during testing, except at locations described in the exception above.

3.7.4 Backfill above the sand bedding shall be compacted sufficiently so that it will not settle under its own weight.

3.8 GROUT

The annulus between the 24-in. OD HDPE pipe and the 30-in. ID reinforced concrete pipe shall be grouted under the levee as shown on the drawings. The grout mix and a detailed grouting procedure shall be submitted to the Owner for approval. Centering spacers at 90-degree intervals on a 20-ft maximum horizontal spacing shall be used to center the 24-in. OD pipe within the 30-in. ID pipe prior to grouting. Contractor shall submit details of the spacers to the Owner for approval.

END OF SECTION

SECTION 02900

SITE RESTORATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Topsoil.
   2. Finish grading.
   3. Seeding.
   4. Fertilizing.
   5. Removal of construction wastes.

1.2 SUBMITTALS

A. Material test reports from qualified independent testing agency indicating and interpreting test results relative to compliance of the following materials with requirements indicated.
   1. Topsoil.
   2. Seed mixture.
   3. Fertilizer analysis.

B. Materials Source. Submit name, telephone number, and address of imported materials suppliers. Provide location map for source of topsoil.

C. Provide materials from same source throughout the work. Change of source requires the Owner approval.

D. Means, methods and location of disposal of construction wastes and general trash.

1.3 DELIVERY, STORAGE AND HANDLING

A. Storage.
   1. Prior to stockpiling topsoil at source for loading and delivery to the Site, treat growing vegetation with application of appropriate specified non-selective herbicide.
   2. Treat when foliage is 6 to 10 inches high and approximately 4 to 6 weeks prior to stockpiling.

PART 2 - PRODUCTS

2.1 TOPSOIL MATERIALS

A. General: Provide approved topsoil from off-site.

B. Topsoil: ASTM D 5268, fertile, friable, naturally sandy loam, pH range of 5.5 to 7, 4 percent organic material minimum, free of stones 1 inch (25 mm) or larger in any dimension, and other extraneous materials harmful to plant growth. Obtain imported topsoil from naturally well drained sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from bogs or marshes.

C. Tests and sampling of imported topsoil.

1. Sampling by Contractor: Test shall include the following:
   a. Routine test, plus:
   b. pH.
   c. Mineral and plant nutrient content.
   d. Organic matter.
   e. Soluble salts.
   f. Mechanical analysis.
   g. Report suitability of topsoil for growth of applicable planting material. State recommended quantities of nitrogen, phosphorus, and potash nutrients and any limestone, aluminum sulfate, or other soil amendments to be added to produce a satisfactory topsoil.
2. Do not strip topsoil until source is approved by the Owner.

2.2 SEED

A. Seed shall be a commercially available mix of Kentucky bluegrass, fescue, perennial and annual rye grasses.

2.3 FERTILIZER

A. Fertilizer shall be a commercially mix suitable for application where new seed is to be placed.

PART 3 - EXECUTION

3.1 STOCKPILING

A. Stockpile materials on site where designated by the Owner.

B. Stockpile in sufficient quantities to meet project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.2 FINISH GRADING

A. Remove all temporary dams and other temporary structures.

B. Remove all rubbish and other construction wastes. Haul off site to disposal area approved by the Owner.

C. Fill all temporary excavations and slurry pits not otherwise filled with material from adjacent pits with topsoil.

D. Regrade site to march original pre-construction elevations and drainage patterns. Grade site surface to prevent free standing surface water.

3.3 SEED APPLICATION

A. Apply seed at rates specified by supplier.

B. Seed shall be applied during growing season unless otherwise approved by the Owner.

3.4 FERTILIZER APPLICATION

A. Apply fertilizer at rates specified by supplier.

3.5 CONSTRUCTION WASTES AND GENERAL TRASH

A. Maintain separate disposal areas for construction generated wastes and general trash; including, but not limited to construction material delivery packaging, discarded personal protective equipment and lunchroom type wastes. Do not mix with spoils and other materials generated by barrier wall and other construction.

3.6 STOCKPILE CLEANUP

A. Remove stockpile, leave area in a clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 02920

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Galvanized steel chain-link fabric.
   2. Galvanized steel framework.

1.2 SUBMITTALS

A. Product Data: Material descriptions, construction details, dimensions of individual components and profiles, and finishes for the following:
   1. Fence and gate posts, rails, and fittings.
   2. Chain-link fabric, reinforcements, and attachments.
   3. Gates and hardware.

B. Shop Drawings: Show locations of fence, each gate, posts, rails, and tension wires and details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, elevations, sections, gate swing and other required installation and operational clearances, and details of post anchorage and attachment and bracing.

C. Product Certificates: Signed by manufacturers of chain-link fences and gates certifying that products furnished comply with requirements.

D. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses.

E. Field Test Reports: Indicate and interpret test results for compliance of chain-link fence and gate grounding and bonding with performance requirements.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed chain-link fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations for Chain-Link Fences and Gates: Obtain each color, grade, finish, type, and variety of component for chain-link fences and gates from one source with

resources to provide chain-link fences and gates of consistent quality in appearance and physical properties.

1.4 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Owner not less than 7 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's written permission.

B. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

A. Steel Chain-Link Fence Fabric: Height indicated on Drawings. Provide fabric fabricated in one-piece widths for fencing in height of 12 feet and less. Comply with CLFMI's "Product Manual" and with requirements indicated below:

1. Mesh and Wire Size: 2-inch mesh, 0.192-inch diameter.
2. Zinc-Coated Fabric: ASTM A 392, with zinc coating applied to steel wire before weaving according to ASTM A 817, Type II, zinc coated (galvanized)] with the following minimum coating weight:
   a. Class 2: Not less than 2 oz./sq. ft. of uncoated wire surface.
3. Coat selvage ends of fabric that is metallic coated during the weaving process with manufacturer's standard clear protective coating.

B. Selvage: Knuckled at both selvages.

2.2 INDUSTRIAL FENCE FRAMING

A. Round Steel Pipe: Standard weight, Schedule 40, galvanized steel pipe complying with ASTM F 1083. Comply with ASTM F 1043, Material Design Group IA, external and internal coating Type A, consisting of not less than 1.8-oz./sq. ft. zinc; and the following strength and stiffness requirements:

1. Line, End, Corner, and Pull Posts and Top Rail: Per requirements for Light Industrial Fence.

B. Post Brace Rails: Match top rail for coating and strength and stiffness requirements. Provide brace rail with truss rod assembly for each gate, end, and pull post. Provide two brace rails extending in opposing directions, each with truss rod assembly, for each corner post and for pull posts. Provide rail ends and clamps for attaching rails to posts.

C. Top Rails: Fabricate top rail from lengths 21 feet or longer, with swedged-end or fabricated for expansion-type coupling, forming a continuous rail along top of chain-link fabric.

D. Intermediate Rails: Match top rail for coating and strength and stiffness requirements.

2.3 TENSION WIRE

A. General: Provide horizontal tension wire at the following locations:
   1. Location: Extended along bottom of fence fabric.

B. Metallic-Coated Steel Wire: 0.177-inch-diameter, marcelled tension wire complying with ASTM A 824 and the following:
   1. Coating: Type II, zinc coated (galvanized) by the hot-dip process, with the following minimum coating weight:
      a. Matching chain-link fabric coating weight.

2.4 INDUSTRIAL SWING GATES

A. General: Comply with ASTM F 900 for the following swing-gate types:
   1. Single gate.

B. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1083 and ASTM F 1043 for materials and protective coatings.

C. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F 900 for the following gate fabric height:
   1. Gate Fabric Height: 6 feet.

D. Frame Corner Construction: As follows:
   1. Welded.

E. Gate Posts: Fabricate members from round galvanized steel pipe with outside dimension and weight according to ASTM F 900.

2.5 FITTINGS

A. General: Provide fittings for a complete fence installation, including special fittings for corners. Comply with ASTM F 626.

B. Post and Line Caps: Hot-dip galvanized pressed steel. Provide weathertight closure cap for each post.
   1. Provide line post caps with loop to receive top rail.

C. Rail and Brace Ends: Hot-dip galvanized pressed steel. Provide rail ends or other means for attaching rails securely to each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:
   1. Top Rail Sleeves: Hot-dip galvanized pressed steel. Not less than 6 inches long.
   2. Rail Clamps: Hot-dip galvanized pressed steel. Provide line and corner boulevard clamps for connecting intermediate rails in the fence line to line posts.

E. Tension and Brace Bands: Hot-dip galvanized pressed steel.

F. Tension Bars: Hot-dip galvanized steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Hot-dip galvanized steel rod and turnbuckle or other means of adjustment.

H. Tie Wires, Clips, and Fasteners: Provide the following types according to ASTM F 626:
   1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
      a. Hot-Dip Galvanized Steel: 0.148-inch-diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.
   2. Round Wire Hog Rings: Hot-dip galvanized steel or aluminum for attaching chain-link fabric to horizontal tension wires.

2.6 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
   1. Material Above Finished Grade: Copper.
   2. Material On or Below Finished Grade: Copper.
   3. Bonding Jumpers: Braided copper tape, 1 inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Ground Rods: Listed in UL 467.
   1. Connectors for Below-Grade Use: Exothermic welded type.
   2. Ground Rods: Copper-clad steel.
      a. Size: 5/8 inch by 96 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance.

1. Do not begin installation before final grading is completed, unless otherwise permitted by the Owner.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

A. General: Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed or compacted soil.

C. Post Setting: Hand-excavate holes for post foundations in firm, undisturbed or compacted soil. Set terminal, line and gate posts in concrete footing. Protect portion of posts aboveground from concrete splatter. Place concrete around posts and vibrate or tamp for consolidation. Using mechanical devices to set line posts per ASTM F 567 is not permitted. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during placement and finishing operations until concrete is sufficiently cured.

1. Dimensions and Profile: As indicated on Drawings.
2. Exposed Concrete Footings: Extend concrete 2 inches above grade, smooth, and shape to shed water.

3.4 CHAIN-LINK FENCE INSTALLATION

A. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment.

B. Line Posts: Space line posts uniformly at 10 feet maximum o.c.

C. Post Bracing Assemblies: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts. Locate horizontal braces at midheight of fabric on fences with

top rail and at two-thirds fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

D. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric.

   1. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same gage and type of wire.

E. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended by fencing manufacturer.

F. Intermediate Rails: Install in one piece at post-height center span, spanning between posts, using fittings, special offset fittings, and accessories.

G. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

H. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.

I. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.

   1. Maximum Spacing: Tie fabric to line posts 12 inches o.c. and to braces 24 inches o.c.

J. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.

3.5 GATE INSTALLATION

A. General: Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.6 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
   a. Gates and Other Fence Openings: Ground fence on each side of opening.
      1) Bond metal gates to gate posts.
      2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Grounding Method: At each grounding location, drive a ground rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:

1. Each Barbed Wire Strand. Make grounding connections to barbed wire with wire-to-wire connectors designed for this purpose.
2. Each Barbed Tape Coil: Make grounding connections to barbed tape with connectors designed for this purpose.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

F. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.7 FIELD QUALITY CONTROL

A. Ground-Resistance Testing Agency: Engage a qualified independent testing agency to perform field quality control testing.

B. Ground-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure ground resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by two-point method according to IEEE 81.

C. Desired Maximum Grounding Resistance Value: 25 ohms.

D. Excessive Ground Resistance: If resistance to ground exceeds desired value, notify The Owner promptly. Include recommendations to reduce ground resistance and proposal to accomplish recommended work.

E. Report: Prepare test reports, certified by testing agency, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results.

3.8 ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free from binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train the Owner's personnel to adjust, operate, and maintain gates.

1. Test and adjust hardware, and other operable components. Replace damaged or malfunctioning operable components.

END OF SECTION

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section specifies cast-in place concrete, including formwork, reinforcement, concrete materials, mix design, placement procedures, finishes, curing, and metal anchor requirements for placement in concrete.

1.3 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Design Mixes: For each concrete mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mix water to be withheld for later addition at Project site.

C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

1. Cementitious materials and aggregates.
2. Form materials and form-release agents.
3. Steel reinforcement and reinforcement accessories.
4. Admixtures.
5. Curing materials.
6. Joint materials.

D. Steel Reinforcement Shop Drawings: Submit original reinforcement shop drawings, prepared by a registered Professional Engineer in the State of Illinois, for fabrication, bending, and placement of reinforcement for concrete. Comply with ACI 315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures". Include bar schedules; diagrams of bent bars; number, type, spacing

and location of bars within structures; and all information necessary for complete fabrication and placement of all reinforcing steel and bar supports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the State of Illinois and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for reinforcement, formwork and shoring installations that are similar to those indicated for this Project in material, design, and extent.

C. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

E. ACI Publications: Comply with the following, unless more stringent provisions are indicated:

1. ACI 301, "Specification for Structural Concrete."
2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle steel reinforcement to prevent bending and damage.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

C. Form Ties: Factory-fabricated, removable or snap-off metal or glass-fiber-reinforced plastic form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that will leave no corrodible metal closer than 1 inch to the plane of the exposed concrete surface.
2. Furnish ties that, when removed, will leave holes not larger than ¼-in diameter in concrete surface.

D. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch minimum.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615, Grade 60, deformed.
B. All reinforcing bars to have lap distance of no less than 54 inches.

2.3 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete.

2.4 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type II.

1. Fly Ash: ASTM C 618, Class C or F.

B. Normal-Weight Aggregate: ASTM C 33, uniformly graded, and as follows:

1. Class: Severe weathering region, but not less than 4S.
2. Nominal Maximum Aggregate Size: 1-1/2 inches.

C. Water: Potable and complying with ASTM C 94.

2.5 ADMIXTURES

A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride.

B. Air-Entraining Admixture: ASTM C 260.

C. Water-Reducing Admixture: ASTM C 494, Type A.

D. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

E. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

2.6 JOINT MATERIALS

A. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

2.7 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

2.8 CONCRETE MIXES

A. Prepare design mixes for each type and strength of concrete determined by either laboratory trial mix or field test data bases, as follows:

1. Proportion normal-weight concrete according to ACI 211.1 and ACI 301.

B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the laboratory trial mix basis.

C. Concrete: Proportion normal-weight concrete mix as follows:

1. Compressive Strength (28 Days): 4000 psi unless noted otherwise on the drawings.
2. Maximum Slump: 4 inches.

3. Maximum Water-Cementitious Materials Ratio: 0.40 for corrosion protection of steel reinforcement in concrete exposed to chlorides from deicing chemicals or salt, saltwater, or brackish water.

D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement in concrete as follows:

1. Fly Ash: 25 percent.

E. Air Content: Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content as follows within a tolerance of plus or minus 1.5 percent:

1. Air Content: 5.5 percent for 1-1/2-inch nominal maximum aggregate size.

F. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

G. Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use water-reducing admixture in concrete, as required, for placement and workability.
2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use water-reducing admixture in pumped concrete and concrete with a water-cementitious materials ratio below 0.50.

2.9 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.10 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, erect, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until concrete structure can support such loads.

B. Construct formwork so concrete is of size, shape, alignment, elevation, and position indicated in Drawings, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
   1. Class B, 1/4 inch.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Chamfer exterior corners and edges of permanently exposed concrete.

G. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

H. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

I. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 REMOVING AND REUSING FORMS

A. Formwork may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete provided concrete is hard enough to not be damaged by form-removal operations and provided curing and protection operations are maintained.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable. Apply new form-release agent.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

3.4 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

1. Place joints as shown on project drawings. Do not continue reinforcement across construction joints.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork and reinforcement is complete and that required inspections have been performed.

B. Before placing concrete, water may be added at Project site, subject to limitations of ACI 301.

C. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

D. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators, unless otherwise specified and approved in mix designs.

E. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows, when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 FINISHING FLOORS AND SLABS

A. General: Comply with recommendations in ACI 302.1R for screening, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Broom Finish: Apply a broom finish to slabs.

1. Immediately after float finishing, slightly roughen surface by brooming with fiber-bristle broom.

3.6 CONCRETE PROTECTION AND CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with recommendations in ACI 305R for hot-weather protection during curing.

B. Formed Surfaces: Cure formed concrete surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing by one or a combination of the methods outlined for unformed surfaces:

C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: The Owner will engage a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include those specified in this Article.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 50 cu. yd. or fraction thereof of each concrete mix placed each day.
2. Slump: ASTM C 143; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
5. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
6. Compression Test Specimens: ASTM C 31; cast and laboratory cure one set of four standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C 39; test one laboratory-cured specimens at 7 days and two at 28 days. One specimen is to be laboratory-cured, held, and tested if necessary at the direction of the Owner.

   a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at age indicated.

C. Strength of each concrete mix will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-and 28-day tests.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, or other requirements have not been met, as directed by Engineer.

3.8 EMBEDDED ITEMS

A. Place and secure anchors as shown on project drawings. Anchors are to be installed in accordance with manufacture's instructions, diagrams, and directions furnished with anchors. Anchors are designed to be installed in cured concrete.

END OF SECTION

SECTION 13500

PIEZOMETERS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section covers furnishing and installing temporary and permanent piezometers, including both open standpipe and vibrating wire, to monitor groundwater. This section also includes the terminal apparatus and portable readout devices required for manual operation of the instruments.

1.2 REFERENCE STANDARDS

A. ASTM C 33: Specification for Concrete Aggregates

B. ASTM D 1586: Test Method for Penetration Test and Split-Barrel Sampling of Soils

C. ASTM D2487: Classification of Soils for Engineering Purposes

1.3 SUBMITTALS

A. Submit a plan showing the proposed drilling and installation equipment and methods.

B. Submit manufacturer's product data for approval at least 10 days before delivery to the site.

C. As-Built Drawings – Within five (5) workdays of installing each piezometer, submit As-Built Drawings showing the exact installed location, the instrument type and identification number (if applicable), and the installation date and time. Accurately record top elevation and as-built geometry of each piezometer following installation and prepare a boring log at each piezometer location using a drill rig to obtain the proper depth. Include details of installed piezometers, instrument calibrations, accessories and protective measures including all dimensions and materials used. Amend project drawings during construction to reflect changes in piezometer installations, as approved by the Owner.

D. Operation and Maintenance Manuals for all equipment (two copies each).

E. Manufacturer's warranty for all vibrating wire piezometers and readout units within two (2) workdays of receipt of the instrument.

1.4 DELIVERY, HANDLING, STORAGE, AND MAINTENANCE

A. All materials shall arrive at the site undamaged and shall be stored indoors, in a clean, dry, and secure area. Instruments shall not be exposed to temperatures outside the manufacturer's stated working temperature range. Any instruments or materials damaged by mishandling will be rejected by the Owner for use and shall be replaced at the Contractor's expense.

B. Maintain all instrumentation installations in progress and all completed instrumentation installations. Immediately repair or replace, as deemed necessary by the Owner, any damage to installations in progress, or installations completed.

PART 2 PRODUCTS

2.1 MATERIALS

A. Covers - Provide covers for piezometers as shown on the Drawings.

B. Piezometer Backfill Sand: Conform with ASTM C 33 specification for fine aggregates with a maximum of 5 percent passing the 200 sieve.

C. Piezometer Backfill Bentonite: Bentonite pellets shall have ½-inch diameter and a dry bulk density of 82 pounds per cubic foot, such as Bentonite-Pi pellets manufactured by Piezometer Research and Development Corporation or approved equal.

2.2 EQUIPMENT

A. Where model numbers are given in this section, they shall be understood to represent models selected on the basis of past factory specifications and project experience demonstrating that the equipment, including stipulations herein, would meet the performance objectives of this Work. Verify with any selected manufacturer that the designated model, or the updated version, meets the design performance outlined by these drawings and specifications. The detailed working drawings and manufacturer's technical specifications submitted in accordance with the drawings and specifications for this Contract shall comprise the criteria for equipment or materials approval.

B. Water Level Indicator – Model 51690030 Water Level Indicator (100 ft length cable), as manufactured by SINCO, Seattle, WA, or approved equal.

C. Permanent Piezometer Casing – Connecting 2-inch diameter, Schedule 40 stainless steel slotted screen (10 slot), and 2-inch diameter, Schedule 40 stainless steel riser pipe.

D. Temporary Piezometer Casing – Connecting 1-inch diameter, Schedule 40 PVC slotted screen (10 slot), and 1-inch diameter, Schedule 40 PVC riser pipe.

E. Vibrating Wire Piezometers – as specified in Section 16900.

F. Bollards – 7-foot long, 6-inch diameter standard weight steel pipe.

2.3 FABRICATION

Piezometers, Electric Vibrating Wire Type - Factory-calibration curves are required for each piezometer, including individual gage factor, temperature correction factor, and barometric pressure at time of calibration. The gages shall be fabricated and tested by the manufacturer. No on-site fabrication shall be allowed.

PART 3 EXECUTION

3.1 PREPARATION

A. Verify that all drill holes have been drilled to the correct size, depth and orientation prior to installation of instruments.

B. Protection - Protect structures and facilities during drilling of the piezometer holes.

3.2 INSTALLATION

A. Furnish all labor, equipment, materials, power supplies and incidentals required to install a complete, fully functional, ready-for-operation instrumentation (control and monitoring) system as specified and shown on the Drawings.

B. Operation and field calibration checks of all instruments shall be demonstrated by the Contractor and witnessed by the Owner shortly before instruments are transported to the installation location.

C. Cables for the piezometers shall be direct bury cable. Five percent extra cable length shall be assumed to allow for deflections after installation.

D. Install piezometers using the following procedures:

1. Advanced borings by means of a rotary tri-cone, coring bit, or hollow-stem auger. If necessary, use a casing to prevent sloughing and maintain an open borehole. The use of drilling mud with bentonite to maintain the hole open shall not be permitted. The use of revert will be allowed in drilling mud. Use clean, fresh water as a drilling fluid to clean out the borehole prior to piezometer installation.

2. Drill borehole within one degree of vertical. The borehole shall be approximately 6-inches in diameter and shall be drilled to approximately 1 ft below the installation depth shown on the Drawings. Dispose of soil cuttings and drilling fluids in the temporary spoil stockpile after solidification. Dispose oil and grease waste, and all other waste in accordance with applicable federal and state regulations, and in locations approved by the Owner.

3. Obtain split-spoon samples (ASTM D1586) at 5-foot intervals in soil. Classify soils using the Unified Soil Classification System (ASTM D2487).

4. Prepare a boring log to document the soil conditions at the piezometer locations. The log shall be prepared by a geologist or geotechnical engineer under the supervision of a registered professional engineer.

5. Install casing as shown on the Drawings. Use stainless steel slotted screen and riser for permanent piezometers, and PVC slotted screen and riser for temporary piezometers. Top and bottom end caps are required. Permanent and temporary piezometer locations are identified on the Drawings.

6. Backfill to 2-feet above screened zone using approved backfill sand pack as shown in Drawings. Install 2-foot thick bentonite seal using approved bentonite pellets. Backfill to ground surface using approved cement grout.

7. Upon completion of the installation, the instrument shall be tested in accordance with recommendations of the manufacturer.

8. Construct casing cover and bollard protection for piezometers as shown on the Drawings.

END OF SECTION

SECTION 16500

ELECTRICAL POWER SUPPLY MATERIALS AND METHODS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. This Section and accompanying drawings are intended to cover the provision of all labor, material, and equipment necessary for the required electrical work for the installation of the Groundwater Migration Control System (GMCS) as shown on the Drawings and as described herein and in other Sections of these Specifications. This Section describes the minimum requirements for the Contractor to provide all labor, materials, and equipment for the following:

1. Provide and install all electrical components, including all arrangements (installation costs, fees, applications, etc.) to provide a new 480-volt, 3-phase electrical service at the Pole Barn on the site for use at the extraction wells.
2. Provide and install all power and control wiring and conduit for the new extraction wells and Automated Control and Monitoring System (ACMS) as shown on the drawings.

B. Furnish and install all appurtenances and elements for complete functioning systems, whether or not specifically indicated in the Contract Documents. Provide services and equipment as specified in the Contract Documents.

C. All electrical splices and devices located at an elevation below the 100-year flood (EL 426 NGVD)shall be rated for NEMA 6P (submersible).

1.2 CODES AND REGULATIONS

A. Comply with the latest editions of the following authorities, including all supplements thereto, and any other authority having jurisdiction within the requirements of this Section.

1. Local Codes
2. National Electrical Code (NEC) as amended (NFPA No. 70, 71, 72, 72C)
3. Occupational Safety and Health Association (OSHA)
4. Building Officials and Code Administration International (BOCA) Code.
5. National Fire Protection Association (NFPA)
6. Underwriter's Laboratories (UL)
7. Factory Mutual (FM)

B. Whenever the Contract Documents require materials, workmanship, arrangement, or construction of higher standard or larger size than is required by the codes and regulations, the Contract Documents shall take precedence.

C. Should there be direct conflict between any codes, ordinances, rules, regulations, and laws, as specified above, and the Contract Documents, the applicable code, ordinance, rule, regulation, or law shall govern.

D. All electrical materials and equipment shall bear the label of Underwriter's Laboratories; listed by them in their list of electrical fittings; and approved by them for purpose for which the material or equipment is to be used, unless the material or equipment is of type for which Underwriter's Laboratories do not list or provide label service.

E. All electrical connectors and conductors shall be copper

1.3 SUBMITTALS

A. The Contractor shall submit the following information, tabulated in booklet form, for each piece of equipment or system furnished under this Section.

B. Shop Drawings:

1. Submit a detailed layout showing the location of electrical components and routing of conduit and wiring.

C. Product Data:

1. Submit supplier's product data for all electrical components including:

a. Wire, conduit and associated fittings;
b. All control components with control wiring diagrams; and,
c. Disconnect switches.

D. Technical Manual (O&M Manual):

1. Include record copies of the Shop Drawings.
2. Provide the supplier's installation and Operation and Maintenance Manuals for each electrical component.

PART 2 PRODUCTS

2.1 CONDUIT AND FITTINGS

A. All underground conduits and fittings shall be rigid nonmetallic, approved for direct burial. Underground conduit and fittings for control wire may be Schedule 40 PVC or, if under a roadway, Schedule 80 PVC.

B. Above ground conduits and fittings shall be galvanized rigid steel, including all upturned elbows and conduits passing through masonry and/or the ground surface.

C. Use only hot-dip galvanized fittings, for elbows, unions, receptacle and switch boxes; type FS or FD, manufactured by Appleton, Crouse-Hinds, O.Z. Electric, Thomas & Betts, or favorably approved equivalent.

D. All conduit, fittings, and connections shall be watertight.

E. Conduit entrances shall be through the bottom or sides of enclosures.

2.2 JOINING AND SEALING OF CONDUIT

A. Effectively seal all threaded joints in conduit and couplings, using code approved pipe thread compound or red lead applied to male thread only, with joint butted properly within coupling.

B. Install conduit with fittings, boxes, etc. of the type required and in the manner required to prevent intrusion of moisture. Seal all terminal ends of service conduits and bushings with favorably reviewed insulating sealing compound.

2.3 JUNCTION AND PULL BOXES

A. Where required for proper execution of the Work, provide all junction and/or pull boxes, each of proper size, and type for location and use, complete with screw covers of size convenient and adequate for proper installation of required number of cable and wires; to conform with code requirements. Provide adequate pull boxes for future pulling and removal of wires.

2.4 WIRE

A. 600V Cable:

1. All 480 volt power wiring shall be metal clad Type CLX XHHW-2, approved for direct burial.

2. All 120/240 volt wiring shall be stranded copper with XHHW insulation. Multi-conductor cables shall have a PVC jacket.
3. All wiring shall be copper, having 600-volt insulation. Aluminum wire shall not be allowed.
4. Wire Manufacturer: Belden, or favorably reviewed equal.

B. Instrumentation Cable:

1. Conductor size shall be as provided by the manufacturer.

C. Execution:

1. Identify all main feeders and branch circuits by color-coded wire as required by Code.
2. Do not use block and tackle or other mechanical means of pulling wire through conduit. All wire or cables pulled in conduit or duct shall be pulled with a pulling compound favorably reviewed by the Owner.
3. On all circuit wiring throughout, allow sufficient slack at splices and outlets to permit connections without straining generally not less than 6 inches in junction or outlet boxes and 10 inches in ducts, troughs or pull boxes.
4. Splicing Terminal and Tap Connections: Make joints and splices only in pull boxes, junction boxes, and outlet boxes in mechanically and electrically secure manner using only approved solderless connectors, lugs, and as approved by Code.
5. Make all terminal connections of mains and feeder circuits using approved high pressure clamping type solderless connectors.
6. Make all branch circuit terminal connections and splices using only 3M Scotchlok electrical spring connectors and insulate with Scotch or other approved plastic electrical tape, or by using nylon "Wing Nut Connectors" with internal spring tension grip insulated with favorably approved plastic electrical tape.
7. Ordinary wire nuts or porcelain type connectors are not acceptable.
8. Properly identify and tag all mains, feeders, and branch circuits in all pull boxes, gutters, troughs, junction boxes, and other areas in which they connect. Similarly, identify and tag wires where two or more circuits run to or pass through same outlet or junction box.
9. Install tags in all pull boxes, troughs, junction and outlet boxes, and in gutter of all panels, as wires are pulled.
10. All tags: Flame resistant linen, wired on, marked in indelible ink; in each case, bearing designation of feeder or circuit.
11. Uninsulated conductors shall be bare type ACSR.
12. All control wire shall be in separate conduit then power distribution wiring.

2.6 GROUNDING

A. Grounding and bonding shall be in accordance with the NEC and with the requirements of the governing utility. All exposed non-current carrying metallic parts of the electrical equipment, metallic raceway systems and neutral conductor of wiring systems shall include grounds driven into ground. Ground rods shall be high-strength steel core, copper clad, 5/8-inch diameter by 10 feet length. Rods shall be UL listed and driven to 2 foot below grade. All grounding conductors shall be of copper.

B. Adequately ground all isolated conduit systems for low tension work.

C. Provide the Owner with test results that demonstrate that the resistance to ground for the grounding system is not more than 15 ohms.

2.7 NAMEPLATES

A. Provide nameplates for all control equipment or engraved laminoid; riveted in place. Nameplates shall be one inch high with ½" lettering of total length equaling length of lettering plus ½" each side.

2.8 DISCONNECT SWITCHES

A. Provide fusible disconnect switch, where indicated on the Drawings. They shall be NEMA 4X outdoors.

B. Type: Heavy duty switch sized for load serviced; non-fusible where used purely as disconnect device. Provide the proper number of poles and a solid neutral where required.

C. Fuses: Where fused switches are required and where the fuse type is not indicated on the drawings, provide Type FRS fuses for 480 volt systems.

D. Shall be rated 480 VAC.

2.9 FLEXIBLE METAL CONDUIT AND FITTINGS

A. Oil and moisture tight galvanized steel flexible conduit with copper bonding conductor and synthetic rubber jacket; "Sealtight" as manufactured by American Brass Co., or favorably reviewed equal, complete with ground bushings.

B. Fittings: Appleton Series "AT" fitters, unions, elbows, gaskets and locknuts, or favorably reviewed equal.

2.10 OUTLET BOXES

A. Except as otherwise specified, provide stamped steel boxes of proper size gauge and type for each location and use; securely fastened in place not supported by conduit. Exposed boxes shall be cast FS or FD type. Provide fixture studs in boxes, where required.

B. Manufacturers: Appleton, Crouse-Hinds, Steel City, Rayco or J.R. Richards.

2.11 SPARE PARTS

A. The Contractor shall provide the following spare parts:

1. Two (2) sets of fuses for each type and size of fuse required.

PART 3 EXECUTION

3.1 WORK BY CONTRACTOR

A. Furnish and install new fused disconnect switches in the existing Pole Barn.

B. Conduit and wiring from the Pole Barn shall be routed in overhead conduit out of the building. Outside of the building, the wiring shall be routed below ground to the control panels at each well.

C. Conduit and wiring from each control panel to the individual extraction pumps shall be routed below ground as shown on drawings.

3.2 QUALITY ASSURANCE/QUALITY CONTROL

A. Prior to the turning over of work as complete unit, test all wiring installed under this contract for proper connections, short circuits and grounds. Conduct tests with the aid of suitable testing instruments in the presence of, and submit results to the Owner.

B. All work must be completed to the satisfaction of the Owner.

END OF SECTION

SECTION 16900

AUTOMATED CONTROL AND MONITORING SYSTEM (ACMS)

PART 1 GENERAL

1.1 SCOPE

A. This section includes performance based technical specifications for the Automated Control and Monitoring System (ACMS). The ACMS is a key component of the Groundwater Migration Control System (GMCS). The primary function of the ACMS will be to monitor stage level of the Mississippi River and automatically adjust pumping rates of the three extraction wells. A secondary function of the ACMS will be to monitor the water level in four pairs of piezometers, which will be equally spaced along the west barrier wall. One piezometer of each pair will be located inside the barrier wall and one will be located outside the wall. The piezometers will be used to monitor groundwater gradients across the barrier wall. Drawing 6-1 shows a plan view of the extraction wells and the automated piezometers in relation to the proposed barrier wall and the Mississippi River.

The ACMS will consist of the following key components:

- Measurement and Control Unit (MCU)
- Automated River Stage Gage
- Power distribution panel
- Pump control panels w/variable frequency drives
- Magnetic flow meters at each extraction well
- Automated piezometer pairs along west barrier wall
- Host/Remote Access PC

The contractor shall be responsible for installing the ACMS described in this document.

B. Requirements include; on-site calibration, project specific operations manual, conducting on-site personnel training and final system acceptance testing for approval by the Owner.

C. Provide one-year maintenance of the ACMS and related instrumentation following final system acceptance by the Owner.

D. All system hardware, software and services, necessary to make the ACMS complete and fully operational, but not expressly specified, shall be provided by the Contractor.

1.2 RELATED SECTIONS

A. Section 02920 – Chain Link Fencing

B. Section 02700 – Piezometer Installation

C. Section 02550 – Effluent Pipeline and Appurtenances

D. Section 02260 – Trenching and Backfilling

E. Section 16500 – Electrical Power Supply

1.3 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA).

B. American National Standards Institute (ANSI) - 37.90a.

C. Electronic Industries Association (EIA).

D. National Electrical Safety Code (ANSI/IEEE)

E. National Electrical Code (N70 –1999)

1.4 SUBMITTALS

A. Submit shop drawings and product data sheets for all components of the ACMS. Final shop drawings are to be approved by the Designer before work can commence.

B. Prior to commencing ACMS installation the Contractor shall provide a description of proposed installation procedures for review by the Owner. This installation plan shall address construction sequencing, cable pulling plans, diagrams, instructions, and precautions required to install, adjust, and calibrate system components.

C. The contractor is responsible for submitting a separate programming manual containing all of the programming provided for the ACMS system as specified in later sections of this document including the programming of the measurement and control unit (MCU). The programming manual shall be updated as changes are made during the one-year warranty period.

D. The contractor shall prepare an ACMS Acceptance Test Plan for review by the Owner. Once approved, the Acceptance Test Plan will be used to verify that all ACMS functions perform properly.

E. The Contractor shall prepare a detailed, project specific, operations and maintenance manual (O&M) Manual. The O&M Manual shall include the following information:

- Wiring diagrams, control diagrams, and control sequence for the ACMS and items of equipment,
- Start-up, proper adjustment, operating, and shutdown procedures,
- Safety Precautions,
- Procedures in the event of equipment failure, and
- Other items of instruction as recommended by the manufacturer of each system component.

F. The contractor is responsible for submitting five sets of final manuals and drawings of the "as built" ACMS. Also provide an electronic copy of manuals in Word 2000 format and drawings in AutoCAD V14 format on CD-ROM. Electronic files include data sheets for each component which shall reference the manufacturer's web site, a list of components with the phone number and/or web site of each component manufacturer, installation instructions and manuals supplied with the equipment purchased, and drawings used to fabricate parts referenced in the drawings.

PART 2 PRODUCTS

2.1 DESCRIPTION

A. Measurement and Control Unit (MCU) - The ACMS MCU equipment shall be Geomation Series 2380 Measurement and Control Units manufactured by Geomation, Golden, Colorado 80401, phone number (720) 746-0100.

B. The following key components will be required to construct the ACMS.

1. Vibrating Wire Pressure Transducers - The open-standpipe piezometer pairs will be automated using Geokon 4500S vibrating wire pressure transducers with built-in surge protection. The pressure range of each sensor is 0-50 psi. The sensors shall be non-vented and use Stainless Steel 316 components with stainless steel sheath on the cable.

2. River Stage Gage – The River Stage Gage (RS-1) is an existing bubbler-type water level indicator owned and operated by the American Bottoms Regional Wastewater Treatment Facility (ABRWTF). The contractor will make necessary contacts and coordinate with ABRWTF to connect to the existing gage terminal block located at the northwest corner of Site R. Output signals from the gage will be 4-20ma.

3. Magnetic Flow Meters – The flow rate at each extraction well shall be monitored using Krohne – Aquaflux Electromagnetic Flow Meters with remote 020F digital LCD readout or approved equivalent. The flow meters shall output a 4-20ma signal with an operating range of 0-400 gpm. The cable shall be potted at the flow meter and rated for submerged operation (NEMA 6). The readout unit shall be installed in the pump control panel enclosure at each well. The flow meter shall be installed inside the flow meter/sampling vault as shown on the drawings.

4. Barometer – Barometric pressure corrections will be required for each of the non-vented vibrating wire pressure transducers. The barometer shall be a Met One Model 091 or approved equivalent. The barometer shall be installed in the MCU enclosure to be located inside the existing pole barn.

5. Power Distribution Panel – There will be a new power distribution panel located inside the southeast corner of the existing pole barn. The power distribution panel will be sized to accommodate power connections for the three extraction well pumps and disconnects. There will also be one 120VAC, 1-Phase individual branch circuit to operate the MCU. All of the wiring from the power distribution panel to the three extraction wells will be in buried conduit. All power cables, running from the power distribution panel to the extraction wells, shall be Belden shielded power cable rated for direct burial. Care shall be taken to ensure that power cables are separated by at least 2 ft from all signal cables except for right angle crossings where necessary. All power for the variable frequency drives (VFDs) and the pump motors will be 480VAC, 60HZ, 3-Phase. There will also be a separate breaker and a separate 120VAC circuit installed at each extraction well location area.

   Contractor shall refer to Section 16500 – Electrical Power Supply for details associated with all ACMS electrical power supply requirements.

6. Pump Control Panel and Variable Frequency Drives - A pump control panel/enclosure shall be located at each extraction well pad. Each control panel enclosure shall consist of a NEMA 4 power ventilated enclosure that contains a variable frequency drive (VFD) for the pump motors. The control panel enclosure shall also house the flow meter LCD readout and interface unit. A manual pump control panel will be used to operate the pumps directly in VFD by-pass mode, and to power a light in the flow meter vault. The pump control panel/enclosure will also contain 480VAC, 3-Phase power, 120VAC, 1-Phase power for the flow meter, two 120VAC duplex outlets, and pass through wiring for the vibrating wire piezometer monitoring water level in each well.

   A Reliance electric SP600 variable frequency AC drive (VFD), or approved equivalent, will operate each pump motor. The VFD will allow variable speed operation of the pump motor and allow a variable pumping flow rate to be

achieved by each pump. By using a flow meter at each well, the flow meter's 4-20 ma output will provide a feedback signal to the MCU to allow closed-loop operation of the pumps. This will allow the VFD to maintain the flow (gpm) set point provided by the MCU for a given river stage elevation. Each VFD will provide switch closure signals to the MCU to indicate fault conditions and accept 4-20ma signals to control the speed and starting/stopping of the pump motors.

7. Automated Phone Dialer – An automated phone dialer shall be located in the MCU enclosure to accept inputs from the MCU indicating fault conditions (e.g., pump failure, VFD faults, water levels, etc). The Sensaphone 2000 manufactured by Phonetics Inc. Aston PA 19014, 610-558-2700 or an approved equivalent shall be used.

C. The ACMS Host/Remote Access PC will serve as host to the on-site MCU for remote users. Necessary hardware and software specifications are presented in the following sections.

D. In addition to the key ACMS components listed above there are various signal and power cables, surge protection modules, conduit, junction boxes, and pull-boxes required. Details associated with these components of the system are included in the following sections.

E. ACMS Installation Contractor - Company specializing in installing and configuring the specified ACMS equipment for applications of this type with minimum of 10-years of experience.

2.2 GENERAL SYSTEM REQUIREMENTS

A. The three extraction well pumping rates will primarily be a function of river stage. Table 6-1 shows the calculated combined pumping rates for the three wells based on river stage. As shown on Table 6-1 the calculated combined pump flow rates range from 0 to 950 gpm for a corresponding river stage range of 413 ft to 374 ft, (amsl). For reference purposes the 100-year flood stage at Site R is about 426 ft, (amsl).

When Mississippi River stage reaches elevation 413 ft, amsl and above the pumping system will automatically shutdown. The system will automatically restart pumping once the river level falls below 413 ft, amsl.

Occasionally it may be necessary to temporarily increase extraction well pumping rates to maintain a "zero" gradient across the barrier wall. As mentioned above, water levels in the four pairs of piezometers, along the west wall of the proposed barrier wall, will be read automatically. If the average water level inside the barrier wall is greater than the average water level outside the barrier wall for a period of

one to two days the extraction well pumping rates will be increased until a "zero" gradient condition is reestablished across the wall.

The ACMS will employ variable frequency drives (VFDs) on each of the extraction well pump motors. The VFDs will provide the ability to optimize overall performance of the GMCS resulting in reduced energy and extracted groundwater treatment costs. The VFDs will be controlled by the MCU.

2.3 VIBRATING WIRE PIEZOMETERS (OPEN-STANDPIPE PIEZOMETERS)

A. Open-standpipe piezometer transducers shall use vibrating wire technology with built-in surge protection. Geokon Model 4500S, 0-50 psi, with stainless steel housing, non-vented transducer shall be used.

B. All vibrating wire transducers shall have a factory-installed cable without splices that will connect to the Geokon LAB3 surge protection module located near the top of the standpipe in a NEMA 6 enclosure.

C. Wiring for the piezometers shall be accomplished by the following method:

1. Using the cable supplied by the sensor manufacturer, wire the transducer to the lightning protection device located near the piezometer location.

2. Use Anixter E-000622DFC cable or approved equivalent (see drawings); signal cable from the lightning protection device to the junction box located between each piezometer pair.

3. At the junction box combine two piezometer cables for each pair into one cable and continue via buried conduit directly to the MCU. The shields for each wire shall also be connected. No splices are permitted from the respective piezometer pair junction box to the MCU at the pole barn.

4. The contractor shall record the signal cable color scheme used and submit that as part of the final project documentation and as-built drawings.

D. Special care shall be taken to appropriately ground individual vibrating wire transducers and the Geokon LAB3 surge protection modules. Suitable grounding shall be provided at each open-standpipe location.

E. Ground Test - Test each ground rod installation by performing a Fall-of- Potential test using a Biddle Digital Earth Tester Model 5/2 or approved equivalent.

1. Record results of each ground rod test.

2. Each measured ground rod shall have measured resistance to ground of 5 ohms or less. When the required ground resistance is not met, additional ground rods shall be provided interconnected with grounding conductors to achieve the 5-ohm ground resistance.

3. The Designer, before the completion of the project, shall approve all grounding measurements.

2.4 RIVER STAGE GAGE

A. American Bottoms Regional Wastewater Treatment Facility (ABRWTF) maintains a bubbler-type gage at their outfall pipe to the Mississippi River immediately north of Site R. ABRWTF currently obtains automated river stage readings via a telephone line connection to the bubbler gage readout unit located near the existing catwalk. Contractor shall contact and coordinate with ABRWTF to share the output signal of the bubbler gage. A 4-20ma output signal can be obtained by direct connection to the existing terminal block and connecting to the MCU via buried conduit.

B. All wiring for the river stage gage shall be without splice until the surge protection device located at the MCU.

2.5 ELECTROMAGNETIC FLOW METERS

A. Three extraction well flow meters will use electromagnetic flow measurement technology.

B. Flow meters shall be mounted in the flow meter/sampling vault at each extraction well and the signal converter and LCD readout unit shall be located in the pump control/VFD enclosure at each well.

C. The flow meters shall output 4-20ma signal levels with a corresponding operating range of 0 to 400 gpm and an accuracy of 0.25% full-scale. The flow meters shall be temperature compensated.

1. They shall operate with a power input of 120VAC.

2. The sensor output shall be 4-20ma using a powered current loop from the MCU with 600-ohm maximum total loop resistance.

3. Zero flow or an empty pipe shall give a stable 4ma signal.

D. Each flow meter signal converter and readout unit shall be mounted in the pump control panel/enclosure.

E. Power for the flow meters shall be from a 120VAC source located at the pump control panel. This power source does not require battery backup, however, it does require that the power supply has adequate input surge protection and grounding.

F. A separate signal cable is required to provide a signal from the flow meter. The signal cable shall be factory sealed at the meter.

2.6 VARIABLE FREQUENCY DRIVE

A. The variable frequency drive (VFD) shall be suitable for operation of 480v, 3Ø, 20hp pump motors. The VFD shall have an analog 4-20ma input to control the speed of the pump and digital inputs to control the start, stop, reset, and manual/automatic operation from the MCU. The VFD shall have digital outputs for running and fault conditions to operate pilot lights on an auxiliary panel at the pump control panel/enclosure and to signal the MCU of its operational status. The VFD shall be suitable for outdoor operation and be self-cooled such that operation in an outdoor-ventilated cabinet in summer ambient conditions shall not result in de-rating of the unit.

B. Operation of the VFDs shall be pulse width modulation with sensorless vector control and shall contain automatic restart and retry options.

C. The VFD shall be suitable for operation with motors up to two hundred feet from the VFD.

D. The VFD shall be in its own NEMA 3R enclosure to protect it from dust, dirt, and moisture.

E. The VFD shall be programmed and operated with an onboard LCD display and keypad.

2.7 MEASUREMENT AND CONTROL UNIT (MCU)

A. Measurement and Control Unit (MCU), to be located in the pole barn, shall acquire readings from the flow meters, well water level transducers and piezometers. All raw reading values shall be converted to engineering units. Both raw and calculated values will be stored. These values and the reading values of the river stage gage will be used to determine the pumping rate from a stored look-up table. The resulting value of pumping rate is sent via analog output to the VFDs. A secondary function of the MCU is to further adjust pump flow rate to maintain "zero" gradient condition across the barrier wall as measured by the automated piezometer pairs. A third function of the MCU is to send all readings data to the host/remote access PC.

B. The MCU and related equipment shall be mounted in a single enclosure located inside the pole barn. This enclosure shall be a NEMA 4x enclosure with either a lock or an entry key. The Contractor shall provide a drawing of the final configuration for review by the Designer before installation.

C. Power to operate the MCU and related equipment shall be 120VAC.

D. All wiring shall enter and exit the enclosure via rigid conduit. All MCU cabling shall be in metal conduit. All entry points to the enclosure shall be sealed against moisture and shall use water resistant fittings.

E. The enclosure and all equipment shall be grounded to a suitable earth ground using components as specified by the equipment manufacturer.

F. Every input/output signal cable shall first pass through a surge protection device at the MCU to protect the MCU from potential electrostatic discharge and potential lightning induced power surges.

G. The MCU measurement module shall be capable of storing up to one year of data in memory.

H. The MCU shall have battery backup to insure performance integrity for at least two days without primary power.

I. The measurement module shall save the program code in non-volatile memory, such as EEPROM, so that after a complete loss of 120VAC power and battery backup, the device shall have the last saved program contained in the system.

2.8 COMMUNICATIONS

A. All communications from the MCU to the Host/Remote Access shall be via dedicated telephone line.

B. Appropriate optically isolated surge protection shall be provided for the telephone line. All equipment is to be approved by the Designer before work can commence.

2.9 POWER SUPPLY

A. MCU shall have a backup battery. Battery operation shall allow the MCU to operate during times that the primary power has been disrupted.

B. The battery shall provide the MCU at least two days of normal operation without primary power present.

C. A separate 24 VDC power supply shall be furnished and installed for the flow meters. The contractor shall have the power source approved by the Designer before installation. This power supply does not require battery backup.

2.10 UNATTENDED PHONE DIALER

A. There shall be an automated phone dialer to send unattended phone, pager, fax, or email messages in case of a system fault. Messages are to be logged and delivered via the phone line whenever there is a pump fault or failure as determined by the VFD programming and output by the VFD controller to the MCU.

B. The MCU shall be wired to the phone dialer to deliver digital voice, fax, or email messages of the fault condition.

C. Reporting response time for a failure shall be less than one minute.

D. The phone dialer shall be programmed for up to 32 destinations and have 8 independent inputs for up to 8 unique messages.

2.11 ACMS HOST/REMOTE ACCESS PC REQUIREMENTS

A. GENERAL REQUIREMENTS

The ACMS Host/Remote Access PC will provide access to the on-site MCU for authorized on-site or remote users. This computer will be used by Owner personnel to obtain automated instrument readings, be advised of any potential alarm conditions and provide the ability to adjust reading frequency and provide remote trouble-shooting of the ACMS.

B. ACMS HOST COMPUTER HARDWARE REQUIREMENTS

1. The ACMS Host Computer shall have the following minimum configurations:

2. Processor – minimum 1Gz Pentium IV or equivalent.

3. Memory - Minimum of 512 Mb of random access memory

4. Hard Disk – minimum 20GB

5. Operating system shall be desktop version of Windows 2000 or Windows XP.

6. I/O: CD-RW for reading and writing data, two serial ports, parallel printer port, USB port, mouse, keyboard, and 56K optically isolated modem.

7. Backup - Travan or equivalent 20GB tape backup unit. Contractor is to supply five tapes.

8. Monitor – High-resolution 17-inch, 0.26-inch dot- pitch or better.

9. Printer - Color Inkjet, HP 9xx series or better

10. Battery Backup - Suitable model shall allow at least 20 minutes of operation, including the monitor, without primary power. The model selected shall also provide lightning protection of all equipment plugged into it and shall include the PC, monitor, and any radio modem, but not the printer. Complete lightning protection, as recommended by the manufacturer, may require that the contractor provide a separate hard connection to the building ground.
11. The PC serial port shall allow the radio modem to operate with the software supplied from the RMU vendor.

C. ACMS HOST COMPUTER SOFTWARE REQUIREMENTS

The ACMS Host Computer shall have the following minimum software applications:

1. Geomation 2380 Series GeoNet Suite Software (latest version) - The software is used to configure the MCU (Geomation 2380), monitor the ACMS, and provide necessary data transfer capability.

2. Microsoft Office 2000 Professional.

3. PCAnywhere from Symantec Corporation – this software will provide remote access to the ACMS Host Computer for remote users.

4. Anti-virus software (Norton or equivalent).

D. MCU ENCLOSURE

1. Material - Steel construction, enclosure 16 gauge minimum, door 14-gauge minimum.

2. Finish - Dip-bath primed and powder coated.

3. Ratings - IP 66, NEMA 4.

4. Installed components:

a. MCU equipment.

b. DIN Rail terminals for each MCU at the maximum expanded capacity. Pre-wiring shall be provided between all installed MCU I/O modules and the DIN rail mounted terminals.

c. Test jacks for each DIN rail terminal for manual readings, test and field calibrations.

d. 24 VDC Excitation power supplies.

e. 4-20 ma converters for converting 0-10v outputs from the MCU to 4-20ma to send signals to the VFDs

f. Barometer for measuring the barometric pressure to compensate non-vented piezometer readings.

g. Telephone auto-dialer for sending fault condition messages.

h. Transient protection hardware.

i. Cable gland feed-through panel.

PART 3 EXECUTION

3.1 INSTALLATION

A. The Contractor shall be responsible for complete installation of all system components, cable, conduit, instruments, transducers, sensors, variable frequency drives, enclosures, power connections, and miscellaneous items to make the ACMS completely operational.

B. The measurement and control unit (MCU) shall be located in an enclosure mounted on the south wall inside the pole barn.

C. The ACMS installation shall comply with all applicable codes and regulations. The work shall be in accordance with the contract documents and shall include: furnishing all labor, tools, equipment, material, installation supervision; receiving, storing, and protecting of equipment and supplies; maintaining up-to-date construction drawings, test and calibration reports, sensor and instrument locations with serial numbers and calibration data, and checking, testing and calibration of all instruments.

3.2 ACMS CONFIGURATION AND PROGRAMMING

A. General - The contractor shall be responsible for all ACMS programming to provide measurement, data conversion, processing, and data logging schedules for each instrument as shown on the Drawings. In addition, the contractor shall create the necessary pumping rate control algorithms to send signal set points to the variable frequency drives that control the extraction well pump motors. Secondary control protocols are required to maintain a "zero" gradient condition across the barrier well as monitored by the automated piezometers.

B. Qualified Personnel - ACMS programming shall be performed by a representative of the manufacturer or a qualified instrumentation system technician with demonstrated experience with such programming.

C. Documentation - The Contractor shall provide all documentation related to ACMS programming to the Designer. All changes in configuration and programming shall be submitted to the Designer within 30 days of such changes.

D. Measurement and Control Unit configuration and programming:

1. The MCU shall be programmed to take a set of readings of all transducers on an hourly basis.

2. The MCU shall convert the automated piezometer readings to elevations in feet and hundredths of a foot after the readings are compensated for changes in barometric pressure and temperature. The barometric pressure reading shall also be stored. Flow meter readings shall be reduced to nearest 0.1 gallons per minute.

3. The MCU shall store the raw readings as well as the engineering unit conversions of the readings in memory. The raw reading for the vibrating wire transducers shall be the frequency in Hz. The raw reading for the flows and barometer shall be the input voltage.

4. Every set of readings shall be date and time stamped using the 24-hour clock. This applies to timed readings as well as forced readings.

5. Every set of readings, including date, time, raw, and calculated values shall be stored at the MCU for download via telephone connection by the ACMS Host/Remote Access Computer.

6. Instrument readings shall be stored in the database of the MCU vendor's interface program in ODBC format.

3.3 TESTING

A. Final Acceptance Test - Once installed the ACMS system shall be tested for operation by qualified personnel. The ACMS Host Computer shall be tested to be sure that data collection and control commands perform reliably. The programming shall be verified by testing instrument data acquisition, data conversions, logging functions, and alarm functions. The Contractor shall prepare an ACMS Acceptance Test Plan for review by the Owner. Once approved, the Acceptance Test Plan will be used to verify the all ACMS functions perform properly. Successful completion of the Acceptance Test, to be conducted with Owner representatives, will indicate final acceptance of the as-installed system by the Owner.

B. Instrument Interface/Calibration - Verify instrument ACMS interface is operational and that each instrument is properly calibrated, and the correct engineering units have been applied.

C. All grounding locations shall be tested using the "Fall-of-Potential" test method. All grounding installations shall meet manufacturer's recommendations for appropriate transient protection.

3.4 TRAINING

A. General - The contractor shall be responsible for providing a 2-day on-site training program for Owner personnel. Training is to be provided covering the subjects of system setup, maintenance, configuration, re-configuration, and system trouble-shooting. The equipment training is to be provided in a project-specific context.

B. Qualified Personnel - ACMS training shall be provided by a representative of the manufacturer or a person authorized by the manufacturer as qualified to provide such training.

3.5 MAINTENANCE

A. General - For the duration of the contract, the contractor shall be responsible for all costs associated with maintenance of the ACMS. The contractor shall be responsible for all damage to the equipment, and the cost of replacement and repair of any damaged equipment. The complete system, and all spare equipment designated in the Equipment List, shall be turned over to the Owner at the end of the contract, and demonstrated to be in good working order.

B. Field-replaceable On-site Spares: Spare parts for the ACMS equipment shall be furnished as follows:

Quantity	Description
1	Geomation Rechargeable battery
1	Geomation Battery charger module
2	Geokon 4500S 0-50 PSI transducers with 150 ft of factory installed cable
2	Geomation Transient arrestor (20 wire)
2	Geokon LAB3 Surge Protection Module

C. Troubleshooting, Repair and System Updates - The Contractor shall provide a one-year Technical Support Contract, to commence immediately following contract closeout, with the manufacturer for telephone and product update support as follows:

1. Troubleshooting assistance for system-wide problem identification.

2. Corrective maintenance in the event of an ACMS system malfunction, using the available field-replaceable on-site spares.

3. To provide factory repairs for failed ACMS equipment components, on a return-to-factory basis, for subsequent return to on-site spares inventory.

4. To provide all updates of ACMS software released during the period of the contract. Such updates shall be provided to the Designer, who will make the decision as to whether or not the update will be installed. If the Designer decides that the updates are in the best interest of the project requirements, the updates shall be performed under the direction of the Designer, who may also provide any new instructions to the contractor for day-to-day system operation associated with this update.

5. At the end of the one-year technical support contract the Contractor shall provide a one-day, on-site refresher course with Owner personnel. The purpose of the course shall be to review and verify that all aspects of the system are operational and that data is being recorded and stored properly and that the Owner understands how to best use the system, troubleshoot the system, maintain the system, and obtain future technical support.

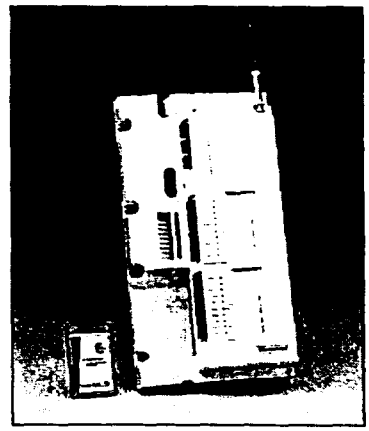
TABLE 6-1

Pumping Rate Lookup Table		
River Stage (ft, amsl)	**Pumping Rate (gpm)**	**River Elevation Comments**
430	0	Highest Recorded River Elevation
413	0	
412	25	
411	50	
410	75	
409	100	
408	125	
407	150	
406	175	
405	200	
404	225	
403	250	
402	275	
401	300	High Monthly Average Flow
400	325	
399	350	
398	375	
397	400	
396	425	
395	450	
394	475	
393	500	
392	525	
391	535	Average Monthly Average Flow
390	550	
389	575	
388	600	
387	625	
386	650	
385	675	
384	700	
383	725	Low Monthly Average Flow
382	750	
381	775	
380	800	
379	825	
378	850	
377	875	
376	900	
375	925	
374	950	Lowest Recorded River Elevation

END OF SECTION

2380 SERIES MCUs

2380/80 MCU



2380/20 MCU

APPLICATIONS

Geotechnical & Structural

- Monitoring Large Civil Construction
- Dam Performance Monitoring
- Dam Early Warning Systems
- Slope Stability Monitoring
- Tunnel & Mine Monitoring
- Bridge & Building Monitoring
- Pipeline Strain Monitoring

Industrial Facilities

- Water Collection & Treatment
- Water Storage & Distribution
- Canal Monitoring & Regulation
- Irrigation System Control
- Gas Well Automation
- Equipment Performance Monitoring
- Energy Distribution & Accounting

Environmental

- Water Quality Monitoring
- Stormwater & Discharge Monitoring
- Conditional Sampling Control
- Flood Warning Systems
- Air Quality Monitoring
- Electronic Weather Stations
- Groundwater Remediation

FEATURES

Configuration Flexibility

- MCUs Operate Stand-Alone or in Multi-Node Networks
- Plug-In I/O Modules Provide Application Flexibility
- Model 20 Accepts One or Two I/O Modules
- Model 80 Provides Expansion to 8 I/O Modules
- Model 80 Suitable for Industry Standard 19" Rack Mounting
- Engineered Weatherproof Enclosures and Accessories Make Field Installation Easy and Reliable

Operation & Functions

- GEONET™ Suite Provides MCU Programming, Data Logging and Data Reporting
- PCMCIA Card Data Storage for Buffering or Data Retrieval
- PCMCIA Adapter Supports Telephone & Satellite Terminal Modems
- Built-in Communications Features Make 2380 MCUs Network-ready
- Internal or External Battery Operation with Built-in Charging
- Battery Recharging by AC, Solar or Both; Ultra Low Power Modes Allow Replaceable Battery Operation

Test & Maintenance

- Plug and Header Field Wiring Terminals for Easy Testing
- MCUs and I/O Expanders are Modular for Quick Field Replacement
- Front Access to All Controls, Indicators and Wiring Terminals
- Simple Diagnostic Indicators Eliminate Guesswork in the Field
- Remote Diagnostics are Provided through GEONET Suite
- Integral Protective Grounding System and Effective Transient Protection

Geomation
Measurement and Control Systems

INTRODUCTION

The 2380 Series Measurement & Control Units (MCUs), together with GEONET Suite PC software, provide a comprehensive system for field data acquisition and control. Whether your application is for a stand-alone field data logger, or a mission-critical real-time network with hundreds of field nodes, Geomation 2380s are the building blocks that make it easy, predictable and cost effective. Also, 2380s are backward-compatible with existing System 2300 networks, requiring only an upgrade to GEONET Suite and Windows 95, 98 or NT.

The 2380 is a third generation standard product MCU from Geomation, building on the features and capabilities of our innovative System 2300 introduced in 1986. The 2380, employing advanced electronics and software technology, brings substantial improvements to the internationally proven Geomation System 2300 architecture. The 2380 MCU, with the new System 2300 data server, GEONET Suite, introduces new capabilities for linking field-distributed instrumentation with enterprise information management systems using open-architecture 32-bit database technology. (See separate Product Data on GEONET Suite.)

System Costs and Economies

Historically, the economic advantages of the Geomation System 2300 have been most apparent to customers who have experience with field automation in one of the following ways:

1) Users with prior experience in field instrumentation systems often recognize the substantial expense of system integration that is avoided by the "total system solution" provided by the Geomation System 2300.

2) Many SCADA System users have endured the frustrations of working with systems implemented with custom software components. Almost without exception, custom implementations fail to meet objectives without substantial and costly on-going support. Custom software support at any price eventually becomes nonviable on hardware and software platforms that reach obsolescence.

Many of these users have been quick to recognize the value of standard products which can be user programmed to meet their initial and changing needs.

To a large extent, the cost advantages of the System 2300 have been most apparent to people having relevant experience and therefore a practical basis for understanding the impact of system architecture on "cost of ownership". When product capabilities are not well conceived from a total system standpoint, or they are incomplete requiring custom low-level software development, then the costs of system use and technical support far exceed the initial cost of the equipment.

The economic benefits of the System 2300 today are based on the same issues that have contributed to its success over the last decade. Specifically, the total system solution provided by the System 2300 mitigates significant cost in the areas of installation, system start up and ongoing support. In short, an umbrella of capability minimizing technical risk comes to the customer straight out of the box from Geomation.

With the introduction of the 2380 MCU, the System 2300 is now even more economical in the initial purchase price, installation, and ongoing support for a wider scale of applications than ever before.

Stand-Alone Data Loggers

The new PCMCIA Adapter allows the 2380 to operate as a *stand-alone* field data logger, without a PC connection. Data logged to an optional on-board PCMCIA memory card in the 2380 can be read by your laptop or desktop PC equipped with a standard PCMCIA adapter. Programming modifications can also be transferred to field-deployed MCUs with PCMCIA memory cards, eliminating the need to take expensive laptop computers to the field.

Even further, as a logging destination node in a multi-node network, the 2380 MCU introduces an entirely new class of datalogger: *a field distributed data logger.*

The distributed data logger is a practical configuration for widely separated instruments. A wireless network can provide easy data transport to a single, accessible logging location where the data can be easily retrieved.

Progressive installations are often desirable in construction monitoring situations. 2380s allow economical data logging during construction, and they are easily connected into multi-node networks for long term performance monitoring when the new structure is completed. The System 2300 can begin as one data logger, then two, and so on, and finally be connected as a real-time monitoring system. The 2380 MCU allows this to be done without cost penalty, either up front or at the end.

Field Networking Anywhere

A hallmark of Geomation technology over the history of the System 2300 has been the innovative and robust user configurable networking capability. Geomation MCUs are network-ready by design. MCUs can be linked by radio, wireline, microwave and public communication networks (including satellite).

2380 MCUs support a minimum of three concurrent inter-node connections, all of which can be different physical connection types. Communication capabilities support bridging and repeating to allow transitions from a wireline sub-network branch to a radio sub-network branch. As another example, one node in a field deployed radio network can be located near a telephone line or a satellite terminal, providing remote project linkage for all MCUs to a distant GEONET Workstation through a public communications access point. These examples of inter-networking satisfy the often required bridging from Remote Area Networks to Wide Area Networks.

INTRODUCTION *(continued)*

Private microwave or satellite networks can be used in the same way to extend wide area coverage. These capabilities allow practical, low cost field deployments in virtually any project situation, making optimum use of existing communication infrastructures. All connections, including telephone-switched connections, are user configurable through GEONET.

Enterprise Connections

With the new SQL database provided in GEONET Suite, the System 2300 supports open-architecture client/server operation for on-line data management, analysis and decision support throughout customer organizations. Other client software programs supporting the ODBC (Open Data Base Connectivity) industry standard, running on Windows 95, 98 or Windows NT can inter-operate seamlessly with GEONET as a real-time data server. As an example, graphic Operator Interface (OI or MMI) and data analysis programs can inter-operate across the enterprise with real-time field data served by the System 2300.

System Scalability

Scalability is a concept for modeling the economy and practicality of different system architectures for applications of varying dimensions. These dimensions typically involve the number of connected devices, and the spatial as well as environmental distribution of the devices. Designing automation systems for high scalability in remote and harsh environments requires special consideration for resources that are taken for granted in systems used strictly in plant or factory environments.

Scalability for arbitrary field automation situations must address the communication requirements for both wide-area, and local/remote-area deployments. On a smaller scale, at the MCU, practical range is imposed for critical resources. When the Remote Unit is located in harsh environments, marginal resources can have a dramatic effect on system reliability and performance.

Major issues include: a) range and cost of I/O expansion, b) ease and practicality of networking multiple nodes in the target environment, c) adequacy of communication bandwidth and system throughput time vs. I/O loading, d) adequacy of power resources at remote nodes for the required instrumentation, data measurement and communication rates, and e) environmental integrity of the electronics packaging in outdoor installations.

The System 2300 is a general purpose system designed for adaptation to a variety of field automation applications and specific project requirements. The success of the System 2300 comes from high scalability in system architecture while supporting extensive user programmability for measurement, control and communication functions. Successful system configuration is easy in spite of inevitable variations in application and field conditions. Perhaps most important, flexibility has been implemented in a way that does not compromise the overwhelming benefits of standard products: reliability, predictable performance, cost, and long-term support.

The 2380 MCU improves System 2300 scalability on every design issue. The most apparent for existing customers is I/O scale. Our historical product line had evolved into two different MCUs to handle variations in I/O scale: The 2350 for large I/O expansion and the 2370 for small I/O count.

The new 2380 MCU is more economical, simpler, and easier to use over a broader range of I/O requirements. Therefore, the 2350 and 2370 MCUs are now both succeeded by the 2380 MCU.

Universal I/O Support

The 2380 MCU is designed to interface to virtually all industry standard analog type transducers and sensors. In addition, MCUs have built-in resources to measure some of the more specialized devices used in hydrological, environmental, and geotechnical applications. Examples include rotary position encoders for water level measurements, digital interfaces for multi-parameter water quality instruments, and vibrating wire sensors used in civil construction applications.

The 2380 has built-in resources for wide dynamic range voltage, resistance, current and frequency measurements, with various excitation sources and operational modes. Field-pluggable I/O Modules support the physical connection, signal routing and multiplexing requirements of a wide range of transducers, sensors and device actuators. Application flexibility is accomplished by selecting the appropriate I/O Module(s) and invoking the measurement (and control) functions built into MCU firmware using GEONET. The enabling of instrumentation functions is downloaded to the MCU locally through a serial port, remotely over a network, or via a PCMCIA card.

Environmental Integrity

Exclusive use of industrial and military grade CMOS electronics assures compatibility with temperature extremes for outdoor installations.

The 2380 MCU has been designed with a very high level of systems integration. The result is a reduction in component count and inter-connections, with increased reliability. High integration also permits more reliable and compact enclosure designs for outdoor environments, with improved defenses against vandalism.

Simple System Operation

The Geomation System 2300 has long been recognized for its ease of operation and user configurability. The high-level user programming methodology facilitated by GEONET leads to the creation of reusable "software instruments".

The 2380 MCU and GEONET Suite extend the usefulness of the software instrument concept by introducing user defined instrument *Groups* and *DataSets*. *Groups* and *DataSets* allow arbitrary groupings and preprocessing of data for exporting to Excel, Word, and other analysis programs.

MCU ARCHITECTURE

Installation & Maintenance

The 2380 MCU has been designed with simple diagnostic indicators visible from the front panel for all essential functions: power, charging, communication ports, and all I/O points. Simple LED indicators provide unambiguous information regarding proper operation, without language barriers. Installation and maintenance is easier for people without specialized skills.

High Integration & Modularity

The 2380 MCU architecture employs advanced electronic technology to implement very high integration of all essential functions. In addition, the base instrument includes the foundation resources to support strategic optional capabilities. Plug-in options are provided for the functions and interfaces which vary according to application requirements. The benefits of 2380 architecture are the reliability and economy which result from high integration of all base functions, and the adaptability offered by plug-in modularity for the variable instrumentation, data storage, and communications requirements.

The 2380 Architecture includes an extensive library of built-in software functions, which allows MCUs to be easily field-configured to fit specific user applications. Most importantly, application-specific configurations are allowed with a minimum of system components and complexity exposed to the user.

In addition to MCU options, Geomation provides a complete complement of engineered accessories for reliable installation and maintenance. The extent of 2380 Series MCU capabilities and the completeness of the Options and Accessories which work in concert with 2380 MCU architecture minimize the costs and difficulties of installation and maintenance. A further result is that standard product reliability and product warranties are offered at a higher "total system solution" level with the System 2300. The 2380 Series MCU Block Diagram identifies the base functionality included in the 2380 MCU architecture, and shows the general relationships of these functions to one another. Geomation provided optional plug-in functions are also shown in the diagram. The Specifications section of this document describes interfacing capabilities to certain external devices and protocols.

Distributed Multi-Processing

The 2380 MCU main system microprocessor interfaces with all MCU hardware via a real-time, multi-tasking executive kernel. The multi-tasking environment allows the MCU to process multiple tasks efficiently, without error, and in proper sequence in spite of the unpredictability of task execution which results from arbitrary user programming.

I/O Modules have separate microcontrollers, with support for multi-processing and bus mastering with the main CPU bus. This means, for example, that the main CPU can go into a deep-sleep mode, conserving power, while certain types of I/O Modules remain fully operational with very low power consumption. The I/O Modules can wake up the main CPU in case of an event requiring CPU resources (e.g., communicating an alarm event to the specified logging destination).

In the general architectural model for processing and memory resources, the main CPU can handle all tasks for a fully-loaded MCU with any allowable complement of installed options.

Time-Keeping & Synchronization

The fundamental difference between MCUs and the Remote Terminal Units (RTUs) of conventional SCADA system architecture is that MCUs are functionally autonomous for local data acquisition, control and communication, while RTUs execute tasks under the timing and direction of a host computer. In other words, MCUs employ a distributed intelligence architecture in normal system operation.
Even though MCUs operate autonomously, they are not isolated. MCUs can share information with each other (peer-to-peer communication) to implement distributed control or wide-area regulation strategies, with central intelligence if required. For remote environments, particularly those with limited power and communication bandwidth, distributed-intelligence is the most economical and effective architecture.

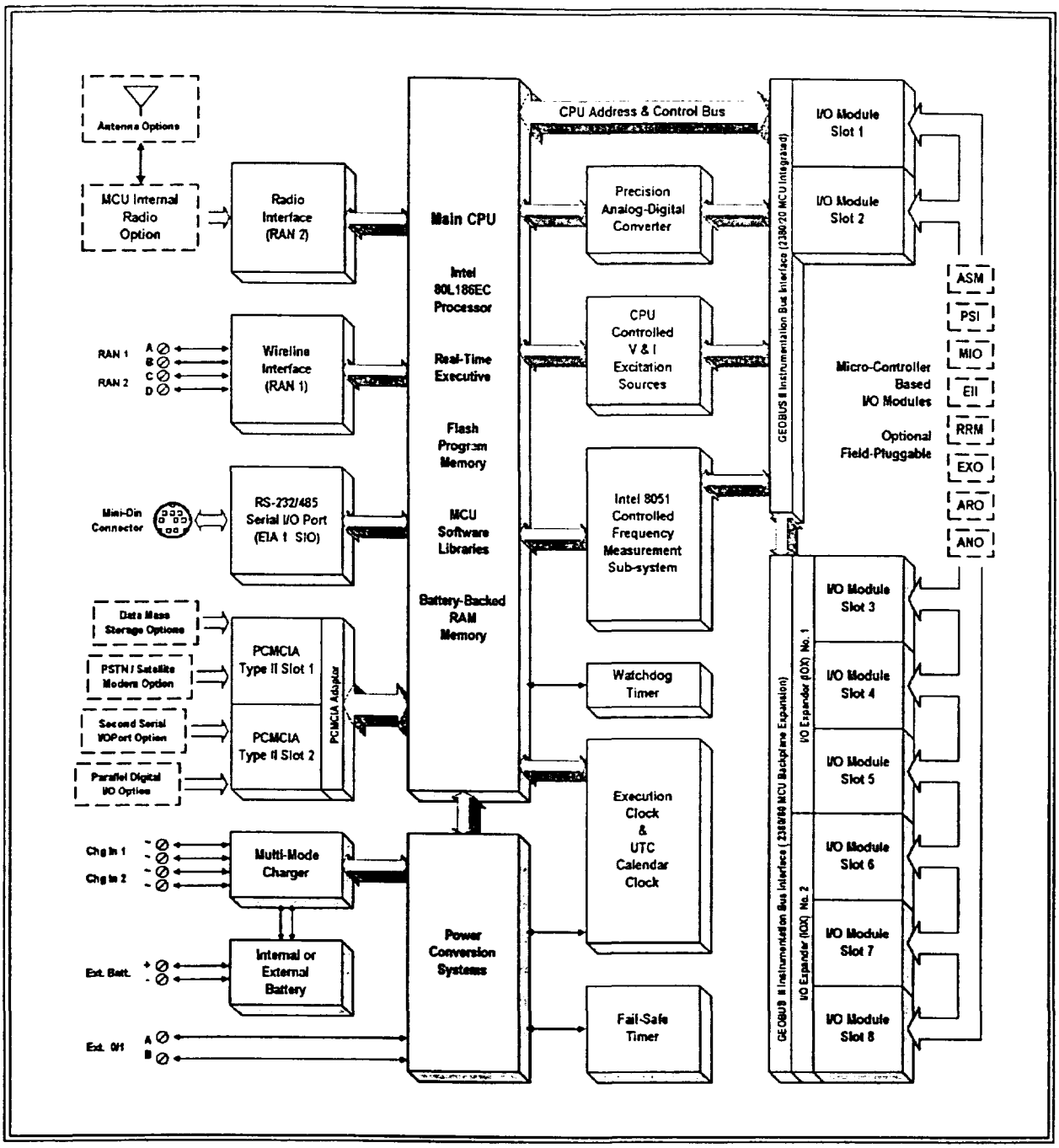
Autonomous operation requires MCUs to know about absolute as well as relative time. Furthermore, MCUs can be deployed over multiple time zones in wide area networks, reporting data to computers in more than one time zone. To assure proper synchronization and reporting of the local time of measurements and events, 2380 MCUs maintain a UTC (Universal Time Coordinate) consisting of Greenwich Mean Time (GMT) plus the geo-coordinate deviation from GMT. MCU clocks are synchronized to GMT by GEONET. MCUs maintain GMT so that they do not get reset improperly by connection with a "foreign" GEONET Workstation. The MCU informs GEONET of its UTC for correctly reporting the date and time of data events.

MCU SPECIFICATIONS

Processor: Intel 80L186EC

Program Memory: Flash EPROM, 256Kx16, field loadable, jumper protected boot block, low-level diagnostic and download monitor
Data & Configuration Memory: 256Kx16, non-volatile static CMOS
Mass Storage: PCMCIA solid state disk option
Clock/Calendar: Non-volati
Accuracy: ±3 sec/month (20°C)
Temperature Coefficient: 50 ppm/°C
UTC reporting to GEONET Stations
Watchdog Time-out Interval: 1.2 sec
Fail-safe Timer Interval: 24 hr
Audible Diagnostic Indicator

MCU ARCHITECTURE *(continued)*



2380 Series MCU Block Diagram – 2380/20 & 2380/80

MCU SPECIFICATIONS *(continued)*

Communication Ports

• EIA 1 SIO: Serial Interface (Standard)
RS-232/RS-485: Software auto-switched
Functions: GEONET Communications Protocol (GCP), Geomation 2390 Series Field Instrument Transponders (FITs), external RS-232/RS-485 connections to 3rd party intelligent instruments
Transient Protection: 600W suppressor diodes, ±15 V common-mode voltage
Connector: 8-pin miniature circular DIN
Indicators: Front panel LEDs: CD, Rcv, Xmt

• RAN 1: Wireline Interface (Standard)
Configurations: 2-wire/4-wire, field strapable
Interface: transformer isolated, 600Ω
Signaling: CCITT V.23, 1200 bps, FSK
Transmit Levels: +3 dBm, 0 dBm, -3 dBm, -6 dBm, -12 dBm, -16 dBm, field setable
Receiver Threshold: -43 dBm, 2.5 dBm hysteresis
Adjustments: CD level, FSK symmetry
Indicators: Front panel LEDs: CD, Rcv, Xmt

• RAN 2: Radio Interface (Standard)
Function: Supports internal Geomation radio transceiver option
Signaling: CCITT V.23, 1200 bps, FSK
Adjustments: CD level, FSK symmetry
Indicators: Front panel LEDs: CD, Rcv, Xmt (See Radio Option for transceiver specifications)

• EIA 2: Telephone Modem (Optional)
Interface: PCMCIA Adapter
(See Telephone Network Modem option for specifications.)

• SDI-12: USGS Fieldbus (Optional)
Interface: Implemented through the EII (Environmental Instrument Interface) I/O Module

Communication Protocols

• INTER-UNIT PROTOCOL: GEONET™ Communications Protocol (GCP)
Type: Proprietary peer-to-peer packet protocol based on SDLC
Error Detection Algorithm: CCITT CRC-16
Link Security: Node-to-node verification and acknowledgment
Network Security: Source node message buffering until end-to-end verification and acknowledgment
Network Services: Field programmable and adaptive message routing. Store-and-forward message routing, repeating and bridging. Message forking to multiple logging destinations.
Application Services: Link failure detection and alarming, with link re-routing capability
Physical Link Support: Point-to-multipoint wireline, radio, microwave, fiber-optic. Point-to-point RS-232, auto-dial/auto-answer PSTN (including cellular).

• FIELD INSTRUMENT PROTOCOLS
Partial list of intelligent instrument drivers implemented in the 2380 MCU, with configuration interfaces implemented in GEONET™ Suite:
Geomation: 2390 Series Field Instrument Transponders (FITs)
USGS: SDI-12 low-power fieldbus

PCMCIA Interface

Physical: Standard PCMCIA interface supports 5 V or 5V/3V PCMCIA cards
Slots: Two Type II
Software Support: Geomation supplied optional mass storage memory cards, telephone modem card, serial I/O card, and parallel digital I/O card.

On-Board Diagnostic Measurements

The system measures and stores by default the following parameters related to the health and well-being of the MCU and its critical subsystems and resources.
Unit Temperature
System Battery Voltage
Charging Voltage
Backup Battery Voltage
Fully Charged Battery: Front panel LED indicator
Charger Mode State: Front panel LED indicator
Communication Port Statistics
Reboot Counters
Calibration Constants: Reference voltages, resistance standards, frequency

Frequency Measurement Subsystem

• EXCITATION
Mode and timing parameters user selectable on an individual measurement channel basis
Single Chirp: Swept square wave from 300Hz up to 1, 2, 3, 4, or 5kHz
Double Chirp: Swept square wave followed by a gated square wave at the frequency of best response
Specified Sweep: Swept square wave from specified starting and ending periods
Duration: 0, 50, 100, 200, 300, 400, or 500 msec
Amplitude: 10Vp-p, zero DC component

• RECEIVER
Bandpass Amplifier: 400Hz to 5000Hz
Sensitivity:
450Hz to 5500 Hz <0.1mV RMS
250Hz to 12000 Hz <10mV RMS
Input Impedance: 5KW at 1KHz, transformer coupled

• PERIOD MEASUREMENT
Method: Time interval for 256 cycles of received signal
Triggering: Triggers and counts on zero crossings
Resolution: 4nsec
Accuracy: ±0.002%, 1 year, T_{cal} ±5C
Temperature Drift: ±.01% -20°C to 55°C ±.05% -40°C to 70°C

DC Measurement Subsystem

• FRONT END
4 Ranges: Differential ±0.1V, ±1V, ±10V, ±50V full scale with 30% overrange, user programmable discrete or autorange per-channel

• ANALOG-TO-DIGITAL CONVERSION
Type: Delta-sigma
Resolution: 19 bits + sign
ADC Throughput: Up to 20 readings/sec
Measurement System Speed: Up to 5 autoranges/sec

MCU SPECIFICATIONS *(continued)*

• SELF CALIBRATION

Method: Interlaced cycles of internal reference sources applied to the front-end
Reference Sources: 10V, 1V, 0.1V, 0V
Long Term Drift: [reference]
Temperature Coefficient: 0.7ppm/°C

• DC VOLTAGE

Range:	±100mV	±1V	±10V	±50V
Full Scale:	±130mV	±1.3V	±13V	±50V
Resolution:	140nV	14µV	140µV	1.4mV
Accuracy:	.005+.01	.005+.01	.005+.008	.01+.02
(% reading + % range)				
CMRR:	>95dB	>85dB	>80dB	>75dB
(DC, 50Hz, 60Hz; 1kW source imbalance)				
ZIN:	>100MΩ	>100MΩ	>100MΩ	1MΩ
Max Input: (H, L to G):	±50V	±50V	±50V	±50V

• DC CURRENT (Using ASM 50W shunt resistors)

Range:	±2mA	±20mA	±200mA
Full Scale:	±2.6mA	±26mA	±260mA
Resolution:	3nA	30nA	0.3mA
Accuracy:	.005+.01	.005+.01	.005+.01
(% reading + % range)			
Max Current:	±70mA	±70mA	±70mA

• CURRENT TRANSMITTERS (Using Base Unit 20W shunt resistor)

Loop Excitation: 24VDC

Range:	±4mA	±40mA
Full Scale:	±5.2mA	±52mA
Resolution:	6nA	60nA
Max Current:	±120mA	±120mA

• RESISTANCE

Scale:	100Ω	1kΩ	10kΩ	100kΩ
Excitation:	5V/70Ω	10V/10kΩ	10V/10kΩ	10V/10kΩ
Range:	120Ω	1.4kΩ	10MΩ	10MΩ
Accuracy:				
100Ω	±0.01Ω	±0.1Ω	±1Ω	±1Ω
1kΩ	—	±0.1Ω	±1Ω	±1Ω
10kΩ	—	—	±5Ω	±5Ω
100kΩ	—	—	±50Ω	±50Ω
1MΩ	—	—	±500Ω	±300Ω

• DC EXCITATION SOURCE

Routing: Can be switched onto any ASM channel under user program control

Voltage Source —
Level: +5V, +10V, +15V, +24V user selectable
Accuracy: ±5%
Noise & Ripple: (20MHz) 20mVRMS 200mVp-p
Source Impedance: 25Ω typ, 50Ω max
Max Current: 100mA

Current Source —
Level: 100mA
Accuracy: ±2%
Compliance Limit: 13.5V
Noise & Ripple: (20 MHz)7µAp-p

Power Subsystems

• POWER CONTROL

Switches: External power switch, internal power switch, main battery disconnect, backup battery disconnect
Operating Modes: Active, idle, sleep, backup
Sleep Activation Sources: Executive commands, Sleep component evaluation, power-miser state detection, low main battery detection, power switch off-transition, software fatal error detection
Boot-up Activation Sources: Main power restored, power switch on-transition, alarm clock wake-up, watch-dog wake-up, fail-safe timer wake-up, GEOBUS Module event detection
Audible Mode Indications: Boot-up, unit active, entering sleep state, resident monitor active

• POWER CONSUMPTION (Based on 12V main supply battery)

Fully Active: 30mA (excludes sensor excitation, optional equipment)
Idle: 20mA (unit awake, but waiting for something to do)
Sleep: 300µA (system shut down, memory retained clock/calendar operating, re-start circuits operational, fail-safe timer running)
Backup Mode: 3µA typ, 50µA max (lithium cell operation, memory retained, clock/calendar operational. Invoked when main battery detached or below 9V)
Absolute Max. Supply Voltage: 16VDC
Absolute Min. Supply Voltage: 10.5VDC

• CHARGER

Type: Multi-stage charge regulator for lead-acid batteries. Automatic low-battery load shedding
Inputs: Dual inputs, AC/DC with DC/DC conversion and thermal shutdown
Min. Charge Input: 17VDC or 17VRMS AC
Max. Charge Input: 35VDC or 35VRMS AC
Low Battery Trickle Current: 25mA
Charge Enable Threshold: 9VDC
Maximum Charge Current: 0.8A
Overcharge Voltage Limit: 14.5VDC
Float Regulation Voltage: 13.8VDC
Charge Shutdown Threshold: 8VDC
Thermal Shutdown: 70°C
Load Shed Threshold: 9.0VDC (can be manually actuated by on-board switch)
Load Restore Threshold: 12VDC
Indicators: Two (charging, fully charged)

Environmental Specifications

• MCU & I/O MODULES

Operating Temperature: -40°C to +70°C
Storage Temperature: -60°C to +125°C
Relative Humidity: 8% to 95%, non-condensing
Operating Altitude: to 4600m pressure altitude
Storage Altitude: to 15,200m pressure altitude
Transient Protection (all connections):
Surge Withstand: IEEE 472 (ANSI C37.90a)
Electrostatic Discharge: 15kV

• TEMPERATURE RATING FOR OPTIONS

External Battery (HRB, EXB): -30°C to +70°C
Internal Battery (INB): -10°C to +40°C
Telephone Modem (TNM, CTIK): -0°C to +70°C
Second Serial Port (SIO-2): -0°C to +40°C
FlashDisk Mass Storage (FMS): -40°C to +85°C

GEOBUS II AND I/O MODELS

GEOBUS II Architecture

The GEOBUS II is a design feature allowing the connection of a wide range of instrumentation to MCUs through a family of bus-pluggable I/O Modules. The basic 2380 MCU, the primary assembly in 2380/20 "bundled" configurations, supports 2 I/O Module positions. The 2380/80 MCU configuration offers 8 I/O Module positions thereby expanding scalability for higher density I/O. In the 2380/80, the GEOBUS II is extended through a passive backplane built into a rugged mounting panel, referred to as the 3-Position Mounting Panel (3MP). The 3MP contains one 2380 MCU and two 2380 IOXs (I/O Expanders), providing the 8 I/O Modules positions (See 2380 Series MCU Block Diagrams – 2380/20 & 2380/80).

GEOBUS II Interface

Implementation:

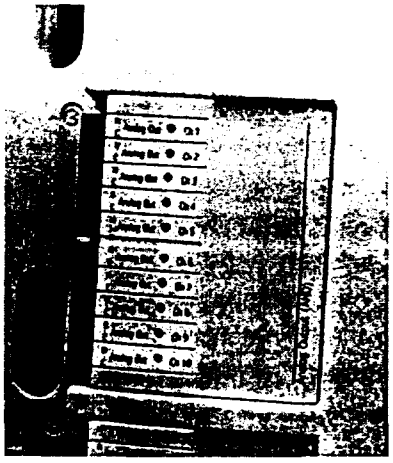
2380/20: Integrated on the MCU System Board, providing for 2 Module positions
2380/80: The MCU integrated bus is extended through a shielded connector on the MCU System Board to a shielded passive backplane on the 3-Position Mounting Panel (3MP). The backplane engages connectors on two 2380 IOXs, providing for 6 additional Module positions, for the total of 8.
Physical: 28kbps serial master-slave, parallel service request lines, analog excitation lines, guarded analog measurement lines, address lines, control lines. Logic level signals with buffer drivers.
Protocol: GEOBUS II Module protocol
Error Checking: Modified CCITT CRC-16
Addressing: Up to 8 I/O Modules in addition to the CPU master and frequency measurement subsystem. Address is determined by physical location on the GEOBUS II.
Module ID: Command response reports module type, protocol level, hardware revision, and I/O Module firmware revision.
I/O Modules are user installable in MCUs and provide direct-connect interfacing to external sensors, transducers, and device actuators. Modules provide field wiring

General I/O Module Functions

screw terminals, indicator lights, signal routing, signal conditioning, voltage-mode or current-mode excitation, multiplexing, and in some cases, analog and digital signal processing. The organization and behavior of these functions are specific to different types of instruments and control devices. Therefore, a family of function-specific as well as mixed-function I/O Modules are offered to handle these variations economically while providing a uniform digital interface to the MCU through the GEOBUS II. Any I/O Module type can be plugged into any GEOBUS II Module position with identical performance, and there are no exclusion rules among Module types that can be plugged into the bus.

I/O Modules assume their "Card Address" by the position (1 through 8) into which they are plugged on the GEOBUS. Position address identification is molded into the Mounting Panels into which the 2380 MCUs and the 2380 IOXs are normally installed.

ANO Analog — Output



General Description —

The ANO is a general purpose, analog voltage output module for independently controlling up to 10 single-ended voltage outputs. The output voltage range is either 0 to +5V or 0 to +10V and is software selectable. The module stores calibration information for each range and each channel. In operation, the module scales the requested output voltage by the stored calibration data and sets the output Digital-to-Analog Converter (DAC) to the 12-bit value corresponding closest to the requested output voltage. An indicator lamp for each channel periodically blinks at a rate proportional to the output voltage.

Typical Applications —

- Driving remote analog or digital panel meter displays
- Simple analog interfacing to RTUs and other monitoring systems
- Proportional or error control signals for control-loop monitoring and tuning

Specifications —

Channels: 10
Output Type: Low power, non-isolated voltage output
Ranges: 0 to +5V, 0 to +10V, relative to channel common
Digital-to Analog Conversion Resolution: 12-bits
Analog Accuracy: ±2mV (10V range), ±1mV (5V range)
Drive Current: 10 mA max

Transient Protection —

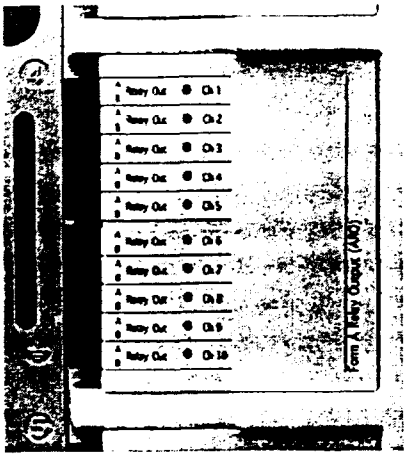
Type: Unipolar suppressor diodes
Breakdown voltage: 15V min
Power: 600W peak pulse power

Calibration —

Technique: Calibration data stored on-module in non-volatile memory; field adjustable
Calibration points: Two point calibration for each range and each channel
Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled H, C
Indicators: One LED for each channel; LED blinks at one of 8 distinct rates proportional to the full scale output
Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)
Wire Size: 28 to 14 AWG

I/O MODELS *(continued)*

ARO — Form A Relay Output



General Description —

The ARO is a general purpose, relay switching module for independently controlling up to 10 two-wire circuits. Output channels on the ARO can be used to switch DC or AC circuits carrying up to 2A DC or peak AC current, with voltage limits of 68V peak or 48V RMS. The solid state relays are protected from electrostatic transients and inductive load switching surges by 1500W transient voltage suppressors.

ARO relays default to the open circuit condition when the MCU is powered down or in the sleep state, or whenever a hardware re-boot occurs. User programmable MCU Evaluators are available for setting selected switches to the on- or off-state and for triggering on-pulses of programmable duration. An indicator lamp for each switch activates whenever the switch contacts are closed.

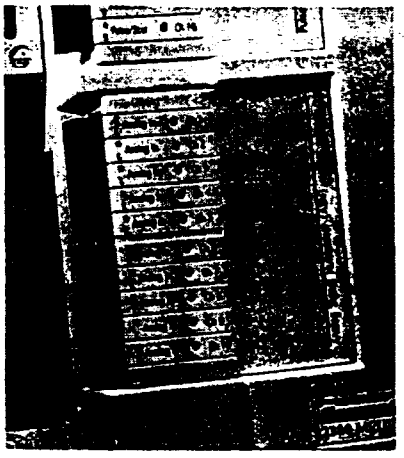
Typical Applications —

- MCU programmed control of low-voltage AC or DC circuits
- Solenoid valve actuation
- Hydraulic drive control
- Interposing relay or contactor signaling for controlling motors and pumps
- Small signal multiplexing

Specifications —

Channels: 10
Switching Action: Form A contact closure (normally open SPST)
Switching Elements: Opto-coupled MOSFET relays, AC connected
Input Voltage Limits: (A to B) ±68Vpeak, 48Vrms
Current Capacity: 2A DC or peak AC at Input Voltage Limits
Contact resistance: 0.34Ω max
Switch Capacitance: 1400pF typical
Leakage Current: 10μA max
Transient Protection: Transient voltage suppressors, 1500W peak power
Type: Bi-directional suppressor diode in parallel with each pair of switch terminals
Breakdown voltage: 68V min
Power: 1500W peak, 14A peak pulse current
Operating Modes: On, Off, or Pulse on. Latest command takes precedence.
Pulse Duration: 0.1 to 6553.5 seconds in 0.1sec increments
Pulse Accuracy: ±5 msec
Fail-Safe: Contacts open on any reboot, power failure, or when MCU is in sleep mode
Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled A, B
Indicators: One LED for each channel; LED lights when channel switch is closed
Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)
Wire Size: 28 to 14 AWG

ASM — Analog Signal Multiplexer



General Description —

The ASM is a general purpose, low-noise Analog Signal Multiplexer for switching up to 10 two-wire circuits into common measurement and excitation resources built into the MCU. The ASM can be used to measure DC voltage, resistance, current, and frequency over multiple ranges. The ASM can also output DC voltage-mode, DC current-mode, and swept AC (chirped) excitation signals under user program control, or under the automatic control of various imbedded "software instruments." Each 2-wire channel has separate measurement and excitation switching which can be applied independently or simultaneously, providing maximum analog excitation and measurement flexibility. Since the ASM enables the MCU for complete multi-channel "multimeter" measurement functions, the ASM is the system workhorse for most general-purpose multi-channel data acquisition applications.

Typical Applications —

- **Voltage Output Transducers:** Low-level and high-level (amplified) devices
- **4-20mA Current Transmitters:** See DC Measurement Subsystem / Current Transmitters
- **Vibrating Wire Instruments:** Direct connection for multiple vendors; see Frequency Measurement Subsystem
- **Thermocouples:** Direct connection for types J, K, T, E, R, S
- **4- and 6-wire DC Resistance Bridges:** "Software Instrument" support for high level programming
- **Potentiometers:** 3-, 4-, and 5-wire configurations
- **DC/DC LVDTs:** With programmed excitation and remote-sense configurations
- **Thermistors:** Direct connection with built-in linearization equations
- **RTDs:** Direct connection with leadwire compensation for 3- and 4-wire configurations

Fundamental Measurements & Excitation —

- **DC Voltage:** See DC Measurement Subsystem / DC voltage
- **2- and 4-terminal Resistance:** See DC Measurement Subsystem / Resistance

I/O MODELS *(continued)*

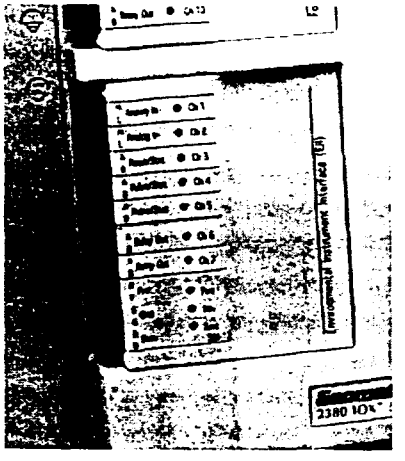
- **DC Current Measurements:** See DC Measurement Subsystem / DC current
- **Frequency:** See Frequency Measurement Subsystem
- **Excitation:** DC voltage-mode, DC current-mode, frequency, swept frequency

Specifications —

Channels: 10 analog, 2-wire, programmable as inputs and excitation outputs
Input Configuration: Bipolar, differential
Switching Elements: Opto-coupled, low-thermal offset MOSFET relays. Separately switched measurement and excitation
Maximum Input: (H, L to G) ±50V
Transient Suppression: 50V bi-directional suppressor diodes per terminal. 1500W peak power
DC Offset: ±2µV maximum differential
Excitation Sources Available through ASM: 5V, 10V, 15V, 24V, & 100µA with 15V compliance limit
Excitation Source Impedance: 50Ω typical
Excitation Duty Cycle: 10sec maximum through ASM, software limited
Thermocouple Reference Junction: On-board electronic reference simulator; can be bypassed for external reference
Thermocouple Reference Junction Accuracy: ±0.5°C, -20°C to +60°C, assuming thermal equilibrium of connection terminals
Thermocouple Linearization Conformity Error
- **Type J:** ±0.5°C, -225°C to 750°C
- **Type K:** ±0.8°C, -275°C to 1350°C
- **Type T:** ±0.3°C, -275°C to 400°C
- **Type E:** ±0.8°C, -275°C to 1000°C
- **Type R:** ±0.8°C, 0°C to 1750°C
- **Type S:** ±0.8°C, 0°C to 1750°C

Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled H, L
Indicators: One LED for each channel; LED lights when channel is addressed for measurement or excitation
Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)
Wire Size: 28 to 14 AWG

EII — Environmental Instrument Interface



General Description —

The Environmental Instrument Interface (EII) I/O Module combines an SDI-12 environmental instrument communications port with Analog Inputs, Pulse/Status Inputs, and Form A Relay Outputs. The EII is similar to the Multi-Function I/O (MIO) Module in that it contains channel-types that are replicated on other modules, namely the ASM, PSI, and ARO. In addition to monitoring environmental instruments, the EII is appropriate for controlling external devices and equipment based on measured parameters when using one or more SDI-12 low-power intelligent sensors. With the exception of the SDI-12 communications port, the EII implements channel types that are fully described and specified for other I/O Modules.

The SDI-12 Interface —

SDI-12 is a voluntary industry standard for interfacing data recorders with microprocessor-based sensors. The merits and limitations of this interface have resulted in industry support being focused around manufacturers of battery powered environmental sensors and data loggers. The predominant emphasis on the SDI-12 interface is the interchangeability of sensors and sensor types for battery powered, field deployed instruments. The standard was originally motivated by the U.S. Geological Survey for applications with the following requirements:

- Battery powered operation with minimal current drain
- Low system cost
- Use of a single data recorder wit multiple sensors on one cable
- Up to 200 feet of cable between a sensor and a data recorder, with transient immunity

Typical Applications —

- Inflow and infiltration studies for water utilities and water resources organizations
- Automatic data collection for hydrographic stations
- Water quality monitoring networks using multi-parameter water quality probes with the SDI-12 interface
- Wastewater sampler control, based on user programmed conditions of water quality, time, flow, and rainfall

Specifications —

Channels: 7
Ports: 1 SDI-12

Channel Types —

2 Analog Input: See ASM description and specifications
3 Pulse/Status Input: See PSI description and specifications
2 Relay Output: See ARO description and specifications

SDI-12 Port Specifications —

Port Type: SDI-12 Data Recorder
Signal Lines —
Data: Serial, bi-directional, 3-state
Power: 9.6V–16V, software switched
Ground: Common to power and data

Transient Suppression —

I/O Channels: ASM, PSI, ARO, EXO specifications apply
Port: SDI-12 specifications apply

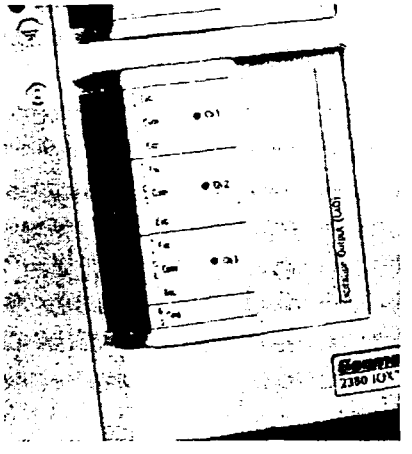
Labeling —

Ch 1, Ch 2: H, L, Analog In
Ch 3, Ch 4, Ch 5: A, B, Pulse/Stat
Ch 6, Ch 7: A, B, Relay Out
SDI-12 Port: Terminals: P, P, Pwr; G, G, Gnd; D, D, Data. LEDs: Pwr, Rcv, Xmt

I/O MODELS (continued)

Indicators —
One LED Per Channel: Channels 1-7, LEDs function same as respective ASM, PSI, ARO channels
Port LEDs: Pwr lights when power is applied; Rcv and Xmt blink during transmit; Rcv blinks during receive
Connectors: 3.5mm pitch screw-clamp terminals (20 per module)
Wire Size: 28 to 14 AWG

EXO — Excitation Output



General Description —

The primary purpose of the EXO Module is to provide isolated and regulated excitation to external instruments and sensors. The fundamental differences between the excitation provided by the EXO and voltage-mode excitation resources built into the MCU and available at Analog Input channels (on the ASM, MIO, and EII) are the following:

1. The EXO provides *low source-impedance* outputs capable of delivering relatively high power to the wiring terminals. A low source-impedance cannot be provided through the small-signal multiplexer switches on Analog Input type channels. The "stiff" output from the EXO can therefore provide the power and regulation typically required by external analog sensors whose measurement performance depends on both short- and long-term DC power supply stability.
2. EXO outputs are derived from plug-in DC/DC converter modules, providing *isolation* from all circuitry in the MCU. The isolation is necessary in the general case to prevent ground loops or other unintended signal interactions that would otherwise convert to significant measurement errors.
3. EXO outputs do not tie up MCU measurement resources. Therefore, no restrictions apply to the duty cycle.

Excitation Power Supply (EPS) Options — An EXO Module can accept from one to three optional plug-in Excitation Power Supplies (EPSs). An EXO must contain at least one EPS to function. EPS outputs are independently controlled by user programming in the MCU. All output voltages that are normally required for sensor or instrument excitation are available in the set of EPSs offered. The following lists the Model Numbers and Descriptions for EPS options:

- EPS-5S+5V Excitation Power Supply for EXO
- EPS-5D±5V (or 10V) Excitation Power Supply for EXO
- EPS-12D±12V (or 24V) Excitation Power Supply for EXO
- EPS-15D±15V (or 30V) Excitation Power Supply for EXO

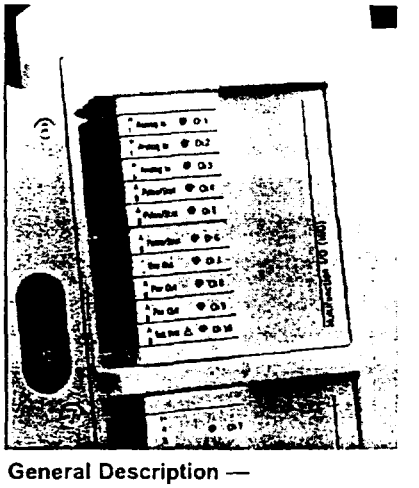
Typical Applications —

- Turn-on of remote equipment under MCU program control, in installations with limited power budgets
- Power-strobed remote sensor excitation, with high isolation and stability

Specifications —

Channels: 3
Type: Isolated single or dual regulated voltage outputs
Control: Independent on, off, or pulsed on; software controlled
Output Power: 3 watts per channel
Output Voltages Available: By pluggable DC/DC converters: 5V, 10V, 24V, 30V, ±5V, ±12V, ±15V
Operating Temperature Range: -25°C to +70°C
Regulation: ±2% of output (1/4 - full load) ±0.05%/°C
Ripple & Noise: 100mVp-p (DC–20 MHz)
Short Circuit Protection: Short-term, self-recovering
Input–Output Isolation: 500VDC
Transient Suppression: 15V suppressor diodes across each supply, 600W peak power
Labeling: Ch 1, Ch 2, Ch 3; 6 terminals per channel: dual COM, +EXC, –EXC per channel
Indicators: One LED per channel; LED is on when the channel is activated
Connectors: 3.5mm pitch screw-clamp terminals (20 per module)
Wire Size: 28 to 14 AWG

MIO — Multi-Function I/O



General Description —

The Multi-Function I/O Module provides a combination of Analog and Pulse/Status Inputs with Excitation and Form A Relay Outputs. The MIO combines channel-types that are replicated on the ASM, PSI, EXO, and ARO Modules. The particular mix of channels on the MIO have been selected to allow economical implementation of closed-loop control for a range of applications with a single I/O Module.

With two exceptions, the MIO implements channel types that are fully described and specified for other I/O Modules. One exception is that the MIO contains an External Power *input* on Channel 10 that can be switched through ARO type relays on

I/O MODELS *(continued)*

Channels 8 and 9. This provides a convenient way to route a control signal required to activate external devices such as solenoids or relays controlling valves or gate actuators. The other exception is that the Exc Out (Ch 7) on the MIO is unipolar only, and does not provide for an optional bipolar connection as implemented on the EXO Module.

Excitation Power Supply (EPS) Option —

Use of the Exc Out provided on Ch 7 requires the selection of an optional plug-in Excitation Power Supply (EPS). This is the same set of DC/DC converter modules used with the EXO module. However, only unipolar configurations are available through the 2-terminal Exc Out channel on the MIO. The EPS output is independently controlled by user programming in the MCU. The following lists the Model Numbers and Descriptions for EPS options as they relate to use on the MIO:

- **EPS-5S:** +5V Excitation Power Supply for MIO
- **EPS-5D:** 10V Excitation Power Supply for MIO
- **EPS-12D:** 24V Excitation Power Supply for MIO
- **EPS-15D:** 30V Excitation Power Supply for MIO

Typical Applications —

- Gate control in open-channel canals, measuring upstream/downstream levels and gate position
- Wide-area flow regulation for irrigation canal operations, with user developed feed-forward control algorithms
- Valve control, based on user programmed algorithms using pressure and flow input parameters

Specifications —

Channels: 10

Types —

3 Analog Input: See ASM description and specifications

3 Pulse/Status Input: See PSI description and specifications

1 Excitation Output: See EXO description and specifications, 2-terminal only: +V, COM or +V, -V

2 Power or Relay Outputs (Selectable **Modes Per Channel) —**

Mode 1 – Form A Relay Output: See ARO description and specifications

Mode 2 – Switched Power: Supplied by the input to Channel 10

1 External Power Input: AC/DC: ±60V peak, 2A current limit

Transient Suppression: ASM, PSI, ARO, EXO specifications apply

Labeling —

Ch 1, Ch 2, Ch 3: H, L, Analog In
Ch 4, Ch 5, Ch 6: A, B, Pulse/Stat
Ch 7: +,-, Exc Out
Ch 8, Ch 9: A, B, Pwr Out
Ch 10: A, B, Ext Pwr D

Indicators —

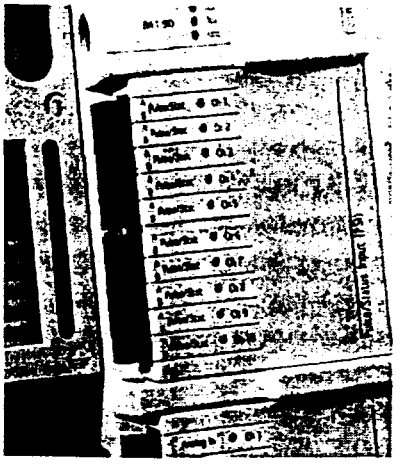
One LED Per Channel: Channels 1–9: LEDs functions same as respective ASM, PSI, ARO, EXO channels

Ch 10 LED: Lights when input voltage exceeds ±4V DC or AC

Connectors: 3.5mm pitch screw-clamp terminals (20 per module)

Wire Size: 28 to 14 AWG

PSI — Pulse/Status Input



General Description —

The PSI Module offers versatile capabilities for handling pulse rate, accumulator, and incremental counting functions. In addition, PSI channels can be used to detect, record and alarm status conditions and times of events. Ten input channels are replicated on the Module, while allowing different channels to operate in different functional modes. Multiple operating modes extend flexibility and economical use of hardware resources. On-board microcontrollers and counters allow the low-power PSI to operate with full capability even when the MCU is in the sleep-state. In fact, the PSI can be programmed so that activity sensed by an input channel can wake the MCU for further processing.

Input conditioning features of PSI input channels allow direct wiring of unipolar signals from external devices. For voltage-level inputs, the detection threshold can be offset to prevent false triggering. Excitation is also provided for sensing external contact closures.

Typical Applications —

- Flow rate and accumulation from gas and liquid flow meters
- Energy monitoring from watt-hour meters
- Background-level radiation monitoring from particle detectors
- General event monitoring
- Equipment status and security monitoring

Specifications —

Channels: 10

Type: Voltage or contact closure inputs, software selectable

Voltage Inputs: Bi-polar or DC offset, software selectable

Input Impedance: 100kΩ

Detector: Threshold crossing with hysteresis

Threshold Levels: 0V or 1.65V, software selectable

Hysteresis: 10mV

Minimum On-Time / Off Time: 250µs

Pulse Rate: 0-1800/s

Contact Closures: Dry contact sensing

Sensing Signal: Pulsed 10V, 1mA

Contact De-Bounce: 8ms on / 8ms off

Functions —

Pulse Rate Functions: Instantaneous or average

Pulse Accumulator: 32-bit counter, continuous accumulation until reset

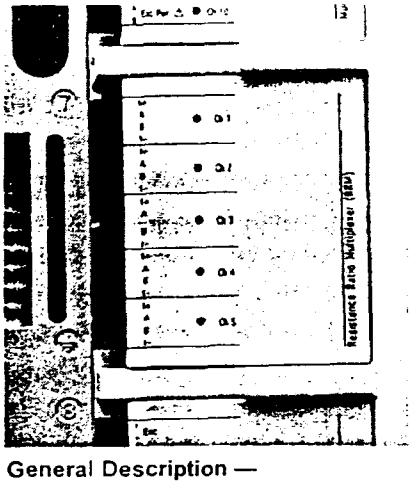
Incremental Counter: Counts occurring since last Evaluation

Status Input: On / off

I/O MODELS (continued)

Power Management Features: Any channel can be enabled to wake up the MCU when a transition occurs, and trigger Evaluations
Transient Suppression: 15V bi-directional suppressor diodes per input terminal, 600W peak power
Labeling: Ch 1, Ch 2, ... Ch 10; two terminals per channel labeled A, B; the B terminals are MCU ground
Indicators: One LED for each channel; LED blinks when input transition occurs, to a maximum rate of 4/s
Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per module)
Wire Size: 28 to 14 AWG

RRM — Resistance Ratio Multiplexer



General Description —

The RRM is a special purpose I/O Module for making multiplexed resistance or resistance ratio measurements on up to 5 channels with 3- or 4-wire configurations. The RRM operates in conjunction with MCU software to accurately measure low-resistance devices normally intended for measurement in a bridge completion circuit.

With low resistance sensing elements, the resistance of the leadwires introduces significant and usually unacceptable error if leadwire resistances are uncompensated. The leadwire configuration of these devices has historically been determined by the leadwire resistance compensation technique used in a bridge completion network. Therefore, the leadwire configuration normally requires a bridge completion circuit for effective leadwire resistance compensation. However, per-channel bridge completion networks are not economical to implement or maintain calibration in multiplexed automatic data acquisition systems.

The optimal leadwire configuration for automatic data acquisition allows true 4-terminal (Kelvin) connections at the sensing resistance element, entirely excluding leadwire resistance errors from the measurement.

For devices that do not allow true Kelvin connections, such as 3-wire resistance devices, an accurate measurement can be made as long as one device node has 2 wires attached. The RRM is designed to make a Kelvin-type measurement at the resistance device node having two leads (for both a current terminal and a potential probe). The RRM *measures* the leadwire resistance through a multi-step sequence. For device nodes that do not have both a potential and current lead, resulting in an embedded leadwire resistance, the measured leadwire resistance from the other node is applied as a dynamic correction to the measured resistance. This embedded leadwire resistance compensation assumes that the current-carrying leads are the same resistance (same wire gauge).

The RRM can be connected to both one-element (3-wire) devices, normally used for temperature measurements, and 2-element (4-wire) devices, in which a resistance ratio measurement is normally used for strain measurements. The RRM, therefore, is specifically designed to accommodate automatic data acquisition retrofit for existing low-resistance devices for which it is impractical or prohibitively expensive to change the leadwire configuration to 4-terminal (Kelvin) connections.

Typical Applications —

- **Four-Wire Half-Bridges:** Carlson meters: resistance ratio strain measurements, total resistance temperature sensing
- **Four-Wire Potentiometers:** Potentiometric ratio with leadwire compensation and immunity to wiper-resistance
- **Three-Wire Resistive Sensors:** RTDs, resistance measurements with lead-wire compensation
- **Four-Wire Resistive Sensors:** RTDs, true Kelvin connections with leadwire error elimination

Fundamental Measurements & Excitation —

Multi-Mode Resistance: Half-bridge, quarter-bridge resistances and resistance ratios with lead wire compensation.
Ratiometric Resistance: See DC Measurement Subsystem / Resistance
Excitation: Voltage-mode with reference resistance in the MCU. See DC Measurement System / DC Excitation Source.

Specifications —

Channels: 5 analog, 4-wire
Terminal Configuration: Positive voltage excitation on I+ with return through I- and internal reference resistor. Voltage measurements from I+ to A, A to B, and B to I-
Switching Devices: Opto-coupled, low thermal offset MOSFET relays. Separately switched measurement and excitation.
Transient Suppression: High pulse-current suppressor diodes, 1500W peak power
DC Offset: <2μV differential
Excitation: +10V with 10KΩ return resistance, or 5V with 70Ω return resistance, autorange selected
Labeling: Ch1, Ch2, ...Ch5; four terminals per channel labeled I+, A, B, I-
Indicators: One LED for each channel; LED lights when channel is activated for excitation or measurement
Connectors: 3.5mm pitch screw-clamp terminals (20 terminals per Module)
Wire Size: 28 to 14 AWG

MCU OPTIONS AND ACCESSORIES

Flashdisk Mass Storage (FMS)

GENERAL DESCRIPTION

High capacity local data storage for the 2380 MCU is provided by an optional PCMCIA Flash Memory Card, which plugs into one of the two PCMCIA Type II sockets in the MCU. The 8 MB card, designated as the FMS-8, has a capacity of 160,000 logged measurements in GEONET format. The FMS-20 has a capacity of 400,000. These non-volatile memory cards are formatted for the 2380 MCU file system and GEONET. The cards operate over the full industrial temperature range of -40°C to +85°C.

In addition to high capacity, the "PC card" removable media has the advantages of being compact and field-rugged from an environmental and handling standpoint. PCMCIA compatibility allows the MCU to accommodate economical memory technologies developed for large markets.

DATA LOGGING

The obvious application for FMS options is stand-alone data logging with an individual MCU. However, beyond the isolated data logger, there are distributed data logging applications where measurements are spatially dispersed. In the distributed situation, multiple MCUs are field-networked to a single MCU, which receives data from all the MCUs and stores the data to a single FMS Card. This configuration is particularly useful when some or most of the MCUs are not conveniently accessible for data retrieval. The user can retrieve data from multiple MCUs at the most convenient location.

BUFFERING FOR SHARED FACILITIES

Flashdisk Mass Storage is also used to buffer remote data in networked configurations that use public telephone, cellular, or satellite networks for data transport. Expanding on the field data logging situations described above, an MCU in a LAN or a Remote Area Network (RAN) can bridge to a Wide Area Network (WAN) through connections to public or private shared access facilities. Buffering large cashes of data before transporting over shared access facilities allows more efficient and economical use of the facilities.

REDUNDANT DATA BACKUP

Many Geomation systems are used to collect critical data during particular events which cannot be repeated, either because they are natural events or else the result of measurements made under non-repeatable conditions. Even though on-line configurations are normally used for such applications, communication links or computers can fail, with potential loss of the critical data. The FMS option allows data to be written to MCU local mass storage, in addition to routine logging over network connections to GEONET. This provides economical operational redundancy for critical data collection applications.

MCU PROGRAMMING

MCU programming, for both instrumentation functions and network topology, can be transferred from GEONET to MCU(s) with an FMS card. The new 2380 MCU file system allows FMS cards to be used both for MCU configuration database storage/transfer as well as measurement data retrieval. Therefore, in manual data logging systems, any configuration modifications are delivered to MCUs in the process of exchanging FMS cards for data retrieval. This simplifies logistics and skills for field data logging support, and eliminates the risk of taking a laptop computer to the field.

Communication Devices

Telephone Network Modem

MCUs support public telephone network connections through a PCMCIA Telephone Modem, designated as the TNM option. The modem plugs into one of the two PCMCIA Type II slots in the MCU. An FMS data storage option is normally used in conjunction with the TNM option for data buffering as described above. The FMS option plugs into the additional Type II slot.

The Hayes Optima 33.6 Modem included in the TNM option is used because of its capacity for superior power management by the MCU. It will operate at data rates to 28,800 bits/s when used with a 2380 MCU transferring data to GEONET Suite. The modem is fully configured by the MCU when the MCU is initially powered up.

If you plan to use the TNM option with telephone systems outside of North America, you should verify the compatibility of this modem type with your public telephone network. If there are further questions regarding compatibility with your telephone system, please contact Geomation Customer Service.

MCU OPTIONS AND ACCESSORIES *(continued)*

Radio Links

Reliability & Simplicity

UHF and VHF Radio Link options integrate tightly with the MCU mechanically and electrically. These radio links provide the most economical and reliable method of networking 2380 MCUs in virtually any field environment as well as in many plant environments. Dependable radio networking has been a long-standing hallmark of the Geomation System 2300. GEONET Communications Protocol (GCP) implemented in MCU software allows all radios to operate on the same frequency using Carrier-Sense Multiple-Access with Collision Avoidance (CSMA/CA). Since the same protocol is used for point-to-multipoint wireline connections, radio operation is identical to wireline operation.

Power & Range

These narrow-band radios are capable of relatively high RF output power (4 watts for UHF & 5 watts for VHF) providing a range of several kilometers, and even much farther with appropriate antenna systems. Since any MCU can be programmed as a repeater for GCP messages from other nodes, systems can be designed to clear terrain obstructions and multiply range to distant locations. The digital repeating feature is important in many field situations. Examples are large area installations over watersheds and municipalities, and extended river and canal reaches. In addition, Geomation can provide a linear amplifier option on special order to boost RF output power to 45 watts.

Due to the long range of signal propagation with these radio links, installations in most countries are governed by a regulatory authority. These authorities normally require users to obtain a location-restricted license in order to assure interference separation among different users of the RF spectrum.

Installations in the USA

For industrial and scientific applications in the U.S., customers may install and use radio linked systems on Geomation held licenses with radios limited to 2 watts of maximum output power. Other restrictions related to antenna height and proximity to national borders apply. (Please contact the Geomation sales or service departments for more details.)

Option Configurations

The RL-EN is the version of the option which includes components for installation in the EN20, EN20-XC, the EN80 or theEN80-XC standard enclosures. This option consists of the radio transceiver itself, a dipole antenna, dummy load, MCU System Board interface card, System Board mounting bracket, a Coaxial Transient Arrestor (CTA), BNC bulkhead feedthru, and coaxial cables for internal installation in Type EN enclosures.

The RL-G version of the option includes everything included in the RL-EN option, plus the CTA Mounting Bracket with fastening hardware, and a 2m grounding cable. The RL-G is for MCUs installed in other enclosures or in buildings without enclosures. A 0.85m coaxial cable is provided with the RL-G to go from the radio output to the CTA. (This cable may need to be replaced or extended if it is not long enough for the installation conditions.)

Radio Links require factory installation for proper set up and adjustment with specialized test equipment. MCUs originally purchased without an RL option may be returned to Geomation for Radio Link installation.

Antennas & Cables

For relatively short range line-of-sight installations of a few of kilometers, the small dipole antenna included with the radio option will probably provide adequate signal strength for reliable communications. For longer range requirements, Geomation offers three high-quality UHF antenna options with different radiation patterns to provide suitable propagation characteristics for most field deployment topologies. Two omni-directional antennas and one directional antenna are included in the antenna options described here. (VHF antenna options can be provided on special order.)

Omnidirectional Antennas

The Standard Omnidirectional Antenna (SOA) is a very rugged broadband collinear type covering the entire frequency range of 406-470 MHz. The radiator assembly is enclosed in a rugged fiberglass radome for maximum protection from severe weather, saltwater and corrosive atmosphere. Specifications: Impedance 50Ω; VSWR < 1.5:1; gain = 0 dB (ref. to the halfwave dipole). Vertical polarization. Input is a Type N female connector. Special construction provides complete weather-protection for the connector inside the supporting pipe. The alternate mounting also provides adequate protection. The SOA includes a cast aluminum mounting base and stainless steel V-bolts for mounting to pipes of 20-54 mm (3/4"-2-1/8") OD. Length: 515mm (20.3"). Net weight: 0.75 kg (1.65 lbs).

The SOA is appropriate for omnidirectional applications, that is, where the MCU needs to communicate with multiple network nodes at different azimuths. This antenna has been chosen because it is compact, rugged, easy to install, and relatively low cost.

The High-gain Omnidirectional Antenna (HOA-n) is a ruggedized precision collinear array design with 6 dB gain (over dipole). This antenna is provided tuned to any specified frequency in the range 406-500 MHz. The "-n" frequency code following the Model Designation specifies a frequency from the Table of Frequencies for Geomation FCC Licenses listed below.
(See above - Installations in the USA.)

A unique parallel feed system eliminates phase lag between elements during icing, and thereby resists changes in pattern often encountered with other omni gain antennas under icing conditions. Specifications: Impedance 50Ω; VSWR < 1.3:1 at F_C ± 6 MHz; Vertical polarization. Input is a Type N female connector. Two heavy anodized castings with stainless steel hardware are provided to attach the HOA to a vertical pipe mast with 2-3/8" maximum OD. Dimensions: 244cm x 12.7cm (96" x 5"), not including ground radials. Net weight: 6.36 kg (14 lbs).

MCU OPTIONS AND ACCESSORIES *(continued)*

The HOA is designed for use as a communications base station antenna. With the System 2300, it would normally be used with a radio Gateway MCU where high gain is required to communicate with distant remote sites that vary in azimuth. High gain in omnidirectional antennas results in increased size, weight and cost. Therefore, the SOA would be preferred for an omnidirectional radio gateway application if the higher gain provided by the HOA is not required by range and the need to overcome loss in the antenna cable.

Directional Antenna

The YAGI Directional Antenna (YDA-n) is a five-element yagi designed for high performance and long-term reliability even under severe environmental conditions. This antenna is provided tuned to any specified frequency in the range 400-512 MHz. The "-n" frequency code following the Model Designation specifies a frequency from the Table of Frequencies for Geomation FCC Licenses listed below.
(See above - **Installations in the USA.**)

A balanced feed design provides equal distribution of energy to the driven element, and allows the entire antenna structure to be kept at DC ground potential. Specifications: Impedance 50Ω; VSWR < 1.3:1 at $F_c \pm$ 0.6%; gain = 10 dB (over dipole). Vertical or horizontal polarization. Input is a Type N female connector. Includes heavy aluminum castings and stainless steel hardware for mounting to 2-3/8" maximum OD circular support. Dimensions: 72.4cm x 33.5cm (28.5" x 13.2"). Net weight: 2.27 kg (5 lbs).

The YDA is appropriate for most remote MCU locations where the communication path is unidirectional. It should also be used for Gateway situations rather than an omnidirectional antenna if all communication with remote nodes is in the same direction. This antenna has been selected because of its quality construction and long term reliability.

Antenna Cables

Coaxial Antenna Cables are provided with connectors to go from the Coaxial Transient Arrestor (CTA) to any of the Antennas

Table of Frequencies for Geomation FCC Licenses (USA)	
-1	457.525MHz
-2	457.550MHz
-3	457.575MHz
-4	457.600MHz
-5	457.750MHz
-6	467.775MHz
-7	467.800MHz
-8	467.825MHz

described above. The CTA is included with the Radio Link options. Antenna Cables are specified separately to accommodate cable length variations between the MCU location and the antenna mounting.

The Standard Antenna Cable (SAC) is 2m in length and has an insertion loss of 0.3dB at 450MHz. This cable is supplied with factory installed connectors: a weatherproof Type N male connector on the antenna end, and a weatherproof BNC male connector on the CTA/Radio end. The SAC should be used for installations where the antenna is collocated with the MCU, and the cable does not have to pass through any openings smaller than 14.5mm (0.57") diameter, the clearance diameter for the smaller BNC connector.

The Extended Antenna Cable (EAC-nn) is ordered to the required length, where -nn specifies the cable length in meters. The EAC is a Times Microwave Systems LMR-240 cable with an attenuation of 0.174dB/m @ 450MHz. This cable is factory-terminated on one end with a weatherproof Type N male connector for the antenna connection. The other end of the cable is not terminated since extended cables are usually fed through a bulkhead cable fitting or a conduit. Therefore, the equipment end of the cable must be field-terminated with the supplied BNC male clamp type connector. The clamp type connector does not require specialized tools for termination.
This cable has the benefit (compared with the LEAC-nn described below) of a smaller diameter [6.1mm (0.240")] and minimum bend radius [19mm (0.75")]. However, the smaller diameter results in higher signal attenuation per unit length. For antenna cables longer than about 20m, it is recommended to use the Low-loss Extended Antenna Cable (LEAC-nn) described below.

The Low-loss Extended Antenna Cable (LEAC-nn) is ordered to the required length, where -nn specifies the cable length in meters. The LEAC is a Times Microwave Systems LMR-400 cable with an attenuation of 0.089dB/m @ 450MHz. This cable is terminated in the same way as the EAC, at one end only, allowing it to be pulled through conduit or cable fittings.

The LEAC has a diameter of 10.3mm (0.405") and a minimum bend radius of 25.4mm (1.0"). This low-loss cable should be used to reduce overall signal attenuation for longer extensions. A gain antenna can be used to overcome loss in the cable.

EIA2 RS-232 Adapter (SIO2)

The SIO2 provides the optional hardware to enable a second RS-232 communication port for the MCU, in addition to the built-in EIA 1 Serial I/O port. The option consists of an RS-232 PCMCIA card and a 3m cable terminated with a D9 connector with socket contacts. The supplied cable mates to a standard COM port on a PC.

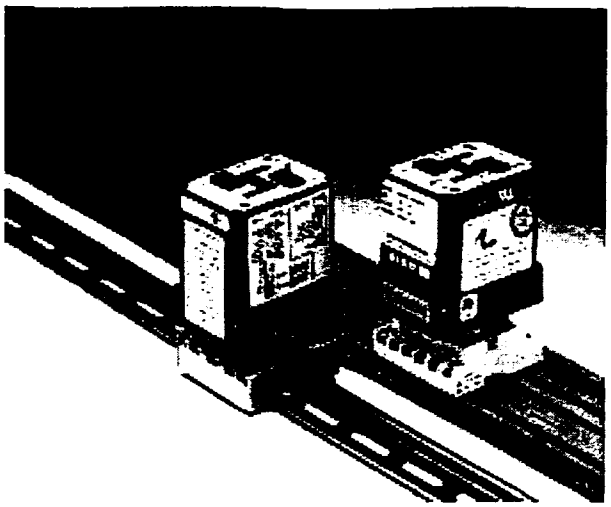
An EIA 2 communication port is automatically enabled when the MCU is powered up with the SIO2 option plugged into either slot of the PCMCIA Adapter. The EIA 2 port supports point-to-point GEONET Communications Protocol (GCP) connections. The SIO2 provides an RS-232 interface only, whereas the EIA 1 port on the MCU provides both RS-232 and RS-485 electrical interfaces.

The primary application for the SIO2 is to allow a GEONET Gateway connection to the MCU through an EIA 2 port if the EIA 1 port is dedicated for another use, such as a Fieldbus Interface.

ACTION PAK®
AP4390/AP4391/ AP4392
MODEL

Benefits

- High Density 2-Channel Package Minimizes Installation Space
- Eliminates Ground Loops with 1500V Input-to-Output, Channel-to-Channel Isolation
- Easy Field Configurable Input Ranges: 10mV to 100V, 1mA to 100mA
- Six (6) Configurable Output Ranges: 0-5V, 0-10V, 0-1mA, 4-20mA, -5 to 5V and -10 to 10V
- Easy Plug-in Installation/ Low Mean-Time-to-Repair
- Selectable 120/240 VAC Power
- Lifetime Warranty



ACTION INSTRUMENTS

Protecting the Integrity of Industrial Process Signals

DC Input, Dual Channel Isolators

Provides Two Independent, Fully Isolated DC Outputs in Proportion to Two DC Inputs

DESCRIPTION

The field configurable AP4390 series dual channel isolators offer wide ranging input and output capability for scaling and transmitting analog DC signals. The AP4390 series will accept input voltage spans from 10mV up to 100 volts, as well as input current spans from 1mA to 100mA. For a full scale output range, the input zero and span potentiometers enable 50% input zero and span adjustability. For example, the 0-10V input range can be elevated to 5-10V or compressed to 0-5V.

The AP4390 series offers six (6) popular ouput ranges which are either positive voltages and currents (e.g. 0-5V, 0-10V, 0-1mA and 4-20mA) or bipolar voltages (-5 to 5V and -10 to 10V). The model number defines the ouput channel ranges as shown in Table 1.

MODEL	CHANNEL	OUTPUT SELECTIONS
AP4390	A	0-5V, 0-10V, 0-1mA, 4-20mA
	B	0-5V, 0-10V, 0-1mA, 4-20mA
AP4391	A	0-5V, 0-10V, 0-1mA, 4-20mA
	B	-5 to 5V, -10 to 10V
AP4392	A	-5 to 5V, -10 to 10V
	B	-5 to 5V, -10 to 10V

Table 1: AP4390 Series Output Ranges. (Bold indicates factory preset ranges.)

The 4-20mA compliance is a powerful 20VDC per channel. All models in the AP4390 series accept bipolar inputs and each I/O channel offers selectable normal or reverse acting operation (e.g. 4-20mA or 20-4mA).

Each Action Pak in the AP4390 series is a dual, three-port, industrial isolator -- both output channels are optically isolated from their respective input channels up to 1500 VDC. The two

invensys
An Invensys Company

APPLICATION

The Action Pak AP4390 series of field configurable isolators is useful in eliminating ground loops, converting signal levels and providing signal drive. The AP4390 series' dual channel design conserves installation space in high density applications and offers superior cost-benefit value over single channel isolators. The wide ranging capability of the AP4390s provides universal spare part coverage.

DIAGNOSTIC LED

TThe AP4390 series is equipped with dual function LED signal monitors. The green, top-mounted LED indicates line power and input signal status. Active line power is indicated by an illuminated LED. If the input signal is 10% above the full scale range, the LED will flash at 8Hz. Below 0%, the flash rate is 4Hz.

OPTION

U Urethane coating of internal circuitry for protection from corrosive atmospheres.

CONFIGURATION

Each channel of the AP4390 series can be independently set for a wide variety of input and output ranges.

FACTORY PRESETS

The factory presets all inputs for 4-20mA. The preset for positive based output channels is 4-20mA and -10 to 10VDC for bipolar voltage output channels (as shown in Table 1 and Figures 1 and 2). The supply power is configured for 120 VAC operation. For other I/O ranges, remove the four base screws and case to access the I/O cards.

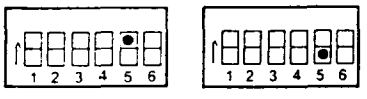
Refer to figures 1 & 2 for configuration and program the I/O channels as desired.

Replace the cover before applying power.

INPUT

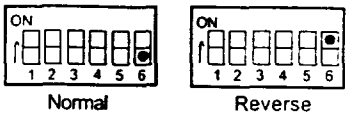
1. Position input jumper "W1" for Current (I) or Voltage (V) input.

2. Set position 5 of the Input Range Selector for Unipolar or Bipolar input operation.



Note: A bipolar range selection will double any range from Table 2 (e.g. 10V span = ±10V bipolar span)

3. Set position 6 of the Input Range Selector for Normal or Reverse operation. Reverse acting produces a decreasing output with an increasing input.



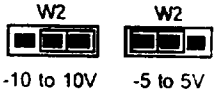
4. Using Table 2, configure positions 1 through 4 of the Input Range Selector for the desired maximum input. Round the desired maximum input value to the next highest range (e.g., 0-70V = 100V range).

WARNING: Do not attempt to change any switch settings with power applied. Severe damage will result.

OUTPUT

1. For the AP4390 channels A and B, and the AP4391 channel B, use Table 3 to configure the output selector switches for one of the four(4) standard output ranges.

2. For the AP4392 channels A and B, and the AP4391 channel B, position output jumper "W2" for -5 to 5V or -10 to 10V.



POWER

1. Configure the AC jumpers for either 120 or 240 VAC operation. See Figure 3.

CALIBRATION

1. Connect the input to a calibrated DC voltage or current source and apply power. Refer to PIN CONNECTIONS. Wait 1 hour for thermal stability before monitoring the voltage/current output.

2. Set the calibrator to the desired minimum input and adjust the Zero potentiometer for the desired minimum output.

3. Set the calibrator to the desired maximum input and adjust the Span potentiometer for the desired maximum output.

4. Repeat steps 2 and 3 for best accuracy.

FACTORY ASSISTANCE

For additional information on calibration, operation and installation please contact Action's Technical Services Group. Call toll-free:

800-767-5726

Table 2: AP4390 Series Input Ranges

Voltage*	Current*	Input Range Selector (SW1)
20mV	2mA	
50mV	5mA	
100mV	10mA	
200mV	20mA	
500mV	50mA	
1V	100mA	
2V		
5V		
10V		
25V		
50V		
100V		

Note: Use jumper (W1) to configure either voltage or current input.

Table 3: AP4390 and AP4391 Output Ranges

Range	Output Range Selector (SW2)
0 to 10V	
0 to 5V	
0 to 1mA	
4 to 20mA	

SPECIFICATIONS

Input	Voltage Input (field configurable)
	Full Scale Range: 10mV to 100V
	Impedance: >100KΩ
	Overvoltage: 400 Vrms, max (Intermittent); 264 Vrms, max (Continous)
	Current Input (field configurable)
	Full Scale Range: 1mA to 100mA
	Impedance: 20Ω, typical
	Overcurrent: 170mArms, max
	Overvoltage: 60VDC
	Common Mode (Input to Ground) 1500VDC, max
	Zero Turn-Up: 50% of full scale range
	Span Turn-Down: 50% of full scale range
Output	Voltage Output
	Output: 0-5V, 0-10V, -5 to 5V, -10 to 10V
	Drive: 10mA, max. (1KΩ min. load @ 10V)
	Current Output
	Output: 0-1mA, 4-20mA
	Compliance: 0-1mA: 10V, max (10KΩ max load)
	4-20mA: 20V, max (1KΩ max load)
LED Indication	
(green)	Input Range
	>110% input: 8Hz flash
	<-10% input: 4Hz flash
Accuracy (Including Linearity, Hysteresis)	<20mV, <2mA: ±0.35% of full scale, typical, 0.5%, max
	>20mV, >2mA: ±0.1% of full scale, typical, 0.2%, max
Response Time (10-90%)	200 mSec., typical
Stability (Temperature)	±0.025% of full scale/°C, typical, ±0.05%/°C, max.
Common Mode Rejection	DC to 60Hz: 120dB
Isolation (Input to Output)	1500 VDC between channels, input, output and power
ESD Susceptibility	Meets IEC 801-2, Level 2 (4KV)
Humidity (Non-Condensing)	Operating: 15 to 95% (@ 45°C)
	Soak: 90% for 24 hours (@ 65°C)
Temperature Range	Operating: -15 to 60°C (5 to 140°F)
	Storage: -25 to 70°C (-13 to 158°F)
Power	Consumption: 4W typical, 6W max
	Standard: selectable 120/240VAC, ±10%, 50-60Hz
Weight	AP4390 0.66lbs
	AP4391 0.68lbs
	AP4392 0.68lbs
Approvals	CSA certified per standard C22.2 No. M1982 (File No. LR42272). UL recognized per standard UL508 (File No. E150323/E99775).

I/O CARD CONFIGURATION

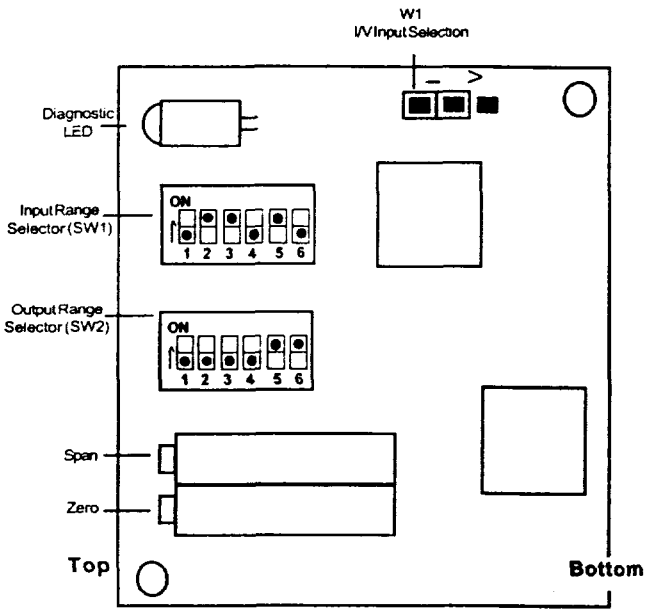


Figure 1: AP4390 and AP4391(A) I/O card factory calibration; 4-20mA input and output (shown sideways to view switches)

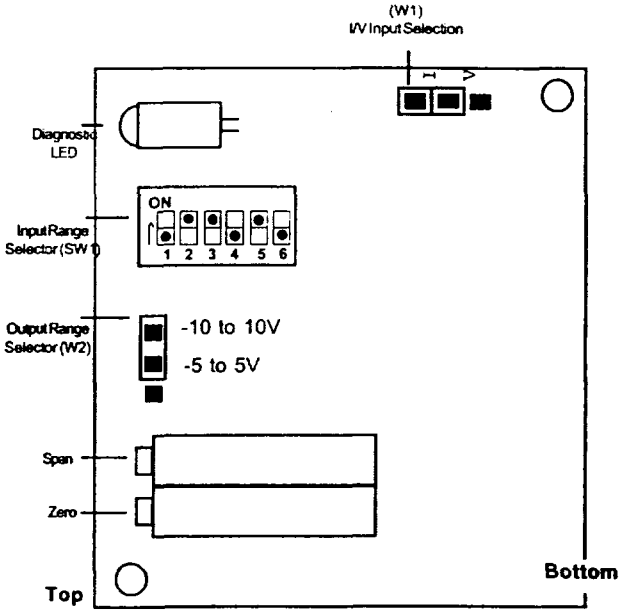
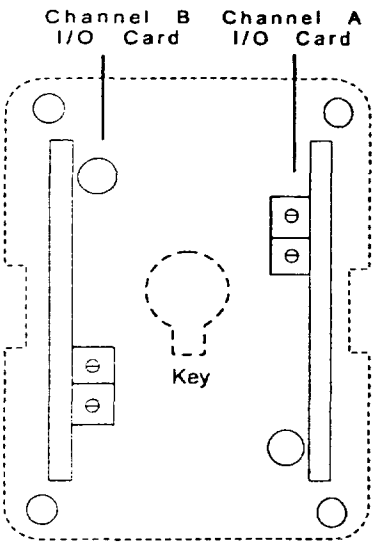


Figure 2: AP4391(B) and AP4392 I/O card factory calibration; 4-20mA input, -10 to10V output (shown sideways to view switches)

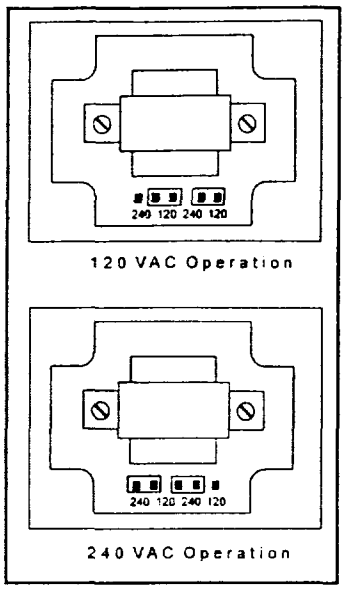
WARNING: Do not attempt to change any switch settings with power applied. Severe damage will result!

WARNING: Applying voltage to the input with W2 in current (I) position will result in damage to the unit.

TOP VIEW DIAGRAMS



WARNING: Do not change with power connected!



MODELS & ACCESSORIES

Mounting

All Action Paks feature plug-in installation. Models AP4390, AP4391 and AP4392 use an 11-pin base and either molded socket M011 or DIN socket MD11 for mounting.

Ordering Information

Specify:

1. Model: AP4390, AP4391 or AP4392
2. Option: U, see text
3. Line Power: 120/240VAC
4. Optional Factory Calibration (C620): specify input range, output range and power.

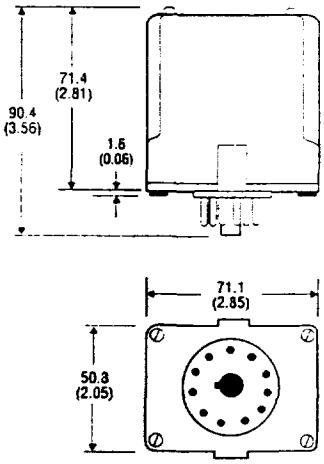
(All power supplies are transformer-isolated from the internal circuitry.)

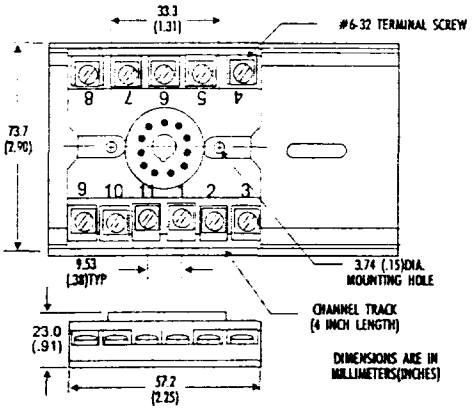
Pin Connections

1 Power (Hot)
2 Spare Termination
3 Power (Neu)
4 Output B (+)
5 Input A (+)
6 Input A (-)
7 Output A (+)
8 Output A (-)
9 Output B (-)
10 Input B (+)
11 Input B (-)

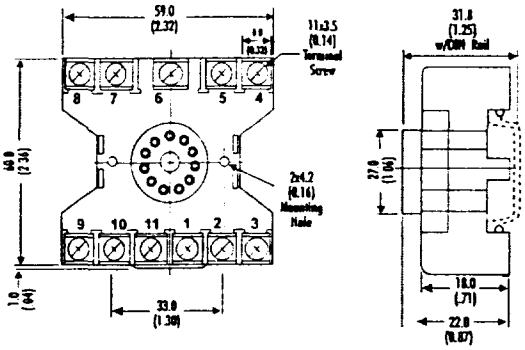
DIMENSIONS

Dimensions are in mm (inches)





M011 (Track/Surface)



MD11 (DIN/Surface)

Eurotherm Action, Inc. **www.eurothermaction.com**
Action Instruments **www.actionio.com**
8601 Aero Drive *San Diego, CA 92123*
858-279-5726 *Service and support: 800-767-5726* *FAX: 858-279-6290*
sales@actionio.com *literature@actionio.com* *support@actionio.com*

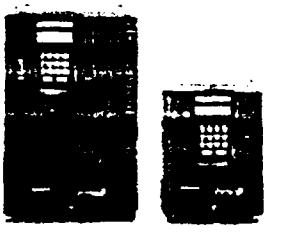
ACTION INSTRUMENTS

721-0527-00-I *11/01*

6SP44X-027 CTAX w/ Frame D4

A full-featured industrial AC drive suitable for wall, machine, flange and washdown mounted installations

UL CE N223



SP600 Wall Mount Style

6SP Series of AC Drives from 0.5 to 20 Horsepower

The new standard in AC Drives, the SP600 provides the benefits of more expensive full-featured drives in a compact, versatile, and cost effective design. Multiple enclosure/packaging options with drive mounted LCD keypad and embedded braking circuitry make this drive very versatile. The wide range of network options available for this product will allow you to maximize data acquisition, control and application flexability.

STANDARD FEATURES

The SP600 AC drive is Reliance Electric's 6th generation of AC drives It breaks new ground and sets the standard by which drives in this class will be measured.

For customers who rely on the simplicity of the SP500, the SP600 provides the "user friendliness" expected by our customers with the advanced features and functionality of a leading edge drive.

The default configuration of the SP600 limits the customer's exposure to a Basic access level of parameters.

But for those who require broader application flexibility, the full access level of parameters gives the user complete access to all of the drive parameters.

Every SP600 is software selectable for either:

- **Volts/Hertz**
- **Sensorless Vector Control (SVC)**

Each method is capable of operating single or multiple motors from one AC Drive[1].

- **Input Voltages/Power Ratings:**
  - 200, 208, 240 (0.5 to 10 HP)
  - 380, 400, 415, 480 (0.5 to 20 HP)
  - 575 (0.5 to 20 HP)
- **Enclosures/Mounting:**
  - Wall or Machine Mount NEMA 1 (IP20)
  - Flange Mount NEMA 1 (IP20)
  - Zero clearance stacking, side by side cabinet mounting with 50°C rating
- **Switching Frequency:**
  - 4 - 10 kHz carrier frequency
  - Increase up to 10 kHz for quiet motor operation. See manual for de-rating.

(1) SVC mode is limited to identical motors coupled mechanically.

- **Detachable Operator Interface:**
  - Multi-line, 6-language LCD OIM for local or remote operation. Allows drive configuration, control, monitoring and diagnostics.
- **Terminal Strip Control:**
  - 24 V Digital Inputs (qty 6), configurable
    - 8 programmable pre-set speed selections possible
  - Analog Inputs, 10 bit resolution
    - Input #1 (0-10 VDC or 4-20 mA)
    - Input #2 (±10 VDC, 0-10 VDC, or 4-20 mA)
  - Analog Outputs, 10 bit resolution
    - 0 - 10 VDC
  - Relay Outputs (qty 2), Form C
- **Braking Transistor Built-in**
  - Optional Drive-mounted or externally mounted braking resistor required
  - Braking Modes: Extended ramp, DC injection, DB

STANDARD FEATURES CON'T

- **Typical OIM Operator Functions:**
  - Start/Stop
  - Forward/Reverse
  - Jog
  - Auto/Manual
  - Clear Fault

OTHER FEATURES

- Configuration and monitoring of a single or multiple drives when using optional V*S Utilities PC Software.
- Intelligent Thermal Management (ITM™) system can reduce carrier frequency or shut the drive off in case of an over-temperature condition.
- UL and NEC approved electronic motor overload protection.
- Adjustable Auto Restart
- Frequency avoidance bands to lock out mechanical resonance points.
- "S" curve acceleration and deceleration for smooth speed transitions.
- Line-to-Line and Line-to-Ground output short circuit protection.
- Fault memory logs that display time stamped drive faults.
- Built-in PI process control functionality.

QUIET MOTOR OPERATION UP TO 600 FT

- The SP600 controller uses IGBT transistors switched at frequencies up to 10kHz to reduce PWM induced motor audible noise. This technology limits the increase of audible motor to not more than 3dba when compared to sine wave operation.
- Unique transistor control circuits also allow drive to operate at motor distances of up to 600 feet, with proper cable type before output filtering considerations must be applied.
- Tested to ensure that the waveform at the motor conduit box will not exceed the limits specified in NEMA MG1 31.40.4.2. at lead lengths of 200 ft.

SERVICE CONDITIONS

- Elevation to 3300 ft (1000 meters)
  - De-rate 3% for every 1000 ft. above 3300 ft.
- Operating temperature ranges:
  - NEMA 1 or IP20 Enclosures: -10°C to 50°C
- Atmosphere:
  - Non-condensing relative humidity: 5% to 95%
- AC line voltage variation: rated input voltage ±10%
- AC line frequency variation (50/60 Hz): 48 - 62 Hz.
- Storage temperature: -40°C to 65°C (-40°F to 149°F)

RATINGS(1)

- 110% OL: 110% of rated horsepower for 1 minute, 150% of rated horsepower for 3 seconds
- 150% OL: 150% of rated horsepower for 1 minute, 200% of rated horsepower for 3 seconds

NOTE: Single-phase operation requires 50% de-rating of drive output current.

(1) See horsepower rating chart

APPLICATION DATA

- Pulse width modulation (PWM): sensorless vector control or volts per hertz control
- Displacement power factor: 0.96
- Frequency stability long term: 0.01% of base speed with digital keypad 0.5% of base speed with analog speed reference
- Linearity (speed reference to output frequency): ± 1.0%

SP600 BRAKE RESISTOR SPECIFICATIONS

The Specifications below are applicable to external braking resistors. See SP600 options section.

Drive Voltage	Frame	Minimum External Resistance (ohms 10%)
230	A	32.9
	B	32.9
	C	28.7
	D	21.7
460	A	63.4
	B	63.4
	C	71.1
460 (15 HP)	D	42.3
460 (20 HP)	D	29.1

POWER RATING OF THE DYNAMIC BRAKE RESISTOR

The average power dissipation of the braking mode must be estimated and the power rating of the Dynamic Brake Resistor chosen to be greater than the average regenerative power dissipation of the drive.

SP600 SPECIFICATIONS

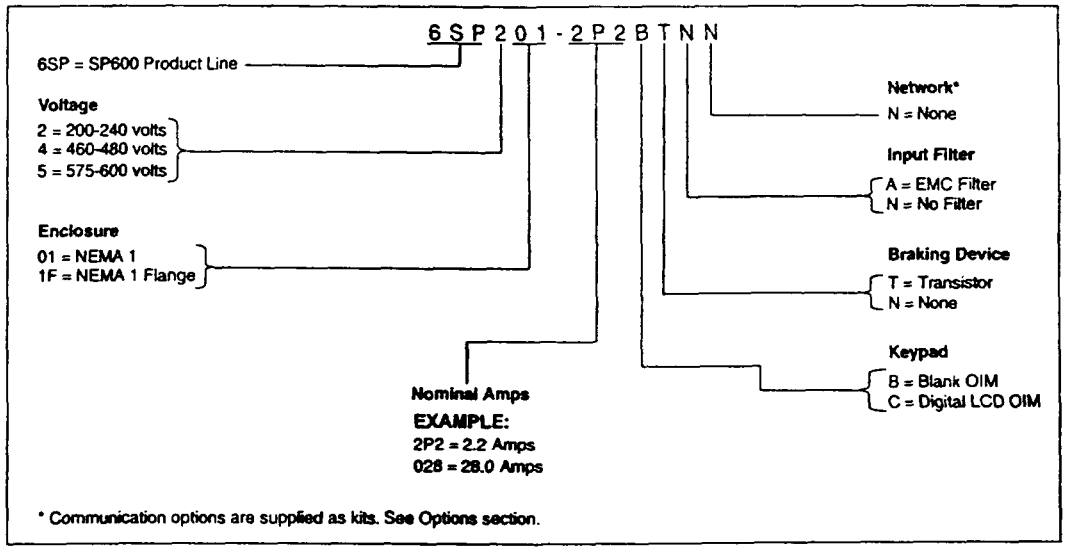
The specifications below are applicable over a constant torque range.

Specification	Fan/Pump and Custom V/Hz	SVC
Speed reguation/accuracy (with slip compensation)	0.5% (40:1 speed range)	0.1% (60:1 speed range)
Operating speed range (with slip compensation)	40:1	120:1
Dynamic speed accuracy (speed response to a 95% step load change)	0.5% base speed	0.1% base speed
Velocity bandwidth (with slip compensation and no encoder)	10 rad/s	20 rad/s (50 rad/s desired)
Minimum settability of velocity bandwidth/slip compensation	0.1 rad/s	0.1 rad/s

DIMENSIONS

Frame	Overall Height	Mount C-C Height (1)	Overall Width	Mount C-C Width (1)	Depth	Weight
A	8.89 (225.8)	8.33 (211.6)	4.80 (121.9)	3.71 (94.2)	7.08 (179.8)	7.8 (3.6)
B	9.24 (234.6)	8.67 (220.2)	6.74 (171.2)	4.83 (122.7)	7.08 (179.8)	10 (5)
C	11.81 (300.0)	11.25 (285.6)	7.32 (185.9)	5.42 (137.6)	7.08 (179.8)	17 (7.6)
D	13.78 (350.0)	13.21 (335.7)	8.68 (220.4)	6.65 (169.0)	7.10 (180.4)	21.5 (9.7)

(1) C-C = center hole to center hole
inches (mm)
lbs (kg)



6SP MODEL - TERMINAL ASSIGNMENTS

Control Terminals

Terminal	Signal Name	Default Functions
1	Digital In 1	Stop/Clear Fault
2	Digital In 2	Start
3	Digital In 3	Function Loss
4	Digital In 4	Jog
5	Digital In 5	Auto/Manual
6	Digital In 6	Speed Select 1
7	24 V Int. Com	Logic Common
8	Digital In Ext.Com	Logic Common
9	+24 VDC Int.	Internal 24 V logic supply
10	+10 VDC Ref. Out	Internal 10 V reference supply
11	Digital Out1 - NO	Fault
12	Digital Out1 - C	
13	Digital Out1 - NC	
	Analog Input 1	Default = 4-20 mA
14	Analog Volts In1 (-)	See Param. 320
15	Analog Volts In1 (+)	Non-isolated
16	Analog Current In1 (-)	
17	Analog Current In1 (+)	
	Analog Input 2	Default = 0 to 10 VDC
18	Analog Volts In2 (-)	See Param. 320
19	Analog Volts In2 (+)	Isolated
20	Analog Current In2 (-)	
21	Analog Current In2 (+)	
22	Analog Out (-) & Reference Common	
23	Analog Volts Out (+)	Drive Output Frequency
24	Digital Out2 - NO	Running
25	Digital Out2 - C	
26	Digital Out2 - NC	

Power Terminals

Terminal	Signal Name	Function
R	R/L1	AC line input
S	S/L2	AC line input
T	T/L3	AC line input
+DC/BR1	DC Brake (+)	DB (+) resistor connection
BRK/BR2	DC Brake (-)	DB (-) resistor connection
U	U/T1	Motor output
V	V/T2	Motor output
W	W/T3	Motor output
PE	PE Ground	Protective Earth
PE	PE Ground	Protective Earth

Output Ratings:
200 - 240 VAC Three-phase Ratings

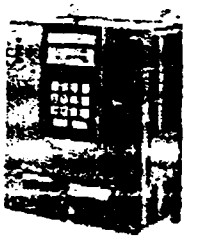
Model Number		Output Amps						Nominal Power Ratings			
		240 VAC Input			208 VAC Input			110% OL Duty		150% OL Duty	
		Cont.	1 Min.	3 Sec.	Cont.	1 Min.	3 Sec.	kW	HP	kW	HP
6SP201	-2P2	2.2	2.4	3.3	2.5	2.7	3.7	0.37	0.5	0.25	0.33
	-4P2	4.2	4.8	6.4	4.8	5.5	7.4	0.75	1	0.55	0.75
	-6P8	6.8	9	12	7.8	10.3	13.8	1.5	2	1.1	1.5
	-9P6	9.6	10.6	14.4	11	12.1	16.5	2.2	3	1.5	2
	-015	15.3	17.4	23.2	17.5	19.2	26.2	4	5	3	3
	-022	22	24.2	33	25.3	27.8	37.9	5.5	7.5	4	5
	-028	28	33	44	32.2	37.9	50.6	7.5	10	5.5	7.5

380 - 480 VAC Three-phase Ratings

Model Number		Output Amps						Nominal Power Ratings			
		480 VAC Input			400 VAC Input			110% OL Duty		150% OL Duty	
		Cont.	1 Min.	3 Sec.	Cont.	1 Min.	3 Sec.	kW	HP	kW	HP
6SP401	-1P1	1.1	1.2	1.6	1.3	1.4	1.9	0.37	0.5	0.25	0.33
	-1P1	2.	2.4	3.2	2.1	2.4	3.2	0.75	1	0.55	0.75
	-3P4	3.4	4.5	6	3.5	4.5	6	1.5	2	1.1	1.5
	-005	5	5.5	7.5	5	5.5	7.5	2.2	3	1.5	2
	-008	8	8.8	12	8.7	9.9	13.2	4	5	3	3
	-011	11	12.1	16.5	11.5	13	17.4	5.5	7.5	4	5
	-014	14	16.5	22	15.4	17.2	23.1	7.5	10	5.5	7.5
	-022	22	24 2	33	22	24.2	33	11	15	7.5	10
	-027	27	33	44	30	33	45	15	20	11	15

WALL MOUNT DRIVES

N223



SP600 shown with LCD OIM

- Motor Power Rating: 0.5 to 20 HP (0.33 to 15 kW)
- Input Voltage: 380-415, 460-480 VAC, 50/60 Hz
- Enclosure: NEMA 1 Ventilated/IP20
- Mounting: Wall/Machine – Panel Mount as IP20
- Models available with LCD OIM keypad
- Models available with internal EMC filter
- Zero clearance side by side mounting

380 - 480 VAC, 50/60 Hz Input: Ratings 0.5 to 20 HP

NEMA 1/IP20 Model Number		Frame Size	With OIM	With Filter	Horsepower Rating 110% OL	Horsepower Rating 150% OL(1)	Drive Amps @ 480 V(3) Continuous(2)	Drive Amps @ 480 V(3) 1 Min.	Drive Amps @ 480 V(3) 3 Sec.	List
6SP401	-1P1BTNN •	A								$904
	-1P1BTAN	B		•	0.5	0.33	1.1	1.2	1.6	992
	-1P1CTNN •	A	•							1,086
	-1P1CTAN	B	•	•						1,174
	-2P1BTNN •	A								956
	-2P1BTAN	B		•	1	0.75	2.1	2.4	3.2	1,044
	-2P1CTNN •	A	•							1,138
	-2P1CTAN	B	•	•						1,226
	-3P4BTNN •	A								1,008
	-3P4BTAN	B		•	2	1.5	3.4	4.5	6	1,096
	-3P4CTNN •	A	•							1,190
	-3P4CTAN	B	•	•						1,278
	-005BTNN •									1,112
	-005BTAN	B		•	3	2	5	5.5	7.5	1,200
	-005CTNN •		•							1,294
	-005CTAN		•	•						1,382
	-008BTNN •									1,258
	-008BTAN	B		•	5	3	8	8.8	12	1,346
	-008CTNN •		•							1,440
	-008CTAN		•	•						1,528
	-011BTAN •	C		•	7.5	5	11	12.1	16.5	1,591
	-011CTAN •		•	•						1,773
	-014BTAN •	C		•	10	7.5	14	16.5	22	1,736
	-014CTAN •		•	•						1,918
	-022BTAN •	D		•	15	10	22	24.2	33	2,350
	-022CTAN •		•	•						2,532
	-027BTAN •	D		•	20	15	27	33	44	2,844
	-027CTAN •		•	•						3,026

(1) Overload of 150% of rated current for 1 minute dependant on actual motor full load amps versus drive continuous amp rating.
(2) Rated for 480VAC input and 4 kHz switching frequency.
(3) See amp rating chart for currents @ 400 VAC.

Model Numbers 6SP401- xxxBxxx are without OIM. OIM option available. See page D1-41 for information.
Model Numbers 6SP401- xxxCxxx are with OIM.
Model Numbers 6SP401- xxxCxAx are with OIM and internal EMC filter.

• Normally carried in stock

DISCOUNT VS-1AC

RELIANCE ELECTRIC

WASHDOWN DRIVES

N223

- Power Rating: 0.5 to 20 HP (0.33 to 15 kW)
- Voltage: 380, 400, 415 & 480 VAC 50/60 Hz
- Enclosure: NEMA 4X/12 Washdown/Dustproof/IP66
- Mounting: Wall/Machine - Panel Mount as IP20
- OIM/Keypad: LCD OIM factory installed

380 - 480 VAC, 50/60 Hz Input: Ratings 0.5 to 20 HP (2)

NEMA 4X/12/IP66 Model Number		Frame Size	Horsepower Rating		Drive Amps @ 480 V(3)			List
			110% OL	150% OL(1)	Continuous(3)	1 Min.	3 Sec.	
6SP44X	-1P1CTNN	B4	0.5	0.33	TBD	TBD	TBD	Contact factory
	-2P1CTNN	B4	1	0.75	TBD	TBD	TBD	Contact factory
	-3P4CTNN	B4	2	1.5	TBD	TBD	TBD	Contact factory
	-005CTNN	B4	3	2	TBD	TBD	TBD	Contact factory
	-008CTNN	B4	5	3	TBD	TBD	TBD	Contact factory
	-011CTAN	C4	7.5	5	TBD	TBD	TBD	Contact factory
	-014CTAN	C4	10	7.5	TBD	TBD	TBD	Contact factory
	-022CTAN	D4	15	10	TBD	TBD	TBD	Contact factory
	-027CTAN	D4	20	15	TBD	TBD	TBD	Contact factory

(1)Overload of 150% or more for 1 minute. Dependent upon actual motor full load amp rating versus the drive continuous amp rating.
(2)Rated for 480 VAC input and 4 kHz switching frequency.
(3) See amp rating chart for currents @ 400 VAC.

ACms

DISCOUNT VS-1AC

E M A R

EMAR
Outdoor
Cabinet Specialists

Outdoor Cabinet Specialist - 2200 E Memorial [illegible] - [illegible]@emarinc.com

Cabinets
Heat Exchanged
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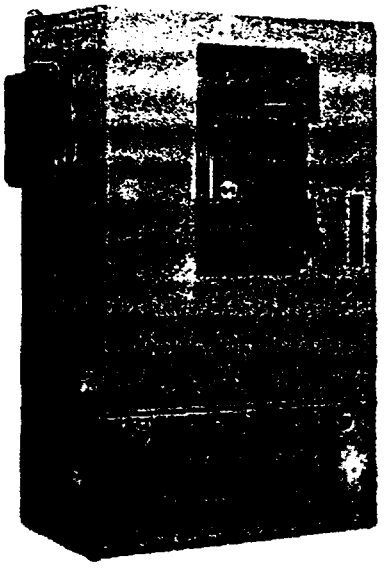
248
448
648
10100
795
196
Air Conditioned
Open Forced Air
Open Passive
Battery Cabinet
Custom Design
Custom Worksheet
Integration
Integration Prep
Wire Harness
Control Panels
Accessories
Battery Shelves
Battery Drawers
Rain / Sun Tarp
Door Keys
Templates
Fan Packs
Base Extenders
Pole Mount Kits
Company Info
Contact EMAR
Mission Statement
History
Home

11000 - Electronics Equipment Enclosure



Features:

1. Dimensions (inches): 29 W x 17 D x 47 H.
2. .125 aluminum construction with powder coat finish.
3. Closed loop cooling using heat exchanger technology. Optional air conditioner available
4. One fixed rack with 31 inches total vertical space.
5. Optional external battery compartment separates the batteries from the electronics.
6. AC load center.
7. Telecordia GR-487 tested.
8. Pad or pole mount.

Cabinets | Custom Design | Integration | Company Info | Home

EMAR Inc.

2200 E. Memorial Drive
Muncie, Indiana 47302
Phone: 765-289-3777
FAX: 765-289-3785
info@emarinc.com

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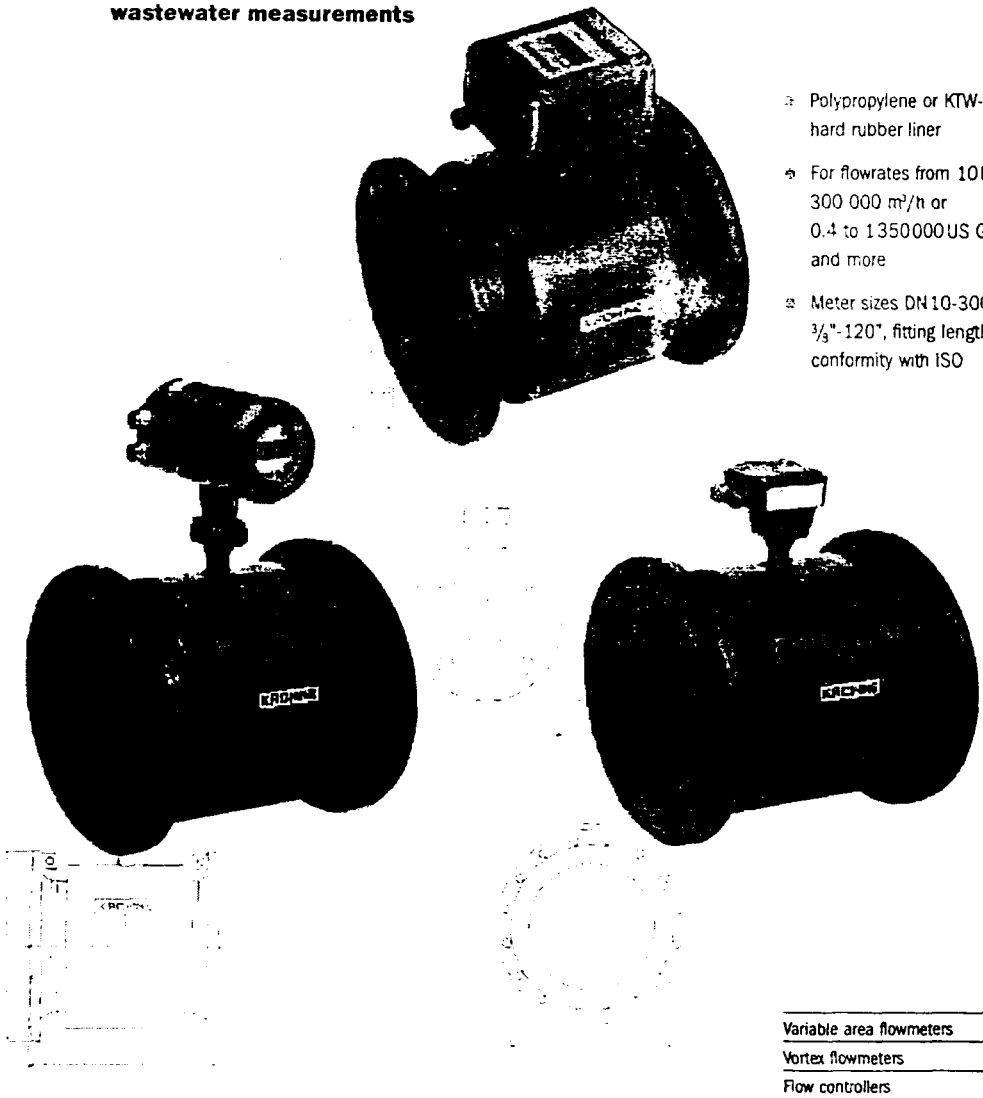
AQUAFLUX
Electromagnetic Flowmeters

... the specialist for water and wastewater measurements



- Polypropylene or KTW-approved hard rubber liner
- For flowrates from 10 l/h to 300 000 m³/h or 0.4 to 1 350 000 US Gal/min and more
- Meter sizes DN 10-3000 and 3/8"-120", fitting length also in conformity with ISO

Variable area flowmeters
Vortex flowmeters
Flow controllers
Electromagnetic flowmeters
Ultrasonic flowmeters
Mass flowmeters
Level measuring instruments
Communications technology
Engineering systems & solutions
Switches, counters, displays and recorders
Heat metering
Pressure and temperature

AQUAFLUX
Electromagnetic Flowmeters

– the specialists for water and sewage

AQUAFLUX
flowmeters measure the volumetric flowrate of electrically conductive liquids.

Fields of application

- Water and wastewater
- Environmental engineering
- Abrasion resistance:
  more than adequate for the application fields
- Chemical resistance:
  alkaline solutions (e.g. NaOH)
  up to 50% at 20°C / 68°F
  acids (e.g. HNO_3)
  up to 5% at 20°C / 68°F

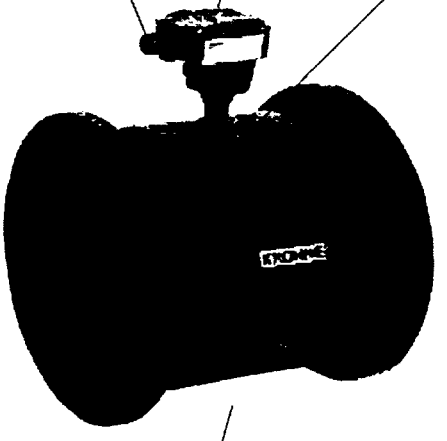
Calibrated on **EN 45 001** certified calibration rigs, accuracy of calibration better than 99.97% of the measured value.

Modular design:

- separate version
  with connection box (see photo),
  signal converter in field housing
  or as 19" plug-in version
- compact version,
  various signal converters
  for direct mounting
  on the primary head

IP 67 as standard, equivalent to NEMA 6, (IP 68 on request), permanently submersible, suitable for ground burial

Fully welded housing, absolutely tight, rugged, resistant to corrosion



For flowrates from 10l/h to 300 000 m³/h or 0.4 to 1350000US Gal/min and more

Meter sizes DN10-3000 and ⅜"-120", fitting length also in conformity with ISO

The responsibility as to the suitability, intended use and corrosion-resistance of the materials used in their construction rests solely with the purchaser.

Technical data

Meter sizes	
Compact systems	DN10 - 1600 and $^3/_8$" - 64"
AQUAFLUX F (separate)	DN10 - 3000 and $^3/_8$" - 120"
Pipe flanges	
to DIN 2501 (= BS 4504)	DN10 - 50 and DN80 / PN40 DN65 and DN100 - 150 / PN16 DN200 - 1000 / PN10 DN1100 - 2000 / PN6 DN2200 - 3000 / PN2.5
to ANSI B 16.5	$^3/_8$" - 24" / Class 150lb / RF
to AWWA	14" - 120" / Class B or D / FF
Electrical conductivity	≥ 20µS/cm
Temperatures	Ambient temperature / Process temperature
Compact systems	- 25 to + **60**°C / - 5 to ≤ + 60°C - 13 to + **140**°F / + 23 to ≤ + 140°F - 25 to + **40**°C / - 5 to ≤ + 90°C - 13 to + **104**°F / + 23 to ≤ + 194°F
AQUAFLUX F (separate)	- 25 to + 60°C / - 5 to ≤ + 90°C - 13 to + 140°F / + 23 to ≤ + 194°F
Max. allowable operating data	Process temperature, operating pressure and vacuum load for the liner, refer to Page 6 "Limits"
Insulation class of field coils	E
Electrode design	
DN10 - 3000 / $^3/_8$" - 120"	flat elliptical electrodes, solidly fitted, surface-polished
Option DN350 - 3000 / 14" - 120"	field-replaceable electrodes WE
Protection category (EN 60 529 / IEC 529)	
Standard	IP67, equivalent to NEMA 6 (with field replaceable electrodes WE: IP65, equivalent to NEMA 4/4X)
Option	IP68, equivalent to NEMA 6
Grounding rings	available as an option
Materials	
Measuring tube	stainless steel 1.4301 (or higher materials number),equivalent to SS 304
Liner	
DN 10 - 0020 / $^3/_8$" - $^3/_4$"	Teflon®-PTFE
DN 25 - 0150 / 1" - 6"	Polypropylen
DN200 - 3000 / 8" - 120"	hard rubber
Electrodes	
Standard	Hastelloy C4
Option	stainless steel 1.4571 or SS 316 Ti, titanium
Field replaceable WE	stainless steel 1.4571 or SS 316 Ti
Connecting flanges*	
DIN: DN10 - 50, DN80 ($^3/_8$" - 2", 3")	steel 1.0402 (C 22) or AISI C 1020
DIN: DN65, ≥ DN100 (≥ 4")	steel 1.0501 (RST 37.2) or AISI C 1035
ANSI	steel ASTM A 105N
Housing*	
DN10 - 40 / $^3/_8$"-1$^1/_2$"	GTW-S 30 (malleable cast iron)
≥ DN50 / ≥ 2"	sheet steel
Terminal box*	
AQUAFLUX F (separate)	die-cast aluminium
Grounding rings (option)	stainless steel 1.4571 or SS 316 Ti

* with polyurethane coating

Teflon® is a registered trademark of DuPont

Dimensions and weights

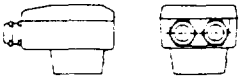
PLEASE NOTE !

The **total dimension for the height** is obtained from **dimension b** (see table) **plus the height** of the terminal box or the signal converter, see drawings.

The **total weight** is made up of the weight of the signal converter (see table) **plus** the weight of the terminal box or signal converter, see below.

Dimension "a" without flange gaskets: not included with flowmeter, to be provided by customer.
Meter size $^3/_8$": flange connection $^1/_2$"

Terminal box

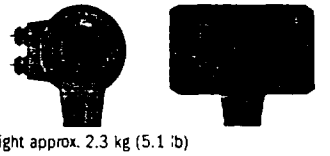


Weight approx. 0.5 kg (1.1 lb)

IFC 010 K and IFC 020 K signal converter

Weight approx. 1.6 kg (3.6 lb)

IFC 090 K signal converter



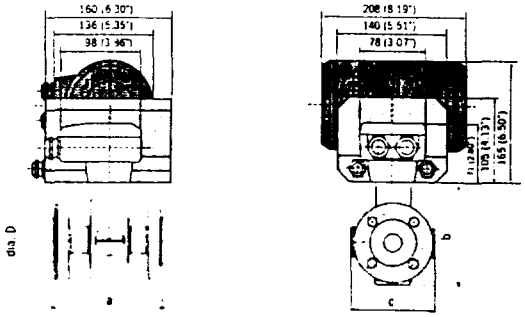
Weight approx. 2.3 kg (5.1 lb)

Flange connections to ...			**Dimensions** in mm (inches)
DIN 2501 (= BS 4504)	DN 10- 300	PN40, 16, 10	see table
	DN350-1000	PN10	see table
	DN350-1000	PN25	see table, dimension "$a_{standard}$" + 200mm
	≥ DN1200	PN6, 2.5	information supplied on request
ANSI B 16.5	$^3/_8$"-24"	150lb / RF	see table
		≥ 300 lb / RF	dimensions supplied on request
AWWA	≥ 14"	Class B, D / FF	dimensions supplied on request

Nominal size			**Dimensions in mm (inches)**								**Approx. weight in kg (lb)**	
DIN		ANSI	a (fitting length)			b	c	dia. D			with DIN	with ANSI
DN	PN (psig)	inches	Standard	ISO 13 359	ANSI			DIN, ISO	ANSI		flanges	flanges
10	40 (580)	$^3/_8$	150 (5.91)	-	150 (5.91)	165 (6.50)	121 (4.76)	90 (3.54)	88.9 (3.50)		5 (11.0)	6 (13.2)
15	40 (580)	$^1/_2$	150 (5.91)	200 (7.87)	150 (5.91)	165 (6.50)	121 (4.76)	95 (3.74)	88.9 (3.50)		5 (11.0)	6 (13.2)
20	40 (580)	$^3/_4$	150 (5.91)	200 (7.87)	150 (5.91)	165 (6.50)	121 (4.76)	105 (4.13)	98.6 (3.88)		7 (15.4)	8 (17.6)
25	40 (580)	1	150 (5.91)	200 (7.87)	150 (5.91)	165 (6.50)	121 (4.76)	115 (4.53)	108 (4.25)		7 (15.4)	8 (17.6)
32	40 (580)	-	150 (5.91)	200 (7.87)	-	180 (7.09)	139 (5.47)	140 (5.51)	-		8 (17.6)	-
40	40 (580)	$1^1/_2$	150 (5.91)	200 (7.87)	150 (5.91)	180 (7.09)	139 (5.47)	150 (5.91)	127 (5.00)		8 (17.6)	9 (19.8)
50	40 (580)	2	200 (7.87)	200 (7.87)	200 (7.87)	218 (8.58)	160 (6.30)	165 (6.50)	152 (6.00)		8 (17.6)	8 (17.6)
65	16 (232)	-	200 (7.87)	200 (7.87)	-	228 (8.98)	173 (6.81)	185 (7.28)	-		10 (22)	-
80	40 (580)	3	200 (7.87)	200 (7.87)	200 (7.87)	235 (9.25)	173 (6.81)	200 (7.87)	191 (7.50)		12 (27)	13 (29)
100	16 (232)	4	250 (9.84)	250 (9.84)	250 (9.84)	286 (11.26)	233 (9.17)	220 (8.66)	228 (8.98)		15 (33)	18 (40)*
125	16 (232)	-	250 (9.84)	250 (9.84)	-	297 (11.69)	233 (9.17)	250 (9.84)	-		19 (42)	-
150	16 (232)	6	300 (11.81)	300 (11.81)	300 (11.81)	327 (12.87)	257 (10.12)	285 (11.22)	279 (10.98)		22 (49)	26 (58) *
200	10 (145)	8	350 (13.78)	350 (13.78)	350 (13.78)	385 (15.16)	291 (11.46)	340 (13.39)	343 (13.50)		34 (75)	42 (95) *
250	10 (145)	10	400 (15.75)	450 (17.72)	400 (15.75)	437 (17.20)	331 (13.03)	395 (15.55)	406 (16.00)		48 (107)	64 (140) *
300	10 (145)	12	500 (19.69)	500 (19.69)	500 (19.69)	500 (19.69)	381 (15.00)	445 (17.52)	533 (21.00)		58 (128)	94 (210) *
350	10 (145)	14	500 (19.69)	550 (21.65)	700 (27.56)	548 (21.57)	428 (16.85)	505 (19.88)	597 (23.50)		78 (172)	129 (285) *
400	10 (145)	16	600 (23.62)	600 (23.62)	800 (31.50)	606 (23.86)	483 (19.02)	565 (22.24)	635 (25.00)		98 (217)	165 (365) *
500	10 (145)	20	600 (23.62)	-	800 (31.50)	651 (25.63)	533 (20.98)	670 (26.38)	699 (27.50)		128 (283)	223 (492) *
600	10 (145)	24	600 (23.62)	-	800 (31.50)	820 (32.28)	585 (23.03)	780 (30.71)	813 (32.00)		164 (362)	306 (675) *
700	10 (145)	28	700 (27.56)	-	flanges to AWWA: dimensions on request	937 (36.89)	694 (27.32)	895 (35.24)	flanges to AWWA: dimensions on request		245 (540)	flanges to AWWA: weight on request
800	10 (145)	32	800 (31.50)	-		1058 (41.65)	922 (36.30)	1015 (39.96)			328 (724)	
900	10 (145)	36	900 (35.43)	-		1164 (45.83)	1026 (40.39)	1115 (43.90)			425 (1000)	
1000	10 (145)	40	1000 (39.37)	-		1278 (50.31)	1132 (44.57)	1230 (48.43)			507 (1118)	

* max. Druckstufe wie mit DIN-Flanschen, s. Spalte "PN"

DN10 - 40 / $^1/_8$" - $1^1/_2$"



Tolerance details for fitting length dimensions "a"

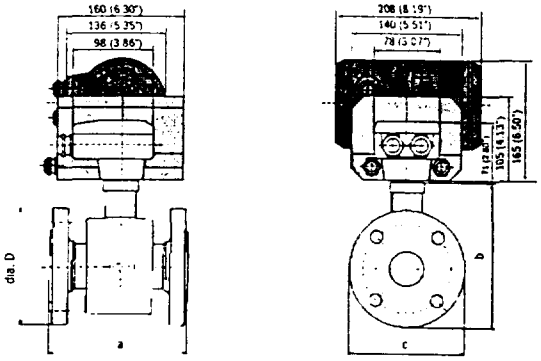
Standard

DN ≤ 300 / ≤ 12" : ±0.5%,
min. ± 1mm / ± 0.04"
DN ≥ 350 / ≥ 14" : ±0.5%

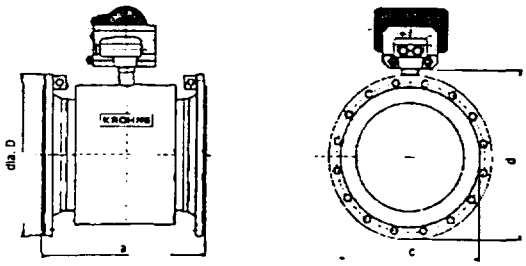
to ISO DIS 13 359

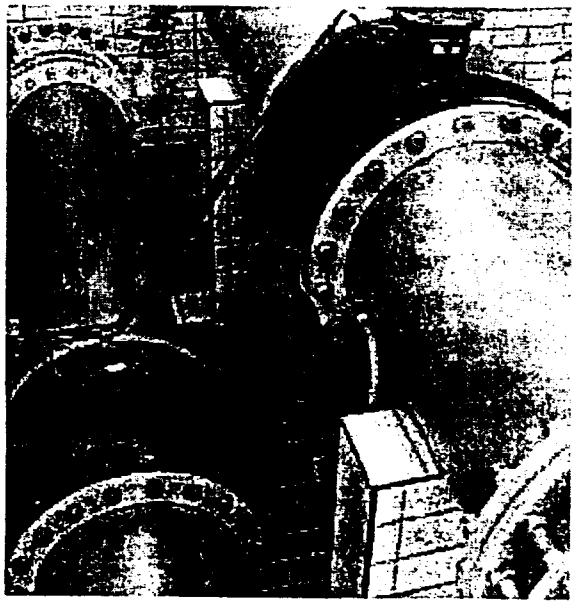
DN ≤ 200 / ≤ 8" : +0/-3
DN ≥ 250 / ≥ 10" : +0/-5

DN50 - 300 / 2" - 12"



DN350 - 1000 / 14" - 24"





AQUAFLUX flowmeter

Limits for pressure and temperature

Teflon® is a registrated trademark of DuPont.

Liner	Flange				Max. operating pressure in bar (psig) at a process temperature of ...									
	Standard	Nominal diameter	Pressure rating Class	S O	≤20 °C	(≤68 °F)	≤40 °C	(≤105 °F)	≤60 °C	(≤140 °F)	≤80 °C	(≤176 °F)	≤90 °C	(≤195 °F)
PTFE	DIN 2501	DN 10 - 20	PN 40	S	40	(580)	40	(580)	40	(580)	40	(580)	40	(580)
	ANSI B 16.5	3/8" - 3/4"	150 lb	S	19.7	(285)	19.6	(284)	19.0	(275)	18.7	(271)	18.1	(262)
			300 lb	O	on request									
Polypropylen	DIN 2501	DN 25 - 50, DN 80	PN 40	S	40	(580)	40	(580)	40	(580)	40	(580)	40	(580)
		DN 65, DN 100 - 150	PN 16	S	16	(230)	16	(230)	16	(230)	16	(230)	16	(230)
	ANSI B 16.5	1" - 6"	150 lb	S	19.7	(285)	19.6	(284)	19.0	(275)	18.7	(271)	18.1	(262)
			300 lb	O	on request									
Hard rubber	DIN 2501	DN 200 - 1000	PN 10	S	10	(150)	10	(150)	10	(150)	10	(150)	-	
			PN 16	O	16	(230)	16	(230)	16	(230)	16	(230)	-	
		≥DN 1200	PN 6 / 2.5	-	on request									
	ANSI B 16.5	"8""	150 lb	S	19.7	(285)	19.6	(284)	19.0	(275)	18.7	(271)	-	
			300 lb	O	23.6	(342)	23.6	(342)	23.4	(342)	22.5	(342)	-	
		10"	150 lb	S	19.7	(285)	19.6	(284)	19.0	(275)	18.7	(271)	-	
			300 lb	O	32.1	(465)	32.1	(465)	32.1	(465)	32.1	(465)	-	
		12""	150 / 300 lb	S / O	19.7	(285)	19.6	(284)	19.0	(275)	18.3	(265)	-	
		14"	150 / 300 lb	S / O	17.8	(258)	17.8	(258)	17.6	(255)	16.9	(245)	-	
		16"	150 / 300 lb	S / O	15.6	(226)	15.6	(226)	15.4	(223)	14.8	(214)	-	
		18"	150 / 300 lb	S / O	13.8	(200)	13.8	(200)	13.7	(198)	13.1	(190)	-	
		20"	150 / 300 lb	S / O	12.4	(179)	12.4	(179)	12.3	(178)	11.8	(171)	-	
		22"	150 / 300 lb	S / O	11.2	(162)	11.2	(162)	11.2	(162)	10.7	(155)	-	
		24"	150 / 300 lb	S / O	14.2	(205)	14.2	(205)	14.1	(204)	13.6	(197)	-	
		28" - 40"	-	-	on request									
	AWWA	≥14"	B	S	6	(90)	6	(90)	6	(90)	6	(90)	-	
			D	O	10	(150)	10	(150)	10	(150)	10	(150)	-	

S = Standard
O = Option

Vacuum - Belastbarkeit

Liner	Meter size		Min. operating pressure in mbar (psig) at product temperature of ...							
	DN mm	inches	≤20°C	(≤68°F)	≤40°C	(≤105°F)	≤60°C	(≤140°F)	80°C	(≤176°F)
PTFE	DN10 - 20	3/8" - 3/4"	0	(0)	0	(0)	0	(0)	0	(0)
Polypropylen	DN25 - 150	1" - 6"	250	(3.6)	250	(3.6)	400	(5.8)	400	(5.8)
Hardrubber	DN200 - 3000	8 - 120	250	(3.6)	250	(3.6)	400	(5.8)	400	(5.8)
	DN350 - 1000	14 - 40	500	(7.3)	500	(7.3)	600	(8.7)	600	(8.7)
	≥ DN1200	≥48"	on request		on request		on request		on request	

Ordering Code

AQUAFLUX Electromagnetic flowmeter (primary head) DN 25 - 150 / 1" - 6" with Polypropylen liner

Code	Primary head		
V325 0 4	Aquaflux F DN 25 / 1"		Polypropylene (PP)
5	Aquaflux F DN 32 / 1 1/4"		Polypropylene (PP)
6	Aquaflux F DN 40 / 1 1/2"		Polypropylene (PP)
7	Aquaflux F DN 50 / 2"		Polypropylene (PP)
8	Aquaflux F DN 65 / 2 1/2"		Polypropylene (PP)
A	Aquaflux F DN 80 / 3"		Polypropylene (PP)
B	Aquaflux F DN 100 / 4"		Polypropylene (PP)
C	Aquaflux F DN 125 / 5"		Polypropylene (PP)
D	Aquaflux F DN 150 / 6"		Polypropylene (PP)

Pressure rating

3	PN 16	DIN 2501 (DN 65, DN 100 - DN 150)	
5	PN 40	DIN 2501 (DN 25 - DN 80 without DN 65)	
A	ANSI 150 lb RF		
M	JIS 20 K	(DN 25 - DN 50)	
N	JIS 10 K	(DN 65 - DN 150)	others on request

Protection category

1	IP 67		
2	IP 68	DS, 10 m	
3	IP 68	BTS, 10 m	
5	IP 67	Ex nA zone 2	
6	IP 68	Ex nA zone 2, 10 m / 30 ft	
8	IP 68	DS/LIYCY, 10 m	
B	IP 67	A Ex / Div 2 (USA)	
E	IP 68	A Ex / Div 2 (USA), 10 m / 30 ft	
G	IP 67		ISO-length
H	IP 68	DS, 10 m	ISO-length
K	IP 68	BTS, 10 m	ISO-length
M	IP 67	Ex nA zone 2	ISO-length
N	IP 68	Ex nA zone 2, 10 m / 30 ft	ISO-length
P	IP 68	DS/LIYCY, 10 m	ISO-length
S	IP 67	A Ex / Div 2 (USA)	ISO-length
W	IP 68	A Ex / Div 2 (USA), 10 m / 30 f	ISO-length

Version / Signal converter

1	Aquaflux F	(*without* converter)	
4	Aquaflux	(modular)	separate version *without* connection box
5	Aquaflux 020 K	(for IFC 020 K)	
6	Aquaflux 020 F	(for IFC 020 F)	
7	Aquaflux 010 K	(for IFC 010 K)	
8	Aquaflux 010 F	(for IFC 010 F)	
A	Aquaflux 080 K	(for IFC 090 K)	
B	Aquaflux 080 F	(for IFC 090 F)	
D	Aquaflux 110 F	(for IFC 110 F)	
L	Aquaflux 020 E	(for IFC 020 E)	
R	Aquaflux 210 E	(for IFC 210 E)	

Language Operating manual								Cable connection
1	D	2	GB	3	US	4	F	PG 13,5
5	D	6	GB	7	US	8	F	1/2" NPT
A	D	B	GB	C	US	D	F	PF 1/2
E	D	F	GB	G	US	H	F	modular/compact

Liner (Option)

0	standard	(DN 25 - DN 150: Polypropylene)
S	provided for protection rings	

Electrodes

1	Stainless Steel 316 Ti
3	Hastelloy C4 (standard)
6	Titanium

Mounting of electrodes

1	fixed

Material of flange

1	Steel St 37-C22 / A 105
2	Stainless Steel 1.4306 (304 L) (DIN / ANSI)
3	Stainless Steel 1.4404 (316 L) (ANSI only)
4	Stainless Steel 1.4571 (316 Ti) DIN only

Primary constant

0	standard	(incl. converter)
5	GK + GKL	(for IFC 010, IFC 020, IFC 090, IFC 110, IFC 210)

V325 | | | | | | | | | 1 | | | **Complete ordering code**

Ordering Code

AQUAFLUX Electromagnetic flowmeter (primary head) DN 10 - 3000 / $^{3}/_{8}$" - 120" with hard rubber (PTFE) liner

Code	Primary head									
V323	0	1	Aquaflux	DN	10	/	3/8"	flanges 1/2"	PTFE	
		2	Aquaflux	DN	15	/	1/2"		PTFE	
		3	Aquaflux	DN	20	/	3/4"		PTFE	
		4	Aquaflux	DN	25	/	1 "		Hardrubber	Option (Standard liner is Polypropylen, see Page 7)
		5	Aquaflux	DN	32				Hardrubber	
		6	Aquaflux	DN	40	/	1 1/2"		Hardrubber	
		7	Aquaflux	DN	50	/	2 "		Hardrubber	
		8	Aquaflux	DN	65	/	2 1/2"		Hardrubber	
		A	Aquaflux	DN	80	/	3 "		Hardrubber	
		B	Aquaflux	DN	100	/	4 "		Hardrubber	
		C	Aquaflux	DN	125	/	5 "		Hardrubber	
		D	Aquaflux	DN	150	/	6 "		Hardrubber	
		E	Aquaflux	DN	200	/	8 "		Hardrubber	
		F	Aquaflux	DN	250	/	10 "		Hardrubber	
		G	Aquaflux	DN	300	/	12 "		Hardrubber	
		H	Aquaflux	DN	350	/	14 "		Hardrubber	
		K	Aquaflux	DN	400	/	16 "		Hardrubber	
		M	Aquaflux	DN	500	/	20 "		Hardrubber	
		N	Aquaflux	DN	600	/	24 "		Hardrubber	
		P	Aquaflux	DN	700	/	28 "		Hardrubber	
		R	Aquaflux	DN	800	/	32 "		Hardrubber	
		S	Aquaflux	DN	900	/	36 "		Hardrubber	
		T	Aquaflux	DN	1000	/	40 "		Hardrubber	
		U	Aquaflux	DN	1200	/	48 "		Hardrubber	
		V	Aquaflux	DN	1400	/	56 "		Hardrubber	
		W	Aquaflux	DN	1600	/	64 "		Hardrubber	
		X	Aquaflux F	DN	1800	/	72 "		Hardrubber	only remote version "F", with signal converter IFC 150 F
		Y	Aquaflux F	DN	2000	/	80 "		Hardrubber	
		Z	Aquaflux F	DN	2200	/	88 "		Hardrubber	
	0	Z	Aquaflux F	DN	2400	/	96 "		Hardrubber	
	9	Z	Aquaflux F	DN	2600	/	104 "		Hardrubber	
	9	Z	Aquaflux F	DN	2800	/	112 "		Hardrubber	
	9	Z	Aquaflux F	DN	3000	/	120 "		Hardrubber	

Pressure rating

1	PN 6	DIN 2501	smooth packing strip	(DN 1200 - DN 2000)
2	PN 10	DIN 2501	smooth packing strip	(DN 500 - DN 1000)
3	PN 16	DIN 2501		(DN 65, DN 100 - DN 150)
5	PN 40	DIN 2501		(DN 10 - DN 80 without DN 65)
A	ANSI	150 lb RF		(48" - 120")
G	PN 2.5	DIN 2501	smooth packing strip	(DN 2200 - DN 3000)
M	JIS 20 K			(DN 10 - DN 50)
N	JIS 10 K			(DN 65 - DN 150)

other pressure ratings on request

Protection category / approvals

1	IP 67			
2	IP 68	DS, 10 m / 30 ft		
3	IP 68	BTS, 10 m / 30 ft		
5	IP 67	Ex nA Zone 2		
6	IP 68	Ex nA Zone 2, 10 m / 30 ft		
8	IP 68	DS/LIYCY, 10 m / 30 ft		
B	IP 67	A Ex / Div 2 (USA)	only ≤ DN 1000 / ≤ 40"	
E	IP 68	A Ex / Div 2 (USA)		
G	IP 67		ISO-length	only ≤ DN 400 / ≤ 16"
H	IP 68	DS, 10 m / 30 ft	ISO-length	
K	IP 68	BTS, 10 m	ISO-length	
M	IP 67	Ex nA Zone 2	ISO-length	
N	IP 68	Ex nA Zone 2, 10 m / 30 ft	ISO-length	
P	IP 68	DS/LIYCY, 10 m / 30 ft	ISO-length	
S	IP 67	A Ex / Div 2 (USA)	ISO-length	
W	IP 68	A Ex / Div 2 (USA)	ISO-length	

Version / Signal converter

1	Aquaflux	(without signal converter)	
4	Aquaflux	(modular)	remote version without connection box
5	Aquaflux 020 K	(for IFC 020 K)	≤ DN 1600
6	Aquaflux 020 F	(for IFC 020 F)	≤ DN 1600
7	Aquaflux 010 K	(for IFC 010 K)	≤ DN 1600
8	Aquaflux 010 F	(for IFC 010 F)	≤ DN 1600
A	Aquaflux 080 K	(for IFC 090 K)	≤ DN 1600
B	Aquaflux 080 F	(for IFC 090 F)	≤ DN 1600
D	Aquaflux 010 F	(for IFC 110 F)	≤ DN 1600
F	Aquaflux 150 F	(for IFC 150 F)	> DN 1600
L	Aquaflux 020 E	(for IFC 020 E)	≤ DN 1600
R	Aquaflux 210 E	(for IFC 210 E)	≤ DN 1600

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Ordering Code

from last page

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Version / Signal converter

1	Aquaflux	(without signal converter)	
4	Aquaflux	(modular)	remote version without connection box
5	Aquaflux 020 K	(for IFC 020 K)	≤ DN 1600
6	Aquaflux 020 F	(for IFC 020 F)	≤ DN 1600
7	Aquaflux 010 K	(for IFC 010 K)	≤ DN 1600
8	Aquaflux 010 F	(for IFC 010 F)	≤ DN 1600
A	Aquaflux 080 K	(for IFC 090 K)	≤ DN 1600
B	Aquaflux 080 F	(for IFC 090 F)	≤ DN 1600
D	Aquaflux 010 F	(for IFC 110 F)	≤ DN 1600
F	Aquaflux 150 F	(for IFC 150 F)	> DN 1600
L	Aquaflux 020 E	(for IFC 020 E)	≤ DN 1600
R	Aquaflux 210 E	(for IFC 210 E)	≤ DN 1600

Language manual / **Cable connection**

1	D	2	GB	3	US	4	F		PG 13,5
5	D	6	GB	7	US	8	F		1/2" NPT
A	D	B	GB	C	US	D	F		PF 1/2
E	D	F	GB	G	US	H	F	(≤ DN 1600)	modular / compact

Liner (option)

0 Standard: Hardrubber ≥ DN 25 / ≥ 1" (PTFE ≤ DN 20 / ≤ 3/8")
4 provided for protection rings ≤ DN 20 / ≤ 3/8" with PTFE

Electrods

1 Stainless steel 1.4571
3 Hastelloy C4 (standard)
6 Titanium

Construction of electrodes

1 fixed mounted
6 WE Stainless steel 1.4571 (only ≥ DN 350 / ≥ 14")

Materialof flanges

1 Stell St 37-C22 / A 105
2 Stainless steel 1.4306 (304 L) (DIN / ANSI)
3 Stainless steel 1.4404 (316 L) (only ANSI)
4 Stainless steel 1.4571 (316 Ti) (only DIN)

Geberkonstante (GK)

0 Standard (≤ DN 1600: IFC 110, IFC 090, IFC 020 / > DN 1600: SC 150)
6 GK + GKH (for IFC 110, IFC 020, IFC 090, SC 150)

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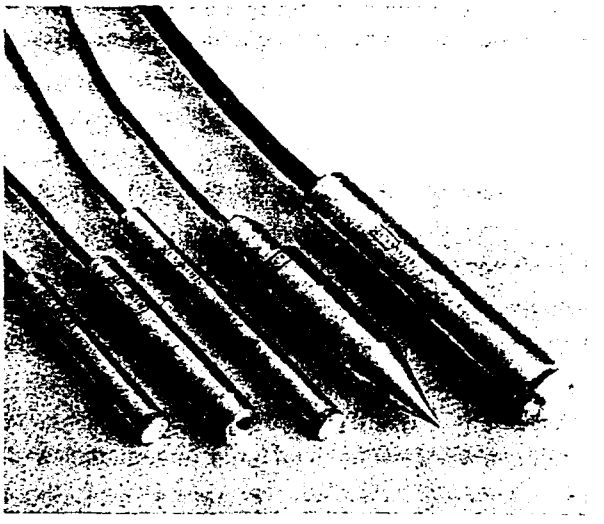
Model 4500

Vibrating Wire Piezometers and Pressure Transducers



- Long-term stability in difficult environments.
- Hermetically sealed.
- High resolution.
- Stainless steel construction.
- Not affected by long cable lengths.
- Readily adaptable to dataloggers.

Geokon vibrating wire piezometers and pressure transducers are designed to measure fluid pressures (e.g. ground water elevations, pore pressures) in boreholes, embankments, foundations, pipe lines, wells, pressure vessels etc. Over 30,000 are in use in applications throughout the world.

The transducer employs a sensitive diaphragm, coupled to a vibrating wire, that converts the fluid pressures to be measured into an equivalent frequency signal. Transmitted through a cable to the readout location, the frequency signal is conditioned and displayed on a portable readout box. Alternatively, dataloggers can be used to record the data automatically. (Low cost battery-operated loggers for remote, unattended data collection are available. See Datalogger data sheets).

Several different models and options are available. The standard sensor is dimensionally small enough to be installed into fills, embankments, boreholes, standpipes or observations wells. A drive-in version is available for pushing directly into soft ground on the end of drill rods. Another model is for use in typical pressure transducer applications where a hydraulic pressure connection is required to permit easy coupling to pressurized tanks, pipelines, earth pressure cells etc.

Construction: Geokon piezometers utilize the latest developments in vibrating wire pressure transducer technology. The transducer is fabricated entirely from stainless steel components, selected to minimize temperature effects, evacuated and welded together to create a hermetically sealed chamber for the vibrating wire element. The ends of the vibrating wire are clamped using a patented swaging technique that ensures high stability while allowing miniaturization of the components.

Electromagnetic coils located close to the wire are used to both pluck the wire and to convert the wire vibrations so produced into an electrical output current whose frequency is identical to the natural resonant frequency of the wire. Changing pressure causes deflection of the diaphragm thereby altering the tension of the wire and its resonant frequency of vibration. Thus for each pressure there is a corresponding frequency output.

Electrical cable: 4-conductor cable is standard. Two of the conductors are used for the built-in thermistor (or VW temperature gage). Gas discharge tubes are included for overvoltage protection. The standard cable has a thick PVC outer jacket. Optional direct burial cable is armored, double-jacketed and bitumen filled. It should be noted that lead wire resistance changes brought about by water penetration, temperature variations and contact resistance do not affect the frequency of the output signal. This factor, coupled with excellent zero stability, makes the Geokon Vibrating Wire Transducer preferable to conventional strain gage transducers for long-term measurements in difficult environments.

In geotechnical environments it is necessary to use a filter stone to prevent soil particles from impinging directly on the diaphragm. The standard filter stone is made from sintered stainless steel with a 50 micron pore size. In partially saturated soils, where air is to be excluded from the piezometer cavity, a high air entry filter stone may be specified. Note that negative pressures (suction) can be measured.

MODELS AVAILABLE

Model 4500 (Standard model) is designed for direct burial in embankments, fills etc. Also for installation inside boreholes or observations wells. Its small size allows for its installation in conventional standpipe piezometer riser pipe. Minimum I.D. is 19 mm. (3/4").

Model 4500DP (Drive point model) has the transducer located inside a housing with an EW drill rod thread and removable pointed nose cone. When screwed onto the end of EW drill rods the unit can be pushed directly into soft ground with the signal cable located inside the drill rod. This model is recoverable at the end of the job.

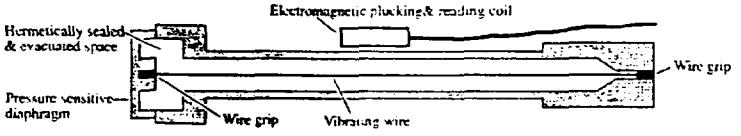
Model 4500B/C (Small diameter models). Model 4500B is designed to go down a 19 mm.(3/4") Sch.80 standpipe. Model 4500C is designed to go down a (1/2)" Sch.80 standpipe.

Model 4500AL/ALV low-pressure model is designed for low-pressure ranges (0-100 kPa, 0-200 kPa). Both sealed (AL), and vented (ALV), sensors are available. For long-term, unattended outdoor use, the unvented version is recommended with compensation for barometric changes provided by a second unvented transducer acting as a barometer. (For pressure ranges below 100kPa and vibrating wire piezometers see Model 4580 brochure).

Model 4500H (Pressure transducer model) is supplied with a 6.4 mm. (1/4") male or female pipe thread fitting to permit the transducer to be coupled directly into hydraulic or pneumatic pressure lines.

Model 4500AR (Autoresonant model) is excited by 12V D.C. and gives a continuous frequency output. For industrial applications the output can be readily adapted to microprocessor-based controls or to continuous 0-10V or 4-20 mA output. Using the Geokon 4500CPR controller, the transducer can follow dynamic pressure variations of up to 120Hz. These units can be hardened for use in high radiation environments.

Transducer Schematic



All models can be read using the Geokon Model GK-403 Portable Readout Box. The box shows the reading on a 6-digit liquid crystal display (LCD). The readings can be displayed in engineering units using calibration data supplied with the piezometer. Junction boxes and terminal boxes are available to protect cable splices and electrical connectors. Automatic and remote recording can be accomplished using any of the range of Geokon Dataloggers (See Datalogger data sheets).

GENERAL SPECIFICATIONS

Standard ranges:	70, 170, 350 = 50 PSI, 700 kPa† 1.7, 3.5, 7, 20, 35, 70 MPa†
Over range:	2x rated pressure
Resolution:	.025%F.S. minimum
Accuracy:	±0.5%F.S. (±0.1%F.S. optional)
Operating temperature:	-20° to 80°C*
Thermal zero shift:	<0.05%F.S./°C
Diaphragm displacement:	<.001 cc at F.S.
Cable:	vinyl, 2 pair, 22ga. 6.4 mm. dia.
Filter:	Standard: 50 micron sintered stainless steel High air entry: Alumina 1,3,5Bar

† psi=kPa x .145 or MPa x 145.
*Special versions available for use up to 220°C.

WEIGHTS AND DIMENSIONS

Model	D mm.	(in.)	L mm.	(in.)	Wt. kg.	(lbs.)
4500S	19.1	(.75)	133	(5.250)	.12	(.26)
4500B	17.5	(.68)	133	(5.250)	.10	(.23)
4500C	11.1	(.438)	127	(5.000)	.09	(.20)
4500AL/V	25.4	(1.00)	133	(5.250)	.25	(.55)
4500DP	33.3	(1.312)	187	(7.375)	.9	(2.0)
4500H	25.4	(1.00)	140	(5.500)	.3	(.66)
4500HD	38.1	(1.50)	203	(8.00)	1.5	(3.3)

Ordering Information:

Specify:

1. Model number.
2. Pressure range.
3. Cable length.

Accessories:

High air entry filter. Junction boxes.
Terminal boxes. Surge protection boxes.
Splice kits. Armored cable.

geokon incorporated

For further information contact us . . . .

48 SPENCER STREET
LEBANON, NH 03766 USA
TEL: 603/448-1562
FAX: 603/448-3216

ENGINEERING SPECIFICATIONS
SENSAPHONE 2000

I. General

The automatic dialer shall be a self-contained microprocessor controlled system capable of monitoring 8 input channels. The system shall be integrated in construction and shall be installed and configured for operation by the user via Microsoft Windows® compatible software provided at no charge. In addition, the software shall provide the ability to produce an internet web page and function as an e-mail server for the system. Voice message recording shall be accomplished via local or remote touch-tone phone. Input channels shall be capable of monitoring analog or digital signals utilizing 10-bit resolution.

Upon detection of any alarm or status change, the system shall commence dialing telephone numbers from a list associated with the particular alarm condition(s) or combination thereof, and deliver the alarm message via a custom voice message, fax, e-mail, modem, numeric pager or alphanumeric pager. The voice alarm message shall be delivered in digitized human voice using messages recorded by the user. The system will continue to call telephone numbers in succession until a positive acknowledgment of the alarm message is received. Acknowledgment can be accomplished from a voice phone call, a modem phone call, or by a callback from either a telephone or a computer with modem. Upon answering, the system shall attempt a data connection. If a connection is made the system shall allow remote access to programming and operation. If a data connection is not made, the system shall recite a voice status report and allow access to remote voice message programming.

The system shall be FCC registered for direct connection to the telephone network. The system shall have a one year warranty from the manufacturer. The system shall be a Sensaphone 2000 by Phonetics, Inc.

II. I/O Channel Attributes and Features

A. Inputs

The system shall come standard with 8 universal input channels. The input resolution shall be 10-bit with scalable lookup tables. All analog input values shall read to one decimal place. All input channels shall be user-configurable as:

1. NO or NC digital dry contact, using 0.5mA loop current
2. 4–20mA analog, using custom look up table
3. 0–5V analog, using custom look up table
4. Temperature from thermistor, using 2.8K or 10K devices
5. Run time accumulator
6. Pulse count

The system shall have the following built-in monitoring features:

1. AC power failure detection
2. Low battery detection

All monitored channels, including built-in monitoring features, shall allow local and remote data programming of pertinent operational data including, but not limited to:

1. Input type (NO/NC, 4–20mA and 0–5V analog, thermistor, run time, pulse count)
2. Units of measure (degrees F, degrees C, inches, feet, psi, volts, amps, pounds, gallons)
3. High and Low limits (-99,999.9 to +99,999.9)
4. Input recognition time (0 seconds to 270 minutes)
5. Alarm reset time (0 seconds to 270 minutes)
6. Alarm call list for each channel
7. Enable/Disable for each channel to dialout for alarm

III. Communications Features

A. Communication Methods

The system shall be able to communicate alarms and other status information using the following methods.

1. Programmable voice
2. Fax
3. Modem
4. Numeric pager
5. Alphanumeric pager
6. Internet E-mail

B. Telephone Specifications

The system shall connect to a standard 2-wire telephone line using pulse or tone dialing methods, with loop start only. The system shall recognize ringer frequencies from 16 to 60 Hz. No leased or dedicated lines shall be required. Call progress detection shall ensure that the alarm dialout is not hindered by no-answers or busy signals.

C. Line Seizure Feature

The system automatically seizes control of the phone line to make an alarm phone call when the alarm occurs. All other calls, including current calls, will disconnect and all extensions will be disabled. Extensions will remain cut off until the alarm is acknowledged.

D. Communications Interface

The system shall have a built-in 14,400 bps modem to allow remote data communication and programming via computer. The system shall have a built-in RS232 serial port for the purpose of local communication and programming via computer. Both communication interfaces shall accept standard Modbus protocol.

E. Destinations (Telephone Numbers and Email Addresses)

The system shall be capable of contacting up to 32 destinations (36 digit telephone numbers /64 character E-mail addresses). There shall be a capability to group the destinations into multiple lists to create calling schedules based on weekdays, weeknights and weekends. In addition, individual input alarms may be programmed to contact specific destinations.

F. Voice Messages

The system shall have the ability to record, store and reproduce voice messages and to use those messages to articulate the location and status of the monitored channels. In absence of user-recorded voice messages, the system shall articulate channel status using the internally resident vocabulary. All digitized speech message data shall be stored in nonvolatile memory. Such nonvolatile memory shall be capable of protecting speech memory for at least 10 years of complete power outage.

There shall be one recorded identification message for the system, and one recorded alarm message for each input channel. Message length shall be 4 seconds per input and 6 seconds for system identification.

G. E-Mail Server Programming

The software shall be capable of functioning as an e-mail server for the purpose of receiving e-mail calls via telephone and forwarding e-mail messages via the internet, from one or more units. The host PC shall be required to have internet access through a dialup connection or continuous service via cable modem, DSL, T1, etc.

H. Web Status Programming

The software shall be capable of polling units via telephone or serial port to automatically retrieve the input values and alarm status, and create a web page for each unit. The software shall automatically upload the web page to an internet server immediately following each poll. The software shall allow

scheduled polling times to be programmed for each unit. The host PC shall be required to have internet access through a dialup connection or continuous service via cable modem, DSL, T1, etc. Storage space on a web server that supports FTP shall also be required.

IV. Programming

A. Local Programming

The system shall have a built-in RS232 port for the purpose of locally programming all system data using an IBM® PC or compatible with Windows® 3.1 or greater, and Sensaphone 2000 programming software (included). All operational data, system setup and configuration data, and all information regarding the status of monitored input channels shall be accessible. In addition, voice messages may be recorded and reviewed using a standard touch-tone telephone.

B. Remote Programming

The system shall have a built-in 14,400 bps modem for the purpose of remotely programming and communicating all system, configuration, and input data using an IBM® PC or compatible with modem, Windows® 3.1 or greater, and Sensaphone 2000 programming software (included). A user-programmable security password shall protect the system from unauthorized tampering. Voice messages may be recorded or reviewed via a phone call using a standard touch-tone telephone.

V. System Features

A. Power

The system shall be provided with a UL/CSA listed 8VAC 1.25A power transformer that the user may plug into a 115V AC outlet, ±10%, 60Hz. Typical power consumption shall be 10 Watts.

B. Battery Backup

The system shall have a battery compartment (batteries not included) to hold 6 "C-cell" Ni-Cad rechargeable batteries (2.2AH recommended). The batteries shall support approximately 8-10 hours of continued system operation in the absence of AC power. (Actual battery backup performance is dependent upon the Amp-Hour rating, age of the batteries, ambient temperature, and the charge condition.) The unit shall include an integrated battery charging circuit. The battery charging shall be intelligent with microprocessor guided precision voltage control, which will activate only when batteries are installed.

C. Local Visual Indication

Each input shall have a corresponding LED that will indicate the alarm and acknowledgment status of each input. The system shall also have LEDs to indicate System On, Battery Condition and Phone Line status.

D. Data Log

The system shall be capable of logging the values of all input channels, the battery voltage and the AC power status. Items to be stored shall be selectable to maximize memory usage. Up to 32,000 total samples can be stored in the unit's nonvolatile memory. The time between logs shall be user-programmable. The system shall have the capability to send the datalog information via fax or e-mail on a time-programmable basis. Datalog information may also be retrieved via computer and modem, by using the polling option of the Sensaphone 2000 Windows® software.

E. Security

The system shall allow the user to program a data password to prevent unauthorized local or remote access to programming.

VI. Remote Operation Features

A. Status Report

The system shall allow the user to call into the unit at any time using any standard telephone to obtain a full status report of all monitored channels. The status report shall be articulated using the resident voice-synthesized English vocabulary, in combination with digitized user-recorded voice messages.

B. Data Status Report

The system shall allow the user to call into the unit with a computer, modem and the Sensaphone 2000 software package. The system shall allow interrogation and programming access to system parameters and status. The real time input status can also be displayed graphically. Real time status snap shots can also be automatically transmitted to E-mail or Fax destinations on a time schedule.

C. Voice Acknowledgment

An alarm on any monitored channel may be acknowledged remotely by pressing tones on a touch-tone telephone keypad or by calling the system back within a specified time period.

D. Data Acknowledgment

An alarm on any monitored channel may be acknowledged remotely by the user via a computer, modem and the Sensaphone 2000 software. Alarms may be acknowledged manually by calling into the unit or they may be acknowledged automatically using the alarm-answer mode of the Sensaphone 2000 software package.

VII. Enclosure and Environmental

A. Enclosure

The system shall be housed in a durable aluminum enclosure with integral mounting brackets for wall or panel mounting. The dimensions shall be 12.1"W x 7.2"H x 1.6"D. The weight shall be 3 lbs.

B. Electrical Protection

Power and telephone connections shall have internal spike and surge protection using metal oxide varistors. All input channels shall have fault protected input circuits.

C. Additional Electrical Surge Protection

Additional Power and Telephone line surge protection shall be available from the manufacturer. When so installed, the system shall be fully warranted against any damage caused by transient surges entering the system through Power or Telephone lines.

D. Environmental

The system shall function over an operating temperature range of 32°F–122°F at up to 0–90% RH, non-condensing. The system may be stored within the temperature range of 0°–130°F.

E. Maintenance

The system manufacturer shall have in-house service facilities and technical assistance available during normal business hours, Monday–Friday 8AM–5PM (EST).

Specifications subject to change without notice.

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