Air Force Civil Engineer Center

FORMER
WILLIAMS AIR FORCE BASE

Site ST012

Former Liquid Fuel Storage Area

BCT Conference Call

16 March 2017

Site ST012 Outline

- Summary of Activities Since Feb BCT meeting
- Mass Estimate Update Summary
- Modeling Summary
- Decision Tree Summary
- EBR Sequencing/Plan
- EBR Monitoring
- Path Forward

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Site ST012 Activities Since January

- Continued SVE operation
- Continued LNAPL screening in accessible SEE wells and Phase I characterization wells
- Planning for completion of SEE decommissioning
- Additional Planning for EBR

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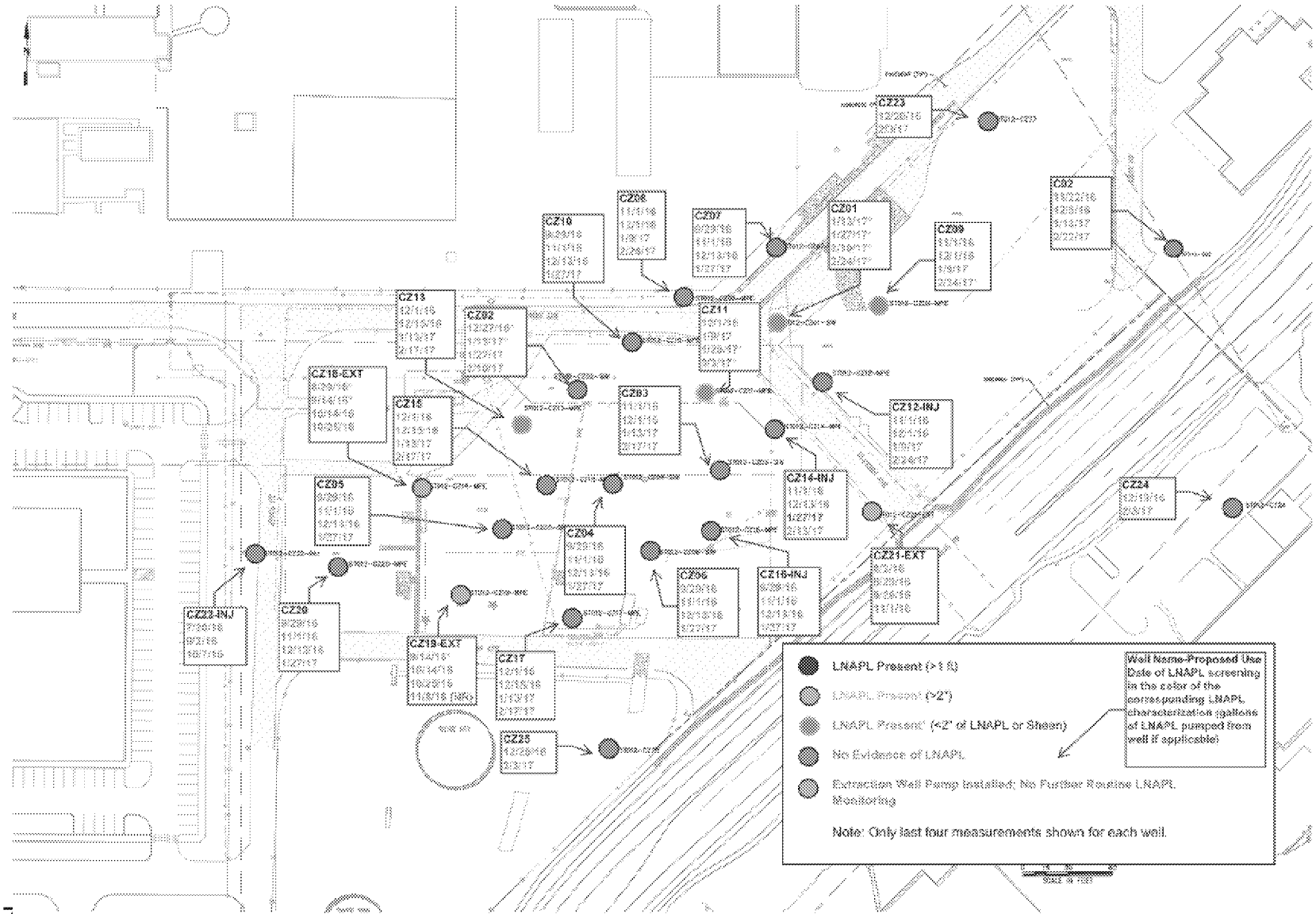
LNAPL Monitoring Update

LNAPL Monitoring/Removal Status
Cobble Zone



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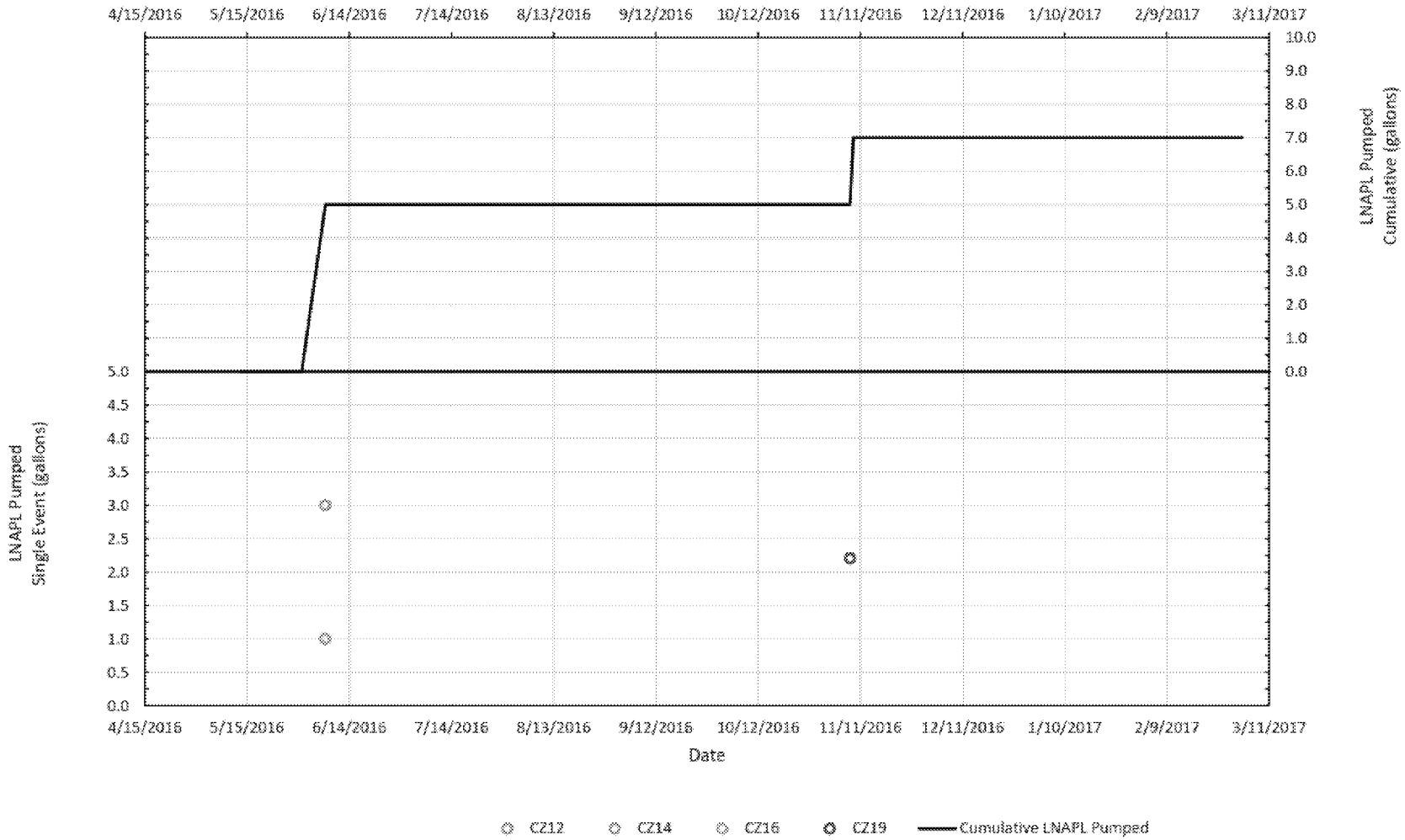
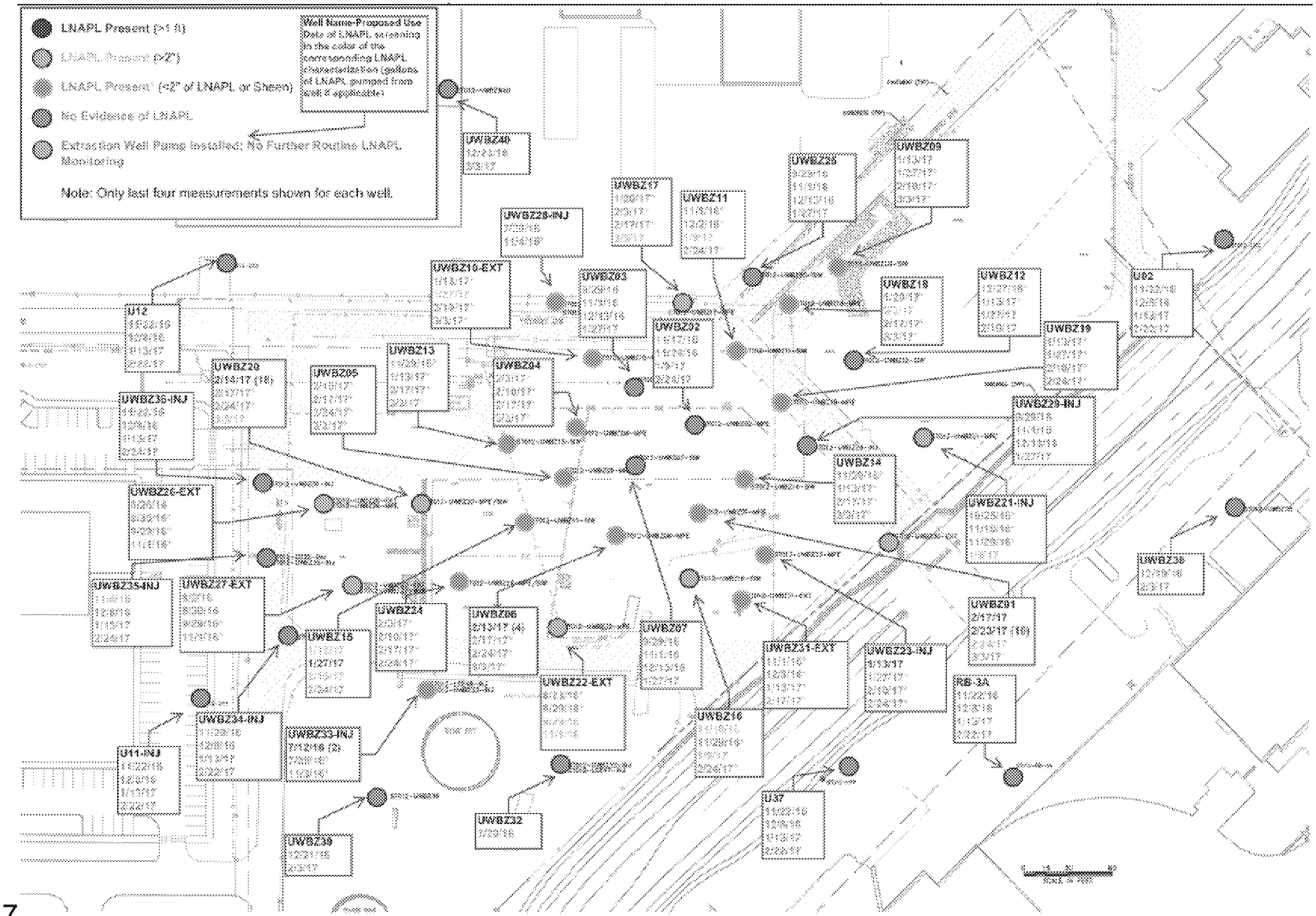
LNAPL Monitoring/Removal Status
Cobble Zone



Note: LNAPL removed from CZ19 during pump installation estimated based on measured thickness in casing

LNAPL Monitoring/Removal Status
Upper Water Bearing Zone



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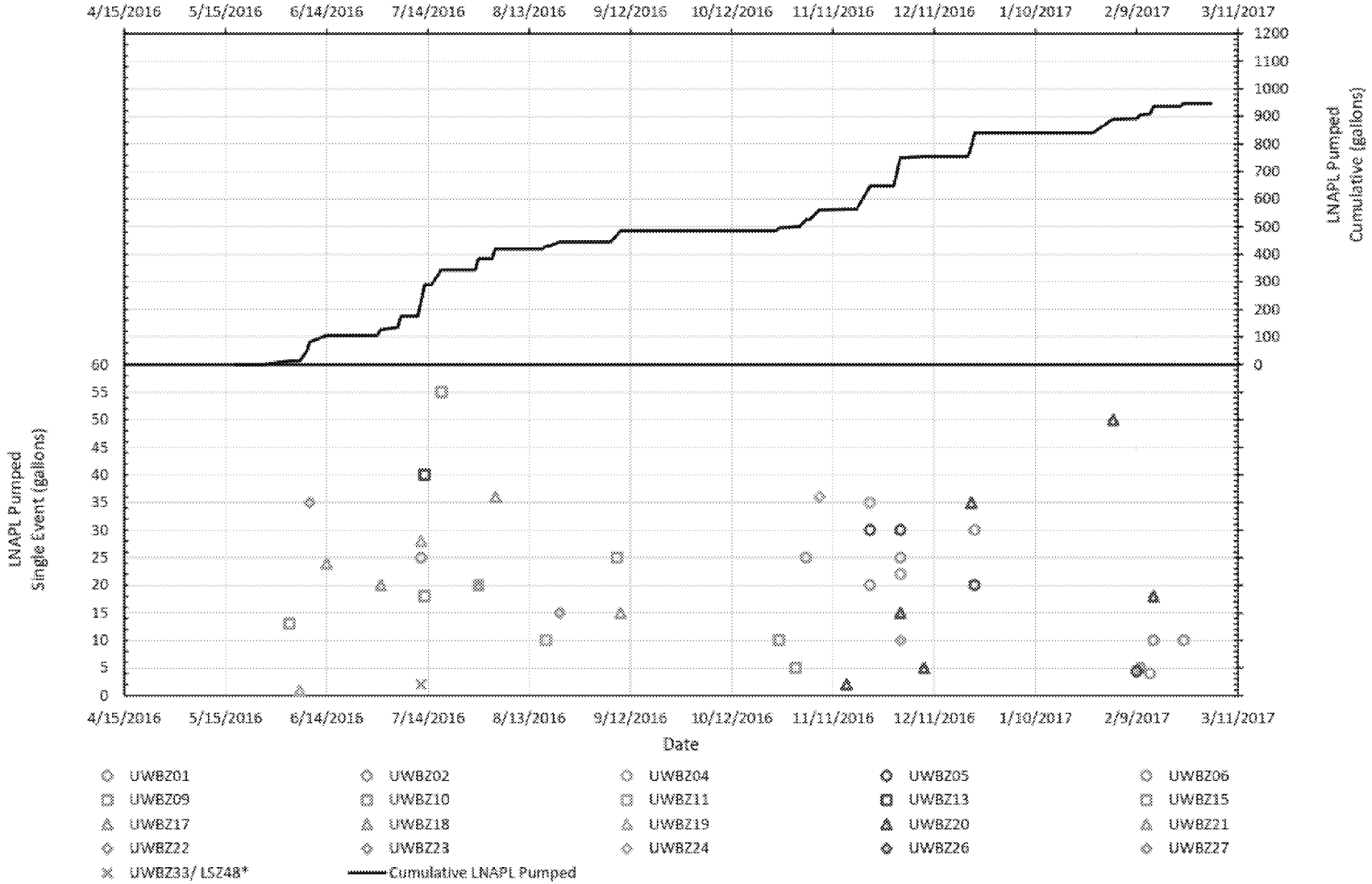
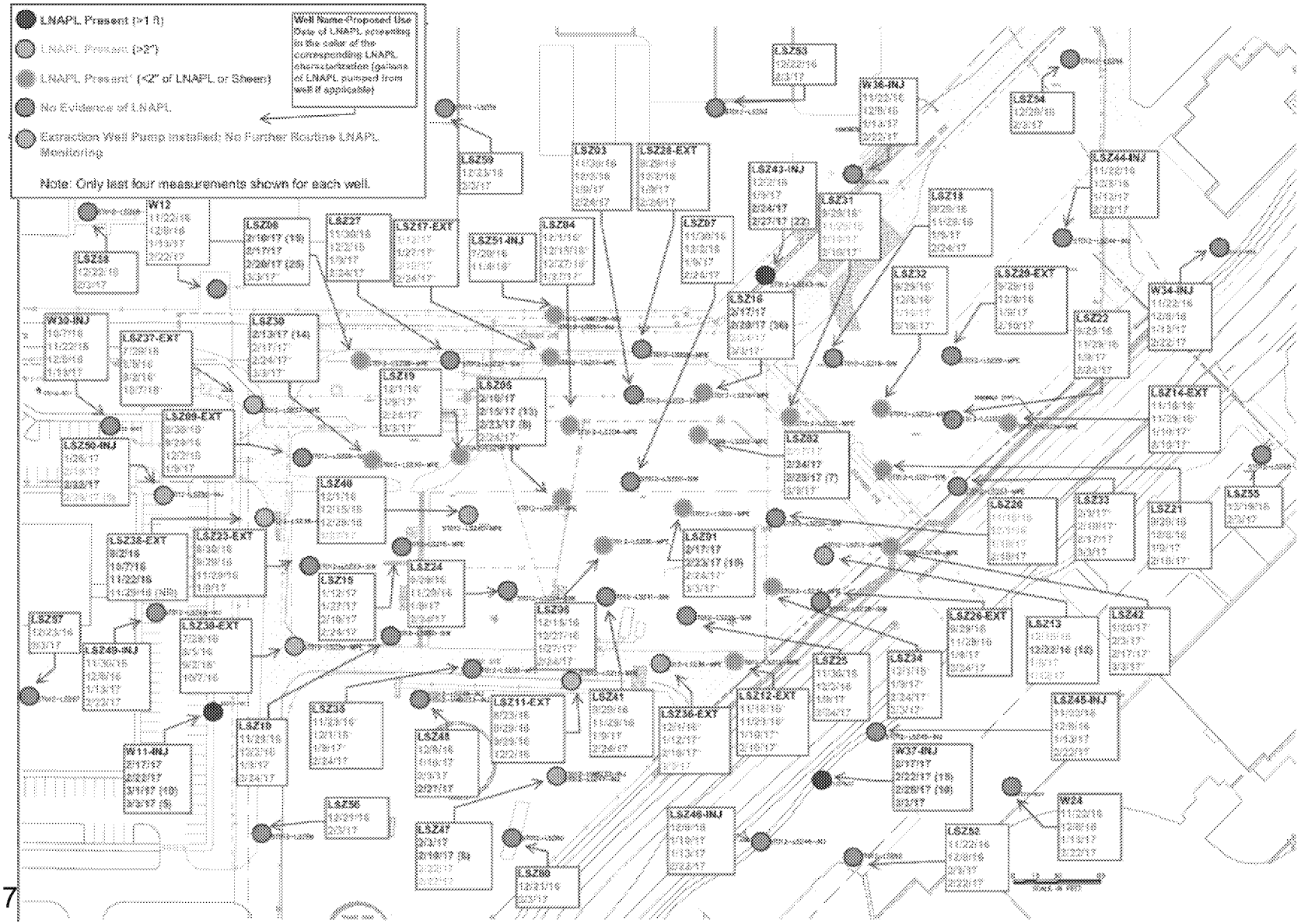
LNAPL Monitoring/Removal Status Upper Water Bearing Zone



Note: LNAPL removed from UWBZ05 estimated based on measured thickness in casing

LNAPL Monitoring/Removal Status Lower Saturated Zone



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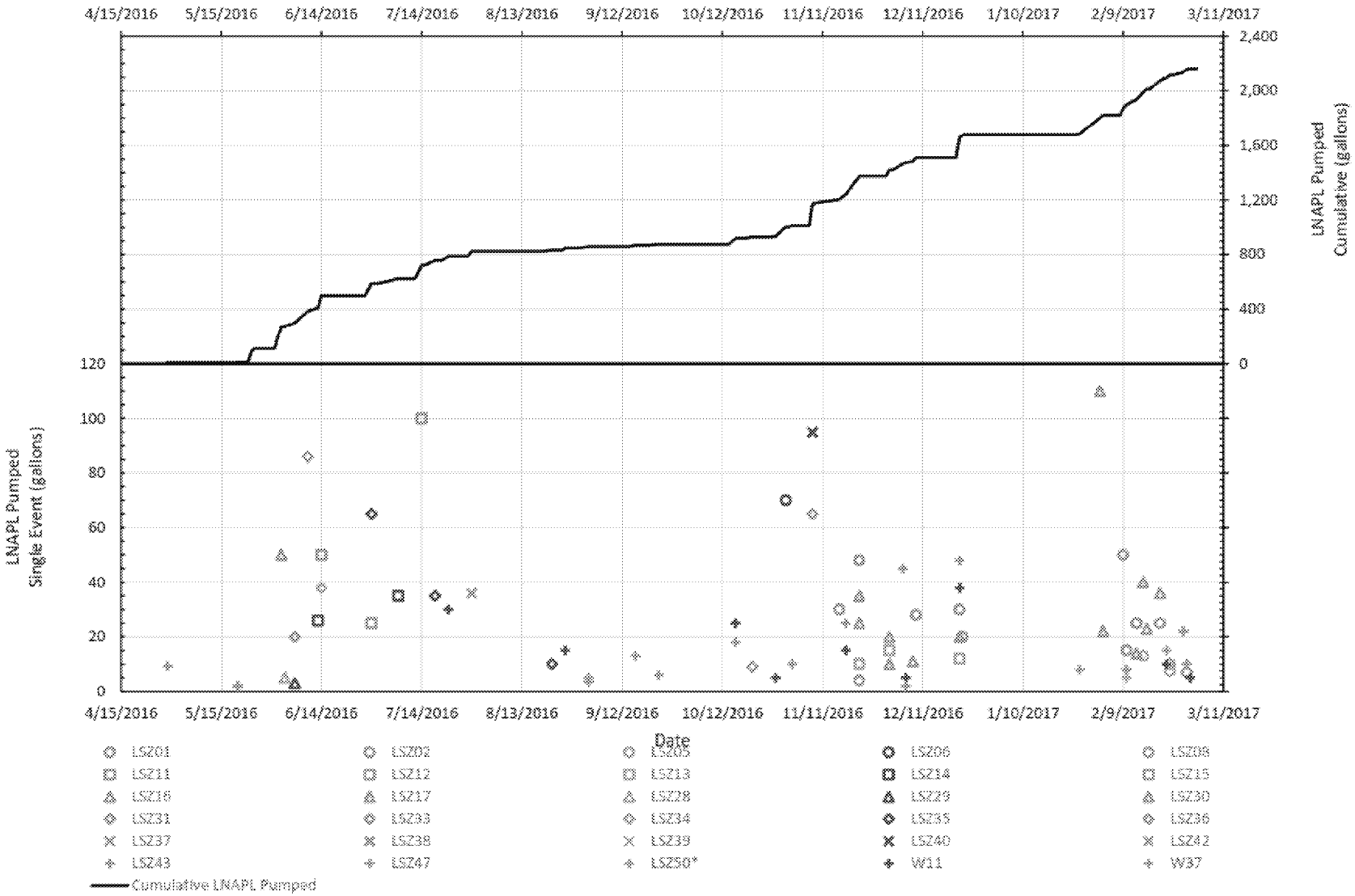
LNAPL Monitoring/Removal Status
Lower Saturated Zone



Note: LNAPL removed from LSZ38 during pump installation estimated based on measured thickness in casing

ST012 LNAPL Monitoring/Removal Summary

- CZ – ~7 gallons of LNAPL removed. An estimated 2 gallons of LNAPL removed from CZ19 during pump installation.
- UWBZ - ~950 gallons of LNAPL removed. ~200 gallons of that since Jan call. Majority of LNAPL from perimeter or outside TTZ.
- LSZ - ~2,200 gallons of LNAPL removed. ~600 gallons of that since Jan call. Majority of LNAPL from perimeter or outside TTZ.

Site ST012 – EBR Applicability

- As discussed in Feb 2017 BCT meeting, AF/EPA/ADEQ to work toward resolution of remaining EBR implementation issues by mid-April 2017
- There is no indication of downgradient LNAPL or dissolved contaminant migration
- Current estimates of mass remaining (equivalent of ~415,000 gallons) are less than EBR demonstration modeling in RD/RAWP (equivalent of ~483,000 gallons)
- Phase 1 EBR injections will target the vast majority of area of contaminant distribution as now understood
- The phased EBR approach provides the flexibility to start remediation on areas of highest known contamination and make adjustments to address additional areas discovered or areas with higher mass
- EBR enhances plume containment by increasing degradation of dissolved contamination at the downgradient perimeter
- Alternate sulfate supplier identified with no arsenic content
- Hydraulic containment pumping would degrade conditions for EBR by cooling and introducing more competing TEAs

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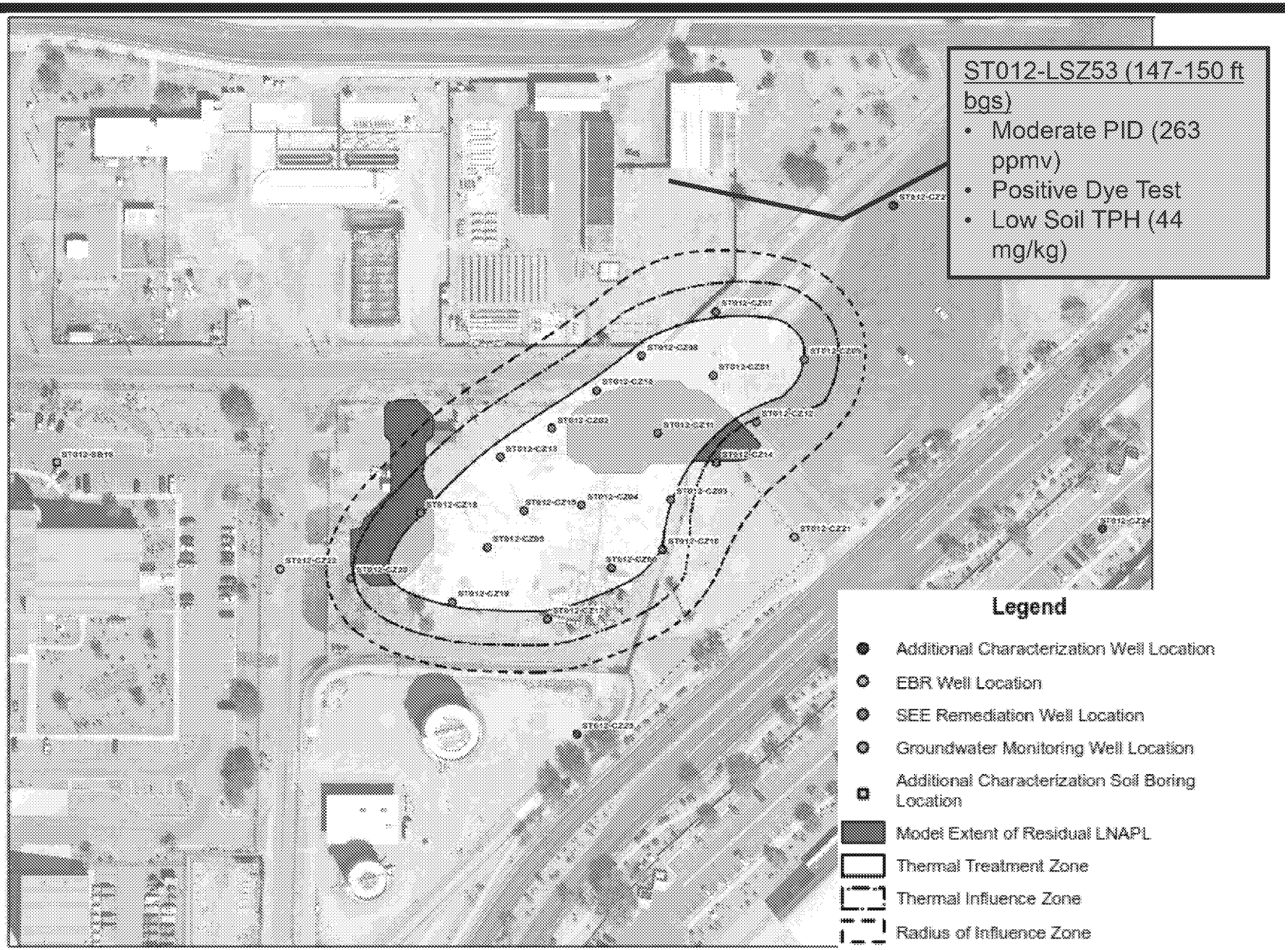
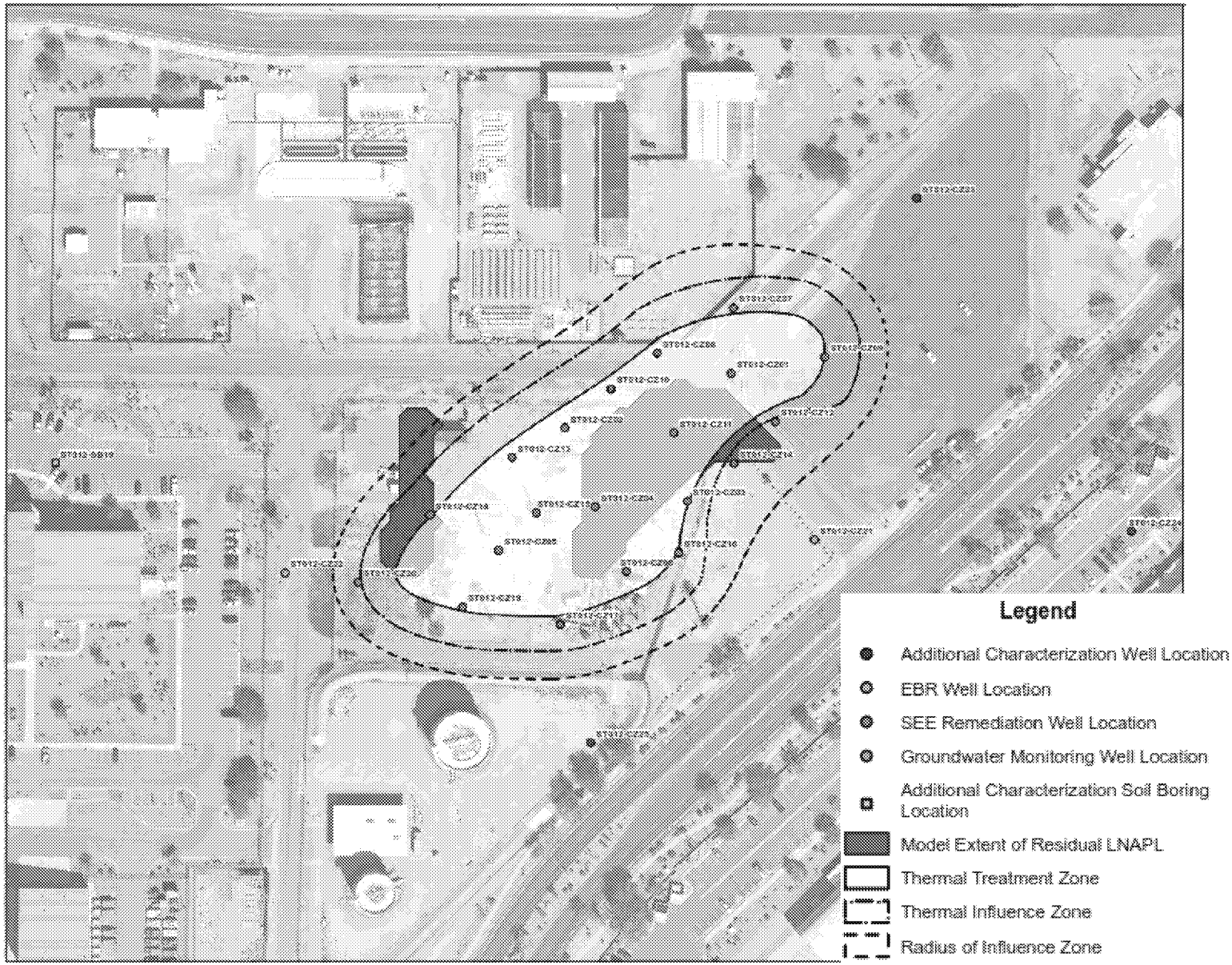
Mass Estimate Update

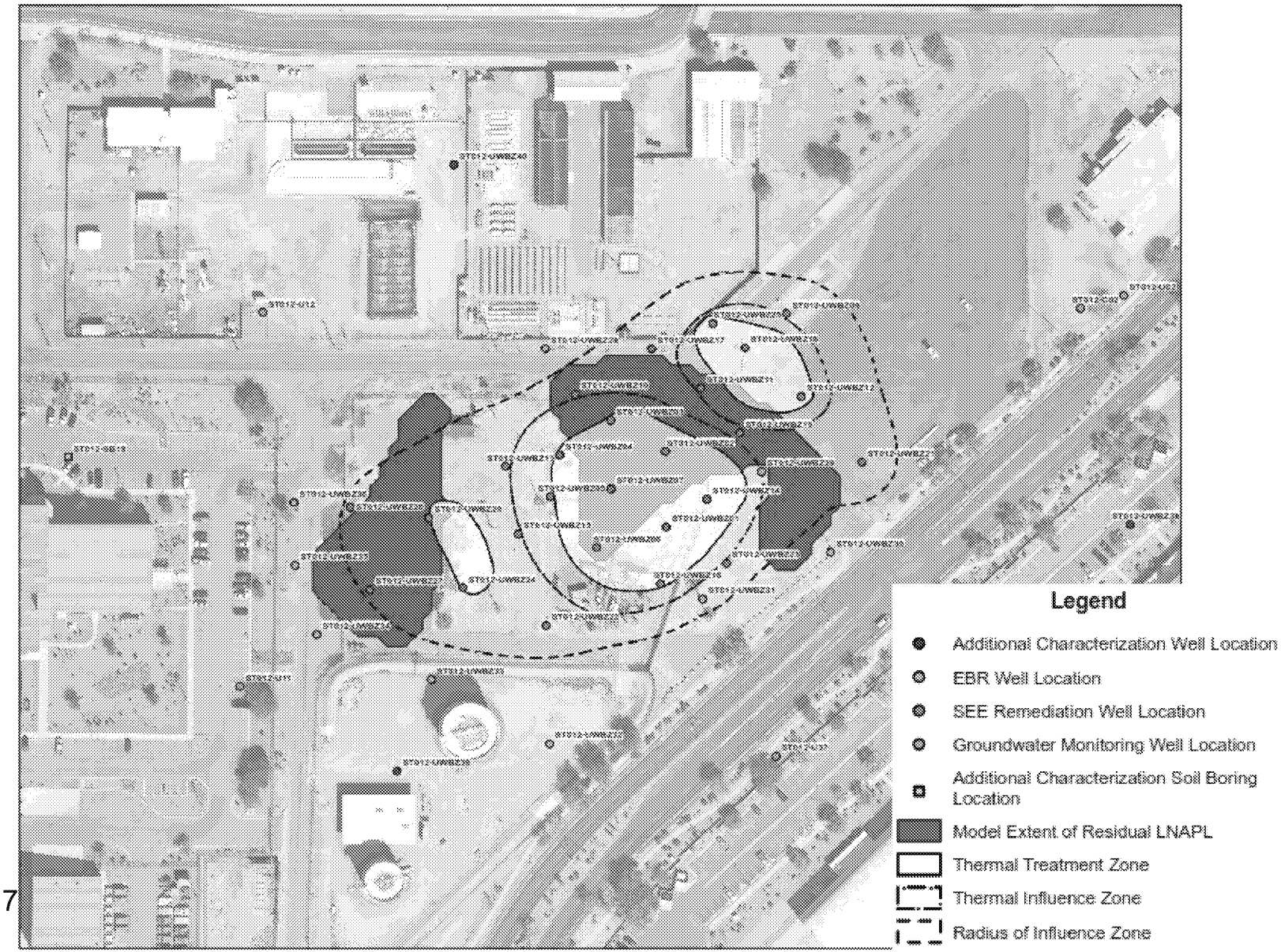
LNAPL Revised Interpretation Cobble Zone-145 ft bgs



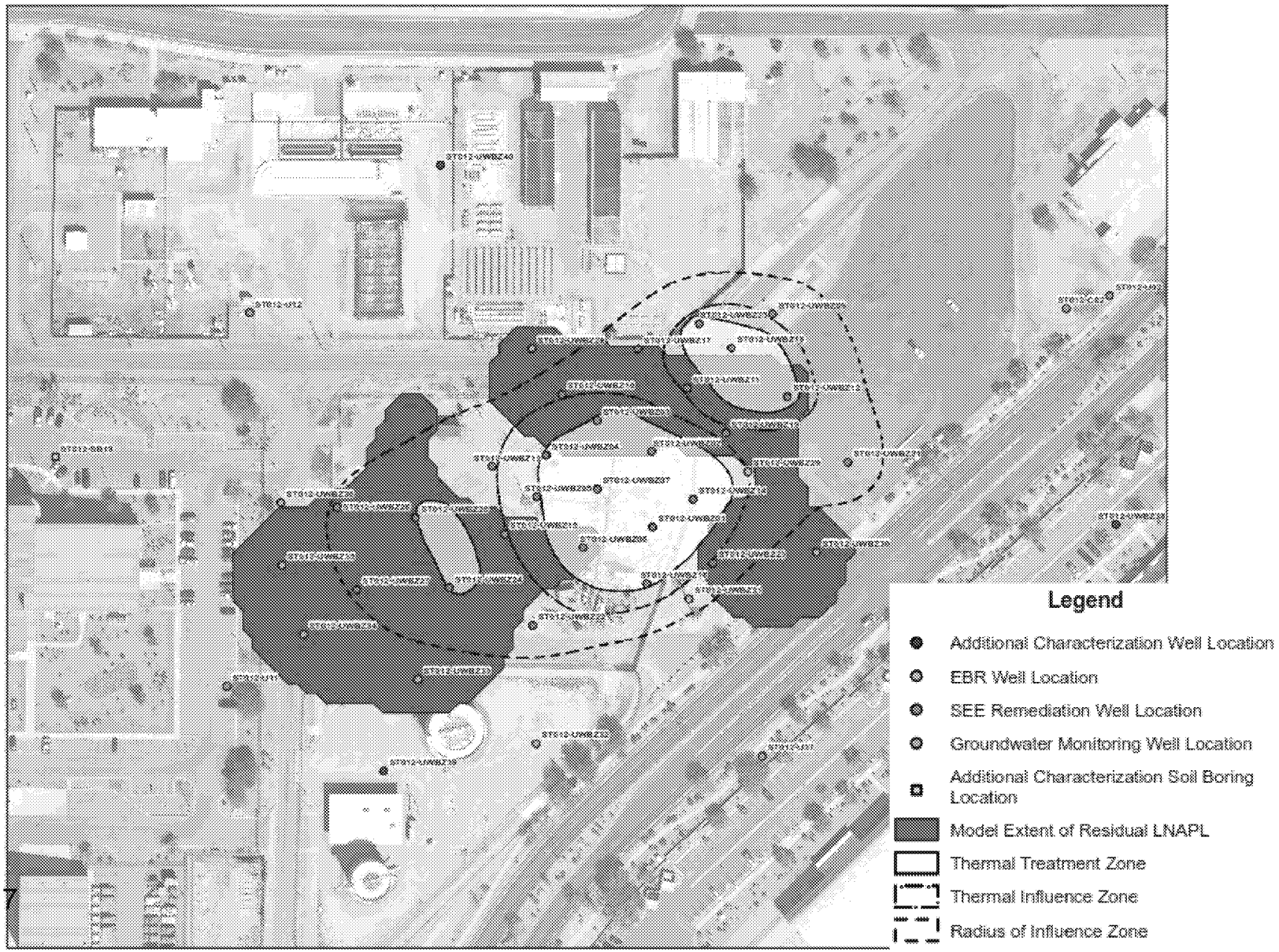
LNAPL Revised Interpretation Cobble Zone-155 ft bgs



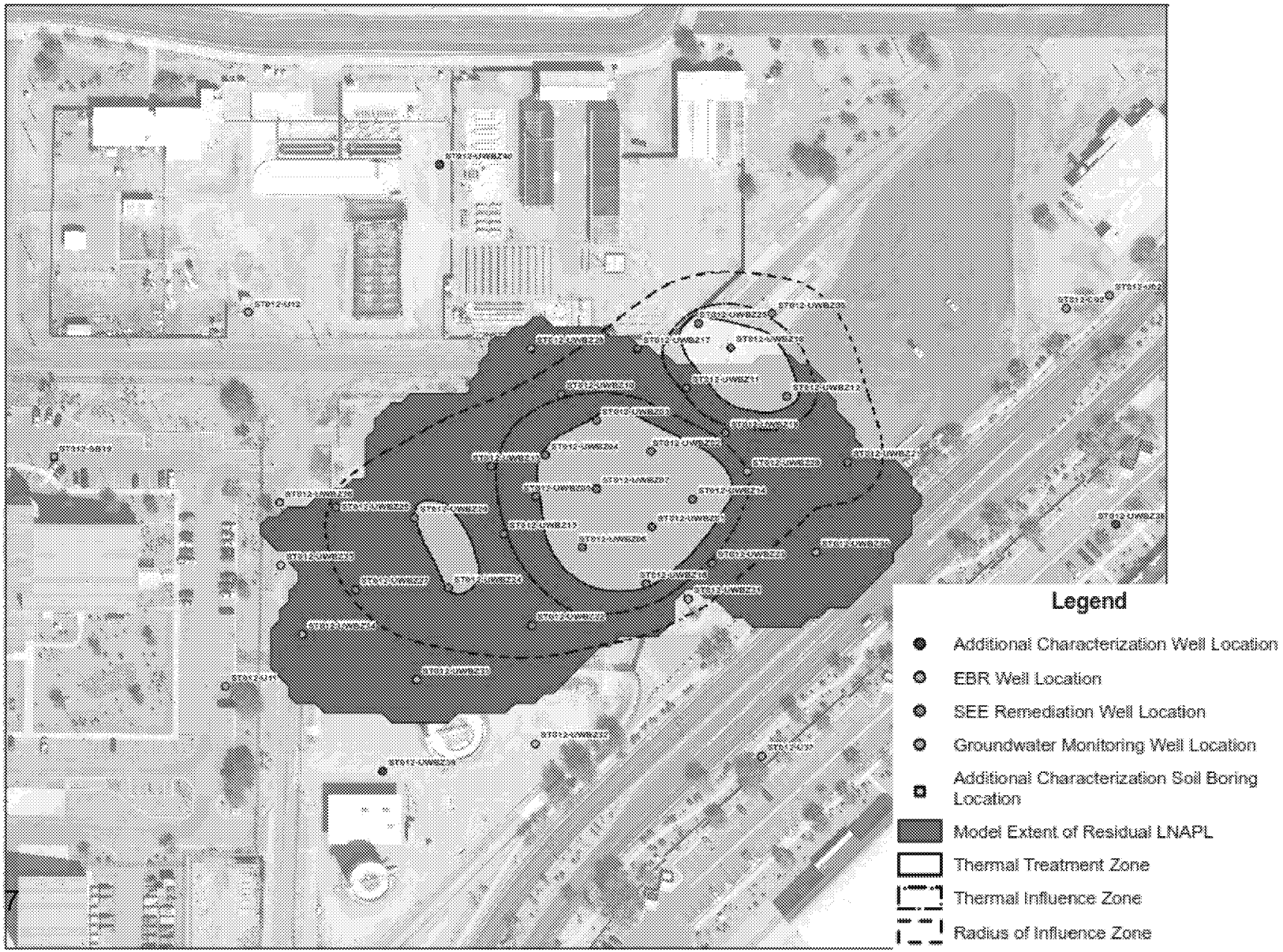
LNAPL Revised Interpretation
Upper Water Bearing Zone-165 ft bgs



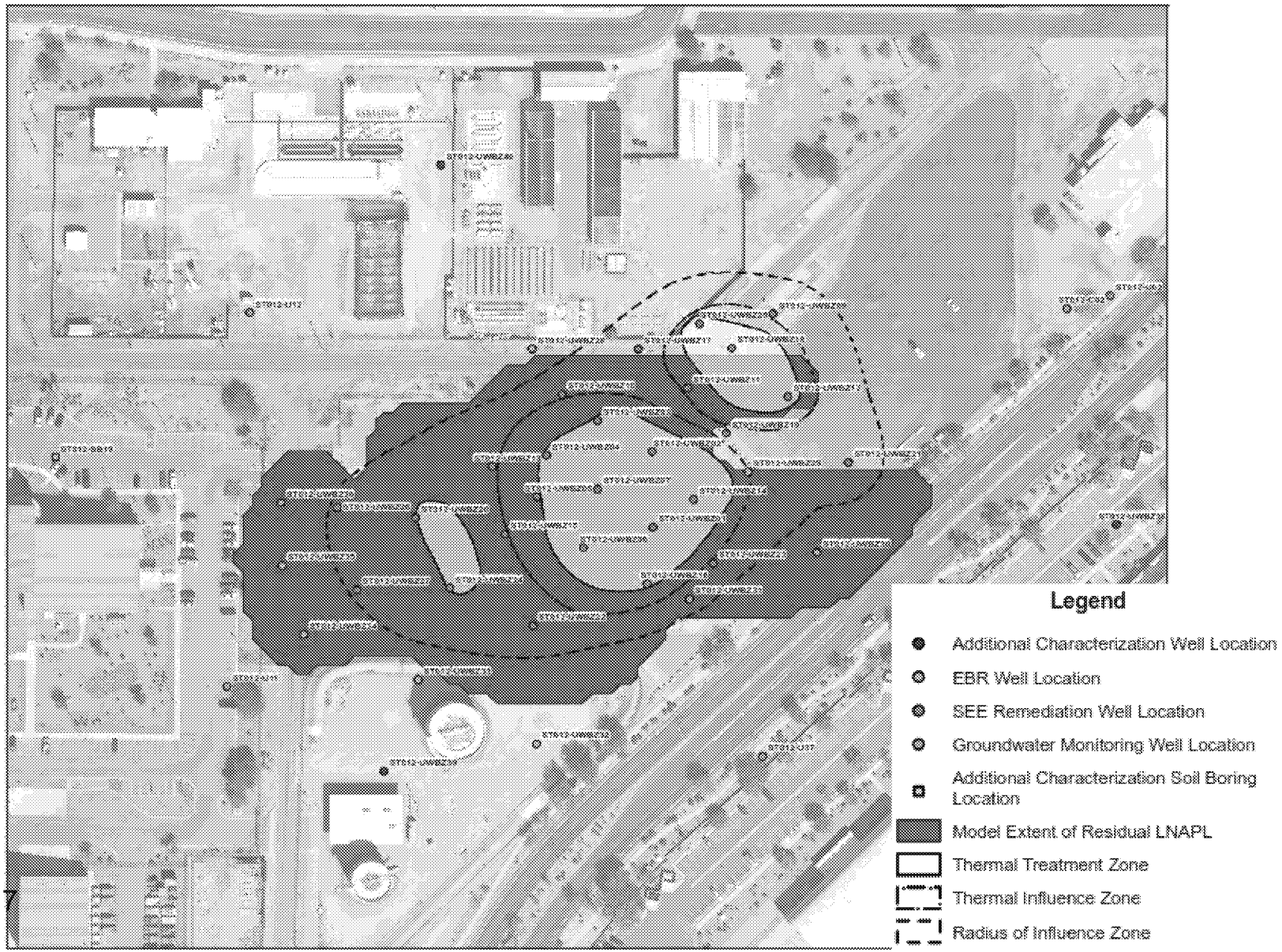
LNAPL Revised Interpretation
Upper Water Bearing Zone-175 ft bgs



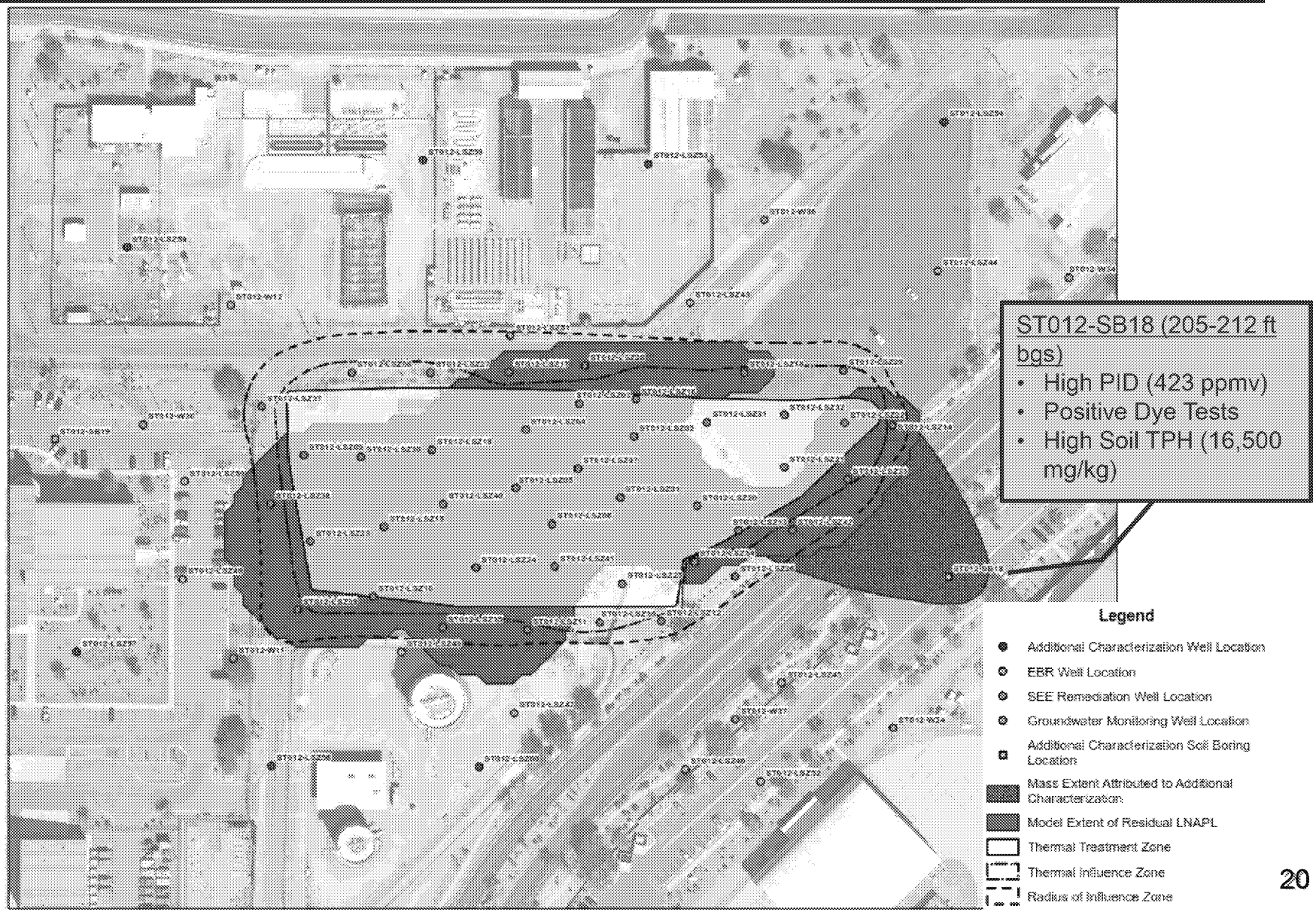
LNAPL Revised Interpretation
Upper Water Bearing Zone-185 ft bgs



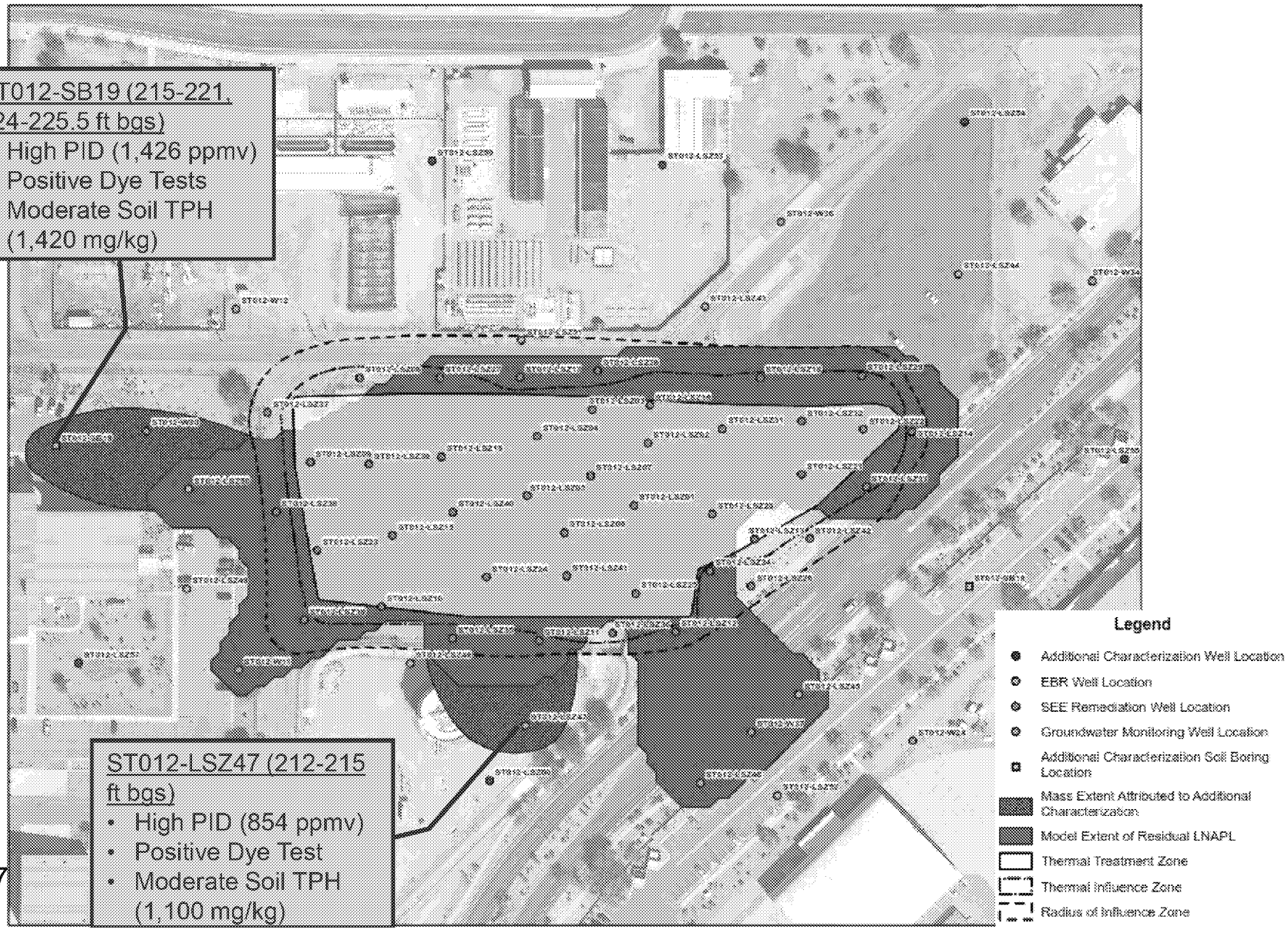
LNAPL Revised Interpretation
Upper Water Bearing Zone/Low Permeability Zone-195 ft bgs



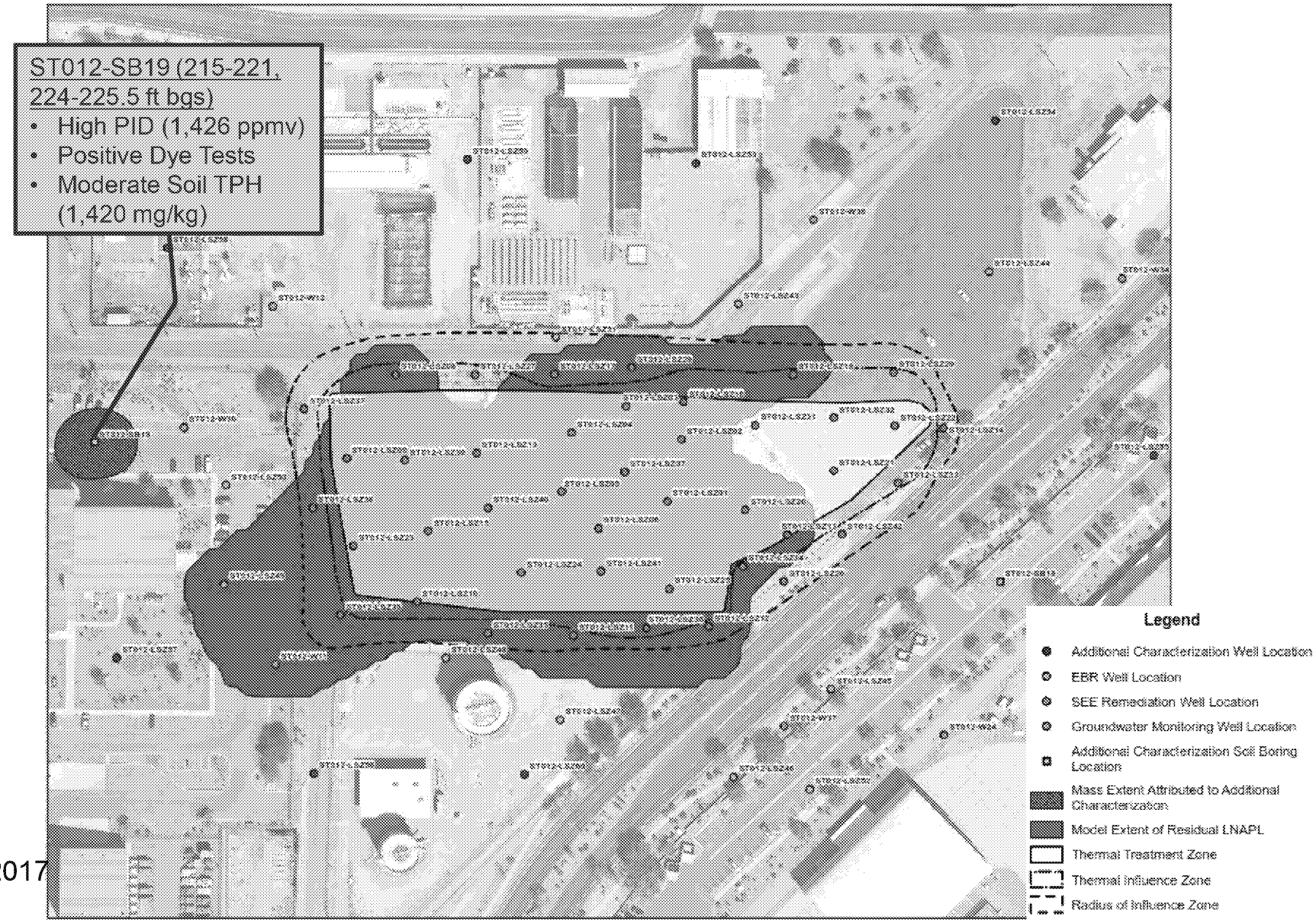
LNAPL Revised Interpretation
Low Permeability Zone/Lower Saturated Zone-205 ft bgs



LNAPL Revised Interpretation
Lower Saturated Zone-215 ft bgs



LNAPL Revised Interpretation
Lower Saturated Zone-225 ft bgs



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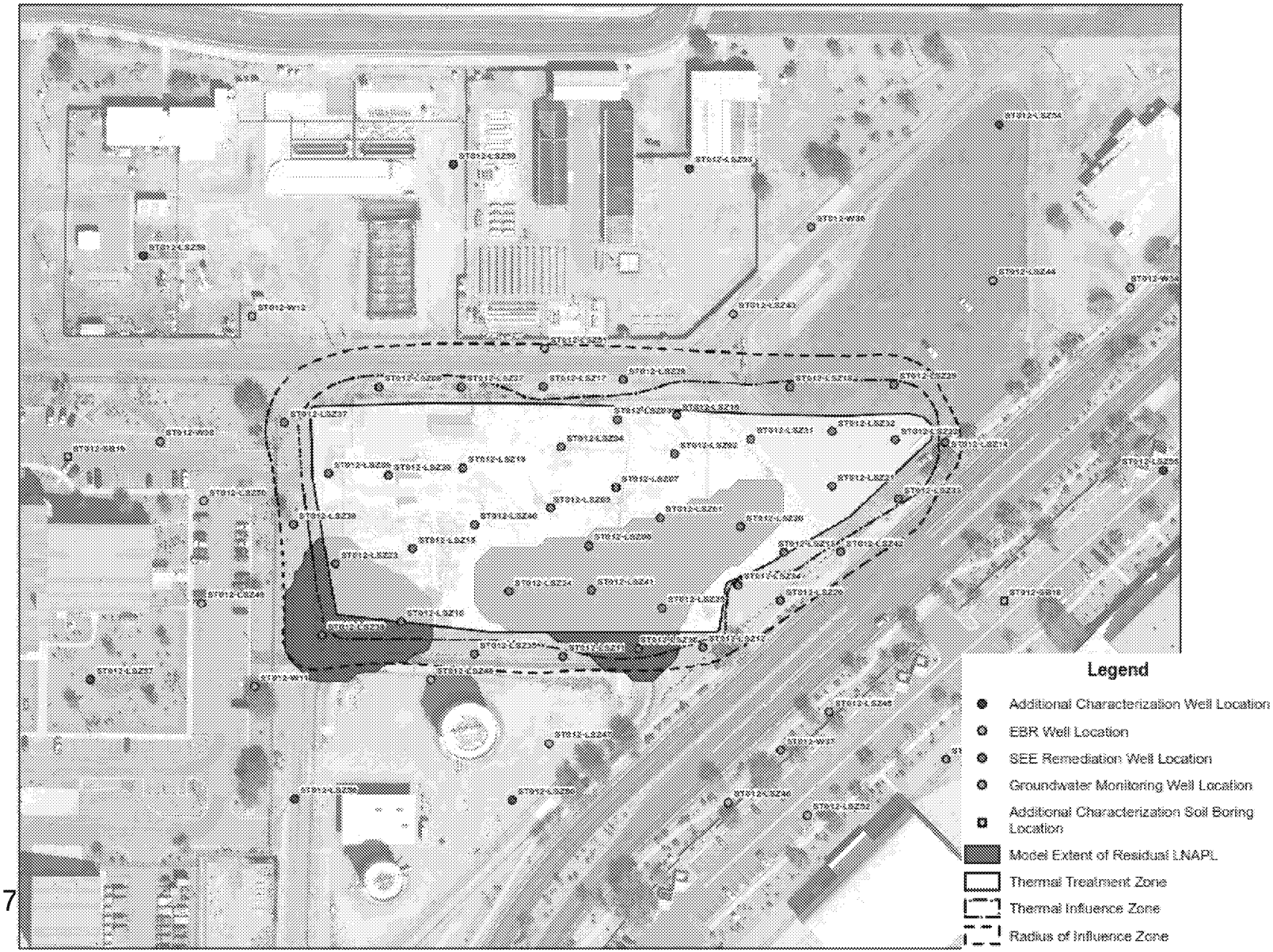
LNAPL Revised Interpretation
Lower Saturated Zone-235 ft bgs



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Revised LNAPL Mass Estimates

Mass Calculation Document/Phase	Estimated Remaining NAPL (gallons)				
	Total	TTZ	TIZ	ROI	EBR
RD/RAWP Appendix E - Post SEE[1]	**483,000**	---	---	---	---
Draft Final Addendum 2[2]	**183,000**	86,000	35,000	31,000	31,000
Revision Based on Incorporating Phase 1 EBR Data[3]	**377,000**	55,000	44,000	134,000	144,000
Revision Based on Incorporating Add. Char. Data[4]	**415,000**	55,000	44,000	134,000	182,000

Notes:

[1] Basis of EBR proof of concept in the Final RD/RAWP

[2] Calibrated estimate of mass removal and mass remaining used in EBR calculations

[3] Calibrated estimate of mass removal and mass remaining incorporating Phase I results and revised interpretation of SEE treatment area extents.

[4] Based on Phase 1 EBR update with additional volumes identified by investigation added to remaining contamination.

EBR - Enhanced Bioremediation

ROI - Radius of Influence

TIZ - Thermal Influence Zone

TTZ - Thermal Treatment Zone

- **Change from Draft Final Addendum 2 to Phase 1 EBR in large part due to relaxing assumptions on residual within SEE TTZs**
- **Additional Characterization changed mass estimate by ~10%**
- **Estimate of mass remaining is less than estimate used in RD/RAWP EBR modeling**

Model Review

Site ST012 Modeling Review Outline

- TEE Pilot Test Report Appendix M – Fate and Transport Modeling (Appendix M)
- FFS Appendix D – Attenuation Modeling for Post Steam Treatment (FFS)
- RD/RAWP Appendix E – Enhanced Bioremediation and SEE Containment Modeling Report (RD/RAWP)
- RD/RAWP Addendum 2 Appendix E – Groundwater Model Outputs (Addendum 2)

Appendix M Model

- Objective was to evaluate TEE and MNA
- Used SEAM3D (solute transport) and Modflow 2000 (groundwater flow)
- Two separate models for UWBZ and LSZ based on lack of hydraulic connection between the two
- 2,180 ft wide by 2,700 ft long model with 20x20 cells
- CZ was part of vadose zone at time of modeling

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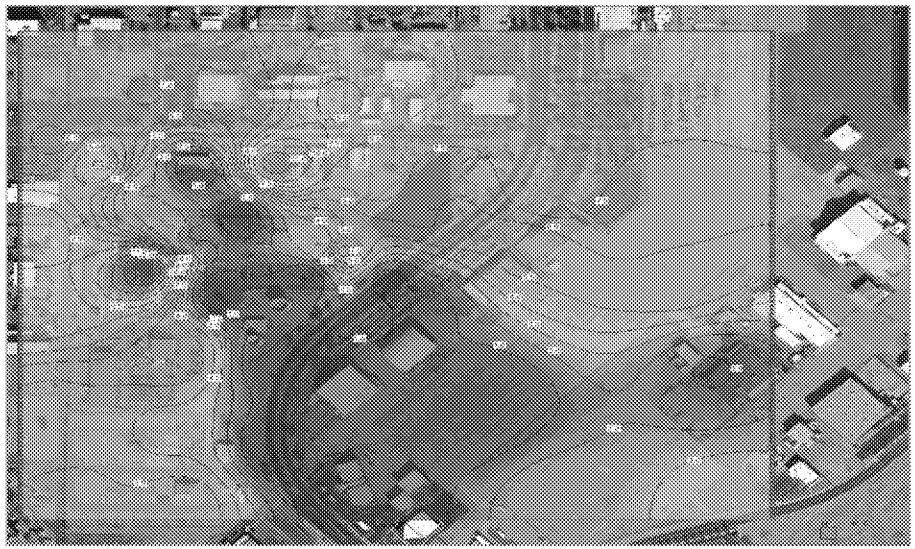
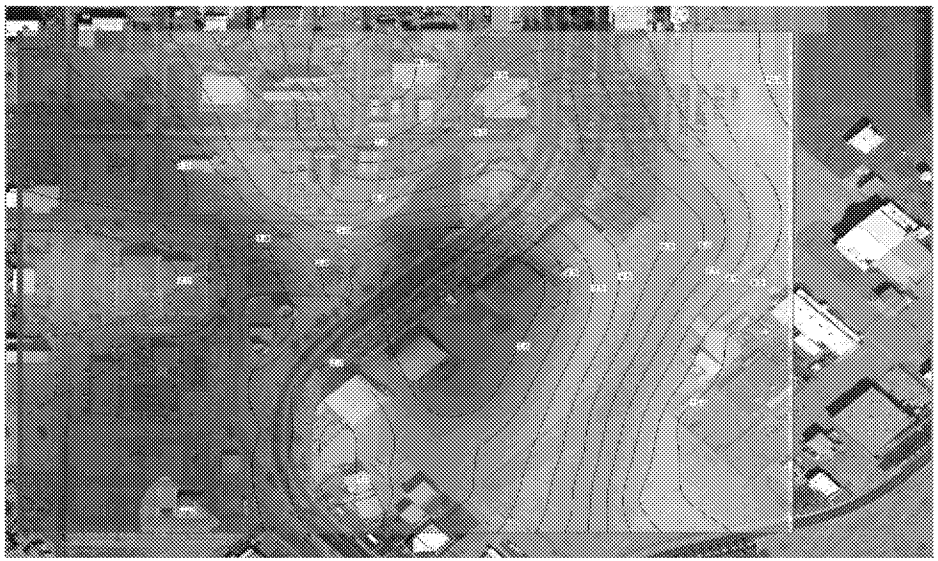
Appendix M Model

- **Conductivities locked at pumping/slug test locations and PEST code used to interpolate and calibrate to observed data**



UWBZ

LSZ



10 Hydraulic Conductivity Contours (ft/day)

FFS Model

- Objective was to evaluate EBR and MNA following SEE
- Created using Groundwater MODFLOW-SURFACT code (change from Modflow & SEAM3D)
- Input parameters based on the TEE Pilot Test fate and transport model
  - assigned CZ an hydraulic conductivity of 70 ft/day; estimated LPZ hydraulic conductivity by calibration; used H:V of 10:1
- Larger model area (3,180 ft wide by 2,660 ft long model with 20x20 cells)
- More model layers (6 Layers: vadose, CZ, UWBZ-1, UWBZ-2, LPZ, LSZ)
- Accounted for mass removal by SEE
- Three mass removal efficiencies for low-permeability layers (10%, 50% and 70% reduction)

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RD/RAWP Model

- Objective was to demonstrate proof of concept/conceptual remedial design for EBR and MNA post SEE
- Started with FFS model parameters
- Updated stratigraphy based on PDI
- Updated LNAPL distribution based on PDI
- Reduced cell size from 20x20 to 5x5 ft for increased resolution in areas for EBR treatment
- Increased model layers from 6 to 13 to refine visual outputs (closer to reality)

RD/RAWP Model

Table E-2.1 Hydrogeologic Properties Summary

Layer	Hydrostratigraphic Unit	Unsaturated Properties				Saturated Conductivity (ft/day)			Confined Specific Storage	Porosity
		Alpha	Beta	Residual Saturation	Brooks-Corey Number	Kx	Ky	Kz		
1	Unsaturated Zone	0.8	1.4	0.111	8	13	13	1.3	$1.00x10^{-05}$	0.30
2	Unsaturated Zone	0.8	1.4	0.111	8	13	13	1.3	$1.00x10^{-05}$	0.30
3	Unsaturated Zone	0.8	1.4	0.111	8	13	13	1.3	$1.00x10^{-05}$	0.30
4	Unsaturated Zone	0.8	1.4	0.111	8	13	13	1.3	$1.00x10^{-05}$	0.30
5	Unsaturated Zone	0.8	1.4	0.111	8	13	13	1.3	$1.00x10^{-05}$	0.30
6	Cobble Zone	0.8	1.4	0.111	8	70	70	7	$1.00x10^{-05}$	0.30
7	Cobble Zone	0.8	1.4	0.111	8	70	70	7	$1.00x10^{-05}$	0.30
8	Upper Water Bearing Zone	0.8	1.4	0.111	8	1	1	0.1	$1.00x10^{-05}$	0.30
9	Upper Water Bearing Zone	0.8	1.4	0.111	8	range 1 to 10	range 1 to 10	range 0.1 to 1.0	$1.00x10^{-05}$	0.30
10	Low Permeability Zone	0.256	1.32	0.111	9.25	$1.00x10^{-07}$	$1.00x10^{-07}$	$1.00x10^{-08}$	$1.00x10^{-07}$	0.30
11	Low Permeability Zone	0.256	1.32	0.111	9.25	$1.00x10^{-07}$	$1.00x10^{-07}$	$1.00x10^{-08}$	$1.00x10^{-07}$	0.30
12	Lower Saturated Zone	0.8	1.4	0.111	8	range 1 to 12	range 1 to 12	range 0.1 to 1.2	$1.00x10^{-05}$	0.30
13	Lower Saturated Zone	0.8	1.4	0.111	8	range 1 to 12	range 1 to 12	range 0.1 to 1.2	$1.00x10^{-05}$	0.30

RD/RAWP Model

- Boundary conditions documented
- No recharge or evapotranspiration but rising groundwater table incorporated
- Transport parameters (dispersivity, porosity, bulk density) same as FFS (dispersivity targeted for refinement in field test)
- Model Calibration - Adjusted perimeter constant head boundaries, LPZ permeability, and calibrated to observed gradients between well triplets in each zone

RD/RAWP Model

- **EBR Evaluation**
  - Injection/extraction approach
  - LNAPL distribution – based on estimates of distribution and assumed removals by SEE
  - LNAPL residual (based on calculated residual from PDI analytical results)
  - Sorption parameters defined (taken from Appendix M)
  - Maximum Utilization Rates defined
  - Use Coefficient and Half Saturation Constant Defined

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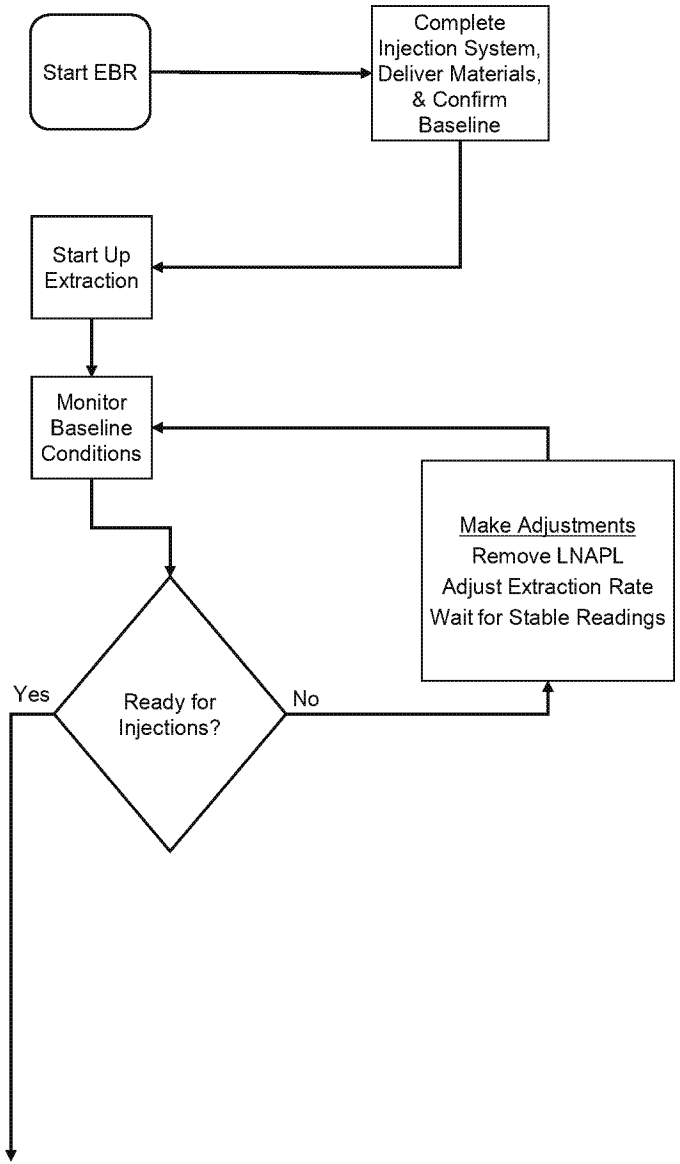
Addendum 2 Model

- Objective was to demonstrate sulfate distribution for Addendum 2 EBR design
- Started with RD/RAWP model
- Recalibrated to recent groundwater conditions
- Updated model transport parameters (dispersivity) based on field test
- Used groundwater transport model to evaluate distribution of sulfate (contaminant degradation previously modeled in RD/RAWP)

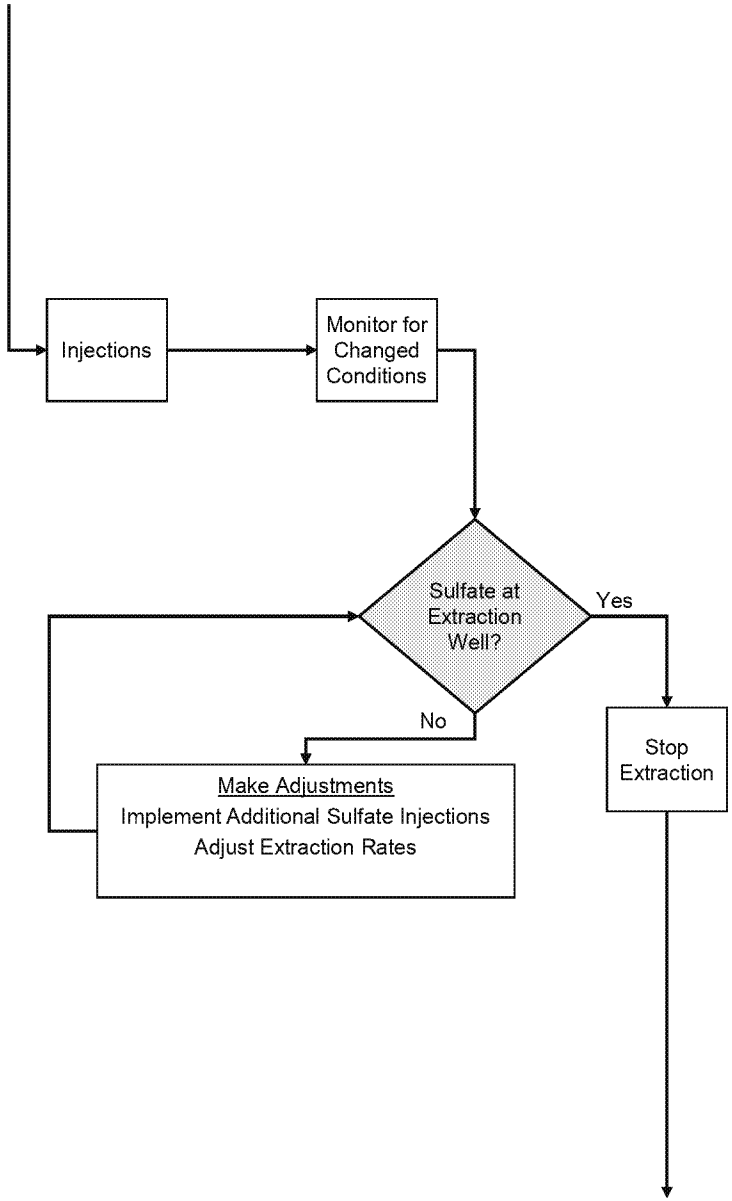
Decision Tree Summary

EBR Decision Tree Prepare for Injections



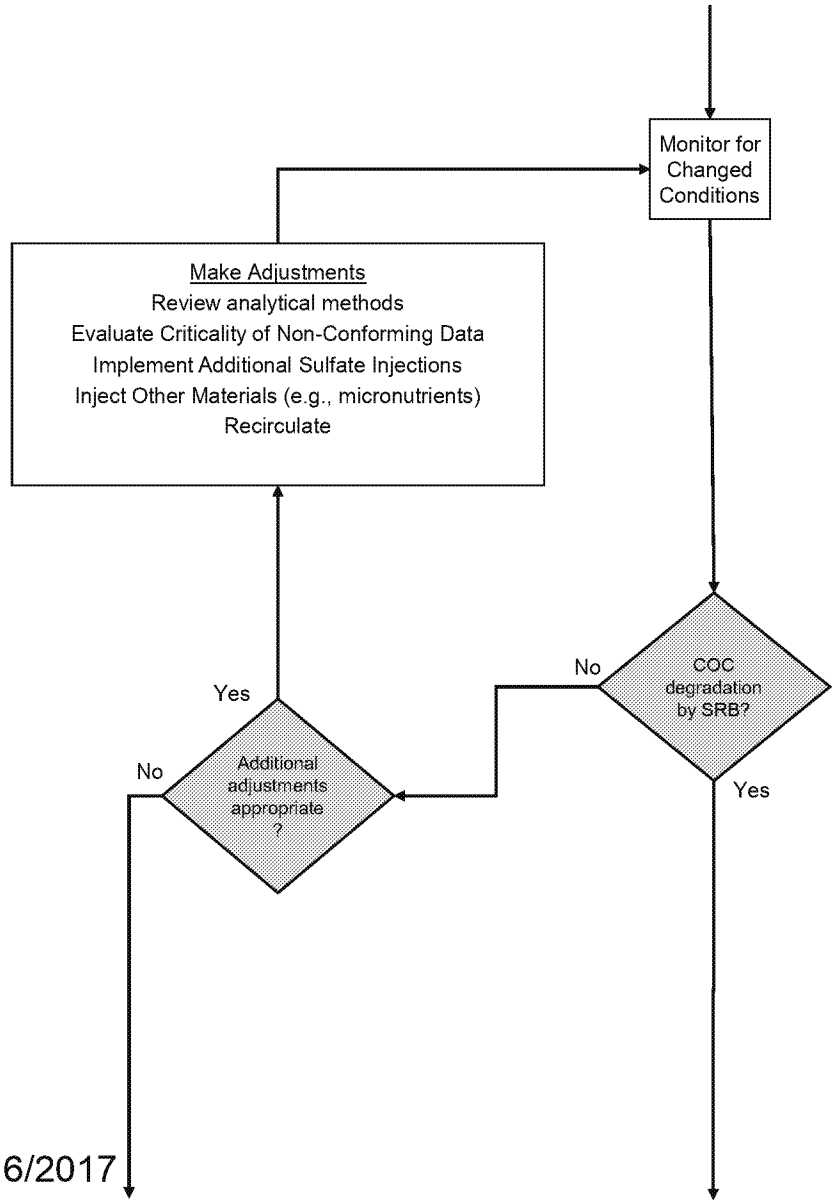
- **Focus on Starting up extraction**
- **Establish if LNAPL removal enhanced by pumping**
- **Decision to start injections based on establishment of hydraulic conditions and no or limited LNAPL accumulations**
- **Evaluations for localized areas (not site-wide)**

EBR Decision Tree
Evaluate When to Stop Extraction



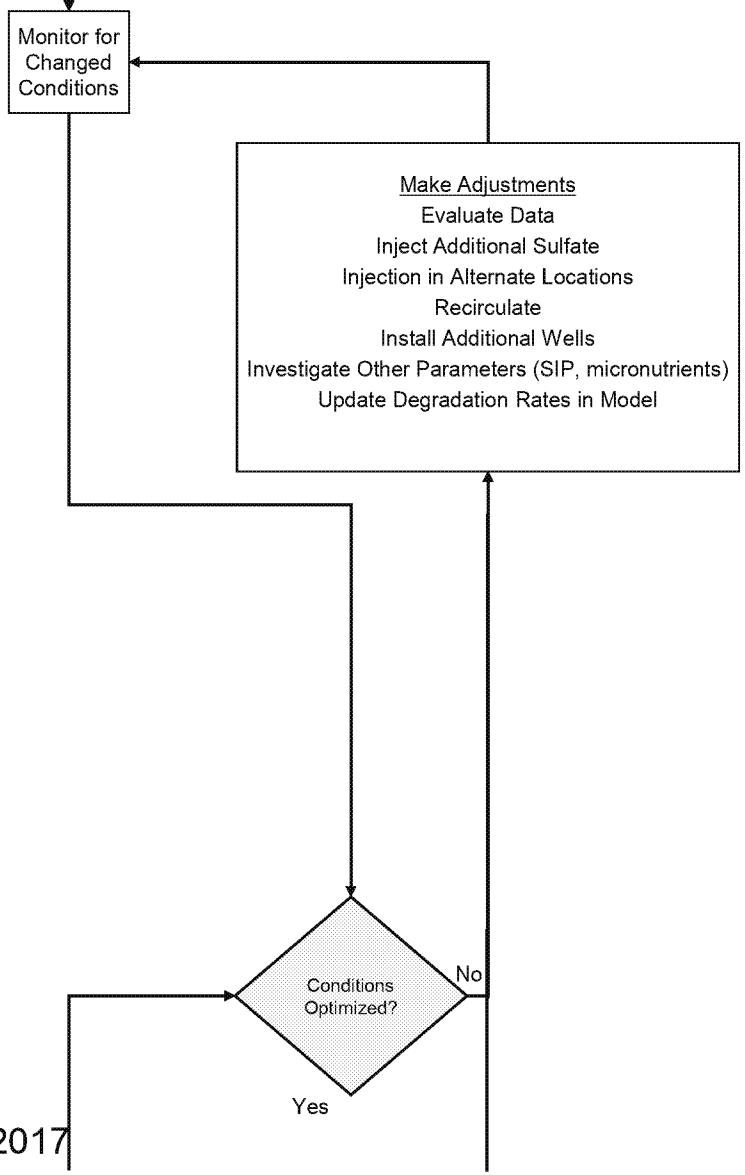
- **Focus on distributing sulfate without extracting sulfate**
- **Measure sulfate at extraction wells**
- **Decision to stop extraction based on sulfate concentrations**
- **Evaluations will be conducted sequentially for target areas (not site-wide)**

EBR Decision Tree Demonstrate EBR Established



- **Focus on demonstration of biological enhancement**
- **Evaluate multiple lines of evidence**
  - **VOCs/TPH**
  - **Geochemical (iron, manganese, nitrate, sulfate, pH, eH, oxygen)**
  - **Microbiology (SIP/PLFA, SIP/DIC, SRB, EBAC)**
- **Make adjustments if degradation by SRB not initially demonstrated**

EBR Decision Tree Optimize EBR



- **Focus on optimization of EBR**
- **Evaluate multiple lines of evidence**
  - **VOCs/TPH**
  - **Geochemical (iron, manganese, nitrate, sulfate, pH, eH, oxygen)**
  - **Microbiology (SIP/PLFA, SIP/DIC, SRB, EBAC)**
- **Make adjustments to optimize degradation**
- **Optimize areas as necessary**

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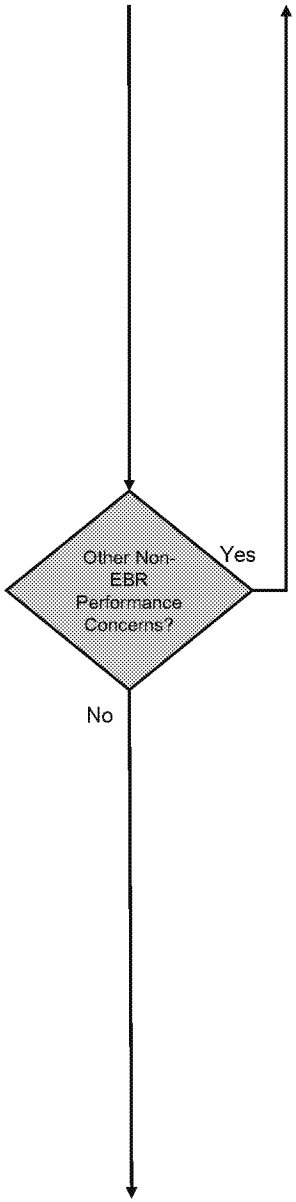
EBR Decision Tree Evaluate Other Concerns



- **Focus on monitoring for:**
  - Increasing LNAPL accumulations
  - VOC migration downgradient
  - Sulfate migration downgradient
  - Arsenic concentrations
  - Biofouling
- **Make adjustments if necessary**
- **Evaluations for localized areas (not site-wide)**

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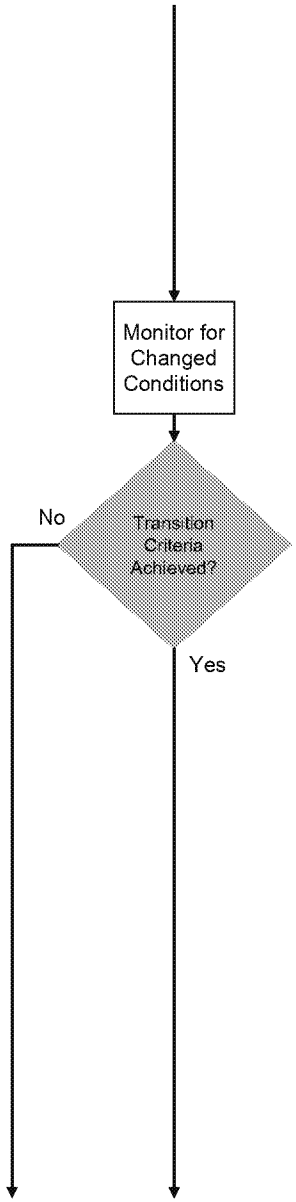
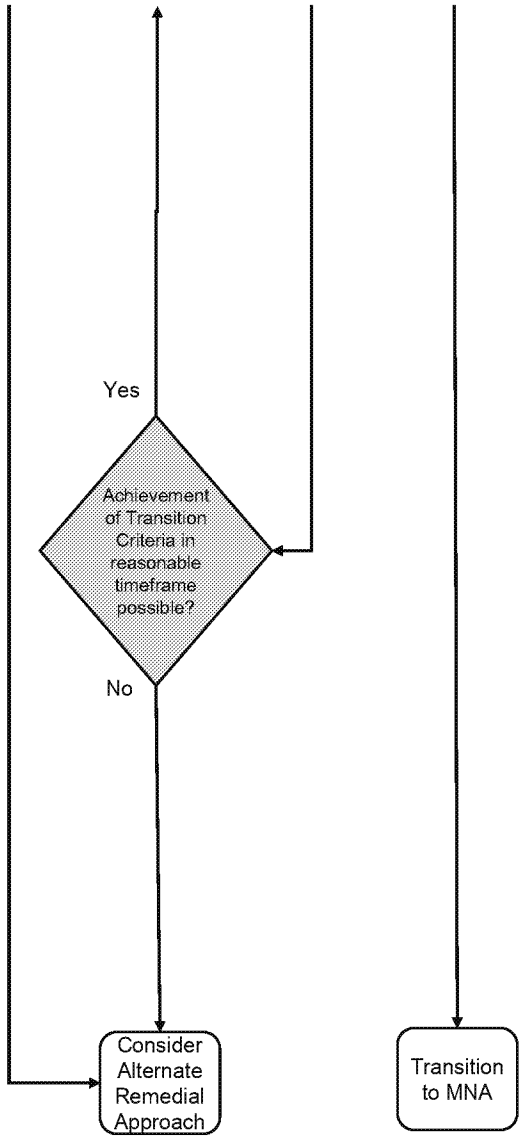
EBR Decision Tree Evaluate for Transition to MNA



- **Focus on demonstration of transition criteria**
  - **Benzene**
  - **Sulfate**
- **Benzene concentration criteria based on RD/RAWP model but subject to model update incorporating update from EBR**
- **Demonstration by zone using average and maximum benzene concentration**

EBR Decision Tree
Evaluate Continuation of EBR



- **Focus on degradation trends**
- **Evaluate if trends support the remedial timeframe**
- **Evaluations by area and site-wide**

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EBR Sequencing

Site ST012 – Implement EBR Approach

1. **Extraction in prioritized areas (areas of recently observed LNAPL prioritized)**
   - W37 area, W11 area
   - UWBZ10/28, UWBZ26/27, and UWBZ23/31 areas, LSZ37/38, LSZ17/51, LSZ11/48 areas
   - UWBZ21/29/30, UWBZ22/32/33 areas, LSZ23/39/49, LSZ14/29 area
   - CZ area
2. **Injections in areas of limited LNAPL recovery – prioritize based on:**
   - Longest travel times first (UWBZ-LSZ-CZ)
   - Higher mass areas first (get process started in areas that may take the longest)
     - ✓ Area of LNAPL recovery
     - ✓ Areas of high dissolved phase (LSZ49, W36)
   - Upgradient first (manage risk for downgradient migration)

Site ST012 – Implement EBR Approach

3. **Preliminary prioritization**
   - UWBZ Upgradient (UWBZ34/35/36 area)
   - LSZ Upgradient (W11/30/LSZ49/50 areas), UWBZ side gradient (UWBZ23/28/32/33 areas), and W37 area
   - UWBZ downgradient (UWBZ21/29 area), LSZ sidegradient (LSZ17/43/47/48/51/W36 areas)
   - LSZ downgradient (LSZ14/29/34 area), CZ (all areas)
4. **Evaluate and optimize following initial injections**
5. **Evaluate additional injection areas**

EBR Monitoring

Site ST012 – EBR Monitoring

Locations	Monitoring/ Analysis	Frequency	Sample Purpose
Injection Well and Injection Solution Sampling			
TEA Injection fluid	• ICP Metals (6010C) • Sulfate (9056A)	• Monthly	• Operational Strategy (verification of TEA concentration)
Injection locations	• VOCs (8260B) • ICP Metals (6010C) • Sulfate and Nitrate (9056A)	• Quarterly	• Performance (dissolved VOCs reduction, TEA solution distribution, dissolved metals monitoring)
Extraction Well Sampling			
Extraction locations	• VOCs (8260B)	• Quarterly	• Performance (dissolved COCs reduction) • Operational Strategy Assessment (bioactivity and TEA distribution)
	• TPH (8015B, DRO/GRO) • ICP Metals (6010C)	• Semiannual	• Performance • Compliance (trace metals monitoring)
	• Sulfate Field Screening • Sulfate (9056A)	• Biweekly during the first month (sulfate only), then transition to monthly thereafter with confirmatory offsite laboratory analysis (9056A) for every 10% of field screening samples • Monthly at extraction wells once extraction turned off • pH and temperature monitoring will stop following shutoff of extraction well	• Operational Strategy Assessment (TEA distribution)
Select extraction wells (5):	• Sulfate Field Screening • Sulfate (9056A)	• Weekly during the first two months, then transition to monthly thereafter with confirmatory offsite laboratory analysis for every 10% of field screening samples	• Operational Strategy Assessment (TEA distribution)

Site ST012 – EBR Monitoring

Locations	Monitoring/ Analysis	Frequency	Sample Purpose
Groundwater Monitoring Well Sampling			
Groundwater monitoring wells[2]	• VOCs (8260B) • ICP Metals (6010C) • Sulfate (9056A)	• Quarterly	• Performance (dissolved COCs reduction) • Operational Strategy Assessment (TEA distribution)
Select monitoring wells (6)	• PLFA and DIC (SIP) • SRB (qPCR) • EBAC (qPCR)	• It is estimated that analysis is likely to occur between six and twelve months following the initiation of sulfate injections based on field conditions (including sulfate travel time and groundwater temperatures). Once initial microbial analysis is conducted, future sampling will be conducted based on evidence of SRB and biodegradation.	• Performance (SRB population, evidence of biodegradation) • Operation Strategy Assessment (TEA distribution)
Annual Groundwater Monitoring Locations	• See AMEC, 2013 with modified locations per Table 5-3 of the RD/RAWP.	• Annual	• Compliance (RODA 2)

Notes:
1 May be modified based on final discharge permit.
2 Water quality parameters (pH, temperature, DO, and ORP) will be evaluated at each sampled well using a flow through cell and calibrated probes.
ASTM – American Society for Testing Materials
DIC – dissolved inorganic carbon
DO – dissolved oxygen
DRO – diesel range organics
EBAC – total eubacteria
FID – flame ionization detector
GAC – granular activated carbon
GC – gas chromatograph
GRO – gasoline range organics
HRGC/HRMS – high resolution gas chromatography/SVOCs- semi-volatile organic compounds high resolution mass spectrometry
LNAPL – light non-aqueous phase liquid
LSZ – lower saturated zone
MPE – multiphase extraction
ORP – oxidation reduction potential
PCBs – polychlorinated biphenyls
PID – photoionization detector
PLC – programmable logic controller
PLFA – phospholipid fatty acids
qPCR – guantified polymerase chain reaction
SEE – steam enhanced extraction
SIP – stable isotope probing
SIW – steam injection well
SRB – sulfate-reducing bacteria
TPH – total petroleum hydrocarbons
VOCs – volatile organic compounds

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Site ST012 Path Forward

- **Finalize RD/RA Work Plan Amendment 2**
  - Resolve any outstanding model questions — Mar-Apr 2017
  - Resolve any decision tree comments — Mar-Apr 2017
  - Incorporate changes into Final RD/RAWP Amend. 2 — Apr-May 2017
- **Start Extraction — Apr 2017**
- **Complete Injection System — Apr 2017**
- **Order Sodium Sulfate — Apr 2017**
- **Begin Injections — May-Jun 2017**

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Site LF004 Landfill Remedial Action

BCT Conference Call
16 March 2017

Site LF004
Former AST SVE System Update

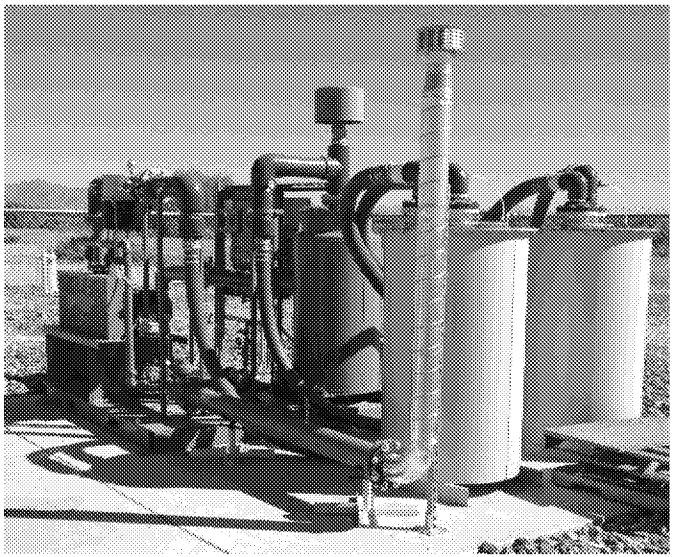
Operations Summary through 3 Mar 2017

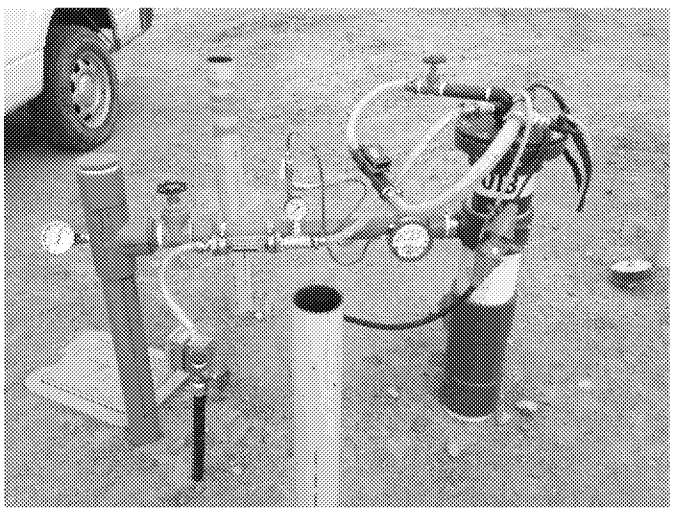
- Analytical data (Dec 2016) indicates TCE and PCE concentration remained below soil vapor goals (SVSLs) in all SVE wells and VMPs except TCE in SVE6-D (2.4 mg/m^3 vs 2 mg/m^3) and VMP11-D (6.2mg/m^3 vs 2 mg/m^3)
- TCE in SVE6-D and VMP11-D decreased from 2.6 in Sep to 2.4 (Dec) and 13 in Sep to 6.2 (Dec),respectively
- Quarterly vapor sampling completed in Feb 2017
- 0.3 pounds removed since 3 Feb 2017.

Site LF004
LF01-W17 Area IWAS System Update

Operations Summary through 3 Mar 2017

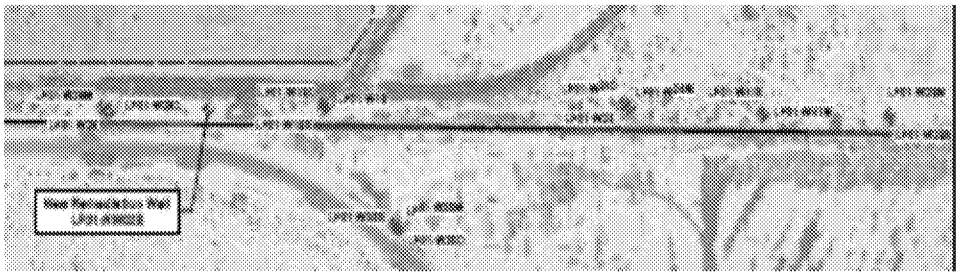
- Began operation 29 Aug 2014 (approximately 29 months of operation)
- Average 99% operational uptime for reporting period
- TCE and PCE concentrations in extracted vapor are 55 and 67 micrograms per cubic meter ($\mu g/m^3$), respectively (Jan 2017); extracted vapor concentrations remain low.
- Estimated 11 pounds of TCE and PCE removed by vapor extraction
- Oxidant screening indicates residual oxidant concentrations range from approximately 0.1 mg/L to 32 mg/L.
- All remediation wells operating
- Nov PDB results indicate only W17S and W17M were above MCLs at 5.8 µg/l and 8.1 µg/l for TCE





Site LF004
Southern Area Oxidant Injection

Activity Summary through 3 Mar 2017



- **Began operation 15 Sep 2014 (approximately 29 months of operation)**
- **Preliminary Nov PDB results indicate only three PCE MCL exceedances: W19S 13 µg/l (12 µg/l dup), W24S at 6.4 µg/L and W24M at 6.2 (5.4 dup) µg/l**
- **Shallow remediation well (LF01-RW02E) groundwater PDB sample results were 5.6 µg/L**
- **Begin oxidant recirculation between LF01-RW02E shallow and LF01-W19 shallow**

LF004 Remediation System Recent and Upcoming Activities

- Operation of IWAS and Southern Area remediation wells will continue
- Focused extraction at SVE6-D and VMP11-D (AST) by SVE system
- Quarterly vapor samples collected in Feb 2017. Analytical results are pending.
- Oxidant injections and recirculation in shallow zone at LF01-RW02E began in Feb 2017
- Landfill Inspection report under AF review
- OPS Report
  - Received EPA comments for OPS report on Jan 24 2017
  - Received ADEQ comments for OPS report on Feb 6, 2017
  - Discussed preliminary response to comments in Feb 2017 BCT meeting
  - Response to regulatory comments under AF review
- Posting of analytical data to Sharepoint will continue as results are available

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Site FT002
Fire Training Area Remedial Action

BCT Conference Call
16 March 2017

Site FT002 Update

- Received EPA comments for FT002 closure report on Jan 5, 2017
- Received ADEQ comments for FT002 closure report on Feb 6, 2017
- Discussed preliminary response to comments in Feb 2017 BCT meeting
- Response to regulatory comments under AF review

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Site ST035

Former Building 760

BCT Conference Call

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ST035 Path Update

- Received ADEQ comments for Site Closure Report on Feb 6, 2017. Response to comments in progress.
- Site closure is anticipated to be May 2017

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Site SS017

Old Pesticide/Paint Shop

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Battle Ready…Built Right!

BCT GENERAL UPDATE

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2017 BCT MEETINGS/CONFERENCE CALLS SCHEDULE

BCT Conference Call

16 March 2017

ACTION ITEMS

BCT Conference Call

16 March 2017