SECTION E

GROUNDWATER MONITORING

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E-1 1000 AREA (SWMU GROUP 9) GROUNDWATER MONITORING WELLS WITH 2014 POTENTIOMETRIC SURFACE (FALL 2014)

E-2 1000 AREA GEOLOGICAL CROSS SECTION

E-3 1100 AREA (SWMU GROUP 10) GROUNDWATER MONITORING WELLS WITH 2014 POTENTIOMETRIC SURFACE (FALL 2014)

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E-5 SWMU GROUP 17 GROUNDWATER MONITORING WELLS WITH 2014 POTENTIOMETRIC SURFACE (FALL 2014)

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E-1 CORRECTIVE MEASURES DECISION CLEAN-UP GOALS D&Z SITE-WIDE MONITORING WELL SAMPLING

E-2 WELL CONSTRUCTION DATA SWMU GROUP 9 (1000 AREA) MONITORING WELL SAMPLING

E-3 WELL CONSTRUCTION DATA SWMU GROUP 10 (1100 AREA) MONITORING WELL SAMPLING DAY & ZIMMERMANN KANSAS LLC - PARSONS, KANSAS

E-4 WELL CONSTRUCTION DATA SWMU GROUP 17 (2700 AREA) MONITORING WELL SAMPLING

APPENDICES

Appendix

E-1 SITE-WIDE GROUNDWATER, CORRECTIVE MEASURES DECISION, IMPLEMENTATION SAMPLING AND ANALYSIS PLAN, PART I - FIELD SAMPLING

E-2 CHECKLIST FOR REVIEW OF FEDERAL RCRA PERMIT APPLICATION

SECTION E – GROUNDWATER MONITORING

E-1 EXEMPTION FROM GROUNWATER PROTECTION REQUIREMENTS [40 *Code of Federal Regulations* {CFR} §270.14(c)]

No exemptions are sought from the groundwater monitoring requirements. Currently, the groundwater monitoring program at Day & Zimmermann Kansas LLC (D&Z) is part of the corrective action program at this facility. Because the treatment system is land-based, the Open Detonation (OD) Grounds must have a groundwater monitoring program in place. The current groundwater monitoring system at this area will meet this requirement.

E-1a Waste Pits [40 CFR §270.18(b) and 264.90(b)(2),(5)]

Not applicable.

E-1b Landfill [40 CFR §264.90(b)(2)]

Not applicable.

E-1c No Migration [40 CFR §264.90(b)(4)]

Not applicable.

E-1d Drip Pad [40 CFR §270.26(b) and 264.90(b)(2)]

Not applicable.

E-2 INTERIM STATUS GROUNDWATER MONITORING DATA [40 CFR §270.14(c)(1) AND 265.90 THROUGH 265.94]

Not applicable; no interim status groundwater monitoring program is in place at the facility.

E-2a Description of Wells [40 CFR §265.91]

Not applicable; no interim status groundwater monitoring program is in place at the facility.

E-2b Description of Sampling and Analysis Procedures [40 CFR §265.92]

Not applicable; no interim status groundwater monitoring program is in place at the facility.

E-2c Monitoring Data [40 CFR §265.92)]

No groundwater monitoring data have been collected under interim status at the facility.

E-2d Statistical Procedures [40 CFR §265.93]

Not applicable.

E-2e Groundwater Assessment Plan [40 CFR §265.93(d)(2)]

Not applicable.

E-3 GENERAL HYDROGEOLOGIC INFORMATION [40 CFR §270.14(c)(2)]

Residents within a 1-mile radius of D&Z receive water from one of two rural water districts or Great Plans Development Authority. The rural water districts purchase water from a wholesaler and supply it to residential users.

Monitoring wells have been installed in the solid waste management units (SWMU) at D&Z, including SWMU 9 – 1000 Area, SWMU 10 – 1100 Area, and SWMU 17 – OD Field. Monitoring well locations are shown on Figures E-1, E-3, and E-5. Generally, the monitoring wells were positioned to surround the portion of the SWMU(s) that were of interest to provide both upgradient and downgradient groundwater sampling points. Currently, the U.S. Army is conducting groundwater monitoring at Burn Pad 6, which is part of SWMU 24. However, these wells are not included in this program, pending results of a 1-year monitoring program that will determine if additional monitoring is required and if so, which wells will be included in the monitoring program. However, the location of the wells associated with Burn Pad 6 have been included on Figure E-7 for completeness.

Depth of the screened interval of the monitoring wells was chosen in the field based on estimated depth of the first saturated zone. Generally, the screened interval of the wells was placed within the uppermost 10 feet of the first saturated zone.

The monitoring wells were drilled by initially sampling the soil and bedrock, and then reaming the borehole to the specified diameter for installation of the monitoring well. Because depth to the bedrock surface is relatively shallow, all monitoring wells were drilled by use of wet rotary methods.

The monitoring wells were installed with the intent of collecting groundwater samples representative of the quality of the uppermost water-bearing zone. The well screen consisted of nominal 10-foot, threaded and flushjoint, 2-inch diameter, Schedule 40 polyvinyl chloride (PVC), factory-slotted material with a slot size of 0.010 inch. Well riser material was flushjoint threaded, Schedule 40 PVC pipe with nominal 2-inch diameter. Both the screen and riser materials were supplied in sealed packaging and were specifically manufactured for monitoring well construction purposes.

Screen and riser sections were joined by threaded flushjoints, sealed with neoprene “o” rings, to form watertight unions and retain 100% of the strength of the screen. Solvent glue was not used at any time in construction of the wells. The bottom of the screen and riser assembly was sealed with a threaded PVC cap. A vented cap was placed at the top of the each well.

Clean, 0.55-0.65 gradation Arkola silica sand was used to construct the filter pack surrounding the screened interval. The filter pack was continuously placed by tremie method from the bottom of the boring to a minimum of 2 feet, but not more than 5 feet above the top of the well screen.

A minimum 2-foot-thick seal consisting of ¼-inch bentonite pellets was placed into the annular space above the filter pack. The top of the bentonite seal was always set at or below the frost line (a minimum of 25 inches below ground), depending on the well construction dimensions. The bentonite pellets were hydrated by the water remaining in the borehole following the sand placement process.

Cement grout, when used, consisted of a mixture of 94 pounds of Portland cement with 3 to 5%, by weight, bentonite powder and not more than 7 gallons of water. The grout was generally poured because the well depths were so shallow. The top of the grout was set at the frost line.

For monitoring well installations near areas of probable ground disturbance (OD Grounds), a low permeability flexible clay seal was used instead of the neat cement grout. This clay seal consisted of

American Colloid Company “Pure Gold Grout” mixed in a ratio of 2.1 pounds grout per gallon of water. The grout was mixed vigorously in a pail and poured because the well depths were so shallow. The top of the clay seal was set at the frost line.

D&Z is within the southeastern part of the Osage Cuesta Physiographic Division of the Central Lowland Province. The region is a plain of low relief, interrupted at intervals by east-facing escarpments. The escarpments are underlain by limestone beds and the relatively flat areas are underlain by weaker beds of shale. The surface-water drainage network is influenced by this physiography in that the escarpments typically correspond to drainage area divisions.

The topographic relief of the area is generally less than 300 feet.

The surface geology generally consists of terrace and floodplain alluvial deposits in the lowlands and residual soils, weathered from bedrock, in the uplands. The bedrock geology, of Pennsylvania Age, is composed of interbedded marine and nonmarine shales and limestones deposited in a cyclothem sequence. These sedimentary rocks are relatively flat lying, with a regional dip to the west-northwest of approximately 20 feet per mile.

The surficial deposits of the region are a combination of Pleistocene-age terrace clays, Holocene floodplain clays, Holocene alluvial sands and gravels, and residual soils. The alluvial clays, sands and gravels occur along major streams such as Labette Creek and the Neosho River. Between major streams, the upland soils consist of residual silts and clays that have weathered from the underlying shales and limestone. Upland soils occasionally contain lenses of sand and gravel resulting from more resistant bedrock units. Also, weathered alluvium is present on the uplands.

All bedrock outcrops in Labette County are of Pennsylvania age. The stratigraphic units underling the eastern portion of the county (near D&Z) are from Marmaton and Cherokee Groups, and consist of the following formations, from youngest to oldest: Lenapah Limestone, Nowata Shale, Altamont Limestone, Bandera Shale, Pawnee Limestone, Labette Shale, Fort Scott Limestone, and Cabaniss Formation (of the Cherokee Group).

Surficial deposits at D&Z consist of Pleistocene terrace alluvium, Holocene floodplain deposits, and residuum from weathered bedrock. The U.S. Department of Agriculture (USDA) has described various series of silt loam and clay soils within D&Z. These soil series can be grouped into the following five parent materials: limestone bedrock residuum, sandstone and sandy shale residuum, shale residuum, pleistoceen age (or older) alluvium, and recent alluvium.

Groundwater resources at D&Z and the surrounding areas are present both in unconsolidated surficial materials and in the bedrock. The water table depth is generally shallow, less than 50 feet. The surficial materials are generally the best potential sources of groundwater in Labette County, and potable water for D&Z and the rural districts is tapped from these units near the Neosho River (about 5 miles east of D&Z) rather than from the bedrock. Bedrock generally does not yield sufficient quantities of water to make it a viable water source, and the water tends to be hard and to contain excessive amounts of chloride, nitrate, and hydrogen sulfide.

The unconsolidated alluvial deposits along the Neosho River and other streams are considered the best regional aquifers for potable and industrial water supply. These deposits may yield up to 100 gallons per minute, but the average long-term yield of the alluvium is considered to be 50 gallons per minute. The Neosho River alluvium, the most extensive unconsolidated aquifer in Labette County, is approximately 35 feet thick and consists of 10 to 30 feet of silt and clay overlying up to 15 feet of sand and gravel. Wells constructed in the alluvium range from 10 to 20 feet deep. Groundwater in the alluvial aquifers is

recharged by direct infiltration of rainfall, infiltration of spring runoff and subsurface flow from consolidated rock aquifers bounding the alluvial valleys, and infiltration of period floodwaters.

E-4 TOPOGRAPHIC MAP REQUIREMENT [40 CFR §270.14(c)(2),(3),(4)(i)]

Figures E-1, E-3, and E-5 show well locations and the topographic relief for each area.

E-5 CONTAMINANT PLUME DESCRIPTION [40 CFR §270.14(c)(2),(4),(7)]

See Section E-9.

E-6 GENERAL MONITORING PROGRAM REQUIREMENTS [40 CFR §270.14(c)(5), 264.90(b)(4) AND 264.97]

See Section E-9

E-6a Description of Wells [40 CFR §264.97(a), (b), (c)]

See Section E-9

E-6b Description of Sampling and Analysis Procedures [40 CFR §264.97(d), (e), (f)]

See Section E-9

E-6c Procedures for Establishing Background Quality [40 CFR §264.97(a)(1), (g)]

See Section E-9

E-6d Statistical Procedures [40 CFR §264.97(h), (i)(1),(5),(6)]

See Section E-9

E-6d(1) Parametric Analysis of Variance (ANOVA) [40 CFR §264.97(h)(1), (i)(2)]

Not applicable

E-6d(2) Nonparametric ANOVA (based on ranks) [40 CFR §264.97(h)(2), (i)(2)]

Not applicable

E-6d(3) Tolerance of Prediction Interval Procedure [40 CFR §264.97(h)(3), (i)(4)]

Not applicable

E-6d(4) Control Chart Approach [40 CFR §264.97(h)(4), (i)(3)]

Not applicable

E-6d(5) Alternative Approach [40 CFR §264.97(h)(5), (i)]

Not applicable

E-7 DETECTION MONITORING PROGRAM [40 CFR §270.14(C)(6). 264.91(a)(4) AND 264.98]

Not applicable

E-7a Indicator Parameters, Waste Constituents, Reaction Products to be Monitored [40 CFR §270.14(c)(6)(i) and 264.98(a)]

Not applicable

E-7b Groundwater Monitoring System [40 CFR §270.14(c)(6)(ii), 264.97(a)(2), (b), (c), and 264.98(b)]

Not applicable

E-7c Background Groundwater Concentration Values for Proposed Parameters [40 CFR §270.14(c)(6)(iii), 264.97(g) and 264.98(c), (d)]

Not applicable

E-7d Proposed Sampling and Analysis Procedures [40 CFR §270.14(c)(6)(iv), 264.97(d), (e),(f) and 264.98(d), (e), (f)]

Not applicable

E-7e Statistically Significant Increase in any Constituent or Parameter Identified any Compliance Point Monitoring Well [40 CFR §264.98(g) and Part 264 Appendix IX]

Not applicable

E-8 COMPLIANCE MONITORING PROGRAM [40 CFR §270.14(c)(7) AND 264.99]

See Section E-9.

E-8a Waste Description [40 CFR §270.14(c)(7)(i)]

Not applicable

E-8b Characterization of Contaminated Groundwater [40 CFR §270.14(c)(7)(ii)]

Not applicable

E-8c Hazardous Constituents to be Monitored in Compliance Program [40 CFR §270.14(c)(7)(iii), 264.98(g)(3) and 264.99(a)(1)]

Not applicable

E-8d Concentration Limit [40 CFR §270.14(c)(7)(iv), 264.94, 264.97(g), (h) and 264.99(a)(2)]

Not applicable

E-8e Alternate Concentration Limits [40 CFR §270.14(c)(7)(iv), 264.94(b) and 264.99(a)(2)]

Not applicable

E-8e(1) Adverse Effects on Groundwater [40 CFR §264.94(b)(1)]

Not applicable

E-8e(2) Potential Adverse Effects [40 CFR §264.94(b)(2)]

Not applicable

E-8f Engineering Report Describing Groundwater Monitoring Systems [40 CFR §270.14(c)(7)(v), 264.95, 264.97(a)(2),(b),(c) and 264.99(b)

Not applicable

E-8g Proposed Sampling and Statistical Analysis Procedures for Groundwater Data [40 CFR §270.14(c)(7)(vi), 264.97(d),(e),(f) and 264.99(c)-(g)]

Not applicable

E-8h Groundwater Protection and Standard Exceeded at Compliance Point Monitoring Well [40 CFR §264.99(h),(i)]

Not applicable

E-9 CORRECTIVE ACTION PROGRAM [40 CFR §270.14(c)(8), 264.99(j) AND 264.100]

The current groundwater monitoring program at D&Z supports the corrective action program, and no interim status monitoring data have been collected and submitted for review and approval.

E-9a Characterization of Contaminated Groundwater [40 CFR §270.14(c)(8)(i)]

As part of the current groundwater monitoring program, the Tetra Tech on behalf of D&Z submitted the semiannual report for Spring 2014 (Semi-Annual Groundwater Monitoring Report Tetra Tech 2014). This report identified the current groundwater monitoring results from each area currently monitored—SWMU Group 9 (1000 Area), SWMU Group 10 (1100 Area), and SWMU Group 17 (OD Fields). The most recent data from each area are summarized below. Table E-1 lists Corrective Measures Decision (CMD) Cleanup Goals, and Tables E-2 through E-4 list the wells to be sampled as part of the ongoing monitoring.

SWMU Group 9 (1000 Area) – Nine monitoring wells will be used to assess the groundwater at this area (see Table E-2). The general direction of groundwater flow was southward and southwestward in the 1000 Area during the spring 2014 sampling events (see Figure E-1). The 1000 Area monitoring wells are on the south slope of a low, broad topographic rise. Figure E-2 shows a geological cross-section of the area. The hydraulic gradient was approximately 0.007 feet per foot (ft/ft) (90 ft/mile [mi]) in spring 2014

(D&Z 2014). The groundwater in the 1000 Area has been impacted by several explosives; however, contaminant levels in the groundwater have decreased between 1992 and 2014. The spring 2014 sampling event showed only two analytes at concentrations exceeding cleanup goals established for this permit. Arsenic was detected at a concentration above the CMD Cleanup Goal in MW 3-3, and lead above the CMD Cleanup Goal in MW 17-5. No explosives were detected above CMD in spring 2014, and no volatile organic compounds (VOC) were detected in any of the wells during the spring 2014 sampling event (Tetra Tech 2014).

SWMU Group 10 (1100 Area) – Twenty-five monitoring wells will be used to assess the groundwater at this area (see Table E-3). The general direction of groundwater flow was to the south during the spring 2014 sampling event (see Figure E-3). Figures E-4a and E-4b show geological cross-sections of the area. The hydraulic gradient was approximately 0.014 ft/ft (74 ft/mi) in spring 2014 (D&Z 2014). The 1100 Area is on the south flank of a low topographic rise that trends from southwest to northeast. A tetrachloroethene (PCE) plume was discovered during installation of additional monitoring wells delineating the explosive plume during 2009. Additional investigations have not identified a specific source for this plume.

Samples collected in spring 2014 contained 1,1-dichloroethene (DCE), trichloroethene (TCE), and PCE at concentrations above CMD Cleanup Goals. In spring 2014, concentrations of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) also were above CMD Cleanup Goals in wells 7-7 and 10-3, but no other constituents exceeded CMD Cleanup Goals (Tetra Tech 2014).

SWMU Group 17 (Open Detonation Fields) – Eight monitoring wells will be used to assess the groundwater at this area (see Table E-4). The most recent groundwater monitoring results from the OD Grounds reported the general direction of groundwater flow southeast across the area during the spring 2014 sampling event (see Figure E-5). Figures E-6a and E-6b show geological cross-sections of the area. The hydraulic gradient was approximately 0.037 ft/ft (195 ft/mi) in spring 2014 (D&Z 2014). No VOCs, metals, or explosives were detected at SWMU 17 during the spring 2014 sampling event.

E-9b Concentration Limit [40 CFR §270.14(c)(8)(ii), 264.94 and 264.100(a)(2)]

The CMD has established limits for groundwater concentration limits for the facility, and these are listed in Table E-1.

E-9c Alternate Concentration Limits [40 CFR §270.14(c)(8)(ii), 264.94(b) and 264.100(a)(2)]

No alternate concentration limits have been established for this facility.

E-9c(1) Adverse Effects on Groundwater Quality [40 CFR §264.94(b)(1)]

As noted in Section E-9a, the following adverse effects on groundwater quality have been identified for each of the SWMUs:

SWMU Group 9 (1000 Area) – Groundwater in the 1000 Area has been impacted by several explosives; however, contaminant levels in the groundwater have decreased between 1992 and 2014. The spring 2014 sampling event showed only two analytes at concentrations exceeding their respective cleanup goals. No explosives were detected above CMD Cleanup Goals in spring 2014, and no VOCs were detected in any of the wells during the spring 2014 sampling event (Tetra Tech 2014)

SWMU Group 10 (1100 Area) – A PCE plume was discovered during installation of additional monitoring wells to delineate the explosive plume during 2009. Additional investigations have not

identified a specific source for this plume, and detections are limited to a single well (MW 12-12). Samples collected in spring 2014 contained 1,1-DCE, TCE, and PCE at concentrations above CMD Cleanup Goals. In spring 2014, concentrations of RDX were above CMD Cleanup Goal in wells MW 7-7 and 10-3. In spring 2014, no other constituents exceeded CMD Cleanup Goals (Tetra Tech 2014).

SWMU Group 17 (Open Detonation Fields) – No VOCs, metals, or explosives were detected at SWMU 17 during the spring 2014 sampling event (Tetra Tech 2014)

E-9c(2) Potential Adverse Effects [40 CFR §264.94(b)(2)]

Currently, groundwater is not used as a water source at the facility, precluding potential adverse effects because no complete exposure pathway exists for residential or commercial industrial use of the groundwater. Also, a current land use control (LUC) on groundwater prevents its use as a drinking water source, as stated in the Corrective Action Decision Document (EPA 2006).

E-9d Corrective Action Plan [40 CFR §270.14(c)(8)(iii) and 264.100(b)]

A current CMD outlines the plan for each of these SWMU areas. The two areas with groundwater contamination identified, SWMU 9 and 10, are currently under a long-term monitoring program with the goal of reducing groundwater contamination to unrestricted use levels. It is anticipated that SWMU 9 (1000 Area) will stay in this program for at least 5 years and at SWMU 10 (1100 Area) will stay in this program for 25 years. To date, no groundwater contamination above unrestricted use levels has been identified at SWMU 17.

E-9e Groundwater Monitoring Program [40 CFR §270.14(c)(8)(iv) and 264.100(d)]

Descriptions of sampling and analysis procedures are included in the Site-Wide Groundwater Corrective Measures Decision Implementation, Sampling and Analysis Plan, Part I – Field Sampling D&Z (2014). See Appendix E-1.

E-9e(1) Description of Monitoring System [40 CFR §270.14(c)(7)(v),(8)]

Descriptions of the sampling and analysis procedures are included in the Site-Wide Groundwater Corrective Measures Decision Implementation, Sampling and Analysis Plan, Part I – Field Sampling D&Z (2014). See Appendix E-1.

E-9e(2) Description of Sampling and Analysis [40 CFR §270.14(c)(7)(v),(8)]

Descriptions of the sampling and analysis procedures are included in the Site-Wide Groundwater Corrective Measures Decision Implementation, Sampling and Analysis Plan, Part I – Field Sampling D&Z (2014). See Appendix E-1.

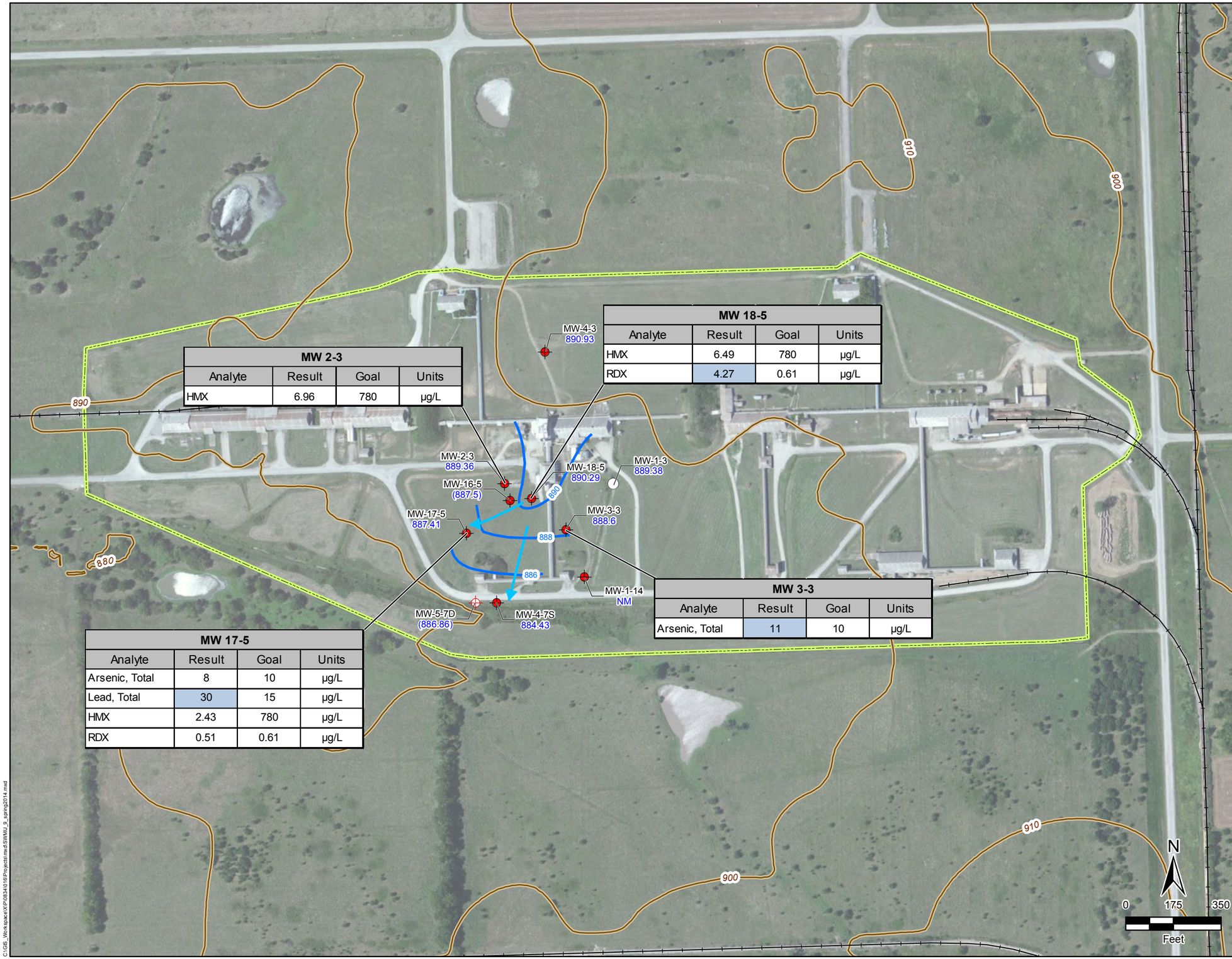
E-9e(3) Monitoring Data and Statistical Analysis and Procedures [40 CFR §270.14(c)(7)(v),(8)]

The goal of the monitoring program is to determine if contaminant concentrations in downgradient groundwater are statistically significantly above established unrestricted use levels. D&Z proposes to use either the parametric analysis of variance (ANOVA) or the ANOVA based on ranks as described in 40 CFR §264.97(h) (1) or (2). Distribution of the data will determine which approach is the most robust and will provide the most sensitivity in making this determination.

E-9e(4) Reporting Requirements [40 CFR §264.100(g)]

D&Z will report annually no later than March 1 of each calendar year the prior calendar year's groundwater monitoring information. The annual report will include documentation of all samples collected and data acquired, and analysis of those data. The report will be submitted in a PDF format on a CD-ROM.

FIGURES

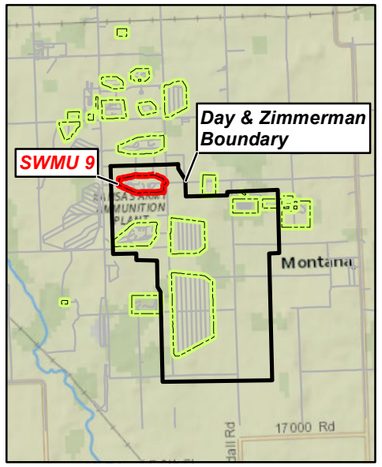


MW 2-3			
Analyte	Result	Goal	Units
HMX	6.96	780	µg/L

MW 18-5			
Analyte	Result	Goal	Units
HMX	6.49	780	µg/L
RDX	4.27	0.61	µg/L

MW 3-3			
Analyte	Result	Goal	Units
Arsenic, Total	11	10	µg/L

MW 17-5			
Analyte	Result	Goal	Units
Arsenic, Total	8	10	µg/L
Lead, Total	30	15	µg/L
HMX	2.43	780	µg/L
RDX	0.51	0.61	µg/L



MW-4-3 890.93 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-5-7D (886.86) — Deep Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-1-3 889.38 — Shallow Static Water Level Only

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

Notes:
AMSL - Above Mean Sea Level
NM - Not Measured
SWMU - Solid Waste Management Unit
µg/L - Micrograms Per Liter

1) Hitboxes are presented for detected concentrations only. Concentrations exceeding goals are highlighted in light blue.
2) Groundwater elevation values in parentheses were not used for contouring.

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-1
Sampling Results in Groundwater
SWMU 9, Spring 2014

TETRA TECH

Date: 9/20/2014 | Drawn By: Nick Wiederholt | Project No: 103P0834.016

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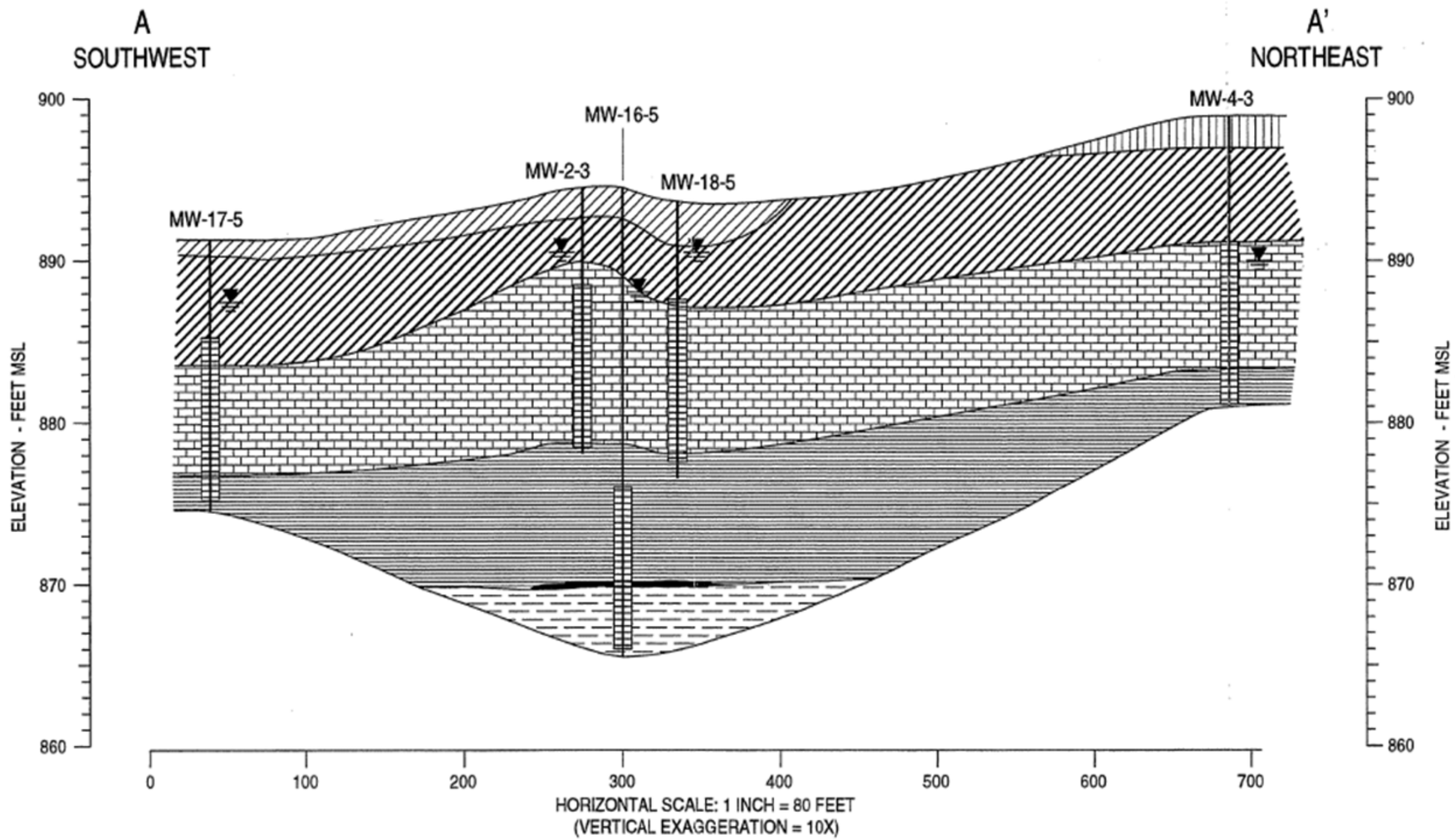

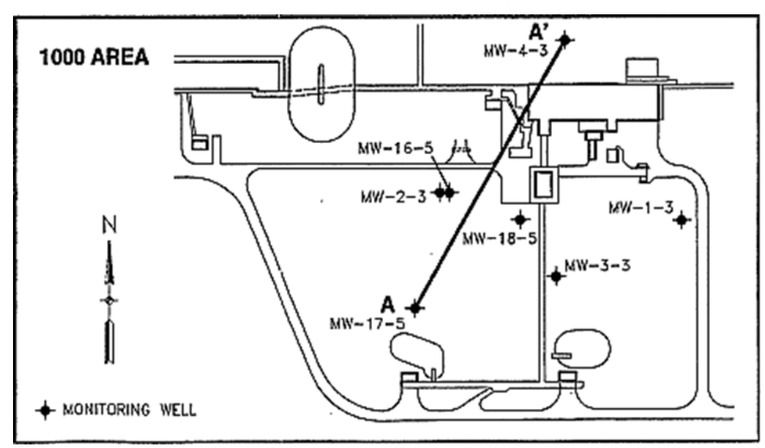

Legend

- SILTY CLAY
- FAT CLAY
- LIMESTONE
- SHALE
- SILTSTONE
- SILT
- COAL, PEAT, AND/OR HIGHLY ORGANIC SHALE
- WATER LEVEL (JULY 15, 1997)
- WELL SCREEN INTERVAL

Source: RFI Report, Kansas Army Ammunition Plant, 1998

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-2
1000 Area - Geologic Cross-Section, A-A'

TETRA TECH

Date: 11/25/2014 Drawn by: Clayton Hayes Project No: 103P0834005.01

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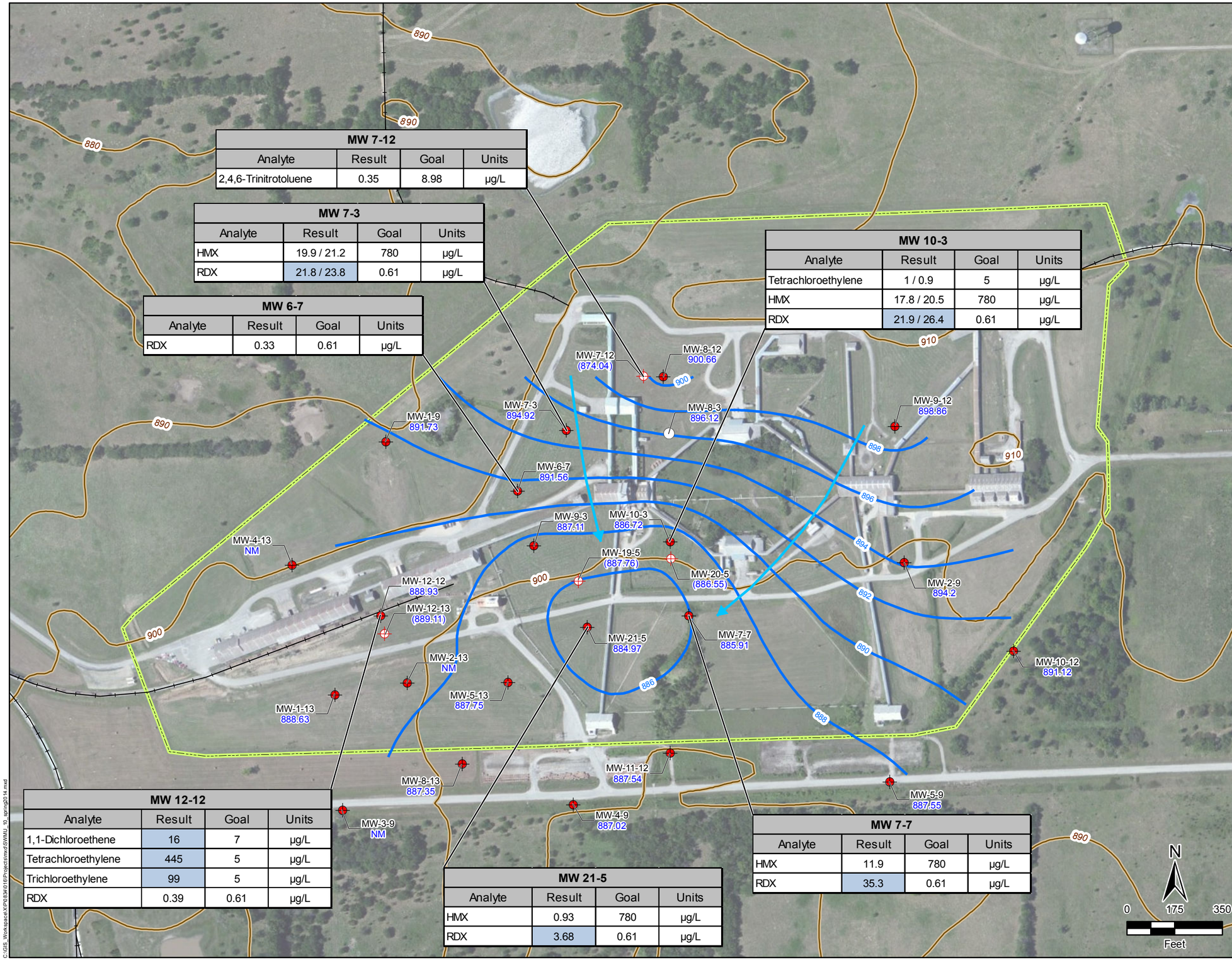


MW 7-12			
Analyte	Result	Goal	Units
2,4,6-Trinitrotoluene	0.35	8.98	µg/L

MW 7-3			
Analyte	Result	Goal	Units
HMX	19.9 / 21.2	780	µg/L
RDX	21.8 / 23.8	0.61	µg/L

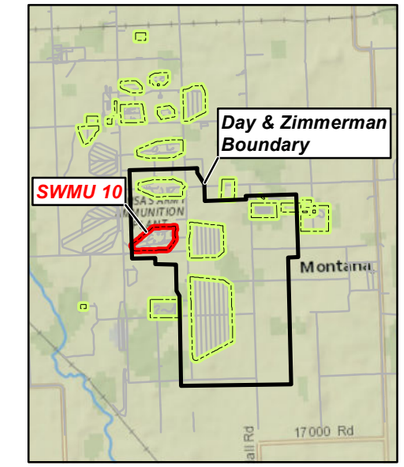
MW 6-7			
Analyte	Result	Goal	Units
RDX	0.33	0.61	µg/L

MW 10-3			
Analyte	Result	Goal	Units
Tetrachloroethylene	1 / 0.9	5	µg/L
HMX	17.8 / 20.5	780	µg/L
RDX	21.9 / 26.4	0.61	µg/L

MW 12-12			
Analyte	Result	Goal	Units
1,1-Dichloroethene	16	7	µg/L
Tetrachloroethylene	445	5	µg/L
Trichloroethylene	99	5	µg/L
RDX	0.39	0.61	µg/L

MW 21-5			
Analyte	Result	Goal	Units
HMX	0.93	780	µg/L
RDX	3.68	0.61	µg/L

MW 7-7			
Analyte	Result	Goal	Units
HMX	11.9	780	µg/L
RDX	35.3	0.61	µg/L



MW-9-12 898.86 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-7-12 (874.04) — Deep Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-8-3 896.12 — Shallow Static Water Level Only

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

Notes:
AMSL - Above Mean Sea Level
NM - Not Measured
SWMU - Solid Waste Management Unit
µg/L - Micrograms Per Liter

1) Hitboxes are presented for detected concentrations only. Concentrations exceeding goals are highlighted in light blue.
2) Groundwater elevation values in parentheses were not used for contouring.

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-3
Sampling Results in Groundwater
SWMU 10, Spring 2014

TETRA TECH

Date: 9/20/2014 | Drawn By: Nick Wiederholt | Project No: 103P0834.016

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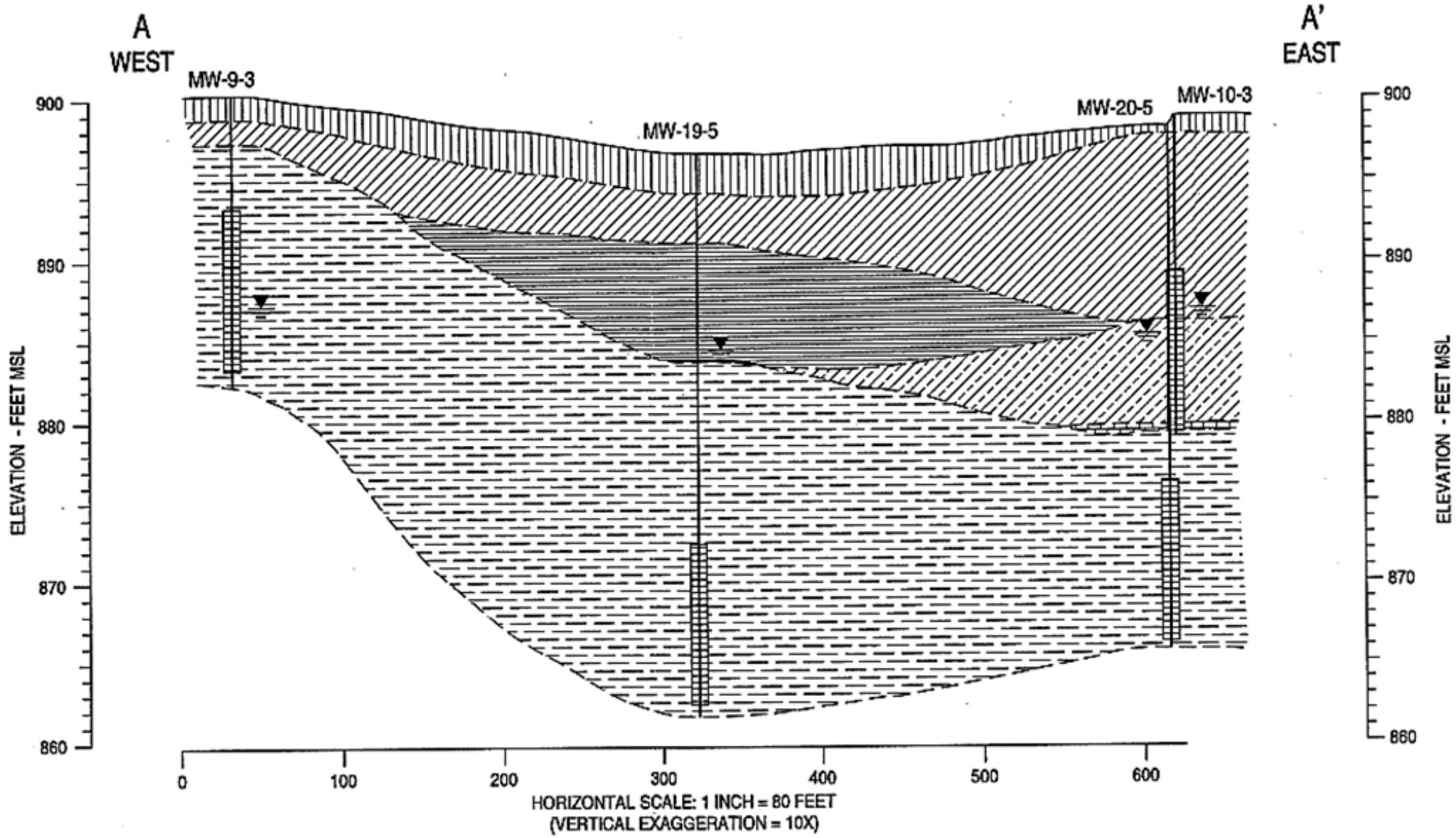

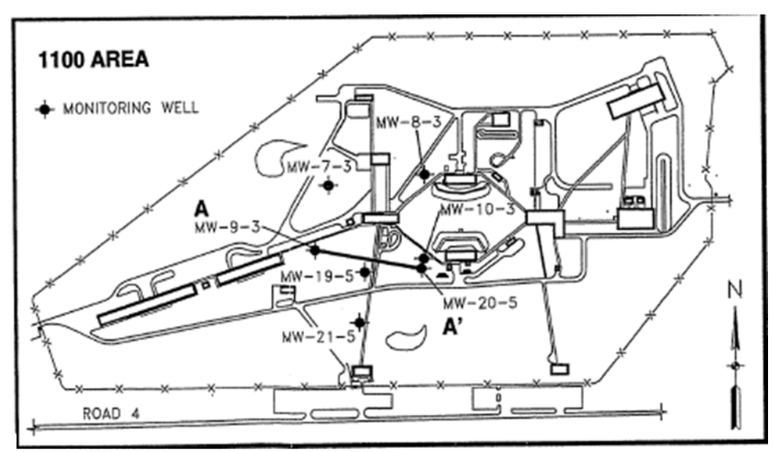

Legend

- CLAY
- SILT
- SHALE
- SHALE/ CLAYSTONE
- CLAYSTONE/ CLAY
- SILTSTONE
- SILTSTONE/ CLAYSTONE
- LIMESTONE
- COAL, PEAT, AND/OR HIGHLY ORGANIC SHALE
- WATER LEVEL (JULY 15, 1997)
- WELL SCREEN INTERVAL

Source: RFI Report, Kansas Army Ammunition Plant, 1998

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-4a
1100 Area - Geologic Cross-Section, A-A'

TETRA TECH

Date: 11/25/2014 | Drawn By: Clayton Hayes | Project No: 103P0834005.01

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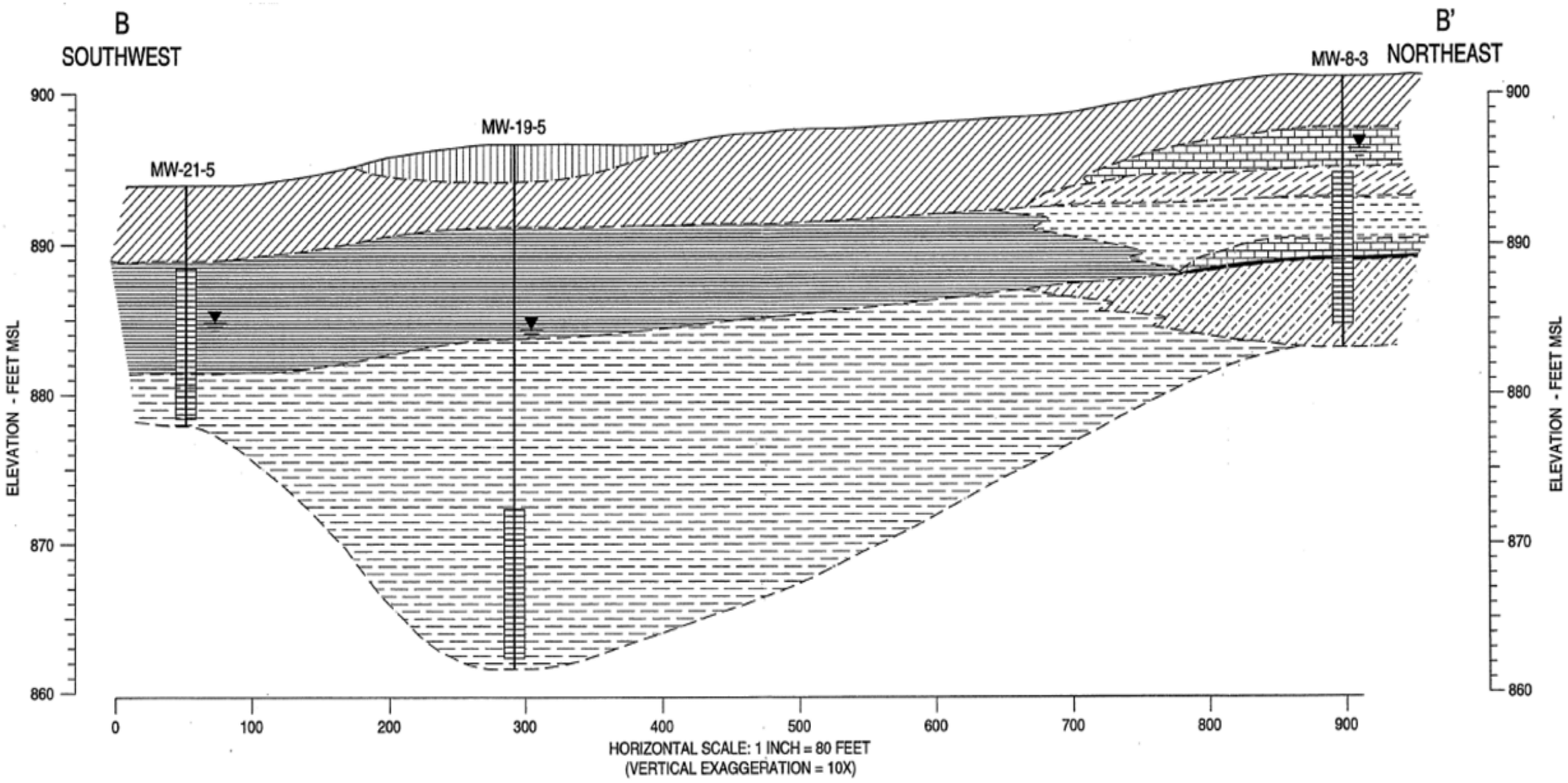

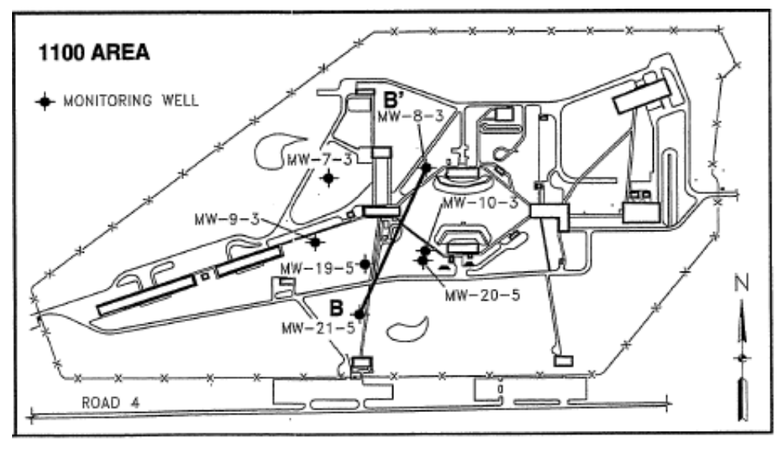

Legend

- CLAY
- SILT
- SHALE
- SHALE/ CLAYSTONE
- CLAYSTONE/ CLAY
- SILTSTONE
- SILTSTONE/ CLAYSTONE
- LIMESTONE
- COAL, PEAT, AND/OR HIGHLY ORGANIC SHALE
- WATER LEVEL (JULY 15, 1997)
- WELL SCREEN INTERVAL

Source: RFI Report, Kansas Army Ammunition Plant, 1998

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-4b
1100 Area - Geologic Cross-Section, B-B'

TETRA TECH

Date: 11/25/2014 Drawn By: Clayton Hayes Project No: 103P0834005.01

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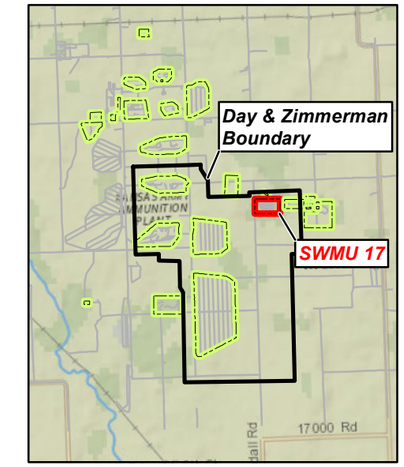

MW-10-1 859.79 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

Notes:
AMSL - Above Mean Sea Level
NM - Not Measured
SWMU - Solid Waste Management Unit

N

0 100 200
Feet

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-5
Sampling Results in Groundwater
SWMU 17, Spring 2014

TETRA TECH

Date: 9/18/2014 | Drawn By: Nick Wiederholt | Project No: 103P0834.016

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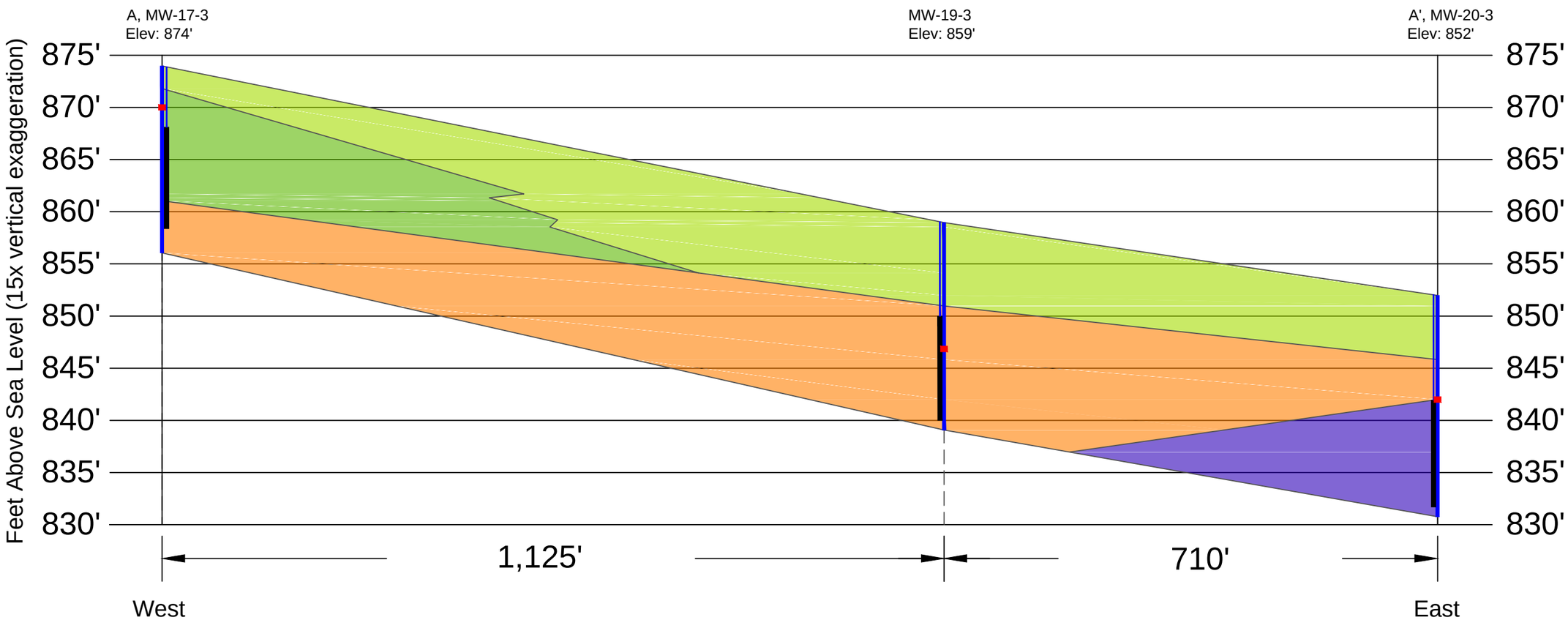

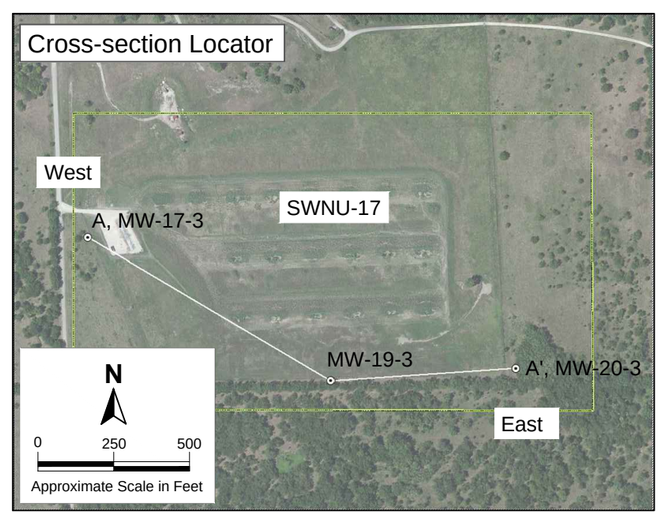

Legend

- Water level - spring 2014
- Well locator
- Screen interval
- Well
- Clay
- Limestone
- Shale
- Silty clay

Elev. Elevation

SWMU Solid waste management unit

Source: ESRI, ArcGIS Online Maps, Global Imagery, 2013

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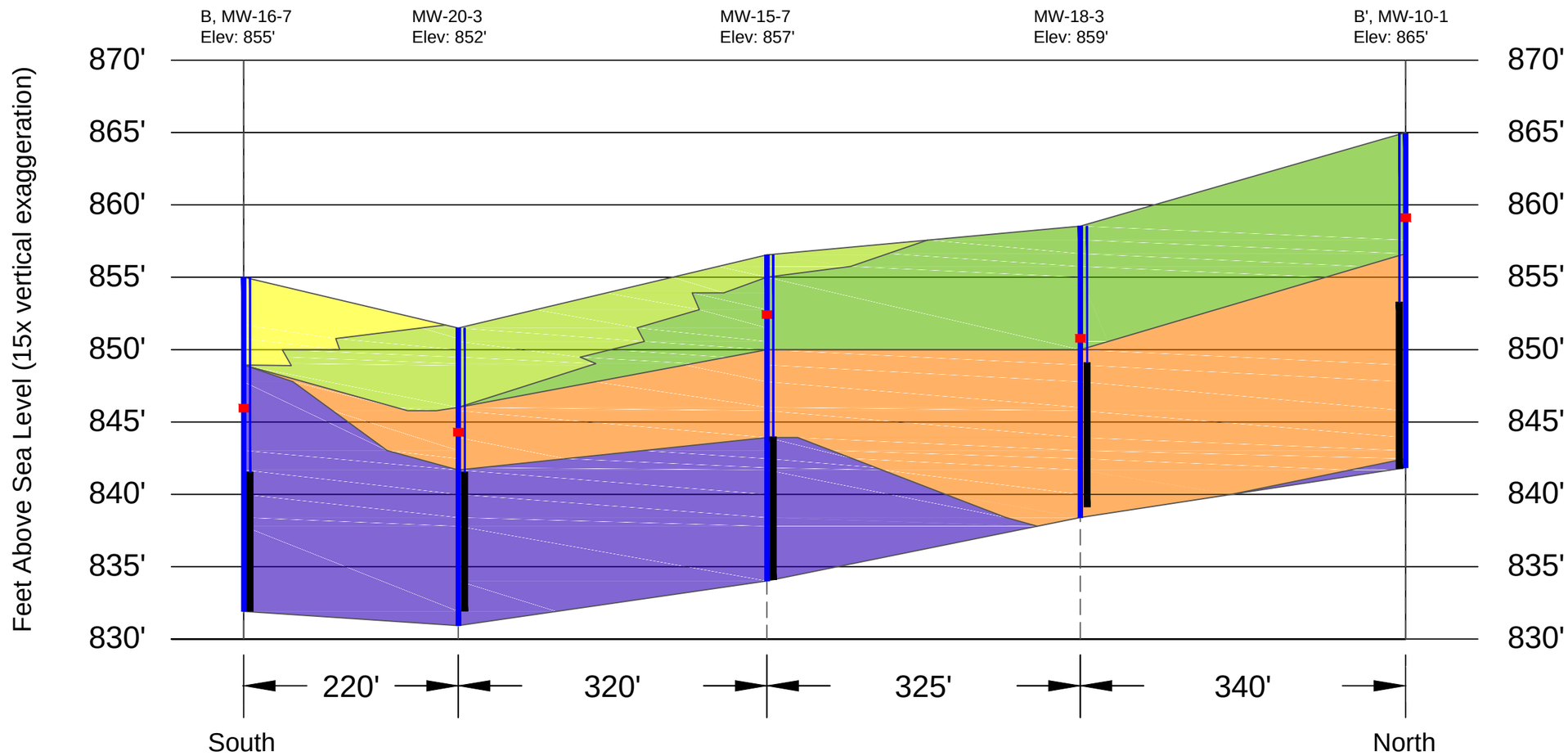
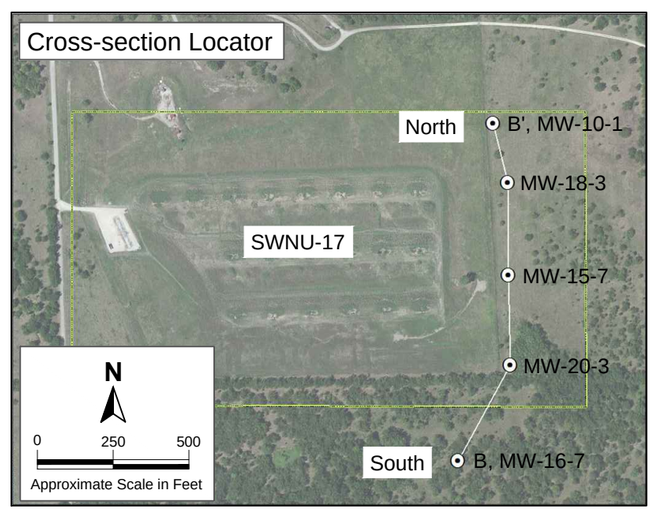
Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-6a
SWMU Group 17
Geological Cross-section, A to A'

TETRA TECH

Date: 11/20/2014 Drawn By: Clayton Hayes Project No: 103P0834005.01





Legend

- Water level - spring 2014
- Well locator
- Screen interval
- Well
- Clay
- Limestone
- Shale
- Silt
- Silty clay
- Elev. Elevation
- SWMU Solid waste management unit

Source: ESRI, ArcGIS Online Maps, Global Imagery, 2013

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Day & Zimmerman, Inc.
Parsons, Kansas

Figure E-6b
SWMU Group 17
Geological Cross-section, B-B'

TETRA TECH

Date: 11/20/2014 Drawn By: Clayton Hayes Project No: 103P0834005.01

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CORRECTIVE MEASURES DECISION CLEAN-UP GOALS
D&Z SITE-WIDE MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Contaminant	Groundwater Cleanup Goal	Basis of Selection
Arsenic	10 µg/L	KDHE RSK
Cadmium	5 µg/L	KDHE RSK
Chromium III (total)	100 µg/L	KDHE RSK
1,1-Dichloroethene	7 µg/L	MCL
2,4-Dinitrotoluene*	8.98	n/a
HMX	5,110 µg/L	KDHE RSK
Lead	15 µg/L	USEPA MCL
RDX	25.9 µg/L	KDHE RSK
Tetryl	407 µg/L	KDHE RSK
TNT	50.7 µg/L	KDHE RSK
Tetrachloroethene	5 µg/L	KDHE RSK
Trichloroethene	5 µg/L	KDHE RSK
Vinyl chloride	2 µg/L	KDHE RSK

Notes:

* Although 2,4-dinitrotoluene has been added to the analyte list for reporting purposes at the request of KDHE, it is not defined as a contaminant of concern in the Corrective Measures Decision (CMD), and no cleanup goal for this compound is specified in the CMD.

µg/L Micrograms per liter
HMX Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
RDX Hexahydro-1,3,5-trinitro-1,3,5-triazine
Tetryl 2,4,6-Trinitrophenylmethylnitramine
TNT 2,4,6-Trinitrotoluene
KDHE Kansas Department of Health and Environment
MCL Maximum Contaminant Level (EPA 2009)
n/a Not applicable
RSK Risk-Based Standards for Kansas (non-residential scenario) Department of Health and the Environment (KDHE 2014). Current values available at http://www.kdheks.gov/remedial/download/RSK_Manual_14.pdf
USEPA U.S. Environmental Protection Agency

TABLE E-2

WELL CONSTRUCTION DATA
SWMU GROUP 9 (1000 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC - PARSONS, KANSAS

Well ID	TOC Elevation (ft amsl)	Ground Elevation (ft amsl)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
1-3	894.48	892.89	9.08 - 19.08	unknown	19.09**
1-14	895.18	893.01	8.98 - 18.98	unknown	19.50**
2-3	896.46	894.77	7.89 - 17.89	17.00	19.06
3-3	894.11	892.13	8.78 - 18.78	14.00	19.23
4-3	900.91	898.95	9.66 - 19.66	18.00	20.22
4-7S	890.13	887.98	8.65 - 18.65	14.00	19.37
5-7D	890.07	887.98	18.07 - 28.07	23.50	28.40
17-5	893.06	891.27	7.79 - 17.79	14.00	18.19
18-5	895.28	893.61	7.67 - 17.67	13.00	17.79

Notes:

* Total depth measurements taken in spring 2014 (D&Z 2014).

** Total depth not measured in spring 2014. This measurement is from the original well construction diagram. Well elevations and construction data from Semi Annual Groundwater Water Monitoring Report, Kansas Army Ammunition Plant. U.S. Army Corps of Engineers (USACE) (2013).

amsl Above mean sea level
BTOC Below top of casing
ft Feet
SWMU Solid Waste Management Unit
TOC Top of casing

TABLE E-3

WELL CONSTRUCTION DATA
SWMU GROUP 10 (1100 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC - PARSONS, KANSAS

Well ID	TOC Elevation (ft amsl)	Ground Elevation (ft amsl)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
1-9	900.47	898.23	4.87 - 14.91	14.5	17.45
1-13	906.70	904.16	12.90 - 22.90	unknown	20.00
2-9	900.27	898.23	11.93 - 21.98	21.3	23.78
2-13	904.02	901.35	9.70 - 19.72	unknown	20.10**
3-9	904.32	902.53	27.92 - 37.76	NS	40.06**
4-9	890.40	888.25	10.12 - 20.12	17.5	22.80
4-13	904.97	902.84	9.07 - 19.07	unknown	19.60**
5-9	892.35	890.17	15.04 - 25.06	24.8	27.70
5-13	898.79	896.51	7.59 - 17.59	unknown	19.00
6-7	902.37	900.47	15.87 - 25.87	23.0	26.43
7-3	904.28	902.17	8.51 - 18.51	16.5	19.31
7-7	894.92	892.93	14.02 - 24.02	20	24.53
7-12	908.15	905.71	26.89 - 36.94	36.5	38.00
8-3	902.93	901.08	8.25 - 18.25	unknown	20.00**
8-12	908.37	905.89	10.48 - 20.48	18	20.99
8-13	898.01	895.95	9.11 - 19.11	unknown	20.00
9-3	902.51	900.30	9.21 - 19.21	17.0	20.30
9-12	906.64	904.03	12.46 - 22.51	18.0	19.80
10-3	900.79	898.85	11.34 - 21.31	17.0	22.09
11-12	892.69	890.00	12.59 - 22.64	20.0	22.90
12-12	904.24	901.91	11.28 - 21.33	17.6	21.85
12-13	905.09	902.36	27.19 - 37.19	unknown	39.00
19-5	898.26	896.63	25.88 - 35.88	31.0	36.27
20-5	899.83	898.27	23.56 - 33.56	30.8	34.33
21-5	895.47	893.91	7.06 - 17.06	15.5	17.72

Notes:

* Total depth measurements taken in spring 2014 (D&Z 2014).

** Total depth not measured in spring 2014. This measurement is from the original well construction diagram. Well elevations and construction data from U.S. Army Corps of Engineers (USACE) (2013).

amsl Above mean sea level
BTOC Below top of casing
ft Feet
SWMU Solid Waste Management Unit
TOC Top of casing

TABLE E-4

WELL CONSTRUCTION DATA
SWMU GROUP 17 (2700 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC - PARSONS, KANSAS

Well ID	TOC Elevation (ft amsl)	Ground Elevation (ft amsl)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
10-1	868.31	864.96	15.51 - 25.51	23.00	25.60
15-7	859.16	856.70	16.06 - 26.06	24.00	26.25
16-7	855.26	853.19	14.76 – 25.06	unknown	26.00
17-3	875.60	873.89	8.70 - 18.70	14.70	19.57
17-7	859.00	856.66	14.80 – 24.80	unknown	24.64**
18-3	860.86	858.80	12.56 - 22.56	20.00	22.75
19-3	861.43	859.45	10.93 – 20.93	18.00	21.79
20-3	854.01	852.26	11.9 - 21.9	17.00	21.30

Notes:

* Total depth measurements taken in spring 2014 (D&Z 2014).

** Total depth not measured in spring 2014. This measurement is from the original well construction diagram. Well elevations and construction data from U.S. Army Corps of Engineers (USACE) (2013).

amsl Above mean sea level
BTOC Below top of casing
ft Feet
SWMU Solid Waste Management Unit
TOC Top of casing

APPENDICES

E-1

SITE-WIDE GROUNDWATER, CORRECTIVE MEASURES DECISION, IMPLEMENTATION SAMPLING AND ANALYSIS PLAN, PART I – FIELD SAMPLING

SITE-WIDE GROUNDWATER CORRECTIVE MEASURES DECISION IMPLEMENTATION SAMPLING AND ANALYSIS PLAN

PART I - FIELD SAMPLING PLAN

Revision 01

FEBRUARY 2015

Prepared for
DAY & ZIMMERMANN KANSAS LLC

Day&Zimmermann
We do what we say.®

Prepared by:

Tetra Tech, Inc.
415 Oak Street
Kansas City, Missouri 64106

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FINAL

SITE-WIDE GROUNDWATER CORRECTIVE MEASURES DECISION IMPLEMENTATION SAMPLING AND ANALYSIS PLAN

PART I - FIELD SAMPLING PLAN

Long Term Groundwater Monitoring
Day & Zimmermann Kansas LLC
Parsons, Kansas

February 2015

I hereby certify that the enclosed *Site-Wide Groundwater Sampling and Analysis Plan, Part I - Field Sampling Plan*, shown and marked in this submittal, is that proposed to be incorporated with Long Term Operations/Long Term Monitoring, Day & Zimmermann Kansas LLC. This plan is in compliance with the Resource Conservation and Recovery Act Corrective Action Permit requirements and is submitted for government approval.

Reviewed by:

Environmental Engineering Manager **Date**

Project Quality Control Systems Manager **Date**

Accepted By:

General Manager **Date**

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	Degrees centigrade
CMD	Corrective Measures Decision
COCs	Contaminants of concern
CQC	Contractor Quality Control
CQCP	Contractor Quality Control Plan
DQCR	Daily Quality Control Report
DO	Dissolved oxygen
ECC	Environmental Chemical Corporation
EPA	United States Environmental Protection Agency
eV	Electron volt
Fe^{+2}	Ferrous iron
FSP	Field Sampling Plan
HMX	1,3,5,7-Tetranitro-1,3,5,7-Tetrazocane
ID	Identification
IDW	Investigation-derived waste
KDHE	Kansas Department of Health and Environment
KSAAP	Kansas Army Ammunition Plant
L	Liter
LQM	Laboratory Quality Manual
LTO/LTM	Long Term Operations/Long Term Monitoring
mV	Millivolt
µg/L	Micrograms per liter
mL	Milliliter
mL/min	Milliliters per minute
MS/MSD	Matrix spike/matrix spike duplicate
NTU	Nephelometric turbidity unit
ORP	Oxidation-reduction potential
PgM	Program Manager
PM	Project Manager
PPE	Personal protective equipment
PPM	Parts per million
PVC	Polyvinyl chloride
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control

QCSM	Quality Control Systems Manager
QCSR	Quality Control Summary Report
RCRA	Resource Conservation Recovery Act
RDX	1,3,5-Trinitro-1,3,5-Triazinane
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SEDD	Staged electronic data deliverable
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
SSHS	Site Safety and Health Specialist
SWL	Static water level
SWMU	Solid Waste Management Unit
TCE	Trichloroethene (trichloroethylene)
TNT	2,4,6-Trinitrotoluene
USACE	United States Army Corps of Engineers
VOA	Volatile organic analysis
VOC	Volatile organic compound

1.0 INTRODUCTION

This Field Sampling Plan (FSP) identifies outlines the Long Term Operations/Long Term Monitoring (LTO/LTM) tasks required in the solid waste management units (SWMU) 9 (1000 Area), 10 (1100 Area) and 17 (2700 Area), by Day & Zimmermann Kansas LLC (D&Z).

The groundwater monitoring program at D&Z is required by the U.S. Environmental Protection Agency (EPA), Region 7, after Resource Conservation and Recovery Act (RCRA) Phase I and Phase II RCRA Facility Investigations (RFI) were conducted at various former Kansas Army Ammunition Plant (KSAAP) sites. A Final Corrective Measures Decision (CMD) and the Final RCRA Permit Modification was issued by the EPA in 2006 and 2012 and provided the sampling guidance, contaminants of concern (COC), and cleanup goals for the former KSAAP sites. These requirements for the 1000, 1100, and 2700 Areas were transferred to D&Z as part of the property transfer from the U.S. Army on July 11, 2013. The current objective of the groundwater monitoring program is to implement site-wide corrective measures for groundwater as set forth in the KSAAP Final CMD (EPA 2006) at the D&Z facility.

This Site-Wide FSP is Part I of the Site-Wide LTO/LTM Groundwater Sampling and Analysis Plan (SAP) at D&Z. The Site-Wide FSP outlines the sampling procedures to be used for collecting groundwater samples from the 1000, 1100 and 2700 areas. The Site-Wide LTO/LTM FSP is a companion document to the Site-Wide Quality Assurance Project Plan (QAPP), which is Part II of the Site-Wide SAP. Section 1.0 of this Site-Wide FSP presents general site background and history. Section 2.0 outlines the project organization and the responsibilities of key personnel. Section 3.0 summarizes the objectives for the D&Z LTO/LTM projects. Section 4.0 lists non-measurement data to be used in this project. Section 5.0 presents groundwater sampling methods and procedures for field measurements, sample container preservation, and decontamination. Section 6.0 summarizes sample Chain-of-Custody Records and documentation procedures. Section 7.0 discusses the sample packing and shipping procedures. Section 8.0 presents procedures for handling investigation derived wastes (IDW). Section 9.0 discusses contractor chemical quality control. Section 10.0 outlines the corrective action process for the D&Z LTO/LTM projects. Section 11.0 is a list of references for past and present environmental projects at D&Z. Many of these documents were used in the preparation of this FSP.

Additionally, the Site-Wide FSP provides the sampling criteria for D&Z LTO/LTM sites addressed in the RCRA Final Permit Modification for D&Z (RCRA ID #KSR000511964). The permit outlines the corrective measures implementation for soil and groundwater contamination.

1.1 Site Location and Description

D&Z is located in the southeast corner of Kansas, approximately 3 miles east of the town of Parsons, and 2 miles south of U.S. Highway 400 in Labette County (see Figure 1-1). The facility is a privately-owned company. The original facility now occupied by D&Z was constructed in 1941-1942 and was part of the former KSAAP. D&Z has operated the facility continuously from March 1, 1970, to the present.

The facility covers approximately 4,000 acres, contains 27.4 miles of roadway, and 9.25 miles of railroad. D&Z has over 954,574 feet of building and storage areas. The Union Pacific Railroad serves the facility. The surrounding land use is primarily agricultural and industrial – owned and managed by the Great Plains Development Authority.

This Site-Wide LTO/LTM FSP addresses the three LTO/LTM sites to be sampled—1000, 1100 and 2700 Areas. These facilities are associated with SWMUs 9, 10, and 17, respectively. Figure 1-2 shows the

layout of the installation. Figures 1-3 through 1-5 illustrate the three LTO/LTM sites and include the locations of groundwater monitoring wells included in the LTO/LTM program at each site.

1.2 Contaminants of Concern

The COCs for each of the active LTO/LTM sites were determined from the Final CMD (EPA, 2006). The COCs for the D&Z Site-Wide sampling are:

- Arsenic;
- Lead;
- Cadmium;
- Chromium (total);
- 1,3,5-trinitro-1,3,5-triazinane (RDX);
- 2,4,6-Trinitrophenylmethylnitramine (Tetryl);
- 2,4,6-Trinitrotoluene (TNT);
- 1,3,5,7-Tetranitro-1,3,5,7-tetrazocane (HMX);
- Vinyl chloride;
- Trichloroethene (TCE);
- Tetrachloroethene (PCE); and
- 1,1-Dichloroethene.

The site-specific analytical requirements are listed in Table 1-1. In addition to the above listed analytes, 2,4-ditnitrotoluene will also be reported by the laboratory and presented in data summary tables in D&Z Site-Wide reports. This compound is not a COC according to the CMD; however, it has been detected at the D&Z site at concentrations exceeding the Kansas Department of Health and Environment (KDHE) Tier 2 Risk-Based Standards for Kansas (RSK) for non-residential properties (KDHE 2014) or is known to have been released to the environment.

1.3 Groundwater Clean Up Goals

The groundwater clean-up goals (and their bases) for the COCs are outlined in the Final RCRA Permit Modification and presented in Table 1-2. These goals are used for comparison and reporting purposes.

1.4 Groundwater Levels

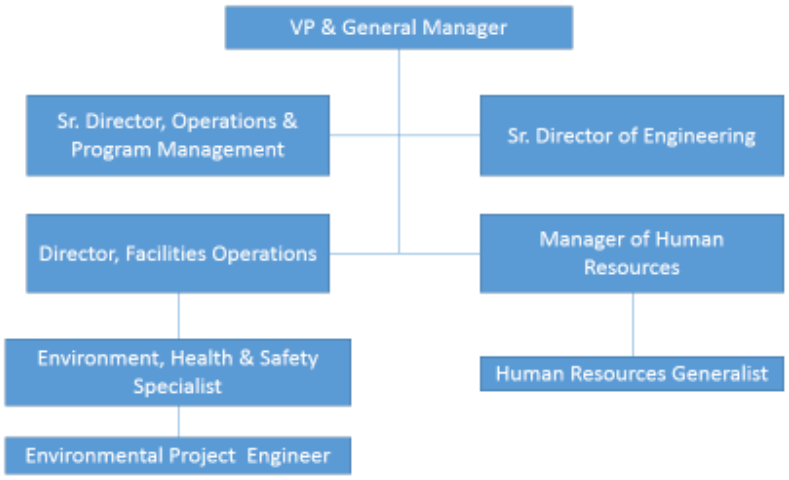
Static water levels (SWL) for each of the active LTO/LTM sites are measured within a 12-hour period during sampling events, and potentiometric surface maps are presented in semiannual and annual reports. Figures 1-3 to 1-5 show the potentiometric surfaces for each LTO/LTM site for Spring 2014.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The following sections describe the organizational structure that will be implemented to ensure the data collected in support of the groundwater monitoring and well sampling activities meet the project objectives and the specific requirements outlined in this Site-Wide FSP. Brief descriptions of the roles and responsibilities of key personnel are presented in Sections 2.1 and 2.2, respectively. The roles and responsibilities of laboratory personnel are listed in Section 2.0 of the Site-Wide QAPP.

The principal organizations involved with the groundwater monitoring well sampling and their responsibilities are as shown

Day & Zimmermann Kansas LLC Organizational Chart



2.1 D&Z Project Team

The project team is responsible for development, execution, supervision, and coordination of the LTM activities at D&Z. A brief description of the roles and responsibilities of key D&Z project personnel are presented in the following subsections.

2.1.1 Program Manager / Project Manager

Mr. Steve Kosman will be the Program Manager (PgM) and Project Manager (PM) for D&Z for the LTM project. D&Z PM/PgM duties and responsibilities include the following:

- Oversight of sampling activities;
- Analytical support;
- Data management; and
- Technical guidance at critical stages of the projects.

The PgM/PM will ensure these subtasks are conducted in accordance with the project work plans.

2.1.2 Quality Control Systems Manager

The Quality Control Systems Manager (QCSM) will be Mr. Dean Cramer. The QCSM will be responsible for the implementation of applicable portions of this Contractor Quality Control Plan (CQCP) during the monitoring well sampling activities. The QCSM will perform oversight for the sampling activities and will perform collateral duties as the Site Safety and Health Specialist (SSHS), as necessary, in accordance with the requirements of the Site Safety and Health Plan (SSHP). The QCSM will have the authority to act independently in all sampling Quality Control (QC) matters.

The following is a list of the QCSM responsibilities:

- Act as spokesman for the field personnel on quality matters;
- Perform QC sampling oversight including verification of sampling records (Chain-ofCustody records and sample labels), verification that sampling schedules are maintained, and verification that sample collection procedures are followed;
- Check Chain-of-Custody Records and lot designation forms for correctness and accuracy;
- Complete requisite checklists for each deviation from the work plan; and
- Identify and implement corrective actions, as necessary.

The QCSM also will generate and maintain daily quality control reports (DQCR) describing all field QC activities, procedures, and tests performed. These records will include the requisite checklists as evidence that the required field QC activities were conducted.

3.0 PROJECT SCOPE AND OBJECTIVES

The project scope and objectives for the active LTO/LTM projects at D&Z are presented below for the Site Wide Monitoring. In general, the D&Z LTO/LTM project sites will require the following:

- Measure groundwater levels at wells at all D&Z areas including SWMU Groups 9, 10, 17 and the monitoring well associated with Burn Pad 6 semiannually in March/April and September/October;
- Measure all well depths at least once per year;
- Document the physical condition of all the wells during each sampling event and note any deficiencies and when the deficiencies are rectified;
- Perform any necessary well repairs during each sampling event (if possible), or at a later time if applicable;
- Collect field measurements of groundwater temperature, dissolved oxygen (DO), specific conductance, pH, oxidation-reduction potential (ORP), turbidity, and ferrous iron (Fe+2) in purge water from all wells sampled;
- Conduct groundwater sampling at the specified areas semiannually;
- Label, package, and ship samples to an KDHE-approved analytical laboratory;
- Analyze groundwater samples using KDHE-approved analytical methodologies;
- Provide an electronic data deliverable in the Staged Electronic Data Deliverable (SEDD) format, Terrabase L2 format, and Access database format; and
- Present and interpret monitoring and analytical data by preparing quality control summary reports (QCSR) by sampling event, as well as semiannual and annual groundwater reports for each site.

Each groundwater report will include data tables from the database presenting full sample results from the appropriate sampling events, and a table providing SWL measurements for the sampling events. Tables 3-1 through 3-3 present the water level and sampling requirements for the D&Z Site-Wide monitoring wells in the 1000, 1100 and 2700 Areas.

4.0 NON-MEASUREMENT DATA ACQUISITION

All previous environmental studies conducted at D&Z will be used as background information for the LTO/LTM Program. The references for these studies are listed in Section 11.0 of this document. A database containing all environmental sampling results for D&Z also will be accessed as needed. This database is maintained by D&Z.

5.0 GROUNDWATER SAMPLING PROCEDURES

This section outlines the general field methods used for collecting groundwater samples from D&Z LTO/LTM groundwater monitoring wells. These procedures will be followed to ensure that samples collected from monitoring wells are representative of the groundwater in the formation in which the well is screened.

5.1 Sampling Equipment and Field Instruments

The following is a list of field sampling equipment and field instrumentation to be used for the Site-Wide D&Z LTO/LTM monitoring well sampling events. Examples of field forms are included in Appendix A, calibration form is in Appendix B, and the calibration procedures are outline in the SOP for low flow groundwater collection.

Field Instruments and Associated Equipment

- Water quality instrument(s) [Horiba U-50 with H20 transmitter or equivalent (includes temperature, DO, specific conductance, pH, and ORP probes)];
- Turbidity meter (Hach 2100P or equivalent);
- Calibration standards (pH, conductance, ORP, and turbidity);
- Ferrous iron field test kit (Hach DR-800 colorimeter and ferrous iron reagent); and
- Water level indicator (Heron Instruments dipper-T or equivalent).

Safety Equipment and Personal Protective Equipment (PPE)

- Steel-toed boots;
- Disposable nitrile rubber gloves;
- Safety glasses;
- First aid kit;
- Fire extinguisher;
- Emergency eye wash; and
- Copy of the project Site Safety and Health Safety Plan.
- Stress drink cooler
- Bug spray
- Sun block

Well Purging Equipment

- Bladder pump with Teflon-lined downhole tubing, air compressor/pump controller (QED Pro Bladder Pump 1 ILR or equivalent);
- Teflon bailer and Teflon-coated line for bailer;
- Graduated bucket; and
- Plastic graduated cylinder.

Field Documentation Materials

- Bound field logbook;
- Field Groundwater Sampling Report/Well purge forms;
- Daily Quality Control Report
- Sample labels;
- Sample log forms;
- Chain-of-Custody Records;
- Indelible ink pens; and
- Copy of this Site-Wide FSP.
- Camera

Decontamination Equipment

- Water containment basin;
- 15-gallon kitchen-type trash cans;
- High purity water (Baxter #C4350-5 or equivalent);
- Spray bottles for water;
- Scrub brushes;
- Alconox detergent or equivalent non-phosphatic detergent;
- Large funnel for dispensing water into polyethylene tank(s);
- Polyethylene tank(s); and
- Trash bags.

Sample Collection and Shipping Equipment

- Coolers for sample holding and shipping;
- Custody seals;
- Sample bottles (40 milliliter (mL) volatile organic analysis (VOA) vials, 500 mL clear glass, 1 liter (L) amber glass, 250 mL polyethylene, and 1L polyethylene);
- Sample preservatives (hydrochloric acid, nitric acid, sulfuric acid, sodium hydroxide, and zinc acetate);
- Auto-pipette for dispensing preservative (Oxford Labware Macro or equivalent);
- pH paper;
- Hand pump for sample filtering;
- 0.45 micron groundwater filter cartridges (for dissolved metals samples);
- Tygon tubing or equivalent for use in filtering dissolved metals samples;
- Bottle mesh;
- Clear tape;
- Bubble wrap or bottle protectors;
- Packing material;
- Strapping tape;
- Storage bags for samples;
- Ice;
- Paper towels;

- Airbills and shipping stickers for coolers.

5.2 Protective Gloves

For this project, nitrile rubber protective gloves will be worn whenever dermal contact with groundwater is possible. Gloves will be worn at all stages of sample handling, including packing.

A new pair of gloves will be donned upon arrival at each new sample location, and again immediately prior to sample collection at that location. Gloves will be removed and discarded after sampling is completed at a well. Special circumstances that may require additional glove changes include a torn or damaged glove, a visibly dirty glove that might contact a sample, or any indication that the glove is contaminated or otherwise compromised. The purposes of gloves on this project are twofold: gloves protect the sampler from exposure to potentially contaminated groundwater, and gloves protect groundwater samples from contaminants that could be introduced by field personnel.

5.3 Water Level Measurement

The SWL in each well will be measured to the nearest hundredth of a foot during each sampling event using a decontaminated water level indicator. Well construction data for the D&Z Site-Wide monitoring wells located in the 1000, 1100 and 2700 Area are found in Tables 5-1 to 5-3.

All water levels will be measured from the permanent mark on the top of the polyvinyl chloride (PVC) well casing. SWLs will be recorded for all wells during a single water level survey event prior to the onset of sampling activities. SWL data will be used to compile groundwater contour maps in the semiannual or annual report. Water levels will also be measured during purging and sampling activities for wells where pump sampling techniques are used. Section 5.6 discusses purging and sampling procedures to be used. In addition to water levels, the total depth of each well will be measured at least once per year.

5.4 Measurement of Water Quality Parameters

Water quality parameters (i.e., well stabilization parameters) will be measured during well purging with an instrument or instruments capable of measuring water temperature, DO, specific conductance, pH, ORP, turbidity, field nitrate, and ferrous iron. A flow-through cell will be used for DO measurement at all wells purged with a pump. Wells purged with a bailer will have DO measured with a downhole DO meter prior to the onset of purging. The downhole meter will be left in the well until DO readings are stable.

Water quality readings will be recorded on the groundwater sample collection field sheet during well purging and will be used along with the volume of water purged from a well to determine when a well is ready to be sampled. Section 5.6 includes specific guidance on when water quality readings should be collected during the purge event.

The water quality instrument(s) will be calibrated at the beginning of each work day during which sampling is performed. DO will be calibrated to within 1 percent of saturation (100 percent); specific conductance will be calibrated to within 2 percent of the standard; pH will be calibrated to within 0.1 pH units for each of two pH standards; ORP will be calibrated to within 2 percent of the standard; turbidity will be calibrated to within 5 percent of the standard value, or one (1) Nephelometric Turbidity Unit (NTU), whichever is greater.

Additional random calibration checks may be conducted at the discretion of the field team leader. Documentation of instrument calibration will be kept in a bound field logbook and/or on a calibration form.

5.5 Well Purging and Sampling

Wells will be purged and sampled using either a non-dedicated, decontaminated stainless steel bladder pump equipped with a Teflon bladder and Teflon-lined polyethylene tubing or a dedicated Teflon bailer. Bladder pumping, using the method described in the Tetra Tech's "Standard Operating Procedure (SOP) for Groundwater Sampling Using Low-Flow Methodology" (see Appendix C), is always preferred over bailing.

5.5.1 Well Purging

The flow charts shown in Figures 5-1 and 5-2 will be used to determine what procedures are required for purging a monitoring well. The following sections describe the purging procedures.

Before purging begins, the well number, date, sampler initials, purge/sample method, weather conditions, and well condition will be recorded on the groundwater sample collection field sheet. The well will be unlocked and opened. The following steps from the Tetra Tech SOP will be followed when purging and sampling a well using the bladder pump low-flow method.

"Standard" Sustainable Recovery Well

For this procedure, diagrammed in Figure 5-1, a "standard" sustainable recovery well is defined as a well in which a stabilized water level can be obtained at a pumping rate equal to or greater than 100 milliliters per minute (mL/min).

1) Obtain well casing and borehole diameters and filter pack percent porosity from well construction records (may be needed for calculations if the well is determined to be a low-recovery well).

2) Calibrate the water quality instruments (e.g., Horiba U50 or equivalent) per manufacturer's instructions and record calibration data in the field logbook or on a calibration log.

3) Check the function of the electronic water level meter per the manufacturer's instructions.

4) Assemble equipment at the well and perform field preparatory activities as described in the project-specific Field Sampling Plan.

5) If using a portable pump:

   - Measure well depth. Using the electronic water level meter, measure and document the depth of the well to the nearest 0.01 foot from the reference mark on the top of the inner well casing.

   - Measure water level. Using the electronic water level meter, measure and document the water level to the nearest 0.01 foot from the reference mark on the top of the inner well casing.

   - Assemble the pump and sampling line components, taking care not to contact any of the

components with potentially contaminated media, and ensure that the discharge line is affixed such that initial discharge is captured in either a graduated 5-gallon bucket or a purge water collection container.

- Determine the depth setting for the portable pump intake. Measure length of pump from intake to tubing and cable attachment. Measure length of tubing and cable needed to set pump at desired depth within the screened interval of the well; and

- Slowly lower the pump into the well casing to the desired depth in the screened interval, taking care not to impact the bottom of the well and cause unnecessary agitation of sediment. Secure the pump in this position by fastening the supporting cable. Record depth of pump intake from the reference mark on the top of the inner well casing.

6) If using a dedicated pump:

- Obtain well depth and depth of pump intake from well construction records, and

- Measure water level with pump in place. Using the electronic water level meter, measure and document the depth to water to the nearest 0.01 foot from the reference mark on the top of the inner well casing.

7) Determine saturated casing volume and saturated borehole volume (saturated casing volume plus saturated filter pack volume) (may be needed for calculations if the well is determined to be a low-recovery well).

8) Determine the casing volume above the pump intake (may be needed for calculations if the well is determined to be a low-recovery well).

9) Determine sampling system volume (volume capacity of pump, tubing, and flow-through cell) (may be needed for calculations if the well is determined to be a low-recovery well).

10) Determine volume necessary to collect all required samples (may be needed for calculations if the well is determined to be a low-recovery well).

11) Connect the flow-through cell and multi-meter to the pump tubing.

12) If the sustainable flow rate is not known for the well, begin purging at 100 mL/min. For wells with historical sustainable flow rate data, use the historical rate.

13) Ensure that no air bubbles are entrained in the pump tubing. Raise the level of the flow-through cell above the well such that water must pump upward through the intake tubing of the cell. This will purge any bubbles through the tubing. After the cell fills with water, it may be lowered.

14) Measure and record the water level and an initial set of water quality indicator parameter measurements.

15) Determine the initial purge flow rate from the well. Using a graduated cylinder, bucket, or other suitable container of known volume and a stopwatch, time the rate of filling.

16) Determine whether the initial purge flow rate causes water level drawdown in the well. Measure and record the water level and water quality indicator parameters at 500 mL or 5-minute intervals.

The water level will be considered stable if water level readings do not decrease over three successive measurements (it is acceptable for the water level to remain unchanged or to increase) and if the volume of water in the casing above the pump intake is equal to or greater than the volume needed for all required samples plus two (2) sampling system volumes.

17) If the initial purge rate of 100 mL/min does not cause drawdown and is an appropriate rate for project analytes and purposes, document that sustainable recovery has been achieved at this rate and go to Step 21 and obtain stabilized indicator parameter readings.

18) If the initial purge rate of 100 mL/min does not cause drawdown and a higher rate is desirable for project-specific reasons, adjust the flow rate and determine whether sustainable recovery can be obtained using the higher flow rate. Record each adjustment made to the pumping rate, the water level, and the multi-meter readings measured immediately after each adjustment. The water level and water quality parameters should be measured and recorded approximately every five (5) minutes. When sustainable recovery has been documented at the higher flow rate, go to Step 21 and obtain stabilized indicator parameter readings. A drawdown of no more than 0.33 feet will be allowed, as described in the SOP in Appendix C and as recommended by the EPA low-flow sampling guidance (EPA 2002).

19) If the initial purge rate of 100 mL/min causes drawdown and alternative equipment with flow rates less than 100 mL/min cannot be used, go to the low-recharge procedure.

20) Once a stabilized water level has been obtained, the field indicator parameters will be monitored for stabilization. If the flow rate is equal to or greater than 100 mL/min, measure and record the water quality indicator parameters at 5-minute intervals.

    If the flow rate is less than 100 mL/min, measure and record the water quality indicator parameters at a time intervals equal to 500 mL divided by the purge rate. Field indicator parameter measurements will be considered stable when three (3) consecutive measurements within the following ranges are obtained:

    - turbidity: ± 10 percent when turbidity is greater than 10 NTU;
    - DO: ± 300 micrograms per liter (µg/L);
    - Eh(ORP): ± l0 millivolt (mV);
    - specific conductance: ± 3 percent of full scale (instrument repeatability);
    - pH: ± 0.l unit; and
    - temperature: ± 0.5°C;

21) Once stabilized field indicator parameter measurements have been obtained, samples may be collected.

22) If the other parameters stabilize but turbidity of less than 50 NTU cannot be attained, the designated point of contact for the D&Z should be notified. Samples will be collected as planned. In addition, samples will be collected and field filtered using 0.45 micron filter and submitted for dissolved metals analysis. The DQCR will be used to document if water level and/or water quality stability criteria are not achieved, and/or turbidity is greater than 50 NTU.

"Low-Recovery" Wells

A "low-recovery" well is defined as a well in which a stabilized water level cannot be obtained, regardless of pumping rate or equipment type. Figure 5-3 diagrams the procedures followed in sampling a "low-recovery" well.

1) If a purge rate of 100 mL/min causes drawdown and/or alternative equipment with flow rates less than 100 mL/min cannot be used, the following procedure should be used.

2) The following information (see procedures for "Standard" Sustainable Recovery Wells) will be needed:

   - Obtain well casing and borehole diameters and filter pack percent porosity from well construction records;
   - Determine saturated borehole volume (casing volume plus saturated filter pack volume);
   - Determine casing volume above the pump intake;
   - Determine sampling system volume (volume capacity of pump, tubing, and flow-through cell); and
   - Determine volume necessary to collect all required samples, including QC samples.

3) Determine whether the casing volume above the pump intake is sufficient for at least 2 sampling system volumes plus required samples.

4) Ensure that the gravel pack and formation are not exposed to atmospheric conditions, as described in the EPA low-flow guidance (EPA 2002)

5) If the casing volume above the pump intake is sufficient for at least 2 sampling system volumes plus required samples, purge slowly at a constant flow rate; measure and record water level and field indicator parameters every 500 mL until 2 (or available) system volumes have been removed; collect samples; document conditions and procedures. (**Note**: water level will not be stable [i.e., drawdown will occur] and indicator parameters may not be stable).

6) If the casing volume above the pump intake is sufficient for at least 1 sampling system volume plus required samples, purge slowly at a constant flow rate; measure and record water level and field indicator parameters every 500 mL until 1 (or available) system volumes have been removed; collect samples; document conditions and procedures. (**Note**: water level will not be stable [i.e., drawdown will occur] and indicator parameters may not be stable).

7) If the casing volume above the pump intake is sufficient for all required samples only, determine whether it is acceptable to collect samples without purging. If this is acceptable for project purposes, collect samples at a constant flow rate without purging; document conditions and procedures.

8) If the casing volume above the pump intake is not sufficient for all required samples, determine whether samples can be prioritized and it is acceptable to collect priority samples without purging. If this is acceptable for project purposes, collect priority samples at a constant flow rate without

purging; document conditions and procedures.

9) If the casing volume above the pump intake is not sufficient for all required samples, samples cannot be prioritized, and/or it is not acceptable for project purposes to collect samples without purging, do not sample; document condition.

10) If the well cannot be sampled using the low-recharge procedure:

- Determine whether diffusion samplers, disposable or dedicated Teflon bailers, or other "passive" methods are acceptable for project purposes and can be used. Diffusion samplers will not be used without prior KDHE approval; and

- Determine whether the well can be removed from the monitoring network.

5.5.2 Sample Collection

After purging is complete, a sample will be collected for field analysis of ferrous iron using the Hach test kit and analyzed immediately. Remaining sample bottles will be filled in the following order (where applicable): volatile organic compounds (VOC), explosive compounds, and total metals (and dissolved metals if turbidity greater than 50 NTU). VOC vials will be filled so that no headspace remains in the capped vials. The sampling team will avoid agitation and splashing of the VOC samples. Record the sample time and sample identification (ID) on the well purge form.

1) Collect a final, post-sample water level reading.

2) Shut the bladder pump off.

3) Place all purge water and overspill from sampling into an appropriate purge water container (e.g., a polyethylene tank inside the sampling vehicle). Refer to Section 8.0 of this Site-Wide FSP for wastewater handling procedures.

4) Close and lock the well.

Low-flow sampling techniques will be used for sample collection whenever possible.

5.6 Sample Container Requirements and Sample Preservation

Sample container and preservation requirements for sampling activities at the active LTO/LTM sites are listed in Table 1-1.

5.7 Field Quality Control Sampling

Field QC samples will be collected, documented, and submitted "blind" to the laboratory, so that the laboratory cannot distinguish between normal and QC samples during analysis. These components of the sampling program will ensure that data of known quality are produced throughout the sampling and analysis tasks for all sampling events.

5.7.1 Field Duplicate Samples

Field duplicate samples will be collected at a frequency of 10 percent. A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process. Duplicate samples will be collected simultaneously or in immediate succession to the normal sample, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis.

5.7.2 Field Blanks

Field blanks will be collected at a rate of one sample for every 10 or fewer liquid investigative samples. Field blanks consist of Type II reagent water or organic-free water (for volatile organic analyses) poured into sampling bottles in an area near expected contamination, and transported to the laboratory for analysis. Field blanks will be analyzed for the same suite of analytes as the associated normal samples.

5.7.3 Rinsate Blanks

A rinsate blank sample will be collected for each day of sampling from decontaminated non-dedicated downhole sampling equipment (i.e., bladder pumps). Rinsate blanks consist of Type II reagent water or organic-free water (for volatile organic analyses) poured into (or pumped through) the groundwater sampling device, collected in the sampling bottle, and transported to the laboratory for analysis. Rinsate blanks will be analyzed for the same suite of analytes as the associated normal samples.

5.7.4 Matrix Spike/Matrix Spike Duplicate Samples

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at 5-percent frequency. These samples are spiked with known concentrations of target analytes at the laboratory. Percent recoveries are used to estimate the accuracy of the analytical method. MS results are compared to MSD results to assess method precision.

5.7.5 Trip Blanks

A trip blank is a sample of organic-free water that is placed in the sample bottle in an uncontaminated area in the laboratory prior to going to the field. Trip blanks are prepared only for VOC samples and are subjected to the same handling as other samples. Trip blanks serve to identify contamination from sample containers or transportation and storage procedures. One trip blank will accompany each shipment or cooler of water samples sent to the laboratory for VOC analysis.

5.7.6 Temperature Blanks

Temperature blanks are bottles of water packaged in each sample cooler, allowing the laboratory to determine the temperature of the shipment without disturbing the field samples. One (1) temperature blank is placed in each cooler with the samples.

5.8 Decontamination Procedures

All reusable downhole equipment (e.g., water level indicator, bladder pump) will be decontaminated between wells using the following procedure:

1) Wash with a potable water/Alconox solution;

2) Rinse with potable water;

3) Spray with distilled, deionized water; and

4) For bladder pumps, circulate distilled, deionized water through the pump. A minimum of three (3) times the volume of the pump chamber and associated tubing will be circulated (approximately 4.5 L of water for a 400-mL bladder pump equipped with 50 feet of 3/8-inch tubing). This decontamination step removes groundwater left inside the pump and pump tubing following sampling of a well.

As a general guideline, samples will first be collected from background (non-contaminated) wells or from wells with the lowest concentration of contaminants whenever possible. Samplers will then proceed to sample wells with progressively higher concentrations of contaminants.

5.9 Preventative Maintenance

The primary objective of a preventative maintenance program is to promote the timely and effective completion of a sampling effort. The preventative maintenance program is designed to minimize the downtime of crucial sampling equipment due to expected or unexpected component failure. In implementing this program, efforts are focused in three primary areas:

- Establishment of maintenance responsibilities;
- Establishment of maintenance schedules for major and/or critical instrumentation and apparatus; and
- Establishment of an adequate inventory of critical spare parts and equipment.

5.9.1 Responsibilities and Procedures

Maintenance responsibilities for field equipment are assigned to the D&Z Project Manager and the field team. The field team using the equipment is responsible for checking the status of the equipment prior to use, and for reporting any problems encountered. The field team is also responsible for ensuring that critical spare parts are included as part of the field equipment checklist. Non-operational field equipment is removed from service and a replacement obtained.

All field instruments will be properly protected against inclement weather conditions during the field work. Each instrument is specially designed to maintain its operating integrity during variable temperature ranges that are representative of ranges that will be encountered during hot- or cold-weather working conditions. At the end of each working day, all field equipment will be taken out of the field and placed in a cool, dry area for overnight storage.

5.9.2 Maintenance Schedules

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each major equipment item. Other maintenance activities are conducted on an as-needed basis. Manufacturers' recommendations will provide the primary basis for the established maintenance schedules. All maintenance activities are to be recorded in a bound field logbook. The information to be entered in the logbook includes:

- Date of service;
- Person performing service;
- Type of service performed and reason for service;
- Replacement parts installed (if appropriate); and
- Miscellaneous information.

5.9.3 Spare Parts

An adequate inventory of spare parts is required to minimize equipment down time. The inventory includes those parts (and supplies) that:

- Are subject to frequent failure;
- Have limited useful lifetimes; or
- Cannot be obtained in a timely manner should failure occur.

The D&Z Project Manager and the field team will be responsible for maintaining an adequate inventory of spare parts. In addition to spare parts and supply inventories, a backup supply of much of the equipment and instrumentation for the field sampling will be available in emergencies.

5.9.4 Well Inspections

Each monitoring well sampled will be inspected prior to sampling to insure the well is in good condition. The sampling team will inspect the well to answer the following questions:

- Is the well label legible?
- Are the survey markers on the well or well pad in good condition?
- Is the steel or PVC outer protective casing in good condition? If it is painted, is the paint in good condition?
- Is the well lock in good condition? Was it properly locked when the sampling team arrived to sample the well?
- Is the well pad in good condition? Does the pad wobble? Is it undermined or cracked?
- Is the inner PVC well casing in good condition?
- Are the well protective posts in good condition? Are any posts loose or leaning?
- Are there any well maintenance items that need to be addressed?

Any maintenance items noted by the sampling team will be noted on the field sheet and a well inspection form for that well and included as part of the data submittals for each sampling event. Urgent well repair items that threaten the integrity of the sampling point will be reported to the D&Z Project Manager before the sampling team completes the sampling event, so that immediate corrective action can be taken. Non-urgent well repair items will be periodically addressed as needed based on the discretion of the D&Z Project Manager.

5.10 Monitoring Well Sampling Order

In general, monitoring wells within a SWMU group will be sampled in order from least contaminated to most contaminated, as measured by analyte concentrations in previous groundwater samples. Sampling the wells in order from least contaminated to most contaminated reduces the possibility of cross-

contamination from one well to another. Sampling all the wells within one SWMU group before starting the next SWMU group reduces the possibility that contaminants particular to one SWMU group will be spread to wells within another SWMU group. The sampling order will be reviewed prior to each new sampling event, and revisions will be made (as necessary) based upon the analytical results from the previous event.

6.0 FIELD OPERATIONS DOCUMENTATION

This section discusses the information that will be included to document individual groundwater samples in the permanent record. The information presented in this section enables maintenance of sample integrity from the point of collection and through transportation and storage.

6.1 Daily Quality Control Reports

A DQCR will be prepared daily, dated, and signed by the QCSM or their designee. The DQCR will include the following information:

- Weather information at the time of sampling including temperature, wind, and humidity;
- Calibration;
- Problems;
- Deviations or problems that may affect data quality objectives;
- Samples collected;
- QC samples collected; and
- Copies of Chain-of-Custody Records.

6.2 Field Logbook and Sample Field Sheets

The field logbook will be a hard bound, water-resistant field book with numbered pages. All pertinent information regarding the Site and sampling procedures will be documented in indelible ink. Notations will be made in logbook fashion with sufficient detail so that decision logic may be traced once reviewed, noting the time and date of all entries. For the first day of groundwater sampling activities for each event, the following information will be included in the field book:

- Name and task-related title of each one of the field sampling team members;
- Name and title of any client representative or Site visitors;
- Purpose of field activity;
- Name and address of field contacts;
- References for all maps of the sampling site;
- Information concerning groundwater sampling changes, scheduling modifications, and change order;
- Information concerning access agreements or conversations with property owners;
- General field observations;
- Water level measurements; and
- Chronology of events.

At the end of daily activities, the author will end the daily chronology by writing the time of the last activity and will draw a diagonal line and sign his or her name across the page over any unused lines.

During subsequent daily groundwater sampling activities, the following information will be included in the field book:

- Project name and number, date, and page number at the page top;
- Weather conditions, temperature, wind speed and direction, and weather forecast for the day;

- Personnel at the site (i.e., sampling crew members and field office personnel);
- Name and title of any visitors;
- Name and title of any oversight personnel;
- Chronology for the day to be filled as the day progresses and internal chronology at each of the sampling points;
- Sample collection method;
- Sample identification number(s);
- Chain-of-Custody Record numbers;
- Sampling methodology, including distinction between grab and composite samples; and
- Sample preservation.

In addition to the field notebook, field sampling forms will be filled out with complete information at the time of sampling of each monitoring well. Appendix A includes an example of the field sampling form that will be used for the groundwater sampling events.

Each sample will be documented in the field sampling form, and the field sampling form will then be used to log the samples on the Chain-of-Custody Records for shipment to the laboratory for analyses.

6.3 Photographs

Photographs will be taken in any circumstance where a photograph is considered necessary documentation. A photographic log will be kept in the fieldbook to identify each of the photos. The photographer will review the photographs when they return from developing and compare them with the photographic log to confirm that the log and photographs match.

6.4 Sample Documentation

This section presents sample documentation procedures, including descriptions of the sample numbering system, sample labels, Chain-of-Custody Records, field records and documentation, and documentation corrections.

6.4.1 Sample Numbering System

A numbering system has been developed to uniquely identify each sample collected during the D&Z LTO/LTM sampling events. The numbering system to be used for the D&Z LTO/LTM is as follows:

Sample Identification:

DZLTM-DDMMYY-XX-GW-YYYY-ZZ

where:

- **DZLTM** identifies the project (D&Z Long-Term Groundwater Monitoring);
- **DDMMYY** is day, month, and year the sample was collected (e.g., 150304 for a sample collected on 15 March 2004);
- **XX** corresponds to the SWMU Group that the well is associated with (9, 10, or 17);
- **GW** is the sample medium (groundwater);
- **YYYY** is a four- (or three-) character identifier for the sampled well (e.g., 1101 for well 11- 1, BH3 for well BH-3, 3206 for well 32-6); and

- **ZZ** is an identifier for the sample type (01 for normal samples, 11 for field duplicate samples, and 21 for equipment blank samples).

Trip blanks will be labeled with "TB" and the collection date.

The numbering system provides a tracking procedure to allow data retrieval and ensures that sample numbers are not duplicated.

A listing of all sample IDs will be maintained by the project database administrator. The field manager will ensure that the sample numbering system is universally applied to samples collected during each project.

6.4.2 Sample Labels and/or Tags

A sample label will be attached to each sample container and completed legibly with indelible ink. The sample labels will be affixed to the sample bottle and covered with clear tape. The labels will identify the name and initials of the sample collector, date and time of sample collection, place of collection, sample number, analysis required, preservatives added, and designation between grab and composite samples. Grab samples are collected from one location at one time. Composite samples are grab samples that are combined and homogenized representing several locations collected at different times. A copy of the sample label is included in Appendix A.

6.4.3 Custody Seals and Chain-of-Custody Records

Custody seals will be attached to the outside of the shipping container in such a manner that the seal must be broken to allow access to the container. The custody seal will provide the sample collection date and the sampler's signature or initials. A copy of the custody seal is included in Appendix A.

Each sample shipment will be accompanied by the Chain-of-Custody Record identifying its contents. This record will be used to document sample custody transfer from the sampler to either other sampling team members (if necessary) or the courier, and finally to the analytical laboratory. The Chain-of-Custody Record ensures that samples can be traced from the time of field collection until they are received and analyzed by the analytical laboratory. The original custody record is shipped along with the samples, while the initiator of the record retains a copy.

The information required for the Chain-of-Custody Record includes:

- Type of sample (grab or composite) and matrix;
- Analytical method numbers and parameter names;
- Sample container size and type, and number of containers per parameter;
- Preservatives, if any;
- Sample number;
- Signature of sampler;
- Date and time of sample collection;
- Project name, location and address; and
- Signatures of persons involved in the chain of possession.

When responsibility for a group of samples changes several times, each custodian is not required to retain a copy of the Chain-of-Custody Record, as long as the original custody record indicates that each person accepting the samples has subsequently relinquished custody appropriately. Chain-of-Custody Records will be completed according to the following protocol:

- The originator will fill in all requested information from the sample labels.
- The originator will sign the "Relinquished by" box and keeps a copy.
- The original record sheet will be shipped with the samples (plastic shipping envelope will be taped to the inside of the cooler top and the original sheet of the Chain-of-Custody Record will be placed in the envelope).
- The person receiving custody will check the sample label information against the custody record, check sample condition, and will note anything unusual under "Remarks" on the Chain-of-Custody Record. The person receiving custody will sign in the adjacent "Received by" box and keep the original.
- The date/time will be the same for both signatures, since custody must be transferred between two individuals (however, when samples are shipped via common carrier [e.g., Federal Express], the date/time will not be the same for both signatures).
- When samples are shipped via common carrier, the original Chain-of-Custody Record will be shipped with the samples and the shipper (e.g., Field Sampling Team Leader) will keep a copy (the shipper also will keep all shipping papers, bills of lading, etc.).
- In all cases, it must be readily seen that the person receiving custody has relinquished it to the next custodian.
- If samples are left unattended or a person refuses to sign, this must be documented and explained on the Chain-of-Custody Record.

6.5 Documentation Procedures

The D&Z Project Manager will maintain field records with sufficient data to recreate all sampling and measurement activities. The requirements listed in Sections 6.2 and 6.3 apply to all measuring and sampling activities. Requirements specific to individual activities are listed in the section that addresses each activity. For each sampling event, supporting documentation will be incorporated in the QCSR and the applicable groundwater report. The documentation will include DQCRs, copies of field logbook pages, field sampling forms, and Chain-of-Custody Records. The QCSRs and groundwater reports, in addition to being submitted to KDHE, also will be archived at D&Z's offices.

6.6 Corrections to Documentation

All original data recorded in the field logbooks, on sample labels, on field sampling forms, and on Chain-of-Custody Records will be written in waterproof indelible ink. If an error is made on an accountable document, corrections will be made by crossing out the error with one line and entering the correct information. The erroneous information will not be obliterated. Any error discovered on a document will be corrected by the person who made the entry. All corrections will be initialed and dated.

7.0 SAMPLE STORAGE, PACKING, AND SHIPPING

This section describes procedures for properly handling and shipping the environmental samples collected at the D&Z sites. The procedures described in this section are performed after samples have been collected, placed in the proper containers, and correctly preserved.

7.1 Sample Storage

Upon collection of the analytical samples at a well, samples will be placed in a cooler with bagged ice and transported back to the field trailer by either the sampling team or the sample manager. At the field trailer, all individual sample containers will be placed in re-sealable plastic bags. All VOC containers for an individual sample (three 40-ml VOA vials) will be placed in a re-sealable plastic bag. Samples will be stored in a cooler with bagged ice in a secure location until shipment.

7.2 Sample Packing

Once the Chain-of-Custody Records are completed and signed, one copy of this document will be made. The copy will be used as a packing list for each individual cooler. In addition, a detailed comparison between each sample label and the entries in the Chain-of-Custody Record will be made by a sampling team member to ensure accuracy. Any disagreement in information should be corrected by following guidelines discussed in Section 6.6. This practice is a quality control mechanism to ensure that all samples are placed in the cooler for shipment and that all paperwork is accurate.

Sample packing will begin by preparing the cooler (such as Coleman or other sturdy cooler) used as the shipping container. Old shipping tags, labels, and any other marks from previous shipments will be removed from the cooler. The inside of the cooler will be cleaned with a paper towel wetted with deionized water. Several layers of styrofoam sheeting will be placed in the bottom and sides of the cooler to cushion the samples. A large plastic garbage bag will be used as a liner for the cooler.

VOA vials will be wrapped in packing foam and then placed in a resealable plastic bag. Two VOC trip blank vials will be shipped in each sample cooler containing VOC samples. The trip blanks will be appropriately labeled, wrapped with one set of VOC samples, and then inserted into the same plastic bag as the set of samples. Sample containers will then be placed upright in the lined cooler in such a way that they will not touch each other during shipment. Packing material such as bubble wrap or bagged ice will be placed between the bottles at the discretion of the shipper. A 40-mL temperature blank supplied by the laboratory will be added to the cooler.

All samples will be shipped to the laboratory on ice and chilled to 4 degrees Celsius. Ice in double-lined bags will be placed around and on top of the sample bottles. Additional inert packing material will be placed in the cooler as needed. The plastic liner bag will be taped shut and an original copy of the Chain-of-Custody Record will be placed in a resealable plastic bag and taped to the inside lid of the cooler. The cooler will then be closed and taped shut with filament-type strapping tape.

At least two signed custody seals will be placed on the cooler and taped over, one on the front and one on the side. Additional custody seals may be used as needed. The shipping information (laboratory address and contact phone number) will be affixed to the top of the cooler. The cooler will be transferred to an overnight shipping company (e.g., Federal Express) or delivered to the laboratory by a sampling team member.

7.3 Sample Shipping

Monday through Friday sample shipping from the D&Z sites typically will be completed via overnight shipping using Federal Express. Friday coolers will be shipped with SATURDAY DELIVERY labels on the coolers so that proper delivery will be guaranteed. The sample manager will notify the laboratory that a shipment will be arriving on Saturday.

Federal Express airbills will be completed with information regarding analytical laboratory address (destination), contact person and phone number, sender address, name and phone number, and project number for internal billing purposes. The type of services required from Federal Express will also be marked appropriately (i.e., next day morning delivery, weekday delivery, Friday shipment marked for SATURDAY DELIVERY). It will be the responsibility of the sample manager to update the information that will be required on the airbills for each sampling event and to contact analytical laboratories to confirm daily shipment arrival. The principal D&Z analytical laboratory's address, contact person name, and phone number are provided below.

Cliff Baker
Continental Analytical Services
525 N. Eighth St. - Salina, KS 67401
785-827-1273

In addition to the Federal Express labels, pre-typed labels will be taped on the cooler top with both the sender and receiver addresses.

The D&Z site mailing address is as follows:

Day & Zimmermann Kansas LLC
23102 Rush Rd
Parsons, KS 67357-8403

8.0 INVESTIGATION-DERIVED WASTES

Management of IDW from groundwater sampling will be performed in accordance with the procedures detailed in the following sections.

8.1 Purged Fluids

Purged fluids are produced as a result of monitoring well sampling. Waste drums will be staged outside of each SWMU Group and the purge water for that area will be placed into these site specific drums. D&Z will sample and analyze purge water, then process it in the onsite wastewater treatment plan and discharge the treated water under the terms of its permit. If purge water cannot be treated onsite, it will be disposed of at Clean Harbors Lone Mountain, LLC at the end of the sampling event. Clean Harbors Lone Mountain is a RCRA permitted landfill (EPA ID Number OKD065438376). The landfill's address and phone number are provided below.

Clean Harbors Lone Mountain LLC
5 miles East & 1 mile North of Jct. US Highways 281 & 412
Waynoka, OK 73860
Phone (580) 697-3500

8.2 Solid Waste

Solid waste is defined as any solid waste generated during the groundwater sampling events such as PPE disposal material, shipping boxes, and materials and office waste. All solid waste will be placed in an on-site dumpster for disposal at a municipal landfill. The rationale for this method of disposal is that the quantity of PPE contamination after decontamination of equipment is low to absent. Also, typical office waste is not contaminated.

8.3 Decontamination Fluids

Decontamination fluids are produced as a result of the decontamination of sampling equipment. Decontamination fluids will be disposed of with the purge water in the polyethylene tanks. The rationale for this type of disposal is that low or non-detectable levels of contaminants are present in the decontamination fluids.

9.0 FIELD ASSESSMENT

The contractor is required to ensure that quality is maintained throughout all field work by means of a three-phase control process (Engineer Regulation 1180-1-6). Contractor Quality Control (CQC) phases (preparatory, initial, and follow-up) are performed onsite by the QCSM, who will summarize the activities of each CQC phase in the daily QC report. The CQC phases are performed for each definable feature of work.

9.1 Three Phase Inspection Procedures

Chemical QC consists of three phases (preparatory, initial, and follow-up) of control that will be performed for sampling activities. ECC also conducts a "fourth phase" or completion inspection which consists of a data review of each sample data package associated with the sampling event and verifying that all planned samples were collected and analyzed.

9.1.1 Preparatory Inspection

The QCSM and the sampling team will discuss sampling requirements for the project as described in Section 5.0 of this Site-Wide FSP. Each sampler will be given copies of the tables from the site-specific sampling attachments, which summarize the required sampling activities. The preparatory session will include a discussion of the following:

- Review of site hazards, both chemical and physical;
- Review of the PPE required during sampling;
- Review of the Site-Wide SAP;
- Review of the sampling techniques to be used;
- Examination of the required sampling equipment and materials; and
- Review of the decontamination procedures.

A Sampling Apparatus and Field Instrumentation Checklist will be used during the sampling activities, and the checklist will include:

- Field notebook;
- Chain-of-Custody Records;
- Dedicated Teflon bailers;
- Sampling jars and bottles;
- Disposable gloves;
- Tyvek suits (optional);
- Deionized water stored in glass or plastic containers for decontamination and equipment blanks;
- Non-phosphate liquid surfactant for decontamination;
- Bagged ice for sample preservation;
- Shipping labels for sample containers;
- Custody seals for sample coolers;
- Packing material; and
- Aluminum foil for wrapping sampling equipment for storage.

To conclude the preparatory inspection, the QCSM will conduct an orientation walk-through of the sampling areas with personnel performing remediation and sampling activities. This phase will be repeated for new sampling personnel joining the team.

9.1.2 Initial Inspection

During the initial inspection, the QCSM will supervise the well inspection of each monitoring well and the initial sampling activities to ensure that required sampling procedures are followed.

9.1.3 Follow-up Inspection

The follow-up inspection requires the QCSM to review the progress of sampling activities to ensure compliance with all sampling methods. Supervision of the sample packaging and shipping, as described in Section 7.0, is part of the follow-up phase of chemical QC.

9.1.4 Completion Inspections

The QCSM will perform a specific Completion Inspection at the completion of the field activities to check that the entire scope of water level measurement and analytical sampling tasks has been performed, and to ensure that the site is cleaned-up and adequately restored. During this Completion Inspection, a punch list will be generated to document any items that do not conform to project plans and specifications. The punch list will serve as the tracking system for the follow-up of open (uncorrected or unfinished) items, and will identify when they are completed and closed. A list of any deficiencies identified will be generated from the Preliminary, Initial, and Follow-up Inspections for each sampling event, and correction or resolution of these deficiencies will be documented in a Completion Inspection. The list of the deficiency items will be corrected prior to the next sampling event.

10.0 CORRECTIVE ACTIONS

This section discusses corrective action procedures to be followed in the event that a discrepancy is discovered by field personnel, and/or the laboratory discovers discrepancies or problems. Typical discrepancies are improper sampling or sample labeling procedures, improper instrument calibration procedures, improper sample preservation, improper analysis requested for a sample, and problems with sample condition upon receipt at the laboratory.

The D&Z Field Manager will be responsible for implementation of the Site-Wide FSP procedures. In the event of any improper sampling procedure, the Field Sampling Team Leader will direct the sampling crew to immediately comply with this Site-Wide FSP and will document the discrepancy and circumstances, and re-collect samples (if necessary) under the proper protocol.

Field instruments will be calibrated as indicated in Appendix B. The instrument calibration logbook will be inspected daily by the QCSM. Any instrument problems will be immediately reported to the QCSM. It will be the responsibility of the QCSM to make arrangements to replace the instrument with another one in proper working condition. Improper instrument calibration and corrective action will be documented in the logbook and reported in the DQCR.

Sample preservation procedures in the field will be supervised by the QCSM. Pre-preserved laboratory containers will be inspected by the QCSM. In the event that any sample appears with the incorrect or insufficient amount of preservative, the sample container will be discarded and a new sample container and label will be used. In the event of sample container breakage or leakage in the field, new samples will be collected. Proper documentation will be completed by the QCSM to document the circumstances. This documentation will be part of the field project file.

Problems related with samples upon receipt at the laboratory will be addressed by the QCSM. In the event of discrepancies between the Chain-of-Custody Record and the sample labels, corrections will be made according to procedures described in Section 6.6. Broken sample containers will be replaced by the sampling crew following groundwater sampling procedures described in Section 5.0. Proper documentation will be attached to the original sample field sheets to document the corrective action.

Any other deviation from the Site-Wide FSP will be initially reported to the QCSM who is responsible for reporting the details in the DQCR to D&Z project management.

11.0 REFERENCES

Day & Zimmerman. 2014. "Spring 2014 Semiannual Groundwater Monitoring Report, Long-Term Groundwater Monitoring." September.

Environmental Protection Agency, U.S. (EPA). 2001. *EPA Requirements for Quality Assurance Project Plans.* EPA QA/R-5.

EPA. 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers.* EPA 542-S-02-001.

EPA. 2006. "Corrective Measures Decision, Kansas Army Ammunition Plant."

EPA. 2009. *National Primary Drinking Water Regulations*. EPA 816-F-09-004. May.

Kansas Department of Health and Environment. 2014. *Risk-based Standards for Kansas, RSK Manual - 5th Version.* October 2010, with revised tables from March 2014.

U.S. Army Corps of Engineers (USACE). 2013. "2012 Annual Site-wide Groundwater Monitoring Report, Kansas Army Ammunition Plant, Parsons, Kansas." August.

TABLES

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TABLE 1-1
CONTAMINANTS OF CONCERN, WATER QUALITY INDICATORS, AND ANALYTICAL REQUIREMENTS
D&Z SITE-WIDE MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Contaminant of Concern	Analysis Method	Holding Time	Container(s)[a]	Preservation	Storage Requirements
Volatile Organic Compounds	SW-846 8260B	14 days, 7 days if not preserved with acid	40-mL vials with Teflon seals[b]	HCl to pH <2 No headspace	4°C
Explosives*	SW-846 8330	7 days preparation, 40 days analysis	(2) 1 L amber glass bottle with Teflon-lined lid	None	4°C
Metals: Total or Dissolved[c] ICP-ES/MS[c]	SW-846 6020A or SW-846 6010B SW-846 7470A	6 months 28 days	(1) 1 L polyethylene bottle; Total analyses[d] (1) 1 L polyethylene bottle; Dissolved analyses[d]	HNO_3 to pH <2 HNO_3 to pH <2, & filter in field for dissolved	4°C

Notes:

In addition to the contaminants of concern, samples will be analyzed for total dissolved solids using Standard Method 2540(C) to assess the impact of turbidity on metals analysis.

a All containers are pretreated and cleaned before being purchased.
b Extra sample volume must be collected for both the matrix spike and matrix spike duplicate analyses.
c Only field samples with turbidity readings of >50 NTUs will be analyzed for dissolved metals.
d Samples to be analyzed for multiple parameters requiring the same preservation technique can be analyzed from the same sample bottle.

SW-846 Test Methods for Evaluation of Solid Waste: Physical/Chemical Methods, U.S. EPA, November 1986, Third edition.
EPA = U.S. Environmental Protection Agency.

* Although 2,4-dinitrotoluene has been added to the explosives analyte list for reporting purposes at the request of KDHE, it is not defined as a contaminant of concern in the Corrective Measures Decision (CMD), and there is no stated cleanup goal in the CMD for this compound.

TABLE 1-2
CORRECTIVE MEASURES DECISION CLEAN-UP GOALS
D&Z SITE-WIDE MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Contaminant	Groundwater Cleanup Goal (µg/L)	Basis of Selection
Arsenic	10	KDHE RSK
Cadmium	5	KDHE RSK
Chromium III (total)	100	KDHE RSK
1,1-Dichloroethene	7	MCL
2,4-Dinitrotoluene*	n/a	n/a
HMX	5,110	KDHE RSK
Lead	15	EPA MCL
RDX	25.9	KDHE RSK
Tetryl	407	KDHE RSK
TNT	50.7	KDHE RSK
Tetrachloroethene	5	KDHE RSK
Trichloroethene	5	KDHE RSK
Vinyl chloride	2	KDHE RSK

Notes:

* = Although 2,4-dinitrotoluene has been added to the analyte list for reporting purposes at the request of KDHE, it is not defined as a contaminant of concern in the Corrective Measures Decision (CMD), and there is no stated cleanup goal in the CMD for this compound.
µg/L =Micrograms per liter
HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine
Tetryl = 2,4,6-Trinitrophenylmethylnitramine
TNT = 2,4,6-Trinitrotoluene
EPA = U.S. Environmental Protection Agency
KDHE = Kansas Department of Health and Environment
MCL = Maximum Contaminant Level (EPA 2009)
µg/L = Micrograms per liter
RSK = Risk-Based Standards for Kansas (non-residential scenario) Department of Health and the Environment (KDHE 2014). Current values available at http://www.kdheks.gov/remedial/download/RSK_Manual_14.pdf

TABLE 3-1
SWMU 9 (1000 AREA) SAMPLING AND WATER LEVEL MEASUREMENT REQUIREMENTS
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	Contaminants of Concern			
	Water Levels	VOCs	Explosives	Metals (Total)*
1-3	1			
1-14	1	1	1	1
2-3	1	1	1	1
3-3	1	1	1	1
4-3	1	1	1	1
4-7S	1	1	1	1
5-7D	1	1	1	1
17-5	1	1	1	1
18-5	1	1	1	1
Total Samples	**9**	**8**	**8**	**8**

Notes:

* Dissolved metals analysis will be used if sample turbidity is greater than 50 NTUs
SWMU = Solid Waste Management Unit
VOCs = Volatile Organic Compounds

QC Requirements:
1 temperature blank per cooler
1 trip blank per cooler containing VOC Samples
1 rinsate blank per week
1 field duplicate (QA) and 1 lab duplicate (QC) sample for every 10 field samples collected
1 MS/MSD pair for every 20 field samples collected

Analytical methods:
VOCs by EPA Method 8260
Explosives by EPA Method 8330
Total metals by EPA Method 6010 / Dissolved metals by EPA Method 6020

TABLE 3-2
SWMU 10 (1100 AREA) SAMPLING AND WATER LEVEL MEASUREMENT REQUIREMENTS
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	Contaminants of Concern			
	Water Levels	VOCs	Explosives	Metals (Total)*
1-9	1	1	1	1
1-13	1	1	1	1
2-9	1	1	1	1
2-13	1	1	1	1
3-9	1	1	1	1
4-9	1	1	1	1
4-13	1	1	1	1
5-9	1			
5-13	1	1	1	1
6-7	1	1	1	1
7-3	1	1	1	1
7-7	1	1	1	1
7-12	1	1	1	1
8-3	1			
8-12	1	1	1	1
8-13	1	1	1	1
9-3	1	1	1	1
9-12	1			
10-3	1	1	1	1
11-12	1	1	1	1
12-12	1	1	1	1
12-13	1	1	1	1
19-5	1	1	1	1
20-5	1	1	1	1
21-5	1	1	1	1
Total Samples	**25**	**22**	**22**	**22**

Notes:

* Dissolved metals analysis will be used if sample turbidity is greater than 50 NTUs
SWMU = Solid Waste Management Unit
VOCs = Volatile Organic Compounds

QC Requirements:
1 temperature blank per cooler
1 trip blank per cooler containing VOC Samples
1 rinsate blank per week

1 field duplicate (QA) and 1 lab duplicate (QC) sample for every 10 field samples collected
1 MS/MSD pair for every 20 field samples collected

Analytical methods:
VOCs by EPA Method 8260
Explosives by EPA Method 8330
Total metals by EPA Method 6010 / Dissolved metals by EPA Method 6020

TABLE 3-3
SWMU 17 (2700 AREA) SAMPLING AND WATER LEVEL MEASUREMENT REQUIREMENTS
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	Contaminants of Concern	
	Water Levels	Explosives
10-1	1	
16-7	1	1
17-3	1	1
17-7	1	1
20-3	1	1
Total Samples	**5**	**4**

Notes:

* Dissolved metals analysis will be used if sample turbidity is greater than 50 NTUs

SWMU = Solid Waste Management Unit
VOC = Volatile Organic Compounds

QC Requirements:
1 temperature blank per cooler
1 trip blank per cooler containing VOC Samples
1 rinsate blank per week

1 field duplicate (QA) and 1 lab duplicate (QC) sample for every 10 field samples collected
1 MS/MSD pair for every 20 field samples collected

Analytical methods:
VOCs by EPA Method 8260
Explosives by EPA Method 8330
Total metals by EPA Method 6010 / Dissolved metals by EPA Method 6020

TABLE 5-1
WELL CONSTRUCTION DATA
SWMU GROUP 9 (1000 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	TOC Elevation (ft AMSL)	Ground Elevation (ft AMSL)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
1-3	894.48	892.89	9.08 – 19.08	unknown	19.09**
1-14	895.18	893.01	8.98 – 18.98	unknown	19.50**
2-3	896.46	894.77	7.89 - 17.89	17.00	19.06
3-3	894.11	892.13	8.78 - 18.78	14.00	19.23
4-3	900.91	898.95	9.66 - 19.66	18.00	20.22
4-7S	890.13	887.98	8.65 - 18.65	14.00	19.37
5-7D	890.07	887.98	18.07 – 28.07	23.50	28.40
17-5	893.06	891.27	7.79 - 17.79	14.00	18.19
18-5	895.28	893.61	7.67 - 17.67	13.00	17.79

Notes:

* Total depth measurements taken in Spring 2014 (Day and Zimmerman 2014).
** Total depth not measured in Spring 2014. This measurement is from the original well construction diagram.
Well elevations and construction data from U.S. Corps of Engineers (USACE) (2013).

AMSL = Above mean sea level
BTOC = Below top of casing
ft = Feet
SWMU = Solid Waste Management Unit

TABLE 5-2
WELL CONSTRUCTION DATA
SWMU GROUP 10 (1100 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	TOC Elevation (ft AMSL)	Ground Elevation (ft AMSL)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
1-9	900.47	898.23	4.87 - 14.91	14.5	17.45
1-13	906.70	904.16	12.90 – 22.90	unknown	20.00
2-9	900.27	898.23	11.93 - 21.98	21.3	23.78
2-13	904.02	901.35	9.70 – 19.72	unknown	20.10**
3-9	904.32	902.53	27.92 - 37.76	NS	40.06**
4-9	890.40	888.25	10.12 - 20.12	17.5	22.80
4-13	904.97	902.84	9.07 – 19.07	unknown	19.60**
5-9	892.35	890.17	15.04 - 25.06	24.8	27.70
5-13	898.79	896.51	7.59 – 17.59	unknown	19.00
6-7	902.37	900.47	15.87 - 25.87	23.0	26.43
7-3	904.28	902.17	8.51 - 18.51	16.5	19.31
7-7	894.92	892.93	14.02 - 24.02	20	24.53
7-12	908.15	905.71	26.89 - 36.94	36.5	38.00
8-3	902.93	901.08	8.25 - 18.25	unknown	20.00**
8-12	908.37	905.89	10.48 - 20.48	18	20.99
8-13	898.01	895.95	9.11 – 19.11	unknown	20.00
9-3	902.51	900.30	9.21 - 19.21	17.0	20.30
9-12	906.64	904.03	12.46 - 22.51	18.0	19.80
10-3	900.79	898.85	11.34 - 21.31	17.0	22.09
11-12	892.69	890.00	12.59 - 22.64	20.0	22.90
12-12	904.24	901.91	11.28 - 21.33	17.6	21.85
12-13	905.09	902.36	27.19 – 37.19	unknown	39.00
19-5	898.26	896.63	25.88 - 35.88	31.0	36.27
20-5	899.83	898.27	23.56 - 33.56	30.8	34.33
21-5	895.47	893.91	7.06 - 17.06	15.5	17.72

Notes:

* Total depth measurements taken in Spring 2014 (Day and Zimmerman 2014).
** Total depth not measured in Spring 2014. This measurement is from the original well construction diagram.
Well elevations and construction data from U.S. Corps of Engineers (USACE) (2013).

AMSL = Above mean sea level
BTOC = Below top of casing
ft = Feet
SWMU = Solid Waste Management Unit

TABLE 5-3
WELL CONSTRUCTION DATA
SWMU GROUP 17 (2700 AREA) MONITORING WELL SAMPLING
DAY & ZIMMERMANN KANSAS LLC – PARSONS, KANSAS

Well ID	TOC Elevation (ft AMSL)	Ground Elevation (ft AMSL)	Screened Interval (ft BTOC)	Pump Intake Depth (ft BTOC)	Total Depth (ft BTOC)*
10-1	868.31	864.96	15.51 - 25.51	23.00	25.60
16-7	855.26	853.19	14.76 – 25.06	unknown	26.00
17-3	875.60	873.89	8.70 - 18.70	14.70	19.57
17-7	859.00	856.66	14.80 – 24.80	unknown	24.64**
20-3	854.01	852.26	11.9 - 21.9	17.00	21.30

Notes:

* Total depth measurements taken in Spring 2014 (Day and Zimmerman 2014).
** Total depth not measured in Spring 2014. This measurement is from the original well construction diagram.
Well elevations and construction data from U.S. Corps of Engineers (USACE) (2013).

AMSL = Mean sea level
BTOC = Below top of casing
ft = Feet
SWMU = Solid Waste Management Unit
TOC = Top of casing

FIGURES

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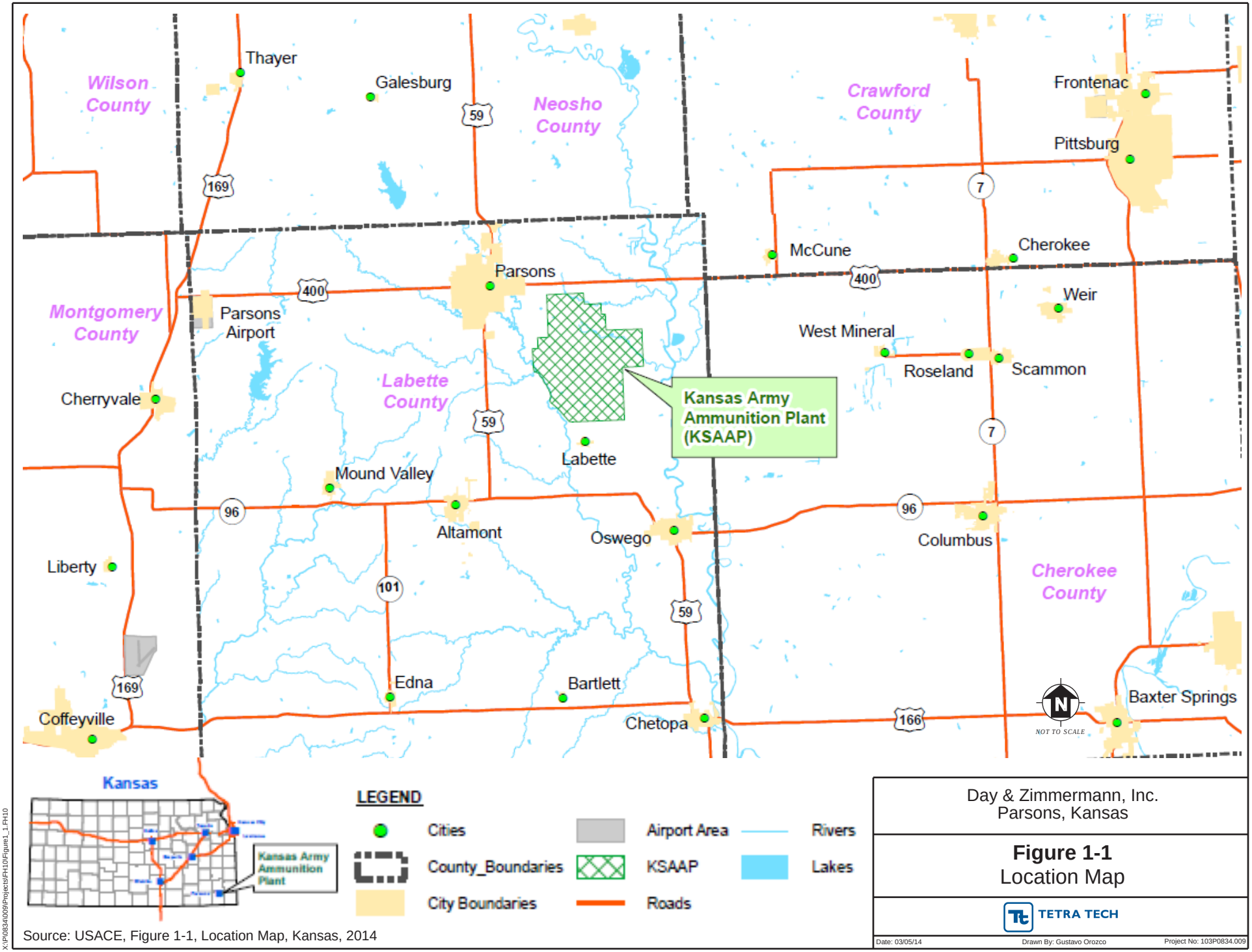

Source: USACE, Figure 1-1, Location Map, Kansas, 2014

Day & Zimmermann, Inc.
Parsons, Kansas

Figure 1-1
Location Map

TETRA TECH

Date: 03/05/14 | Drawn By: Gustavo Orozco | Project No: 103P0834.009

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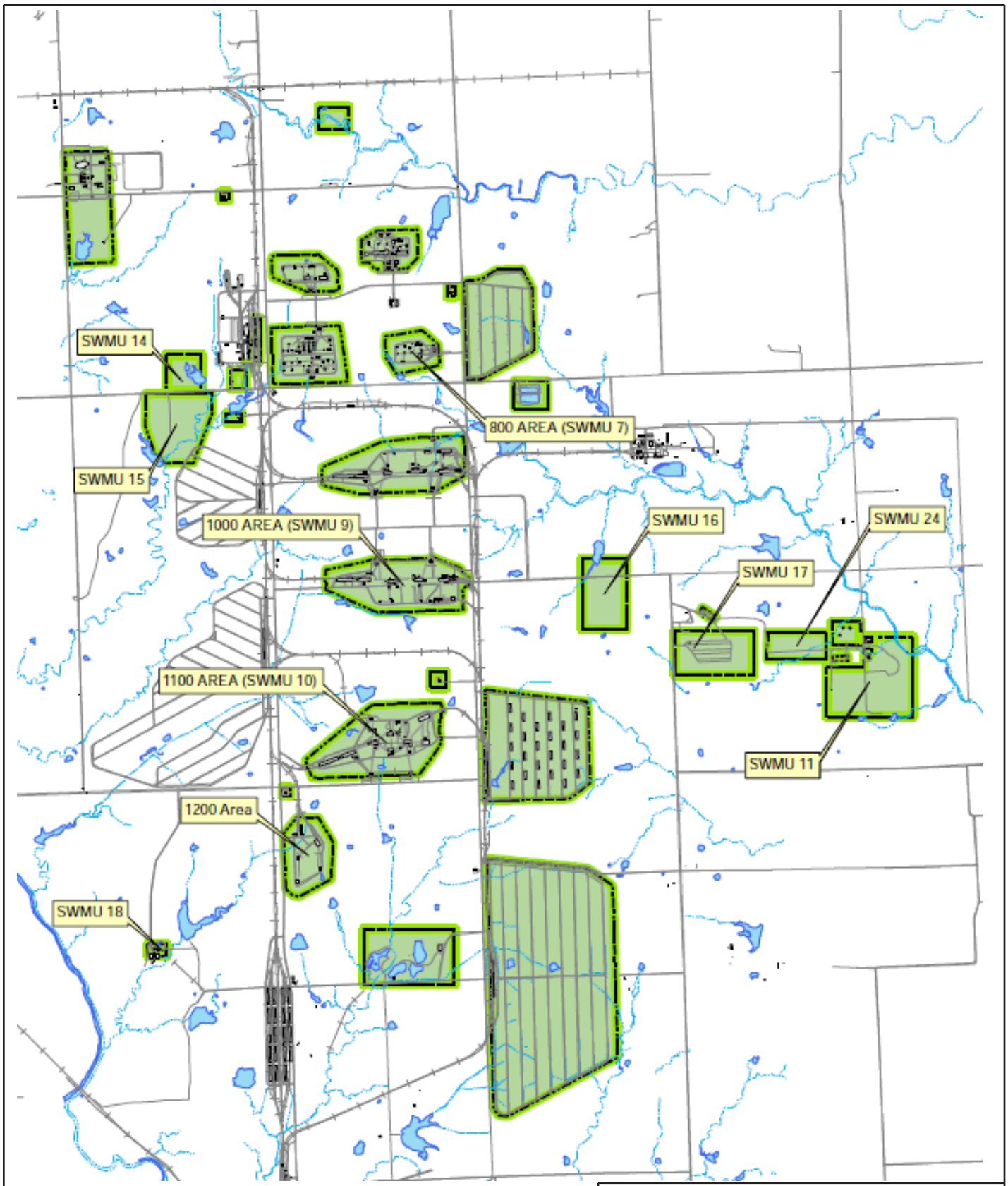

Legend

Buildings
Railroads
SWMU
Ponds
Roads
Rivers

NOT TO SCALE

Source: USACE, Figure 1-2, Installation Map, Kansas, 2014

Day & Zimmermann, Inc.
Parsons, Kansas

Figure 1-2
Installation Map

TETRA TECH

Date: 03/05/14 | Drawn By: Gustavo Orozco | Project No: 103P0834.009

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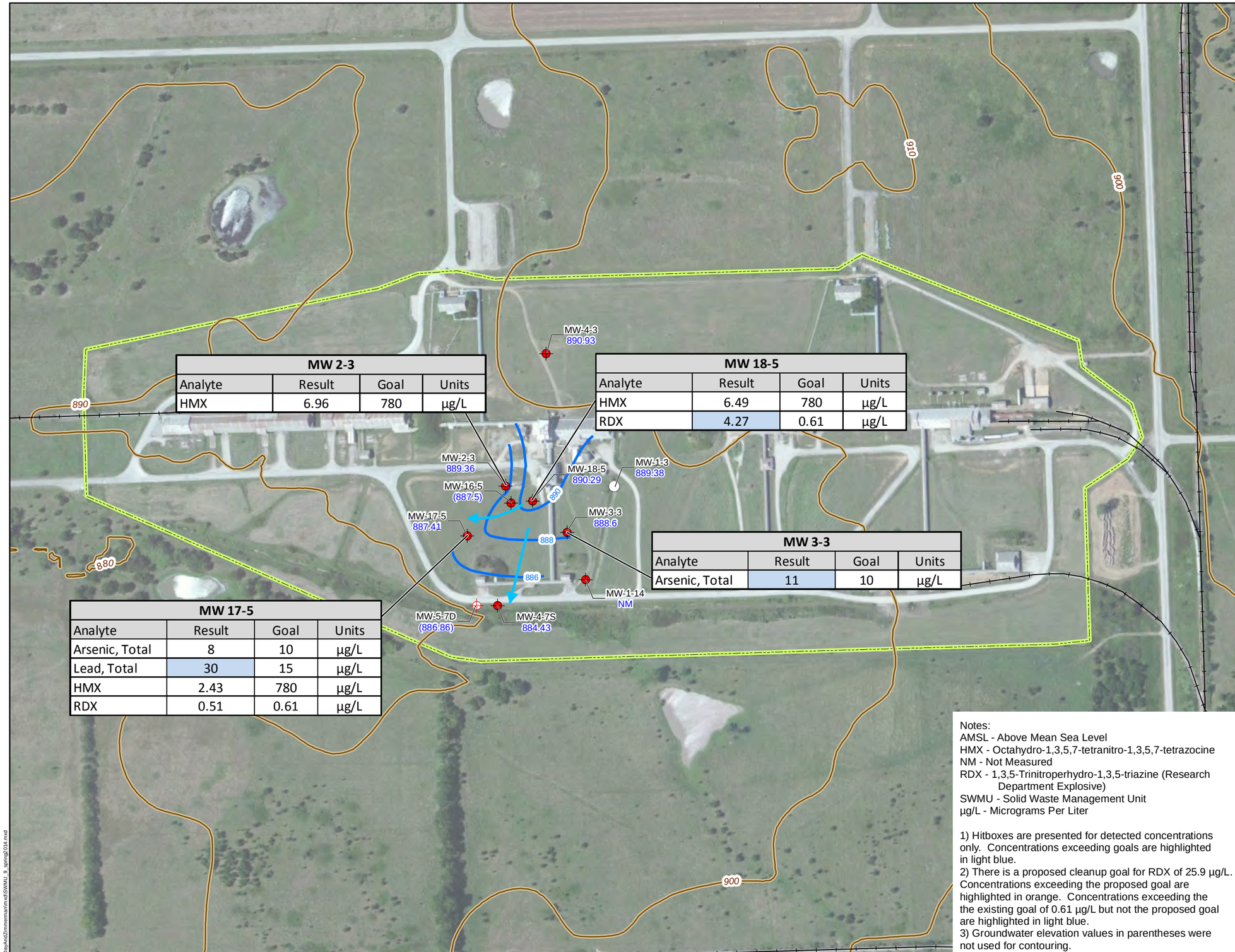


MW 2-3			
Analyte	Result	Goal	Units
HMX	6.96	780	µg/L

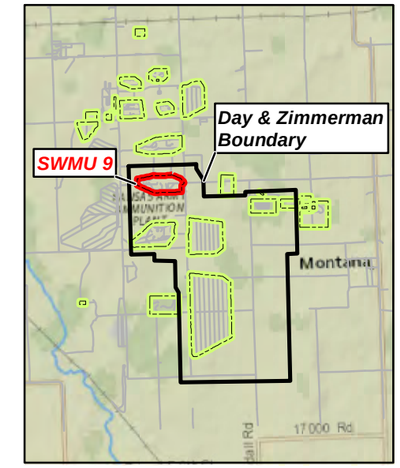
MW 18-5			
Analyte	Result	Goal	Units
HMX	6.49	780	µg/L
RDX	4.27	0.61	µg/L

MW 3-3			
Analyte	Result	Goal	Units
Arsenic, Total	11	10	µg/L

MW 17-5			
Analyte	Result	Goal	Units
Arsenic, Total	8	10	µg/L
Lead, Total	30	15	µg/L
HMX	2.43	780	µg/L
RDX	0.51	0.61	µg/L

Notes:
AMSL - Above Mean Sea Level
HMX - Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
NM - Not Measured
RDX - 1,3,5-Trinitroperhydro-1,3,5-triazine (Research Department Explosive)
SWMU - Solid Waste Management Unit
µg/L - Micrograms Per Liter

1) Hitboxes are presented for detected concentrations only. Concentrations exceeding goals are highlighted in light blue.
2) There is a proposed cleanup goal for RDX of 25.9 µg/L. Concentrations exceeding the proposed goal are highlighted in orange. Concentrations exceeding the the existing goal of 0.61 µg/L but not the proposed goal are highlighted in light blue.
3) Groundwater elevation values in parentheses were not used for contouring.



MW-4-3 890.93 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-5-7D (886.86) — Deep Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-1-3 889.38 — Shallow Static Water Level Only

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

N

0 175 350
Feet

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmermann, Inc.
Parsons, Kansas

Figure 1-3
Sampling Results in Groundwater
SWMU 9, Spring 2014

TETRA TECH

Date: 9/20/2014 Drawn By: Nick Wiederholt Project No: 103P0834.016

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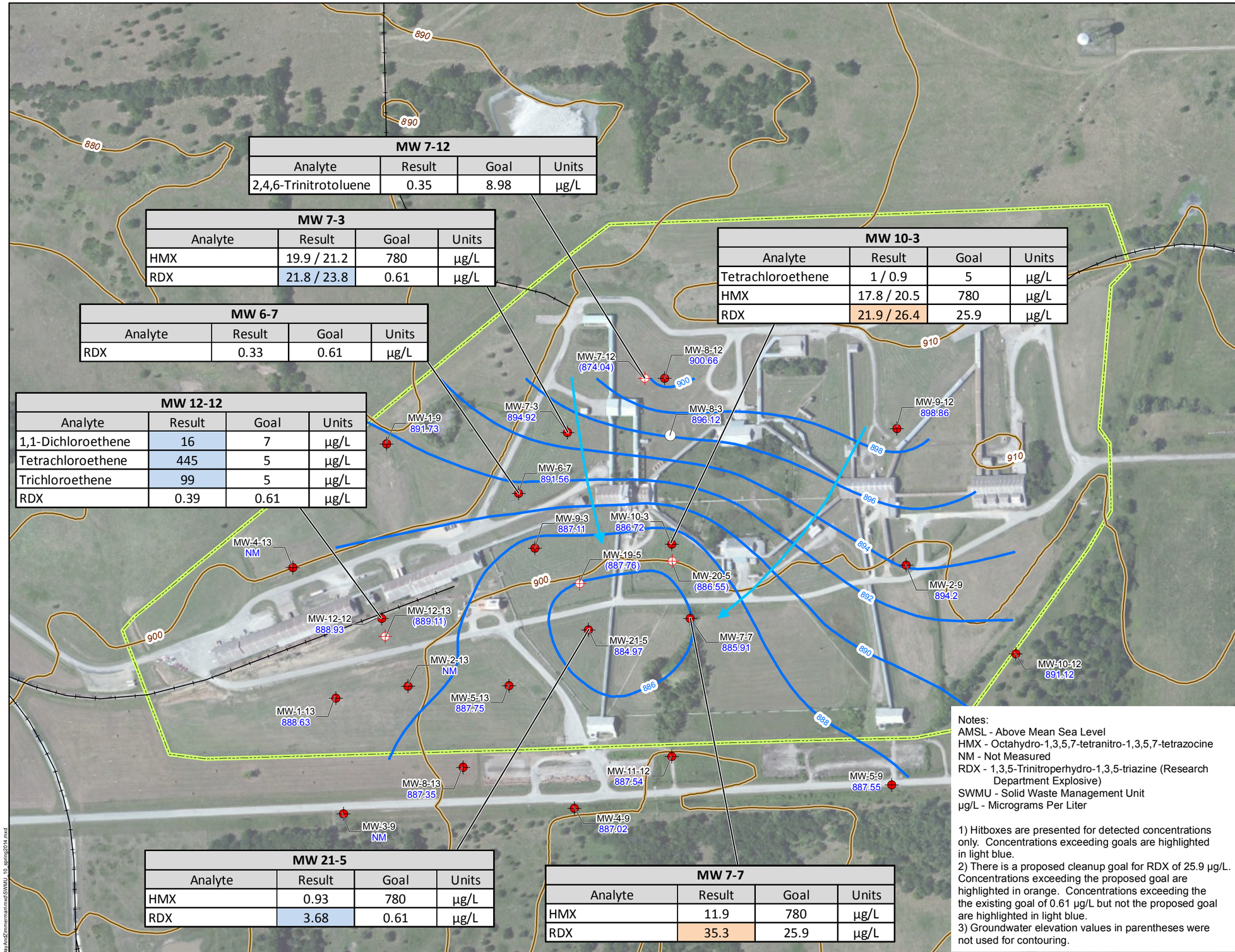


MW 7-12			
Analyte	Result	Goal	Units
2,4,6-Trinitrotoluene	0.35	8.98	µg/L

MW 7-3			
Analyte	Result	Goal	Units
HMX	19.9 / 21.2	780	µg/L
RDX	21.8 / 23.8	0.61	µg/L

MW 6-7			
Analyte	Result	Goal	Units
RDX	0.33	0.61	µg/L

MW 12-12			
Analyte	Result	Goal	Units
1,1-Dichloroethene	16	7	µg/L
Tetrachloroethene	445	5	µg/L
Trichloroethene	99	5	µg/L
RDX	0.39	0.61	µg/L

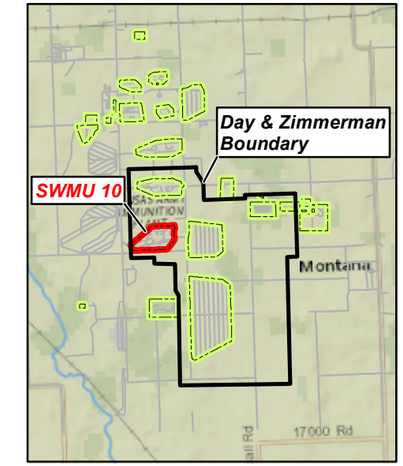
MW 10-3			
Analyte	Result	Goal	Units
Tetrachloroethene	1 / 0.9	5	µg/L
HMX	17.8 / 20.5	780	µg/L
RDX	21.9 / 26.4	25.9	µg/L

MW 21-5			
Analyte	Result	Goal	Units
HMX	0.93	780	µg/L
RDX	3.68	0.61	µg/L

MW 7-7			
Analyte	Result	Goal	Units
HMX	11.9	780	µg/L
RDX	35.3	25.9	µg/L

Notes:
AMSL - Above Mean Sea Level
HMX - Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
NM - Not Measured
RDX - 1,3,5-Trinitroperhydro-1,3,5-triazine (Research Department Explosive)
SWMU - Solid Waste Management Unit
µg/L - Micrograms Per Liter

1) Hitboxes are presented for detected concentrations only. Concentrations exceeding goals are highlighted in light blue.
2) There is a proposed cleanup goal for RDX of 25.9 µg/L. Concentrations exceeding the proposed goal are highlighted in orange. Concentrations exceeding the the existing goal of 0.61 µg/L but not the proposed goal are highlighted in light blue.
3) Groundwater elevation values in parentheses were not used for contouring.



MW-9-12 898.86 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-7-12 (874.04) — Deep Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

MW-8-3 896.12 — Shallow Static Water Level Only

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

N

0 175 350
Feet

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmermann, Inc.
Parsons, Kansas

Figure 1-4
Sampling Results in Groundwater
SWMU 10, Spring 2014

TETRA TECH

Date: 9/20/2014 Drawn By: Nick Wiederholt Project No: 103P0834.016

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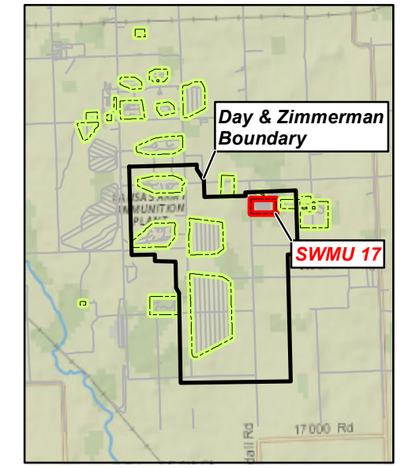

MW-10-1 859.79 — Shallow Groundwater Monitoring Well with Groundwater Elevation (in Feet AMSL)

Topographic Contour (in Feet AMSL)

Groundwater Elevation Contour (in Feet AMSL)

Groundwater Flow Direction

SWMU Boundary

Notes:
AMSL - Above Mean Sea Level
NM - Not Measured
SWMU - Solid Waste Management Unit

N

0 100 200
Feet

Source: ESRI, ArcGIS Online Basemaps, 2014

Day & Zimmermann, Inc.
Parsons, Kansas

Figure 1-5
Sampling Results in Groundwater
SWMU 17, Spring 2014

TETRA TECH

Date: 9/18/2014 | Drawn By: Nick Wiederholt | Project No: 103P0834.016

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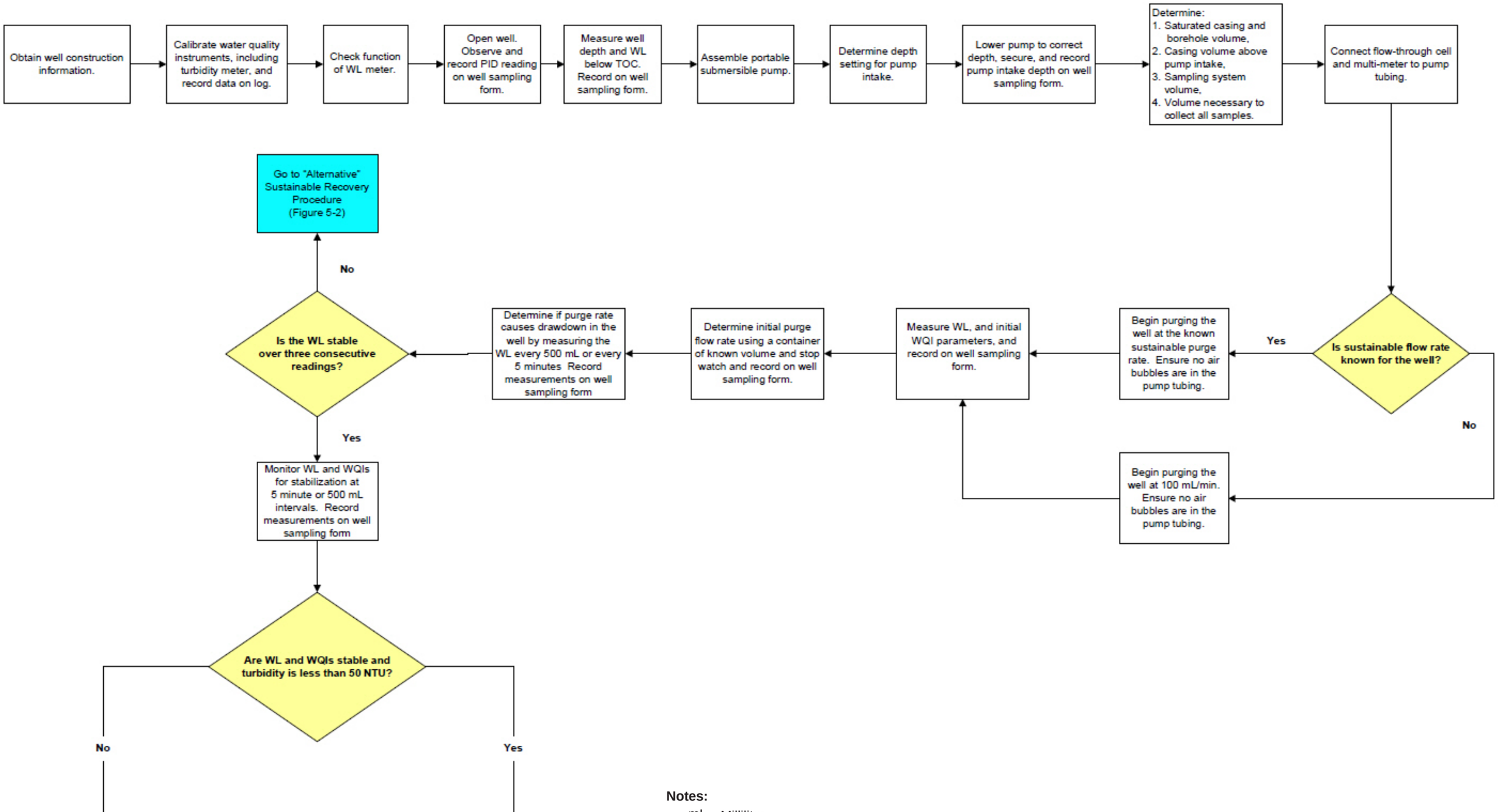

Notes:

mL	Milliliter
min	Minute
NTU	Nephelometric turbidity units
PID	Photoionization detector
TOC	Top of casing
WL	Water level
WQI	Water quality indicator

Source: ECC, Figure 5-1, Long-Term Monitoring, Kansas Army Ammunition Plant, 2003

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Day & Zimmermann Kansas LLC
Kansas Division
23102 Rush Road
Parsons, Kansas 67357

Site-Wide Groundwater Corrective Measures
Decision Implementation
Part I - Field Sampling Plan
Day & Zimmermann Kansas LLC, Parsons, Kansas

Figure 5-1
"Standard" Sustainable Recovery Well
Low-Flow Purging and Sampling Flow Chart

TETRA TECH

Date: 1/23/2015 Drawn By: Nick Wiederholt Project No: 103P0834005.01

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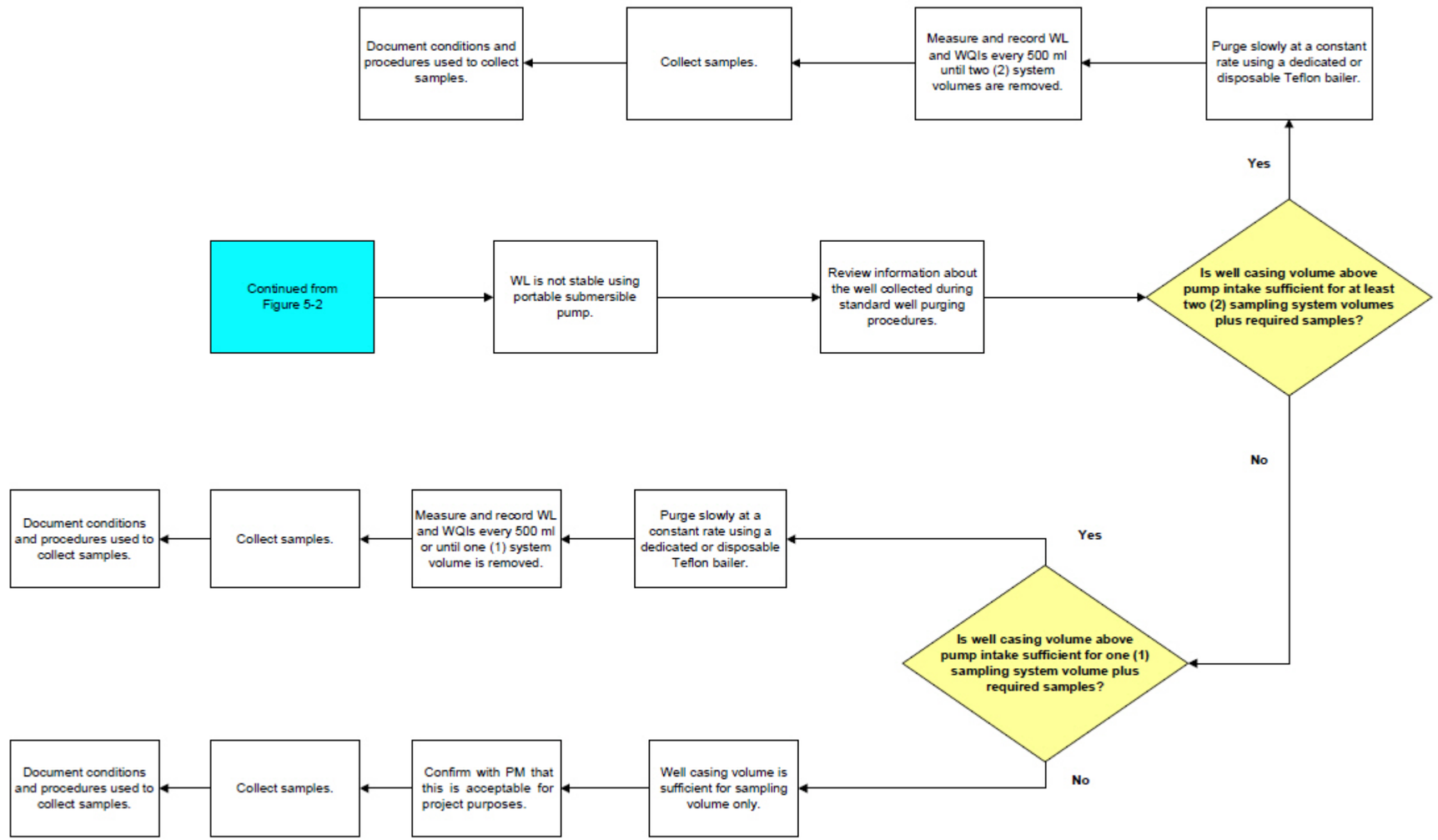

Notes:

mL	Milliliter
PM	Project manager
WL	Water level
WQI	Water quality indicator

Source: ECC, Figure 5-2, Long-Term Monitoring, Kansas Army Ammunition Plant, 2003

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Parsons, Kansas 67357

Site-Wide Groundwater Corrective Measures
Decision Implementation
Part I - Field Sampling Plan
Day & Zimmermann Kansas LLC, Parsons, Kansas

Figure 5-2
"Low Recovery" Well
Low-Flow Purging and Sampling Flow Chart

TETRA TECH

Date: 1/23/2015 | Drawn By: Nick Wiederholt | Project No: 103P0834005.01

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APPENDIX A

FIELD FORMS

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Day Zimmermann Kansas LLC

Micropurge Groundwater Sampling Data Sheet

Day&Zimmermann
We do what we say.

Well Name:		**Screen Interval:**	
Well Location:		**Sample Depth:**	
Project:		**Static Water Level:**	
Sample Date:		**Well Depth:**	
Sampling Personnel:			
Sample ID:		**PID Reading (background):**	
Duplicate ID:		**PID Reading (headspace):**	
Field QC Designation:		**Immiscible Layer Present:**	

Water Quality Information

Time	Discharge Rate (mL/min)	Dissolved Oxygen (mg/L)	pH	Eh/ORP (mV)	Temp (C)	Sp. Cond (umhos/cm/º C)	Turbidity (NTU)	Depth to Water (ft)

Notes: Sample can be collected following 3 consecutive readings with values within 10% of each other.
Purge rate should be < 500 mL/min and drawdown should be less than 0.3 foot.

Comments:

Day&Zimmermann
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Sheet ___ of ___

WELL DEVELOPMENT DATA SHEET

BORING NO. _____ **WELL NO.** _____

Project _____
Project No. _____
Date(s) of Installation _____
Date(s) of Development _____
Personnel/Company _____
_____
Type of Rig Used _____

Casing Diameter/Type _____
Borehole Diameter _____
Screened Interval(s) _____
Total Length of Well Casing_____
Measured Total Depth (TOC) Initial _____
Final _____
Initial Depth to Water
(TOC) _____ Date _____ Time _____
Stabilized Depth to Water
(TOC) _____ Date _____ Time _____

DEVELOPMENT

TECHNIQUE(S) EQUIPMENT TYPE/CAPACITY

____ Jetting (Airlift) _____
____ Surge Block _____
____ Bailing _____
____ Pumping _____
____ Other _____

FLUIDS ADDED

Lost Drilling Fluid:_____ Gallons
Lost Purge Water: _____ Gallons
Water During Installation:_____ Gallons
Total Fluids Added: _____ Gallons
Source of Added Water: _____
Ground Water Quality Parameters of
Added Water Measured: Y N
Sample Collected of Added Water: Y N
Sample Designation of Added Water: _____

PURGE VOLUME CALCULATION

Casing Volume: _____ Ft. of water
x _____ Gallons/Foot
= _____ Gallons per Single Casing Volume
Sand Pack Volume: _____ Ft. of Saturated Sand Pack
x _____Gallons/Foot (borehole diameter)
= _____ Gallons (in borehole)
- _____ Gallons of Casing Volume
= _____ x 0.3 (Assuming porosity = 30%)
= _____ Gallons Within Sand Pack
Single Purge Volume: _____ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: _____ Gallons
Actual Purge Volume: _____ Gallons
Volume Measured by: _____
Rate of Development _____ Gallons/Minute (Hour,Day)
Pumping Rate/Depth _____ @ _____ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness _____

INSTRUMENT CALIBRATION

pH Meter: _____ Spec. Conductance Meter:_____
pH 4.0 = _____ @ _____ °C Standard _____ µmhos/cm@ 25°C
pH 7.0 = _____ @ _____ °C Reading _____ µmhos/cm @ _____ °C
pH 10.0 = _____ @ _____ °C Turbidity Meter: _____
Dissolved Oxygen Meter: _____ Other: _____

Total Volume Discharged	Rate of Discharge	Time	Temp	pH	Specific* Conductance	Turbidity or D.O.	Clarity, Odor, PID Readings, Other:

Development Completed at _____ Gallons Discharged. Date: _____ Time: _____
Criteria: _____ Personnel: _____

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

Chain of Custody Record

Name:
Address:

Phone Number:

Page 1 of 1

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Project Account Code	Lab Matrix	Survey Location

Contact Person	Sampler(s) Signature	Survey Type	Survey Initiation Date	Sample Matrix

Sample ID	Date	Time	Composite / Grab	Equipment Used	Sample Location	No. of Containers	Analysis Required: Fecal Coliform	E. coli	TSS	CBOD5	TP, N-N, TKN, NH3	Orthophosphate	Metals (Cd, Cu, Pb, Ni, Zn)	Hexavalent Chromium	Hardness				Remarks

Relinquished By: Sampler	Date	Time	Accepted By: Field Runner	Date	Time	Remarks
Relinquished By: Field Runner	Date	Time	Received By: Laboratory	Date	Time	Remarks

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APPENDIX B

CALIBRATION FORM

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INSTRUMENT CALIBRATION CHECKLIST

Site: _____

Date: _____

Complete daily. Answer each question by checking the appropriate column (yes, no, or N/A). If a No is checked, provide explanation in the Corrective Actions section.

	Yes	No	N/A
1. Was the appropriate type of field equipment available on-site? List the equipment utilized on-site:	☐	☐	☐
Photoionization detector	☐	☐	☐
pH meter	☐	☐	☐
Specific conductivity meter	☐	☐	☐
Turbidimeter	☐	☐	☐
Other (specify):	☐	☐	☐
Other (specify):	☐	☐	☐
Other (specify):	☐	☐	☐
2. Was each piece of field equipment calibrated prior to the day's activities following the applicable SOP, manufacturer's instructions, and/or UFP-QAPP Worksheet #22 requirements?	☐	☐	☐
3. Was each piece of field equipment subjected to a continuing calibration verification at the end of the day to verify the linearity of the results?	☐	☐	☐
4. If an anomaly was detected during the day's activities, was the piece of field equipment subjected to a continuing calibration verification to verify the linearity of the results OR re-calibrated as applicable?	☐	☐	☐
5. If a piece of equipment continuously failed calibration requirements, was it removed from service and another piece of equipment calibrated and used during field activities?	☐	☐	☐

Corrective Actions:

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APPENDIX C

STANDARD OPERATING PROCEDURE (SOP) FOR GROUNDWATER SAMPLING USING LOW-FLOW METHODOLOGY

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SOP APPROVAL FORM

TETRA TECH, INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLE COLLECTION
USING LOW-FLOW SAMPLING METHODOLOGY

SOP NO. 015

REVISION NO. 2

Last Reviewed: November 2014

Carla J Bunk

Quality Assurance Approved	November 24, 2014 Date

1.0 BACKGROUND

Groundwater sample collection is an integral part of environmental site characterization. Groundwater samples must be collected from the aquifer and submitted to a laboratory for analysis. Therefore, samples must be collected and handled in a manner that minimizes alteration of the chemical characteristics of the groundwater.

In the past, most sample collection techniques followed federal and state guidance that included removing water in the casing of a monitoring well (purging), followed by sample collection. The water in the casing was removed so that groundwater from the formation could flow into the casing and be available for sample collection. Samples were commonly collected with a bailer, bladder pump, controlled flow impeller pump, or peristaltic pump. Depending on the analysis, samples were often preserved during collection. Often, samples to be analyzed for metals were filtered through a 0.45-micron filter before they were preserved and placed into the sample container.

Research conducted by several investigators has demonstrated that movement of contaminants while sorbed onto colloid particles constitutes a significant component of contaminant transport. Colloid mobility in an aquifer is a complex, aquifer-specific transport issue, and its description is beyond the scope of this standard operating procedure (SOP). However, concentrations of suspended colloids have been measured during steady-state conditions and during purging. Investigation results indicate that standard purging procedures may cause a significant increase in suspended colloids, which in turn may bias analytical results.

Low-flow sample collection (also known as micropurge, low-stress, or minimal drawdown) is a groundwater sampling method that minimizes increased colloid mobilization by removing water from a well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. During low-flow sampling, groundwater is discharged from the aquifer at a rate that minimizes the cone of depression around the sampled well (a rate of discharge less than or equal to the rate of recharge). Research indicates that colloid mobilization will not increase above steady-state conditions during low-flow discharge. Therefore, a groundwater sample collected using this method is more likely to represent steady-state groundwater chemistry.

1.1 PURPOSE

The purpose of this SOP is to describe the procedures to be used to collect a groundwater sample from a well using low-flow sampling methodology. The following sections describe the equipment to be used and the methods to be followed to promote uniform sample collection techniques. Sampling is to be conducted by field personnel who are experienced in sample collection and handling for environmental investigations.

1.2 SCOPE

This SOP applies to groundwater sampling using low-flow sampling methodology. It is intended to be used as an alternate SOP to SOP No. 010 (Groundwater Sampling). This SOP provides procedures for various methods of low-flow sample collection. The type of sampling pump to be used should be specified in the project-specific work plan or field sampling plan (FSP).

1.3 DEFINITIONS

Colloid: Suspended particles that range in diameter from 5 nanometers to 0.2 micrometers.

Dissolved oxygen: The ratio of the concentration or mass of oxygen in water relative to the partial pressure of gaseous oxygen above the liquid, which is a function of temperature, pressure, and the concentration of other solutes.

Flow-through cell: A device connected to the discharge line of a groundwater purge pump that allows regular or continuous measurement of selected parameters of the water and minimizes contact between the water and air.

pH: A measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to 7. The pH is equal to $-\log_{10} c$, where c is the hydrogen ion concentration in moles per litre.

Oxidation-reduction potential: A numerical index of the intensity of oxidizing/reducing conditions within a system, with the hydrogen-electrode potential serving as a reference point of zero volts.

Specific conductance: The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of aqueous solution at a specified temperature.

Turbidity: A measurement of the suspended particles in a liquid that have the ability to reflect or refract part of the visible portion of the light spectrum.

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA), Office of Research and Development. April 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. Publication: EPA/540/S-95/504. Accessed at: http://www.agsolve.com.br/pdf/artigos/407EPA.pdf

EPA, Office of Solid Waste and Emergency Response. May 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Publication: EPA542-S-02-001. Accessed at: http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf

EPA, Science and Ecosystem Support Division. March 2013. *Operating Procedure – Groundwater Sampling*. Publication SESDPROC-301-R3. Accessed at: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf

1.5 REQUIREMENTS AND RESOURCES

The following equipment is required to complete low-flow groundwater sample collection:

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, or impeller)
- Power source for the pump (such as a battery or generator, or compressed air source)
- Discharge flow controller
- Flow-through cell
- pH probe
- Dissolved oxygen (DO) probe
- Turbidity meter
- Oxidation-reduction potential (ORP) probe (if required – see Section 2.1)
- Specific conductance (SC) probe
- Temperature probe
- Meter to display data for the probes

- Calibration solutions for pH, SC, turbidity, ORP, and DO probes, as necessary
- Container of known volume for flow measurement or calibrated flow meter
- Data recording and management system

2.0 PROCEDURE

The following procedures and criteria are based on EPA guidance titled Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (1996) and Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers (2002). These references may be consulted for a more detailed description of low-flow sampling theory.

Low-flow groundwater sampling is most commonly accomplished with low discharge-rate pumps, such as bladder pumps, piston pumps, controlled velocity impeller pumps, or peristaltic pumps. Bailers and high-capacity submersible pumps are not considered acceptable low-flow sample collection devices. The purged water is monitored (in a flow-through cell or other constituent monitoring device) for chemical and optical parameters that indicate steady-state flow conditions between the sample extraction point and the aquifer. Samples are collected when steady-state conditions are indicated.

Groundwater extraction equipment may be permanently installed in the monitoring well as a dedicated system, or it may be brought on site by the sampling team for temporary groundwater sampling. Most investigators agree that dedicated systems will provide the best opportunity for collecting samples most representative of steady-state aquifer conditions, but the scope and budget of a particular investigation will dictate equipment selection.

2.1 EQUIPMENT CALIBRATION

Before samples are collected, the monitoring meters used to measure pH, ORP (if required), DO, turbidity, and SC should be calibrated according to manufacturers' directions. (See SOP No. 061 for procedures regarding the measurement of groundwater indicator parameters.) All meters should be calibrated each day before sampling occurs. Before the meters are calibrated, be sure to record the expiration date of the calibration solutions and their identifying lot numbers. The pH meter calibration should bracket the pH range of the wells to be sampled (acidic to neutral pH range [4.00 to 7.00] or neutral to basic pH range [7.00 to 10.00]). It is common to use either a 2-point or a 3-point calibration for

pH. The DO meter should be calibrated to one point (air-saturated water) or two points (air-saturated water and water devoid of all oxygen).

The SC meter and turbidity meter cannot be calibrated in the field; instead, they are checked against a known standard. The offset of the measured value of the calibration standard can be used as a correction value. Samplers should refer to project- or region-specific guidance regarding the use of ORP as a stabilization parameter. The ORP probe, if used, cannot be calibrated in the field, but is checked against a known standard (such as Zobell solution). The instrument should display a millivolt (mV) value that falls within the range set by the manufacturer. The measured value should be corrected for site-specific variance from standard temperature (25 °C) because ORP is temperature dependent. The ORP probe should be replaced if the reading is not within the manufacturer's specified range. All calibration data should be recorded on the Low-Flow Groundwater Sampling Data Sheet (example included as Figure 1), in a digital format, or in a field logbook.

2.2 WELL PURGING

The well to be sampled should be opened, and groundwater in the well allowed to equilibrate to atmospheric pressure. Equilibration should be determined by measuring the depth to water below the marked reference at the well. This reference point (which is typically the top of the well casing, but can be also be referenced to ground surface) is generally specified in the sampling protocol for the particular job, event, or client. Ground water level readings are taken over two or more 5-minute intervals. Equilibrium conditions exist when the measured depth to water varies by less than 0.01 foot over two consecutive readings. The measurement of the total depth of the well should be made after samples have been collected, unless the datum is required to place non-dedicated sample collection equipment. Depth to water and total well depth measurements should be made in accordance with procedures outlined in SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement).

If the well does not have a dedicated sample collection device, a new or previously decontaminated portable sample collection device should be inserted in the well. If non-dedicated sampling equipment is used, the least contaminated wells should be purged and sampled first and the most contaminated wells should be purged and sampled last (if past sampling data are available to make this determination). The intake of the device should be positioned at the midpoint of the well screen interval or the midpoint of the water column if the level is below the top of the well screen. The device should be installed slowly to minimize turbulence within the water within the casing and to minimize mixing of stagnant water above

the screened interval with water in the screened interval. After it has been installed, the flow controller should be connected to the sample pump, and the flow-through cell connected to the outlet of the sample collection device. The calibrated groundwater chemistry monitoring probes should be installed in the flow-through cell. If a flow meter is used, it should be installed ahead of the flow-through cell.

If the well has a dedicated sample collection device, the controller for the device should be connected to the sample pump. The flow meter and flow-through cell should be connected in line to the discharge tube and the probes installed in the flow-through cell.

The controller should be activated and groundwater extracted (purged) from the well. The purge rate should be monitored and should not exceed the recharge capacity of the well. The well recharge capacity is defined as the maximum discharge rate that can be obtained with less than 0.1 meter (0.33 foot) drawdown. The maximum purge rate should not exceed 1 liter per minute (L/min) (0.25 gallon per minute) and should be adjusted to achieve minimal drawdown.

Water levels, effluent parameters, and flow rate should be continuously monitored while the well is purged. Purging should continue until the measured chemical and optical parameters are stable. Stable parameters are defined as monitored chemistry values that do not fluctuate by more than the following ranges over three successive readings at 3- to 5-minute intervals:

- pH ±0.1 unit
- SC ±3 percent
- Turbidity ±10 percent, when greater than 10 nephelometric turbidity units (NTUs)
- DO ±10 percent or 0.3 milligrams per liter (mg/L)
- ORP ±10 mV (if required)
- Temperature (while listed in EPA guidance, this parameter is described as the least important and is not required to be stable if all other parameters have been met)

Purging will continue until these stabilization criteria have been met, excluding temperature, or three well casing volumes have been purged. If three casing volumes of water have been purged and the stabilization criteria have not been met, a comment should be made on the data sheet that sample collection began after three well casing volumes were purged.

The volume of water in the well is based on the following formula:

$$V = \pi r^2 h \times 7.48$$

where

V	=	static volume of water in the well (gallons)
r	=	inside radius of the well (feet)
h	=	length of water in the well (total well depth minus depth to water) (feet)
7.48	=	conversion factor (cubic feet to gallons)

Common well diameter sizes and corresponding volumes are listed below.

- 1-inch well = h x 0.041 gallons per foot (gal/ft)
- 2-inch well = h x 0.163 gal/ft
- 3-inch well = h x 0.367 gal/ft
- 4-inch well = h x 0.652 gal/ft

For wells with water table screen intervals: If a stabilized drawdown in the well cannot be maintained within 0.33 foot or the water level is approaching the bottom of the screened interval, reduce the flow rate or turn the pump off for 15 minutes and allow for recharge. The well should not be pumped dry. Resume pumping at a lower flow rate; if the water draws down to the bottom of the screened interval again, turn the pump off and allow for recovery. If sufficient yield cannot be obtained, consider an alternative sampling method.

For wells with submerged or targeted screen intervals: If a stabilized drawdown in the well cannot be maintained within 0.33 foot or the water level is approaching the top of the screened interval, reduce the flow rate, or turn the pump off for 15 minutes, and allow for recovery. The well should not be pumped dry. Resume pumping at a lower flow rate; if the water draws down to the top of the screened interval again, turn pump off and allow for recovery. If sufficient yield cannot be obtained, consider either further drawdown or an alternative sampling method.

Wells that are slow to recharge should be identified and purged at the beginning of the workday to maximize the efficiency of field work. Samples should be collected from these wells within the same workday. Professional judgment should be exercised regarding representative groundwater sample collection from wells that recharge slowly.

The final pH, SC, ORP (if required), turbidity, and DO values should be recorded. All data should be recorded using the Low-Flow Groundwater Sampling Data Sheet (Figure 1), a data entry form on a personal digital assistant (PDA), or in a field logbook.

2.3 SAMPLE COLLECTION

After the well has been purged, the flow-through cell (and any flow meter) will be disconnected, and groundwater samples should be collected directly from the discharge line. Discharge rates should be adjusted so that groundwater is dispensed into the sample container with minimal aeration of the sample. Samples collected for analysis of volatile organic compounds (VOCs) should be dispensed into the sample container at a flow rate equal to or less than 100 milliliters per minute. Samples collected with the use of a peristaltic pump for VOC analysis may require collection by the "soda straw" method or other approved means that prevent the sample from being drawn through the latex portion of the hose.

The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (method A) or by filling it via suction applied by the pump head (method B). If method A is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method B is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Samplers should avoid completely emptying the tubing when filling the sample vials when using method B to prevent introducing water that was in contact with the flexible pump head tubing.

Samplers should also refer to project- or region-specific guidance when collecting VOC samples. Samples should be preserved and handled as described in the investigation field sampling plan or quality assurance project plan. Depending on the project-specific types of analyses required, the preferred order of sample collection is as follows:

1. Volatile organic compounds (VOCs)
2. Purgeable organic halogens (POXs)
3. Total organic halogens (TOXs)
4. Cyanide
5. Extractable organics
6. Purgeable organic carbon (POC)
7. Total metals

8. Dissolved metals
9. Total organic carbon (TOC)
10. Phenols
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

See SOP No. 010 (Groundwater Sampling) for more information on groundwater sample collection.

2.3 HEALTH AND SAFETY CONSIDERATIONS

In addition to the procedures outlined in this SOP, all field staff must be aware of and follow the health and safety practices that result from the Activity Hazard Analyses (AHA) for the project. The AHAs include critical safety procedures, required controls, and minimum personal protective equipment (PPE) necessary to address potential hazards. The hazards specific to project tasks must be identified and controlled to the extent practicable and communicated to all project personnel via the approved, project-specific Health and Safety Plan (HASP).

FIGURE 1

LOW-FLOW GROUNDWATER SAMPLING DATA SHEET

Date/Time of Sample Collection: _____/_____Project
Site/Subsite: _____
Sample ID: _____
Field ID: _____ Point Name: _____
Depth to Well Bottom: _____ ft. below top of casing (PVC cap)
Depth to Water Level: _____ ft. below PVC cap
Depth to Water Level: _____ ft. below PVC cap prior to sampling
Method of Purging: Bladder Pump ____ Submersible Pump ____
Peristaltic Pump ____
Static Well Volume: 1-inch well ____Gallons /2-inch well ____Gallons
Control Box Settings: Box # _____ Refill _____ Discharge _____
Throttle _____ psi
Total Purged: _____ Gallons
Actual Purge Rate: _____ Gallons/Min.

Purge Calculations

PHYSIO-CHEMICAL PARAMETERS DURING PURGING

Measure in order listed**	Initial Reading									Stabiliz-ation Criteria	Final
Time											
pH										+/-0.1	
Temperature (°C)										NC*	
Specific Conductance (µmhos/cm)										+/-3%	
Turbidity (NTU)										+/-10%	
Dissolved Oxygen (mg/L)										+/-10% or +/-0.3	
ORP (mV)										+/-10	
Volume Purged (Gal)											

*NC = No Criteria. **Stabilization criteria listed should be used unless project-specific plans specify alternate stabilization criteria.

Duplicate Sample Collected? No Yes (Sample ID of Duplicate) _____
MS/MSD Sample Collected? No Yes _____
Sample Remarks (odors, colors, sediment): _____
Comments: _____
Sample(s) Collected By: _____

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

STATIC WATER LEVEL, TOTAL WELL DEPTH,
AND IMMISCIBLE LAYER MEASUREMENT

SOP NO. 014

REVISION NO. 1

Last Reviewed: July 2009

	July 2009
Quality Assurance Approved	Date

1.0 BACKGROUND

Measurement of static water level, total well depth, and any immiscible layers is necessary before a well can be sampled and groundwater flow direction can be determined. If an immiscible layer is present, its depth and thickness must be determined. In addition, the static water level and total depth of a monitoring well are often needed to determine a purging volume prior to sampling.

1.1 PURPOSE

This standard operating procedure (SOP) provides guidelines for field personnel measuring: (a) static water levels, (b) total water depths, and (c) immiscible layers in monitoring wells or piezometers.

1.2 SCOPE

This SOP describes the methodologies for measuring static water level, total well depth, and immiscible layer depth and thickness.

1.3 DEFINITIONS

Electrical Water Level Meter: An electrical probe used to determine the depth to fluid. The probe has a light or sound alarm connected to an open circuit. The circuit is closed and the alarm is activated when the probe contacts a conducting fluid such as water.

Immiscible Layer: A liquid phase that cannot be uniformly mixed or blended with water. Heavy immiscible phases or dense nonaqueous-phase liquids (DNAPL) sink in water; light immiscible phases or light nonaqueous-phase liquids (LNAPL) float on water.

Interface Probe: An electrical probe used to determine the presence and thicknesses of LNAPL or DNAPL in the water column of a monitoring well.

Ionization Detector: A photoionization detector (PID) or a flame ionization detector (FID) is used to measure the level of volatile organic compounds (VOC) in the gaseous phase. Ionization detectors are generally not compound-specific and thus measure only total volatile organic compounds. A PID generally cannot detect as complete a range of compounds as the FID. This difference is the result of the relative ionization energies of the two detectors. Most PIDs cannot detect methane, but FIDs can. The

Photovac and Minirae are examples of PIDs; the Foxboro organic vapor analyzer (OVA) is an example of an FID.

Static Water Level: The level of water in a monitoring well or piezometer left open and allowed to stabilize by equilibrating to existing atmospheric pressure prior to measuring. The static water level can be measured as the depth to water or as the elevation of water relative to a reference mark or datum.

Total Well Depth: The distance from the ground surface to the bottom of a monitoring well or piezometer

1.4 REFERENCES

Tetra Tech EM Inc. 2009. SOP No. 002, General Equipment Decontamination

U.S. Environmental Protection Agency (USEPA). 2007. "Groundwater Level and Well Depth Measurement." Region 4, Field Branches Quality System and Technical Procedures. November 1. http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Level-Measurement.pdf

U.S. EPA. 2000. "Manual Water Level Measurement." Environmental Response Team. SOP #2043 (Rev. #0.0, 02/11/00). http://www.dem.ri.gov/pubs/sops/wmsr2043.pdf

1.5 REQUIREMENTS AND RESOURCES

The equipment required for measuring static water levels, total well depths, and immiscible layers is as follows:

- Electrical water level meter
- Interface probe
- PID or FID
- Decontamination supplies (wash and rinse solutions, buckets, paper towels, etc.)
- Keys or wrenches for well locks and well caps
- Light source such as a flashlight or mirror to inspect inside well vaults

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific health and safety plan
- Appropriate signage and traffic control to protect personnel during monitoring activities

2.0 PROCEDURES

This section provides general guidance followed by specific procedures for measurement of static water level, total well depth, and immiscible layer.

Procedures for measuring the depth to water and the depth to the bottom of a monitoring well should be identified in the planning stage of field work. Also at this stage, measuring devices should be chosen, and an individual should be assigned to take and record measurements.

All measurement instruments should be decontaminated before and after use and between measurement locations. Refer to SOP No. 002, General Equipment Decontamination. In addition, as a general rule wells with the lowest known contaminant concentrations should be measured first followed by progressively more contaminated wells. This technique helps avoid cross-contamination from a more contaminated water source to a less contaminated water source resulting in inaccurate or false sample analytic results.

Before initiating any measuring activities, the ambient air at a monitoring well head should be monitored for possible emissions of VOCs using a PID or an FID. The site-specific health and safety plan for on-site activities should provide action levels and the rationale for selection of the appropriate ionization detector.

The sampling team should wear appropriate respiratory protection equipment when necessary. The sampling team should approach wells from the upwind side and systematically survey the inside of the well casing, the area from the casing to the ground, the area from above the well casing to the breathing zone, and the area around the well for VOCs. VOC monitoring for comparison to action levels should occur in the breathing zone(s) rather than from within the well casing. If PID or FID readings of VOCs are above action levels, the sampling team should retreat to a safe area and determine if engineering controls, increased PPE, or both are necessary to reduce exposure to VOCs above action levels listed in the site-specific health and safety plan.

Sampling team should be careful when opening a well to check for insects or reptiles within the protective casing and use appropriate work gloves when reaching inside. The site-specific health and safety plan should be consulted for information on insects or reptiles that may be present in the project area.

2.1 STATIC WATER LEVEL MEASUREMENT

An electric water level meter is typically used to measure static water levels. The electrical probe of the meter is lowered into the monitoring well until the light or sound alarm is activated indicating the probe has touched the water surface. To ensure accuracy, the well or piezometer should be opened to allow groundwater in the well to equilibrate with atmospheric pressures before measuring depth to water. Ideally, static groundwater measurements will be collected prior to purging or sampling activities. The static water level is read directly from the graduated tape on the meter to the nearest 0.01-foot. Two to three measurements should be taken over several minutes to ensure water levels are not fluctuating. If water levels continue to fluctuate, the groundwater has not equilibrated or become static. Measurements should continue until static water levels readings are obtained before recording a final measurement. If the monitoring well top is not flush with the ground surface, the distance between the static water level and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth to static water below ground surface. Surveyed elevations should be used if available to establish the water level elevation. The well number, measurement date and time, and individual readings should be recorded in a field logbook.

2.2 TOTAL WELL DEPTH MEASUREMENT

Total well depth can also be measured using an electric water level meter. The electrical probe of the indicator is lowered into the monitoring well until resistance is met, indicating that the probe has reached the bottom of the well. During measurement, the probe should be positioned in the well so that resistance is met, but there is no slack in the measuring tape. The total well depth is read directly from the graduated tape on the indicator to the nearest 0.01-foot. Measurements become less accurate with increased depth as the length of measuring tape deployed increases and the distance under the water column increases making it more difficult to determine if the bottom of the well has reached. In this circumstance, a weighted water level meter or measuring tape may be necessary to allow the user to “feel” the bottom of the well. Care should be taken to ensure the use of only inert and chemical-free weighted devices such as stainless steel are used. If the monitoring well top is not flush with the ground surface,

the distance between the bottom of the well and the top of the riser pipe should be measured; the height of the riser pipe above ground surface should then be subtracted from the first measurement to determine the depth from ground surface to the bottom of the well. The well number, measurement date and time, and individual readings should be recorded in a field logbook.

2.3 IMMISCIBLE LAYER DETECTION AND MEASUREMENT

A LNAPL immiscible layer in a monitoring well can be detected by slowly lowering an interface probe to the surface of the water in the well. When the audible alarm sounds, the depth of the probe should be recorded. If the alarm is continuous, a light immiscible layer has been detected. To measure the thickness of this layer, the probe should then be slowly lowered until the alarm changes to an oscillating signal. The oscillating alarm indicates that the probe has reached a water layer. The probe depth at the time the alarm begins oscillating should be recorded as the depth to water. The thickness of the light immiscible layer should then be determined by subtracting the depth at which a continuous alarm occurred from the depth at which the alarm began to oscillate. The well number, measurement date and time, individual readings for depth and thickness, and average values for depth and thickness should be recorded in a field logbook.

To determine whether a DNAPL immiscible layer is present, the interface probe is lowered into the monitoring well and allowed to slowly drop below the water causing an oscillating alarm. If the alarm changes from an oscillating to a continuous signal, a heavier immiscible layer has been detected, and the probe depth should be recorded at that point. Total well depth obtained in Section 2.2 should be used for calculating the thickness of the DNAPL layer within the well casing. The DNAPL layer is then calculated by subtracting the depth at which the alarm became continuous from the total well depth. This procedure provides an estimate of the thickness of the DNAPL layer in the monitoring well. The well number, measurement date and time, and individual readings for depth and thickness should be recorded in a field logbook.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF GROUNDWATER INDICATOR PARAMETERS

SOP NO. 061

REVISION NO. 2

Last Reviewed: July 2009

	July 2009
Quality Assurance Approved	Date

1.0 BACKGROUND

Various water quality monitoring systems can be used for determining groundwater indicator parameters in the field. Commonly measured field indicator parameters include pH, specific conductance, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO) and turbidity. Groundwater field measurements are typically collected in conjunction with groundwater sampling or monitoring well development (see SOPs 010, 015, and 021).

Various types of water quality systems exist including down-hole systems and flow through cells. Tetra Tech used several common water quality meters including various types of In-Situ, YSI, Hydac, and Horiba meters (see Figure 1 at the end of this SOP). The sampling team should select the type of meter or monitoring system based on site-specific conditions including data collection needs, the types of wells being sampled, and the sampling procedures used. Multiple parameter systems should be used when multiple field parameters are to be measured.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the general requirements and procedures for using various water quality monitoring systems for determining groundwater pH, specific conductance, temperature, ORP, DO and turbidity in the field.

1.2 SCOPE

This SOP applies to general procedures for calibrating and operating water quality monitoring systems in the field. The project work plan or field sampling plan should identify the types of systems to be used and the actual project-specific field parameters to be measured. For each type of water quality system, the manufacturer's manual should be consulted for specific operating instructions.

1.3 DEFINITIONS

Single Parameter System: A meter or monitoring system consisting of a single probe designed to measure a single indicator parameter.

Multiple Parameter System: A meter or monitoring system consisting of multiple probes capable of measuring multiple indicator parameters.

Open Container Measurements: Field measurements performed in an open container such as a cup, a jar, or a bucket where an air/water interface exists.

Flow-Through Chamber or Cell: A plastic cell or chamber connected to the sample pump discharge tubing so that a continuous flow of water passes across the probes. Additional tubing is used to route water from the flow-through cell to a waste container or final discharge point.

Down-Hole Monitoring System: A meter or monitoring system where probes are submerged by inserting them into the well. The probes are attached to the meter (located at the well head or ground surface) by one or more cables.

pH: A measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14 with strongly acidic solutions at the low end, strongly basic solutions at the high end, and "pure" or neutral water at 7. Field measurements of pH are recorded in standard units.

Specific Conductance: The ability of a solution to conduct electricity; a measure of the solution's ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity. Conductivity of the same water changes substantially with temperature. Specific conductivity is generally found to be a good measure of the concentration of total dissolved solids (TDS) and salinity. Conductivity is measured by placing two electrodes (with opposite electrical charge) in the water. For a known electrical current, the voltage drop across the electrodes reveals the solution's resistance. Since the resistance of aqueous solution changes with temperature (resistance drops with increasing temperature), the resistance is corrected to the resistance of the solution at 25 ºC. Field measurements are recorded in units of microsiemens per centimeters (µS/cm).

Temperature: The degree of hotness or coldness of the solution being measured. Field measurements are typically recorded in degrees Celsius (°C).

ORP: ORP, or redox potential, is the tendency of a chemical species to acquire electrons and be reduced. In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when new chemical species are introduced. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (to be oxidized by reducing the new species). Just as the transfer of hydrogen ions between chemical species determines the pH of an aqueous solution, the transfer of electrons between chemical species determines the reduction potential of an aqueous solution. Like pH, the reduction potential represents an intensity factor. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity. Field measurements are typically recorded in millivolts (mV).

DO: Dissolved oxygen (or oxygen saturation) is a relative measure of the amount of oxygen dissolved or carried in a given medium. In aquatic environments, dissolved oxygen is a relative measure of the amount of oxygen (O_2) dissolved in the water. Field measurements are typically recorded in milligrams per liter (mg/L).

Turbidity: Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids). Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand, very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid. Field measurements are typically recorded in Nephelometric Turbidity Units (NTU).

1.4 REFERENCE

Essential Handbook of Ground-Water Sampling by Gillian Nielsen, 2007.

Tetra Tech EM Inc. July 2009. SOPs 010, 015, and 021

1.5 REQUIREMENTS AND RESOURCES

The following items are typically required to measure groundwater pH, specific conductance, temperature, ORP, DO, and turbidity using this SOP:

- Single or multiple parameter water quality measuring system
- Specific conductance calibration solutions
- Buffer solutions of pH 4, 7, and 10 for pH calibration
- Distilled or deionized water
- Rinse bottle
- 50-milliliter (mL) sample cups or beakers
- Sample tubing and connectors (specific to each type of system)
- Waste container to collect purge water
- Logbook or field data sheets

2.0 PROCEDURES

The procedures outlined in this SOP are general and may apply to various types of water quality monitoring systems to measure groundwater pH, specific conductance, temperature, ORP, DO and turbidity in the field. General procedures for testing and calibrating the monitoring systems are presented first, followed by procedures for using the instruments and making field measurements. Each particular monitoring system should be identified in the project work plan or field sampling plan and should be operated in accordance with the manufacturer's instruction manual.

2.1 TESTING AND CALIBRATION PROCEDURES

Each field meter or monitoring system should be calibrated according to manufacturer's specifications. In general, equipment should be thoroughly cleaned then calibrated and tested before the start-up of sampling at each site. Equipment should be calibrated and tested using manufacturer provided solutions and standards. Care should be taken to rinse the probes between testing and calibration to prevent cross contaminating solutions. Solutions should be poured from the manufacturer's container into another container to prevent compromising the entire solution provided by the manufacturer. Calibration and testing of field equipment should be documented each time it is performed in field logbooks (or field data sheets, if applicable). If testing and calibration measurements are out of tolerance, the instrument must be serviced or repaired.

2.2 FIELD MEASUREMENT PROCEDURES

Each field meter or monitoring system should be operated according to manufacturer's specifications. The actual field procedures will vary depending on the type of monitoring system being used (open container systems, flow-through cell systems, or down-hole systems) and the types of field parameters being measured. In addition, most systems include a data logging option. A description of open container, flow-through cell, and down-hole measurement processes are discussed below, followed by a general procedural summary and a summary of common errors associated with field measurements of indicator parameters.

2.2.1 Open Container Measurements

Open container measurements consist of collecting groundwater and placing it in a cup or container for field measurements using a hand held system. This method of field measurements is commonly used when bailing wells, but can also be used when pumping wells. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications. Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan. To make open container field measurements, samplers collect groundwater from the well and place in a cup or container large enough to adequately submerge the probe or probes, as specified in the manufacturer's operations manual. For open containers, measurements should be taken in the following order: temperature, specific conductance, pH, and turbidity. Open container systems are not recommended for low-flow sampling as flow-through systems are more appropriate. The probes and

cup or container should be thoroughly rinsed after each field measurement and between sampling locations.

2.2.2 Flow-Through Cell Measurements

Flow-through cell systems consist of measuring groundwater parameters as a continuous flow of water passes across the probes through a cell or chamber, and is primarily used when pumping wells and using low-flow sampling procedures. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications. Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan.

The flow-through cell or chamber is placed "in line" between the discharge tubing of the pump and the container used to collect purged water. The outlet from the pump must be connected to the sample chamber input. The sample chamber outlet must then be connected or routed to a waste container (or to another designated discharge point). Tubing, fittings, and adaptors are generally required and may be provided by the manufacturer. Pump discharge tubing and chamber inlets and outlets are typically 1/2 or 3/8 inch diameter.

After the cell or chamber is connected to the pump discharge tubing and waste collection container, the sensors should be inserted into the sensor mounting plate in their respective ports. Any unused sensor ports must have plugs installed to close off the sample chamber. The probe cables are then connected to the meter following manufacturer's specifications.

With the system connected, the sampler should turn on the pump according to the manufacturer's instructions and then turn on the water quality monitor. Before recording any values, the sample chamber should be full, all air should be voided, and all of the displayed values should be stable. The probes and sample chamber should be thoroughly rinsed between sampling locations.

2.2.3 Down-Hole Measurements

Down-hole measurement systems consist of inserting the probes (or a multi-parameter sensor housing) inside a well to obtain field measurements, and is primarily used when pumping wells. Prior to field measurements, the equipment must be cleaned and calibrated following manufacturer's specifications.

Field measurements should then be made at the frequency and for the indicator parameters specified in the project work plan or field sampling plan.

The probes or sensor are attached to a hand held meter or control unit by a cable and lowered inside the well to be sampled. Limiting factors when using down-hole systems include probe or sensor diameters and available cable lengths. The probes should be thoroughly decontaminated between sampling locations...

2.2.4 General Procedures for Field Measurements of Indicator Parameters

The following section discusses general procedures that typically apply to making field measurements of indicator parameters using various types of field instruments. Each particular type of meter or monitoring system should be identified in the project work plan or field sampling plan and should be operated in accordance with the manufacturer's instruction manual.

1. Inspect the instrument and batteries prior to the field effort.
2. Check the integrity of the buffer solutions used for field calibration since frequent replacement is necessary as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at proper levels and no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended) following manufacturer's instructions and record data in field logbook or on field data sheets.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to several minutes. If the parameter values continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be occurring in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize should be clearly noted in the logbook or field data sheet. For DO, provide for sufficient flow past the membrane by gently stirring the sample. Probes without stirrers placed in wells (down-hole measurements) may be gently moved up and down to achieve the required mixing.
6. Read and record the value of each parameter being measured making sure units of measure are clearly recorded.
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in accordance with manufacturer's instructions

2.2.5 Common Errors or Problems Associated With Field Measurements

The project work plan or field sampling plan should clearly identify the types of parameters to be measured, the measurement frequency, and "stabilization" requirements. It is essential to ensure that the type of monitoring system selected is compatible with the monitoring well sampling or development methods to be utilized. Some common errors to avoid are identified below:

- No, or incorrect equipment calibration
- Incorrect or expired calibration standards
- Poor equipment maintenance
- Inadequate training or unfamiliarity with equipment
- No record of units of measure and "+" or "-" values for ORP
- Too much time taken to measure temperature sensitive parameters
- DO and ORP measured in closed systems (flow-through cell or down-hole) instead of closed cell systems

FIGURE 1

THE HORIBA U-10 WATER QUALITY MONITORING SYSTEM
THE IN-SITU TROLL 9500 LOW-FLOW SYSTEM
THE YSI HAND HELD 556 METER

Horiba U-10

In-Situ Troll

YSI 556

E-2

CHECKLIST FOR REVIEW OF FEDERAL RCRA PERMIT APPLICATION

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SECTION E. GROUNDWATER MONITORING

Section and Requirement		Federal Regulation	Review Consideration[a]	Location in Application[b]	See Attached Comment Number[c]
E-1	Exemption from Groundwater Protection Requirements	270.14(c)		Section E-1	
E-1a	Waste Piles	270.18(b); 264.90(b)(2), (5)		NA	
E-1b	Landfill	270.14(c); 264.90(b)(2)		NA	
E-1c	No Migration	270.14(c); 264.90(b)(4)		NA	
E-1d	Drip Pad	270.26(b); 264.90(b)(2)		NA	
E-2	Interim Status Groundwater Monitoring Data	270.14(c)(1)		NA	
E-2a	Description of Wells	270.14(c)(1)	A copy of topographic map provided for 270.14(b) on which location and identification of each interim status monitoring well is indicated. Details of design and construction of each interim status monitoring well.	NA	
E-2b	Description of Sampling and Analysis Procedures	270.14(c)(1); 265.92	A copy of facility's groundwater sampling and analysis plan.	NA	
E-2c	Monitoring Data	270.14(c)(1); 265.92	Provide all interim status monitoring results.	NA	
E-2d	Statistical Procedures	270.14(c)(1); 265.93	Provide information relating to statistical procedures.	NA	
E-2e	Groundwater Assessment Plan	270.14(c)(1); 265.93(d)(2)	If required, based on statistical comparison results, provide specific plan for groundwater quality assessment program along with results obtained from implementation of plan.	NA	
E-3	General Hydrogeologic Information	270.14(c)(2)	Include description of regional and site-specific geologic and hydrogeological setting.	Section E-3	
E-4	Topographic Map Requirements	270.14(c)(2), (3),(4)(i)		Section E-4	
E-5	Contaminant Plume Description	270.14(c)(2), (4),(7)	In some cases, contaminant plumes may be defined under groundwater quality assessment programs carried out during interim status period which may not address complete list of Appendix VIII constituents as required under 270.14(c)(4). Additional monitoring may be required to identify concentration of each Appendix VIII constituent in plume.	Section E-9	
E-6	General Monitoring Program Requirements	270.14(c)(5); 264.90(b)(4); 264.97		Section E-9	
E-6a	Description of Wells	270.14(c)(5); 264.97(a),(b),(c)		Section E-9	
E-6b	Description of Sampling and Analysis Procedures	270.14(c)(5); 264.97(d),(e),(f)		Section E-9	

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SECTION E. GROUNDWATER MONITORING

Section and Requirement		Federal Regulation	Review Consideration[a]	Location in Application[b]	See Attached Comment Number[c]
E-6c	Procedures for Establishing Background Quality	270.14(c)(5); 264.97(a)(1),(g)		Section E-9	
E-6d	Statistical Procedures	270.14(c)(5); 264.97(h), (i)(1),(5),(6)		Section E-9	
E-6d(1)	Parametric Analysis of Variance (ANOVA)	270.14(c)(5); 264.97(h)(1), (i)(2)		NA	
E-6d(2)	Nonparametric ANOVA (based on ranks)	270.14(c)(5); 264.97(h)(2), (i)(2)		NA	
E-6d(3)	Tolerance or Prediction Interval Procedure	270.14(c)(5); 264.97(h)(3), (i)(4)		NA	
E-6d(4)	Control Chart Approach	270.14(c)(5); 264.97(h)(4), (i)(3)		NA	
E-6d(5)	Alternative Approach	270.14(c)(5); 264.97(h)(5),(i)		NA	
E-7	Detection Monitoring Program	270.14(c)(6); 264.91(a)(4); 264.98		NA	
E-7a	Indicator Parameters, Waste Constituents, Reaction Products to be Monitored	270.14(c)(6) (i); 264.98(a)		NA	
E-7b	Groundwater Monitoring System	270.14(c)(6) (ii); 264.97(a) (2),(b),(c); 264.98(b)	Identify number, location, and depth of each well, and describe well construction materials.	NA	
E-7c	Background Groundwater Concentration Values for Proposed Parameters	270.14(c)(6) (iii); 264.97 (g); 264.98(c), (d)		NA	
E-7d	Proposed Sampling and Analysis Procedures	270.14(c)(6) (iv); 264.97 (d),(e),(f); 264.98(d),(e), (f)		NA	
E-7e	Statistically Significant Increase in any Constituent or Parameter Identified at any Compliance Point Monitoring Well	270.14(c)(6); 264.98(g); Part 264 Appendix IX		NA	
E-8	Compliance Monitoring Program	270.14(c)(7); 264.99		NA	

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SECTION E. GROUNDWATER MONITORING

Section and Requirement		Federal Regulation	Review Consideration[a]	Location in Application[b]	See Attached Comment Number[c]
E-8a	Waste Description	270.14(c)(7)(i)	Description must include historical records of volumes, types, and chemical composition of waste placed in units in waste management areas.	NA	
E-8b	Characterization of Contaminated Groundwater	270.14(c)(7)(ii)	For each well at point of compliance and for each background well, provide concentrations of each constituent in 261 Appendix VIII, major cations and anions, and constituents listed in Table 1 of 264.94, if not already mentioned above.	NA	
E-8c	Hazardous Constituents to be Monitored in Compliance Program	270.14(c)(7) (iii); 264.98 (g)(3); 264.99(a)(1)		NA	
E-8d	Concentration Limits	270.14(c)(7) (iv); 264.94, 264.97(g),(h); 264.99(a)(2)		NA	
E-8e	Alternate Concentration Limits	270.14(c)(7) (iv); 264.94 (b); 264.99(a)(2)	Provide justification for establishing alternate concentration limits. Justification must address the following two factors.	NA	
E-8e(1)	Adverse Effects on Groundwater Quality	270.14(c)(7)(iv); 264.94(b)(1)		NA	
E-8e(2)	Potential Adverse Effects	270.14(c)(7)(iv); 264.94(b)(2)		NA	
E-8f	Engineering Report Describing Groundwater Monitoring Systems	270.14(c)(7) (v); 264.95; 264.97(a)(2), (b),(c); 264.99(b)	Provide details supporting representative nature of groundwater quality at background monitoring points and compliance monitoring point.	NA	
E-8g	Proposed Sampling and Statistical Analysis Procedures for Groundwater Data	270.14(c)(7)(vi); 264.97(d),(e),(f); 264.99(c) - (g)		NA	
E-8h	Groundwater Protection Standard Exceeded at Compliance Point Monitoring Well	270.14(c)(8); 264.99(h),(i)		NA	
E-9	Corrective Action Program	270.14(c)(8); 264.99(j); 264.100		Section E-9	

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SECTION E. GROUNDWATER MONITORING

Section and Requirement		Federal Regulation	Review Consideration[a]	Location in Application[b]	See Attached Comment Number[c]
E-9a	Characterization of Contaminated Groundwater	270.14(c)(8)(i)	For each well at point of compliance and for each background well, provide concentrations of each constituent in 261 Appendix VIII, major cations and anions, and constituents listed in Table 1 of 264.94, if not already determined by the above.	Section E-9a	
E-9b	Concentration Limits	270.14(c)(8)(ii); 264.94; 264.100(a)(2)		Section E-9b	
E-9c	Alternate Concentration Limits	270.14(c)(8)(ii); 264.94(b); 264.100(a)(2)	Provide justification for establishing alternate concentration limits. Justification must address the following two factors.	NA	
E-9c(1)	Adverse Effects on Groundwater Quality	270.14(c)(8); 264.94(b)(1)		Section E-9c(1)	
E-9c(2)	Potential Adverse Effects	270.14(c)(8); 264.94(b)(2)		Section E-9c(2)	
E-9d	Corrective Action Plan	270.14(c)(8)(iii); 264.100(b)	Provide detailed plans and engineering report on corrective actions proposed for facility, including maps of engineered structures, construction details, plans for removing waste, description of treatment technologies, effectiveness of correction program, description of reinjection system, additional hydrogeologic data, operation and maintenance plans, and closure and post-closure plans.	Section E-9d	
E-9e	Groundwater Monitoring Program	270.14(c)(8)(iv); 264.100(d)		Section E-9e	
E-9e(1)	Description of Monitoring System	270.14(c)(7)(v),(8)		Section E-9e(1)	
E-9e(2)	Description of Sampling and Analysis Procedures	270.14(c)(7)(v),(8)		Section E-9e(2)	
E-9e(3)	Monitoring Data and Statistical Analysis Procedures	270.14(c)(7)(v),(8)		Section E-9e(3)	
E-9e(4)	Reporting Requirements	270.14(c)(7); 264.100(g)		Section E-9e(4)	

Notes:

[a] Considerations in addition to the requirements presented in the regulations.
[b] For each requirement, this column must indicate one of the following: NA for not applicable, IM for information missing, or the exact location of the information in the application.
[c] If application is deficient in an area, prepare a comment describing the deficiency, attach it to the checklist, and reference the comment in this column.