Long-Term Monitoring Plan
Revision 1
KRY Site, Kalispell, Montana

Prepared for

BNSF Railway Company
Helena, Montana

Prepared by

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Project Number: 231385

May 5, 2015

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May 5, 2015

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1.0 INTRODUCTION

This Long-Term Monitoring Plan (Plan) has been prepared by TRC Environmental (TRC) on behalf of the BNSF Railway Company (BNSF). This Plan describes the groundwater monitoring to be performed at the Kalispell Pole and Timber, Reliance Refining Company, and Yale Oil Corporation facilities, collectively referred to as the KRY Site, beginning with the April 2015 semi-annual sampling event (the site plan in presented on Figure 1). This Plan is being implemented after completion of a major portion of the Record of Decision (ROD, Montana Department of Environmental Quality [MDEQ], 2008) remedies, which started in the fall of 2011 (chemical oxidation) and continued through 2012 and 2013 (chemical oxidation, soil excavation, land treatment unit construction, and dioxin/furan repository construction). As a result of, and to accommodate remedy implementation, numerous monitoring wells were removed and/or abandoned. This Plan establishes a revised network of monitoring wells by using monitoring wells that have a long-term data record, monitoring wells that are appropriately located to monitor remedy performance, and proposed additional monitoring locations. This Plan also addresses operational and reporting requirements for the land treatment unit and the dioxin/furan repository.

In a letter dated, February 2, MDEQ provided comments on BNSF's proposed monitoring program table and figure presented prior to at a meeting with MDEQ on January 14, 2015. MDEQ's comments have been addressed in this written plan.

1.1 PURPOSE AND OBJECTIVE

The intent of this Plan is to cover long-term ongoing site-wide groundwater monitoring beginning in 2015, as well as long-term inspection and maintenance of the dioxin repository cap, operation of the land treatment unit (LTU), and inspection and maintenance of the site fencing and vegetation. The objectives for groundwater monitoring are to confirm satisfactory performance of the remedy, and are listed below. A description of each of the Plan objectives is discussed in more detail in Section 2.0.

- Gauge groundwater elevations to identify groundwater flow directions and gauge light non-aqueous phase liquid (LNAPL) to determine product thickness, and monitor progress of LNAPL recovery, as necessary;
- Monitor groundwater following construction of the pentachlorophenol (PCP) LTU, and the dioxin/furan repository to determine if releases of constituents of concern (COC) from the LTUs, retention ponds or repository have occurred;
- Installation of additional monitoring wells in eastern KRY to track the potential presence and distribution of LNAPL following source removal excavation;
- Observe changes in the concentrations of KRY Site major COCs [PCP, extractable petroleum hydrocarbons (EPH), volatile petroleum hydrocarbons (VPH), dioxins/furans, and metals] due to source removal and in-situ chemical oxidation (ISCO) groundwater treatment;
- Monitor groundwater quality following implementation of source area excavation and LNAPL ROD remedies to evaluate monitored natural attenuation (MNA) in petroleum impacted areas;
- Monitor groundwater to meet the requirements of the 2013 Explanation of Significant Differences (ESD, MDEQ 2013) related to the buried sawdust area and groundwater sampling for metals;
- Inspection and maintenance of the dioxin/furan repository;

- Operation of the PCP LTU; and
- Inspection and maintenance of the site fencing and vegetation.

This Plan will replace the current groundwater sampling plan approved in 2013 (AECOM, 2013a) and the 2010 groundwater monitoring work plan (AECOM, 2010). The KRY Site environmental requirements, criteria and limitations (ERCLs) related to groundwater sampling are provided in Appendix A.

2.0 GROUNDWATER MONITORING

Site-wide groundwater monitoring, to include groundwater elevation monitoring, LNAPL monitoring, and groundwater quality monitoring, will be conducted on a semi-annual basis in the spring and fall to coincide with high and low groundwater elevations periods. Groundwater monitoring under this Plan will begin in spring 2015. Monitoring activities will be conducted in accordance with the referenced and attached project operating procedures (POPs), however, if a disagreement exists between the POPs and the text of this document, the Plan text will take precedence. This Long-Term Plan is considered a living document, and hence, subject to change. The frequency, duration, and locations of site-wide groundwater monitoring in the future will be dependent upon the results of the data collected up to that point in time and upon consultation with MDEQ. Flexibility will be maintained during presentation of semi-annual data to modify the Plan as needed, including adding or removing monitoring locations and/or COCs depending on concentrations and distribution of site contaminants observed during sampling. Semi-annual long term monitoring to track ROD performance began in 2014; the duration of semi-annual sampling will be evaluated following the completion of the fall sampling event in 2019.

Refer to the *Residential Groundwater Monitoring Work Plan* (AECOM, Revision 1, 2014) for the residential sampling plan, and the *KRY Sawdust/Methane Vapor Monitoring Plan* (AECOM 2013) for methane sampling in the buried sawdust area; this work plan does not address the plans and methodology for residential or methane sampling. However, the residential wells to be monitored are included on Table 1 (analytical sampling matrix) for reference purposes.

MDEQ will be notified at least 2 weeks prior to conducting the groundwater monitoring events, to allow MDEQ the opportunity to provide oversight. BNSF will exercise best efforts to obtain access for monitoring on the residential properties. If BNSF encounters any difficulty in obtaining access, it will notify MDEQ at least 10 days in advance of the scheduled sampling in order that MDEQ may assist with access. Notice will be given to property owners of groundwater sampling plans at least 2 weeks prior to accessing the wells.

2.1 GROUNDWATER ELEVATIONS AND LNAPL MONITORING

Groundwater elevations and LNAPL measurements will be collected semi-annually in spring (April) and fall (October) to coincide with high and low groundwater elevations periods. Groundwater elevation and LNAPL monitoring will be schedules to coincide with the groundwater quality sampling, discussed in Section 2.2, below. Groundwater and LNAPL elevations will be gauged in accordance with Project Operation Plan (POP) 231 Water-Level Measurements included in Appendix B. Groundwater elevations and LNAPL measurements will be collected from wells identified on Table 1 and on Figure 2. Groundwater elevation measurements will be collected from locations throughout the KRY Site to continue to track groundwater flow direction and prepare groundwater potentiometric surface maps.

The ROD specifies LNAPL is to be removed to the maximum extent practicable, which is defined as a threshold thickness of 1/8 inch or less of LNAPL over a two year, semi-annual period. Prior to the implementation of the final LNAPL remedy; however, interim LNAPL recovery will continue at the site. Passive LNAPL collection by absorbent socks or active LNAPL collection by pumping total fluids with a peristaltic pump or bailer will be maintained in AMW-08, KRY111A, and MW-5 on western KRY and in MW-23 on eastern KRY (and other site wells containing greater than a 0.1 foot LNAPL thickness, including OMW-4A and KPT-21 on western KRY and MW-42 on eastern KRY).

2.1.1 *Proposed Monitoring Locations*

Additional groundwater elevation and LNAPL monitoring locations are proposed for installation in eastern KRY in areas where previous source area excavation and LNAPL removal activities were performed in 2013. The monitoring wells will be installed in the shallow groundwater aquifer with well screens intersecting the water table. Monitoring frequency of these wells will coincide with semi-annual site-wide monitoring. The eight proposed monitoring locations are identified as MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, and MW-17 on Figure 1. Following installation, all eight proposed wells will be included with the semi-annual groundwater elevation and LNAPL monitoring, as specified on Table 1.

The proposed monitoring wells will be installed by sonic drilling methods. Continuous cores will be collected at each monitoring well location and logged by field personnel. Head space readings will be collected on soil cores using a photo ionization detector (PID). Wells will be advanced to a depth of 5 feet below the water table and wells will be screened across the water table. Monitoring wells will be completed using a stick-up surface completion. A protective steel casing and bollard posts will be installed at each monitoring well location to protect the well integrity. Prior to drilling, a "one-call" utility locate will be performed to ensure the drilling locations are clear of buried utilities. Due to the possible presence of underground utilities, specific well locations may need to be adjusted in the field, after consultation with MDEQ.

Monitoring wells will be constructed of 2-inch outside diameter Schedule 40 polyvinyl chloride (PVC) pipe with a 0.020-inch slotted PVC screen. The monitoring wells will be constructed with 10-foot screens, from approximately 5 feet above water table to approximately 5 feet below water table. The specific screen intervals will be determined in the field by the project geologist to ensure proper lithologic units are intersected by the well screen. The monitoring well installation will be conducted according to protocols outlined in TRC Standard Operating Procedure (SOP) 007 (Appendix B). Following monitoring well installation, well development will take place at least 24 hours prior to any groundwater sampling at the newly installed wells, in accordance with TRC SOP 006 (Appendix B). Following installation, the monitoring wells will be surveyed for horizontal coordinates (North American Datum 1983) and vertical elevation (North American Vertical Datum 1988), including top of casing elevation and ground surface elevation. Soil cuttings from the well installation activities will be collected and placed in the PCP LTU for treatment. Water produced from the well development will be collected and placed in the noncomingled PCP retention pond.

2.2 GROUNDWATER QUALITY MONITORING

Groundwater quality monitoring will be conducted through semi-annual groundwater sampling at selected wells on the site to meet the objectives for this plan, stated in Section 1.1. The semi-annual groundwater sampling will be conducted in spring and fall, to coincide with high and low groundwater elevations periods, as well as the groundwater elevation and LNAPL monitoring, described in Section 2.1 above. The following sub-sections discuss the sampling rationale in the monitoring areas, the sampling methodology, and the analytical methods to be used. Table 1 presents the groundwater monitoring matrix, summarizing the analyses to be performed at each well sampled, along with the rationale for the monitoring to be conducted at each well. Figure 2 presents the groundwater sampling locations.

2.2.1 *Land Treatment Unit and Repository Area Groundwater Monitoring*

The PCP LTU, the two LTU retention ponds and the dioxins/furans repository require groundwater monitoring to confirm that COCs are not released to groundwater during the life of the units. Groundwater monitoring will be conducted at locations adjacent to and down-gradient of the LTU, the LTU retention ponds, and repository areas to track groundwater concentrations trends of PCP and dioxins/furans over time and compare concentrations to ROD cleanup levels. The following wells will be tracked to assess the groundwater adjacent to and down-gradient of the units: KPT-10, KPT-21, KRY-105A, MW-4, MW-7, and OMW-4A. Groundwater quality parameters will be collected from the LTU and repository monitoring locations and include PCP, dioxins/furans, EPH/VPH, metals and MNA parameters. The analyses to be performed are presented on Table 1 and the monitoring locations are displayed on Figure 2.

2.2.2 *Post Remedial Action Area Monitoring*

Remedial action activities including source area soil excavation, ISCO groundwater treatment, and LNAPL recovery occurred at the site between 2010 and 2013. The changes in groundwater concentrations in these remedial action areas will be tracked during long term groundwater monitoring to assess the effectiveness of the remedial actions performed to date at achieving ROD cleanup levels. Areas targeted for post remedial action monitoring are located within and/or down-gradient of active remediation areas. In western KRY, the monitoring network will include wells located in ISCO injections areas (KPT-5, MW-4, MW-7, MW-9, and OMW-4A,), areas down-gradient of ISCO injection locations (GW-5, KPT-10, KPT-21, MW-9, and OMW-6) and up-gradient location KRY101A. On southeastern KRY, deep down-gradient monitoring well KRY-129B will be sampled in addition to down-gradient wells GWY-10 and GWY-14. Groundwater quality parameters to be collected from post remedial action area monitoring locations are presented in Table 1 and the monitoring locations are displayed on Figure 2.

Additional ISCO injection activities are planned for 2015. In addition to the long term semi-annual groundwater sampling to monitor the effectiveness of ISCO groundwater treatment, groundwater samples will be collected from wells KRY-121A and deep well KRY-121B for a period of one year (two semi-annual sampling events) following ISCO injection activities. These samples will be analyzed for PCP, to confirm that ISCO injection events are not displacing or mobilizing PCP impacts. After two semi-annual events showing no increase in PCP concentration at KRY-121A and KRY-121B, sampling will be discontinued at these wells. One year of semi-annual sampling at these wells will be implemented following any future ISCO injection events.

2.2.3 *Targeted Areas Current Conditions Evaluation*

One year of groundwater sampling (two semi-annual events) will be conducted in 2015 at seven monitoring wells to assess current groundwater quality conditions in selected areas of the site. The samples from each well will be analyzed for selected COCs, based on the area of the site. A monitoring matrix summarizing the locations, analyses, and sampling rationale is provided in Appendix C. Following the two semi-annual monitoring events, the results from these seven wells will be evaluated. Discontinuation of sampling, or incorporation into the long-term monitoring plan for each of these wells may be recommended, based on the results.

2.2.4 *Buried Sawdust Area Monitoring*

As identified in the ESD, the decomposition of buried sawdust in the northwestern portion of the KRY Site has the potential to create reducing geochemical conditions that can cause the metals that occur in the sawdust areas to be mobilized and become dissolved in groundwater at concentrations in excess of site ROD cleanup levels. Groundwater samples will be collected from the following wells to monitor potential dissolved metal migration from the degradation of the buried sawdust: KRY103A, KRY105A, KRY-108A, IW-1, IW-2, IW3, IW4, IW5, IW-6 and background well KRY101A. Groundwater quality parameters to be collected from buried sawdust area monitoring locations are presented in Table 1 and the monitoring locations are displayed on Figure 2. Methane monitoring from soil vapor sampling locations will be completed, and results presented, under the provisions of the *KRY Sawdust/Methane Vapor Monitoring Plan* (AECOM, 2013).

2.2.5 *Petroleum Hydrocarbon Trend Monitoring*

Concentrations of petroleum compounds currently exist in groundwater at the KRY Site that are closely tied to the presence of LNAPL in contact with groundwater. The selected remedy relies on excavation of contaminated soils and removal of LNAPL (through excavation, passive and active skimming, trenching and ISCO injections) followed by MNA to track the effectiveness of the remedial action, as well as continued natural degradation, in petroleum impacted areas. The remedial excavations and ISCO activities were performed at the site in 2012 and 2013. Additional ISCO injection activities are planned for 2015. Passive and active LNAPL recovery has been ongoing at the site since 2003. The monitoring to track compliance with ROD cleanup levels of petroleum hydrocarbons will be occur through sampling for VPH/EPH and/or metals in areas that are primarily located inside the inferred extent of the smear zone. Table 1 presents the locations to be sampled and analyzed for VPH/EPH and/or metals, and the monitoring locations are displayed on Figure 2.

2.2.6 *MNA Parameter Monitoring*

MNA evaluation parameters including sulfate, nitrate, nitrite, and ferrous iron will be collected as a tool to track groundwater conditions that are favorable for natural attenuation to occur throughout the site. MNA parameters will also be used to compare groundwater conditions within the historical plume to groundwater conditions in up-gradient and down-gradient locations. MNA monitoring will be implemented at locations presented in Table 1 and the monitoring locations are displayed on Figure 2. Additional groundwater treatment in petroleum-impacted areas may occur in the future. As a result, MNA monitoring locations and analytical parameters may be modified as additional remedial actions are performed.

2.2.7 *Sampling Methodology*

The wells proposed for groundwater quality sampling and the rationale for sampling are listed in Table 1. The locations and proposed sampling parameters are shown on Figure 2.

Groundwater quality samples will be collected semi-annually from wells shown in Table 1, except where LNAPL is present. Samples will be collected using low flow methods in accordance with POP 230 Groundwater Sampling (included in Appendix B) and field forms (included in Appendix C). The purpose for using low flow sampling is twofold: first to collect representative samples that are not affected by the agitation that a bailer introduces, and second, to reduce the volume of purge water.

Field parameters of the groundwater, including temperature, pH, conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity, will be collected during and at the conclusion of purging prior to collecting groundwater samples. Field parameters will be recorded on the groundwater sampling records, as specified in POP 230 Groundwater Sampling (included in Appendix B).

Groundwater samples will be packaged and shipped under chain-of-custody control to the project laboratory in accordance with POP 110 Packaging and Shipping included in Appendix B.

2.2.7.1 Purge Water Disposal

Purge water produced during sampling activities throughout the KRY Site will be collected and placed on the PCP LTU if in operation. Otherwise the water will be drummed, and sent off site for disposal as a hazardous waste (F032) or tested to determine if it contains PCP.

2.2.8 *No-Purge Sampling Trial*

In an effort to reduce purge water generated from groundwater sampling at the site, and to reduce labor costs of long-term monitoring, trial sampling using no-purge sampling techniques will be conducted using similar protocols for sampling as the low-flow purging method. Trial no-purge sampling will occur during both semi-annual groundwater monitoring events in 2015. Low-flow purging samples will also be collected at the locations of the trial no-purge sampling to provide data for comparison. The trial sampling will be conducted at wells KPT-21, MW-8, and OMW-4A. These wells were selected as samples from these locations are analyzed for the complete list of site COCs and should provide a range of results concentrations to compare to the low-flow samples collected.

After the two semi-annual trial events in 2015, the results of the trial sampling will be evaluated for precision and quality compared to the low-flow results. The results will likely not be identical due to typical variation in sampling data. The no-purge sampling results will be compared to the low-flow results using various statistical and quantitative comparison analyses, which may include regression analyses (with X-Y scatter plots), statistical tests (sign tests and Wilcoxon Signed-Rank tests), relative percent difference (RPD), and absolute difference. The multiple methods of comparison will be assessed together to develop conclusions about the comparability of the no-purge sampling results to the low-flow results. Also, the field activities will be reviewed and evaluated for efficiency, reduction in purge water, and labor cost savings.

Until otherwise proposed and approved, the results of the low-flow sampling at these wells will continue to be used for data trend evaluation and comparison to ROD cleanup Levels. In addition, if no-purge sampling is approved for sampling, a return to low-flow sampling protocol will occur for site closure decision making.

2.2.8.1 No-Purge Sampling Methodology

Sampling procedures for the no-purge sampling trial will remain similar to the low-flow sampling methodology provided in POP 230 Groundwater Sampling (included in Appendix B). Set-up, decontamination, and sample collection procedures will remain in accordance with POP 230, however, the wells will not be purged with the low-flow methodology. Instead of low-flow purging, bladder pumps will be used at low-flow rates to extract only the volume necessary to collect field parameter measurements and fill the sample containers. The no-purge samples will be collected prior to the purging for the low-flow samples to be collected at the trial wells.

2.2.9 *Analytical Methods*

Groundwater samples will be analyzed for the following constituents:

- PCP via SW-846 by EPA method 8151A for non-residential wells;
- PCP via EPA method 515.4 for residential wells (Method 515.4 is the most current method version and is replacing method of 515.1)
- EPH and VPH via Massachusetts Department of Environmental Protection EPH policy method consistent with the Montana Department of Environmental Quality Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases;
- Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) by modified SW-846 EPA method 8290;
- Dissolved metals (iron and manganese) by EPA method 6010B; and
- Monitored Natural Attenuation parameters: nitrate and nitrite by EPA Method 300.0, sulfate by EPA Method 375.4, ferrous iron by Hach field test kit, and dissolved oxygen, ORP, conductivity, temperature, pH, and turbidity using field instruments.

A summary of analyses for each monitoring well is presented in Table 1. Samples will be submitted to Test America Analytical Testing Corporation of Tacoma, Washington. Samples results will be reported at reporting limits that are below the groundwater clean-up levels as listed in the ROD.

2.3 ENVIRONMENTAL REQUIREMENTS, CRITERIA AND LIMITATIONS

Appendix A contains a table of ERCLs. The source of the ERCLs listed in this table is the MDEQ Remedial Action Work Plan dated October 2, 2009. Highlighted items on the table contain the ERCLs that are applicable to activities conducted at the KRY Site under this monitoring plan, including groundwater sampling.

2.4 QUALITY ASSURANCE/QUALITY CONTROL AND DATA MANAGEMENT

Quality Assurance/Quality Control (QA/QC) samples will be collected during semi-annual groundwater monitoring. QA/QC samples to be collected include field duplicates, field blanks (for PCP, VPH/EPH, and metals analyses), and trip blanks (for coolers containing samples for VPH analysis). Field duplicates and field blanks will be collected at a frequency of one per 20 analytical samples collected during all semi-annual groundwater monitoring events, as summarized on Table 1.

Field data records will, wherever possible, be organized into standard formats. In addition to maintaining a field logbook, various forms will be completed to document data acquisition. Groundwater sampling forms (included in Appendix D) will be completed to document the conditions, location, and time of groundwater sample collection, as well as the field parameters specified in this plan. Additionally, groundwater and LNAPL gauging levels will be recorded on a site gauging form (included in Appendix D). Field data records for field parameters and fluid level gauging will be input to electronic format. The electronic data entry will be checked for quality control, then the field parameters and fluid level gauging data will be loaded to the project database. Documentation of instrument calibration frequency and any maintenance will be recorded in a project field notebook. Instruments will be calibrated according to the manufacturers' instructions.

Sample custody procedures are documented in the POP 110 (**Appendix B**) and will be followed for all samples submitted for laboratory analysis. A copy of each chain of custody will be retained in the project file. Samples will be in the custody of the sampler and within their sight until shipped to the laboratory in a sealed cooler that contains a copy of the chain of custody in a sealed plastic bag taped to the inside cover. The laboratory will keep a copy of the chain of custody and shipping invoice as proof of custody.

Laboratory analytical results will be validated for precision, accuracy, and completeness prior to reporting. Precision is the measure of variability of individual sample measurements. Field precision is determined through the analysis of field duplicate samples. Laboratory precision is determined by the examination of laboratory duplicates, matrix spike duplicates, and laboratory control sample duplicate results. Accuracy is the measure of the system bias. Sampling accuracy is determined by evaluating field blank and trip blank results, which should verify that contaminants have not been introduced to the samples. The level of accuracy is determined by examination of laboratory control samples, matrix spikes, post digestion spikes, and system monitoring or surrogate recoveries. Completeness is the overall measure of the ratio of samples planned versus the number of samples with verified analyses. Determination of completeness includes review of the chain of custody records, laboratory analytical methods and detection limits, and a review of laboratory project narratives. Analytical method compliance will also be determined by evaluating sample integrity, holding time, system performance checks, initial and continuing instrument calibrations, laboratory blanks, internal standards, and target analyte identification against method specified requirements.

The laboratory will provide results in both report and electronic data deliverable (EDD) format. EDDs will be checked against the laboratory reports, then loaded to the project database.

2.5 REPORTING

Following the analytical data validation, written semi-annual and annual groundwater monitoring reports will be submitted to MDEQ. The spring semi-annual sampling report will contain the following:

- Table with a summary of samples collected and analytical methods;
- Spring lab data validation report;
- Tables summarizing the analytical results for each class of compound analyzed with comparisons to ROD cleanup levels;
- COC concentration figures for dissolved PCP, dioxins/furans, petroleum fractions and metals, with listings adjacent to each well symbol stating COC concentration and isoconcentration contour lines depicting individual chemical concentrations (e.g. PCP, dioxins, etc), including, at a minimum, three labeled isoconcentration lines: 1) the DEQ-7 required reporting value or, if no reporting value exists, the laboratory reporting limit, 2) the DEQ-7 water quality standard or the ROD cleanup level or both if they differ, and 3) line(s) that identify increasing concentrations above the cleanup level;
- Potentiometric surface contour maps of shallow and deep groundwater; and
- A LNAPL thickness figure.

The annual report will include:

- Report text discussing the monitoring results for spring and fall groundwater sampling events;
- Deviations to the work plan for spring and fall data (if applicable);
- Fall lab data validation;
- Tables with a summary of samples collected and analytical methods for spring and fall sampling;
- Summary of the measured groundwater elevations;
- Tables summarizing the analytical results for each class of compound analyzed with comparisons to ROD cleanup levels;
- Tables of MNA parameters will be compared between up-gradient, source area, and down-gradient wells;
- Potentiometric surface contour maps of spring and fall shallow and deep groundwater;
- LNAPL thickness figure with spring and fall data;
- COC concentration figures for dissolved PCP, dioxins/furans, petroleum fractions and metals, with listings adjacent to each well symbol stating COC concentration for spring and fall data and isoconcentration contour lines depicting individual chemical concentrations (e.g. PCP,

dioxins, etc), including, at a minimum, three labeled isoconcentration lines: 1) the DEQ-7 required reporting value or, if no reporting value exists, the laboratory reporting limit, 2) the DEQ-7 water quality standard or the ROD cleanup level or both if they differ, and 3) line(s) that identify increasing concentrations above the cleanup level;

- The fall data validation report as an appendix;

- Copies of spring and fall log books, any photographs taken during sampling, laboratory data reports, and field sampling forms for spring and fall sampling will be included as appendices; and,

- An explanation of the wells involved in free-product recovery, the volume of product recovered, and the final disposition of the product, including waste manifests and other related documents, will also be included in the report as an appendix.

The spring and fall monitoring reports will be submitted to MDEQ within 60 days of receipt of final laboratory data reports. Each report will be submitted in both hard copy, compiled electronic PDF format, and modifiable electronic format.

Inspection and maintenance of the dioxin/furan repository at the site will be performed in accordance with the *Dioxins/Furans Soil Repository Operations Plan* (AECOM, 2012a). Likewise, operation and maintenance of the PCP LTU will be performed in accordance with the *Pentachlorophenol Land Treatment Unit Operations Plan* (AECOM, 2012b). These plans also include inspections and maintenance of site fencing. Inspection, maintenance, and reporting for site vegetation will be conducted in accordance with *Dioxins/Furans Soil Repository Operations Plan* (AECOM, 2012a) and the *Weed Management Plan* (AECOM, 2012c). All aspects of long-term monitoring at the KRY Site, including the monitoring in this Long-Term Plan, as well as the three plans referenced above, will be reported in one annual report each year.

3.0 HEALTH, SAFETY, AND ENVIRONMENT

All site work will be conducted in accordance with the site-specific health and safety plan (HASP). The HASP will be available for on-site inspections and all on-site personnel will be required to follow the procedures outlined in the HASP. The HASP includes contingency measures to be taken in the event of unanticipated situations during fieldwork operations. In addition, safety "tailgate" meetings will be initiated at the inception of fieldwork each day and after lunch or breaks at the discretion of the field investigation manager.

Water produced during sampling activities throughout the KRY Site will be collected and placed in the PCP retention pond, if in operation. Otherwise the water will be drummed, and sent off-site for disposal as a hazardous waste (F032) or tested to determine if it contains PCP. Groundwater sampling disposables will be drummed and sent off site as hazardous waste if suspected of containing PCP, otherwise the material will be bagged and sent to the local landfill.

4.0 REFERENCES

AECOM. 2010. Groundwater Monitoring Work Plan. Prepared for BNSF Railway Company. April 2010.

AECOM. 2012a. Dioxins/Furans Soil Repository Operations Plan. Prepared for BNSF Railway Company. May 2012.

AECOM. 2012b. Pentachlorophenol Land Treatment Unit Operations Plan. Prepared for BNSF Railway Company. May 2012.

AECOM. 2012c. Weed Management Plan. Prepared for BNSF Railway Company. May 2012.

AECOM. 2013. KRY Sawdust/Methane Vapor Monitoring Plan. September 25.

AECOM. 2014. Residential Groundwater Monitoring Work Plan, Revision 1. May 2014.

Tables

Table 1: Groundwater Monitoring Network - Analytical Sampling Matrix
Long Term Monitoring Plan
KRY Site: Kalispell, MT

Well No.	Deep (D)/ Shallow (S)	Chemical Analysis								Monitoring Rationale							
		8151A PCP	8290 Dioxins/ Furans	MASS EPH/VPH	(1) MNA Parameters	6010B Metals (Dissolved As, Fe, Mn)	(2) Field Parameters	LNAPL[7]	GW Elev.	Repository	LTU	PCP Data Trends	D/F Data Trends	EPH/VPH Data Trends	Sawdust	MNA Parameters	Post-ISCO Monitoring[8]
AMW-8	S							X	X								
GW-5	S	X					X		X			X					
GWRR-4[6]	S								X								
GWY-3	S								X								
GWY-10	S	X					X		X			X					
GWY-13	S								X								
GWY-14	S	X			X	X	X		X			X				X	
IW-1	S					X	X		X						X		
IW-2	S					X	X		X						X		
IW-3	S					X	X		X						X		
IW-4	S					X	X		X						X		
IW-5	S					X	X		X						X		
IW-6	S					X	X		X						X		
KPT-5	S	X	X		X		X		X			X	X			X	
KPT-10	S	X			X	X	X		X		X	X				X	
KPT-12	S							X	X								
KPT-16	S	X						X	X			X					
KPT-21	S	X	X	X	X	X	X		X	X	X	X	X	X		X	
KRY-101A	S	X	X	X	X	X	X		X			X	X	X	X	X	
KRY-101B	D								X								
KRY-102A	S								X								
KRY-102B	D								X								
KRY-103A	S					X	X		X						X		
KRY-104A	S								X								
KRY-105A	S	X				X	X		X		X	X			X		
KRY-107A	S								X								
KRY-107B	D								X								
KRY-108A	S				X	X	X		X						X	X	
KRY-111A[5]	S							X	X								
KRY-111B	D								X								
KRY-112A	S								X								
KRY-113A	S								X								
KRY-113B	D								X								
KRY-114A	S			X		X		X	X					X			
KRY-115A	S								X								
KRY-118A	S								X								
KRY-121A[8]	S	X							X								X
KRY-121B[8]	D	X							X								X
KRY-123A	S							X	X								
KRY-125A	S								X								
KRY-126A	S								X								
KRY-128A	S								X								
KRY-129A	S								X								
KRY-129B	D	X					X		X			X					
KRY-133A	S								X								
KRY-134A	S								X								
KRY-137A	S			X		X		X	X					X			
MW-4	S	X	X	X	X		X	X	X	X	X	X	X	X		X	
MW-5	S							X	X								
MW-6	S							X	X								
MW-7	S	X	X	X			X		X	X	X	X	X	X			
MW-8	S	X	X	X	X	X	X	X	X			X	X	X		X	
MW-9	S	X	X	X			X	X	X			X	X	X			
MW-10	S							X	X								
MW-11	S			X	X	X		X	X					X		X	
MW-12	S							X	X								
MW-13	S			X	X	X		X	X					X		X	
MW-14	S							X	X								
MW-15	S							X	X								
MW-16	S							X	X								

Table 1: Groundwater Monitoring Network - Analytical Sampling Matrix
Long Term Monitoring Plan
KRY Site: Kalispell, MT

Well No.	Deep (D)/ Shallow (S)	Chemical Analysis								Monitoring Rationale							
		8151A	8290	MASS	(1)	6010B	(2)										
		PCP	Dioxins/ Furans	EPH/VPH	MNA Parameters	Metals (Dissolved As, Fe, Mn)	Field Parameters	LNAPL[7]	GW Elev.	Repository	LTU	PCP Data Trends	D/F Data Trends	EPH/VPH Data Trends	Sawdust	MNA Parameters	Post-ISCO Monitoring[8]
MW-17	S							X	X								
MW-23	S							X	X								
MW-40	S							X	X								
MW-41	S							X	X								
MW-42	S							X	X								
MW-43	S							X	X								
OMW-4A	S	X	X	X	X	X	X		X	X	X	X	X	X		X	
OMW-6	S	X					X	X	X			X					
RW-10[3,4]	D	X	X	X			X					X	X	X			
RW-12[3,4]	D	X	X	X			X					X	X	X			
RW-1[3,4]	D	X	X	X			X					X	X	X			
RW-13[3,4]	D	X	X	X			X					X	X	X			
RW-7[3,4]	D	X	X	X			X					X	X	X			
SB-1-14	S							X	X								
SB-4-14	S							X	X								
SB-6-14	S							X	X								
SB-7-14	S							X	X								
SB-8-14	S							X	X								
SB-9-14	S							X	X								
SB-11-14	S							X	X								
Total wells sampled:		23	13	16	11	19	28	33	75								

QA/QC Sampling:							
Field Duplicate	1 per 20	1 per 20	1 per 20		1 per 20		
Field Blank	1 per 20		1 per 20		1 per 20		
Trip Blank			1 per cooler				

Notes:

1 MNA Parameters include: Sulfate (EPA 375.4), Fe2+ (Hach field test kit), Nitrate/Nitrite (EPA 300), Chloride (EPA 300)

2 Field Parameters include: ORP, DO, conductivity, Temperature, pH, Turbidity

3 Residential wells will be analyzed for PCP by EPA method 515.4

4 Residential wells will only be analyzed for EPH, not VPH

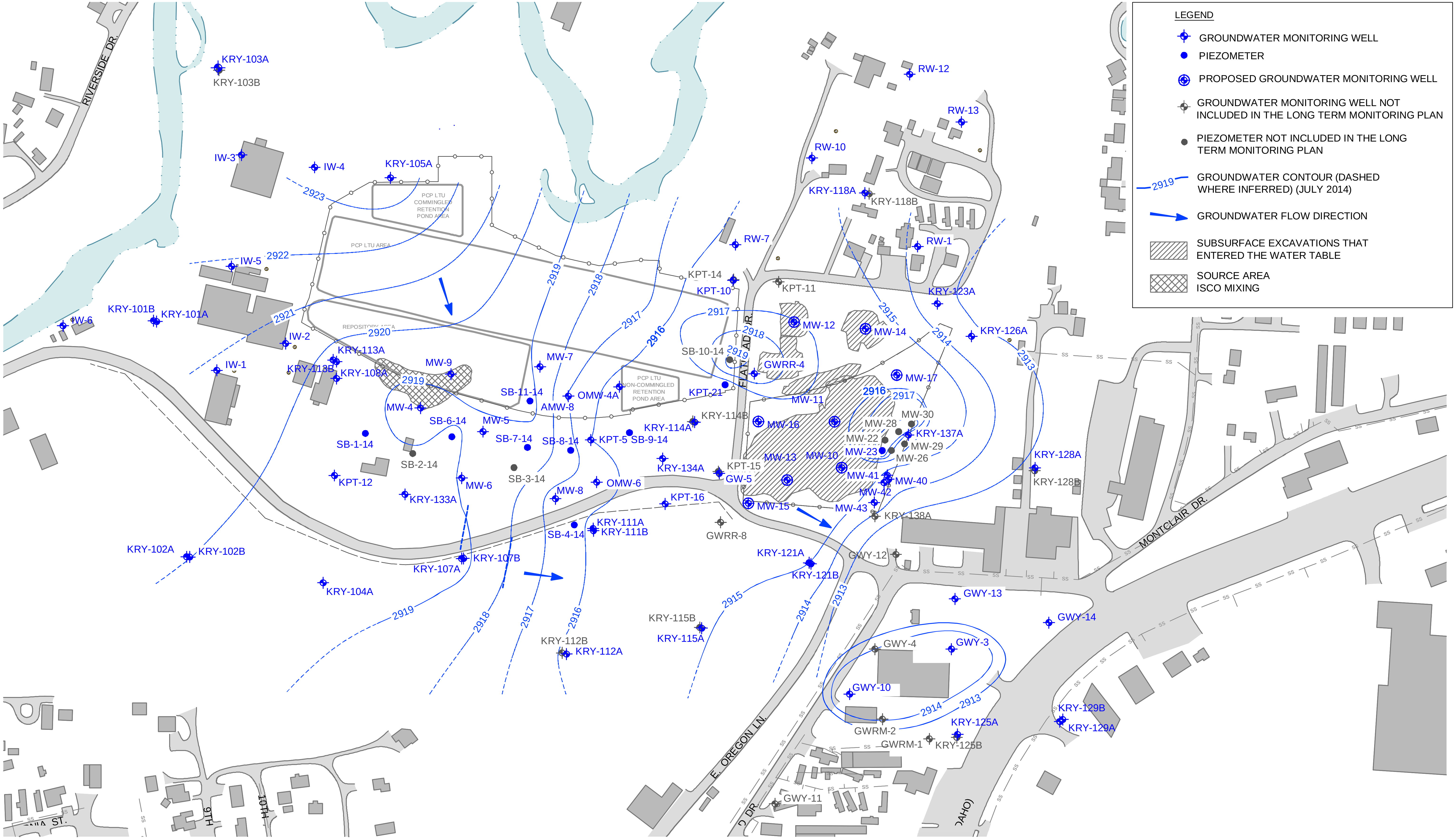
5 KRY 111A was not selected for sampling due to the likely present of LNAPL.

6 GWRR-4 was not selected for sampling since groundwater flow from this well is in the direction of the LTU.

7 All wells to be gauged or sampled will be checked for the presence of LNAPL. Wells check marked in the LNAPL column are located within a historical LNAPL area. LNAPL will not be sampled from these wells.

8 Sampling for PCP at KRY-121A and KRY-121B will occur for 2 semi-annual monitoring events following the 2015 ISCO injection events. Further monitoring will be assessed once results area received.

Figures



125 0 250

1"=250'

N

J:_TRC\BNSF\KRY Management\231385\0000\300\BNSF KRY GW LTMP Figs 1 & 2.dwg
STEHLE, DIANAH Plot Date: April 29, 2015

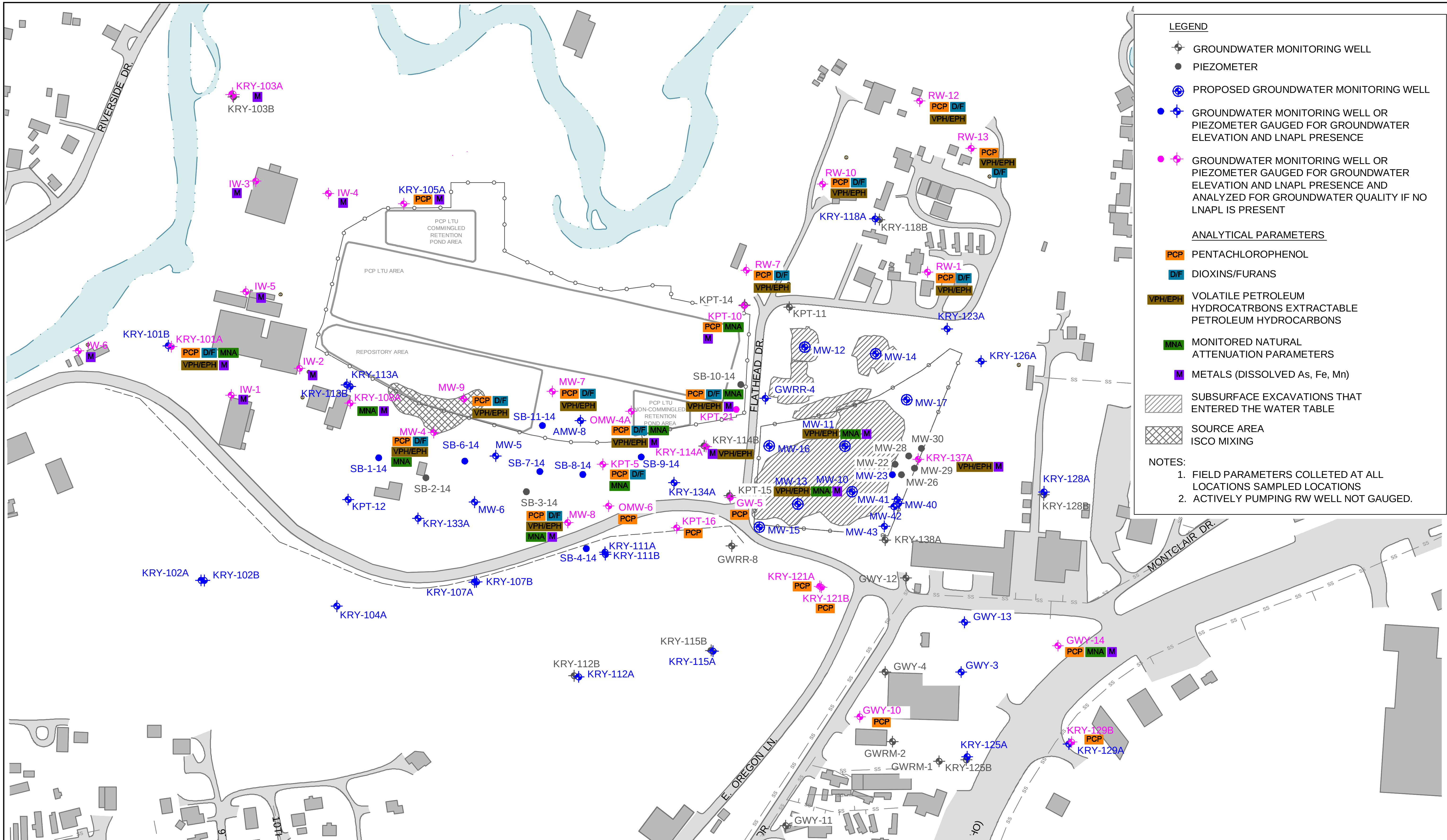
DATE: 2/18/15	DRAWN BY: JW
DESIGN BY: TK	CHECKED BY: AC
SCALE: AS SHOWN	JOB NUMBER: 217536

BNSF RAILWAY
800 NORTH LAST CHANCE GULCH, SUITE 101
HELENA, MT 59601
PHONE: (406) 447-2301
www.bnsf.com

TRC
1526 COLE BLVD., SUITE 150
LAKEWOOD, CO 80401
PHONE: (303) 792-5555
www.trcsolutions.com

FIGURE 1: WELL LOCATIONS AND GROUNDWATER CONTOURS

KRY SITE
KALISPELL, MONTANA



J:_TRC\BNSF\KRY Management\231385\0000\300\BNSF KRY GW LTMP Figs 1 & 2.dwg
STEHLE, DIANAH Plot Date: April 29, 2015

DATE: 2/18/15	DRAWN BY: JW
DESIGN BY: TK	CHECKED BY: AC
SCALE: AS SHOWN	JOB NUMBER: 231385

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FIGURE 2: LONG TERM GROUNDWATER MONITORING NETWORK

KRY SITE
KALISPELL, MONTANA

Appendix A

Site Environmental Requirements, Criteria and Limitations

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
CONTAMINANT SPECIFIC REQUIREMENTS		
Groundwater		
40 Code of Federal Regulations (CFR) 141 40 CFR 143.3	Maximum Contaminant Levels and Maximum Contaminant Level Goals (Relevant) Because the groundwater in the area near the site is currently and has been used as a drinking water source, the MCLs and non-zero MCLGs specified in 40 CFR Part 141 (Primary Drinking Water Standards) are identified. The Evergreen Water and Sewer District operates two wells located northeast of the site. In addition, there are numerous commercial, industrial, and residential wells on or near the site that use the groundwater. Secondary Maximum Contaminant Levels (Relevant) Because the groundwater in the area near the site is currently and has been used as a drinking water source, the Secondary Maximum Contaminant Levels (SMCLs) specified in 40 CFR Part 143.3 are relevant requirements which are ultimately to be attained by the remedy for the site. 40 CFR 143.3 contains standards for iron, manganese, color, odor, and corrosivity which are relevant to the remedial action.	Wastes generated during implementation of the Work Plan will be placed in the PCP retention pond, stored and treated or disposed of in such a manner as to not re-impact groundwater quality. Excess groundwater collected during sampling activities will be disposed. Free product and other contaminated media will be treated, recycled, or disposed of in accordance with solid and hazardous waste ERCLs in a manner that does not degrade the aquifer.
Section 75-5-605, Montana Code Annotated (MCA) Section 75-5-303, MCA	Causing of Pollution Section 75-5-605 of the Montana Water Quality Act (Applicable) prohibits the causing of pollution of any state waters. Section 75-6-112, MCA (Applicable) provides that it is unlawful to discharge drainage or other waste that will cause pollution of state waters used as a source for a public water supply or for domestic use as well as prohibits other unlawful actions Placement of Wastes Section 75-5-605, MCA (Applicable) also states that it is unlawful to place or cause to be placed any wastes where they will cause pollution of any state waters. Nondegradation Section 75-5-303, MCA (Applicable) states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected, with certain limited exceptions.	To prevent state waters from degradation/pollution, wastes generated during the investigation activities will be placed in the PCP retention pond, stored and treated or disposed of in such a manner as to not re-impact groundwater quality. Excess groundwater, free product, and other contaminated media will be treated, recycled or disposed of in accordance with solid and hazardous waste ERCLs in a manner that does not degrade the aquifer.
Administrative Rules of Montana (ARM) 17.30.1006 ARM 17.30.1011	Montana Groundwater Pollution Control System (Applicable) ARM 17.30.1006 (Applicable) classifies groundwater into Classes I through IV based upon its specific conductance and establishes the groundwater quality standards applicable with respect to each groundwater classification. Based upon its specific conductance, the groundwater at the site must meet the standards for Class I groundwater. These standards are applicable. Concentrations of substances in Class I may not exceed the human health standards for groundwater listed in Circular DEQ-7, Montana Numeric Water Quality Standards, February 2006. In addition, no increase of a parameter may cause a violation of Section 75-5-303, MCA (Applicable). For the primary contaminants of concern, the Circular DEQ-7 standards and MCLs are listed below. All levels are given in µg/l unless noted. Arsenic: 10, Benzene: 5, Dioxin/furans: 0.000002 (background of 5.61 pg/L is the cleanup level), Ethyl benzene: 700, Iron: 300, Manganese: 50 (background leel of 778 is the cleanup level), Naphthalene: 100, Pentachlorophenol: 1, Toluene: 1000. For concentrations of parameters for which human health standards are not listed in DEQ-7, ARM 17.30.1006 allows no increase of a parameter to a level that renders the waters harmful, detrimental or injurious to the beneficial uses listed for Class I water. ARM 17.30.1011 (Applicable) provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with Section 75-5-303, MCA, and ARM Title 17, chapter 30, subchapter 7.	To prevent state waters from degradation/pollution, wastes generated during the investigation activities will be placed in the PCP retention pond, stored and treated or disposed of in such a manner as to not re-impact groundwater quality. Excess groundwater, free product, and other contaminated media will be treated, recycled or disposed of in accordance with solid and hazardous waste ERCLs in a manner that does not degrade the aquifer.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Surface Water		
Montana Water Quality Act, Section 75-5-101, et seq., MCA Federal Clean Water Act, 33 U.S.C. § 1251, et seq.	The Montana Water Quality Act, Sections 75-5-101 et seq., establishes requirements for restoring and maintaining the quality of surface and ground waters and the Federal Clean Water Act, 33 U.S.C. Sections 1251 et seq., establishes requirements for restoring and maintaining the quality of surface waters. Under these Acts the state has authority to adopt water quality standards designed to protect beneficial uses of each water body and to designate uses for each water body. Montana's regulations classify state waters according to quality, place restrictions on the discharge of pollutants to state waters and prohibit the degradation of state waters. Under the State Water Quality Act, 75-5-101, et seq., MCA, Montana has Promulgated regulations, ARM 17.30.601 et seq., (Applicable) to protect, maintain, and improve the quality of surface waters in the state.	To prevent state waters from further degradation, wastes generated during the remedial activities will be placed in the PCP retention poind, stored and treated or disposed of in such a manner as to not re-impact groundwater quality. Excess groundwater, free product, and other contaminated media will be treated, recycled or disposed of in accordance with solid and hazardous waste ERCLs in a manner that does not impact water quality. Best management practices (BMPs) will be implemented to prevent impact of surface waters from site contaminants or sediment.
ARM 17.30.608	Pursuant to the authority and criteria established by Montana surface water quality regulations, ARM 17.30.601, et seq., Montana has established the Water- Use Classification system. ARM 17.30.608 (Applicable) provides that the Stillwater River mainstream from Logan Creek to the Flathead River is classified as B-2. The Whitefish River from the outlet of Whitefish Lake to the Stillwater River is also classified as B-2. The Flathead River above Flathead Lake is classified as B-1.	
ARM 17.30.623	ARM 17.30.623 (Applicable) provides the classification standards and beneficial uses for the B-1 classification and provides that concentrations of carcinogenic, bioconcentrating, toxic, or harmful parameters that would remain in the water after conventional water treatment may not exceed DEQ-7 standards. The section also provides the specific water quality standards that must be met for B-1 classification. These standards include the following criteria: 1) Dissolved oxygen concentration must not be reduced below the levels given in DEQ-7; 2) Hydrogen ion concentration (pH) must be maintained within the range of 6.5 to 8.5 at less than 0.5 pH unit. Natural pH outside this range must b maintained without change and natural pH above 7.0 must be maintained; 3) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units, except as permitted by Section 75-5-318; 4) Temperature increases must be kept within prescribed limits; 5) No increase is allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids which will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish or other wildlife. 6) True color must be kept within specified limits; 7) E-coli must be kept below specified limits.	
ARM 17.30.624	ARM 17.30.624 (Applicable) provides the classification standards and beneficial uses for the B-2 classification and provides that concentrations of carcinogenic, bioconcentrating, toxic, or harmful parameters that would remain in the water after conventional water treatment may not exceed DEQ-7 standards. The section also provides the specific water quality standards that must be met for B-2 classification. These standards include the following criteria: 1) Dissolved oxygen concentration must not be reduced below the levels given in DEQ-7; 2) Hydrogen ion concentration (pH) must be maintained within the range of 6.5 to 9.0 at less than 0.5 pH unit. Natural pH outside this range must b maintained without change and natural pH above 7.0 must be maintained; 3) the maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units, except as permitted by Section 75-5-318; 4) Temperature increases must be kept within prescribed limits; 5) No increase is allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids which will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish or other wildlife. 6) True color must be kept within specified limits; 7) E-coli must be kept below specified limits.	
DEQ-7 standards	DEQ-7 provides that if both Aquatic Life Standards or the Human Health Standards for the same analyte exist, the more restrictive of these standards will be used as the applicable standard. For the primary Contaminant of Concern the DEQ-7 surface water standard is listed below. Dioxin/furans: 0.00000005 µg/l Creeks, rivers, ditches, and certain other bodies of surface water must meet these requirements as provided under ARM 17.30.602(33).	
ARM 17.30.637	ARM 17.30.637 (Applicable) requires state surface waters to be free from substances attributable to discharges that will: (1) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (2) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (3) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (4) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (5) create conditions which produce undesirable aquatic life. ARM 17.30.637 (Applicable) also states that no waste may be discharged and no activities conducted which, either alone or in combination with other waste activities, will cause violation of surface water quality standards.	
ARM 17.30.705	ARM 17.30.705 (Applicable) provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.708.	

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Air Quality		
The Clean Air Act (42 USC §§ 7401 et seq.) Sections 75-2-101, et seq., MCA ARM 17.8.204 and 206 ARM 17.8.220	The Clean Air Act (42 USC §§ 7401 et seq.) provides limitations on air emissions resulting from cleanup activities or emissions resulting from with erosion of exposed hazardous substances. Sections 75-2-101, et seq., MCA (Applicable) provides that state emission standards are enforceable under the Montana Clean Air Act. ARM 17.8.204 and 206 (Applicable) establish monitoring, data collection, and analytical requirements to ensure compliance with ambient air quality standards and require compliance with the Montana Quality Assurance Project Plan. DEQ may determine more stringent requirements to be necessary. ARM 17.8.220. (Applicable) Settled particulate matter shall not exceed a 30 day average of 10 grams per square meter.	Groundwater sampling does not include excavation of impacted soil and therefore will not result in air emissions.
ARM 17.8.222	ARM 17.8.222 (Applicable) Lead in ambient air shall not exceed a 90 day average of 1.5 micrograms per cubic meter of air.	Groundwater sampling does not include excavation of lead-impacted soil and therefore will not result in lead emissions.
ARM 17.8.210, 17.8.211, 17.8.212, 17.8.213, and 17.8.214	Ambient air standards for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds occur at the site in connection with any remedial action, these standards would be applicable.	Groundwater sampling will not result in emissions of these compounds.
ARM 17.8.223	ARM 17.8.223. (Applicable) PM-10 concentrations in the ambient air shall not exceed a 24 hour average of 150 micrograms/cubic meter of air and an annual average of 50 micrograms/cubic meter of air.	Groundwater samping does not include excavation of soil and therefore will not result in particulate emissions.
	LOCATION SPECIFIC REQUIREMENTS	
The Endangered Species Act (Relevant)		
16 U.S.C. § 1531 et seq., 50 CFR Part 402, 40 CFR 6.302(h), 40 CFR 257.3-2 Montana Nongame and Endangered Species Act, §§ 87-5-101 et seq. ARM 12.5.201	This statute and implementing regulations (16 U.S.C. § 1531 et seq., 50 CFR Part 402, 40 CFR 6.302(h), and 40 CFR 257.3-2) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat. Compliance with this requirement involves consultation with the U.S. Fish and Wildlife Service (USFWS) and a determination of whether there are listed or proposed species or critical habitats present at the Site, and, if so, whether any proposed activities will impact such wildlife or habitat. No endangered or threatened species or critical habitat have been identified at the site and no federal actions or activities are anticipated. §§ 87-5-101 et seq. (Applicable) Endangered species should be protected in order to maintain and to the extent possible enhance their numbers. These sections list endangered species, prohibited acts and penalties. See also,§ 87-5-201, MCA, (Applicable) concerning protection of wild birds, nests and eggs. ARM 12.5.201 (Applicable). Certain activities are prohibited with respect to specified endangered species.	No threatened or endangered species have been identified at the KRY site. The work included in this work plan will be completed in approximately one week and does not involve significant disturbance of potential habitats. Therefore, the work will not impact threatened or endangered species.
Migratory Bird Treaty Act (Relevant)		
16 U.S.C. § 703, et seq.	This requirement (16 U.S.C. § 703 et seq.) establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial action to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	The work included in this work plan will be completed in approximately two weeks and does not involve significant disturbance of potential habitats. The work will not impact migratory birds.
Bald Eagle Protection Act (Relevant)		
16 U.S.C. § 668, et seq.	This requirement (16 U.S.C. § 668 et seq.) establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the USFWS during remedial design and remedial action to ensure that any cleanup of the site does not unnecessarily adversely affect the bald and golden eagle.	The work included in this work plan will be completed in approximately two weeks and does not involve significant disturbance of potential habitats. The work will not impact bald or golden eagles
Historic Sites, Buildings, Objects, and Antiquities Act (Relevant)		
16 U.S.C. 461, et seq.	These requirements, found at 16 U.S.C. 461 et seq., provide that, in conducting an environmental review of a proposed action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR 62.6(d) to avoid undesirable impacts upon such landmarks.	None have been identified. The work inlcuded in this work plan does not involve significant disturbance.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Resource Conservation and Recovery Act (Relevant)		
40 CFR 264.18	This requirement (40 CFR 264.18) provides location standards for owners and operators of hazardous waste management units. Portions of new management units must not be located within 200 feet of a fault which has had displacement in Holocene time and management units in or near a 100 year floodplain must be designed, constructed, operated, and maintained to avoid washout.	Groundwater sampling does not involve waste management units.
Fish and Wildlife Coordination Act (Relevant)		
16 U.S.C. 661, et seq. and 40 CFR 6	These standards are found at 16 U.S.C. § 661 et seq. and 40 CFR 6 and require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a funded or authorized action provide for adequate protection of fish and wildlife resources.	Groundwater sampling does not involve modification to a stream or other water body.
Floodplain Management Order (Relevant)		
40 CFR Part 6, Executive Order No. 11,988	40 CFR Part 6, Executive Order No. 11,988 (Relevant) requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. A portion of the site is in a floodplain.	The work included in this work plan is outside of the designated floodplain.
Floodplain and Floodway Management Act and Regulations (Applicable)		
	A portion of the site is in a designated floodplain. The following standards are included here to indicate the restrictions on any related activities that might occur in or affect the floodway or floodplain.	The work included in this work plan is outside of the designated floodplain.
Section 76-5-401, MCA and ARM 36.15.601	Section 76-5-401, MCA and ARM 36.15.601 (Applicable) allows certain open-space residential, agricultural, industrial-commercial, recreational and other uses within the designated floodway, provided they do not require structures other than portable structures, fill or permanent storage of materials or equipment.	
ARM 36.15.701	ARM 36.15.701 (Applicable) allows certain activities in the flood fringe. Permitted and unpermitted uses allowed within the floodway are also allowed in the flood fringe providing minimum requirements for structures, fill, and roads.	
ARM 36.15.605(2) and 36.15.703	ARM 36.15.605(2) and 36.15.703 (Applicable) prohibit certain uses anywhere in either the floodway of the flood fringe. Prohibited obstructions include: a) a building for living purposes, b) a structure or excavation that will cause water to be diverted from designated flood way, c) construction or storage of any object subject to flotation or movement during flooding. Also, the following obstructions are prohibited in the designated floodway: a) mobile homes, b) commercial buildings, c) solid, hazardous, or sewage waste disposal, d) storage of toxic, flammable, hazardous, or explosive materials.	
Section 76-5-402, MCA	Section 76-5-402, MCA (Applicable) allows uses in the floodplain outside the flood way. Allows any use permitted in the designated floodway, as well as structures that meet minimum requirements for fill and floodproofing.	
Section 76-5-404, MCA	Section 76-5-404, MCA (Applicable) establishes that it is unlawful to alter an artificial obstruction or designated floodway without a permit. This section applies to any remedial action in the designated floodplain or designated floodway where such action requires more than maintenance.	
Section 76-5-406, MCA and ARM 36.15.216	Section 76-5-406, MCA and ARM 36.15.216 (Applicable) contain substantive factors which address obstruction or use within the floodway or floodplain. Factors that must be considered in addressing any obstruction or use within the floodway or floodplain include: the danger to life and property from backwater or diverted flow caused by the obstruction or use; the danger that the obstruction or use will be swept downstream to the injury of others; the availability of alternate locations; the construction or alteration of the obstruction or use in such a manner as to lessen the danger; the permanence of the obstruction or use; the anticipated development in the foreseeable future of the area.	
ARM 36.15.604	Further conditions or restrictions that generally apply to specific activities within the floodway or floodplain can be found at ARM 36.15.604 (Applicable). The proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount, 0.5 of a foot or as otherwise determined by permit-issuing authority, or significantly increase flood velocities. The following applicable regulations provide substantive conditions and restrictions applicable to specific obstructions or uses.	
ARM 36.15.602(1)	ARM 36.15.602(1) provides for excavation of material from pits or pools provided that: a) a buffer strip of undisturbed land of sufficient width to prevent flood flows from channeling into the excavation is left between the edge of the channel and the edge of the excavation, b) the excavation meets all applicable laws and regulations of other local and state agencies, c) excavated material is stockpiled outside the designated floodway	
ARM 36.15.602(5)(b)	ARM 36.15.602(5)(b) provides for storage of materials and equipment provided that the material or equipment is readily removable within the limited time available after flood warning. Storage of flammable, toxic, or explosive materials shall not be permitted	

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
ARM 36.15.603	ARM 36.15.603 provides for water diversions or changes in place of diversion. All new water diversions or changes in place of diversion require permits or approval as provided for in the Montana Water Use Act of 1973, sections 85-2-302 and 85-2-402, MCA.	
ARM 36.15.606	ARM 36.15.606 requires all flood control works (levees, floodwalls, and riprap) to comply with specified safety standards.	
ARM 36.15.701(3)(c)	ARM 36.15.701(3)(c) requires that roads, streets, highways and rail lines must be designed to minimize increases in flood heights.	
ARM 36.15.701(3)(d)	Structures and facilities for liquid or solid waste treatment and disposal must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with DEQ regulations, which include certain additional prohibitions on such disposal. ARM 36.15.701(3)(d).	
ARM 36.15.702(1)(2)	ARM 36.15.702 (1)(2)provides for floodproofing of residential, commercial, and industrial structures through construction, substantial improvement, and alteration.	
Montana Natural Streambed and Land Preservation act and Regulations (Applicable)		
Section 75-7-101, et seq., MCA and ARM 36.2.401 et seq.	Section 75-7-101, et seq., MCA and ARM 36.2.401 et seq. (Applicable) apply if a remedial action alters or affects a streambed (including a river or its banks.	This work plan does not involve a streambed or its banks.
ARM 36.2.410	ARM 36.2.410 (Applicable) establishes minimum standards and guidelines which would be applicable if a remedial action alters or affects a streambed, including any channel change, new diversion, riprap, or other stream bank protection project. See§ 75-7-102,MCA.	
Section 75-7-111, MCA	Section 75-7-111, MCA (Applicable) provides that a person planning to engage in any activity that will physically alter or modify the bed or banks of a stream or river must give written notice to the Board of Supervisors of a Conservation District, the Directors of a Grass Conservation District, or the Board of County Commissioners if the proposed project is not within a district.	
Solid Waste Management Act and Regulations (Applicable)		
Solid Waste Management Act, Sections 75-10-201 et seq., MCA and ARM 17.50.501 et seq.	Regulations promulgated under the Solid Waste Management Act, Sections 75-10-201 et seq., MCA, (Applicable) and pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act, 42 U.S.C§§ 6901 et seq. (RCRA Subtitle D), specify requirements that apply to the location of any solid waste management facility. At the site, these requirements specifically apply to the petroleum land treatment unit and the dioxin/furan repository described in the Record of Decision.	Non-hazardous IDW (e.g., personal protective equipment) and other solid waste (plastic wrapping, cardboard, etc.) will be double-bagged in a plastic bag and placed in a waste disposal dumpster for collection and appropriate disposal as solid waste. Hazardous waste (e.g. purge water) generated during groundwater sampling will be placed in in the PCP retention pond or appropriate containers (drums with locking lids accompanied by overpack drums or other secondary containment for drums of water) that meet the requirements of RCRA and stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) that meets the requirements of RCRA pending characterization and offsite disposal at a hazardous waste disposal facility. The access-controlled outdoor temporary storage location will be located outside of the 100-year floodplain.
Section 75-10-212, MCA	Section 75-10-212, MCA (Applicable) prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.	
ARM 17.50.505(1)	ARM 17.50.505(1) (Applicable) provides locational requirements for solid waste management facilities. These requirements include: 1) must be located where a sufficient acreage of suitable land is available, 2) may not be located in a 100-year floodplain, 3) may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems, 4) must be located to allow for reclamation and reuse of the land, 5) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas, 6) only Class III disposal facilities may be approved where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility.	Investigation derived waste (IDW) generated during implementation of the remedial action will be placed in drums with lids that can be tightened down (as well as overpack and/or other secondary containment for drums that will hold water) and temporarily stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) in a manner that meets solid waste requirements. The temporary storage location will be located outside of the 100-year floodplain. IDW will be stored in such a way as to prevent pollution of the environment and public and private water supply systems and in compliance with RCRA requirements . There are no known rock fractures or fissures, and no hydraulically connected springs at the facility.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
ARM 17.50.505(2) ARM 17.50.506	ARM 17.50.505(2) (Applicable) specifies special requirements for solid waste management facilities including: 1) Class II landfills must confine solid waste and leachate to the disposal facility. If there is potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters, 2) adequate separation of group II wastes from underlying or adjacent water must be provided (the extent of separation shall be established on a case-by-case basis), 3) new disposal units or lateral expansions may not be located in wetlands ARM 17.50.506 (Applicable) provides design requirements for landfills. Landfills must either be designed to ensure that MCLs are not exceeded or the landfill must contain a composite liner and leachate collection system which comply with specified criteria. ARM 17.50.502(27) defines a landfill as an area of land or an excavation where wastes are placed for permanent disposal, and that is not a land application unit, surface impoundment, injection well, or waste pile.	Any solid waste generated during groundwater sampling (PPE, etc.) will disposed of at the Flathead County landfill, which is a licensed landfil that meets these requirements.
ARM 17.50.511	ARM 17.50.511 (Applicable) provides specific operational and maintenance requirements for solid waste management systems. Operational and maintenance requirements include: run-on and runoff control systems, fencing around sites to prevent unauthorized access, and prohibitions of point and nonpoint source discharges which would violate the Clean Water Act requirements.	Any solid waste generated during groundwater sampling (PPE, etc.) will disposed of at the Flathead County landfill, which is a licensed landfil that meets these requirements.
ARM 17.50.523	ARM 17.50.523 (Applicable) requires that waste be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle. This applies to the off-site disposal of the lead contaminated soils.	Non-hazardous solid waste (i.e., personal protective equipment) will be double-bagged in a plastic bag and placed in a waste disposal dumpster for collection and appropriate disposal as solid waste.
ARM 17.50.525	ARM 17.50.525 (Applicable) states that the DEQ may conduct inspections st solid waste management facilities at reasonable hours upon presentation of appropriate credentials.	Any solid waste generated during groundwater sampling (PPE, etc.) will disposed of at the Flathead County landfill, which is a licensed landfil that meets these requirements.
ARM 17.50.530 ARM 17.50.530(1)(b) ARM 17.50.531	ARM 17.50.530 (Applicable) sets forth the closure requirements for landfills, including the repository described in the Record of Decision. The requirements for the repository cover include: 1) cap must be minimum of 24 inches, 2) cover designed to minimize infiltration and erosion, 3) design and construct cover such that it has permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoil or a permeability no greater than 1 x 10^5 cm/sec, whichever is less, 4) minimize erosion of final cover so that the layer contains a minimum of six inches of earthen material, 5) revegetate the final cover with native plant growth within one year of placement. ARM 17.50.530(1)(b) (Applicable) allows an alternative final cover design if the infiltration layer achieves reduction in infiltration at least equivalent to the stated criteria and the erosion layer provides protection equivalent to the stated criteria. ARM 17.50.531 (Applicable) Sets forth post closure care requirements for Class II landfills and is applicable to dioxin/furan contaminated soil repository. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure actions must comply with the groundwater monitoring requirements found at ARM Title 17, chapter 50, subchapter 7. The groundwater monitoring requirements of ARM 17.50.701 et seq. will be coordinated with the other monitoring requirements specified by the Record of Decision.	Any solid waste generated during groundwater sampling (PPE, etc.) will disposed of at the Flathead County landfill, which is a licensed landfil that meets these requirements.
	ACTION SPECIFIC REQUIREMENTS	
Point source Controls		
ARM 17.30.1201 et seq, and ARM 17.30.1301 et seq.	ARM 17.30.1201 et seq, and ARM 17.30.1301 et seq. would be applicable if point sources of water contamination are retained or created by any remediation activity. Applicable Clean Water Act standards would apply to those discharges.	Purge water generated during groundwater sampling will be placed in the PCP retention pond or appropriate containers (drums with locking lids accompanied by overpack drums or other secondary containment for drums of water) that meet the requirements of RCRA and stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) that meets the requirements of RCRA pending characterization and offsite disposal at a hazardous waste disposal facility. The access-controlled outdoor temporary storage location will be located outside of the 100-year floodplain.
Dredge and Fill Requirements (Applicable)		
	The selected remedy does not involve depositing dredge and fill material into water of the United States. No activities requiring a Section 404 Permit are anticipated	Groundwater sampling does not involve dredge and fill.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Air Quality Regulations (Applicable)		
The Clean Air Act (42 USC §§ 7401 et seq.) Sections 75-2-101, et seq., MCA ARM 17.8.220	The Clean Air Act (42 USC §§ 7401 et seq.) provides limitations on air emissions resulting from cleanup activities or emissions resulting from erosion of exposed hazardous substances. Sections 75-2-101, et seq., MCA (Applicable) provides that state emission standards are enforceable under the Montana Clean Air Act. ARM 17.8.220. (Applicable) Settled particulate matter shall not exceed a 30 day average of 10 grams per square meter.	Groundwater sampling will not result in generation of air emissions.
ARM 17.8.222	ARM 17.8.222 (Applicable) Lead in ambient air shall not exceed a 90 day average of 1.5 micrograms per cubic meter of air.	Grroundwater sampling will not result in the generation of lead particulate emissions.
ARM 17.8.223	ARM 17.8.223. (Applicable) PM-10 concentrations in the ambient air shall not exceed a 24 hour average of 150 micrograms/cubic meter of air and an annual average of 50 micrograms/cubic meter of air.	Groundwater sampling will not result in the generation of particulate emissions.
ARM 17.8.210, 17.8.211, 17.8.212, 17.8.213, and 17.8.214	Ambient air standards for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds occur at the site in connection with any remedial action, these standards would be applicable.	Groundwater sampling will not result in emissions of these compounds.
ARM 17.8.304 and 17.8.308 ARM 17.24.761	ARM 17.8.304 and 17.8.308 (Applicable) state that no person shall cause or authorize the production, handling, transportation, or storage of any material; or cause or authorize the use of any street, road, or parking lot; or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Emissions of airborne particulate matter shall not exhibit an opacity of 20% or greater averaged over six consecutive minutes. ARM 17.24.761 (Relevant) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities and requires that a fugitive dust program be implemented.	Groundwater sampling will not result in the generation of particulate emissions.
Groundwater Act (Applicable)		
Section 85-2-505, MCA Section 85-2-516, MCA ARM 17.30.641	Section 85-2-505, MCA (Applicable) precludes the wasting of groundwater. Wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater. Section 85-2-516, MCA (Applicable) states that within 60 days after any well is completed a well log report must be filed by the driller with the Montana Bureau of Mines and Geology. ARM 17.30.641 (Applicable) states that water quality monitoring, including methods of sample collection, preservation, and analysis used to determine compliance with the standards must be in accordance with 40 CFR Part 136 (July 1, 2007) or other method allowed by the department.	Water quality monitoring will be conducted using methods approved by MDEQ.
ARM 17.30.646	ARM 17.30.646 (Applicable) requires that bioassay tolerance concentrations must be determined using the latest available research results for the materials, by bioassay tests procedures for simulating actual stream conditions as set forth in 40 CFR Part 136 (July 1, 2007).	Groundwater sampling does not involved streams.
ARM 36.21.670-678 and ARM 36.21.810	ARM 36.21.670-678 and ARM 36.21.810 (Applicable) specify certain requirements that must fulfilled when abandoning monitoring wells.	Groundwater sampling does not involve any monitoring wells that require abandonment.
Substantive MPDES Permit Requirements (Applicable)		
ARM 17.30.1342-1344	ARM 17.30.1342-1344 (Applicable) set forth the regulations and substantive requirements applicable to all Montana Pollutant Discharge Elimination System (MPDES) and National Pollution Discharge Elimination System (NPDES) permits.	Groundwater sampling will not result in discharges to surface water. Purge water generated during groundwater sampling will be placed in appropriate containers (drums with locking lids accompanied by overpack drums or other secondary containment for drums of water) that meet the requirements of RCRA and stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) that meets the requirements of RCRA pending characterization and offsite disposal at a hazardous waste disposal facility. The access-controlled outdoor temporary storage location will be located outside of the 100-year floodplain.
Technology-Based Treatment (Applicable)		
ARM 17.30.1203 and 40 CFR Part 125	40 CFR Part 125 provides criteria and standards for the imposition of technology-based treatment requirements. For toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT), for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified , BCT/BAT technology-based treatment requirements are determined on a case by case basis using best professional judgment (BPJ).	Groundwater sampling will not result in discharges to surface water.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Storm Water Runoff		
ARM 17.30.1341-1344	ARM 17.30.1341-1344 (Applicable) states that storm water point sources require a Storm Water Discharge General Permit. The permit requires the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment. MPDES permits are applicable to storm water runoff discharges.	Groundwater sampling activities will not occur within 100+ feet of surface water and will not create a disturbance greater than 1/8 acre. Therefore, a permit is not required.
ARM 17.24.633	ARM 17.24.633 (Relevant) requires that all surface drainage from a disturbed area be treated by the best technology currently available (BTCA).	
RCRA Subtitle C Requirements and corresponding State requirements (Applicable, as incorporated by the Montana Hazardous Waste act)		
RCRA, 42 U.S.C. §§ 6901 et seq., and Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA	The Resource Conservation and Recovery Act (RCRA), 42 U.S.C. Sections 6901 et seq., and the Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA, and regulations under these acts establish a regulatory structure for the generation, transportation, treatment, storage and disposal of hazardous wastes. These requirements are applicable to substances and actions at the site which involve the active management of hazardous wastes, including excavation of listed hazardous waste and the pentachlorophenol land treatment unit described in the Record of Decision. Some requirements may also apply to the lead-contaminated soil if subsequent sampling reveals it is a characteristic hazardous waste.	Wastes generated during implementation of the Work Plan will be managed in accordance with the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. Sections 6901 et seq., and the Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA. If hazardous waste needs to be transported outside the Facility, a hazardous waste transporter will be used and the hazardous waste will be manifested. Wastes will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal. Non-hazardous solid waste (i.e., personal protective equipment) will be double-bagged in a plastic bag and placed in a waste disposal dumpster for collection and appropriate disposal as solid waste.
40 CFR 261	Wastes may be designated as hazardous by either of two methods: listing or demonstration of a hazardous characteristic. Listed wastes are the specific types of wastes determined by EPA to be hazardous as identified in 40 CFR Part 261, Subpart D (40 CFR 261.30 - 261.33) (Applicable as incorporated by the Montana Hazardous waste Act). Listed wastes are designated hazardous by virtue of their origin or source, and must be managed as hazardous wastes regardless of the concentration of hazardous constituents. Characteristic wastes are those that by virtue of concentrations of hazardous constituents demonstrate the characteristic of ignitability, corrosivity, reactivity or toxicity, as described at 40 CFR Part 261, Subpart C (Applicable, as incorporated by the Montana Hazardous Waste Act).	Wastes generated during implementation of the Work Plan will be managed in accordance with the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. Sections 6901 et seq., and the Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA. If hazardous waste needs to be transported outside the Facility, a hazardous waste transporter will be used and the hazardous waste will be manifested. Wastes will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal. Non-hazardous solid waste (i.e., personal protective equipment) will be double-bagged in a plastic bag and placed in a waste disposal dumpster for collection and appropriate disposal as solid waste.
40 CFR 261.31	40 CFR 261.31 defines F032 waste as: wastewaters (except those that have not come into contact with process contaminants), process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations (except potentially cross-contaminated wastes that have had the F032 waste code deleted in accordance with § 261.35 of this chapter or potentially cross-contaminated wastes that are otherwise currently regulated as hazardous wastes and where the generator does not resume or initiate use of chlorophenolic formulations). This listing does not include K001 bottom sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol. Media at the KRY Site is contaminated with PCP from process residuals, preservative drippage, and spent formulations from a wood treating process that used chlorophenolic formulations. Therefore, the KRY Site contains F032 listed hazardous wastes and the various media and wastes contaminated by the F032 wastes are hazardous pursuant to 40 CFR Part 261.	

Appendix A Environmental Requirements, Criteria, and Limitations
KRY Site, Kalispell, Montana

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
40 CFR Part 262	The RCRA requirements specified are applicable for the treatment, storage, and disposal of these F032 wastes. The lead-contaminated soil at the KRY Site will be further characterized to determine if it is a hazardous waste. The RCRA regulations at 40 CFR Part 262 (Applicable, as incorporated by the Montana Hazardous Waste Act) establish standards that apply to generators of hazardous waste. These standards include requirements for obtaining an EPA identification number and maintaining certain reports. These standards are applicable for any waste which will be transported offsite.	Hazardous IDW generated during implementation of the work plan will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal. Non-hazardous solid waste (i.e., personal protective equipment) will be double-bagged in a plastic bag and placed in a waste disposal dumpster for collection and appropriate disposal as solid waste. Hazardous IDW will be transported outside the Facility for disposal at a RCRA-permitted disposal facility for FO32 waste. A hazardous waste transporter will be used and the hazardous waste will be manifested under BNSF's current EPA generator ID number. No hazardous waste will be disposed of onsite.
40 CFR Part 263	The RCRA regulations at 40 CFR Part 263 (Applicable, as incorporated by the Montana Hazardous Waste Act) establish standards that apply to transporters of hazardous waste. These standards include requirements for immediate action for hazardous waste discharges. These standards are applicable for any on-site transportation. These standards are independently applicable for any off-site transportation.	
40 CFR 264, Subpart B	The regulations at 40 CFR 264, Subpart B (Applicable, as incorporated by the Montana Hazardous Waste Act) establish general facility requirements. These standards include requirements for general waste analysis, security and location standards.	
40 CFR 264, Subpart F	The regulations at 40 CFR 264, Subpart F (Applicable, as incorporated by the Montana Hazardous Waste Act) establish requirements for groundwater protection for RCRA-regulated solid waste management units (including land treatment units). Subpart F provides for three genera types of groundwater monitoring: detection monitoring (40 CFR 264.98); compliance monitoring (40 CFR 264.99); and corrective action monitoring (40 CFR 264.100). Monitoring wells must be cased according to 264.97(c). Monitoring is required during the active life of a hazardous waste management unit. If hazardous waste remains, monitoring is required for a period necessary to protect human health and the environment.	This work plan does not include constructing a solid waste management unit.
40 CFR Part 264, Subpart G	40 CFR Part 264, Subpart G (Applicable, as incorporated by the Montana Hazardous Waste Act) establishes that hazardous waste management facilities must be closed in such a manner as to (a) minimize the need for further maintenance and (b) control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or to the atmosphere. Requirements for facilities requiring post-closure care include the following: the facilities must undertake appropriate monitoring and maintenance actions, control public access, and control post closure use of the property to ensure that the integrity of the final cover, liner, or containment system is not disturbed. In addition, all contaminated equipment, structures and soil must be properly disposed of or decontaminated unless exempt and free liquids must be removed or solidified, the wastes stabilized, and the waste management unit covered.	This work plan does not include establishment of a hazardous waste management facility.
40 CFR Part 261, Subpart I	40 CFR Part 264, Subpart I (Applicable, as incorporated by the Montana Hazardous Waste Act) applies to owners and operators of facilities that store hazardous waste in containers. These regulations are applicable to any storage of purge water or other media containing F032 hazardous waste. The related provisions of 40 CFR 261.7 regarding residues of hazardous waste in empty containers are also applicable, as incorporated by the Montana Hazardous Waste Act).	Wastes generated during implementation of the Work Plan will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be temporarily stored in an access-controlled outdoor location (i.e., fully-enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal.
40 CFR Part 264, Subpart L	40 CFR Part 264, Subpart L (Applicable, as incorporated by the Montana Hazardous Waste Act) applies to owners and operators of facilities that store or treat hazardous waste in piles. The regulations include requirements for the use of run-on and run-off control systems and collection and holding systems to prevent the release of contaminants from waste piles. These regulations are applicable to any storage in waste piles at the site.	Groundwater sampling will not involve a hazardous waste pile.
40 CFR Part 264, Subpart M	40 CFR Part 264, Subpart M (Applicable, as incorporated by the Montana Hazardous Waste Act) applies to owners and operators of facilities that treat hazardous waste in land treatment units. These regulations are applicable to the design and operation of the pentachlorophenol land treatment unit discussed in the Record of Decision.	Groundwater sampling will not involve a land treatment unit.
40 CFR Part 264, Subpart S	40 CFR Part 264, Subpart S (Applicable, as incorporated by the Montana Hazardous Waste Act) provides special provisions for cleanup; 40 CFR 264.552 allows the designation of a corrective action management unit (CAMU) located within the contiguous property under the control of the owner or operator where the wastes to be managed in the CAMU originated and provides requirements for siting, managing, and closing the CAMU. The CAMU-eligible waste at the KRY Site includes the F032-contaminated soil that must be managed to implement the cleanup. Placement of the CAMU-eligible waste does not constitute land disposal of hazardous waste. If staging piles are needed during remediation, compliance with 40 CFR 264.554 will be required.	
40 CFR 264.554	40 CFR 264.554 sets forth a new storage unit called the staging pile. A staging pile must be located within the contiguous property under the control of the owner/operator where the wastes to be managed in the staging pile originated. The staging pile must be designed so as to preven or minimize releases of hazardous wastes and hazardous constituents into the environment, and minimize or adequately control cross-media transfer, as necessary to protect human health and the environment (for example, through the use of liners, covers, run-off/run-on controls, as appropriate). The staging pile must not operate for more than two years and cannot be used for treatment.	Groundwater sampling will not involve a staging pile.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
40 CFR 268	Because F032 listed waste is present at the site, the RCRA Land Disposal Restrictions (LDRs) treatment levels set for at 40 CFR Part 268 are applicable requirements (as incorporated by the Montana Hazardous Waste Act) including the treatment levels for F032 listed wastes for the disposal of hazardous wastes generated at the facility. With the exception of treated soils, hazardous wastes are prohibited from disposal onsite.	Hazardous IDW generated during implementation of the work plan will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be stored in an access-controlled outdoor location (i.e., fully enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal. Hazardous IDW will be transported outside the Facility for disposal at a RCRA-permitted disposal facility for F032 waste. A hazardous waste transporter will be used and the hazardous waste will be manifested under BNSF's current EPA generator ID number. No hazardous waste will be disposed of onsite.
Hazardous Waste Identification Rule (HWIR), 63 Fed. Reg. 65874, 40 CFR 268.49(c) (1)(C), and 40 CFR 268.48	The Hazardous Waste Identification Rule (HWIR) for Contaminated Media promulgated at 63 Fed. Reg. 65874 (November 30, 1998) allows listed waste treated to levels protective of human health and the environment to be disposed of onsite without triggering land ban or minimum technology requirements for these disposal requirements. Treated soils containing hazardous waste will need to meet site-specific cleanup levels as well as the LDR treatment standards (applicable, as incorporated by the Montana Hazardous Waste Act)(40 CFR 268.49(c) (1)(C)), which require that contaminated soil to be land disposed be treated to reduce concentrations of the hazardous constituents by 90 percent or meet hazardous constituent concentrations that are ten times the universal treatment standards (UTS) (found at 40 CFR 268.48), whichever is greater, to avoid triggering land ban.	
40 CFR Part 270	40 CFR Part 270 (Applicable, as incorporated by the Montana Hazardous Waste Act) sets forth the hazardous waste permit program. The substantive requirements set forth in 40 CFR Part 270, Subpart C (permit conditions), including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.	Hazardous IDW generated during implementation of the work plan will be placed in drums with lids that tighten and overpack or other secondary containment for water that meet the requirements of RCRA. The drums of IDW will be stored in an access-controlled outdoor location (i.e., fully enclosed locked storage unit) in a manner that meets RCRA requirements pending disposal. Hazardous IDW will be transported outside the Facility for disposal at a RCRA-permitted disposal facility for F032 waste. A hazardous waste transporter will be used and the hazardous waste will be manifested under BNSF's current EPA generator ID number. No hazardous waste will be disposed of onsite.
40 CFR 264.116 and .119, 40 CFR 264.228(a)(2)(i), and 40 CFR 264.228(a)(2)(iii)(B)(C)(D) and .251(c)(d)(f)	For any management (i.e., treatment, storage, or disposal) or removal or detention, the RCRA regulations found at 40 CFR 264.116 and .119 (governing notice and deed restrictions), 40 CFR 264.228(a)(2)(i) (addressing de-watering of wastes prior to disposal), and 40 CFR 264.228(a)(2)(iii)(B)(C)(D) and .251(c)(d)(f) (regarding run-on and run-off controls), are relevant requirements for any waste management units created or retained at the site that contain non-exempt waste. A construction de-watering permit covers similar requirements and is applicable to the site.	
Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA	The Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA (Applicable) and regulations under this act establish a regulatory structure for the generation, transportation, treatment, storage and disposal of hazardous wastes. These requirements are applicable to substances and actions at the site which involve listed and characteristic hazardous wastes.	Wastes generated during implementation of the Work Plan will be handled/transported in accordance with applicable RCRA regulations under BNSF's current EPA generator ID number. If hazardous waste needs to be transported for disposal outside the Facility, a hazardous waste transporter will be used, the hazardous waste will be manifested, and a spill prevention response plan will be in place prior to transport. Hazardous waste to be disposed of offsite at a permitted RCRA disposal facility will be transported by a hazardous waste transporter and will be manifested. No hazardous waste will be disposed of onsite.
ARM 17.53.501-502	ARM 17.53.501-502 (Applicable) adopts the equivalent of RCRA regulations at 40 CFR Part 261, establishing standards for the identification and listing of hazardous wastes, including standards for recyclable materials and standards for empty containers, with certain State exceptions and additions.	
ARM 17.53.601-604	ARM 17.53.601-604 (Applicable) adopts the equivalent to RCRA regulations at 40 CFR Part 262, establishing standards that apply to generators of hazardous waste, including standards pertaining to the accumulation of hazardous wastes, with certain State exceptions and additions.	
ARM 17.53.701-708	ARM 17.53.701-708 (Applicable) adopts the equivalent to RCRA regulations at 40 CFR Part 263, establishing standards that apply to transporters of hazardous waste, with certain State exceptions and additions.	
ARM 17.53.801-803	ARM 17.53.801-803 (Applicable) adopts the equivalent to RCRA regulations at 40 CFR Part 264, establishing standards that apply to hazardous waste treatment, storage and disposal facilities, with certain State exceptions and additions.	
ARM 17.53.1101-1102	ARM 17.53.1101-1102 (Applicable) adopts the equivalent to RCRA regulations at 40 CFR Part 268, establishing land disposal restrictions, with certain State exceptions and additions.	
Section 75-10-422 MCA	Section 75-10-422 MCA (Applicable) prohibits the unlawful disposal of hazardous wastes.	
ARM 17.53.1201-1202	ARM 17.53.1201-1202 (Applicable) adopts the equivalent to RCRA regulations at 40 CFR Part 270 and 124, which establish standards for permitted facilities, with certain State exceptions and additions.	
Underground Injection Control Program		
40 CFR 144 and 146	The Underground Injection Control Program set forth at 40 CFR 144 and 146, set forth the standards and criteria for the injection of substances into aquifers. Wells are classified as Class I through V, depending on the location and the type of substance injected. For all classes, no owner may construct, operate or maintain an injection well in a manner that results in the contamination of an underground source of drinking water at levels that violate MCLs or otherwise adversely affect the health of persons. Each classification may also contain further specific standards, depending on the classification. Compliance with these regulations requires application to the EPA's Underground Injection Control Program fo a permit to conduct in-situ chemical oxidation groundwater remediation described in the Record of Decision.	Groundwater sampling does not involve injection.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Free Product Removal		
	Information generated during the Remedial Investigation indicates that all known tanks have been removed from the KRY Site but that underground piping associated with the tanks may remain. In addition, there is free product at the site. Therefore, certain storage tank regulations are applicable.	Groundwater sampling does not involve removal of free product or tanks,
40 CFR Part 280, Subpart F	40 CFR Part 280, Subpart F (Relevant) sets forth requirements for Release Response and Corrective Action for underground storage tank (UST) systems containing petroleum or hazardous substances. These include initial response, initial abatement measures, site characterization free product removal, and investigations for soil and groundwater cleanup.	Groundwater sampling does not involve removal of free product or tanks,
40 CFR 280.43	40 CFR 280.43 (Relevant) specifies groundwater monitoring requirements for underground storage tanks and requires that the monitoring methods used be able to detect the presence of at least 1/8 of an inch of free product on top of the groundwater in the monitoring wells.	An interface probe capable of detecting the presence of at least 1/8 of an inch of free product on top of groundwater will be used to gauge free product thickness in the monitoring wells.
40 CFR 280.64	40 CFR 280.64 (Relevant) provides that where investigations in connection with leaking underground storage tanks reveal the presence of free product, owners and operators must remove free product to the maximum extent practicable as determined by the implementing agency. This regulation also requires that the free product removal be conducted in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site, and that properly treats, discharges or disposes of recovery byproducts in compliance with applicable local, State and Federal regulations. 40 CFR 280.64 also provides that abatement of free product migration is a minimum objective for the design of the free product removal system provides that any flammable products must be handled in a safe and competent manner to prevent fires or explosions.	This workplan does not involve removal of free product, nor the design of a free product recovery system.
ARM 17.56.407(1)(f)(vi)	ARM 17.56.407(1)(f)(vi) (Relevant) specifies groundwater monitoring requirements for underground storage tanks and requires that the monitoring methods used be able to detect the presence of at least 1/8 of an inch of free product on top of the groundwater in the monitoring wells.	An interface probe capable of detecting the presence of at least 1/8 of an inch of free product on top of groundwater will be used to gauge free product thickness in the monitoring wells.
ARM 17.56.602(1)(c)	ARM 17.56.602(1)(c) (Relevant) requires that after a release from an underground storage tank system is identified in any manner, owners and operators must investigate to determine the possible presence of free product, begin free product removal as soon as practicable, conduct free product removal in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site, and that properly treats, discharges or disposes of recovery byproducts in compliance with applicable local, state and federal regulations, This regulation also provides that abatement of free product migration is a minimum objective for the design of the free product removal system and provides that any flammable products must be handled in a safe and competent manner to prevent fires or explosions.	This work plan does not involve removal of free product or tanks.
ARM 17.56.607	ARM 17.56.607 (Relevant) specifies that all free product must be removed to the maximum extent practicable before a release may be considered resolved.	This work plan does not involve removal of free product.
ARM 17.56.702	ARM 17.56.702 (Applicable) requires that all tanks and connecting piping which are taken out of the service permanently must be removed from the ground. This applies if any remaining underground piping is encountered during remedial activities.	This work plan does not involve removal of free product or tanks.
Reclamation Requirements (Relevant)		
 Section 82-4-231, MCA Section 82-4-233, MCA Section 82-4-336, MCA ARM 17.24.519	Certain portions of the Montana Strip and Underground Mining Reclamation Act and Montana Metal Mining Act are relevant requirements for activities at the KRY Site. No mining activities are occurring at the KRY Site, these requirements are relevant for the management and reclamation of areas disturbed by excavation, grading , or similar actions Section 82-4-231, MCA: Requires operators to reclaim and revegetate affected lands using most modern technology available. Operators must grade, backfill, topsoil, reduce high walls, stabilize subsidence, control water, and minimize erosion, subsidence, land slides and water pollution. Section 82-4-233, MCA: Operators must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration Section 82-4-336, MCA: Disturbed areas must be reclaimed to utility and stability comparable to areas adjacent. ARM 17.24.519: Pertinent areas where excavation will occur will be regraded to minimize settlement.	Disturbance associated with sampling activities will be minimal and no reclamation will be required.

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
ARM 17.24.631(1), (2), (3)(a) and (b)	ARM 17.24.631(1), (2), (3)(a) and (b): Disturbances to the prevailing hydrologic balance will be minimized. Changes in water quality and quantity, in the depth to groundwater and in the location of surface water drainage channels will be minimized, to the extent consistent with the selected response alternatives. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, mulching, and control of toxic-forming waste materials.	
ARM 17.24.633	ARM 17.24.633: Surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.	
ARM 17.24.635, 636, and 637	ARM 17.24.635, 636, and 637: Set forth requirements for temporary and permanent diversions.	
ARM 17.24.638	ARM 17.24.638: Sediment control measures must be implemented during operations.	
ARM 17.24.640	ARM 17.24.640: Discharges from diversions must be controlled to reduce erosion and enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	
ARM 17.24.641	ARM 17.24.641: Practices to prevent drainage from acid or toxic forming spoil material into ground and surface water will be employed.	
ARM 17.24.643 - 646	ARM 17.24.643 through 17.24.646: Provisions for groundwater protection, groundwater recharge protection, and groundwater and surface water monitoring.	
ARM 17.24.701 and 702	ARM 17.24.701 and 702: Requirements for redistributing and stockpiling of soil for reclamation. Also outline practices to prevent compaction, slippage, erosion, and deterioration of biological properties of soil.	
ARM 17.24.703	ARM 17.24.703: When using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use; and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.	
ARM 17.24.711	ARM 17.24.711: Requires that a diverse, effective and permanent vegetative cover of the same seasonal variety and utility as the vegetation native to the area of land to be affected must be established. This provision would not be relevant and appropriate in certain instances, for example, where there is dedicated development.	
ARM 17.24.713	ARM 17.24.713: Seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed.	
ARM 17.24.714	ARM 17.24.714: Mulch or cover crop or both must be used until adequate permanent cover can be established.	
ARM 17.24.716	ARM 17.24.716: Establishes method of revegetation.	
ARM 17.24.717 and Section 82-4-233, MCA	ARM 17.24.717: Relates to the planting of trees and other woody species if necessary, as provided in§ 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover.	
ARM 17.24.718	ARM 17.24.718: Requires soil amendments if necessary to establish a permanent vegetative cover.	
ARM 17.24.721	ARM 17.24.721: Specifies that rills or gullies must be stabilized and the area reseeded and replanted it the rills and gullies are disrupting the reestablishment of the vegetative cover or causing or contributing to a violation of water quality standards for a receiving stream.	
ARM 17.24.723	ARM 17.24.723: Requires periodic monitoring of vegetation, soils, water, and wildlife.	
ARM 17.24.724	ARM 17.24.724: Specifies how revegetation success is measured.	
ARM 17.24.726	ARM 17.24.726: Sets the required methods for measuring vegetative success	
ARM 17.24.731	ARM 17.24.731: If toxicity to plants or animals is suspected, comparative chemical analysis may be required	
ARM 17.24.751	ARM 17.24.751: Measures to prevent degradation of fish and wildlife habitat will be employed.	
ARM 17.24.761	ARM 17.24.761 (Relevant) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities and requires that a fugitive dust program be implemented.	

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Noxious Weeds (Applicable)		
Section 7-22-2101(8)(a), MCA	Section 7-22-2101(8)(a), MCA defines "noxious weeds" as any exotic plant species established or that may be introduced in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities and that is designated: (i) as a statewide noxious weed by rule of the department of agriculture; or (ii) as a district noxious weed by a district weed board, following public notice of intent and a public hearing.	Noxious weeds are a significant problem at the KRY site. Sampling activities conducted under this work plan will cause minimal disturbance to the landscape.
ARM 4.5.201 - 204	ARM 4.5.201 - 204 list designated noxious weeds.	
Section 7-22-2109(2)(b), MCA	Section 7-22-2109(2)(b), MCA requires that the board establish weed management criteria.	
Section 7-22-2152, MCA	Section 7-22-2152, MCA requires that any person proposing certain actions including but not limited to a solid waste facility, a highway or road, a commercial, industrial, or government development, or any other development that needs state or local approval and that results in the potential for noxious weed infestation within a district shall notify the district weed board at least 15 days prior to the activity. The person committing the action shall submit a written plan specifying the methods to be used to accomplish revegetation.	
OTHER LAWS (NON-EXCLUSIVE LIST)		
	The following laws are included to provide a reminder of other legally applicable requirements for actions being conducted at the KRY Site. This is not an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning.	
29 CFR 1910	The federal Occupational Safety and Health Act regulations found at 29 CFR 1910 are applicable to worker protection during remedial activities	A site specific health and safety plan (HASP) has been developed for the activites on the KRY Site. The HASP includes information on site hazards, job procedures, emergency response, personnel training requirement, site control, air monitoring, and personnel protection equipment.
ARM 17.38.101	ARM 17.38.101 (Applicable) provides construction standards for reconstruction or modification of any public water supply line or sewer line. This regulation would be applicable if the remedial action at the site requires any reconstruction or modification of public water supply or sewer lines.	This work plan does not involve modifying a public water supply line or sewer line.
Section 85-2-101, MCA	Section 85-2-101, MCA declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.	This work plan does not involve establishing a controlled groundwater area.
Parts 3 and 4 of Title 85, Chapter 2, MCA	Parts 3 and 4 of Title 85, Chapter 2, MCA set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting water of the state. Specific requirements are set forth below	
Section 85-2-301, MCA	Section 85-2-301, MCA provides that a person may only appropriate water for a beneficial use.	
Section 85-2-302, MCA	Section 85-2-302, MCA specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefore except by applying for and receiving a permit from the Montana Department of Natural resources and Conservation (DNRC).	
Section 85-2-306, MCA	Section 85-2-306, MCA specifies the conditions on which groundwater may be appropriated and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.	
Section 85-2-311, MCA	Section 85-2-311, MCA specifies the criteria which must be met in order to appropriate water and includes requirements that: 1) there are unappropriated waters in the source of supply, 2) the proposed use of the water is a beneficial use, and 3) the proposed use will not interfere unreasonably with other planned uses or developments.	
Section 85-2-402, MCA	Section 85-2-402, MCA specifies that an appropriator may not change an appropriated right except as provided in this section with approval of the DNRC.	
Section 85-2-412, MCA	Section 85-2-412, MCA provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water, over and above what is actually necessarily used, such surplus must be returned to the stream	

ERCLs for Groundwater Monitoring

Federal or State ERCL Citation	Description	Preliminary Identification of Compliance
Section 85-2-506, MCA	Pursuant to § 85-2-506, MCA, designation of a controlled groundwater area may be proposed if: (i) excessive groundwater withdrawals would cause contaminant migration; (ii) groundwater withdrawals adversely affecting groundwater quality within the groundwater area are occurring or are likely to occur; or (iii) groundwater quality within the groundwater area is not suited for a specific beneficial use.	
Section 85-2-507, MCA	Pursuant to § 85-2-507, MCA the Montana Department of Natural Resources and Conservation may grant either a permanent or temporary controlled groundwater area. The maximum allowable time for a temporary area is two years, with a possible two-year extension.	
Sections 50-70-101 et seq., MCA	The Occupational Health Act of Montana regulations found at Sections 50-70-101 et seq., MCA are applicable to the health and safety of workers during remedial activities.	A site specific health and safety plan (HASP) has been developed for the field activities on the KRY Site. The HASP includes information on site hazards, job procedures, emergency response, personnel training requirement, site control, air monitoring, and personnel protection equipment.
ARM 17.74.101	ARM 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is applicable to limited categories of workers and for most workers the similar federal standard at 29 CFR 1910.95 applies.	
ARM 17.74.102	ARM 17.74.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR 1910.1000 applies.	
Sections 50-71-201, 202, and 203, MCA	Sections 50-71-201, 202, and 203, MCA state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.	
Sections 50-78-201, 202, and 204, MCA	Sections 50-78-201, 202, and 204, MCA state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.	

Appendix B

Project Operating Procedures

BNSF KRY Project Operating Procedure (POP) 110 Packing and Shipping Samples

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) KRY Project POP 110 describes proper packaging methods and shipment of samples to minimize the potential for sample breakage, leakage, or cross-contamination, and provide a clear record of sample custody from collection to analysis. Specific project requirements as described in an approved Work Plan, Task Hazard Analysis (THA), or Site-Specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

The Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (1976) (RCRA) regulations (40 CFR Section 261.4 (d)) specify that samples of solid waste, water, soil, or air collected for the purpose of testing are exempt from regulation when any of the following conditions apply:

- Samples are being transported to a laboratory for analysis
- Samples are being transported to the collector from the laboratory after analysis
- Samples are being stored:
    - By the collector prior to shipment for analysis
    - By the analytical laboratory prior to analysis
    - By the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case

BNSF KRY POP 110 deals only with these sample types.

2.0 Responsibilities

The field sampling coordinator is responsible for the enactment and completion of the chain of custody and the packaging and shipping requirements outlined here and in project-specific sampling plans.

3.0 Health and Safety

This section presents the generic hazards associated with packing and shipping samples and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP and THAs will address additional requirements and will take precedence over this document. Note that packing and shipping samples usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or EHS Coordinator.

Health and safety hazards with packing and shipping of samples include the following:

- Exposure to sample preservatives – Know the types of sample preservatives sent to you by the analytical laboratory. Understand the potential exposures (inhalation, ingestion skin contact) and use chemically impervious gloves to protect your hands from acids in particular.
- Anticipate the potential for spills – Glass containers are subject to breakage and if dropped on the floor will create a spill. Know how to contain the spill, have spill response materials available, and understand the proper disposal methods for spilled materials. Wear personal protective equipment (PPE) to clean up the spill as appropriate (Level C or D).
- Broken glass – Be aware of the possibility for broken glass in previously used coolers. Inspect the cooler before you place samples in it and clean out any broken glass safely (i.e. with a small brush).
- Coolers can be heavy – Use proper lifting techniques to pick up loaded coolers. Bend your legs and lift with a straight back to avoid a back injury.
- Do not use your teeth to cut tape to size, use a tape dispenser.

4.0 Supporting Materials

The following materials must be on hand and in sufficient quantity to ensure that proper packing and shipping methods and procedures may be followed:

- Chain of custody forms and tape
- Sample container labels
- Coolers or similar shipping containers
- Duct tape or transparent packaging tape
- Zip-lock type bags

- Protective wrapping and packaging materials
- Ice
- Shipping labels for the exterior of the ice chest
- Transportation carrier forms (Federal Express, Airborne, etc.)
- PPE as specified in the Site-Specific HASP
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants (including sample preservatives)
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

All samples must be packaged so they do not leak, break, vaporize, or cause cross-contamination of other samples. Waste samples and environmental samples (e.g., groundwater, soil, etc.) should not be placed in the same shipping container. Each individual sample must be properly labeled and identified. A chain of custody record must accompany each shipping container. When refrigeration is required for sample preservation, samples must be kept cool during the time between collection and final packaging.

All samples must be clearly identified immediately upon collection. Each sample bottle label (Figure 1) will include the following information:

- Client or project name, or unique identifier, if confidential
- A unique sample description
- Sample collection date and time
- Sampler's name or initials
- Indication of filtering or addition of preservative, if applicable
- Analyses to be performed

After collection, identification, and preservation (if necessary), the samples will be maintained under chain of custody procedures as described below.

5.1 Chain Of Custody

A sample is considered to be under custody if it is in one's possession, view, or in a designated secure area. Transfers of sample custody must be documented by chain of custody forms (Figure 2). The chain of custody record will include, at a minimum, the following information:

- Client or project name, or unique identifier, if confidential
- Sample collector's name
- Mailing address and telephone number
- Designated recipient of data (name and telephone number)
- Analytical laboratory's name and city
- Description of each sample (i.e., unique identifier and matrix)
- Date and time of collection
- Quantity of each sample or number of containers
- Type of analysis required
- Date and method of shipment

Additional information may include type of sample containers, shipping identification air bill numbers, etc.

When transferring custody, both the individual(s) relinquishing custody of samples and the individual(s) receiving custody of samples will sign, date, and note the time on the form. If samples are to leave the collector's possession for shipment to the laboratory, the subsequent packaging procedures will be followed.

5.2 Packing for Shipment

To prepare a cooler for shipment, the sample bottles should be inventoried and logged on the chain of custody form. Be careful for any broken glass. As each sample bottle is logged on the chain of custody form, it should be wrapped with protective material (e.g., bubble wrap, matting, plastic gridding, or similar material) to prevent breakage. The protective material should be secured with tape. Each sample bottle cap should be checked during wrapping and tightened, if needed. Avoid over tightening, which may cause bottle cap to crack and allow leakage. Additional packaging material, such as bubble wrap, should be spread throughout the voids between the sample bottles.

Most samples require refrigeration as a minimum preservative. To ensure that samples are received by the laboratory within required temperature limits, place ice in the cooler, making sure that ice is present on all sides of each sample. To prevent liquid leaking in the cooler, the ice will be placed in two sealed zip lock type bags.

Place the original completed chain of custody record in a zip-lock type plastic bag and place the bag on the top of the contents within the cooler or shipping container. Alternatively, the bag may be taped to the underside of the container lid. Retain a copy of the chain of custody record with the field records.

Close the top or lid of the cooler or shipping container and rotate/shake the container to verify that the contents are packed so that they do not move. Add additional packaging if needed and reclose. Place signed and dated chain-of-custody seal (Figure 3) at two different locations (front and back) on the cooler or container lid and overlap with transparent packaging tape. The chain of custody seal should be placed on the container in such a way that opening the container will destroy the tape. Packaging tape should encircle each end of the cooler at the hinges. Use proper lifting techniques when picking up the cooler.

Sample shipment should be sent via an overnight express service that can guarantee 24-hour delivery. Retain copies of all shipment records as provided by the shipper.

6.0 Quality Assurance/Quality Control

Recipient of sample container should advise shipper and/or transporter immediately of any damage to the container, breakage of contents, or evidence of tampering.

7.0 Documentation

The documentation for support of proper packaging and shipment will include the laboratory chain of custody records and transportation carrier's airbill or delivery invoice. All documentation will be retained in the project files.

Figure 1 Sample Label

Sample Label

Sample I.D.	______________________
Location	______________________
Date ________	Time ______ Sampled By ______
Test(s)	______________________
Pres	______________________

Figure 1

Figure 2 Chain of Custody Record

Chain of Custody Record   № 3133

Project Name:	Project Number:	Analysis Requested	Page____of____
Send Report To:	Sampler (Print Name):		
Address:	Sampler (Print Name):		
	Shipment Method:		
	Airbill Number:		Purchase Order #:________
Phone:	Laboratory Receiving:		
Fax:			

Field Sample ID	Sample Date	Sample Time	Sample Matrix	Number of Containers												Comments, Special Instructions, etc.	Lab Sample ID (to be completed by lab)

Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:

Sample Custodian Remarks (Completed By Laboratory):

QA/QC Level	Turnaround	Sample Receipt	
Level I ☐	Routine ☐	Total # Containers Received?	
Level II ☐	24 Hour ☐	COC Seals Present?	
Level III ☐	1 Week ☐	COC Seals Intact?	
Other ☐	Other _____	Received Containers Intact?	
		Temperature?	

White: Lab Copy   Yellow: PM Copy   Pink: Field Copy   Gold: PM/QA/QC Copy

Figure 2

Figure 3 Chain of Custody Seal

Chain of Custody Seal

Custody Seal

Date ______________________________

Signature __________________________

Seal No. ___________________________

Figure 3

BNSF KRY Project Operating Procedure (POP) 230 Groundwater Sampling

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) KRY Project POP 230 describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells. Specific project requirements as described in an approved Work Plan, Task Hazard Analysis (THA), or Site-Specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have the responsibility to ensure that all groundwater sampling is performed in accordance with the project-specific sampling program and this POP. In addition, the field sampling coordinator must ensure that all field workers responsible for conducting groundwater sampling activities are fully apprised of this POP and other pertinent project documents.

3.0 Health and Safety

This section presents the generic hazards associated with low flow groundwater sampling and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP and THA will address additional requirements and will take precedence over this document. Note that low flow groundwater sampling usually requires Level D personal protection unless there is a potential for exposure to airborne site contaminants.

Health and safety hazards include but are not limited to the following:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure there is a safe means of access/egress to the wellhead.
- Dermal exposure to potentially contaminated groundwater. Ensure that proper personal protective equipment (PPE) is used to mitigate the impact of splashes of groundwater to skin and/or eyes.

- Exposure to site contaminants. If there is product in the well, take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.
- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

4.0 Supporting Materials

The following section includes basic types of materials and equipment necessary to complete groundwater sampling activities. Project specific equipment will be selected based upon project objectives and site conditions (e.g., the depth to groundwater, purge volumes, analytical parameters, well construction, and physical/chemical properties of the analytes).

4.1 Project Documentation and Set-Up

- Work Plan
- Sampling Plan
- POP 231
- HASP
- Project Contact List
- Laboratory, and other subcontractor, work orders (signed)

4.2 Purging/Sample Collection

The following equipment will be used to purge monitoring wells and collect groundwater samples:

- Low flow bladder sampling pump
- Teflon lined tubing
- Teflon bladders
- O-rings and grab plates
- Water level measurement equipment
- In-line water quality meter (e.g., flow-through cell) with individual temperature, pH, specific conductance, dissolved oxygen (DO), salinity, and oxidation-reduction potential (ORP) probes

- Turbidity meter
- Sample containers, labels and preservation solutions (if necessary)
- Coolers and ice
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- Field data sheets and log book
- Decontamination equipment
- Paper towels
- Well keys
- Disposable gloves
- Tubing cutters
- Plastic sheeting
- Personal protective equipment
- Cloth towel(s) or other suitable insulating material to insulate the flow-through cell
- Buckets and intermediate containers

5.0 Methods and Procedures

The following sections describe the methods and procedures required to collect representative groundwater samples.

5.1 Water-Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. A static-water level will be measured in the well prior to purging and sample collection. The water level is needed for estimating the purge volume and also may be used for mapping the potentiometric surface of the groundwater. Whenever possible, water level measurements will be collected at all of the wells on-site within 24 hours of each other, or a period reasonable to site conditions. Water-level measurements will be collected using an electronic or mechanical device following the methods described in POP 231.

The location of the measurement point for water level measurements for each well should be clearly marked on the outermost casing or identified in previous sample collection records. This point usually is established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If the measuring point from previous investigations is not marked, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form. The location should be described on the groundwater sampling form.

After opening the well, the field sampler will check for indications of an airtight seal resulting in a pressure difference within the well compared to ambient conditions. If this is the case, the field sampler will allow a minimum of 5 minutes for the water level to stabilize before collecting a down-hole measurement. To obtain a water level measurement, the field sampler should lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time, the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in POP 120.

5.2 Purging and Sample Collection Procedures

Wells will be purged and sampled using low-flow sampling techniques.

Purging must be performed for all wells prior to sample collection. The volume of water present in each well must be computed using two measurable lengths: length of water the water column and monitoring well inside diameter. The following data can be used in this field calculation:

Inside Diameter of casing (inches)	Gallons/foot
1 1/4	0.077
1 1/2	0.10
2	0.16
3	0.37
4	0.65
6	1.64

A low flow bladder pump will be used to purge water. The inlet of the pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1 to 2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liter per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. The pump rate should generally not exceed 0.3 L/min. However, some aquifers may be able to sustain higher flow rates without excessive drawdown. Efforts will be made to limit drawdown to 0.5 foot. If the well recharge is not adequate enough to maintain proper water levels, the well will be pumped dry. The well will be sampled after water level in the well has recovered.

If the well being sampled is newly installed and developed or has been redeveloped, sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new well. Wells developed with stressful measures (e.g., backwashing, jetting, compressed air, etc.) may require as long as a 7-day interval before sampling.

Groundwater will be pumped from the well into a sealed flow-through assembly containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter.

The flow-through assembly must be placed as close as possible to the well to be sampled. The tubing that connects the well discharge to the flow-through cell must be as short as possible.

It is essential to properly calibrate the Water Quality Meter for the specific parameters being monitored, according to the procedures identified in the instrument manual. Calibration procedures and results must be documented in the site field notebook.

Field parameters values will be recorded on the Groundwater Sampling Form (attached) or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; the change between successive readings of temperature, pH and conductivity are less than 10 percent, and turbidity is reduced to 10 NTUs or less. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements is considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

Each sample container will be slowly filled by pouring sample water gently down the inside of the container with minimal turbulence. During sample collection, the tubing will not be allowed to contact the sample containers.

Sample labels and chain of custody will be filled out and include the following information at a minimum: sample location, sample name, sampler name or initials, requested analysis, preservative, date and time. Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis.

Non-dedicated equipment will be decontaminated between each well. Disposable parts of the bladder pump may be thrown away and replaced in between each sample instead of decontaminating those parts. Additionally, the tubing may be left in the well and be dedicated to each well; therefore, the tubing will not require decontamination.

5.3 Field Parameter Monitoring

Field personnel should familiarize themselves with the field parameters to be monitored. Certain field parameters such as DO and ORP should correlate to each other. If available, historical sampling forms should be reviewed prior to sampling for an initial understanding of the range of values previously obtained at each sample location. Often it is useful to photocopy the past sampling forms and have them available in the field for comparison purposes. Understanding the past results and current conditions can indicate well damaged or if meters are working properly.

5.4 Sample Preparation and Filtration

Prior to transport or shipment, groundwater samples may require preparation and/or preservation. Field preparation includes preservation in the form of chemical additives and temperature control. Specific handling and preservation requirements will be in accordance with POP 110 and the project-specific sampling plans. A clean pair of gloves and decontaminated sampling tools will be used when handling the samples during collection to prevent cross contamination.

In general, groundwater samples will need to be placed on ice and inside coolers to protect the samples from the sun and to decrease their temperature to or below 4 degrees Celcius.

Field personnel should contact the laboratory prior to going out into the field to ensure necessary lab containers are available and sample preservation procedures are followed. Items such as preservative safety and clear versus opaque jars are examples of items that should be discussed with the laboratory. Sample receiving dates also should be discussed with the laboratory.

6.0 Field Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) requirements dictated by the project specific sampling plans include, but are not limited to, blind field duplicates, equipment rinse blanks (ERB), and field blanks. These samples will be collected at the following frequencies:

- Duplicate – 1 per 10 samples
- ERB – 1 per day of sample collection activities or per type of field equipment used to collect samples only when non-dedicated sampling methods are used
- Field Blank – as determined for the project
- Trip Blanks – shall be included with all VOCs, methane and other samples that consist of dissolved gas phase compounds.

7.0 Documentation

Various documents will be completed and maintained as a part of groundwater sample collection. These documents will provide a summary of the sample collection procedures and conditions, shipment method, analyses requested, and the custody history. These documents may include:

- Field book
- Groundwater sampling forms
- Sample labels
- Chain of custody
- Shipping receipts
- Sample nomenclature protocol

All documentation will be stored in the project files. Sample nomenclature protocol should be discussed with the project data management personnel to ensure consistency between sampling events.

BNSF KRY Project Operating Procedure (POP) 231 Water-Level Measurements

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) KRY Project POP 231 describes the measurement of water levels in groundwater monitoring wells or piezometers. Water-level measurements are fundamental to groundwater and solute transport studies. Water-level data are used to indicate the directions of groundwater flow and areas of recharge and discharge, evaluate the effects of manmade and natural stresses on the groundwater system, define the hydraulic characteristics of aquifers, and evaluate stream-aquifer relations. Measurements of the static-water level also are needed to estimate the amount of water to be purged from a well prior to sample collection.

Specific project requirements as described in an approved Work Plan, Task Hazardous Analysis (THA), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have the responsibility to oversee and ensure that all procedures are performed in accordance with the project-specific sampling program and this POP.

3.0 Health and Safety

This section presents the generic hazards associated with the collection of water-level measurements. The site-specific HASP and THA will address additional requirements and will take precedence over this document. Appropriate personal protective equipment (PPE) must be worn as determined in the Site-Specific HASP, which typically consists of Level D protection. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or Environment, Health, and Safety (EHS) Coordinator.

Health and safety hazards during groundwater level measurements may involve:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure that you have safe means of access/egress to the wellhead.

- Exposure to site contaminants. If there is methane or free product in the well take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.

- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

4.0 Supporting Materials

This section identifies the types of equipment that may be used for measurement of groundwater levels. Based on project objectives, observed or probable well contamination, and well construction, a project-specific equipment list will be determined from the following equipment:

- Water-level and/or product-level measuring device
- Distilled water dispenser bottle
- Methanol or isopropyl in properly labeled dispenser bottles
- Plastic sheeting
- PPE as specified in the Site-Specific HASP
- Fluid-level monitoring logs and field book
- Paper towels or chemical-free cloths
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

When taking a series of fluid-level measurements at a number of monitoring wells, it is generally good practice to go in order from the least to the most contaminated well. Additionally, the measurement of all site wells should be done consecutively and before any sampling activities begin. This will ensure the data are representative of aquifer conditions. All pertinent data should be entered in the Fluid-Level Monitoring Log or the project field book.

5.1 Well Evaluation

Upon arrival at a monitoring well, the surface seal and well protective casing should be examined for any evidence of frost heaving, cracking, or vandalism. All observations should be recorded in the fluid-level monitoring log or the project field book.

The area around the well should be cleared of weeds and other materials prior to measuring the static-water level (avoid contact with poison ivy or other allergenic plants). A drop cloth or other material (e.g., plastic garbage bag) may be placed on the ground around the well, especially if the ground is disturbed or potentially contaminated. This will save time and work for cleaning equipment or tubing if it falls on the ground during preparation or operation. The well protective casing should then be unlocked and the cap removed.

5.2 Measuring Point Location

The measuring point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point usually is established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water-level measuring point should be marked on the north side of the well casing and noted in the Fluid-Level Monitoring Log or the project field book. Monitoring well measurements for total depth and water level should be consistently measured from one reference point so that these data can be used for assessing trends in the groundwater.

5.3 Water-Level Measurement

Water-level measurements shall be made using an electronic or mechanical device. Several methods for water-level measurement are described below. The specific method to be used will be defined in the project-specific sampling plan.

5.3.2 Electrical Methods

Many types of electrical instruments are available for water-level measurement; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Electrodes generally are contained in a weighted probe that keeps the tape taut while providing some shielding of the electrodes against false indications as the probe is being lowered into the well. Before lowering the probe into the well, the circuitry can be checked by dipping the probe in water and observing the indicator (a light, sound, and/or meter).

To obtain a water-level measurement, slowly lower the decontaminated probe into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. At this time, the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement.

In wells having a layer of NAPL floating on the water, the electric tape will not respond to the oil surface and, thus, the fluid level determined will be different than would be determined by a steel tape. The difference depends on how much NAPL is floating on the water. Dual media tapes are recommended in that instance to measure both NAPL and water levels using the same measuring device. The procedure is discussed in Section 5.4.

Water-level measurement should be entered in the fluid-level monitoring log or the project field book. The water-level measurement device shall be decontaminated immediately after use.

5.4 Procedures for Immiscible Fluids

At those facilities where monitoring to determine the presence or extent of immiscible fluids is required, the sampler will need to use special procedures for the measurement of fluid levels. The procedures required will depend on whether light NAPL (LNAPL) that form lenses floating on top of the water table or dense NAPL (DNAPL) that sink through the aquifer and form lenses over lower permeability layers are present.

In the case of LNAPL, measurements of immiscible fluid and water level usually cannot be accomplished by using normal techniques. For example, a chalked steel-tape measurement will only indicate the depth to the immiscible fluid (not the depth to water) and a conventional electric water-level probe generally will not respond to non-conducting immiscible fluids.

To circumvent these problems, the use of special techniques and equipment can be specified. These techniques have been specially developed to measure fluid levels in wells containing LNAPL or DNAPL, particularly petroleum products. One method is similar to the chalked steel-tape method. The difference is the use of a special paste or gel rather than ordinary carpenters chalk. Such indicator pastes, when applied to the end of the steel tape and submerged in the well, will show the top of the oil as a wet line and the top of the water as a distinct color change. Another method, similar to the electric-tape method, uses a dual purpose probe and indicator system. The probe can detect the presence of any fluid (through the wetting effect) and also can detect fluids that conduct electricity. Thus, if a well is contaminated with low density, non-conducting LNAPL such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction. However, when the probe is lowered deeper to contact water, electrical conduction will be detected. The detection of a DNAPL would be similar.

5.5 Measurement of Total Depth

During water-level measurement, the total depth of the well also may be measured. This measurement gives an indication of possible sediment buildup within the well that may significantly reduce the screened depth. The same methods used for measuring water levels (e.g., steel tape or electrical probes) may be used to measure the total well depth.

The most convenient time to measure the total well depth is immediately following measurement of the water level and prior to removing the measurement device completely from the well. The measurement device (steel tape or electrical probe) is lowered down the well until the measurement tape becomes slack indicating the weighted end of the tape or probe has reached the bottom of the well. While the probe remains touching the bottom and the tape pulled taut, the total well depth shall be recorded into the field book.

6.0 Quality Assurance/Quality Control

To ensure that accurate data are collected, repeated measurements of the fluid depths should be made. The readings should be within 0.01 to 0.02 feet of each other. A secondary check, if data are available, is to compare previous readings collected under similar conditions (e.g., summer months, wells pumping, etc.).

7.0 Documentation

Data will be recorded into the fluid-level monitoring log form, the project field book, or, if groundwater sampling, the groundwater sample collection record. Additional comments, observations, or details also will be noted. These documents will provide a summary of the water-level measurement procedures and conditions and will be kept the in project files.

Title: **Well Development**	Procedure Number: **RMD 006**
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Authorization Signatures

Elizabeth P. Schwartz 10/21/13	Elizabeth Denly 10/21/13
Technical Reviewer Date Elizabeth Schwartz, PG	Remediation Practice Quality Coordinator Date Elizabeth Denly

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ATTACHMENTS

1.0 INTRODUCTION

1.1 Scope and Applicability

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for the development of wells. Well development is completed to (1) evacuate any water added during the drilling of wells, (2) establish a good hydraulic connection between the well and the surrounding water-bearing zone, (3) settle the sand pack and formation following the disruptive drilling and installation activities, (4) alleviate clogging, smearing or compaction of formation materials at the borehole wall due to the drilling process, and (5) remove fine particles (e.g., silt or clay) from the water column and sand pack in order to obtain groundwater samples that are representative of the water-bearing zone in which the well is installed and/or enhance groundwater extraction and injection rates. Well development typically occurs for all newly installed wells and can also be implemented to refurbish an older well where significant silt/sediment build-up has occurred, as may be observed when the measured depth to bottom of a well is notably shallower than the recorded constructed depth to bottom.

1.2 Summary of Method

Proper well development includes initial and ongoing water-level and water quality measurements, implementation of the development method, management of the development wastes, equipment decontamination, and documentation. First, the well should be opened and initial measurements (e.g., headspace air monitoring readings, depth to water, total depth of the well) are collected and recorded. The well is developed using the method selected for each project based on the lithology, site conditions, and objectives and requirements of the project. Development of the well continues until the water is visually clear and free of sediments (e.g., turbidity <10 nephelometric turbidity units [NTU]), until a minimum number of well volumes has been evacuated (depending on regulatory requirements) or until water quality parameters such as pH, temperature, and specific conductivity stabilize, depending on project requirements. All purge water is containerized for proper characterization and disposal at an appropriate facility unless prior approval to discharge to land surface has been obtained from appropriate sources (e.g., governing regulatory agency). Final measurements (e.g., depth to water, total depth of the well, total water removed) are recorded in the field book or on the Well Development Form (Attachment A). Equipment is decontaminated, as appropriate, prior to use in the next well.

After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours). In addition, more vigorous well development methods (e.g., surging) may require a relatively longer setup time before development. If a less vigorous method (e.g., bailing) is being used, development may be initiated shortly after installation when grout is not used in well installation or if the sealant is above the water table. Regardless, the method used for development should not interfere with the setting of the well seal, which should be considered in preparing the work plan.

Well development also provides an opportunity to collect data that can be used to estimate the hydraulic conductivity (permeability) of the screened water-bearing formation. These estimates can be used to estimate groundwater flow velocities, and are often needed to project the extent of plume migration, estimate monitored natural attenuation rates, and other investigative tasks. Estimates of hydraulic conductivity and aquifer transmissivity can be derived from a measure of a well's specific capacity; i.e., flow rate divided by water-level drawdown (expressed in gallons per minute per foot [gpm/ft] of drawdown). The data needed to estimate specific capacity are the flow rate (purge rate during development, measured with a flow meter or a 5-gallon bucket and stopwatch), the static (pre-pumping) depth to water, and the pumping depth to water. The duration of pumping when the pumping depth to water is measured should also be noted.

Several development methods may be used depending on site conditions and project requirements. There are several regulatory agency guidance documents (e.g., USGS, 1997) as well as ASTM standards available for reference. If possible, select a development method that avoids introduction of air, foreign water, or chemicals to the aquifer during development. A few development methods are outlined in Section 2.0.

1.3 Equipment

The following list of equipment may be utilized during the development of wells. Site-specific conditions may warrant the use of additional items or deletion of items from this list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Field book and forms
- Well keys
- Socket wrench
- Centrifugal or submersible pump and tubing/hosing
- Water quality meter (including parameters such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP) and dissolved oxygen (DO))
- Flow-through cell
- Turbidity meter
- Plastic beaker, jar, or disposable plastic cups
- Bailer and cord
- Large-capacity DOT-approved containers (if required)
- Five-gallon buckets
- Surge block
- Bulk supply of deionized/organic-free water
- Well construction diagrams and previous well development data (if available)
- Equipment decontamination supplies

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface.

Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and, therefore, floats on the surface of the water.
Monitoring Well	A well made from a polyvinyl chloride (PVC) pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
Non-aqueous Phase Liquid (NAPL)	Petroleum or other fluid that is immiscible in water and tends to remain as a separate liquid in the subsurface.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Separate-phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Low-permeability Formation	A geologic formation that has very slow recharge and discharge rates due to small pore spaces in the formation material. A clay formation is considered to have low permeability and a very slow recharge rate compared to a more permeable formation, such as sand or gravel.
Surge Block	A disc-shaped or cylindrical device that closely fits the well casing interior and is operated like a plunger below the water table to force water in and out of the well as a well development tool.
Total Depth of Well	Distance from the measuring point to the bottom of the well.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

When present, special care should be taken to avoid contact with contaminated groundwater, LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

1.6 Cautions and Potential Problems

The following cautions or problems may be associated with well development:

- The observed presence of NAPL may warrant alternative goals and objectives for the well other than immediate development. The Project Manager should be contacted for direction on how to proceed.
- Low-yielding wells (e.g., at clay-bedrock interface, tight bedrock formations, etc.) may produce insufficient water to achieve optimal development including parameter stabilization.
- High-yielding wells (e.g., in coarse sand and gravel aquifers) may require the removal of large quantities of water to approach optimal development.
- Long well screens and/or larger diameter wells may require more time and effort to ensure adequate development of the entire interval depending on the development method employed.
- Development of wells should occur from the least-contaminated well to the most-contaminated well, if known.
- Overpumping is not as vigorous as surging and jetting and is probably the most desirable method for the development of new wells. The possibility of disturbing the filter pack is greatest with jetting well development methods, which are generally reserved for redevelopment of clogged extraction or injection wells. Surging or jetting may be preferred methods for supply, recovery, or injection wells (if constructed with metal screens) to achieve higher well efficiencies.
- The introduction of external water or air by jetting may alter the chemistry of the aquifer.
- Surging with compressed air may produce "air locking" in the water-bearing zone, preventing water from flowing into the well.
- Exercise caution with the use of surge blocks in PVC screen and pipe as the well could be damaged.
- Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casings are especially susceptible to becoming lodged (stuck) if used in well development applications.
- Prior to sampling a well, sufficient time should be allowed for equilibration with the formation after development. Refer to the governing regulatory agency for guidance regarding the required/recommended time interval between well development and sampling.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project work plan. These requirements may include:

  - OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
  - 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Well development will be completed on wells after the grout, annular seals, and protective casings are deemed sufficiently stable (i.e., 24 to 48 hours after installation) for the development method being utilized and/or after required regulatory agency timeframe requirements. Development may be performed immediately after well installation if grout is not used during well installation or if the sealant (i.e., bentonite seal) is above the water table, in accordance with the regulatory requirements. Various well development methods, including surging, pumping, hand bailing, and jetting, are summarized below, followed by step-by-step well development procedures.

2.1 Well Development Methods

Surging Method

Surge and Pump: To increase the effectiveness of well development, the well can be surged and then pumped. Surging may be accomplished in several ways, but essentially water is rapidly forced into and out of a well in a wash and backwash action. One method of surging is to simply turn the pump on for a few minutes and then turn it off for a few minutes. Surging can also be accomplished with a surge block, which is a piston-like device attached to the end of a drill rod or pipe. The block is plunged up and down along the screened interval, similar to a piston in a cylinder, to flush water in and out of the well. Periods of surging are typically followed by a period of water extraction to remove the sediment brought into the well. Surge blocks are best utilized for wells screened in lithologies of medium to high porosities and hydraulic conductivities. Exercise caution with the use of surge blocks in PVC screens which can be damaged by tight-fitting surge blocks.

A surge block method is used alternately with either a bailer or pump, so that materials that have been agitated and loosened by the surging action are removed. The cycle of surging-pumping/bailing is repeated until satisfactory development is achieved.

The surge block, usually attached and operated by a drill rig, is lowered to the top of the well screen and then operated in a surging action with a typical stroke of about three feet. The surging action is usually initiated at the top of the well screen and gradually worked downward through the screened interval so that sand or silt loosened by the surging action cannot cascade down on top of the surge block and prevent removal from the well. The surge block is removed at regular intervals and the fine material that has been loosened is removed by a bailer or pump.

Surging is initially gentle and the energy of the action is gradually increased during the development process. By controlling the speed, length and stroke of the surge block, the surging activity can range from very rigorous to very gentle.

Pumping Method

Pumping develops a well by creating a surging action as a result of variable flow rates. An electric submersible pump or compressed air-operated air displacement pump is installed into the well. The rate of flow is varied at levels adjacent to the well screen.

Overpumping: A simple method of well development is overpumping, where water is simply pumped from the well at a high rate.

Many pumps can also be used to surge a well, employing a similar method as with the surge block. While either off or running, the pump may be plunged up and down along the screened interval, in effect flushing water and sediment in and out of the well and adjacent filter pack.

Hand Bailing Method

Surge and Bail: Instead of a surge block, a bailer can be used in a similar manner since the diameter of the bailer is commonly slightly smaller than the diameter of the well. A water-filled bailer can be plunged up and down, followed by periods of bailing out sediment suspended in the water column. The impact of the bailer as it strikes the surface of the water produces an outward surge of water through the well construction and into the formation. This action tends to break sediment bridges that may have formed during well installation. Movement of water back into the well suspends fine sediments into the water column, which are removed with the bailer.

Bailers are good well development tools for wells screened in low-permeable formations. Deep wells or large purge volume wells should not be developed with bailers, as development with a bailer would be very labor intensive.

Jetting Method

Another method of development is high-velocity hydraulic jetting. Using a specialized jetting tool, jets of water are directed horizontally at the sides of the well from inside the well to loosen fine-grained material and drilling mud residue from the formation. The loosened material is flushed into the well and can be removed through concurrent pumping or by bailing. Caution should be used when using a jetting method of development as there is the possibility of disturbing the well filter pack. For product recovery, a jetting method of development can push product away from the well and can delay or completely prevent product from coming back into the well.

2.2 General Procedures for Well Development

1. The project plan will be consulted regarding any project-specific well development requirements.

2. Consult the well completion diagram and boring log to determine the well construction (well diameter, depth and length of screen), soil core vapor screening results, lithology of the screened interval, and depth to water.

3. If potable water was introduced into the water-bearing zone during well installation, the estimated amount of water lost to the formation during the drilling process should be removed during well development to ensure connection with formation water during the development process.

4. Select the appropriate method and equipment to implement development of the well. Ensure any non-dedicated equipment is clean and decontaminated prior to use and also in between wells. The development equipment should be the appropriate length to reach the entire length of the well screen. The method should be capable of evacuating the development water to the surface and into containers if required.

5. Measure the static DTW and total depth of the well using RMD SOP 004, and determine the amount of standing water in the well (well volume). Record the DTW and calculate the water column volume of the well.

To calculate the volume of water in the well, the following equation (Equation 1) is used:

Well Volume (V) = πr^2 h (cf)
where:
π = pi (3.14)
r = radius of well in feet (ft)
h = height of the water column in ft. [This may be determined by subtracting the DTW from the total depth of the well as measured from the same reference point.]
cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) for common size wells are as follows:

Well Diameter (inches)	Volume (gal/ft)
2	0.1631
3	0.3670
4	0.6524
6	1.4680

If the volumes for the common size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f)
where:
h = height of the water column (feet)
f = the volume in gal/ft

6. Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.

7. Initiate water removal from the well and record the initial water quality measurements including pH, temperature, specific conductivity, DO, ORP and turbidity (as required by project specifications) in the field book or on the Well Development Form. Record any odors, water color/clarity, changes in air monitoring results or other observations in the field book or on the Well Development Form.

8. Optional step to estimate the permeability of the formation: Estimate flow rate of extracted water, in gallons per minute (gpm). The flow rate can be measured with a 5-gallon bucket and stop watch, or timed transfer to any vessel which can be measured. Measure DTW in the well during pumping to derive an estimate of water-level drawdown. Calculate the approximate specific capacity (gpm/ft of drawdown). Tracking the improvement of specific capacity can provide a direct measure of the effectiveness of well development and can determine when development is no longer providing improvement.

9. In general, well development should proceed until the following criteria are met (note: certain regulatory agencies may have more stringent well development requirements):

   a. Water can enter as readily as hydraulic conditions allow.

   b. A representative sample can be collected.

- In general, representative conditions can be assumed when the water is visibly clear of sediments (e.g., turbidity <10 NTU).
- In addition to clear water, a further criterion for completed well development is that the other water quality parameters mentioned above stabilize to within 10 percent between readings over one well volume. During well development, pH, specific conductivity, DO, ORP, temperature and turbidity can additionally be monitored to establish natural conditions and evaluate whether the well has been completely developed.

c. The duration, along with any measured water quality parameters (e.g. pH, temperature, specific conductivity, DO, ORP and turbidity) should be recorded on the Well Development Form.

In some instances, collection of a sample with a turbidity of 10 NTU or less is difficult or unattainable. If a well does not provide a sediment-free sample, development can stop when all of the following conditions are met:

- Several procedures have been tried,
- Proper well construction has been verified,
- Turbidity has stabilized within 10 percent over three successive well volumes, and
- Specific conductivity and pH have stabilized over at least three successive well volumes.
  (It should be noted that pH, temperature, and specific conductivity may not stabilize if water quality has been degraded).

d. The sediment thickness remaining in the well is less than 1 percent of the screen length or less than 0.1 foot for screens equal to or less than 10 feet.

e. A minimum of three times the standing water volume in the well (to include the well screen, casing, plus saturated annulus, assuming 30 percent annular porosity) should be removed. If water was added as part of the well installation and development, attempts should be made to recover the volume of water added, plus the three well volumes.

10. Measure the total depth of the well, to determine the amount, if any, of sand/silt removed during development of the well.

11. Note the final water quality parameters in the field book or on the Well Development Form. The time between well development and sampling will depend on project objectives and regulatory requirements.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following Quality Assurance/Quality Control procedures apply:

- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

- Record well development measurements on field forms or in a field book. See Attachment A for an example of a Well Development Form.
- The following additional information should be recorded on the field form or in a field book:

    - Well/piezometer or monitoring point identification number
    - Well/piezometer or monitoring point location (sketch of the sample point or reference to a location figure)
    - Date of well installation
    - Date(s) and time of well development
    - Static DTW before and after development
    - Quantity of water removed and initial and completion times
    - Quantity and source of water added to well to facilitate development, if applicable
    - Type and capacity of pump or bailer used
    - Description of well development techniques
    - Visual or sensory description (e.g., odors, product, etc.)
    - Time and date measurements were taken
    - Personnel performing the task
    - Weather conditions during task
    - Other pertinent observations
    - Measurement equipment used
    - Calibration procedures used
    - Decontamination procedures used

6.0 REFERENCES

U.S. EPA *A Compendium of Superfund Field Operations Methods*. EPA/540/P-87/001. December 1987.

U.S. EPA Environmental Response Team, Standard Operating Procedures, *Monitor Well Development*, SOP 2044. October 23, 2001.

U.S. Geological Survey, Guidelines and Standard Procedures for Studies of Ground-Water Quality: *Selection and Installation of Wells, and Supporting Documentation*. Water-Resources Investigations Report 96-4233. 1997.

Ohio EPA, Division of Drinking and Ground Waters, *Chapter 8: Monitoring Well Development, Maintenance, and Redevelopment.* Technical Guidance Manual for Ground Water Investigations. February 2009 (Rev 2).

Sanders, Laura L. *A Manual of Field Hydrogeology*. New Jersey: Prentice-Hall, 1998. pp. 260-261.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	OCTOBER 2013	NOT APPLICABLE

ATTACHMENT A

EXAMPLE WELL DEVELOPMENT FORM

Results you can rely on

Well Development Form

Project:	Project No.:	Date/Time:	Sheet ___ of ___
TRC Personnel:			

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

____
____
____

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) _______ ft.

Riser Stick-up (from ground) _______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ _____

WELL MATERIAL ☐ PVC ☐ SS ☐ ___

Well Depth ____ ft. ☐ top of riser ☐ top of casing ☐ ________ ☐ measured ☐ historical

Water Depth ____ ft.

Height of Water Column ____ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

$[Vol. = r^2 h(0.163)]$

______ Total gallons purged

FIELD WATER QUALITY MEASUREMENTS

Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									
Time									
pH (Std. Units)									
Eh (millivolts)									
Conduct. (µmhos/cm)									
Temp. (C)									
Turb. (NTU)									
DO (mg/l)									
Purge Volume (gal.)									
Estimated purge rate (gpm)									
Static (pre-pumping) Depth to Water (ft)									
Pumping Depth to Water (ft)									

EQUIPMENT USED: ___________

NOTES/COMMENTS: ___________

Signed:___________________

September 2013

ATTACHMENT B

SOP FACT SHEET

WELL DEVELOPMENT

PURPOSE AND OBJECTIVE

Well development is completed to (1) evacuate any water added during the drilling of wells, (2) establish a good hydraulic connection between the well and the surrounding water-bearing zone, (3) settle the sand pack and formation following the disruptive drilling and installation activities, (4) alleviate clogging, smearing or compaction of formation materials at the borehole wall due to the drilling process, and (5) remove fine particles (e.g., silt or clay) from the water column and sand pack in order to obtain groundwater samples that are representative of the water-bearing zone in which the well is installed and/or enhance groundwater extraction and injection rates. State and federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable.

WHAT TO BRING

- Field book or field forms
- Well keys, socket wrench, and device to remove standing water from flush-mount manholes.
- Water level meter and extra batteries
- Water quality meters, including turbidity meter
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing
- Bailer and cord
- Surge block
- Equipment decontamination supplies
- Indelible marking pens or markers
- Means of containerizing purge water

OFFICE

- Prepare/update the HASP; make sure the field team is familiar with the latest version.
- Review the work plan with the Project Manager and/or the field lead.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure, test equipment and make sure it is in proper working order.

ON-SITE

- Review the HASP with all field personnel, conduct Health & Safety tailgate meeting.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities, pedestrian traffic etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.

GENERAL DEVELOPMENT PROCEDURES

- Well development will be completed on wells after the grout, annular seals, and protective casings are deemed sufficiently stable (i.e., 24 to 48 hours after installation) for the development method being utilized and/or after required regulatory agency timeframe requirements.
- Measure the static water level and total depth of the well using RMD SOP 004, and determine the amount of standing water in the well (well volume). Calculate volume of water in one well volume.
- Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.
- Initiate water removal from the well and record the initial field water quality measurements including pH, temperature, conductivity, DO, ORP and turbidity (as required by project specifications) in the field book or on the Well Development Form. Record any odors, water color/clarity, changes in air monitoring results or other observations in the field book or on the Well Development Form.
- Well development procedures may include surging, overpumping, bailing, and jetting.
- Continue well development procedures until criteria have been met (e.g., turbidity <10 NTU, stabilization of water quality parameters, sediment thickness remaining in well is less than 1 percent of screen length) and a minimum of three times the standing water volume in the well has been removed.

WATER DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

Title: Groundwater Monitoring Well Installation		Procedure Number: RMD 007	
		Revision Number: 0	
		Effective Date: January 2014	
Authorization Signatures			
Technical Reviewer James Peronto	Date	Remediation Practice Quality Coordinator Elizabeth Denly	Date

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the construction and installation of groundwater monitoring wells. TRC typically employs a drilling subcontractor to perform the actual construction and installation. The SOP conforms to *A Compendium of Superfund Field Operations Methods* (EPA/540/P-87/001) and American Society for Testing and Materials (ASTM) standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004). A thorough discussion of well design, installation, materials, and potential problems is found in *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring*, Chapter 10: Design and Installation of Ground-Water Monitoring Wells (Nielsen and Schalla 2006). In general, this SOP conforms to typical practices utilized in the field; project-specific and local or state regulatory requirements should be applied, as needed.

1.1 Scope and Applicability

The objective of a groundwater monitoring well is to provide for the collection of representative groundwater samples and hydrologic data on the target saturated zone. These objectives require that the well be installed and developed (well development is presented in RMD SOP 006) using suitable materials, equipment, and procedures that will best represent the actual hydraulic conditions. Specific monitoring well design and installation procedures depend on project-specific objectives and subsurface conditions. The well construction activity should include consideration of the potential impact on the groundwater quality and measures to rectify that impact to the extent practicable. The following aspects should to be considered prior to well installation:

- Borehole drilling method
- Well construction materials
- Well depth
- Screen length
- Location, thickness, and composition of annular seals
- Well completion and protection requirements

Monitoring well installation will be performed in accordance with the applicable regulatory agency standards and the project-specific work plan. Drilling methods used to pilot the borehole for monitoring well installation will be dependent on the physical nature of the subsurface materials (unconsolidated materials and/or consolidated materials) at the project site.

1.2 Summary of Method

The most common type of monitoring well installations are single-screen, single casing wells designed to monitor one specific interval within the groundwater. Monitoring wells are typically 2 inches (inside) diameter, but may be larger or smaller depending on the project requirements. With direct push technology being used more frequently, 1-inch diameter wells are also frequently used. Monitoring wells most commonly consist of 5 or 10 feet of well screen with an interconnected length of blank well casing that extends to the surface. The annulus between the screen and the formation is filled with a filter pack of appropriately-sized sand depending on the formation material. The annulus between the blank casing and the borehole is filled with an annular seal to the ground surface. A surface completion usually consisting of a traffic-rated well vault or monument that protects the well from damage or unauthorized use is installed at or above the surface.

For more complicated monitoring well installations, such as situations requiring very small screen intervals (such as with fractured rock), open boreholes, or multiple zones of interest, the well design can be modified to suit the application. See Nielsen and Schalla (2006) for additional information on less conventional well installations.

In general, all well materials (other than filter sand, seals, and grout) are typically provided by the manufacturer and are individually plastic-wrapped. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

1.3 Equipment

The following list of equipment may be used during the installation of groundwater monitoring wells. Many of these materials may be supplied by the drilling subcontractor. Specific details on these materials are described in Section 2.2. Site-specific conditions may warrant the use of additional items or deletion of items from the list.

- Appropriate level of personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Weighted tape measure appropriate to the depth of well
- Well screens with appropriately sized slot openings
- Well casings/risers
- Well end caps
- Centralizers
- Graded sand for filter pack (appropriate for formation and screen slot size)
- Fine-grained sand (for use between filter pack and annular seal)
- Bentonite pellets or granules/chips
- Powdered bentonite
- Type I Portland cement
- Redi-Mix concrete
- Protective surface casing (for aboveground or “stick-up” wells)
- Lockable well cover
- Steel manhole/curb box (for flush-mounted wells)
- Equipment decontamination supplies

1.4 Definitions

Annulus/annular space	The space between the well casing/screen and the borehole wall.
Annular seal	An interval of low-permeability material placed above the filter pack designed to inhibit the flow of water into or through the annulus.
Bentonite	A naturally occurring deposit of volcanic ash that has partially weathered to form an absorbent swelling clay, consisting mostly of montmorillonite.
Bridge(-ing)	An obstruction within the annulus that may prevent circulation or complete installation of annular materials.
Casing – pipe (well casing)	Rigid pipe constructed in threaded or welded sections installed to temporarily or permanently counteract caving of the borehole or to isolate an interval to be monitored.
Casing - protective	A section of larger diameter pipe placed over the uppermost end of a monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access.
Caving (sloughing)	The inflow or collapse of unconsolidated material into a borehole that occurs when the borehole walls lose their cohesive strength, or a detached section of consolidated material is dislodged into the borehole.
Cement (Portland cement)	A mixture of calcareous, argillaceous, or other silica-, alumina-, and iron-oxide-bearing materials that is manufactured and formulated to produce a hardened material when mixed with water. Type I Portland cement as classified by ASTM C150 Standard Specification for Portland Cement is a general purpose cement most commonly used for monitoring wells when the special properties (e.g., sulfate resistance, high early strength, low heat of hydration) specified for other types are not required.
Centralizer	A device that assists in centering the riser pipe and screen in the borehole or casing.
Filter pack (gravel pack; sand pack)	An annular material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.

Flush-threaded	Casing or riser that is threaded and sized in such a manner that the inside and outside diameters are maintained between sections and joints.
Grout	A low-permeability material placed in the annulus between the well casing or riser and the borehole wall (typical well construction), or between the riser and casing, to maintain the alignment of the casing and riser and to prevent movement of groundwater or surface water into the annular space.
Riser	Sections of blank pipe that connect to the well screen and extend to or above the ground surface.
Tamping device	A heavy object attached to a measuring tape, rope or wire used to slip inside the annular space to ensure annular materials are properly placed per the designed depth criteria and to prevent bridging.
Tremie pipe	A tube or string of piping used to convey filter pack and annular seal materials from the ground surface to fill the annulus.
Vented end cap	A covering device that slips over or into the top of the well riser with a hole drilled in it to allow continuous equilibration of the potentiometric surface with the atmospheric pressure.
Well screen	Pipe (typically polyvinyl chloride [PVC] or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing.

1.5 Health & Safety Considerations

Drilling operations can create a hazardous environment. The potential for injury is fairly high around a drill rig. Level D PPE, including a hardhat, gloves, steel-toed safety shoes, and safety glasses, must be worn at a minimum. Hearing protection is also standard for drilling personnel. Tyvek clothing is recommended when mixing grout. Most well installations are performed with the assistance of the hoist on the drill rig mast as the downhole drill pipe or augers are removed when the well materials are placed. Therefore, TRC personnel must be mindful of the same hazards that apply during drilling. TRC staff should only approach the drill rig if necessary to monitor the breathing zone, confirm depths of materials, or confer with the driller. Before approaching the drill rig, direct eye contact should be made with the driller so they are aware of your presence. The following safety requirements should be adhered to while performing drilling activities:

- The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

- Serious injuries have occurred while the driller removes casing using a cable and winch. The winch should only be used to move augers or piping – NOT to pull casing, piping or augers from the ground. Use of the drill string is the safest means to pull casing, auger, or piping as the well materials are placed.

- Exposure to potential contaminants can occur from vapors coming from the open boring and from contaminated groundwater being forced out of the boring when grouting.

- While the exposure duration is very low, the dusts from well sand, bentonite, and cement can harm the lungs. Workers should avoid the dust produced when placing the well materials.

- Cement is highly caustic and can irritate the skin. Chemical-resistant gloves should be worn if contact with cement is necessary.

- The bags of sand, cement, and bentonite typically do not require a knife to cut them open. A dull instrument, such as a screwdriver, is sufficient.

- Cutting PVC well casing or screen should be conducted using a PVC cutting tool or hacksaw.

1.6 Cautions and Potential Problems

Well installation is typically conducted by the drilling subcontractor. TRC personnel serve to observe and document the installation and to serve as quality control that the well is installed according to the project specifications. The following cautions or problems may be associated with well installation

- Wells are often specified to be installed as “water table” wells with the screen designed to intersect the top of the water table. The difficulty arises in being able to determine if the water surface as measured in the open borehole will remain the same once the well is installed.

- It is also common that “water table” conditions do not exist due to a confining layer or fractured rock environments. In such cases, the well screen is placed in the producing formation or fracture, and the screen may not intersect the potentiometric surface.

- A well screen should never be placed such that the screen straddles a confining unit, thus connecting two separate aquifer units.

- Flush-mount well constructions require appropriate design to account for vehicular traffic and potential water infiltration into the surface completion among other things. In general, wells with flush-mount completions should not be located in low-lying areas or drainage paths where water influx can be a recurring problem. Appropriate design should consider a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault can drain.

- Aquifer or other pressure conditions at some locations may warrant consideration of a vent hole in the well cap. For flush-mount well completions, a vent hole can provide a means for ambient surface water to enter the well if the if the completion is not designed properly. Careful consideration should be given to well completion design, including vented well caps, depending on the circumstances at the location.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training

2.0 PROCEDURES

Monitoring well installation is typically conducted by a subcontractor experienced in such installations following completion of a soil boring. A qualified TRC representative provides oversight and documentation that the well is properly installed. Subcontractor personnel should not be on the site without a TRC representative being present unless specific prior approval has been given by TRC. The TRC representative should prepare a Monitoring Well Installation Form (Attachment A) that documents the well completion details.

2.1 Preparation

Prior to the initiation of field work, the Project Manager or field technical lead (site manager) will secure the services of a qualified drilling contractor. A contract between TRC and the drilling contractor should be executed before mobilization. At a minimum, the drilling contractor must meet the following requirements:

- have the appropriate licenses, registrations and/or certifications for drilling and monitoring well installation in the state in which the work is being conducted,
- have the proper equipment in good operating condition and free of leaks (fuel, hydraulic fluid, lubricants, and similar compounds) available to perform the type of well installation required, and
- have experienced personnel who are OSHA-trained to work on hazardous waste sites.

Before the start of field tasks, the TRC field representative is responsible for coordinating the following items with the drilling subcontractor personnel:

- familiarizing the subcontractor with the objectives of the investigation,
- providing and reviewing a copy of the project-specific work plan with the subcontractor,
- providing and reviewing a copy of the project HASP with the subcontractor,
- determining overhead hazards including power lines, buildings, trees and verifying local/city regulatory requirements if tree roots will be damaged, and
- performing a daily health and safety review with the subcontractor.

Compliance with state and federal requirements is required prior to the installation of monitoring wells. TRC is responsible for ensuring that all required permits have been obtained prior to the start of work. If state regulations require the driller to obtain drilling permits and/or utility clearance approvals, TRC personnel must review the documentation prior to the start of work. This documentation may include, but is not limited to, the following:

- notification and approval to drill/install a monitoring well (access agreement),
- registration or notification of the well installation,
- permit for water withdrawals,
- well abandonment when the project is completed, and
- applicable dig-safe permits or approvals (utility clearance).

Copies of any permits and notification forms must be provided to TRC.

2.2 Materials

Unless approved in writing by TRC, no lubricants or glue shall be used in any manner that could possibly contaminate samples, boreholes, or monitoring wells. The following provides a detailed description of the key features of well installation and how their proper selection and use is necessary to complete an effective groundwater monitoring well.

2.2.1 Well Screens

Monitoring well screens most commonly consist of two-inch diameter, flush-threaded, Schedule 40, PVC, machine-cut, slotted, wire wrap and/or V-wire screen. Up to two-inch or smaller diameter PVC is often used for wells installed using direct-push drilling methods. Four-inch diameter (and larger) wells are most typically used to accommodate larger pumps for groundwater and/or non-aqueous phase liquid (NAPL) recovery – but may also be used for groundwater monitoring. The screen slot size should be selected to retain a minimum of 90% of the filter pack material (see below). The most commonly used slot size is 0.010-inch (0.25 mm) slot openings.

In wells installed at depths greater than 100 feet, Schedule 80 PVC well screens can be used to minimize narrowing of the slots from the increased weight of the riser string. Note that the inside diameter of Schedule 80 riser pipe is slightly smaller than Schedule 40. That difference may cause difficulty when inserting some downhole monitoring equipment or instrumentation.

PVC screens can be adversely affected (typically by weakening or swelling) by concentrations of organic solvents that exceed 25% of the solubility limit. If such subsurface contaminant conditions are possible, the type and concentration of solvent should be researched in more detail prior to well installation. Stainless steel is also a common choice for well screens, but under certain conditions, metals (including iron, nickel, lead, and chromium) have been known to leach from stainless steel screens; in addition, stainless steel screens are costly. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations.

Manufactured prepacked well screens are commercially available and generally consist of a standard, slotted Schedule 40 PVC well screen pipe (typically 0.5 to 2.0 inch diameter) wrapped in a stainless steel mesh filled with filter sand (typically 20-40 grade silica sand). Additional finer sand pack is commonly added directly above the installed prepack as a grout barrier. Since the sand is packed around the slotted PVC before the well screen is installed, using prepacked screens guarantees that sand will be located directly adjacent to and uniformly around the well screen. Prepacked well screens are typically installed by direct push drilling techniques. The use of prepacked well screens generally makes well installation quicker and more efficient than traditional methods. However, their use for permanent groundwater wells for chemical groundwater quality monitoring should first be verified to determine consistency with project-specific and state regulatory requirements.

2.2.2 Riser and End Caps

Monitoring well riser and end caps will consist of appropriately sized, flush-threaded material compatible with the well screen. Other materials or sizes may be specified in the project-specific work plan as required by site conditions or local regulations. The top cap should be vented to allow the passage of air, unless the well is to be installed at or below the ground surface (i.e., “flush mount well”). In that case, the top of the well should be sealed with an expansion cap/plug or a protective watertight manhole provided to prevent the inflow of storm water runoff into the well.

2.2.3 Filter Pack

A filter pack (also known as “sand pack” or “gravel pack”) will be required in any formation other than coarse sand and gravels containing less than 10% fines (silts and clays) by weight. In such formations (i.e. well-to-moderately sorted sands and gravels), a filter pack may not be necessary and the formation can be allowed to collapse around the screen; however, most regulatory guidance requires a filter pack be constructed. The purpose of the filter pack is to inhibit transport of fine-grained formation material into the well screen and stabilize the formation so as to avoid excessive caving/sloughing during installation and development. The introduction of coarser material than the natural formation also results in increasing the effective diameter of the well.

The filter pack material shall be composed of washed, graded, commercially-produced silica sand. Based upon field estimates of grain size distribution of the screened aquifer materials, a sand pack should be selected. A detailed discussion of filter pack determination is found in Nielsen and Schalla (2006). ASTM Standard D5092, *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* (ASTM 2004), may also be consulted for further guidance on specifications for sand packs for various conditions. If grain size information is not known for the formation, several sand packs should be available during well construction based upon known or presumed geological information for the site. The most common choice of filter pack sand is 20-40 mesh for 0.010-inch screen slots.

One to two feet of clean, fine sand can be used (required in some states) as a buffer between the annular seal and the filter pack to provide added protection that grout invasion into the filter pack and/or the well screen will not occur. This layer is sometimes referred to as the “secondary filter pack.” The sand should be well sorted quartz sand; 40-60 mesh sand is typically used for this purpose.

2.2.4 Annular Seal

An annular seal, typically a minimum of 2 feet thick, is placed above the filter pack and screen to inhibit the boring from serving as a pathway for the vertical movement of water. Without an annular seal, the wellbore annulus can serve to transport contaminants between geologic units (for example, from unconfined to confined aquifer or from the vadose zone to the groundwater). The annular seal will consist of bentonite pellets, chips, granules, or slurry (produced from powdered bentonite). Bentonite swells rapidly when in contact with water. Coated bentonite pellets are preferable in situations where the bentonite must travel through a water column greater than 30 feet, because uncoated pellets may expand and bridge the annulus above the desired depth. Larger bentonite chips may also be used since they also swell at a slower rate than pellets and granules. The selection of the form of bentonite will depend upon the location of the top of the filter pack relative to the water table. If the seal is placed in the vadose zone, the seal will be hydrated with potable water. The volume of water necessary to hydrate the bentonite chips or pellets is dependent on the pellet size, volume of pellets used, and manufacturer's requirements. Granular bentonite is the best choice in situations where the seal is placed in the vadose zone – particularly in arid climates. Other forms of bentonite require longer contact times with water to form an adequate seal. Note that if the seal may be exposed to NAPL, it can shrink and crack. In addition, in situations with total dissolved solids (TDS) concentrations >5,000 parts per million (ppm) or chloride concentrations >8,000 ppm, bentonite will not swell; in these situations, neat cement should be considered as an alternative seal.

2.2.5 Grout

In certain wells, the annular space above the bentonite seal to the ground surface may be grouted with a mixture of 95% Portland cement or equivalent, and 5% bentonite grout, mixed with potable water to the specifications of the concrete manufacturer. This equates to 6 gallons of water added to each 94-pound sack of Type I Portland cement with 3- to 8% powdered bentonite added to improve the workability of the slurry. Bentonite should be prehydrated before adding to the cement to limit clumping. Note that bentonite does not swell considerably when mixed with cement. Grout is generally mixed in a container or barrel using pumps and may include an electric paddle or rotating vane blender.

Note: Grout mixtures may vary based on applicable regulatory requirements or site-specific subsurface conditions.

2.2.6 Surface Protective Casing

The primary purpose of a protective surface completion is to prevent surface water runoff from entering the well, and to prevent unauthorized access to the well. There are two types of protective casings used for surface completions of monitoring wells: (1) the above ground completion and (2) the below ground or flush-mount manhole-type completion, which is typically used in high traffic or public areas where the well could be damaged by equipment or is deemed unsightly.

<u>Above-Ground Completion</u>

An above-grade surface completion (i.e., a well monument) consists of rigid surface casing (typically galvanized or steel coated with rust-proofing or anodized aluminum). The inside diameter of the casing should be at least 2 inches larger than the well casing and be long enough to extend 2.5 to 3 feet above and below the ground surface. The casing is set in the annular seal and/or the surface seal that consists of either concrete (in warm to moderate climates) or bentonite (in cold climates). Bollards are often used around the aboveground surface casing to prevent vehicular damage.

The surface casing shall have a cap with provision for a lock that cannot be easily removed and leave at least 3 to 6 inches of clearance between the top of the well casing and the cap. The base of the casing, at the point where it shall extend above the concrete pad, should have a small weep hole drilled through the casing to prevent the build-up of precipitation or ice between the steel casing and well riser.

Flush-Mount Completion

Flush-mount well completions are generally selected or may be required in areas where vehicular traffic or equipment operation is an important consideration and an above-ground completion may not be a viable option. Depending on the expected activity in the area of the flush-mount completion and the existing surface conditions, the strength and durability of the completion will need to be designed appropriately. An appropriate completion may not be noticed, but a poor completion will generate negative comments with increasing wear and tear. In general, flush-mount completions should be located away from local low areas that drain or accumulate water, if at all possible.

Well completions flush with the pavement or ground surface may be accomplished by various means including the use of well can cylinders or elaborate vaults, and sufficient concrete to stabilize the structure within its surroundings. Regardless of the surface completion, the interior of the flush-mount completion should include the following characteristics: 1) rubber gasket to provide a cover seal; 2) locking capability for well security; 3) drainage management; and 4) sufficient interior space to accommodate any equipment (e.g., dedicated pump) that may be placed in the well.

Flush-mount well completions should provide a minimum of 2 inches of annular space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective steel "skirt" should extent at least 1 foot below the top of the well vault. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. Depending on location considerations, the well completion may be sloped slightly away from the well or completed truly flush with the surroundings. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole so water that accumulates in the vault will drain.

2.3 Monitoring Well Installation

Boreholes to be completed as monitoring wells will be advanced and logged in accordance with RMD SOP 005 (Visual-Manual Procedure for Soil Description and Identification). Equipment used to advance the boring and install the monitoring well will be decontaminated prior to the start of the boring.

All downhole well construction materials (with the exception of the protective casing) should be clean prior to use at the site. In general, all well materials (other than filter sand, seals, and grout) are typically provided individually plastic-wrapped by the manufacturer. If required by the project-specific work plan or at the discretion of the TRC inspector, well materials (other than filter sand, seals, and grout) may be steam-cleaned, rinsed with deionized water, and covered in plastic prior to installation of the well to prevent the introduction of foreign contaminants into the aquifer. Decontamination and bagging can also be conducted by the manufacturer, prior to delivery to the site. Furthermore, well construction materials shall be properly stored until use to ensure their good condition and cleanliness.

2.3.1 Procedures

Monitoring wells will be installed by the drilling subcontractor under the direction of a qualified TRC geologist, environmental scientist, or engineer. Monitoring wells will be installed using the following general procedures which may be dependent on the site-specific requirements.

1. Prior to mobilizing to the site, the construction details of the well to be installed will be provided to the driller, including well identifiers, locations of wells, boring diameter, well materials, screen slot size, screen lengths/depths, riser length, well depths, filter pack materials and depths, annular seal, grouting requirements, and well surface completion requirements.

2. All well materials shall be inspected to ensure that they are new and clean prior to installation.

3. Sections of screen and riser will be threaded together and lowered into the borehole to the predetermined depth. It is preferable to keep the drilling string or temporary casing in the hole while well materials are placed and slowly remove them as the well materials are installed. Centralizers may be used on the well riser in deeper wells to ensure proper well placement within the center of the borehole. Centralizers should not be placed within the location of the annular seal. Once the well is completed, the well cap should have a hole drilled in the top for venting, if possible.

4. The selected well packing materials will be introduced into the annulus in a manner so as to ensure an adequate well pack and seal. Approximately 0.5 to 1.0 foot of filter pack may be placed at the base of the boring to establish a stable base for the well materials. The thickness of each layer of well materials placed in the annulus will be measured with a weighted measurement tape and recorded to the nearest 0.10 foot. The weighted tape may also act as a tamping device to reduce bridging. Augers or casing will be removed sequentially during sand pack installation and the well will remain at the desired depth during auger or casing withdrawal.

   The primary filter pack may be placed using a rigid tremie pipe to minimize the potential for sand bridging in the annulus. The primary filter pack should extend at least 2 feet above the top of the well screened interval. One to 2 feet of fine sand as the secondary filter pack can then be placed above the primary filter pack (if required). However, the height of the filter pack may differ from that specified here due to shallow well depth limitations and project-specific work plan requirements. The secondary filter pack should not extend into a different aquifer unit as the primary filter pack. The depth of each interval of filter pack and volume of material used must be recorded on the Monitoring Well Installation Form and/or the field book.

5. The annular bentonite seal installation technique will vary with the depth of the water table. The appropriate type of bentonite will be selected to suit the objectives of the installation program. The bentonite should be poured slowly into the annular space to minimize bridging, with periodic tamping. The volume of the annular space should be calculated and compared to the volume of bentonite used as a check to make sure bridging in the annular

space has not occurred. If a tremie pipe is used for installation of the annular seal, either coated pellets or slurry should be used because bridging may occur as the bentonite swells. The preferred method of annular seal placement is by using the drilling rods or augers as a conductor casing, except in deep or difficult wells. The annular seal typically ranges from 1 to 5 feet in thickness. Annular seals in wells installed above the water table will be hydrated typically with 10 to 20 gallons (added in 5-gallon increments) of water and allowed to swell prior to the emplacement of a cement-bentonite grout mixture (if the well is to be grouted). In arid or highly permeable formations, the bentonite pellets should be allowed to swell for 1 hour. The high TDS concentration of cement grout does not act to hydrate bentonite, so it is important to allow the bentonite to hydrate fully in water. The level and volume of material(s) used for the annular seal are then recorded on the Monitoring Well Installation Form and/or the field book.

6. Once the annular seal is sufficiently hydrated, a cement-bentonite grout (or other type depending on local regulation) is placed to fill the remaining annulus of the boring. Depending on the depth of the well and water table, the grout may be tremied into the desired location from the bottom up. A side-discharge tremie is preferred so as to not disturb the annular seal. The tremie can remain near the bottom until grouting is completed. Grout requires 8 to 48 hours to set, but it does not become rigid like cement. The grout mixture (percentage of cement to bentonite) will be recorded and will be in accordance with the project-specific work plan or recommended guidance and Section 2.2.5 of this SOP. The grout will be pumped into the boring around the well materials to the surface. If necessary, after solidification of the grout and settling occurs, the grout may need to be topped off with additional grout mixture. The need for additional grout will be based on the intended surface completion for the well. The composition and volume of material(s) used for the grout are then recorded on the Monitoring Well Installation Form and/or the field book.

7. For wells finished above-grade, the protective casing may be cemented in place as described in Section 2.2.6 or completed with grout and bentonite in areas subject to frost heave. The protective casing should be in a plumb position and installed with at least half of the casing below ground and below the frost line (3- to 5 feet below ground surface). The protective casing should have a granular material placed in the base and a weep hole drilled through the casing to allow drainage of water that accumulates in the protective casing. Once completed, the well will be locked and typically allowed to settle for a minimum of 24 hours prior to well development. After well installation, development of a well should occur as soon as reasonably possible to enable representative sampling within the parameters of the project schedule. Some regulatory agencies require minimum timeframes for the newly-installed well materials, such as the bentonite seal or grout column, to cure before initiating well development (e.g., 24 or 48 hours).

   In some instances, a concrete pad is often constructed around wells to provide a working surface and more significant protective surface seal; this concrete pad is required by law in some states. These pads should be a minimum of 4 inches in thickness and are typically a minimum of 2 feet by 2 feet. It is recommended that the concrete pad extend 4 to 6 inches below the ground surface within six inches of the borehole. In areas of traffic or periodic mowing, three or four guard posts ("bumper guards" or bollards) may be positioned around the well to protect the well from equipment. The ground or pad around the well head should be sloped away from the well to promote drainage away from the surface completion. The guard posts consist of 3- to 4-inch diameter steel pipes set 3 to 4 feet outside the concrete pad. The pipes are set at least 3 feet in the ground and are filled with concrete. The well "stickup" and the guard posts should be painted a bright color (typically "safety yellow") for visibility. The type and details of the surface completion should be sketched, photographed or otherwise recorded on the Monitoring Well Installation Form and/or the field book.

8. Depending on the location of the well, flush-mounted utility boxes (i.e., well vaults or manholes) or above-ground, steel, protective casings with locking caps will be used to complete the well. Flush-mount wells should be located outside of areas that accumulate ponded water or areas of runoff, if at all possible, to minimize the potential for well damage by freeze/thaw conditions or for surface water to flow into the completed well.

   The well top should extend a minimum of 4 inches from the bottom of the cement or grout base with sufficient distance to the vault cover to accommodate any equipment (e.g., dedicated pump) that may be placed in the well. The well vault should also include a rubber gasket to make it water tight and is typically tightened with lug bolts.

   Flush-mount well vaults should provide a minimum of 2 inches of free space around the outside of the well (i.e., a 6-inch diameter vault for a 2-inch well). The protective, steel "skirt" should extent at least 1 foot below the top of the well vault. The vault will be sealed in concrete or cement grout that extends 4 to 6 inches away from the vault and extends a minimum of 1 foot below the frost depth. As most flush-mount wells are installed in paved areas, the concrete used to set the well vault should be compatible with the bearing capacity of the existing pavement. The vault should be set slightly higher than the existing grade and the concrete sloped (1- to 2% slope) away from the manhole to promote drainage away from the well. In cold-weather areas where snow removal occurs, the well may have to be set flush with the pavement to avoid damage. The inside of the manhole annulus should be filled with a drainage layer of sand or gravel with a weep hole, so water that accumulates in the vault will drain. Below-grade wells should be fitted with a locking, water-tight friction cap or expandable plug because below-grade wells often fill with water.

9. The wells should be permanently marked with the well identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized. Keyed-alike weatherproof brass padlocks should be installed on each well casing.

10. The manufacturer, type, weight, and number of bags or other containers of each type of well sand, cement, bentonite, and any other grout materials should be counted and documented on the Monitoring Well Installation Form and/or the field book as a means of determining if the amount used is consistent with the information obtained by the drilling subcontractor.

11. All information concerning well installation details will be recorded on a Monitoring Well Installation Form (examples provided in Attachment A).

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

There are minimal wastes other than general refuse and PPE that is generated during well installation. Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following quality assurance/quality control procedures apply:

- Check well construction materials to ensure these materials conform with the project-specific work plan and project specifications.
- Operate field instruments according to the manufacturers' manuals.
- Calibrate field instruments at the proper frequency, if utilized.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record well installation measurements on field forms or in a field book. See Attachment A for an example of a Monitoring Well Installation Form.

The following additional information should be recorded in the field book and/or Monitoring Well Installation Form:

- Well/piezometer or monitoring point identification number
- Well permit number (if applicable)
- Date of well installation
- Type of drilling method used and model number of rig
- Ground surface elevation (if known)
- Diameter and depth of borehole
- Depth of well bottom
- Depth of top and bottom of screened interval
- Depth of top and bottom of filter pack
- Depth of top and bottom of secondary filter pack (if used)
- Depth of top and bottom of annular seal
- Depth of top and bottom of grout seal
- Type, diameter, length, and screen slot size of well screen
- Type, diameter and length of riser
- Type, diameter, and length of casing (if used)
- Type, gradation, and volume/mass of filter pack
- Type and volume/mass of secondary filter pack (if used)
- Method used for filter pack placement

- Well lock type (i.e., padlock) and key number
- Type and volume of bentonite or other material used for annular seal
- Method used for annular seal placement
- Type, volume, and mix percentages of grout used
- Method used for grout placement
- Source of water used
- Type and length of protective casing
- Type and dimensions of well vault
- Type, number and array of protective posts (if used)
- Type and dimensions of surface completion/seal
- Measurement of "stickup" above or below ground
- Initial depth to groundwater
- Other pertinent observations
- Measurement equipment used
- Decontamination procedures used

6.0 REFERENCES

ASTM. 2004. *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers*, ASTM Standard D 5092, ASTM, West Conshohocken, PA 2004, pp. 20.

EPA. 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, US EPA. August 1987.

Nielsen, D.M. and Ronald Schalla. 2006. *Design and Installation of Ground-Water Monitoring Wells.* In Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring. Second Edition. David M. Nielsen ed. CRC Press. Boca Raton, FL. pp. 339 – 805.

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	JANUARY 2014	NOT APPLICABLE

ATTACHMENT A
EXAMPLE MONITORING WELL INSTALLATION FORMS

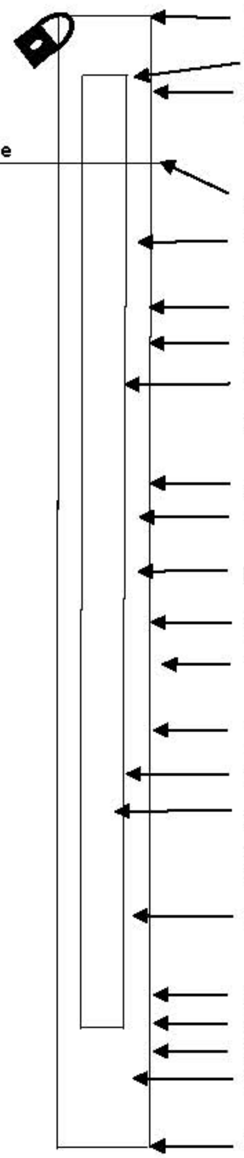
Monitoring Well Construction Summary

Well ID.

Project: ____ No.: ____	Depth to Ground Water: ____
Client: ____ Date Completed: ____	Development Date: ____
Location: ____	Development Method: ____
Boring Contractor: ____ Method: ____	Notes:
TRC Geologist: ____	

Ground Surface

Generalized Stratigraphy and Water Level



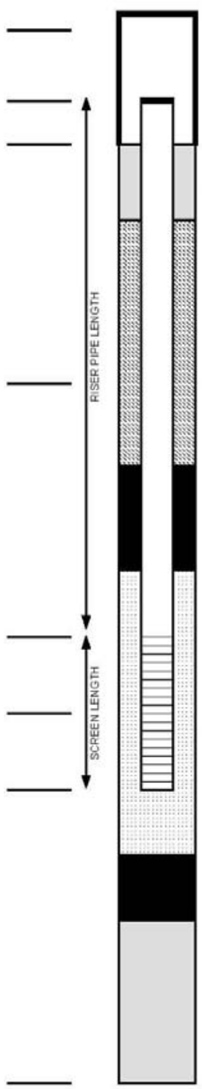
	Height/Depth ( )	Elevation ( )
Top of protective casing:	____	____
Top of riser pipe:	____	____
I.D. of protective casing: ____		
Type of protective casing: ____		
Ground Surface Elevation:	____	____
Type/thickness of surface seal: ____		
Bottom of protective casing	____	____
Borehole diameter: ____		
Riser pipe I.D.: ____		
Type of riser pipe: ____		
Top of grout:	____	____
Type of grout/backfill: ____		
Method of grout/backfill: ____		
Top of seal:	____	____
Type and thickness of seal: ____		
Top of filter pack:	____	____
Elevation/Depth top of screen:	____	____
Type of screen: ____		
Slot size: ____		
I.D. of screen: ____		
Type of filter/sand pack: ____		
Bottom of screen:	____	____
Bottom of well:	____	____
Bottom of filter pack:	____	____
Type of backfill below monitoring well: ____		
Bottom of borehole:	____	____

AF-374 November 2013

TRC WELL CONSTRUCTION DIAGRAM (FLUSH-MOUNT)

PROJ. NAME:			WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:		CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)



0.0 GROUND SURFACE

TOP OF CASING

SURFACE SEAL MATERIAL

SURFACE SEAL

GROUT/BACKFILL MATERIAL

GROUT/BACKFILL METHOD

GROUT

BENTONITE SEAL MATERIAL

BENTONITE SEAL

TOP OF SCREEN

FILTER PACK MATERIAL

BOTTOM OF SCREEN

BOTTOM OF FILTER PACK

BENTONITE PLUG

BACKFILL MATERIAL

HOLE BOTTOM

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________

PIPE SCHEDULE: ____________

PIPE JOINTS: ____________

SCREEN TYPE: ____________

SCR. SLOT SIZE: ______

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________

TIME DEVELOPING: ____ HOURS

WATER REMOVED: ____ GALLONS

WATER ADDED: ____ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________

COLOR BEFORE: ____________

CLARITY AFTER: ____________

COLOR AFTER: ____________

ODOR (IF PRESENT): ____________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

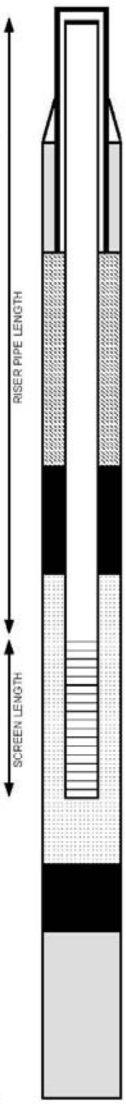
LOCK KEY NUMBER: ____________

REVISED 11/2013

TRC WELL CONSTRUCTION DIAGRAM (ABOVE-GRADE)

PROJ. NAME:			WELL ID:	
PROJ. NO:	DATE INSTALLED:	INSTALLED BY:		CHECKED BY:

ELEVATION (BENCHMARK: USGS)	DEPTH /HEIGHT RELATIVE TO GROUND SURFACE (FEET)
____	____ TOP OF CASING
____	0.0 GROUND SURFACE
	SURFACE SEAL MATERIAL ____
	____ SURFACE SEAL
	GROUT/BACKFILL MATERIAL ____
____	GROUT/BACKFILL METHOD ____
	____ GROUT
	BENTONITE SEAL MATERIAL ____
	____ BENTONITE SEAL
____	____ TOP OF SCREEN
____	FILTER PACK MATERIAL ____
____	____ BOTTOM OF SCREEN
	____ BOTTOM OF FILTER PACK
	____ BENTONITE PLUG
	BACKFILL MATERIAL ____
____	____ HOLE BOTTOM



NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: ____________________

PIPE SCHEDULE: ____________________

PIPE JOINTS: ____________________

SCREEN TYPE: ____________________

SCR. SLOT SIZE: __________

BOREHOLE DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: ____________________

TIME DEVELOPING: ________ HOURS

WATER REMOVED: ________ GALLONS

WATER ADDED: ________ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: ____________________

COLOR BEFORE: ____________________

CLARITY AFTER: ____________________

COLOR AFTER: ____________________

ODOR (IF PRESENT): ____________________

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:		T/PVC		
DTB AFTER DEVELOPING:		T/PVC		
SWL BEFORE DEVELOPING:		T/PVC		
SWL AFTER DEVELOPING:		T/PVC		
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☐ YES ☐ NO

LOCK KEY NUMBER: ____________

REVISED 11/2013

ATTACHMENT B
SOP FACT SHEET

GROUNDWATER MONITORING WELL INSTALLATION

PURPOSE AND OBJECTIVE

The objective of a groundwater monitoring well is to provide for the collection of representative groundwater samples and hydrologic data at the target saturated zone. These objectives require that the well be installed and developed (well development is presented in RMD SOP 006) using suitable materials, equipment, and procedures that will best represent the actual hydraulic conditions.

WHAT TO BRING

- Personal protection equipment (PPE), as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator
- Weighted tape measure
- Equipment decontamination supplies

OFFICE PREPARATION

The TRC field representative is responsible for coordinating the following items with the drilling subcontractor personnel:

- Providing and reviewing a copy of the project-specific work plan and HASP.
- Verifying that buried utility clearance notifications/approvals have been completed. Obtain notification date and number.
- Verifying that all required permits have been obtained prior to the start of work.
- Copies of any permits and notification forms must be obtained by TRC.

ON-SITE PREPARATION

- Conduct daily Health & Safety tailgate meetings, as appropriate.
- Verify that underground utilities have been marked out and that the mark outs are clear. Identify if any overhead obstructions or limited access areas exist near proposed borings.
- Verify that appropriate PPE is worn by all personnel and work area is safe (e.g., utilize traffic cones; minimize interference with on-site activities etc.).

GENERAL MONITORING WELL INSTALLATION PROCEDURES

Monitoring wells shall be installed by a drilling subcontractor under the direction of a qualified TRC geologist, environmental scientist, or engineer. The TRC representative should prepare a written record of the monitoring well installation. Monitoring wells will be installed using the general procedures presented in the SOP and any site-specific work plan which may be dependent on the site- or location-specific requirements. A summary of various acceptable well construction materials is presented in the SOP. The following summarizes several key aspects of monitoring well installation procedures.

- All well materials shall be inspected to ensure that they are new and clean prior to installation.
- Once the well is completed, the well cap should have a hole drilled in the top for venting, if possible.
- The thickness of each layer of well materials placed in the well annulus should be measured with a weighted measurement tape and recorded to the nearest 0.10 foot.
- The appropriate type of bentonite seal should be selected to suit the objectives of the installation program.
- The bentonite seal material should be poured slowly into the annular well space to minimize bridging, with periodic tamping. The volume of the annular space should be calculated and compared to the volume of bentonite used as a check to make sure bridging in the annular space has not occurred. If a tremie pipe is used for installation of the annular seal, either coated pellets or slurry should be used because bridging may occur as the bentonite swells.
- Grout mixtures may vary based on applicable regulatory requirements or site-specific subsurface conditions. Depending on the depth of the well and water table, the grout may be tremied into the desired location from the bottom up. Grout requires 8 to 48 hours to set, but it does not become rigid like cement.

GROUNDWATER MONITORING WELL INSTALLATION

- The ground or pad around the well head should be sloped away from the well to promote drainage away from the surface completion.
- Flush-mount wells should be located outside of areas that accumulate ponded water or areas of runoff, if at all possible, or constructed to minimize the potential for well damage by freeze/thaw conditions or for surface water to flow into the completed well.
- Completed wells should be permanently marked with the well identification number either on the cover or an appropriate place (i.e., in concrete pad) that will not be easily damaged and/or vandalized. Keyed-alike weatherproof brass padlocks should be installed on each well casing.
- All information concerning well installation details should be recorded on a Monitoring Well Installation Form (examples provided in Attachment A of SOP).

WASTE DISPOSAL

There are minimal wastes other than general refuse and PPE that are generated during well installation. Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

DATA MANAGEMENT AND RECORDS MANAGEMENT

Record well installation measurements on field forms or in a field book. See Attachment A of the SOP for an example of a Monitoring Well Installation Form.

DOS AND DO NOTS OF MONITORING WELL INSTALLATION

DOs:

- DO have the following items when going into the field:
  - Site-specific work plan
  - Site-specific HASP
  - PPE (e.g., steel-toed safety boots, hard hat, gloves)
  - Field book and indelible black ink, ball-point pens or markers
- DO review existing soil boring logs, groundwater contour maps, or geologic cross sections, if available.
- DO have the telephone numbers for the driller, testing laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO call the Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them.
- DO check well construction materials to ensure the materials conform with the work plan and project specifications.
- DO inspect all well materials to ensure that they are new and clean prior to installation.
- DO document the manufacturer, type, weight, and number of bags or other containers of each type of well sand, cement, bentonite, and any other well materials used.
- DO make sure that the wells are permanently marked with a well identification number.
- DO make sure the completed well cover is securely locked.
- DO mark the location on the top of the well casing from which water level measurements are obtained following well completion.

DO NOTs:

- DO NOT sign anything in the field unless authorized in writing by client. This includes waste disposal documentation, statements, etc; call the Project Manager if there is an issue.
-

Appendix C

Targeted Area Current Conditions Evaluation Analytical Sampling Matrix

Appendix C: Targeted Areas Current Conditions Evaluation - Analytical Sampling Matrix
Long Term Monitoring Plan
KRY Site: Kalispell, MT

Well No.	Deep (D)/ Shallow (S)	Chemical Analysis						Monitoring Rationale
		8151A	8290	MASS	(2)			
		PCP	Dioxins/ Furans	EPH/VPH	Field Parameters	LNAPL[1]	GW Elev.	
KPT-12	S	X	X		X	X	X	Delineate southwestern extent of groundwater impacts
KRY-108A	S	X	X		X		X	Near source area mixing
KRY-138A		X	X		X		X	Near potential PCP LNAPL area
MW-12	S	X	X	X	X	X	X	Near small PCP excacvation
MW-14	S	X	X	X	X	X	X	Near LNAPL excavation
MW-15	S	X	X	X	X	X	X	Near large hydrocarbon excavation
MW-16	S	X	X	X	X	X	X	Near historic edge of plume

Notes:
Wells listed on this table will be samples for the selected analyses for one year (two semi-annual monitoring events).
Following the two semi-annual monitoring events, the results from these seven wells will be evaluated. Discontinuation of sampling, or incorporation into the long-term monitoring plan for each of these wells may be recommended, based on the results

1 Wells check marked in the LNAPL column are to be checked for the presence of LNAPL.
LNAPL will not be sampled from these wells.

Appendix D

Field Forms

Groundwater Sampling Form

Project/Site: BNSF KRY

Well ID: ______________

Sampler(s): __________

Well Condition

Bump Posts: ______________________ Visibility: ____________ Secured: __________________

Well Label: ______________________ Surface Pad: __________

Fluid Level/Purge Volume Information

Date: ______________ Time: ______________

Purge Method: __________

Depth to water (ft): ________

Depth to product (ft): ________

Total depth (ft): __________

Water column thickness (ft): ________

One Purge Volume (gal): ________

Well Diameter: 2” 4”

Purge Vol. Multiplier: 0.163 0.653

Groundwater Field Parameters

Date: __________ Start Time: __________

Time	Volume Evacuated (gal)	pH (SU)	SpCond. (mS/cm) or (µS/cm)	Temp. (°C)	Dis. Ox. (ppm) or (mg/L)	ORP (mV)	Turb. (NTU)	Sample Appearance/Description

Meter Calibration Information

Probes	Date	Time	Comments
DO Calibration			
pH and SpC Calibration			
ORP Calibration			
Turbidity			

Sample Collection and Analytical Information

Date: __________ Time: ______________

Laboratory: ______________________ COC Seal: ______ Shipped by: __________

Shipping Container: ________________ Field Instrument(s): ______________________________

Check Box**	Parameters	Method	Container(s)	Preservative	Comments
☐	Pentachlorophenol	8151A	1L Amber	None	
☐	Pentachlorophenol	515.4	250 ml Amber	None	Residential Wells Only
☐	Dioxins/Furans	8290	1L Amber	None	
☐	EPH	MT EPH	1L Amber	HCl	
☐	VPH	MT VPH	40 ml VOA (3)	HCl	
☐	Sulfate	375.4	250 ml poly	None	
☐	Dissolved Fe, Mn	6010B	250 ml poly	Nitric Acid	
☐	Ferrous Iron	Hach Kit	NA	None	
☐	Nitrate/Nitrite/Chloride	300	250 ml poly	HNO_3	
☐	TOC	415.1	250 ml poly	H_2SO_4	

Comments: ____

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Groundwater Elevation Sampling Form
BNSF KRY

Well ID	DATE	TIME	Depth To LNAPL (Feet)	Depth To Water (Feet)	Total Depth (feet)	**Comments** (observations, reasons for not obtaining measurements, difficulties obtaining measurements, well obstructions, unusual conditions)
AMW-8						
GW-5						
GWRR-4						
GWY-3						
GWY-10						
GWY-13						
GWY-14						
KPT-5						
KPT-10						
KPT-12						
KPT-16						
KPT-21						
KRY-101A						
KRY-101B						

Groundwater Elevation Sampling Form
BNSF KRY

Well ID	DATE	TIME	Depth To LNAPL (Feet)	Depth To Water (Feet)	Total Depth (feet)	**Comments** (observations, reasons for not obtaining measurements, difficulties obtaining measurements, well obstructions, unusual conditions)
KRY-102A						
KRY-102B						
KRY-103A						
KRY-104A						
KRY-105A						
KRY-107A						
KRY-107B						
KRY-108A						
KRY-111A						
KRY-111B						
KRY-112A						
KRY-113A						
KRY-113B						
KRY-114A						

Groundwater Elevation Sampling Form
BNSF KRY

Well ID	DATE	TIME	Depth To LNAPL (Feet)	Depth To Water (Feet)	Total Depth (feet)	**Comments** (observations, reasons for not obtaining measurements, difficulties obtaining measurements, well obstructions, unusual conditions)
KRY-115A						
KRY-118A						
KRY-121A						
KRY-123A						
KRY-125A						
KRY-126A						
KRY-128A						
KRY-129A						
KRY-129B						
KRY-133A						
KRY-134A						
KRY-137A						
MW-4						
MW-5						
MW-6						
MW-7						
MW-8						
MW-9						

Groundwater Elevation Sampling Form
BNSF KRY

Well ID	DATE	TIME	Depth To LNAPL (Feet)	Depth To Water (Feet)	Total Depth (feet)	**Comments** (observations, reasons for not obtaining measurements, difficulties obtaining measurements, well obstructions, unusual conditions)
MW-10						
MW-11						
MW-12						
MW-13						
MW-14						
MW-22						
MW-23						
MW-26						
MW-28						

Groundwater Elevation Sampling Form
BNSF KRY

Well ID	DATE	TIME	Depth To LNAPL (Feet)	Depth To Water (Feet)	Total Depth (feet)	**Comments** (observations, reasons for not obtaining measurements, difficulties obtaining measurements, well obstructions, unusual conditions)
MW-30						
MW-40						
MW-41						
MW-42						
MW-43						
OMW-4A						
OMW-6						
SB-1-14						
SB-2-14						
SB-3-14						
SB-4-14						
SB-6-14						
SB-7-14						
SB-8-14						
SB-9-14						
SB-10-14						
SB-11-14						