Revised Addendum No. 4 to DEQ Version of Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s)

Burlington Northern Livingston Shop Complex
Livingston, Montana

BNSF Railway Company
REVISED
ADDENDUM NO. 4 TO DEQ VERSION OF TASK L
SUPPLEMENTAL INVESTIGATION WORK PLAN FOR
BEDROCK AQUIFER(S)

Burlington Northern Livingston Shop Complex
Livingston, Montana

Prepared for
BNSF RAILWAY COMPANY

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# TABLE OF CONTENTS

| LIST OF TABLES | iii |
| LIST OF FIGURES | iii |

## 1.0 INTRODUCTION

1.1 BACKGROUND ................................................................. 1-2

1.2 HEALTH AND SAFETY.......................................................... 1-3

1.3 ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS) .......................................................... 1-4

1.4 PERMITS ........................................................................................ 1-4

## 2.0 PROPOSED SCOPE OF WORK

2.1 OBJECTIVES ........................................................................................ 2-1

2.2 SCOPE OF WORK ................................................................................. 2-3

2.2.1 Well Construction ................................................................. 2-4

2.2.2 Pressure Transducers ............................................................. 2-11

2.2.3 Groundwater Monitoring .......................................................... 2-11

2.3 SCHEDULE ........................................................................................ 2-11

2.4 DATA REPORTING ............................................................................... 2-12

REFERENCES.............................................................................................. R-1
LIST OF TABLES

TABLE 1  BEDROCK AND ALLUVIAL WELL DATA SUMMARY

LIST OF FIGURES

FIGURE 1  PROPOSED BEDROCK AND ALLUVIAL AQUIFER MONITORING WELL LOCATIONS

FIGURE 2  ALLUVIAL AQUIFER/BEDROCK GROUNDWATER ANALYTICAL RESULTS, GWMD-1/GWMD-2 SAMPLING EVENTS

FIGURE 3  ALLUVIAL AQUIFER/BEDROCK GROUNDWATER ANALYTICAL RESULTS, GWMD-2 QUARTERLY EVENTS

FIGURE 4  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 10-1 AND ISCO-24R

FIGURE 5  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 10-2 AND ISCO-2

FIGURE 6  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 10-3 AND 12-7

FIGURE 7  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 10-4 AND 12-8

FIGURE 8  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 10-7 AND 12-9

FIGURE 9  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 12-1-5 AND 12-10

FIGURE 10  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 13-8 AND 13-1

FIGURE 11  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 13-9 AND E-7

FIGURE 12  BEDROCK AND ALLUVIAL AQUIFER TRANSDUCER DATA – WELL PAIR 13-10 AND 13-5
1.0 INTRODUCTION

This Revised Addendum No. 4 to DEQ Version of Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s) (Addendum No. 4) describes additional investigative work to be performed to address the requirements of “Task L: Investigation of Volatile Organic Compounds (VOCs) in Bedrock Aquifer(s)” of the Statement of Work for Spring 2005 Activities dated August 2005 (Spring 2005 SOW) for the Burlington Northern Livingston Shop Complex in Livingston, Montana (Facility) [Montana Department of Environmental Quality (DEQ) 2005]. The scope of the additional investigation described herein was developed in cooperation with, and in accordance with the requirements of, the DEQ based upon the findings of prior investigation work, including investigation work performed in accordance with:


- Addendum No. 1 to DEQ Version of Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s) (Revision No. 1), Burlington Northern Livingston Shop Complex Facility, Livingston, Montana (Addendum No. 1) (Kennedy/Jenks Consultants 2012).

- Addendum No. 2 to DEQ Version of Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s) (Addendum No. 2), Burlington Northern Livingston Shop Complex Facility, Livingston, Montana (Kennedy/Jenks Consultants 2013a).

- Addendum No. 3 to DEQ Version of Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s) (Addendum No. 3), Burlington Northern Livingston Shop Complex Facility, Livingston, Montana (Kennedy/Jenks Consultants 2013b).

On 12 August 2014, a Task L technical discussion session took place via conference call between BNSF Railway Company (BNSF), Kennedy/Jenks Consultants, the Livingston Remediation Group’s (LRG) sub consultant Water & Environmental Technologies, Inc. (WET), Dr. Bernie Kueper, and the DEQ and its consultant CDM Smith. The scope of work described in
this addendum was developed based on interactive discussion that took place between the parties during that session and subsequent conference calls.

During the 12 August 2014 technical discussion session, the parties agreed that four new bedrock monitoring wells (14-1, 14-2, 14-3, and 14-4) and one new alluvial aquifer monitoring well (14-5) would be constructed at the locations shown on Figure 1. In subsequent conference calls between BNSF, Kennedy/Jenks Consultants, Dr. Bernie Kueper, DEQ, and CDM Smith on 16 September 2014 and 28 October 2014, it was agreed that the soil borings will be advanced using sonic drilling and wireline coring methods (as opposed to air rotary methods previously used) to obtain discrete lithologic cores of the alluvial and bedrock materials (see Section 2.2.1). Per DEQ’s request, the term “shallow bedrock” used below will refer to the upper 10 feet of the bedrock formation; deeper formations will be referred to simply as “bedrock”. DEQ also requested (on 28 October 2014) that BNSF consider the completion of three groundwater monitoring wells within the shallow bedrock and one well within the deeper bedrock.

1.1 BACKGROUND

Between 2010 and 2013, 18 bedrock wells (designated as 10-1 through 10-8, 11-1, 12-1 through 12-6, and 13-8 through 13-10) and 11 alluvial aquifer wells (designated as 12-7 through 12-10 and 13-1 through 13-7) were constructed as part of the Task L supplemental investigation (SI) activities. Groundwater samples were collected from these wells and selected existing alluvial aquifer wells as part of the Task L SI activities as well as the ongoing Facility-wide groundwater monitoring program (Groundwater Monitoring Program Directives No. 1 and No. 2); see Figures 2 and 3. The groundwater data indicated elevated concentrations of tetrachloroethene (PCE) in groundwater samples collected from bedrock wells 10-2 and 13-9 [maximum concentrations of 9,760 and 55,600 micrograms per liter (µg/L), respectively], exceeding 1 percent of the solubility of PCE and indicating the likely presence of dense non-aqueous phase liquid (DNAPL) along the groundwater flow path leading to these monitoring points. These two bedrock wells are located east of the Locomotive Shop in the proximity of manways associated with the industrial wastewater sewer line.
In accordance with Addendum No. 2 and Addendum No. 3, transducers were deployed in nine alluvial aquifer/bedrock well pairs to evaluate seasonal fluctuations in groundwater levels and assess potential upward and downward components of the hydraulic gradient (see Table 1). In addition, groundwater levels were also collected from four additional bedrock wells and the closest alluvial aquifer wells on a quarterly basis (see Table 1). Based on the transducer data, a slight downward vertical gradient was determined for six of the well pairs and a slight upward vertical gradient was determined for two of the well pairs. The vertical gradient in the remaining well pair is variable. Hydrographs for the nine well pairs containing transducers are included as Figures 4 through 12. For water level data collected on a quarterly basis by hand from bedrock and nearby alluvial aquifer wells, a downward vertical gradient was determined for wells 10-5/L-87-6 and 11-1/07-1. A variable vertical gradient and upward vertical gradient was determined for wells 10-8/92-2 and 12-5/07-11, respectively; these four wells are located east of, and in close proximity to, the Yellowstone River.

Based on the Task L SI data obtained to date, the DEQ is requiring the construction of one additional bedrock well, three shallow bedrock wells, and one new alluvial aquifer well identified by the parties during the 28 October 2014 conference call. Construction of the new wells described in this addendum will provide additional alluvial aquifer/shallow bedrock or alluvial aquifer/bedrock well pairs (as discussed in Section 2.2.2). The future monitoring of these new well pairs will assist in further evaluation of the potential PCE mass flux between the alluvial aquifer and shallow bedrock.

1.2 HEALTH AND SAFETY

The existing Task-Specific Health and Safety Plan (HASP) for Task L will be reviewed and updated as necessary prior to start of Addendum No. 4 field activities. The Task-Specific HASP is designed for use in conjunction with the 2008 Facility-Wide Health and Safety Plan (Revision No. 3) (Kennedy/Jenks Consultants 2008). A copy of the final, signed Task-Specific HASP (if updated) will be submitted to DEQ before the start of field activities for inclusion in the Facility-Wide HASP.
1.3 ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)

ERCLs developed by DEQ for the Facility are included in Appendix A of the Record of Decision (ROD) (DEQ 2001). An analysis of how the proposed field activities will comply with ERCLs is provided in the previously approved Task L Work Plan. Planned activities identified in this Addendum No. 4 will comply with ERCLs. All well construction activity described herein will be performed by a Montana-licensed well driller and in compliance with Title 36, Chapter 21, Subchapter 8 of the Administrative Rules of Montana (36.21.8 ARM).

1.4 PERMITS

The City of Livingston requires permits to construct groundwater monitoring wells; these permits will be obtained prior to well construction activities.
2.0 PROPOSED SCOPE OF WORK

This Addendum No. 4 has been prepared for use in conjunction with the previously approved Task L Work Plan and addenda thereto along with the *Facility-Wide Sampling and Analysis Plan* (Facility-Wide SAP) (Kennedy/Jenks Consultants 2006). The Facility-Wide SAP addresses general protocols and procedures to be followed during implementation of supplemental investigations and remedial design/remedial action (RD/RA) tasks at the Facility. The Facility-Wide SAP addresses (1) health and safety considerations (including location of underground utilities); (2) personnel and equipment decontamination; (3) calibration and use of field measuring devices and instrumentation; (4) sample collection, preservation, packaging, and shipping; (5) borehole logging; (6) well construction and development; and (7) handling and disposal of investigation-derived waste (IDW). Field activities will be performed in a manner consistent with the Standard Operating Guidelines (SOGs) identified in the Facility-Wide SAP, unless otherwise stated.

Field protocols/procedures for well construction-related activities, and soil and groundwater sampling that were described in the previously approved Task L Work Plan and addenda thereto are not repeated in this Addendum No. 4 unless a modification is proposed.

2.1 OBJECTIVES

The overall objective of the Task L SI is to investigate the water-bearing bedrock in accordance with the requirements of the Spring 2005 SOW.

The objective of performing the Addendum No. 4 scope of work is to provide additional data and information to further evaluate: 1) the subsurface spatial distribution of PCE DNAPL and dissolved PCE concentrations in groundwater; 2) the vertical component of the hydraulic gradient between the alluvial aquifer and shallow bedrock; and 3) the potential for PCE mass within shallow bedrock to migrate upward into the alluvium at a level sufficient to sustain the PCE concentrations observed in the alluvial aquifer plume. The additional data and information will be acquired beneath the Former Electric Shop, Locomotive Shop, and manways associated
with the industrial wastewater sewer line east of existing bedrock well 13-9. These are locations where PCE potentially may have been released into the groundwater. New data and information from each location investigated under this Addendum No. 4 will be evaluated to ascertain whether the subsurface conditions encountered and/or groundwater sampling results indicate that PCE as DNAPL is present at or near the location.

The rationales for selecting the locations for the new monitoring wells proposed in this Addendum No. 4 are as follows:

- **Shallow bedrock well 14-1** will be constructed inside of the Former Electric Shop adjacent to existing alluvial aquifer well 89-3 which is located immediately downgradient of the former vapor degreaser pit PCE source area (see Figure 1). Well 89-3 is an alluvial aquifer well that was constructed in 1990 to a total depth of 35 feet below ground surface (bgs). The well is screened from 24 to 34 feet bgs. The top of bedrock is located approximately 34 feet bgs. Historically, groundwater samples collected from this well have consistently reported some of the highest concentrations of PCE in alluvial aquifer groundwater at the Facility. The maximum PCE concentration (712 µg/L) was detected in a passive diffusion bag sample collected from well 89-3 near the bottom of the well screen (approximately 31 feet bgs) in August 2008, prior to the initial in situ chemical oxidation pilot testing in this area.

- **Shallow bedrock well 14-2** will be constructed inside of the Locomotive Shop between the Transfer Pit and Locomotive Shop manways. This well will be located near alluvial aquifer well ISCO-7 adjacent to the active industrial wastewater sewer line (where the sewer line transitions from an approximate north-south to east-west alignment) (see Figure 1). An elevated estimated PCE concentration of 9,850 micrograms per cubic meter (µg/m³) was detected in shallow passive soil gas sample ESL-4D collected near this sewer line transition point during the passive soil gas survey that was conducted in June 2013 as part of the Task L Addendum No. 3 scope of work.

- **Bedrock well 14-3** will be constructed adjacent to the industrial wastewater sewer line manway and alluvial aquifer well 13-4 (see Figure 1). PCE releases to the subsurface likely occurred in the past at other industrial wastewater sewer line manways upstream.
of this manway. The manway is located approximately 200 feet east of bedrock well 13-9, where the highest concentrations of PCE in bedrock groundwater at the Facility have been detected.

- Shallow bedrock well 14-4 and alluvial aquifer well 14-5 will be constructed as a well pair adjacent to the industrial wastewater sewer line manway (see Figure 1). PCE releases to the subsurface likely occurred in the past at other industrial wastewater sewer line manways upstream of this manway.

2.2 SCOPE OF WORK

The scope of work of this Addendum No. 4 includes the following:

- Construct three shallow bedrock monitoring wells 14-1, 14-2, and 14-4, at the locations shown on Figure 1.

- Construct bedrock monitoring well 14-3 at the location shown on Figure 1.

- Construct alluvial aquifer well 14-5 at the location shown on Figure 1.

- Install pressure transducers in the four newly created alluvial aquifer/shallow bedrock and alluvial aquifer/bedrock well pairs, and record piezometric head level data in the wells on a twice daily basis for a period of 1 year.

- Perform an initial groundwater sampling event following completion and development of the newly constructed wells and quarterly sampling for VOCs and general water chemistry parameters for 1 year in accordance with DEQ’s Groundwater Monitoring Directive No. 2 (GWMD-2).
2.2.1 Well Construction

Prior to well construction activities, well permits will be obtained from the City of Livingston. The wells will be constructed by a Montana-licensed well driller and in compliance with 36.21.8 ARM.

Data/information acquired during borehole advancement and well construction (e.g., depth to groundwater, depth to bedrock, soil/bedrock conditions, etc.) and the specific well construction details will be documented on appropriate field forms (boring/well construction log) in accordance with the previously approved Task L Work Plan and addenda thereto as well as applicable SOGs in the Facility-Wide SAP.

2.2.1.1 Alluvial Aquifer Well Construction. One new alluvial groundwater monitoring well (14-5) will be constructed at the location shown on Figure 1. The alluvial aquifer well will be constructed using the procedures and protocols outlined in Task F Stage I – Part 1 Remedial Action Plan for VOC-Containing Alluvial Aquifer Groundwater (DEQ Version) dated April 2007 (DEQ 2007)\(^1\). The well will be constructed using a short (3-foot long) screened interval, with the bottom of screen set at or just above the contact with bedrock.

The borehole for well construction will be advanced using Sonic drilling methods to the base of alluvium (approximately 35 to 40 feet bgs based on review of alluvium thickness maps). Continuous soil cores will be examined, photographed, and logged during drilling. At least four soil samples will be collected per borehole in the alluvial aquifer based on field observations [i.e., staining, sheen, photoionization detector (PID), etc.]. One sample will be collected from just above the water table, two will be collected in the saturated zone, and one will be collected at the base of the alluvium. These four samples will be submitted for analysis of VOCs using EPA Method 8260.

At least four soil samples collected from the alluvial aquifer during the drilling program will be submitted for fraction organic carbon (foc) analysis using the Walkley-Black method. The

\(^1\) Alluvial aquifer wells were constructed in 2007 as part of Task F Stage I – Part 1. The Task F Stage I – Part 1 Remedial Action Plan for VOC-Containing Alluvial Aquifer Groundwater (DEQ Version) provides DEQ-approved protocols and procedures for alluvial aquifer well construction.
samples submitted for foc analyses will not show indications of impacts (i.e., field screening methods) and will be representative of the types of alluvial material(s) encountered, including any fine grained deposits that may be interbedded within coarse sand and gravel units in the alluvium.

The soil sample collected at the base of alluvium and any soil samples exhibiting visual signs of impact, will be field screened using the oil-in-soil screening method to test for the presence of NAPL.

Soil sampling is intended to enhance the current understanding of PCE partitioning from the alluvium to groundwater. The soil sample results will also be used to evaluate DNAPL presence using Calculations 1 and 2 in Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites (EPA 2009).

2.2.1.2 Bedrock Well Construction. One new bedrock groundwater monitoring well (14-3) will be constructed at the location shown on Figure 1. Borehole advancement and well construction will be performed in general accordance with the Task L Work Plan, unless otherwise stated below. The new bedrock well will be constructed in a manner that is the substantial equivalent of the manner in which well 10-2 was constructed.

The boring for the bedrock monitoring well will be drilled through the overlying alluvium and into shallow bedrock using sonic drilling techniques. Based on field conditions, wireline coring may be selected to drill through the competent rock to completion. Four samples will be collected from the alluvial aquifer as described in Section 2.2.1.1. The use of sonic drilling and wireline coring methods will allow for collection and logging of rock cores (see Section 2.2.1.3). A pair of protective (isolation) casings will be set into the bedrock and grouted in place. The intent of isolation casings is to provide a seal that isolates the bedrock materials from the overlying VOC-containing alluvial aquifer groundwater and reduces the potential for channeling of the alluvial aquifer groundwater along the casing/borehole interface as well as through potentially disturbed (e.g., crushed or fractured) bedrock at the casing/borehole interface. Further details of this protective (first isolation) casing installation are provided below.
To provide additional isolation to further limit the potential hydraulic communication of VOC-containing water between the overlying alluvial aquifer and the bedrock, double-cased "telescoping" well construction techniques will be used during advancement of the well borings. The telescoped second isolation casing will be advanced inside of the protective isolation casing described above to approximately 10 to 15 feet below the top of bedrock and sealed with cement, bentonite grout, or a mixture thereof. The purpose of the second telescoped isolation casing is to isolate both the alluvium and shallow bedrock zones from the screened interval of the completed deep bedrock well. Further details of this second isolation casing installation are provided below.

BNSF has communicated its concerns to DEQ about the potential for downward migration of PCE within the bedrock that may be caused by the required Task L drilling. One measure that has been incorporated into the bedrock well drilling methods for Task L to avoid causing unintended downward migration of PCE is the use of the permanent isolation casings. However, if DNAPL is confirmed to be present at the base of the alluvial aquifer on the basis of either visual observation or hydrophobic dye testing, the boring will not be extended into bedrock.

Drilling will continue into competent bedrock to the first water-bearing interval where a monitoring well will be completed. A well screen length of 5 feet is planned. Data/information acquired during borehole advancement and well construction (e.g., depth to groundwater, depth to bedrock, soil/bedrock conditions, etc.) and the specific well construction details will be documented on appropriate field forms (i.e., boring/well construction log) in accordance with the previously approved Task L Work Plan and addenda thereto as well as applicable SOGs in the Facility-Wide SAP.

Though not anticipated based on existing bedrock wells, if a water-producing zone is not encountered within 100 feet of the ground surface, the well boring will be abandoned without constructing a well, following consultation with and approval of DEQ. DEQ will be consulted regarding additional requirements for borehole abandonment, if any. Cuttings from the borehole will be removed from the borehole during drilling. No foam or other density-altering materials will be used during drilling without consultation with and approval of DEQ.
The outer borehole will be advanced to approximately 5 feet into the shallow bedrock and the outer isolation casing, with a nominal diameter of 8 to 10 inches, will be set into the top of the bedrock surface and grouted in place using Portland cement. (It is estimated depth to bedrock at the well location is approximately 35 to 40 feet bgs). Grout will be pumped into the annular space from the base of the boring to within 3 feet of the ground surface using a tremie pipe. The casing may optionally be sealed using the Halliburton method where the bottom of the borehole inside the isolation casing will be filled with grout, and the grout will then be forced from the inside of the casing into the annular space between the casing and borehole wall. A cement additive, such as bentonite clay, may be used if approved in the field by DEQ. The upper 3 feet of the well seal will be completed using concrete.

After placement of the grout seal, water present inside the outer isolation casing will be removed to the extent practicable. The depth to any residual water inside the casing will be recorded, and the grout seal will then be allowed to set for a minimum of 24 hours. The saturated thickness of the overlying alluvial aquifer at the well boring locations is expected to be approximately 15 feet, which should provide sufficient hydraulic pressure to test the seal. Following the minimum 24-hour grout curing, the depth to water in the casing, if any, will be recorded and compared to the previous measurement. If the casing seal is effective, water should not enter the isolation casing. If water has entered the isolation casing and the seal is not considered satisfactory, the annular space will be re-grouted and tested again.

After the outer seal exhibits satisfactory performance, the isolation casing will be flushed with potable water, and a sample of the final rinse water will be collected and analyzed for VOCs using EPA Method 8260. Following receipt of laboratory results of the rinse water sample, the boring will then be advanced through the grout seal, and a grab groundwater sample will be collected from the interval directly below the seal. The groundwater sample will be submitted for analysis of VOCs using EPA Method 8260 on a 24-hour turnaround time. A second inner isolation casing, with an inner diameter of 5 to 6 inches will then be advanced to approximately 10 to 15 feet below the top of bedrock, and a bentonite grout seal will be placed in the annular space between the outer and inner casings, using the methods described above. After the inner casing seal exhibits satisfactory performance using the test methods described above, the casing will be flushed with potable water, and a sample of the rinse water will be collected and analyzed for VOCs using EPA Method 8260. Activities will be staggered between boring
locations to the extent practicable (e.g., when the seal at one location is being tested, work to advance the well boring at another location will be performed) to minimize downtime.

Bedrock below the casing will be cored using sonic drilling techniques or wireline coring to the first water-bearing zone [i.e., minimum sustained yield of 0.5 to 1 gallon per minute (gpm)] or to a total depth of 100 feet bgs (whichever comes first) for monitoring well construction. The bedrock core will be logged to identify rock composition, bedding structure and orientation, primary and secondary fractures, and fracture infilling. The bedrock cores will be photographed and retained in boxes for future examination. If any indications of DNAPL presence are found (sheens, visible DNAPL), the boring will not be extended deeper.

In contrast to previous bedrock completions, downhole geophysical logging will not be performed on the one bedrock or three shallow bedrock wells (see Section 2.2.1.3). Continuous cores will be collected from bedrock zone and examined to evaluate lithology and competency.

The bedrock well screened interval will be determined based on field observations of the formation producing water during the rock coring. When groundwater is encountered in the boring, a short production test will be conducted [see page 5-7 of Task L Work Plan (DEQ 2010)]. If groundwater is produced from the borehole for a minimum of 10 minutes at a minimum rate of 0.5 to 1 gpm, a well will be constructed. (Note: Based on field conditions, the flow rate criteria may be adjusted in the field with DEQ approval.) If the water production is less than 0.5 to 1 gpm, drilling will continue.

Following coring, bedrock below the inner casing will be reamed as necessary to the total depth for well construction as determined from coring and hydraulic testing. The bedrock well will be completed using 2-inch-diameter polyvinyl chloride (PVC) Schedule 40, slotted and blank casing. The screen will have a slot size of 0.010 inch, and 20/40 or equivalently fine sand filter pack will be installed in the annulus from the bottom of the well to a minimum of 1 foot above the top of the top of the screen. A minimum of 1 foot of hydrated bentonite chips will be placed at the top of filter pack; hydrated bentonite chips or cement/bentonite grout will then be placed to the ground surface. The well will be completed at the surface similarly to the other wells constructed at the Facility.
Based on previous bedrock well construction activities, it is anticipated that the new bedrock monitoring well will be constructed following completion of drilling to a total depth of about 50 to 60 feet bgs. In summary, the well completion will be based on the lithologic and hydraulic properties of bedrock observed during drilling and testing. Generally, the screened interval will be selected based on the observation of groundwater yield to the borehole, as discussed above.

Due to the proposed drilling methods, and installation of the isolation casings, well construction materials will be 2-inch nominal diameter Schedule 40 PVC well casing and screen, to allow minimum annular horizontal thickness of 1.5 inches around the well casing. The screen length will be kept to a minimum length, but an attempt will be made to completely straddle the zone that produces an appreciable groundwater yield. It is anticipated that the screen length will be 5 feet unless a thicker water-producing zone is observed.

Following construction, the new monitoring well will be developed as appropriate by surging and over-pumping and/or hand-bailing to remove fine-grained particles that might have entered the well and filter pack (if placed) during construction. A Montana State registered land surveyor will survey the new wellhead to determine the vertical elevation with respect to the North American Vertical Datum 1988 (NAVD88) in accordance with SOG-5. Horizontal location will also be surveyed.

2.2.1.3 Shallow Bedrock Wells. Shallow bedrock monitoring wells 14-1, 14-2, and 14-4 will be drilled using sonic drilling techniques, advanced to approximately 7 feet below the alluvium/bedrock contact. Kennedy/Jenks Consultants field geologist will log the alluvium and shallow bedrock conditions using the procedures established in the Facility-Wide SAP. Specifically, the following details will be noted and logged on the Boring and Well Construction Log:

- Depth of the base of alluvium.
- Type of bedrock and indications of weathering below the contact.
- Moisture content.
• Degree of fracturing and apparent permeability of the shallow bedrock zone.

• PID head-space readings at the base of alluvium and in the shallow bedrock zone.

• Oil-in-Soil test kit results on soil at the base of alluvium, and in the shallow bedrock zone.

Soil samples will be collected from the alluvium and submitted for analysis of VOCs using EPA Method 8260, as described above.

The well completion will meet the following requirements:

• Well completed in the shallow bedrock zone will be screened no higher than 2 feet below the alluvium/bedrock contact.

• A minimum 1-foot seal above the filter pack will be used.

• The well will be completed with a 5-foot screened interval extending from 2 to 7 feet below the alluvium/bedrock contact.

Drilling and well construction will be accomplished using Sonic methods, and the subsurface materials will be examined, logged, and sampled, as described above. A single, nominal 8- to 10-inch-diameter isolation casing will be installed 2 feet into the shallow bedrock and sealed with cement grout as described above. Water present inside the isolation casing will be removed and the grout seal will then be allowed to set for a minimum of 24 hours. Following the minimum 24-hour grout curing, the depth to water in the casing, if any, will be recorded and compared to the previous measurement. If water has entered the isolation casing and the seal is not considered satisfactory, the annular space will be re-grouted and tested again. Otherwise, drilling will continue to a depth of 7 feet below the alluvium/bedrock contact, then a shallow bedrock groundwater monitoring well will be constructed using 2-inch-diameter PVC Schedule 40 casing with a 5-foot screen. The screen will have a slot size of 0.010 inch, and 20/40 or equivalently fine sand filter pack will be installed in the annulus from the bottom of the well to a minimum of 1 foot above the top of the top of the screen. A minimum of 1 foot of
hydrated bentonite chips will be placed at the top of filter pack; hydrated bentonite chips or cement/bentonite grout will then be placed to the ground surface. The well will be completed at the surface similarly to the other wells constructed at the Facility.

2.2.2 Pressure Transducers

Hobo U2 Water Level Loggers (pressure transducers) and non-submerged loggers for barometric pressure will be placed in the newly created alluvial aquifer/shallow bedrock (bedrock) well pairs (i.e., 89-3/14-1, ISCO-7/14-2, 13-4/14-3, and 14-5/14-4). Piezometric data will be gathered from these transducers for a period of 1 year following their installation into the well pairs to supplement existing transducer data (see Table 1) in evaluating seasonal fluctuations in groundwater levels and assessing potential vertical hydraulic gradients between the alluvial aquifer and bedrock groundwater. The transducers will be calibrated and set to read/record twice daily at or about 11:00 AM and 11:00 PM. Data will be downloaded approximately every 2 weeks using a Hobo Waterproof Shuttle.

2.2.3 Groundwater Monitoring

Quarterly sampling of the new alluvial aquifer/bedrock monitoring wells for VOCs and general water chemistry parameters will be performed in accordance with GWMD-2. Upon completion of four quarters of groundwater monitoring for VOCs and general water chemistry parameters, BNSF will consult with DEQ regarding a possible reduction in groundwater sampling frequency to a semiannual basis.

2.3 SCHEDULE

Upon DEQ approval of Addendum No. 4, drilling subcontractor contracting and scheduling will be initiated. It is anticipated that alluvial aquifer/bedrock well construction activities will commence in December 2014. The schedule is subject to contractor availability, weather
conditions, and other unforeseen field conditions that could affect completion of work. The DEQ will be notified prior to start of field activities and of any potential schedule delays.

2.4 DATA REPORTING

Information derived from performance of the work described in this Addendum No. 4 will be forwarded to DEQ upon receipt and also be provided to DEQ in quarterly status and/or annual monitoring and maintenance reports, as appropriate and required by the Spring 2005 SOW.

Following completion of Task L SI activities (as determined by DEQ), BNSF will prepare a Task L Supplemental Investigation Report in accordance with Section 5.1.5 of the Spring 2005 SOW as described in Sections 6.0 and 7.0 of Task L Work Plan.
REFERENCES


Montana Department of Environmental Quality. 2001. Record of Decision, Burlington Northern Livingston Shop Complex. Montana Department of Environmental Quality, Remediation Division, Helena, MT.


## Table 1
### Bedrock and Alluvial Well Data Summary
Burlington Northern Livingston Shop Complex

<table>
<thead>
<tr>
<th>Well Pair</th>
<th>Hydrograph Figure Reference</th>
<th>Interpreted Vertical Flow Direction</th>
<th>Transducer Installation Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Down</td>
<td>June 2013</td>
<td>1 year data collection complete</td>
</tr>
<tr>
<td>10-1 and ISCO-24R</td>
<td>Graphical Data Presented on Figure 4</td>
<td>Down</td>
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<td>10-2 and ISCO-2</td>
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<td>10-3 and 12-7</td>
<td>Graphical Data Presented on Figure 6</td>
<td>Variable</td>
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<td>10-4 and 12-8</td>
<td>Graphical Data Presented on Figure 7</td>
<td>Up</td>
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<td>10-7 and 12-9</td>
<td>Graphical Data Presented on Figure 8</td>
<td>Down</td>
<td>June 2013</td>
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<tr>
<td>12-1 and 12-10</td>
<td>Graphical Data Presented on Figure 9</td>
<td>Down</td>
<td>June 2013</td>
<td>1 year data collection complete</td>
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<td>13-8 and 13-1</td>
<td>Graphical Data Presented on Figure 10</td>
<td>Up</td>
<td>October 2013</td>
<td>In progress</td>
</tr>
<tr>
<td>13-9 and E-7</td>
<td>Graphical Data Presented on Figure 12</td>
<td>Down</td>
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<td>In progress</td>
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</table>

### Notes:
- (a) The interpreted vertical flow is taken between the bedrock well and the nearest alluvial well (well pair). If comparisons were previously made between the bedrock well and more distal alluvial wells, those data are not considered due to the increasing influence of the horizontal gradient with distance between wells.
- (b) In many cases, the observed gradient between the bedrock and alluvial well being compared, is within the range of what would be imparted by the horizontal gradient (of 0.004) given the distance between wells.
- (c) Wells too far apart for quantifiable vertical gradient interpretations.
- (d) "NM" denotes not measured.

| Well Designation | Distance Between Wells (feet) | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Date | Vertical Gradient | Gradation Summary |
|------------------|------------------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|------|-------------------|
| 10-5             |                              |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |
| L-87-6           | 84.8(d)                      | 2/16/2012 | -0.47            | 6/22/2012 | -0.42          | 12/12/2012 | NM(b)                   | 2/26/2013 | NM                   | 6/10/2013 | NM                   | 9/23/2013 | NM                   |
| 10-8             |                              |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |
| 92-2             | 84(c)                        | 2/16/2012 | -0.04            | 6/21/2012 | 0.32           | 12/14/2012 | -0.04                  | 2/24/2013 | -0.05               | 6/8/2013   | 0.10                  | 9/21/2013 | 0.03                 |
| 11-1             |                              |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |
| 07-1             | 9.7                          | 2/16/2012 | -0.22            | 6/22/2012 | -0.25          | 12/15/2012 | -0.21                  | 2/27/2013 | -0.23               | 6/11/2013 | -0.22                  | 9/20/2013 | -0.25                 |
| 12-5             |                              |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |      |                   |
| 07-11            | 7.8                          | 2/16/2012 | 0.13             | 2/25/2013 | -0.50          | 6/7/2013   | 0.09                   | 9/21/2013 | 0.33                 |

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Note:
Data Excluded indicates time ranges of data that are excluded from vertical gradient calculations because of disturbance by groundwater sampling events, transducer malfunction, or other anomalies.
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Bedrock and Alluvial Aquifer Transducer Data
Well Pair 10-3 and 12-7

11/14 (Revision No.1)

Figure 6
Note:
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Well Pair 10-7 and 12-9

Hydraulic Head (feet H2O)


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Bedrock and Alluvial Aquifer Transducer Data
Well Pair 10-7 and 12-9

K/J 1496021*16

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Well Pair 12-1 and 12-10

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Bedrock and Alluvial Aquifer Transducer Data
Well Pair 12-1-5 and 12-10

K/J 1496021*16

11/14 (Revision No.1)
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Bedrock and Alluvial Aquifer Transducer Data
Well Pair 13-9 and E-7

K/J 1496021*16
11/14 (Revision No.1)
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