M E M O R A N D U M

MWH
2353 130th Avenue N.E., Suite 200
Bellevue, Washington 98005
Phone: (425) 602-4000
Fax: (425) 602-4020

To: Mary Kauffman, IDEQ

Date: September 18, 2006

From: Dean Brame, MWH

Reference: P4 Production Southeast Idaho Mine-Specific Selenium Program

Subject: Submittal of Version 4 Revised Draft of the Monitoring Well Installation Technical Memorandum

---

Mary,

Please find enclosed *Version 4 Revised Draft Monitoring Well Installation Technical Memorandum* for Ballard, Henry, and Enoch Valley Mines. The doucument includes mine-specifie conceptual hydrogeologic models, data from all groundwater sampling events, and the rationale and scope of work for new monitor well installations.

We look forward to finalizing the technical memorandum. Monsanto's goal is to install the new proposed monitoring wells as soon as possible. We appreciate the agencies effort in helping us achieve this goal.

Sincerely,

Dean Brame

cc:

Mark Dietrich, IDEQ
Mike Rowe, IDEQ
Doug Tanner, IDEQ
Dave Tomten, USEPA
Joe Wallace, USEPA
Lorraine Edmond, USEPA
Tim Mosko, CH2M Hill
Jeff Jones, USFS
Will Frymire, USFS
Jeff Cundick, USBLM
Chris Morris, IDL
Al Ruberry, IDL
Sandi Arena, USFWS
Christina Cutler, Shoshone Bannock Tribes

Bob Geddes, Monsanto
Glen Kurowski, Monsanto
Jim McCulloch, Monsanto
Dale Ralston, RHS
Bill Wright, MWH
Cary Foulk, MWH

Ballard Mine. Looking west from the east side of West Ballard Pit

P_4 PRODUCTION
SOUTHEAST IDAHO MINE-SPECIFIC SELENIUM PROGRAM

Version 4 Revised Draft
Monitoring Well Installation Technical Memorandum for Final 2005 Phase II Supplemental SI Groundwater Work Plan

Prepared by

MWH

2353 130th Avenue N.E., Suite 200
Bellevue, Washington 98005

September 2006

Prepared for:

P4 PRODUCTION
SOUTHEAST IDAHO MINE-SPECIFIC
SELENIUM PROGRAM

Version 4

Draft Monitoring Well Installation Technical Memorandum for Final 2005 Phase II Supplemental SI Groundwater Work Plan

---

Ballard, Henry, and Enoch Valley Mines

September 2006

Prepared by:

MWH

Bellevue, Washington

TABLE OF CONTENTS

Section **Page**

1.0 INTRODUCTION 1

2.0 PROGRAM AREA PHYSICAL DESCRIPTION 3

2.1 LOCATION 3
2.2 CLIMATE 3
2.3 PHYSIOGRAPHY AND SURFACE WATER DRAINAGE 3
2.4 REGIONAL GEOLOGY 4
2.5 WATER RESOURCES 5
2.6 REGIONAL HYDROGEOLOGY 5
2.6.1 Alluvial Groundwater Systems 5
2.6.2 Bedrock Groundwater Systems 5
2.7 SELENIUM RELEASE 7

3.0 GROUNDWATER INVESTIGATION SCOPE, RESULTS, AND EVALUATION 9

3.1 GROUNDWATER INVESTIGATION SAMPLING EFFORTS 9
3.1.1 Domestic and Agricultural Well Sampling 9
3.1.2 Existing Well Sampling 9
3.1.3 Seep, Spring, and Headwater Stream Sampling 10
3.1.4 Geochemical typing of wells, seeps, and springs 10
3.2 GROUNDWATER INVESTIGATION NON-SAMPLING EFFORTS 15
3.2.1 Review of Available Hydrogeologic Information 15
3.2.2 Aerial Mapping of Ballard Mine 15
3.2.3 Water balance 15
3.2.4 Spring flow characterization 15
3.2.5 Investigation of Existing Wells 15
3.2.6 Update of conceptual hydrogeologic site model 17
3.2.7 Preparation of a Monitoring Well Installation Technical Memorandum 17

4.0 MINE-SPECIFIC CONCEPTUAL HYDROGEOLOGIC MODELS 18

4.1 ENOCH VALLEY MINE 18
4.1.1 Enoch Valley Mine Site History and Description 18
4.1.2 Enoch Valley Mine Site Geology 18
4.1.3 Enoch Valley Mine Conceptual Hydrogeologic Model 19
4.2 HENRY MINE 20
4.2.1 Henry Mine Site History and Description 20
4.2.2 Henry Mine Site Geology 20
4.2.3 Henry Mine Conceptual Hydrogeologic Model 21
4.3 BALLARD MINE 22
4.3.1 Ballard Mine Site History and Description 22
4.3.2 Ballard Mine Site Geology 22
4.3.3 Ballard Mine Conceptual Hydrogeologic Model 23

5.0 MONITORING WELL INSTALLATION RATIONALE AND SCOPE OF WORK 25

5.1 ENOCH VALLEY MINE 25
5.2 HENRY MINE 29
5.3 BALLARD MINE 30
5.4 BOREHOLE GEOPHYSICES 34
5.5 WELL ABANDONMENT 35
5.6 AQUIFER MATERIAL TESTING 35
5.7 GROUNDWATER MONITORING 35
5.8 MONITORING WELL SURVEY DATA 35

5.9 SUBMITTALS 36

6.0 FIELD METHODS 37

6.1 DRILLING 37
6.2 GEOPHYSICAL LOGGING 37
6.3 WELL INSTALLATION, ABANDONMENT AND DEVELOPMENT 38
6.4 AQUIFER MATERIAL TESTING 39
6.5 GROUNDWATER SAMPLING 39
6.5.1 Static Water Level Measurement 39
6.5.2 Groundwater Sample Collection 39

7.0 LABORATORY ANALYSES 41

7.1 GROUNDWATER ANALYSES 41
7.2 AQUIFER SOLIDS ANALYSES 43
7.2.1 Total Metals Analyses 43

8.0 SCHEDULE 44

9.0 REFERENCES 45

LIST OF TABLES

1 Generalized Stratigraphy of the Program Area
2 2004 and 2005 Water Levels in Groundwater Wells
3 Groundwater Flow Fields and Associated Sampling Stations
4 Proposed New Monitoring Wells
5A Well Construction Details- New Wells
5B Well Construction Details – Existing Boring
6 Groundwater Monitoring Analyses
7 Aquifer Solids Analyses

LIST OF FIGURES

1 Unfiltered Selenium Concentration in Agricultural and Domestic Wells
2 Enoch Valley Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations
3 Henry Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations
4 Ballard Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations
5 Proposed Well Construction Diagram for EVM Well MW009

LIST OF DRAWINGS

1 Site Location Map
2 Site Topography and Groundwater Monitoring Locations
3 Surficial Geology, Alluvial Flow Fields, and Groundwater Monitoring Locations
4 Conceptual Geologic Cross Sections of Enoch Valley, Henry and Ballard Mines
5 Conceptual Cross-Section for Proposed Well Locations MW007 and MW008 EVM
6 Geology and Cross Section Location Map for Proposed Well MW010 Henry Mine
7 Conceptual Cross-Section for Proposed Well Location MW010 Henry Mine
8 Geology and Cross Section Location Map for Proposed Well MW011 Henry Mine
9 Conceptual Cross-Section for Proposed Well Location MW011 Henry Mine
10 Ballard Mine Detail and Cross-Section Location for Proposed Well MW006
11 Conceptual Cross-Section for Proposed Well Location MW006 Ballard Mine

APPENDICES

A Drawings
B Unfiltered Censored Results
C Filtered Censored Results
D Unfiltered and Filtered Uncensored Results
E Major Ion Plots
F Well Logs
G Standard Operating Procedures
Borehole Drilling and Logging
Monitoring Well Installation
H Standard Operating Procedures
Low Stress Purging and Sampling Procedures for
the Collection of Groundwater Samples from Monitoring Wells
I Draft 2005 Phase II Supplemental SI Groundwater Health and Safety Plan

1.0 INTRODUCTION

This *Monitoring Well Installation Technical Memorandum* (Monitoring Well Tech Memo) is presented in fulfillment of Activity No. 3b-5 of the *Final 2005 Phase II Supplemental SI Work* Plan (MWH, April 2005) (Phase II Groundwater Work Plan). The Phase II Groundwater Work Plan is an addendum to the *P4 Production Southeast Idaho Mine-Specific Selenium Program 2004 Comprehensive Site Investigation Final Work Plans for Ballard, Henry and Enoch Valley Mines (MWH, March 2004)* (2004 SI Work Plan). The Phase I groundwater investigation tasks were presented in the 2004 SI Work Plan and were initiated in 2004 following approval from Idaho Department of Environmental Quality (IDEQ) and the other Agencies. The Phase I and Phase II groundwater investigations are being conducted in accordance with the requirements of the AOC signed by P4 Production, IDEQ, United States Environmental Protection Agency (USEPA), and United States Forest Service (USFS). This work supports the comprehensive mine-specific site investigations.

The groundwater investigation is being conducted in an effort to identify, characterize, and monitor groundwater flow systems associated with the potential sources at the P4 Production mines. This investigation is being conducted in a phased approach, such that the initial phases of work focus on information gathering and development of site hydrogeologic conceptual models. The initial phases also incorporate gathering easily accessible chemical data, such as sampling of seeps, springs and existing groundwater wells to identify specific areas of interest and further investigation. This Monitoring Well Technical Memo has been prepared in support of Phase II activities and provides the rationale and scope of work for installation of several new monitoring wells located at each of the mine sites to target specific flow pathways identified through development of the conceptual model. The information obtained from the monitoring and installation of these new wells will be used to refine the conceptual model and may give rise to new data needs.

The contents of this Monitoring Well Tech Memo are as follows:

- Section 1.0 Introduction – This section describes the purpose and scope of the memo.
- Section 2.0 Program Area Physical Description – This section provides a discussion of the physical description of the program area, including a discussion of site location, physiography, climate, and regional geology and hydrogeology.
- Section 3.0 Groundwater Investigation Scope, Results, and Evaluation – This section describes the efforts and results of the groundwater investigation conducted at the mines.
- Section 4.0 Mine-Specific Conceptual Hydrogeologic Models – This section discusses the specific characteristics and features of the Enoch Valley, Henry, and Ballard Mines and provides an overview of the conceptual hydrogeologic model for each site.
- Section 5.0 Monitoring Well Installation Rationale and Scope of Work – This section describes the rationale and scope of work for additional Phase II investigations to be conducted, including well installations and groundwater sampling. The rationale provided incorporates the results of the groundwater investigations in relation with the site-specific hydrogeologic conceptual models, described in Section 4.0.
- Section 6.0 Field Methods – This section describes the field methods in support of the proposed work.

- Section 7.0 Laboratory Analyses – This section describes the proposed analytical work.
- Section 8.0 Schedule – This section provides the tentative schedule for proposed work.
- Section 9.0 References – This section contains the references to citations in the text.

2.0 PROGRAM AREA PHYSICAL DESCRIPTION

This section provides a discussion of the physical description of the program area, including a discussion of site location, physiography, climate, and regional geology and hydrogeology.

2.1 LOCATION

The Enoch Valley, Henry and Ballard Mines are located in Caribou County in southeastern Idaho. Enoch Valley Mine (EVM), operated by the Monsanto Company (P4 Production) since 1989, is located in T6S, R43E, approximately 19 miles northeast of Soda Springs, Idaho. Henry Mine was operated by the Monsanto Company from 1969 to 1989 and is located in T6S, R42/43E, to the southeast of the town of Henry, Idaho. The Ballard Mine is a historic phosphate mine that was operated by the Monsanto Company from 1951 to 1969 and is located in T7S, R42/43E. The locations and topography of the vicinity of these mine sites are shown on Drawing 1, *Site Location Map*.

2.2 CLIMATE

The climate of southeastern Idaho is semi-arid with hot summers and cold winters. The climate is strongly influenced by topography, which in turn influences wind patterns, temperature and precipitation. North trending mountain ranges in the region create a natural barrier for water-saturated Pacific air masses. The rain shadow effect causes the Snake River Plain region to be semi-arid with a middle-latitude steppe climate. A National Weather Service station at Conda, Idaho, located four miles northeast of the P4 Production Plant in Soda Springs, reports approximately 19 inches of precipitation annually. Precipitation during the colder months is generally in the form of snow, while precipitation during the summer is primarily associated with localized, orographic thunderstorms.

2.3 PHYSIOGRAPHY AND SURFACE WATER DRAINAGE

The study area lies within the northern region of the Basin and Range Physiographic province, which is characterized by north- and northwest-trending mountain ranges and valleys in this area. Elevations in the area range from approximately 6,150 feet above mean sea level (AMSL) near the Blackfoot Reservoir and approximately 6,400 feet AMSL in the valleys, to approximately 6,900 feet AMSL at Henry and Ballard Mines and 7,700 feet AMSL at Enoch Valley Mine. Local relief of 1,000 to 1,500 feet is common in the area. Henry and Enoch Valley Mines are oriented along the slopes of two adjacent ridges, the Wooley Range and Rasmussen Ridge, respectively, which are separated by Enoch and Rasmussen Valleys. Long Valley is located to the west of Henry Mine and to the north of Ballard Mine, which is comprised of several pits in the Fox Hills. Wooley Valley lies to the east of the Fox Hills and Ballard Mine (Drawing 1).

Stream baseflow originates from springs in the mountain and valley areas. There are several small to medium size springs in the program area, typically located in the alluvial valleys or at the break in slope on the ridges. These springs are discharge points for groundwater systems that range from isolated alluvial aquifers to intermediate flow paths from sedimentary formations. Many headwater streams at higher elevations only flow during snowmelt runoff, but others are fed by large perennial springs.

The program area is drained by tributaries to the Blackfoot and Little Blackfoot Rivers, which flow into the Blackfoot Reservoir. From the Reservoir, the Blackfoot River flows northwest to the Snake

River. Surface water from the Henry Mine and northern portions of the Ballard and Enoch Valley Mines drains to the north and into the Reservoir via the Little Blackfoot River. Tributaries to the Little Blackfoot River include Long Valley Creek and Lone Pine Creek. The majority of surface water from Ballard Mine drains south to the Blackfoot River via small intermittent tributaries and to the east/southeast via Wooley Valley Creek (intermittent flow). Surface water from the southern portion of Enoch Valley Mine drains to Rasmussen and Angus Creeks that flow south to the Blackfoot River and into the Blackfoot Reservoir. Some of the above-mentioned creeks and streams are not officially named, but rather have been given designations (in some cases, local names are used) for the purpose of these site investigations.

2.4 REGIONAL GEOLOGY

The geology of the Basin and Range Province is characterized by linear, north-trending, fault-bounded ranges and basins formed by extensional tectonism. This extensional tectonism overprints an earlier period of compressional tectonics that included major overthrusting associated with the Bannock Thrust Zone, which resulted in synclinal-anticlinal folds and some faulting during the Upper Cretaceous and Paleocene periods. The extensional Basin and Range block faulting has occurred since the Oligocene period with differential subsidence and uplift occurring mostly with normal faulting, resulting in the current major valleys and ridges.

The principal stratigraphic units in the program area range in age from Mississippian to Quaternary and are described in Table 1, *Generalized Stratigraphy of the Program Area*.

Ranges in southeastern Idaho are generally composed of deformed Paleozoic and Mesozoic sedimentary rocks, including thick marine clastic units, cherts and limestones. The valleys are largely filled in with Quaternary alluvium and colluvium that overlie Pleistocene basalt flows in some places. Thick rhyolite flows of the Snake River Plain region and rhyolite domes south of the Blackfoot Reservoir comprise most of the remaining volcanic sequences in the region.

Massive accumulations of marine sediment occurred during the Paleozoic era over a large area of eastern Idaho, southwestern Montana, and northern Utah. During Permian time the Phosphoria Formation was deposited, creating the western phosphate field which includes the southeastern Idaho phosphate resource area. The Phosphoria Formation includes four members: the Meade Peak Phosphatic Shale, Rex Chert, Cherty Shale, and Retort Phosphatic Shale. (The Retort Shale is not present in the program area.) The Meade Peak member, which ranges in thickness from about 55 to 200 feet, is the source of most of the extracted phosphate ore. This is the oldest member of the Phosphoria Formation and is typically overlain by either the Rex Chert or the Cherty Shale. The Retort member is discontinuous and is found in the north and eastern parts of the region (USGS and USFS, 1977).

Other significant sedimentary units in the area include the Triassic Dinwoody Formation, which is made up of upper and lower units consisting of limestone, siltstone and shale layers. The lower Dinwoody Formation is directly above the Phosphoria units in stratigraphic section. The upper and lower units are often separated by a distinct layer of Woodside Shale. The Meade Peak member of the Phosphoria Formation is underlain by the upper unit of the Wells Formation, which consists of sandstone interbedded with limestone and dolomite. In some locations, the Grandeur Limestone of the Park City Formation is present above the Wells and is usually considered part of the Wells Formation for mapping purposes.

Geologic mapping of the area was conducted in 1927 by the U.S. Geological Survey (USGS) (Mansfield, et al., 1927). A geologic map of the program area has been prepared based on this mapping and is presented in Drawing 3.

2.5 WATER RESOURCES

Water resource uses in the program area include municipal supplies, industrial use, power generation, irrigation, stock watering, recreational use, wildlife use, and cold-water biota use. . Groundwater use in the program area is dependent on several variables including population and land use, availability and quality of surface water and availability and quality of groundwater. In the more remote regions, groundwater use is generally limited to livestock watering. In the valleys surrounding the mined areas, groundwater is primarily used for livestock watering, limited domestic use, and mine site water-supply. Mine site uses include domestic use at the Degerstrom/Enoch Valley Mine Office and Shop building, dust abatement, and washing equipment. In the vicinity of Soda Springs, groundwater is used for municipal supplies, irrigation, industrial uses and domestic supplies. The Soda Springs municipal water-supply comes primarily from Formation Creek and Ledger Creek that are natural springs located northeast of town.

2.6 REGIONAL HYDROGEOLOGY

Groundwater in the region can be divided into shallow groundwater within basin-fill alluvium and shallow to intermediate groundwater flow systems in sedimentary bedrock units.

2.6.1 Alluvial Groundwater Systems

Alluvium and colluvium up to 150 feet thick in the valleys is recharged by direct precipitation and shallow flow from the topographic ridges. Alluvial groundwater systems interact directly with streamflow along the valleys, acting alternately as a source of recharge and discharge to the streams at different locations. Where the bedrock sedimentary units contact alluvium, groundwater will similarly move between the bedrock and alluvium depending on the hydraulic characteristics of the units and the hydraulic gradients at different locations. Due to this interaction, the alluvial groundwater is generally present as unconfined and the water table surface and groundwater flow mirrors surface topography and surface water flow directions.

2.6.2 Bedrock Groundwater Systems

Recharge to the bedrock units generally occurs within the topographically high ridges and flows downward, typically along the dip of the geologic beds. Groundwater flow through bedrock units is controlled by several factors including the hydraulic properties of the units (i.e., horizontal and vertical hydraulic conductivities) and hydraulic gradients, the areal extent, thickness and orientation of the geologic units, as well as structural controls such as folding, fracturing and faulting. Fracturing of bedrock rock units (especially chert and limestone) has the potential to create significant secondary hydraulic conductivity in an otherwise low-conductivity unit. Major and minor fault zones can have a significant impact on groundwater flow paths either by acting as a conduit to flow (typical of normal faulting) or as a barrier to flow (more typical of thrust faults). There is no field evidence that ground water discharge occurs along the trace of the Enoch Valley Fault in the vicinity of the mine.

TABLE 1 GENERALIZED STRATIGRAPHY OF THE PROGRAM AREA [1] P4 PRODUCTION MINES					
AGE		**FORMATION**	**MEMBERS**	**GENERAL DESCRIPTION**	**HYDROGEOLOGIC CHARACTERISTICS [2]**
CENOZOIC	Quaternary	ALLUVIUM (Qal and Qw)	--	Alluvium or colluvium	Supports local groundwater flow system.
CENOZOIC	Quaternary/ Tertiary	BASALT (Qb)	--	Basalt flows	Can support intermediate groundwater flow system where fractured.
MESOZOIC	Triassic	THAYNES (Trt)	Several Members	Mostly limestone with sandstone layers. Some siltstone and shale members.	Supports intermediate groundwater flow system.
MESOZOIC	Triassic	DINWOODY FM (Trd)	Upper Unit	Grey, fossiliferous limestone interbeded with olive-brown calcareous siltstone	Supports intermediate groundwater flow system.
MESOZOIC	Triassic	DINWOODY FM (Trd)	Woodside Shale	Reddish-brown siltstone and shale. Discontinuous in program area.	Does not support groundwater flow system.
MESOZOIC	Triassic	DINWOODY FM (Trd)	Lower Unit	Olive-brown calcareous siltstone and shale with thin-bedded limestone	Supports intermediate groundwater flow system.
PALEOZOIC	Permian	PHOSPHORIA FM (Pp)	Retort Phosphatic Shale	Phosphatic shale. Discontinuous in program area.	Does not support groundwater flow system. Low hydraulic conductivity layer.
PALEOZOIC	Permian	PHOSPHORIA FM (Pp)	Cherty Shale	Thin-bedded dark-brown to black cherty mudstone, siliceous shale and argillaceous chert	Does not support groundwater flow system. Low hydraulic conductivity layer.
PALEOZOIC	Permian	PHOSPHORIA FM (Pp)	Rex Chert	Thick-bedded black to white chert with some mudstone and some limestone lenses	May support groundwater flow where highly fractured in areas.
PALEOZOIC	Permian	PHOSPHORIA FM (Pp)	Meade Peak Phosphatic Shale (Ppm)	Dark-brown to black mudstone, limestone and phosphorite. Meade Peak member is typically mined.	Does not support groundwater flow system. Low hydraulic conductivity layer.
PALEOZOIC	Permian/ Pennsylvanian	PARK CITY FM [3]	Grandeur Limestone	Light grey dolomite and cherty dolomite with some sandstone. Discontinuous in program area. Often mapped with Wells Fm.	--
PALEOZOIC	Permian/ Pennsylvanian	WELLS FM (PPw)	Upper Unit (PPwu)	Light grey to reddish-brown sandstone, some interbedded limestone and dolomite	Supports groundwater flow systems.
PALEOZOIC	Permian/ Pennsylvanian	WELLS FM (PPw)	Lower Unit (PPl)	Medium bedded grey chety limestone, some interbedded sandstone	Supports groundwater flow systems.
PALEOZOIC	Mississippian	BRAZER OR MONROE CANYON FM (Mb)	Brazer Limestone	Light grey limestone with interbedded sandstone, occasionally with grey and green shale.	--

1. Stratigraphy based on Ralston, et al., 1980 and Ralston, et al., 1983.
2. Notes on hydrologic characteristics are based on several sources of information. Information not available for all units.
3. Often mapped as part of the Wells Formation.

The Thaynes, Dinwoody, Phosphoria, and Wells Formations are the principal sedimentary formations in the program area through which groundwater flow may occur. Hydrogeologic research conducted in the area indicate the following regarding potential bedrock groundwater systems in the area:

- The Thaynes and Dinwoody Formations typically support intermediate groundwater flow systems (Ralston et al., 1977; Ralston et al., 1980).

- The Phosphoria Formation does not support any major groundwater flow systems; however, the Rex Chert member may transmit groundwater where locally fractured (Ralston et al., 1977; Ralston et al., 1980). The main ore-bearing unit of the Phosphoria formation, the Meade Peak Phosphatic Shale, is relatively impermeable due to low vertical hydraulic conductivity (McGregor, 1993; Ralston et al., 1980).

- The Wells Formation supports a regional groundwater system (Ralston et al., 1977; Ralston et al., 1980). The Wells Formation has the highest hydraulic conductivity compared to the other bedrock units in the region (BLM, 1999).

In general, the flow systems in the Thaynes and Dinwoody formations are separated from the lower Wells Formation by the low hydraulic conductivity of the Phosphoria formation (in particular the Meade Peak member). This causes the upper flow systems in the Thaynes and/or Dinwoody Formations to be local in extent while the lower flow system in the Wells Formation may be more regional.

A spring survey was conducted of the southeast Idaho phosphate field to gain evidence of the potential groundwater system(s) (Winter, 1980; Ralston et al., 1980). A total of 88 springs were identified in the survey. Of these, 42 springs flowed from the Thaynes or Dinwoody Formations at an average discharge rate of 25 gallons per minute (gpm). The Phosphoria Formation supported the fewest springs (three) while the eight springs from the Wells formation flowed at the highest average rate of 130 gpm. This spring survey provides evidence of the types and extent of typical flow systems in each of the bedrock units. Many of these springs are a source of perennial flow for surface water streams in the region.

2.7 SELENIUM RELEASE

Selenium is the main constituent of concern that is being released at the program mine sites, as well as other historic mine sites within the resource area. Elevated selenium concentrations have been observed in samples of waste rock, in vegetation growing on the dumps, and in surface water stock ponds at the mines (which include the pit ponds and runoff control ponds constructed in, on or adjacent to waste rock dumps). The Meade Peak member of the Phosphoria Formation is the source of produced phosphate ore. Concentrations of selenium in the Meade Peak member are higher than typical concentrations found in other marine sedimentary rocks. However, phosphate ore (phosphorite) is only temporarily stockpiled at the mine sites prior to transport to the processing plant near Soda Springs, and is therefore not considered to be a continual source of selenium release at the mine sites. Waste rock mostly consists of carbonate rock, mudstone and shales of the surrounding Phosphoria Formation. Selenium concentrations in these waste materials have been reported as being 100 to 1,000 times greater than the averages in continental crust (USGS and USFS, 1977).

Waste rock is disposed of as backfill to open pits or in large waste rock dumps located at each mine site; it is the weathering of this material that contributes most to the mobilization of selenium to

waters. Direct precipitation falling onto the dumps and/or infiltrating snowmelt results in weathering and oxidizing the waste rock and leaching selenium into the water. This selenium-rich water may be transported via one or more potential pathways: (1) surficial runoff over the dumps, (2) shallow interflow through the uppermost layers of the dumps (3) direct infiltration into the dumps under both unsaturated and saturated flow conditions. Water traveling as surface runoff or shallow interflow may be transported quickly to the surface water system or may infiltrate to groundwater. Water infiltrating through waste rock may emerge as seeps or be transported directly to the groundwater systems. Groundwater flow paths range from shallow interflow at the near-surface, to intermediate flow paths, to more regional groundwater flow pathways. The potential groundwater transport pathways at the mine sites are the focus of this study.

3.0 GROUNDWATER INVESTIGATION SCOPE, RESULTS, AND EVALUATION

The following sections describe the efforts and results of the groundwater investigation that is being conducted to investigate potential impacts to groundwater as a result of mining activities at Enoch Valley Mine, Henry Mine and Ballard Mine. The investigation of the mines has been conducted in three parts: a regional investigation for the Idaho Mining Association (1997-2002); interim surface water and sediment sampling effort (2002-2003); and mine-specific site investigations (2004-present). The scope of these investigations focussed on accumulating, evaluating, and summarizing existing geologic and hydrogeologic information, and also included sampling of existing wells, seeps, springs, and headwater streams. Information derived from the investigations has been used to update the mine-specific conceptual hydrogeologic models presented in Section 4.0 and support the rationale for the installation of several new monitoring wells at each mine as presented in Section 5.0.

3.1 GROUNDWATER INVESTIGATION SAMPLING EFFORTS

3.1.1 Domestic and Agricultural Well Sampling

A well inventory was conducted to identify all domestic and agricultural wells within an approximately 3-mile radius of the mines. Information was obtained from borelogs filed with IDWR regarding the construction of the wells and geologic units encountered. Existing mine wells and domestic and agricultural wells identified in the well survey were sampled in 2004. The locations of these stations are shown in Drawings 2 and 3. Analytical data for all stations and sampling events are provided in Appendices B, C, and D. As potential receptor points, these samples were analyzed for total metals concentrations and compared to the United States Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) standards. As presented in these tables, only one agricultural well, AW005, exceeded the MCL standard for zinc. This windmill-driven well is steel cased and was not adequately purged prior to sampling; therefore, it is likely that the zinc concentration reflects water in the casing in contact with the steel pipe. This well will not be sampled in the future without adequate purging in adherence to the QAPP. As presented in Figure 1, total selenium concentration in all the wells was consistently below the USEPA MCL standard for drinking water by an order of magnitude or more. Boring logs and well completion diagrams were filed with IDWR for some of these locations, and are included in Appendix F.

3.1.2 Existing Well Sampling

All production and monitoring wells at the mines have been sampled. The locations of the wells are shown on Drawings 2, 3, and 10. All analytical data for each sampling event are provided in Appendices B, C, and D. Borelogs and well completion diagrams were filed with IDWR for some of these locations and are included in Appendix F. As presented in Figures 2 and 3, no elevated total selenium concentrations have been detected in Enoch Valley Mine or Henry Mine wells. At Ballard Mine, elevated total selenium was detected in monitoring well MW001. This well is on the east side of the West Ballard Pit. As indicated by cross-section A-A' on Drawing 11, the well is drilled through the phosphoria formation. Further investigation of the well may be needed to ensure a proper seals have been made. This well may also be cleaned and rehabilitated to reduce turbidity which may be influencing the water sample.

3.1.3 Seep, Spring, and Headwater Stream Sampling

As indicated in Table 3 seeps, springs, and headwater streams act as groundwater monitoring locations, especially within the shallow groundwater system. The locations of these stations are shown in Drawings 2, 3, and 10. Analytical data for all stations and sampling events are provided in Appendices B, C, and D. As presented in Figure 2, elevated total selenium concentrations have been detected at EVM in the south dump seep MDS026 and the headwater stream MST144. At Henry Mine no elevated total selenium concentrations have been detected in any of the surrounding seeps, springs, or headwater streams as shown in Figure 3. As presented in Figure 4, elevated total selenium concentrations have been detected at Ballard Mine in seeps MDS030, MDS031, MDS032, and MDS033; springs MSG003and MSG006; headwater streams MST067, MST069, MST095, and MST096.

3.1.4 Geochemical typing of wells, seeps, and springs

An analysis of the major ion concentrations from existing groundwater analytical data has been performed using 2004 groundwater data to evaluate whether water-typing may be used to characterize/identify groundwater flow systems in the vicinity of the mines. Piper diagrams have been produced and are included in Appendix E. In general, most groundwater wells fall within the range of calcium-bicarbonate waters. Notably, domestic wells DW002 and DW006 and monitoring wells MW003 and MW004, located near mapped basalt flows, contained higher contribution of chloride, sodium, and potassium. Also, Enoch Valley Mine production wells PW006 and PW020 trended toward calcium-sulfate waters. Un-impacted springs and dump seeps were characterized as calcium-bicarbonate, while impacted springs and seeps at Ballard (i.e., ST069, SG006, DS030-DS033) and EVM (DS025 and DS026) are more generally characterized as calcium-sulfate waters.

Figure 1
Unfiltered Selenium Concentration in Agricultural and Domestic Wells

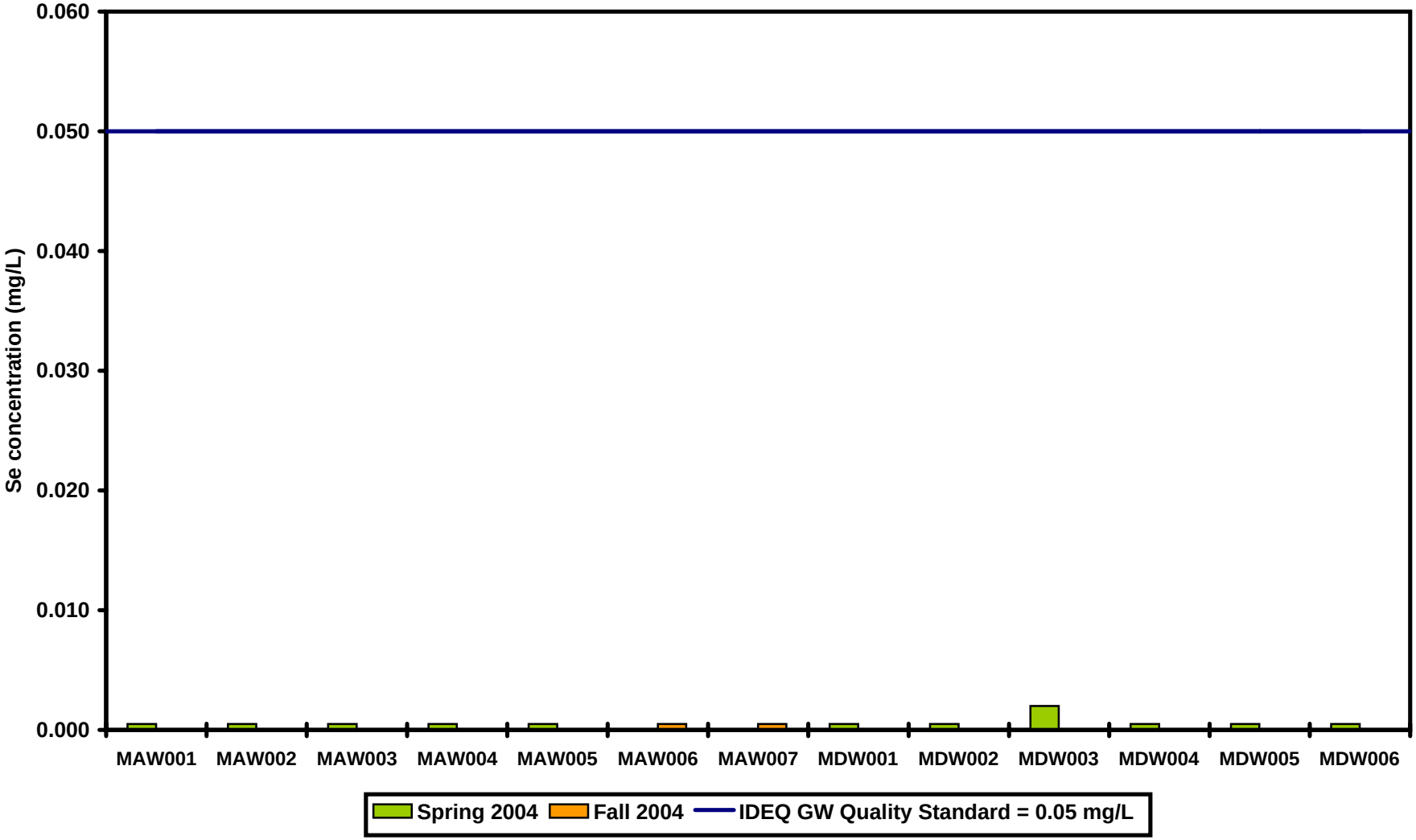


Figure 2
Enoch Valley Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations

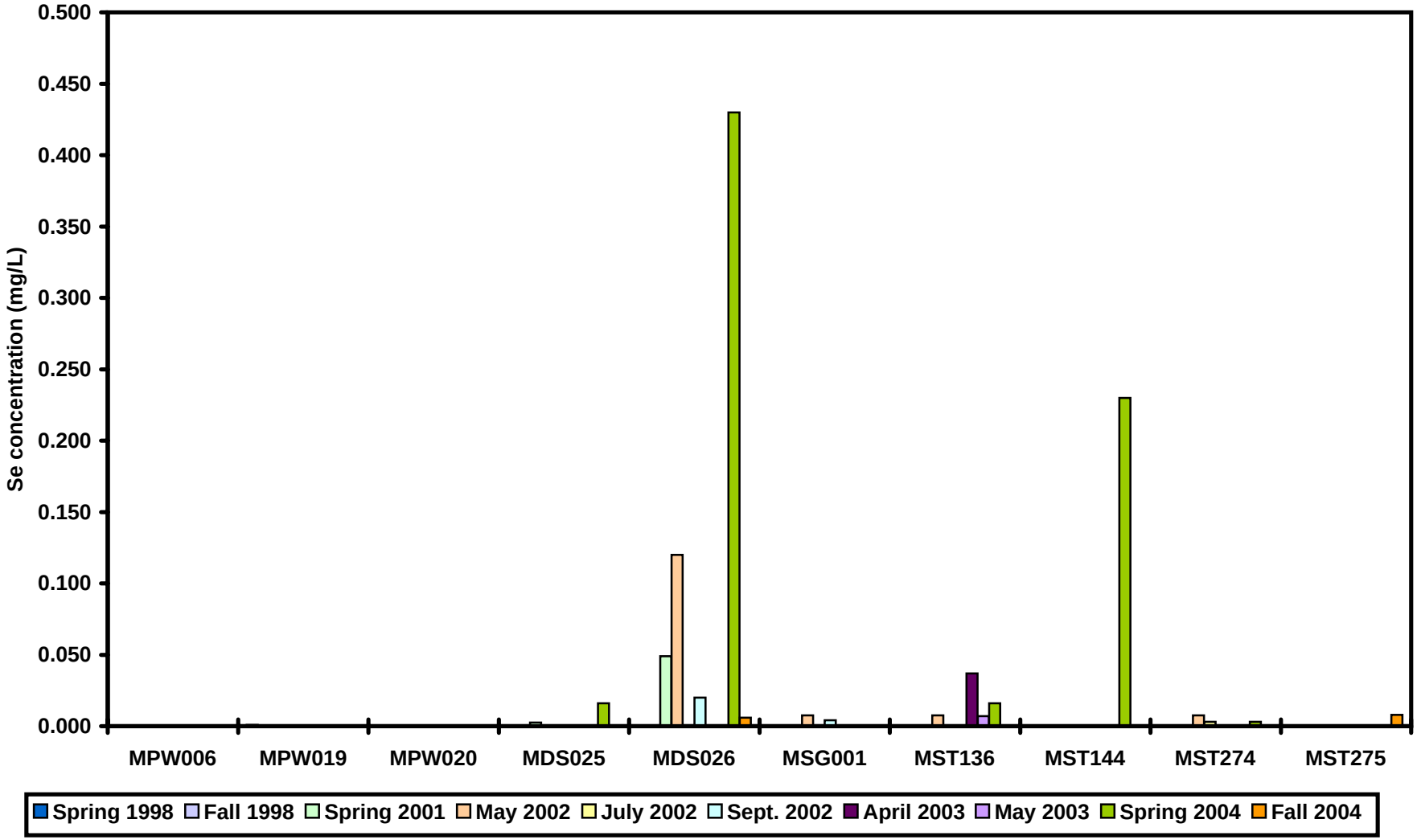


Figure 3
Henry Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations

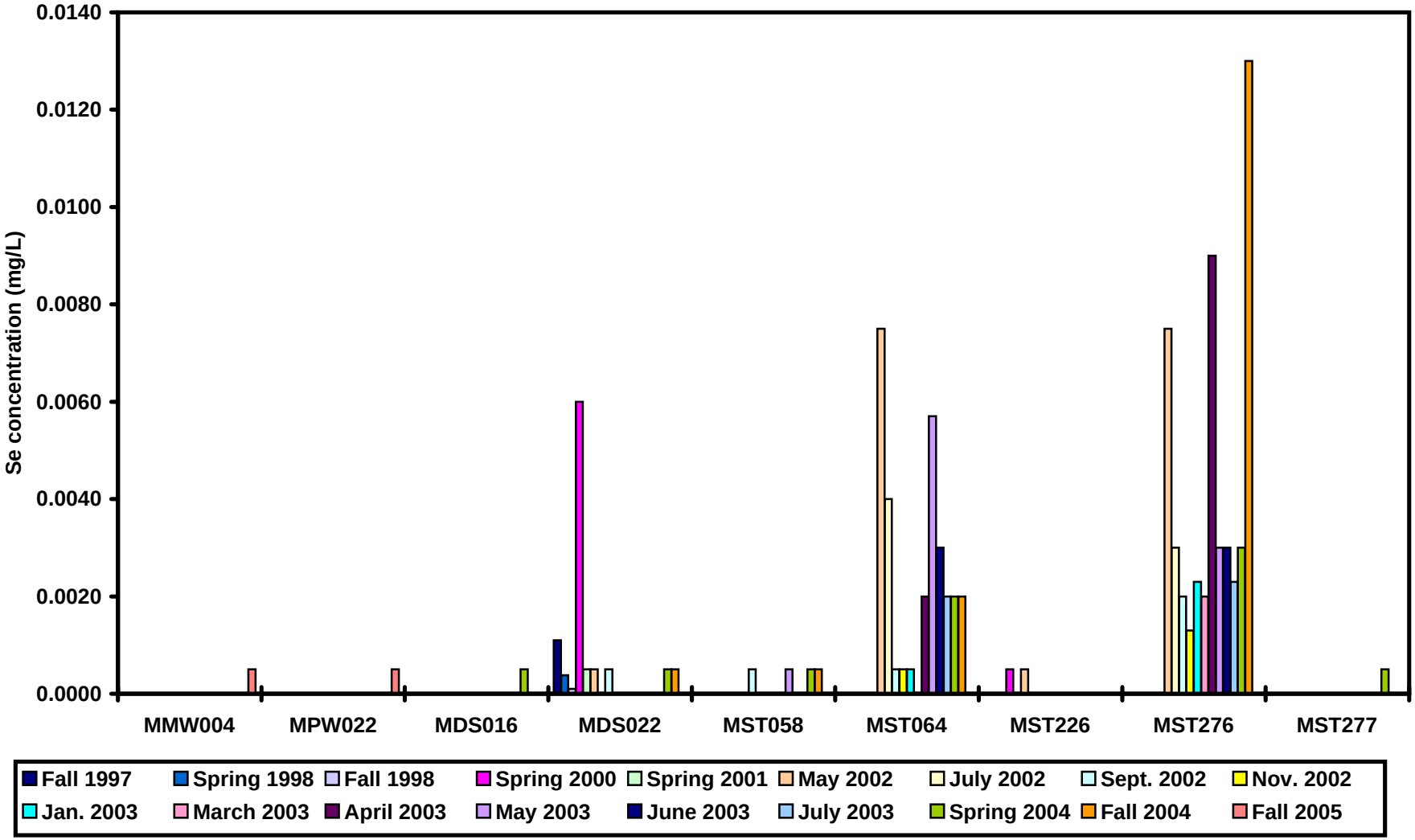
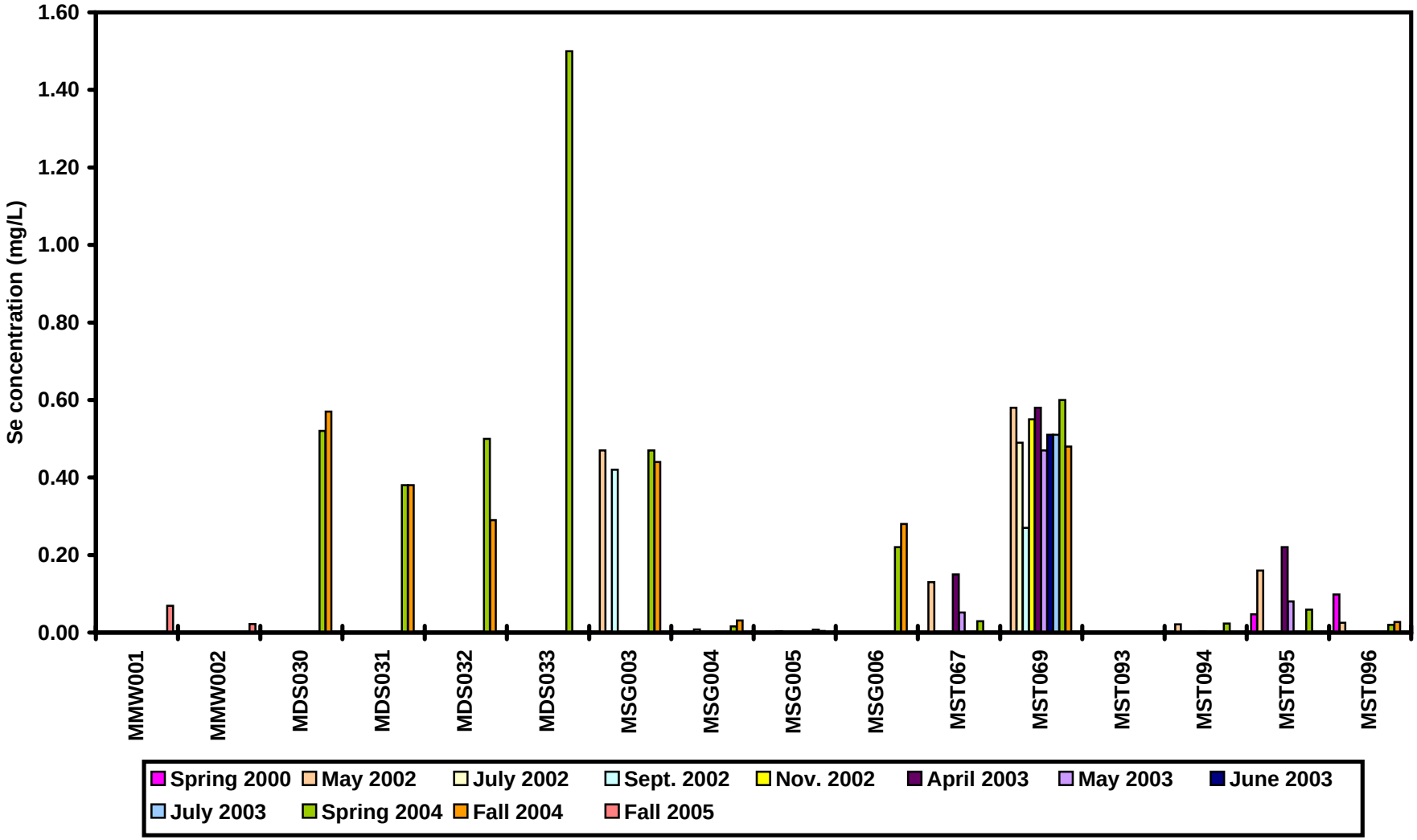


Figure 4
Ballard Mine: Unfiltered Selenium Concentration in Groundwater Monitoring Stations



3.2 GROUNDWATER INVESTIGATION NON-SAMPLING EFFORTS

3.2.1 Review of Available Hydrogeologic Information

The review included gathering geologic and cross-sections maps, existing mine maps, and verbal accounts from mine geologists with regard to faults and water bearing zones encountered during mining activities. Information obtained from P4 Production's archived files and from a literature review was compiled to prepare geologic maps and cross-sections of areas of interest, as presented in this document. Additional geologic mapping and information specific to the historic mine sites (specifically Henry and Ballard Mines) was gathered from archived files. Pre- and post-mining topographic maps were found for Henry Mine and were digitized to produce cross-sections included in this report. Also, geologic mapping and cross-sections for Ballard Mine were used. All information has been used to further develop the hydrogeologic conceptual models presented in Section 4.0.

3.2.2 Aerial Mapping of Ballard Mine

It was determined that recent topographic information for Ballard Mine was not available; therefore, aerial photography and topographic mapping of Ballard Mine was completed in 2005. This map is incorporated into this document as Drawing 10.

3.2.3 Water balance

This task was listed as Subtask 4a, Section 4.4.1 under Task 4: Soil Investigation in the final site investigation work plans. This task has not been completed. It has been included in this technical memorandum because it will provide information relevant to the groundwater investigation.

A water balance will be developed for the site using regional and local climatic data and site-specific information, as available. The water balance will focus on the waste rock piles at the mines. Components of the water balance will include average annual precipitation, estimates of evaporation and transpiration, as appropriate, and estimates of runoff and seepage based on the characteristics of the waste rock piles. The water balance will be semi-quantitative and will utilize site data as available.

3.2.4 Spring flow characterization

Due to a low spring runoff event, analysis of recession of flow from the springs was not completed during the Phase I investigation. This task is being completed during the 2006 field season.

3.2.5 Investigation of Existing Wells

Existing Well Log Compilation and Search: Existing well logs were obtained from Idaho Department of Water Resources (IDWR) for several domestic and agricultural wells in the valleys surrounding the mines. These logs are compiled in Appendix F. Additional information concerning the construction of wells AW008, MW003, MW004, PW006, and PW023 was pursued in 2005. Based on discussions with the landowner, it was determined that AW008, located at a farmhouse in a field west of Ballard Mine, was a shallow, hand-dug well in alluvial material. It was determined that the well PW006 (Agrium production well) consists of two wells that are connected in series to the pumping system. Logs for both these

wells (PW006A and PW006B) were found and are included in Appendix F. The logs indicate that the wells are 390 and 650 feet deep, respectively, and are drilled into alluvium, mudstone, shale and sandstone/limestone (likely Dinwoody Formation). Well logs for MW003, MW004 and PW023 could not be found.

Downhole Camera Investigation: Downhole camera videos were produced for wells: MW001, MW002, MW003, MW004, MW005, and PW023. Downhole video of well AW008 was proposed in the Phase II work plan; however recently obtained information revealed the well to be a shallow hand-dug well and not conducive to sampling, therefore, a downhole camera video was not produced. Wells MW001, MW002 and MW005 are cased with PVC, and the purpose of the camera was to verify well condition, total depths, and screened intervals. Wells MW003, MW004, and PW023 are constructed of steel casing at the surface. The quality of the downhole camera images was variable based on water clarity. In some of the wells, particularly MW003 and MW004, the presence of yellowish-colored flocculent floating in the water column obscured the view of the boring walls. In PW023, entrained sediment blurred the view.

Camera logging of MW001 and MW002 confirmed that the wells were in good condition and depths and screened intervals were consistent with their respective well logs. The camera log of MW005, located adjacent to the Little Blackfoot River, indicated one open interval in the PVC casing from 16 to 17.5 feet depth, and a total depth of 30 feet bgs. Wells MW003, MW004, and PW023 are constructed of steel casing near the surface and continue as open boreholes to their total depths. Well MW003 contains approximately 25 feet of steel surface casing and has a total depth of 138 feet. Fractured bedrock was visible from approximately 35 feet to the bottom of the borehole, and yellowish-colored flocculent was visible through much of the open interval. Well MW004 appears to contain steel casing to its total depth of 77 feet, and also contained significant amounts of yellowish-colored flocculent on the casing walls. Well PW023 contains approximately 160 feet of steel surface casing and continues as an open borehole to a total depth of 310 feet. Light-colored, fractured rock was visible from 160 feet to the bottom of the boring.

Water Level Measurements: Groundwater levels were obtained periodically during 2004 and 2005 field seasons. These data are presented in Table 2 below.

Table 2
2004 and 2005 Water Levels in Groundwater Wells
(Feet Below Top of Casing)

Well Name	Well ID	2004		2005			
		May	October	May	June	July	October
Ballard Pit Well East	MW001	292.96	292.3	289.60	285.22	284.41	287.82
Ballard Pit Well West	MW002	225.14	226.55	227.30	227.10	225.56	224.05
Henry North Pit Monitoring Well S	MW003	12.23	51.2	10.82	9.95	12.71	NM
Henry North Pit Monitoring Well N	MW004	48.93	55.25	45.30	41.55	39.89	45.21
Henry South Pit Dewatering Well	PW022	NA	77.55	77.53	74.00	74.65	76.34

NM-Not Measured

3.2.6 Update of conceptual hydrogeologic site model

A conceptual hydrogeologic site model was presented in the 2004 SI Work Plan. The updated mine-specific models are presented in this memorandum in Section 4.0.

3.2.7 Preparation of a Monitoring Well Installation Technical Memorandum

This report provides the rationale and scope of work for the proposed new monitoring wells, as well as additional tasks in support of the Phase II groundwater investigations.

4.0 MINE-SPECIFIC CONCEPTUAL HYDROGEOLOGIC MODELS

Conceptual hydrogeologic models have been developed for Enoch Valley Mine, Henry Mine, and Ballard Mine. The models use geologic, hydrogeologic, and sampling information to identify potential shallow and deep groundwater flow paths that may be affected at the mine sites. A matrix of potential sources, the groundwater flow paths emanating from each, and how they are evaluated is given in Table 3. Groundwater sampling stations include dump seeps, springs, headwater streams, and existing and proposed wells within the vicinity of the mines. These locations are shown on Drawings 2 and 3.

4.1 ENOCH VALLEY MINE

4.1.1 Enoch Valley Mine Site History and Description

The Enoch Valley Mine (EVM) began operation in 1989 and was recently mined out in 2004. The mine lease area is approximately 3½ miles long by ½ mile wide and consists of three federal phosphate leases and two State of Idaho leases. It includes 55 acres owned by P4 Production, 838 acres administered by the Idaho Department of Lands (IDL), and 582 acres of US Forest Service (USFS) land as shown in Drawing 2.

The EVM mine plan called for mining to progress from the north and south ends of the property towards the center. Mining began at the north end of the property in 1989. In the Spring of 2000, the active north and south mine pits were finally joined near the middle of the lease. At the end of 2001, the total output of phosphate ore was 14.6 million dry net tons (DNT). Phosphate ore removed from Enoch Valley Mine produced approximately 1.2 million tons annually. Active mining was completed at EVM in 2004.

The North and South Dumps art the two main waste rock dumps at EVM. Both dumps contain cherty shales and some black shales. The EVM North Dump completely backfills approximately 60% of the north pit. This area covers approximately 93 acres and is completely reclaimed. The remaining 40% of the north pit (at the southern end) has been partially backfilled. The South Dump has been almost completely reclaimed and covers approximately 308 acres. The total volume of waste rock at EVM was 51.5 million bank cubic yards as of December 31, 2001.

4.1.2 Enoch Valley Mine Site Geology

The topography and site layout of the EVM is shown on Drawing 2. Topography of the EVM site is dominated by the long, low ridgeline of Rasmussen Ridge, which trends northwest to southeast. On the west side of Rasmussen Ridge lies Enoch and Rasmussen Valleys. These valleys drain surface water north to the Little Blackfoot River (via Lone Pine Creek) and south to the Blackfoot River (via Rasmussen and Angus Creek), respectively. Elevations range from about 6,600 feet to over 7,000 ft AMSL. The phosphate outcrops and pits are located along the west slope of the ridge.

Surficial geology of the area is presented on Drawing 3. The geology shown is pre-mining and pits and waste rock dumps are drawn in their representative locations. A conceptual cross-section through this area is shown on Drawing 4, *Conceptual Geologic Cross Sections of Enoch Valley, Henry and Ballard Mines.* As shown on these drawings, Rasmussen Ridge is composed of bedrock units folded within the Snowdrift Anticline. The Meade Peak member (phosphate ore deposit) outcrops along the west ridge of the anticline and dips to the west, parallel to the ridge slope. The other members of the Phosphoria Formation lie adjacent to this layer and outcrop below the Meade Peak along the ridge.

The Wells Formation outcrops and forms the top of Rasmussen Ridge. The Enoch Valley Fault runs parallel to the strike of the anticline and through the Wells Formation just above the Meade Peak outcrop. This normal fault shifted the block of Wells Formation on the northeast above the units on the southwest side of the fault. Rasmussen and Enoch Valleys are composed of the Dinwoody and Thaynes Formation, overlain by Quaternary alluvium/colluvium and basalt in areas.

Outlines of the pits and waste rock dumps are shown in plan view in Drawing 3 and conceptually in cross-section on Drawing 4. As shown on these drawings, the EVM pit is oriented along the outcrop of the Meade Peak Member of the Phosphoria Formation. The majority of the pit ends in the Phosphoria Formation with exception of portions of the eastern flank, which is excavated to the contact with the Wells Formation. The North Dump is partially backfilled into the pit and extends north onto Dinwoody Formation and alluvium above Enoch Valley. The South Dump is backfilled into the pit onto the Phosphoria and Wells Formations, and extends south and west on Dinwoody Formation and alluvium/colluvium of Rasmussen Valley.

4.1.3 Enoch Valley Mine Conceptual Hydrogeologic Model

Potential groundwater flow paths at EVM are discussed below. These flow paths are controlled by several factors including site topography, hydrogeologic properties of bedrock units, and site geology and structure. The postulated alluvial groundwater flow paths emanating from the EVM area are listed in Table 3 and presented in plan view on Drawing 3 Conceptual alluvial and deep groundwater flow paths are shown in cross-section on Drawing 4

At the EVM site, the ridge top, above the pits, consists primarily of Wells Formation that has a relatively high hydraulic conductivity. Therefore, a significant portion of precipitation and/or snowmelt onto the ridges will infiltrate into the area underlain by Wells Formation to recharge the regional aquifer associated with this formation. Because the mine pits are located near the tops of the ridges, and because of significant infiltration into the Wells Formation above, only a relatively small amount of runoff flows to the backfilled pits. Therefore the main source of water to the waste rock dumps and backfilled pits consists of direct precipitation and snowmelt. As a result, a relatively limited amount of water is expected to infiltrate through the backfilled EVM mine pits or waste rock dumps.

As shown in Drawing 3, the footprint of the mine pits are mostly located on Phosphoria Formation. Therefore, water infiltrating the backfilled waste rock to the contact with the Phosphoria Formation will be confined by the low transmissivity which is characteristic of these units. The extremely low vertical hydraulic conductivity, particularly of the lower Meade Peak member, impedes the transport of water to the underlying Wells Formation. Therefore, water contacting the Phosphoria Formation via infiltration will generally flow above the Phosphoria and into the Dinwoody or Thaynes Formations and eventually into alluvium of the valleys. In the high-walls of the pits that have been excavated into the Wells Formation, a potential pathway exists for infiltrating water to enter the Wells Formation directly. Due to the relatively higher horizontal (parallel to beds) versus vertical (perpendicular to beds) hydraulic conductivity of sedimentary units, the groundwater flow would be directed generally parallel to bedding and down structural dip within the Wells Formation. The strike of the Wells Formation near the mine is northwest-southeast with a dip to the southwest.

Substantial portions of the EVM waste rock dumps have been placed directly on the Dinwoody Formation and alluvium of the valleys. These formations have moderate to high hydraulic conductivity and reportedly support intermediate groundwater flow systems. The relatively shallow flow paths through these units will be intermediate in distance and will exchange flow with overlying alluvium and interact directly with surface water. Water flowing within these units will generally

follow the surficial drainages and alluvial channels of Lone Pine Creek to the north and Rasmussen Creek to the south.

In conclusion, the most significant flow path for water being transported from and through the EVM waste rock dumps is into the Dinwoody Formation and the alluvial deposits within the valleys. Shallow flow from the EVM North Dump will generally move northwest toward Lone Pine Creek and flow from the South EVM Waste Rock Dump will generally be directed southeast toward East Fork Rasmussen Creek and southwest toward Rasmussen Creek, as shown in Drawing 3. There is also some potential for water to move through the backfilled pits and enter the Wells Formation, and flow southwest, down structural dip.

4.2 HENRY MINE

4.2.1 Henry Mine Site History and Description

The Henry Mine, operated by the Monsanto Company from 1969 to 1989, is located in T6S and R42/43E, approximately one mile southeast of the town of Henry, Idaho. The Henry Mine lease area is approximately five-miles long and one-half-mile wide. It includes 840 acres owned by P4 Production, 40 acres administered by the BLM, and 1,200 acres administered by the Idaho Department of Lands (IDL). Of these 2,080 acres, 1,000 were disturbed during mining operations, and 680 acres have successfully been reclaimed to date. The remaining unreclaimed areas include mine pits and portions of the haul road. The Henry Mine plan called for five mine panels or pits along five miles of phosphate outcrop. Shipping the ore from the mine to the plant in Soda Springs was by trucks with two or three belly-dump trailers. Phosphate ore removed from Henry Mine was estimated to be one million tons annually during the active mining phase (USGS, 2001), for a total estimate of 18 million tons during the active mining phase. Mining operations were completed at the North Pit in October 1989 (USGS, 2001). Final reclamation was completed in 1990 and reclamation bonds were relinquished in December of 1993 and November 1995. The volume of waste rock at Henry Mine is approximately 99.6 million bank cubic yards. There are currently six waste rock dumps associated with these pits at the site. The surface area of the existing waste rock dumps is estimated at 620 acres.

4.2.2 Henry Mine Site Geology

Topography of Henry Mine, shown in Drawing 2, is dominated by the northwest-southeast trending ridgeline of the Wooley Range. Near the north end of the lease, the Little Blackfoot River cuts across the property and flows northwest into the Blackfoot Reservoir. All surface water from the mine area eventually flows to the Little Blackfoot River via intermittent flow through Long Valley Creek on the west side of the mine area or Lone Pine Creek on the east side, or directly to the Little Blackfoot. Elevations at the site range from 6,200 to 6,800 ft AMSL. Mine pits were developed along the eastern side of this steeply-sloping ridgeline and are located along a five-mile stretch of Phosphoria outcrop. The waste rock dumps are located to the east of the mine pits with exception of the Henry Mine Canyon Fill Dump MWD087, which is located to the west of the center pit.

Surficial geology at the Henry Mine is presented on Drawing 3, and a representative cross-section is presented in Drawing 4. As shown in these drawings, the Wells Formation makes up the top of the western ridge of the Wooley Range (west and above the mine pits) and continues in outcrop to the west into Long Valley. In places, alluvium and basalt flows have been deposited over the older bedrock units of Wells Formation, specifically in the valley through which the Little Blackfoot River divides North Henry Mine from Center Henry Mine. The Meade Peak Member outcrops along the east flank of the western ridgeline of the Wooley Range and dips to the east. Adjacent members of the Phosphoria Formation outcrop further down the ridge below the Meade Peak unit, and some older

alluvium has been deposited within a mid-ridge valley. At the southern end of Center Henry Mine, a relict alluvial channel drains west into Long Valley.

Outlines of the pits and waste rock dumps are shown in plan view in Drawing 3 and conceptually in cross-section on Drawing 4. The geology shown is pre-mining and pits and waste rock dumps are drawn in their representative locations. As indicated in the drawings, the mine pits are oriented along the Meade Peak member outcrops. The center pit is backfilled with waste rock deposited on Phosphoria Formation. However, portions of the Henry Mine Dumps are located on alluvium in the mid-ridge valley and on the adjacent Dinwoody Formation. Also, portions of the Henry Mine North Dump and Henry Mine Canyon Fill Dump are located on Wells Formation above Long Valley.

4.2.3 Henry Mine Conceptual Hydrogeologic Model

Similar to the characteristics of EVM, described above, the Wells Formation outcrops at the topographic ridge top, above the mine pits. Due to infiltration into the Wells Formation above, only a relatively small amount of runoff flows to the backfilled pits. Therefore the main source of water to the waste rock dumps and backfilled pits is of direct precipitation and snowmelt. As a result, a relatively limited amount of water is expected to infiltrate through the backfilled Henry mine pits or waste rock dumps.

Similar to EVM, much of the footprint of the Henry mine pits and waste rock dumps are located on Phosphoria Formation which, due to the extremely low vertical hydraulic conductivity of the units, impedes the transport of water to the underlying Wells Formation. Therefore, water contacting the Phosphoria Formation via infiltration will generally flow above the Phosphoria and into the Dinwoody or Thaynes Formations and eventually into alluvium of the valleys. However, water may enter the Wells Formation through the high-walls of the pits that have been excavated into the Wells Formation and from the North Henry Dump (MWD085) and the Henry Mine Canyon Fill Dump (MWD087). Due to the relatively higher horizontal (parallel to beds) versus vertical (perpendicular to beds) hydraulic conductivity of sedimentary units, the groundwater flow would be directed generally parallel to bedding and down structural dip within the Wells Formation. The Wells Formation in the vicinity of the Henry Mine strikes northwest – southeast with a dip to the northeast. Water recharging the Wells Formation would follow flow paths controlled locally by formation strike and dip and on a larger scale by the regional flow to the west.

Waste rock dump, MWD086, on the eastern side of the center pit, and the south dump, MWD090, are placed mostly on alluvium with some on Dinwoody Formation in the mid-ridge valley. Water that infiltrates or runs off these waste rock dumps will enter this shallow groundwater flow system. These flow paths will be intermediate in distance and will exchange flow with overlying alluvium and interact directly with surface water. Water flowing within these units will generally follow the surficial drainages and alluvial channels north toward the basalt that is present along the Little Blackfoot River and northeast toward Lone Pine Creek.

In conclusion, the most significant flow path for groundwater being transported at Henry Mine is from the Center waste rock dumps into the Quaternary alluvial deposits within the valleys. Shallow flow from these dumps will generally move north toward the Little Blackfoot and northeast toward Lone Pine Creek. Another potential flow path is via water infiltrating through backfilled pits or waste rock and directly into the Wells Formation. Water recharging the Wells Formation would follow flow paths controlled locally by formation strike, northwest-southeast, and dip, northeast and on a larger scale by the regional flow to the west.

4.3 BALLARD MINE

4.3.1 Ballard Mine Site History and Description

The Ballard Mine is a historic phosphate mine located in T7S and R42/43E, which was operated by the Monsanto Company from 1951 to 1969. Ballard Mine was originally leased to the J.R. Simplot Company in December 1948. Simplot never developed the lease and in 1951 the Simplot Company assigned the lease to the Monsanto Chemical Company. A second Ballard Mine federal lease was issued to Monsanto in July 1955 to include additional phosphate ore deposits. During the 18 years of production (1951 - 1969), approximately 10.4 million dry net tons of phosphate rock were mined and removed from the two federal leases. The Ballard Mine lease areas combined are approximately 1.7 miles long and 1.2 miles wide. Within this area, approximately 191 acres were mined for phosphate rock, about 317 acres of land were covered by waste rock dumps and approximately 96 acres were used as service areas for the mine (Lee, 2001). Conversion of phosphate ore to elemental phosphorus occurred at the P4 Production Company plant, north of Soda Springs, Idaho. Approximately 20 million bank cubic yards of waste rock were stripped, and of that amount, two million cubic yards were used to backfill the pits with the remaining 18 million cubic yards hauled to the dumps (Lee, 2001).

Reclamation had started on the earlier pits even before mining operations were completed. In the 1960s and early 1970s, the Ballard Mine waste rock dumps were used for experimental plantings for reclamation. In the early 1980s, a study was conducted by Monsanto on cost-effective reclamation activities that might be completed at Ballard Mine. Some small projects that included highwall reduction, spreading of soil, breaking up of hard floors and subsequent plantings were initiated as part of the study.

4.3.2 Ballard Mine Site Geology

Topography of Ballard Mine (Drawing 10) is dominated by moderately-sloped, north-northwest trending ridges that make up the Fox Hills. Surface water from the northern portions of the Ballard Mine area flows north to Long Valley Creek towards the Little Blackfoot River. Most of the Ballard Mine area drains east to Wooley Valley Creek, a tributary of the Blackfoot River, or south/southwest to intermittent tributaries of the Blackfoot River. Elevations at the site range from 6,400 to 7,100 ft AMSL. The Ballard Mine site has six distinct open mine pits and six distinct waste rock dumps clustered within the ridges and side slopes. Unlike the other two mine sites, the layout of the Ballard Mine area is more complicated because the Phosphoria outcrop is not continuous. Therefore the pits are not located along a continuous strike of Meade Peak Member, but rather are scattered throughout the hills where the Meade Peak outcrops are at or near the surface.

Surficial geology at the Ballard Mine is presented on Drawing 10. The geology shown is pre-mining and outlines of pits and waste rock dumps are drawn in their respective location and conceptually in cross-section in Drawing 4. As shown in these drawings, the Ballard Mine area is cut by several north-northwest trending, sub-parallel normal faults including the Slug Valley Normal Fault, which is buried near the site through Wooley Valley. These faults have, in several locations, offset the Phosphoria members and resulted in displacing the Meade Peak member (phosphate ore deposit) towards or away from the surface. In general, the mine pits reflect the locations where the Meade Peak is at or near the ground surface. Surface geology in the area generally consists of an outcrop of Wells Formation (and a small area of the Meade Peak) which has been displaced upwards by two normal faults. To the west and east of these primary faults, Phosphoria and Dinwoody Formations outcrop on the side slopes and into the valleys that have been filled with alluvium. Just west of the mine site, a large basalt flow exists at the surface, covering the underlying geology. The Blackfoot

River flows across this basalt flow just downgradient of the Ballard Mine inflows. To the south is a large outcrop of Dinwoody Formation on the adjacent ridge.

The mine pits at Ballard Mine are located adjacent to and bisecting faults that have displaced the Meade Peak member towards the ground surface. Waste rock dumps are backfilled into the pits and are deposited on Phosphoria Formation, Wells Formation, Dinwoody Formation and alluvium in both Wooley Valley and the valleys to the west.

4.3.3 Ballard Mine Conceptual Hydrogeologic Model

The conceptual groundwater flow paths emanating from Ballard Mine area are discussed below. Similar to the other mine sites, water entering the ground from the pits and waste rock piles that are located on the Phosphoria Formation will tend to follow the strike and dip of the formation because of the low hydraulic conductivity of the unit. The low hydraulic conductivity, both with bedding and across bedding, impedes the transport of water across the Phosphoria Formation to the underlying Wells Formation. In addition, the waste rock dumps are reclaimed and covered with topsoil over much of the dumps to further limit water infiltration. As a result of these characteristics and engineering controls, very little water is likely to be transported through mine pits or waste rock placed on Phosphoria Formation. Furthermore, the extremely low vertical hydraulic conductivity, particularly of the lower Meade Peak member, impedes the transport of water from above and within the Phosphoria units to the underlying Wells Formation.

At Ballard Mine portions of the waste rock dumps are located on the Wells Formation. Water draining through these dumps is capable of moving into the Wells Formation. Water recharging the Wells Formation would follow flow paths controlled locally by formation strike and dip and on a larger scale by the regional flow to the west. The strike of the Wells Formation is generally north-south with the dip dependent on location. The waste dumps located west of the West Ballard Pit, (MMP035) overlie an eastward dipping section of the Wells Formation (see cross-section C-C′). The Middle Ballard Pit (MMP036) overlies a westward dipping section of the Wells Formation. The Ballard Pit, MMP040, overlies a structural syncline with dips both to the east and west.

Portions of all Ballard waste rock dumps are placed on alluvium and Dinwoody Formation on the side slopes and valleys. Water that infiltrates or runs off these waste rock dumps will enter shallow groundwater flow systems. These flow paths will be intermediate in distance and will exchange flow with overlying alluvium and interact directly with surface water. Water flowing within these units will generally follow the surficial drainages and alluvial channels, specifically toward Wooley Valley Creek to the east, to the Blackfoot River tributaries to the southwest, or to Long Valley Creek to the northwest.

In conclusion, the most significant flow paths for water originating in the waste rock areas at Ballard Mine is through the Quaternary alluvial deposits within the valleys, with flow to the northwest to Long Valley, to the east to Wooley Valley and to the southwest to the Blackfoot River. Water recharging the Wells Formation would follow flow paths controlled locally by formation strike and dip and on a larger scale by the regional flow to the west.

Table 3
Groundwater Flow Fields and Associated Sampling Stations

Enoch Valley Mine

Flow Direction	Groundwater Sampling Stations				
	Headwater Streams	Seeps	Springs	Wells	
				Receptor	Monitor
Alluvium					
Northwest to Lone Pine Creek	MST059 MST060 MST061		MSG001	DW002 AW002 AW001	MW012
Southeast to East Fork Rasmussen Creek	MST274	MDS026		AW005	MW007 MW008
Southwest to Rasmussen Creek	MST136 MST144	MDS025			MW013
Wells Formation					
Southwest down structural dip from eastern ridge	ND	ND	ND		MW009

Henry Mine

Flow Direction	Groundwater Sampling Stations				
	Headwater Streams	Seeps	Springs	Wells	
				Receptor	Monitor
Alluvium					
Northeast to Lone Pine Creek	MST058 MST064 MST226 MST276	MDS016 MDS022	MSG002	DW003	MW010 MW014
Basalt					
Northwest toward Little Blackfoot River	ND	ND	ND		MW009
Wells Formation					
Northeast down structural dip from western ridge	ND	ND	ND		MW011

Ballard Mine

Flow Direction	Groundwater Sampling Stations				
	Headwater Streams	Seeps	Springs	Wells	
				Receptor	Monitor
Alluvium					
Southwest to Blackfoot River	MST066 MST067 MST068 MST069			AW008	MW-15A MW-16A
Northwest to Long Valley Creek	MST050			AW006	MW017
East to Wooley Valley Creek	MST093 MST094 MST095 MST096		MSG004 MSG005 MSG006		MW018
Wells Formation					
East/Southeast down structural dip near West Ballard pit MMP035	ND	ND	ND		MW001 MW002 MW006

ND-Not Determined

5.0 MONITORING WELL INSTALLATION RATIONALE AND SCOPE OF WORK

Monitoring wells will be installed at EVM, Henry Mine, and Ballard Mine in the locations shown on Drawings 2, 3 and 10. Summaries of the proposed well installations and construction details are presented at the conclusion of this section in Tables 4, 5A, and 5B. The purpose and rationale for the proposed monitoring well locations and targets are described in more detail in the sections below.

This groundwater investigation is being conducted in a phased approach. The information obtained from the monitoring and installation of these new wells will be used to refine the conceptual model and may give rise to new data needs. Additional groundwater investigation needs may warrant installation of additional monitor wells.

Descriptions of the field methods that will be used to conduct this scope of work are included in Section 6.0, and laboratory analyses are described in Section 7.0. The scope of work consists of the following tasks, described in more detail at the end of this section.

5.1 ENOCH VALLEY MINE

As presented in the EVM conceptual hydrogeologic model, the most significant flow path for water being transported from and through the EVM waste rock dumps is into the alluvial deposits and Dinwoody Formation within the valleys. Flow from the EVM North Dump will generally move northwest toward Lone Pine Creek and flow from the South EVM Waste Rock Dump will generally be directed southeast toward East Fork Rasmussen Creek and southwest toward Rasmussen Creek, as shown in Drawing 3.

Several groundwater monitoring stations exist within the alluvial flow fields surrounding EVM, as indicated in Table 3. An additional four new monitor wells, MW007, MW008, MW012, and MW013, will be installed to monitor flows within the alluvium and Dinwoody Formation from the North and South EVM dumps. Soil and rock samples from the well borings, groundwater sample analytical data, and water quality field parameter measurements from these wells, will aid in the characterization of groundwater along the shallow flow paths.

Monitor wells MW007 and MW008 will be drilled at the toe and downgradient of the EVM South Waste Rock Dump and will target shallow groundwater within either the alluvium or Dinwoody Formation, depending on where groundwater is encountered. These wells will monitor groundwater flow from the south dump toward the southeast into East Fork Rasmussen Creek. The wells will be downgradient of dump seep MDS026. Monitor well MW012 will monitor groundwater flow from EVM North Dump into the alluvial flow field of Lone Pine Creek. The well will be upgradient of three headwater stream stations and three receptor wells within the valley. Monitor well MW013 will monitor groundwater flow from the center portion of the EVM South Dump into the alluvial flow field of Rasmussen Creek. The well will be downgradient of two headwater stream stations and dump seep MDS025.

MW007: This well will be located near the toe of EVM South Waste Rock Dump, near South Dump Seep, MDS026. A conceptual cross-section showing the proposed location is presented in Drawing 5, *Conceptual Cross-Section for Proposed Well Locations MW007 and MW008*. The boring may be drilled through approximately 20 feet of waste rock and into native alluvium or Dinwoody Formation below. Preferably, MW007 will be located such that it will be completed in the alluvium; however, depending on groundwater depth, it may be completed in the Dinwoody Formation below. Steel surface casing will be installed through the waste

rock (if encountered) and organic soil horizon to isolate the potential seleniferous material from the lower portions of the borehole during drilling. The well will be screened in the underlying native formation at first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The total depth of the well is anticipated to be approximately 100 feet below ground surface (bgs).

MW008: This well will be located at the toe of the EVM South Waste Rock Dump, downgradient of dump seep MDS06 and approximately 700 feet southeast and downgradient of well MW007. The well will monitor groundwater flow from the south dump toward the southeast into East Fork Rasmussen Creek. The boring will be drilled in native alluvium or Dinwoody Formation and the well will be screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. It is anticipated that the well will be drilled approximately 100 feet bgs. It is presumed that surface topography and the presence of an alluvial channel will dictate groundwater gradient and flow direction in the unconfined groundwater system from this area. Therefore, there is a high probability that MW008 has been sited in the downgradient flow direction from the EVM South Dump and well MW007.

MW012: This well will be located near the western edge of the EVM North Waste Rock Dump. The well will monitor groundwater flow in the Lone Pine Creek alluvial flow field. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 30 feet bgs.

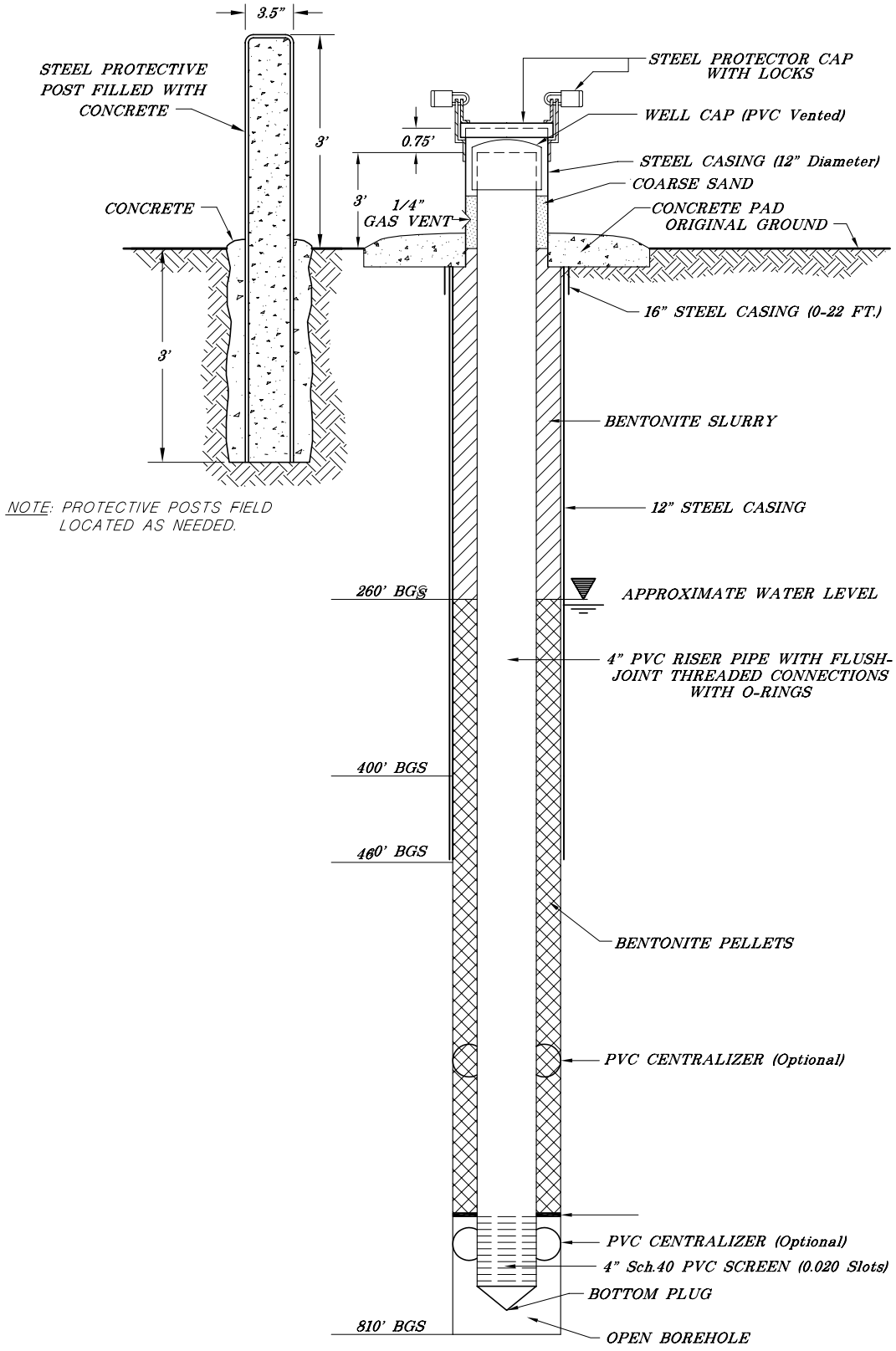
MW013: This well will be located in the alluvial flow field of Rasmussen Creek near the center of the EVM South Waste Rock Dump . The well will be downgradient of dump seep MDS025. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 30 feet bgs.

The conceptual model of EVM suggests that there is also potential for water to move through the backfilled pits and enter the Wells Formation, flowing primarily down structural dip to the southwest. Monitor well MW009 will be installed within an existing production well converting it to a monitoring well. The well will target the Wells Formation down dip and downgradient of the backfilled EVM Pit and South Waste Rock Dump. A conceptual cross-section, showing this well location is presented in Drawing 4*, Enoch Valley Mine Conceptual Cross-Section A-A'*. The well is described below in more detail.

MW009: The location for MW009 was selected for two reasons. First, the site is down dip and down gradient from mine-impacted areas overlying the Wells Formation. Second, a borehole exists that can be completed as a monitor well within the upper stratigraphic section of the Wells Formation.

It is proposed that well MW009 be completed by modifying the existing boring of EVM production well, PW020, which has most recently been used by Degerstrom for road maintenance but is currently not in use. The well log, obtained from IDWR records, is included in Appendix F. Well PW020 currently consists of 12" steel casing to a depth of 460 feet bgs and open borehole to 810 feet bgs. The well log indicates Phosphoria Formation to a depth of 720 feet, overlying Wells Formation from 720 feet to the bottom. The driller's report log indicates a water-bearing zone in the limestone from 720 –726 feet bgs, and that the boring is "losing water" at 800-810 feet bgs. It is proposed that the PW020 boring be converted to a

monitoring well, MW009, for the Wells Formation by installing 4-inch diameter PVC casing to approximately 730 feet bgs, and maintaining the open interval from 720 – 725 feet within the Wells Formation. Geophysical logging of the open borehole will be performed prior to setting the well to evaluate the signature of the Phosphoria Formation and confirm the contact depth with the Wells Formation, and potentially to identify and isolate a more specific interval for monitoring. The well construction details will be modified according to the results of the logging. The remainder of the PW020 boring will be sealed by installing a packer above the open interval, targeted at 720 feet bgs, and sealing the remainder of the borehole with bentonite slurry to the surface. A well construction diagram for MW009 is provided in Figure 5, *Proposed Well Construction Diagram for EVM Well MW009.*



REV. No.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
	Issued for Draft Tech Memo	10/05	P.Anderson	K.Conrath	P.Anderson

MWH

PROJECT No.: 1010076.011602
AutoCAD FILE: Well Diagram MW009
SCALE: As Shown
FIGURE No: 5

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROPOSED WELL CONSTRUCTION DIAGRAM FOR EVM WELL MW009

5.2 HENRY MINE

As presented in the Henry Mine conceptual hydrogeologic model, the most significant flow path for groundwater being transported at Henry Mine is from the Center waste rock dumps into the Quaternary alluvial deposits within the valleys. Shallow flow from these dumps will generally move north toward the Little Blackfoot and northeast toward Lone Pine Creek.

Several groundwater monitoring stations exist within the alluvial flow field of Lone Pine Creek, as indicated in Table 3. Two additional new monitor wells, MW010 and MW014, will be installed to monitor flows within the alluvium from Center Pit #1 Overburden Dump and the South Pit Overburden Dump. One well, MW019, will be installed to monitor flow in the basalt that is present along the Little Blackfoot River. The proposed wells are described below in more detail. Soil and rock samples from the well borings, groundwater sample analytical data, and water quality field parameter measurements from these wells, will aid in the characterization of groundwater along the shallow flow path.

MW010: One well, designated MW010, will be drilled near the existing production well, PW023, and will target shallow groundwater within the alluvium or Dinwoody Formation downgradient of both Henry Mine Center Pit Waste Rock Dump (MWD086) and Henry Mine South Pit Waste Rock Dump (MWD090). Based on pre-mining topographic maps, the well will be located along a mapped drainage and associated alluvial channel. The location of this well is shown in plan view with post-mining topography on Drawing 6, *Geology and Cross Section Location Map for Proposed Well MW010 Henry Mine*. A conceptual cross-section showing this location is presented in Drawing 7, *Conceptual Cross-Section for Proposed Well Location MW010 Henry Mine.*

The existing well, PW023, was originally used as a dewatering well during mining and has most recently been used to fill the adjacent pond for stock watering. Based on the downhole camera logs, well PW023 consists of 6" steel casing to a depth of 160 feet bgs, and open borehole to 310 feet bgs; the water level in the well was at 32 feet bgs, indicating a large saturated interval. There is no well log for this boring, however, it is presumed based on site geology that this well is open to the Dinwoody Formation. This well is located in an appropriate location for monitoring the Center Henry Pit and waste rock; however, the open interval is excessive for use as a monitoring point. Therefore, it is proposed that well MW010 be installed in the vicinity of PW023.

It is anticipated that well MW010 will be drilled approximately 100 feet bgs, and constructed with a 20-foot screened interval. It is possible that the well will be located on waste rock, and if so, the steel surface casing will be installed through the waste rock and underlying organic soil horizon to isolate these units. Geophysical logging will be performed both in PW023 and in the new boring prior to setting the well to evaluate the signature of the Dinwoody Formation and to confirm the appropriate depth for placing the well screen. The well construction depths in the new boring will be modified according to the results of the logging.

MW014: This well will be located near the northeastern edge of the Henry Mine Southern Waste Rock Dump (MWD090) and monitor groundwater flow in the Lone Pine Creek alluvial flow field. The well will be downgradient of dump seep MDS022 and spring MSG002. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 30 feet bgs.

MW019: This well will be installed on the north side of the Center Pit #2 Overburden Dump (MWD088) to monitor flow from this dump into the basalt along the Little Blackfoot River. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 10 feet bgs.

The conceptual model for Henry Mine indicates there is a potential for water to infiltrate through the backfilled pit or waste rock and enter the Wells Formation. Water moving within the Wells Formation will follow structural dip to the northeast. Monitor well MW011 will be installed to monitor this flow path. The proposed well is described below in more detail.

MW011. A second well, MW011, will be installed northwest of the Henry Min Pit to monitor groundwater within the Wells Formation in a potentially affected flow path from the backfilled pit. The location of the well is shown in plan view with post-mining topography on Drawing 8, *Geology and Cross Section Location Map for Proposed Well MW011 Henry Mine,* and a conceptual cross-section showing this location is presented in Drawing 9, *Conceptual Cross-Section for Proposed Well Location MW011 Henry Mine*.

The location for proposed well MW011 was selected based on the following criteria: 1) penetrate the uppermost stratigraphic section of the Wells Formation where it is saturated; 2) if possible, locate the well where waste material or the Phosphoria Formation is not penetrated by the well before reaching the Wells Formation; and 3) locating the well at a site reasonably accessible for a drilling rig. The well was not located high on the ridge (near section B-B') because the upper stratigraphic section would not be saturated. The well was not located within the mine-impacted area or east of the mine because of the desire not to penetrate waste material or the Phosphoria Formation. The site selected for MW011 allows sampling of the upper stratigraphic section of the Wells Formation at a site where groundwater can move along strike and dip from under the mine-impacted area (pits and waste dumps).

5.3 BALLARD MINE

As discussed in the conceptual hydrogeologic model for Ballard Min, the most significant flow paths for water originating in the waste rock areas at Ballard Mine is through the Quaternary alluvial deposits within the valleys. Flow from the eastern overburden areas, MWD082 and MWD084, will generally move east toward Wooley Valley Creek; flow from overburden areas, MWD081, MWD083, MWD093 will be southwest toward the Blackfoot River; and flow from overburden area MWD080 will be northwest toward Long Valley Creek.

Several groundwater monitoring stations exist within the alluvial flow fields surrounding Ballard Mine, as indicated in Table 3. An additional four new monitor wells, MW-15A and MW-16A, MW017, and MW018 will be installed to monitor flows within these alluvial flow fields. Soil and rock samples from the well borings, groundwater sample analytical data, and water quality field parameter measurements from these wells, will aid in the characterization of groundwater along the shallow flow paths.

MW-15A and MW-16A: These wells will be located southeast of overburden dumps MWD080, MWD081, MWD083 on the southeastern side of Ballard Mine. The wells will be installed near headwater stream stations MST067 and MST069. Whetstone Associates is

installing these wells in fall 2006. Well construction details have not been obtained at this time.

MW017: This well will be located west of overburden dump MWD080 on the northwester side of Ballard Mine. The well will monitor flow in the alluvial flow field of Long Valley Creek. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 30 feet bgs.

MW018: This well will be located near an existing intermittent creek channel flowing out of overburden dump MWD082 on the southeastern side of Ballard Mine. The well will be downgradient of headwater stream station MST095 and monitor flow in the alluvial flow field of Wooley Valley Creek. The boring will be drilled in native alluvium and screened in first groundwater with sufficient yield to provide water samples using standard low-stress sampling methods. The depth is anticipated to be approximately 30 feet bgs.

At Ballard Mine, the potential flow path through the Wells Formation near the West Ballard Pit will be further investigated. Water recharging the Wells Formation would follow flow paths controlled locally by formation strike and dip and on a larger scale by the regional flow to the west. .The strike of the Wells Formation at the Ballard Mine is generally north-south with the dip dependent on location. The waste dumps located west of the West Ballard Pit overlie an eastward dipping section of the Wells Formation (see cross-section C-C´). The Middle Ballard Pit overlies a westward dipping section of the Wells Formation The conceptual model of Ballard Mine suggests there is potential for water to move through the dumps and enter the Wells Formation. Groundwater flow likely is in the southern direction following a combination of the structural strike and dip. Monitor well MW006 will be installed at the southern end of the west pit, MMP035. The well will monitor groundwater flow downgradient of existing wells MW001 and MW002, which are also completed in the Wells Formation. The proposed well is described below in more detail.

MW006: This well will be drilled on the south end of the Ballard West Pit and will target groundwater in the upper stratigraphic section of the Wells Formation, similar to existing wells MW001 and MW002. The location of these wells are shown in plan view with post-mining topography on Drawing 10, *Geology and Cross Section Location Map for Proposed Well MW006 Ballard Mine,* and conceptual cross-sections showing this location is presented in Drawing 11, *Conceptual Cross-Section for Proposed Well Location MW006 Ballard Mine*. As discussed in Section 3.1.2, with regard to groundwater monitoring, elevated total selenium concentration was detected in Ballard Mine monitoring well MW001, screened in Wells Formation. The proposed well has been sited at the south end of Ballard Mine West Pit. The boring will be drilled on an exposed outcrop of Wells Formation and will be completed at the depth of first water within the Wells Formation. The total depth of the well is anticipated to be between 300 and 350 feet bgs, based on the well logs and water levels of MW001 and MW002. The well will be constructed using 4-inch PVC casing with a 20- to 40-foot screen, depending on the water-bearing zones encountered during drilling. The primary purpose of well, MW006 is to verify the groundwater flow direction and assess groundwater conditions downgradient of MW001 and MW002, assuming that groundwater flow is controlled by a combination of strike and dip and toward topographically lower areas. The location of the new well will be within the footprint of the pit and surrounded by waste rock; therefore, potential impact from the waste rock may be expected. However, the compartmentalized geology at Ballard Mine requires that the new well be placed near the existing wells (MW001 and MW002) to ensure that the wells are hydraulically connected (a possible fault zone to the south of the West Ballard Pit confines the placement of the new well to the south).

TABLE 3 PROPOSED NEW MONITORING WELLS				
New Well Identification	**Location of New Well**	**Estimated Total Depth (feet)**	**Targeted Geology**	**Primary Purpose**
ENOCH VALLEY MINE				
MW007	South of EVM South Dump; near edge of dump footprint.	100	First groundwater encountered (alluvium or Dinwoody Fm)	Monitor shallow flow path from EVM South Dump into East Fork Rasmussen Creek alluvial flow field.
MW008	South of EVM South Dump; south and downgradient of MW007.	100	First groundwater encountered (alluvium or Dinwoody Fm)	Monitor shallow flow path from EVM South Dump into East Fork Rasmussen Creek alluvial flow field.
MW009	PW020 Boring	810	Wells Fm	Monitor deep flow path from EVM into Wells Fm.
MW012	Northwest of EVM North Dump in Lone Pine Creek alluvial flow field	30	Alluvium	Monitor shallow flow in alluvial flow path of Lone Pine Creek.
MW013	Southwest of EVM in Rasmussen Creek alluvial flow field	30	Alluvium	Monitor shallow flow in alluvial flow path of Rasmussen Creek.
HENRY MINE				
MW010	Southeast of Center Henry Pit; near PW023.	150	First groundwater encountered (alluvium or Dinwoody Fm)	Monitor shallow flow path from Henry Mine Center Dumps into alluvium or Dinwoody Fm.
MW011	Northwest of Center Henry Pit; south of Little Blackfoot River.	150	Wells Fm	Monitor shallow/deep flow path from Henry Center Pit/Dump into Wells Fm.
MW014	Southeast of Henry Mine center pit in Lone Pine Creek alluvial flow field.	30	Alluvium	Monitor shallow flow in alluvial flow path of Lone Pine Creek.
MW019	North of Henry Mine center pit	10	Basalt	Montior flow in basalt near Little Blackfoot River.
BALLARD MINE				
MW006	South of West Ballard Pit; south of Waste Rock Dumps.	350	Wells Fm	Monitor deep flow path from Ballard West Pit/Dumps into Wells Fm.
MW-15A	Southeast of Ballard Mine to Blackfoot River	30	Alluvium	Monitor shallow flow in alluvial flow path of Blackfoot River. (To be installed by Whetstone Assoc.)
MW-16A	Southeast of Ballard Mine to Blackfoot River	30	Alluvium	Monitor shallow flow in alluvial flow path of Blackfoot River. (To be installed by Whetstone Assoc.)
MW017	Northwest of Ballard Mine into Long Valley Creek alluvial flow field	30	Alluvium	Monitor shallow flow in alluvial flow path of Long Valley Creek.
MW018	East of Ballard Mine in Wooley Valley alluvial flow field	30	Alluvium	Monitor shallow flow in alluvial flow path of Wooley Valley Creek.

TABLE 5A (all depths in feet)
WELL CONSTRUCTION DETAILS – NEW BORINGS
ENOCH VALLEY, HENRY, AND BALLARD MINES

New Well Identification	Location of New Well	Estimated Drilling Depth	Estimated Bottom of Boring	Estimated Bottom of Well	Surface Casing		Well Casing		Well Screen		10-20 Sand		#60 Sand		Hydrated Bentonite Pellets		Bentonite Slurry	
					Material	Depth from Surface	Material	Depth from Surface	Material	Length	From	To	From	To	From	To	From	To
ENOCH VALLEY MINE																		
MW007	South of EVM South Dump; near edge of dump footprint.	100	100	100	6" Steel	40	4" PVC	100	4" PVC	20	100	75	75	70	70	60	60	0
MW008	South of EVM South Dump; south and downgradient of MW007.	100	100	100	6" Steel	20	4" PVC	100	4" PVC	20	100	75	75	70	70	60	60	0
HENRY MINE																		
MW010	Southeast of Center Henry Pit; near PW023.	150	150	150	6" Steel	20	4" PVC	150	4" PVC	20	150	125	125	120	120	110	110	0
MW011	Northwest of Center Henry Pit; south of Little Blackfoot River.	150	150	150	6" Steel	20	4" PVC	150	4" PVC	20	150	125	125	120	120	110	110	0
BALLARD MINE																		
MW006	South of West Ballard Pit; south of Waste Rock Dumps.	350	350	350	6" Steel	20	4" PVC	350	4" PVC	20	350	325	325	320	320	310	310	0

TABLE 5B (all depths in feet)
WELL CONSTRUCTION DETAILS-EXISTING BORING

New Well Identification	Location of New Well	Estimated Drilling Depth	Estimated Bottom of Boring	Estimated Bottom of Well	Surface Casing		Well Casing		Well Screen		Packer Depth	Bentonite Pellets		Bentonite Slurry	
					Material	Depth from Surface	Material	Depth from Surface	Material	Length		From	To	From	To
ENOCH VALLEY MINE															
MW009 (PW020)	PW020 Boring	NA	810	810	12" Steel	460	4" PVC	725	Open	725-810	725	725	WL	WL	0

N/A Not Applicable
WL Water Level

5.4 BOREHOLE GEOPHYSICES

Borehole geophysical logging will be performed in all new monitoring well borings and existing wells with open boreholes. Geophysical logs will likely include natural gamma measurements, induced polarization (IP), resistivity (R) and self potential (SP) as well as, caliper, water temperature, and water resistivity. Descriptions of these techniques are provided in Section 6.0, Field Methods. These techniques will be useful in both existing and new borings for identifying the stratigraphic units and the changes in lithology through the boring. In particular, the natural gamma log measures variations in the natural radioactivity originating from changes in concentrations of the trace elements uranium (U) and thorium (Th) as well as changes in concentration of the major rock forming element potassium (K). Therefore, the gamma log can typically distinguish between shales and sandstones/limestones due to the low potassium content of most sandstones/limestones compared to shales. This logging will be useful for distinguishing between the Phosphoria Formation (shales) and the Wells Formation (limestone/sandstone). Where the stratigraphy of certain boreholes is generally known (i.e., PW022, Phosphoria Formation, and PW020, Phosphoria and Park City/Wells Formation), the geophysical logs may be used to identify a general signature for the known units. Geophysical logging of new borings may help identify the stratigraphic units and the variations in lithology and contacts between units. Specifically:

PW020/MW009 – Geophysical logging may identify the contact between the Phosphoria Formation and the Wells Formation. This logging will also be useful for identifying the general signature of the Phosphoria and Wells Formations. The Wells Formation will then be screened by the new well, MW009, and the overlying Phosphoria Formation will be sealed to the surface.

PW022 – Geophysical logging may be used to identify the general signature of the Phosphoria Formation.

PW023 – Geophysical logging may identify the general signature of the Dinwoody Formation, and possibly identify whether the borehole penetrates the underlying Phosphoria Formation.

MW003 – Geophysical logging may identify the formations penetrated by the borehole – i.e., whether the borehole is entirely within basalt and Phosphoria Formation, or whether the Wells Formation is encountered.

MW006 – Geophysical logging may be used to confirm that this new well boring is within the Wells Formation.

MW007 – Geophysical logging may be used to identify the signature within the alluvium or Dinwoody Formation.

MW008 – Geophysical logging may be used to identify the signature within the alluvium or Dinwoody Formation.

MW010 – Geophysical logging may be used to identify the signature within the alluvium or Dinwoody Formation.

MW011 – Geophysical logging may be used to confirm that this new well boring is within the Wells Formation

5.5 WELL ABANDONMENT

Up to two wells may be abandoned during monitoring well installation field activities, as discussed below. The specified monitoring wells will be abandoned in accordance with Idaho Department of Water Resources (IDWR) rules and regulations (specifically IDAPA 37.03.09.12a).

MW003: Water level readings indicate that this well may be open to both basalt and Phosphoria Formation. Specifically, in spring 2004 the water level in the well approximately 11 feet bgs and in fall 2004 the water level in the well was approximately 50 feet bgs. Only dissolved selenium concentration data is available for this well; however, the dissolved selenium concentration in spring 2004 was 0.005mg/L while in fall 2004 it was elevated to 0.058 mg/L. This seasonal change in selenium concentrations may reflect two separate flow systems. It is proposed that MW003 be abandoned and replaced with wells MW021 (basalt) and MW011 (Wells Fm.).

MW005: It was determined, based on the downhole camera investigation, that MW005 is not a useful groundwater monitoring point and will be abandoned. This well is located within the floodplain of the Little Blackfoot River near center Henry Mine. Based on the downhole camera investigation, it was determined that this well was screened from 16 to 17.5 feet bgs, and therefore collects near-surface water during high water periods. This well does not represent a useful groundwater monitoring point.

5.6 AQUIFER MATERIAL TESTING

Aquifer material (soil/rock) samples will be collected from drill cuttings during drilling of new borings. Two samples from each boring will be sent to the laboratory for chemical analyses. Samples will be selected from the depth interval where water is first encountered in the borehole, and the sample at the bottom of the borehole. In the borehole for MW007, a sample will be collected in native ground just below the contact of the waste rock (if encountered) and the native surface. Samples will be analyzed for total metals and total organic carbon. Sample collection procedures are described in Section 6.0 and laboratory testing is detailed in Section 7.0. The purpose of aquifer material testing is to obtain the concentrations of total metals and total organic carbon present in the aquifer solids.

5.7 GROUNDWATER MONITORING

Following new well installation all monitor wells, including existing monitor wells, will be sampled. Low stress sampling techniques will be used where possible. Low flow sampling may not be possible in existing wells if dedicated pumps are already installed, or if the required sampling equipment cannot access the well. Samples will be analyzed for the parameters listed in Table 6, *Groundwater Monitoring Analytes* (Section 7.1). In addition to the groundwater parameters that are typically analyzed, these groundwater samples may also be analyzed for the speciated selenium compounds, selenate and selenite.

5.8 MONITORING WELL SURVEY DATA

Following installation of the new monitoring wells, the following survey data will be collected at the sites and placed on the topographic maps.

New/Existing Wells: Horizontal coordinates, elevation of the top of PVC well casing, elevation of the top of the steel surface casing, and approximate ground surface elevations for the following:

- EVM: MW007, MW008, MW009 (PW020), MW012, MW013, and PW019
- Henry Mine: MW003, MW004, MW010, MW011, MW014, MW019, PW022, and PW023
- Ballard Mine: MW001, MW002, MW006, MW-15A, MW-16A, MW017, and MW018

5.9 SUBMITTALS

The following will be prepared and submitted to IDEQ for distribution to the various regulatory agencies:

- Boring logs and well construction diagrams;
- Geophysical logs;
- Monitoring well abandonment forms;
- Groundwater sample collection forms;
- Groundwater analytical data;
- Soil sampling forms;
- Soil analytical data;
- Survey data;
- Geologic maps and cross sections

6.0 FIELD METHODS

This well installation work plan consists of drilling, installation, and development of new groundwater monitoring wells; borehole geophysics; soil and groundwater sampling and analysis; abandonment of existing groundwater wells; and surveying. The procedures regarding the above listed activities are outlined below, and standard operating procedures (SOPs) for selected activities are included in Appendix G and H. All sampling activities conducted for this investigation will be in accordance with Field Sampling Plan (PgmFSP) and Quality Assurance Plan (PgmQAP), which were submitted to the Agencies for review and approved with the 2004 SI Work Plan in March 2004.

6.1 DRILLING

A Field Engineer/Geologist will supervise the drilling operations. The Field Engineer/Geologist will maintain a drill log noting lithology, sampling interval, and other pertinent information. It is anticipated that samples will be collected approximately every 10 feet (where possible) in the unsaturated zone from the cuttings, or with a split spoon sampler, if necessary. During drilling in the saturated zone or through rock that cannot be sampled with a split spoon sampler, the Field Engineer/Geologist will collect samples from the cuttings. Cuttings are collected for lithologic characterization and analytical testing. All groundwater monitoring wells installed during this investigation will be permitted through the Idaho Department of Water Resources (IDWR) and will be constructed according to their guidelines. A more detailed description of drilling methods is outlined in Appendix G.

6.2 GEOPHYSICAL LOGGING

A subcontractor, to be determined, will conduct Geophysical logging of the boreholes. Borehole geophysical logging will be performed in all new monitoring well borings and existing wells with open boreholes. Geophysical logs will likely include natural gamma measurements, induced polarization (IP), resistivity (R) and self potential (SP), as well as, caliper, water temperature, and water resistivity measurements.

Gamma-ray measurements detect variations in the natural radioactivity originating from changes in concentrations of the trace elements uranium (U) and thorium (Th) as well as changes in concentration in an isotope of the major rock forming element potassium (K). Since the concentrations of these naturally occurring radioelements vary between different rock types, natural gamma-ray logging provides an important tool for lithologic mapping and stratigraphic correlation. Gamma-ray logs are important for detecting alteration zones, and for providing information on rock types. For example, in sedimentary rocks, sandstones can often be easily distinguished from shales due to the low potassium content of the sandstones compared to the shales. In sedimentary rocks, the potassium isotope is, in general, the principal source of natural gamma radiation, primarily originating from clay minerals.

The Induced Polarization (IP) tool consists of an assembly of electrodes, usually including a current electrode and two potential (measurement) electrodes. A square wave current with an 'off' time between positive and negative parts of the waveform is transmitted (waveforms may be from 1 second to 8 seconds duration). Potential measurements made at selected times in the waveform can be related to the IP effect (chargeability of the rocks), the resistivity (R) of the rocks, and to self-potentials (SP) generated in the rocks. The transmitter is a constant current source located at the surface.

In time domain IP measurements, the ratio of the secondary voltage measured during the current off-time to the primary voltage measured during the current on-time is related to the electrical polarizability of the rock and is called chargeability. A high chargeability response is an indication of the presence of metallic sulphides and oxides or cation-rich clays.

The electrical resistivity (R) of rocks depends on several factors including the presence of conductive minerals such as base metal sulphides or oxides and graphite in the rock. Most rocks without these minerals are usually poor conductors and their resistivities are governed primarily by their porosity, degree of fracturing, salinity of the pore water, the degree of saturation of the pore spaces, and to a lesser extent by the intrinsic minerals that constitute the rock. Some alteration processes such as silicification and carbonatization tend to reduce the porosity and hence increase the resistivity of the rock. In igneous and metamorphic rocks, the resistivity log is useful mainly in mapping conductive minerals and fracture zones. In sedimentary rocks, the resistivity log is frequently used in lithologic mapping because changes in lithology are often associated with changes in porosity.

SP anomalies are mainly an indication of the presence of graphite and/or high concentrations of base metal sulphides including pyrite. Large self potentials observed within and around sulfide and graphite bodies are mainly caused by electrochemical processes. Low resistivity anomalies correlating with SP and IP anomalies are, therefore, good indications of the presence of conductive minerals. SP anomalies can be also generated by fluid flow in porous media.

Measurement of caliper will provide fracture characteristics in uncased sections. Water temperature can help in identification of vertical flow within the borehole. Water resistivity might be useful in identification of different water sources.

6.3 WELL INSTALLATION, ABANDONMENT AND DEVELOPMENT

A Field Engineer/Geologist will monitor all well installation procedures performed by the drilling company and record dates and times of events. In general, wells will be installed by lowering PVC casing down the borehole to specified depths. Screened intervals will be dependent on the water bearing units encountered. The sand pack will be tremied down hole until the depth is a total of 5 to 10 feet above the top of the screened interval (depending upon the geology and water units encountered). Bentonite pellets will be placed above the sand pack to form a seal. Bentonite pellets will be used if this zone is below water in the casing; otherwise, bentonite slurry may be used. The remainder of the annular space will be grouted with bentonite grout mixture or bentonite slurry. All wells will have steel surface casing to isolate surface material and organic-rich soil horizons. Surface completions will include a stick-up of approximately 2.5 feet above ground. All surface casings will be fitted with a locking cap and locked with a P4 Production lock.

Once the wells have been installed, the Field Engineer/Geologist will monitor development performed by a pump crew. The goal of monitoring well development is to remove fines and drilling fluid residue from the gravel pack and the natural formation in the vicinity of the screened interval, this will ensure good communication between the aquifer and the well. The well development process is comprised of: (1) application of sufficient energy in a monitoring well to create groundwater flow reversals (surging) in and out of the well and the gravel pack to release and draw fines into the well; and (2) pumping or bailing to draw drilling fluids out of the borehole and adjacent natural formation along with fines that have been surged into the well.

Development will be accomplished by surging and bailing/pumping. A bailer will be used to clean out any fines that have settled on the bottom of the well. Next, a surge block will be used to agitate the water, causing it to move in and out of the screen. This will draw in fines from the gravel pack breaking up any bridges that may have occurred during the placement of the gravel pack. After surging for a few minutes, the bailer will be lowered again to clean out any fines brought into the casing from surging. This cycle will continue until minimal fines are being pulled out with the bailer. At this point, a submersible pump will be lowered down the well. Pumping will begin at a low flow rate and will gradually be increased. The discharge flow rate will be increased (if possible) until the well is pumping at its maximum yield without draw down beneath the pump. Pumping will continue until the water is clear of sediment and field parameters are consistent. A more detailed description of well installation and development is provided in Appendix G.

6.4 AQUIFER MATERIAL TESTING

Aquifer material (soil/rock) samples will be collected from drill cuttings during drilling of new borings. Samples will be collected for the purpose of archiving from cuttings in composited 10-ft intervals, at changes in lithology, or more frequently based on field conditions. Material will be collected, double bagged, and labeled with the boring location and name, depth interval, date and time, project information and sampler initials. Two samples will be collected from each boring for laboratory analysis. These samples will include the depth interval where water is first encountered in the borehole, and the sample at the bottom of the borehole. Samples will be placed on ice and sent to the analytical laboratory for analysis; all other samples will be archived on site. All soil samples will be collected as described in the 2004 SI Work Plan Quality Assurance Plan (PgmQAP) that was submitted to the agencies in March 2004.

6.5 GROUNDWATER SAMPLING

6.5.1 Static Water Level Measurement

Measurement of the static water level is performed using a 500-foot electronic water level indicator. The same measuring point on the casing is used to ensure the measurements are consistent. For MWH field studies, the wellhead reference point will be at the top of casing (PVC) - north side. Static water level measurements will be taken in all new wells before sampling, and in surrounding site wells.

6.5.2 Groundwater Sample Collection

Low-stress sampling techniques, in accordance with EPA protocol, will be used for sampling wells, where possible. Low-stress sampling may not be possible in existing wells if dedicated pumps are already installed, or if the required sampling equipment cannot access the well. Detailed sampling protocol is included in Appendix H. The sampling protocol states requirements for water level stabilization and parameter stabilization. The following parameters are monitored during sample collection: turbidity, dissolved oxygen, specific conductance, temperature, pH, and ORP/Eh. Bladder pumps for low-stress sampling will be set at least 20 feet (if possible) below the air-water interface in the well, and pumped through tubing to the surface. The wells will be purged in accordance with USEPA protocols, such that water from the formation will be transported from the aquifer to the surface with minimal agitation. Samples will be field-filtered (for dissolved analysis) using dedicated 0.45 um filters, and bottles will be filled with little headspace remaining. Groundwater sampling and shipping protocol will be consistent with the 2004 SI Work Plan PgmQAP (March 2004) and according to SOP-NW-5.3, Collection of Groundwater Quality Samples, which is located in Appendix B of the PgmQAP.

For sample collection for selenium speciation analyses, the sample bottles will be filled with nitrogen gas and the sampled groundwater will displace the nitrogen gas during filling to reduce contact with the atmosphere during this sampling step. Samples will be flash frozen and shipped on dry ice via overnight delivery to the analytical laboratory for analysis. Additionally, one duplicate sample from each well will be field spiked with a laboratory-supplied selenite spike to provide quality assurance/quality control evaluation to both field and laboratory procedures. Also, a second duplicate sample will be preserved with EDTA, which complexes the dissolved iron in the sample, thereby eliminating the potential for iron to co-precipitate with dissolved selenium following sampling.

7.0 LABORATORY ANALYSES

The following sections describe analytical laboratory testing that will be performed on groundwater and solid samples.

7.1 GROUNDWATER ANALYSES

Table 6 presents the groundwater analytes, associated methods, estimated detection limits (EDL), reporting units, and estimated holding times. ACZ Laboratories will perform all other analyses including dissolved selenium. ACZ Laboratories will perform all analyses except selenium speciation, which will be analyzed by Applied Speciation and Consluting. University of Idaho Laboratory will perform the analyses on field duplicate samples.

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
Phone: (800) 334-5493

University of Idaho
Holm Research Center
2222 W 6th St
Moscow, ID 83844
Phone: 208-885-7081

Applied Speciation and Consulting, LLC
953 Industry Drive
Tukwila, WA 98188
Phone: (206)219-3779

TABLE 6 GROUNDWATER MONITORING ANALYSES				
Parameter	**Method**	**EDL**	**Reporting Units**	**Holding Time (days)**
alkalinity, total	SM2320B	2	mg/L	14
aluminum*	M200.7 ICP	0.03	mg/L	180
antimony*	M200.8 ICP/MS	0.0004	mg/L	180
arsenic*	M200.8 ICP/MS	0.0001	mg/L	180
barium*	M200.7 ICP	0.0001	mg/L	180
beryllium*	M200.7 ICP	0.0001	mg/L	180
cadmium	M200.8 ICP/MS	0.0001	mg/L	180
calcium	M200.7 ICP	0.2	mg/L	180
chloride	M300.0	0.5	mg/L	28
chromium*	M200.8 ICP/MS	0.0001	mg/L	180
cobalt*	M200.7 ICP	0.01	mg/L	180
copper*	M200.7 ICP	0.01	mg/L	180
gross alpha*	M900.0	2	pCi/L	180
gross beta*	M900.0	4	pCi/L	180
hardness	Calculation	1.5	mg/L	-
iron*	M200.7 ICP	0.01	mg/L	180
ferrous iron, dissolved (Field)	HACH	0.01	mg/L	-
ferric iron, dissolved	Calculation	0.01	mg/L	-
lead*	M200.8 ICP/MS	0.0001	mg/L	180
manganese*	M200.8 ICP/MS	0.0005	mg/L	180
magnesium	M200.7 ICP	0.2	mg/L	180
mercury*	M245.1	0.0002	mg/L	28
molybdenum*	M200.7 ICP	0.01	mg/L	180
nickel	M200.8 ICP/MS	0.0006	mg/L	180
nitrogen (as nitrate and nitrite)	M 353.2	0.02	mg/L	28
nitrogen (total Kjedahl)	M 351.2	0.1	mg/L	28
orthophosphate	M 365.1	0.005	mg/L	28
pH	M150.1	0.1	pH	-
potassium	M200.7 ICP	0.3	mg/L	180
selenium	SM3114 B, AA-Hydride	0.001	mg/L	180
selenite	IC-ICP/MS	0.01	µg/L	1
selenate	IC-ICP/MS	0.01	µg/L	1
silver*	M200.7 ICP	0.01	mg/L	180
sodium	M200.7 ICP	0.3	mg/L	180
sulfate	M300.0	0.5	mg/L	28
thallium*	M200.8 ICP/MS	0.0001	mg/L	180
total dissolved solids*	M160.1	10	mg/L	7
total suspended solids*	M160.2	10	mg/L	7
uranium*	M200.8 ICP/MS	0.0001	mg/L	180
vanadium	M200.8 ICP/MS	0.0002	mg/L	180
zinc	M200.8 ICP/MS	0.002	mg/L	180

* Analytes included as a screening for one groundwater sampling event.
Methods are for media (non-blank) samples. Equipment and field blanks will be analyzed for unfiltered results as analyte methods allow.
For regulatory compliance, all media samples will be analyzed for unfiltered metals as analyte methods allow.
For water typing, media samples will be analyzed for filtered metals.
EDL - Estimated Detection Limit

7.2 AQUIFER SOLIDS ANALYSES

7.2.1 Total Metals Analyses

Aquifer solid material will be collected during drilling and analyzed for total metals concentrations, paste pH, and total organic carbon (TOC). Table 7, *Aquifer Solids Analyses*, presents the analyte list with the associated method, estimated detection limits (EDL), reporting units, and estimated holding times.

TABLE 7
AQUIFER SOLIDS ANALYSES

Parameter	Method	EDL	Reporting Units	Holding Time
paste pH	USDA No 60 (21A)	0.01	units	
total organic carbon (TOC)	ASTM D4129-88	0.02	%	
aluminum	M3050B / M6010B ICP	3.0	mg/kg	6 months
cadmium	M3050B / M6010B ICP	0.5	mg/kg	6 months
chromium	M3050B / M6010B ICP	1.0	mg/kg	6 months
iron	M3050B / M6010B ICP	1.0	mg/kg	6 months
manganese	M3050B / M6010B ICP	0.5	mg/kg	6 months
nickel	M3050B / M6010B ICP	1.0	mg/kg	6 months
selenium	M3050B / SM3114B	0.1	mg/kg	6 months
vanadium	M3050B / M6010B ICP	0.5	mg/kg	6 months
zinc	M3050B / M6010B ICP	1.0	mg/kg	6 months

8.0 SCHEDULE

The following activities will be conducted in support of the groundwater investigation:

2007 Activities

1. New monitoring well installations;
2. Proposed monitoring well abandonment;
3. Survey new and existing monitoring well locations;
4. Groundwater sampling after new well installations;
5. Data submittal – one month after data validation is complete.

Lee, 2001.

Mansfield, G.R., 1927. *Geography, Geology and Mineral Resources of Part of Southeastern Idaho*. U.S. Department of the Interior, Geological Survey, Professional Paper 152.

McGreggor, D., 1993. *Hydrogeologic Evaluation of the A and B Pits in the Lower Dry Valley, Caribou County, Idaho.* Unpublished MS Thesis, University of Idaho.

MWH, March 2004. *P4 Production Southeast Idaho Mine-Specific Selenium Program 2004 Comprehensive Site Investigation Final Work Plans for Ballard, Henry and Enoch Valley Mines (MWH, March 2004)* (2004 SI Work Plan).)

MWH, April 2005. *Final 2005 Phase II Supplemental SI Groundwater Work Plan* (Phase II Groundwater Work Plan). April 2005.

MWH, April 2005. Phase I Data Transmittal. April 2005. Distributed via CD and email.

Ralston, D.R., Mohammad, O.M.J., Robinette, M.J., and Edwards, T.K., 1977. *Solutions to Water Resource Problems Associated with Open Pit Mining in the Phosphate Area of Southeastern Idaho*. Completion Report for Groundwater Study Contract No 50-897. U.S. Department of Agriculture, Forest Service, 125 p.

Ralston, D.R., Wai, C.M., Brooks, T.D., Cannon M.R., Corbet T.F., Singh, H. Winter, G.V., 1980. *Interaction of Mining and Water Resource Systems in the Southeastern Idaho Phosphate Fields*. Idaho Water and Energy Research Institute, University of Idaho, Moscow, Idaho. February 1980.

Ralston, D.R., Mayo, A.L., Arrigo, J.L., Baglio, J.V., Coleman, L.M., Hubbell, J.M., and Souder, K., 1983. *Thermal Ground Water Flow Systems in the Thrust Zone in Southeastern Idaho*. Submitted to Idaho Department of Water Resources. Idaho Water and Energy Research Institute, University of Idaho, Moscow, Idaho. May 1983.

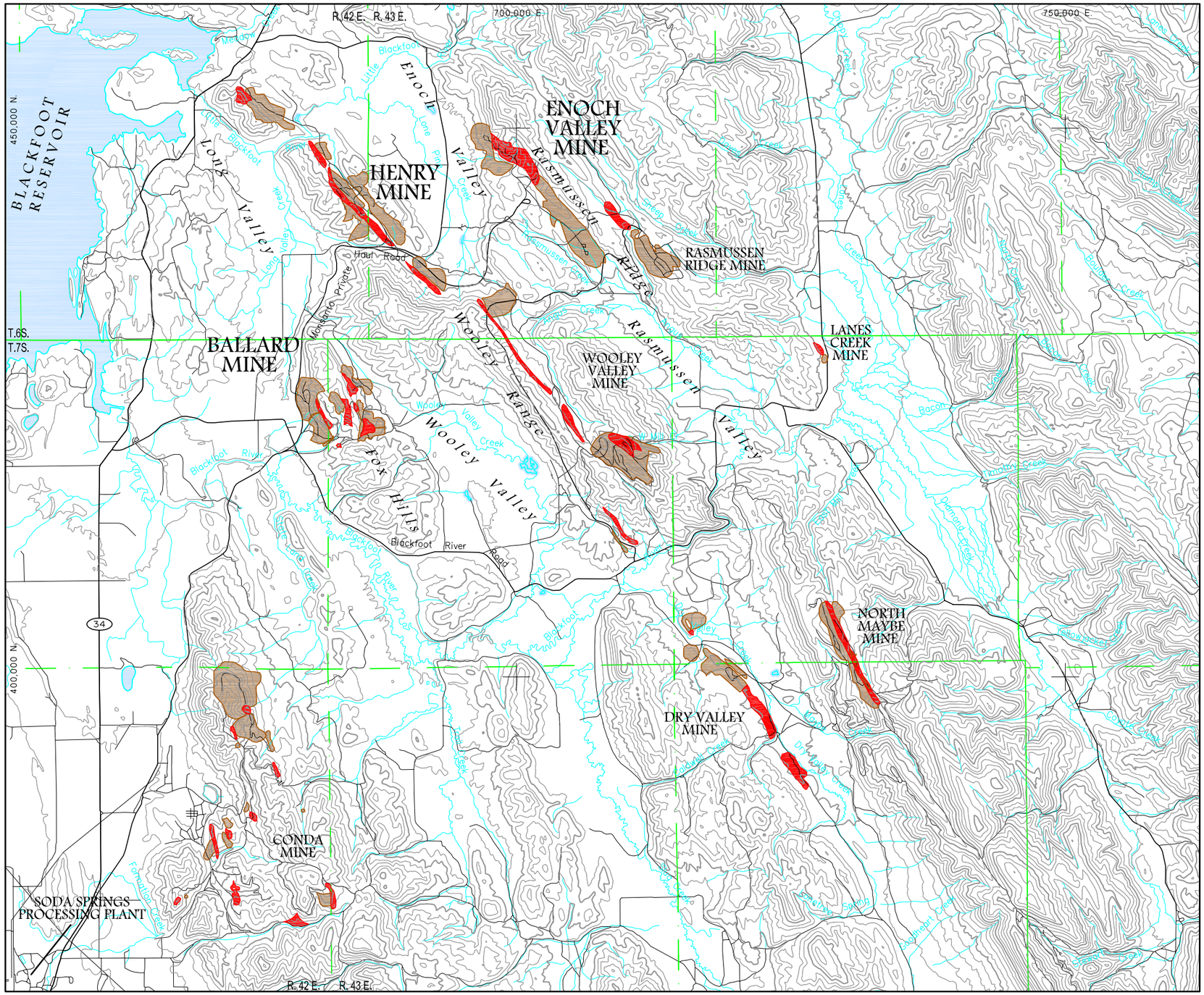
U.S. Bureau of Land Management (BLM), 1999. *Draft Environmental Impact Statement, Dry Valley Mine-South Extension Project*.

U.S. Geological Survey (USGS) and U.S. Forest Service (USFS), 1977. *Final Environmental Impact Statement, Development of Phosphate Resources in Southeastern Idaho. Volumes I, II, III and IV*. United States Department of the Interior, Washington D.C.

U.S. Geological Survey (USGS), 2001.

Winter, G.V., 1980. *Groundwater Flow Systems of the Phosphate Sequence, Caribou County, Idaho*. M.S. Thesis, University of Idaho.

Appendix A
Drawings



LEGEND

- CONTOURS
- CREEKS/RIVERS
- LAKES
- ROADS
- TOWNSHIP AND RANGE
- MINE PIT LOCATION
- WASTE ROCK DUMP LOCATION

MAP KEY

SCALE
0 5,000 10,000
Feet

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
1	Issued for Draft Tech Memo	10/06	P.Anderson	K.Conrath	C.Foulk
0	Issued for Work Plan	1/04	P.Anderson	N.Gonzalez	P.Anderson

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

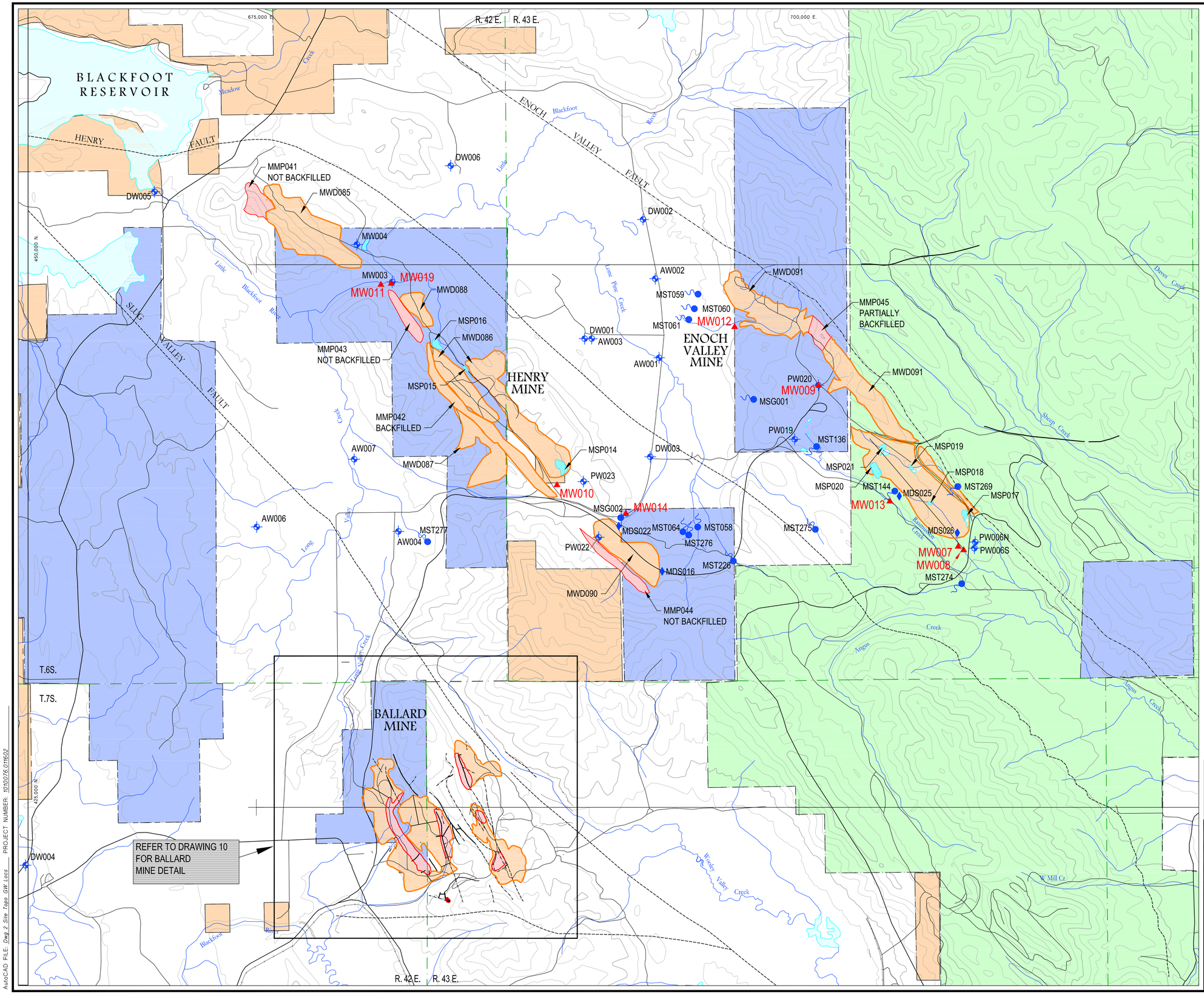
PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
SITE LOCATION MAP

MWH

Sheet 1 Of 1 Sheets
SCALE: *As Shown*
DRAWING No. **1**

AutoCAD FILE: *Dwg 1 Site Location Map* PROJECT NUMBER: *1010076.011602*



LEGEND

- CONTOURS
- CREEKS/RIVERS
- PONDS
- HIGHWAY
- ROADS
- RAILROAD
- TOWNSHIP AND RANGE
- MINE PIT LOCATION (APPROXIMATE)
- WASTE ROCK PILE LOCATION (APPROXIMATE)
- FAULT
- INFERRED FAULT
- FAULT CONCEALED BY SURFACE DEPOSITS
- MW010 — PROPOSED GROUNDWATER WELL MONITORING LOCATION
- PW023 — GROUNDWATER WELL MONITORING LOCATION
- MDS022 — WASTE ROCK DUMP SEEP
- MSG002 — SPRING STATION
- MST064 — HEADWATER STREAM STATION
- NATIONAL FOREST
- BUREAU OF LAND MANAGEMENT
- STATE OF IDAHO

NOTES:

AW = AGRICULTURAL WELL
DW = DOMESTIC WELL
MW = MONITORING WELL
PW = PRODUCTION WELL
DS = DUMP SEEP
ST = SPRING FED STREAM LOCATION
MP = MINE PIT
WD = WASTE ROCK DUMP
SP = SPRING

STATE OF IDAHO
STUDY AREA

MAP KEY

SCALE
0 2000' 4000'
CONTOUR INTERVAL

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
2	Issued for Draft Tech Memo Ver4	08/06	D.Brame	S.Farnam	C.Floulk
1	Issued for Draft Tech Memo Rev.2	03/06	D.Brame	C.Fowler	C.Foulk
0	Issued for Draft Tech Memo	10/04	P.Anderson	K.Conrath	P.Anderson

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

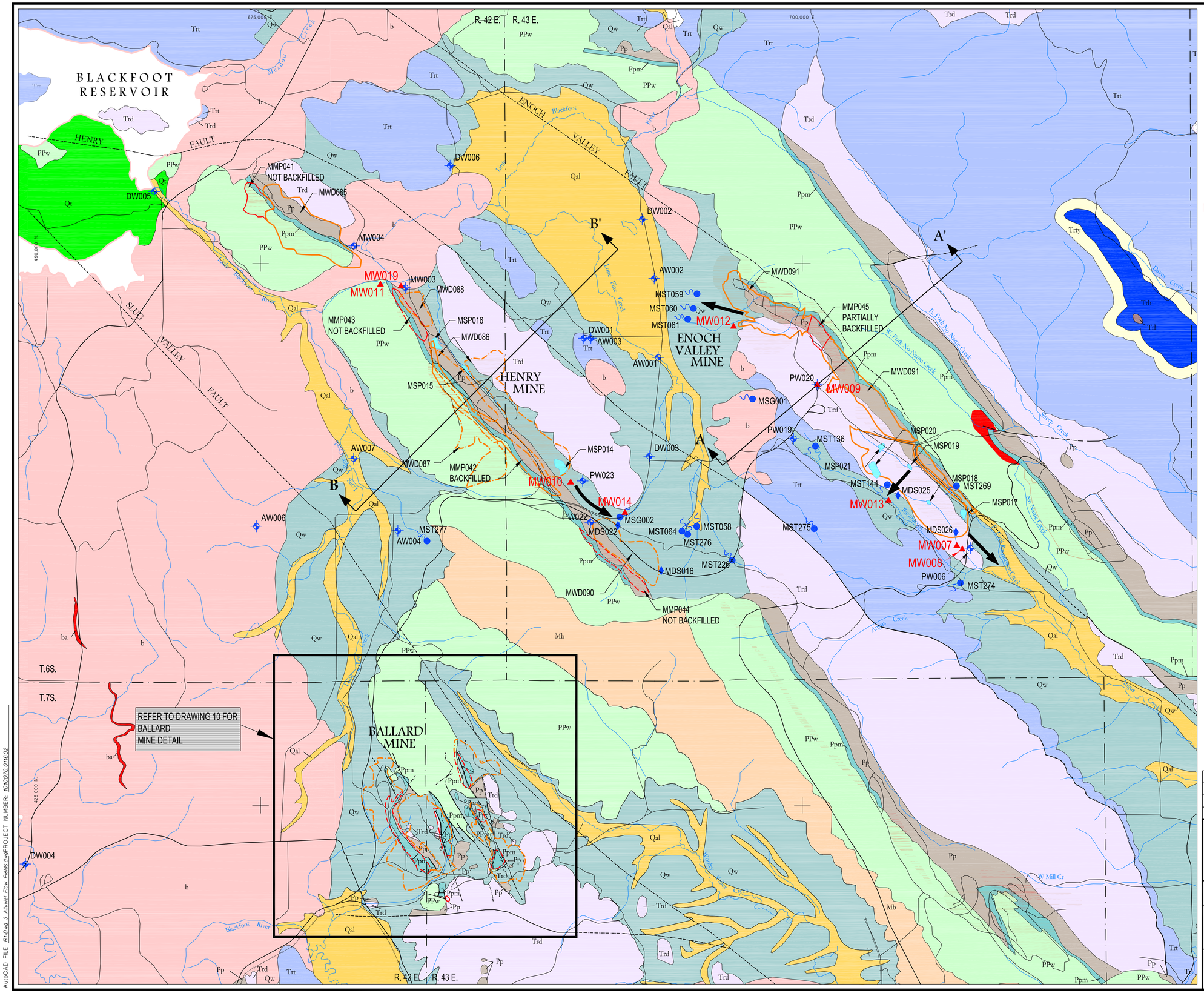
PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
SITE TOPOGRAPHY AND GROUNDWATER MONITORING LOCATIONS

MWH

Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 2

AutoCAD FILE: Dwg 2 Site Topo GW Locs PROJECT NUMBER: 1010076.01602



LEGEND

- CREEKS/RIVERS
- PONDS
- HIGHWAY
- ROADS
- RAILROAD
- TOWNSHIP AND RANGE
- FAULT LINE
- INFERRED FAULT
- FAULT CONCEALED BY SURFACE DEPOSITS
- MINE PIT LOCATION (APPROXIMATE)
- WASTE ROCK PILE LOCATION (APPROXIMATE)
- MW010 — PROPOSED GROUNDWATER WELL MONITORING LOCATION
- PW023 — GROUNDWATER WELL MONITORING LOCATION
- MDS022 — WASTE ROCK DUMP SEEP
- MSG002 — SPRING STATION
- MST064 — HEADWATER STREAM STATION
- POSTULATED ALLUVIAL FLOW PATH
- A A' — CROSS-SECTION LOCATION

GEOLOGIC KEY

b	BASALT
ba	BASALTIC ASH
Qal	ALLUVIUM
Qt	TRAVERTINE
Qw	HILL WASH AND OLDER ALLUVIUM
Trl	DEADMAN LIMESTONE
Trh	HIGHAM GRIT
Trt	THAYNES FORMATION
Trty	TIMOTHY SANDSTONE (THAYNES MEMBER)
Trd	DINWOODY FORMATION (WOODSIDE SHALE)
Pp	PHOSPHORIA FORMATION
Ppm	MEADE PEAK MEMBER
PPw	WELLS FORMATION
Mb	BRAZER LIMESTONE

NOTES:
AW = AGRICULTURAL WELL
DW = DOMESTIC WELL
MW = MONITORING WELL
PW = PRODUCTION WELL
DS = DUMP SEEP
ST = SPRING FED STREAM LOCATION
MP = MINE PIT
WD = WASTE ROCK DUMP
SP = SPRING

STATE OF IDAHO
STUDY AREA
MAP KEY

SCALE
0 2000 4000
Feet

N

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
1	Issued For Draft Tech Memo Ver4	08/06	D.Brame	S.Farnam	C.Floulk
0	Issued for Technical Memorandum	08/06			

P4 PRODUCTION
Southeast Idaho Mine-Specific Selenium Program

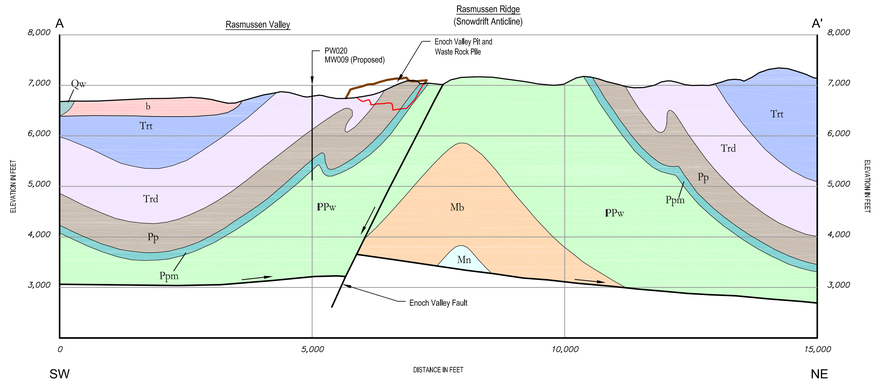
PROJECT: Monitoring Well Installation Tech Memo

DRAWING TITLE: SURFICIAL GEOLOGY, ALLUVIAL FLOW FIELDS AND GROUNDWATER MONITORING LOCATIONS

MWH

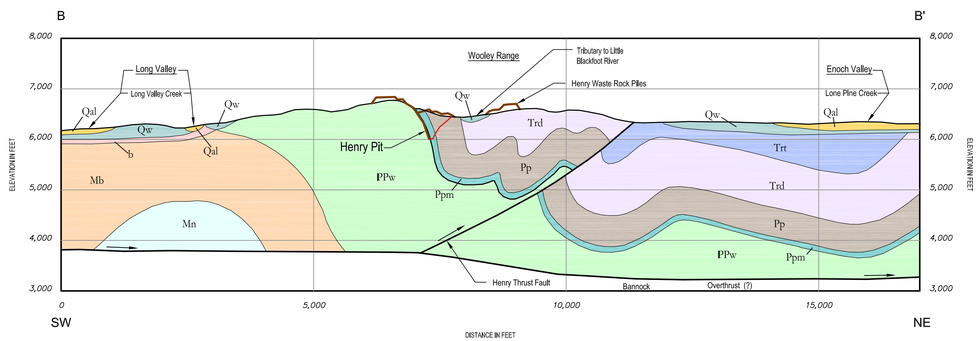
Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 3

AutoCAD FILE: Rt-Dwg 3 Alluvial Flow Fields.dwgPROJECT NUMBER: 1010076.016G2



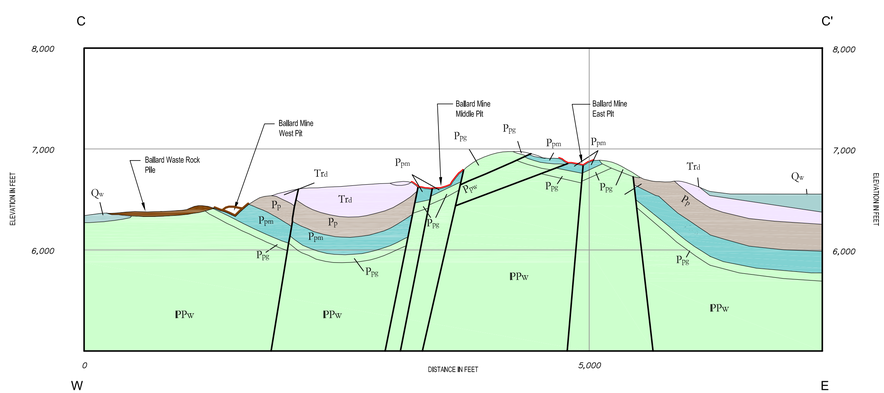
ENOCH VALLEY MINE CONCEPTUAL CROSS-SECTION A-A'

SCALE IS APPROXIMATE



HENRY MINE CONCEPTUAL CROSS-SECTION B-B'

SCALE IS APPROXIMATE



BALLARD MINE CONCEPTUAL CROSS-SECTION C-C'

SCALE IS APPROXIMATE

LEGEND

b	BASALT
Qal	ALLUVIUM
Qw	HILL WASH AND OLDER ALLUVIUM
Trt	THAYNES FORMATION
Trd	DINWOODY FORMATION (WOODSIDE SHALE)
Pp / Ppm	PHOSPHORIA FORMATION MEADE PEAK MEMBER
PPw	WELLS FORMATION
Mb	BRAZER LIMESTONE
Mn	MADISON LIMESTONE
	FAULT (DASHED WHERE INFERRED)
	MINE PIT LOCATION (CONCEPTUAL)
	WASTE ROCK PILE LOCATION (CONCEPTUAL)

NOTE:
1. GEOLOGIC CROSS-SECTIONS BASED ON MANSFIELD, ET AL., 1927 USGS PROFESSIONAL PAPER 152.

SCALE
0 1,500 3,000
Feet

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Draft Tech Memo	10/04	P.Anderson	K.Conrath	P.Anderson

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

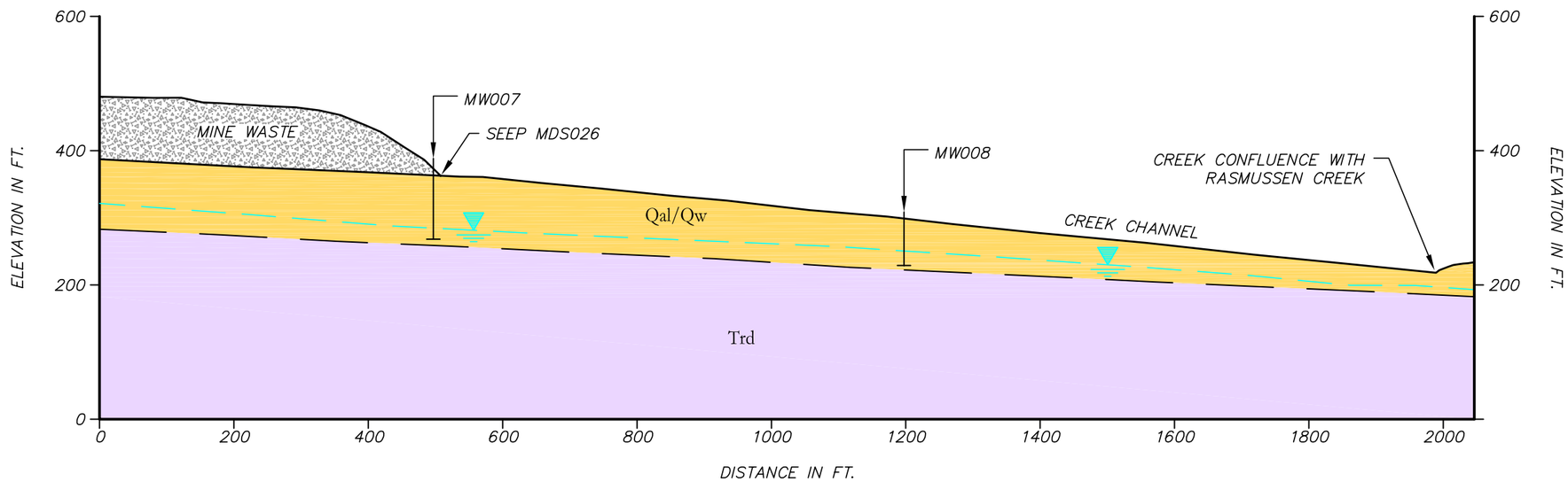
PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
CONCEPTUAL GEOLOGIC CROSS-SECTIONS OF ENOCH VALLEY, HENRY, AND BALLARD MINES

MWH

Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 4

AutoCAD FILE: Dwg 4 Conceptual sections PROJECT NUMBER: 1003675.01B01



CONCEPTUAL CROSS-SECTION

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 100' 200'

LEGEND

Qal	ALLUVIUM
Trd	DINWOODY FORMATION (WOODSIDE SHALE)
	MAPPED CONTACT
	INFERRED CONTACT
	WATER LEVEL

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Tech Memo	10/05	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
CONCEPTUAL CROSS-SECTION FOR PROPOSED WELL LOCATIONS MW007 AND MW008 ENOCH VALLEY MINE

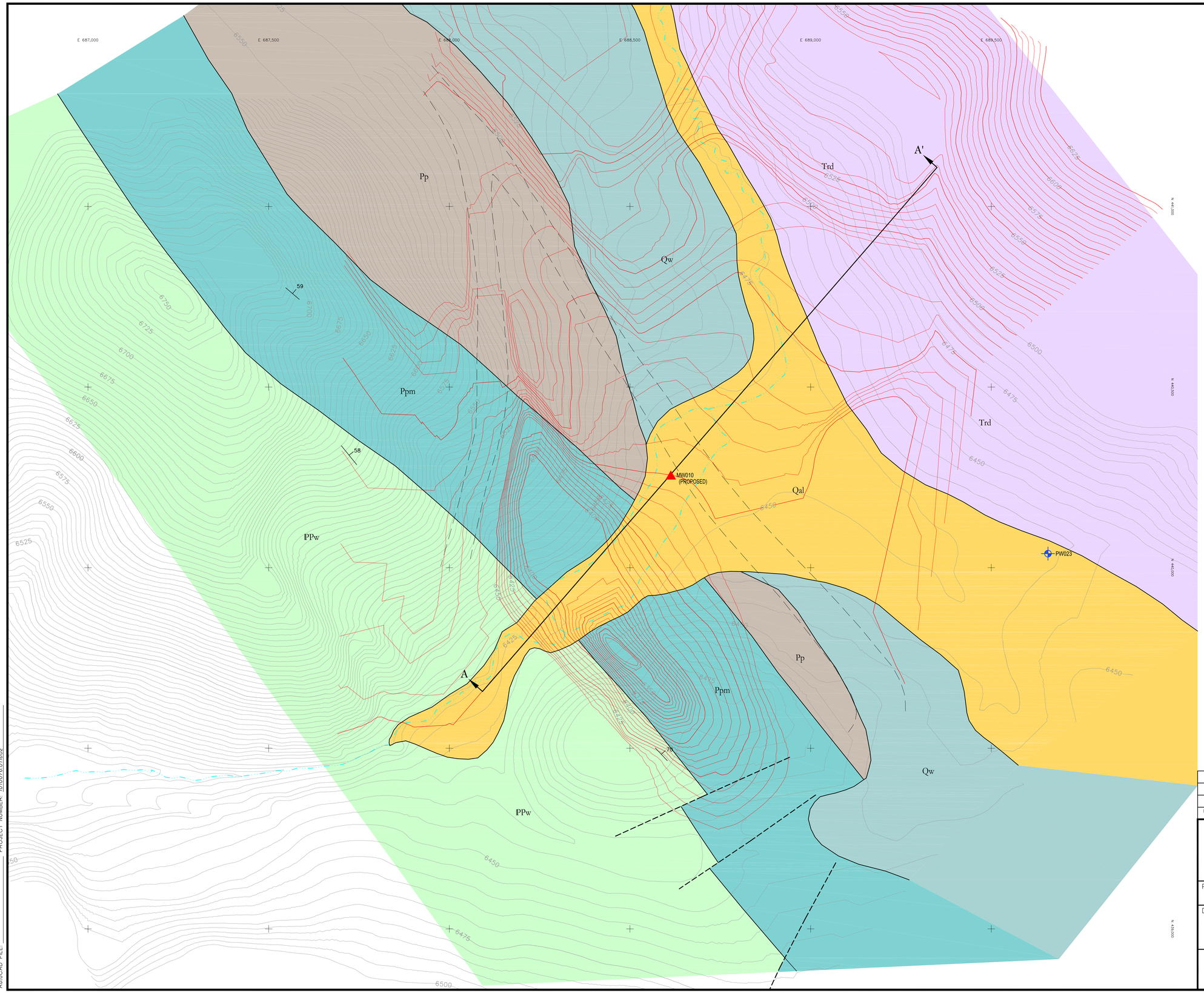
MWH

Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 5

AutoCAD FILE: Dwg_5_Sect_EVM.dwg PROJECT NUMBER: 1010076.011602



LEGEND

- PRE-MINE CONTOURS
- POST MINE CONTOURS
- CREEKS/RIVERS
- 73° STRIKE SYMBOL (with dip angle)
- A A' CROSS-SECTION LOCATION

GEOLOGIC KEY

- Qal — ALLUVIUM
- Qw — HILL WASH AND OLDER ALLUVIUM
- Trd — DINWOODY FORMATION (WOODSIDE SHALE)
- Pp — PHOSPHORIA FORMATION
- Ppm — MEADE PEAK MEMBER
- PPw — WELLS FORMATION
- MW010 — PROPOSED WELL LOCATION
- PW023 — EXISTING WELL LOCATION
- FAULT
- INFERRED FAULT

N

SCALE

120' 0 120' 240'

CONTOUR INTERVAL 5 FT.

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Tech Memo	10/06	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
GEOLOGY AND CROSS-SECTION LOCATION MAP FOR PROPOSED WELL MW010 HENRY MINE

MWH

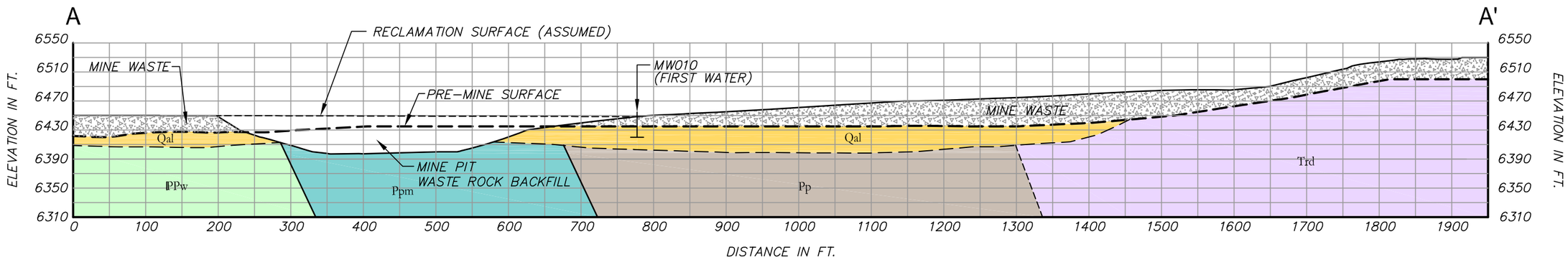
Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 6

PROJECT NUMBER: 1010076.016602

AutoCAD FILE:



CROSS-SECTION A-A'

HORIZONTAL SCALE
0 75' 150'

VERTICAL SCALE
0 75' 150'

LEGEND

Qal	ALLUVIUM
Trd	DINWOODY FORMATION (WOODSIDE SHALE)
Pp	PHOSPHORIA FORMATION
Ppm	MEADE PEAK MEMBER
Ppw	WELLS FORMATION
———	MAPPED CONTACT
— — — —	MAPPED CONTACT

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
1	Issued For Draft Tech Memo Ver4	09/06	D.Brame	S.Farnam	C.Floulk
	Issued for Tech Memo	10/06	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
CONCEPTUAL CROSS-SECTION FOR PROPOSED WELL LOCATION MW010 HENRY MINE

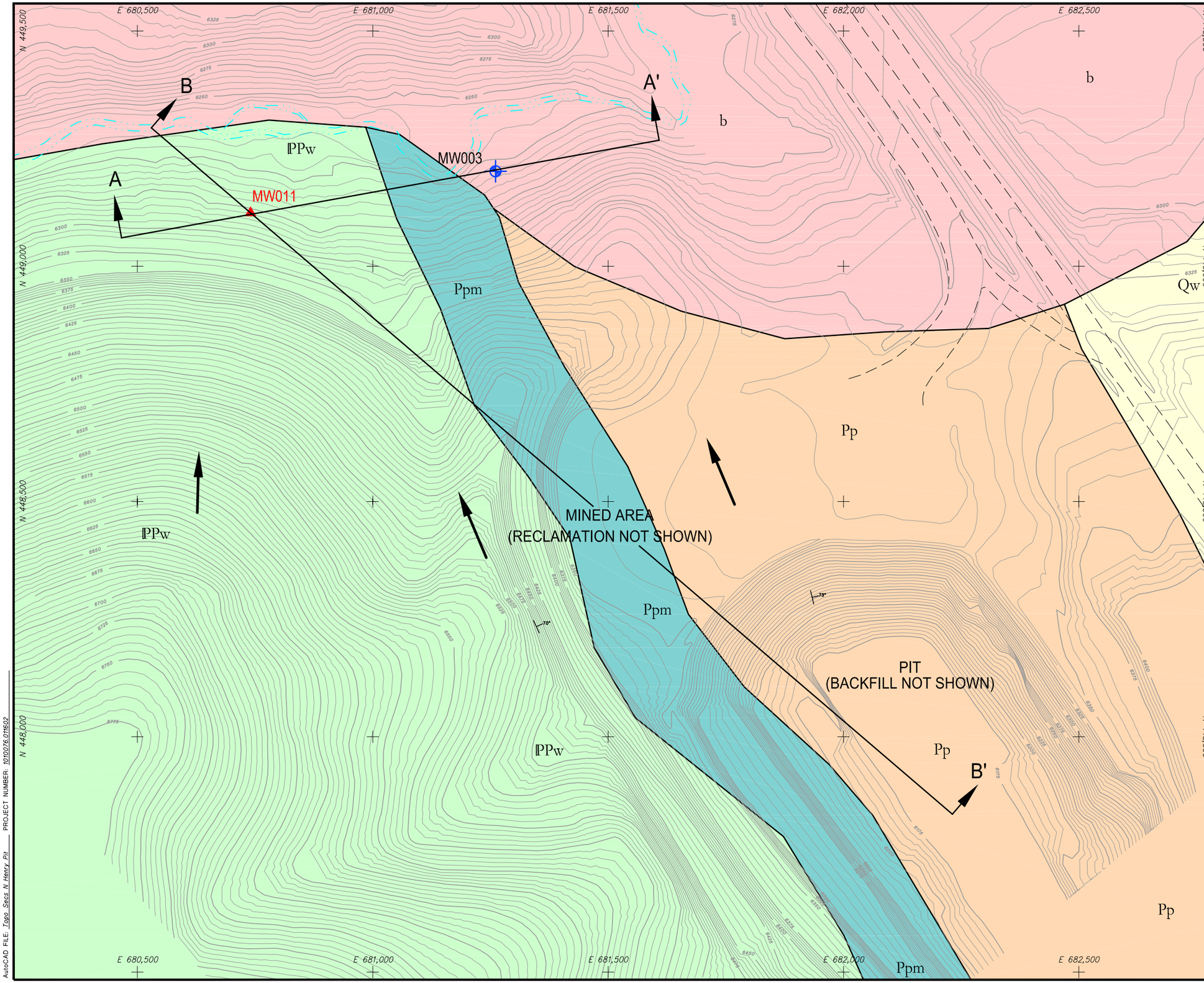
MWH

Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 7

AutoCAD FILE: P1-Dwg_7_Geo_Henry_MW010 PROJECT NUMBER: 1010076.01602



LEGEND

- TOPOGRAPHIC CONTOUR
- ROAD
- GEOLOGIC UNIT CONTACT
- 73° STRIKE SYMBOL (with dip angle)
- MW003 MONITORING WELL
- MW011 MONITORING WELL (Proposed)
- PREDICTED GROUNDWATER FLOW DIRECTION
- A A' CROSS-SECTION LOCATION

GEOLOGIC KEY

- b — BASALT
- Pp / Ppm — PHOSPHORIA FORMATION MEADE PEAK MEMBER
- PPw — WELLS FORMATION
- Qw — HILL WASH AND OLDER ALLUVIUM

SCALE

100' 0 100' 200'

CONTOUR INTERVAL 5 FT.

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Tech Memo	10/05	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
GEOLOGY AND CROSS-SECTION LOCATION MAP FOR PROPOSED WELL MW011 HENRY MINE SITE

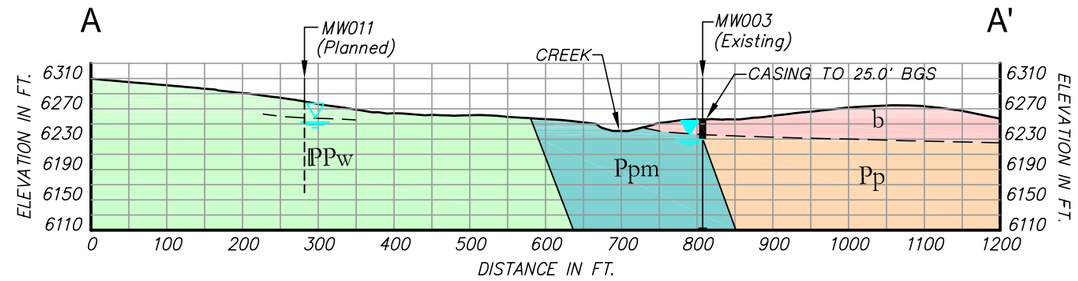
MWH

Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 8

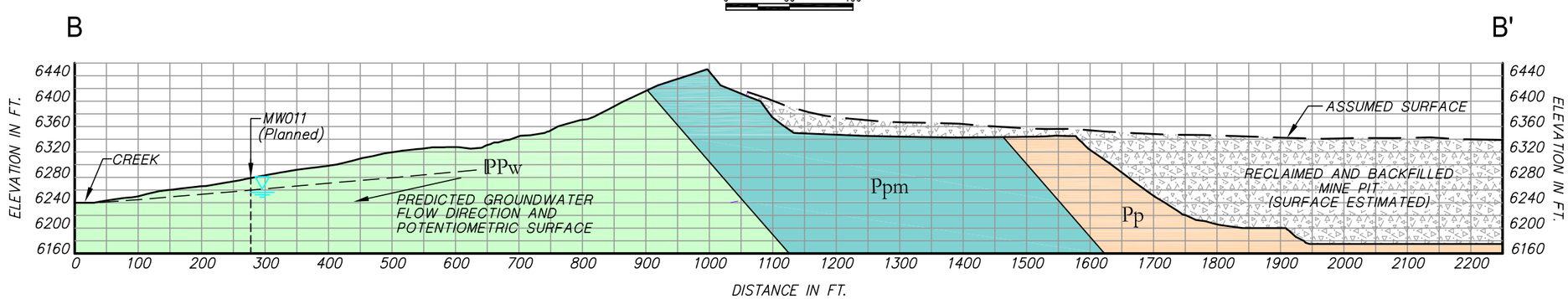
AutoCAD FILE: Topo_Secs_N_Henry_Pit PROJECT NUMBER: 1010076.016.02



CROSS-SECTION A-A'

HORIZONTAL SCALE
0 50 100

VERTICAL SCALE
0 50 100



CROSS-SECTION B-B'

HORIZONTAL SCALE
0 50 100

VERTICAL SCALE
0 50 100

LEGEND

WATER LEVEL (MEASURED)

WATER LEVEL (PREDICTED)

GEOLOGIC KEY

b	BASALT
Pp	PHOSPHORIA FORMATION
Ppm	MEADE PEAK MEMBER
PPw	WELLS FORMATION

MAPPED CONTACT

INFERRED CONTACT

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
	Issued for Technical Memorandum	10/05	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
CONCEPTUAL CROSS-SECTIONS FOR PPOPOSED WELL LOCATION MW011 HENRY MINE

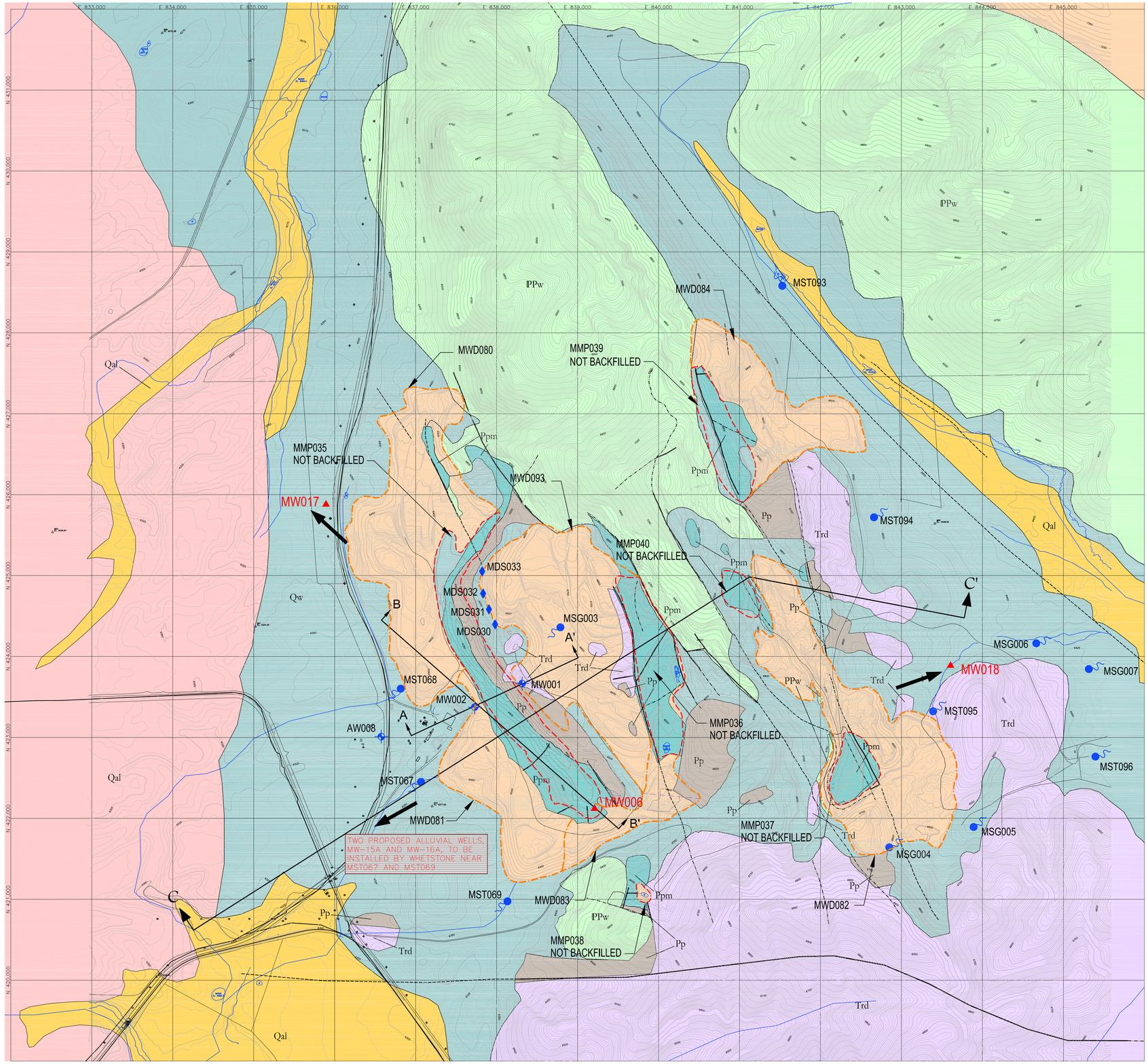
MWH

Sheet 1 Of 1 Sheets

SCALE: As Shown

DRAWING No. 9

AutoCAD FILE: Topo_Secs_North_Henry.dwg PROJECT NUMBER: 1010076.011602



LEGEND

- CONTOURS
- CREEKS/RIVERS
- HIGHWAY
- ROADS
- MINE PIT LOCATION (APPROXIMATE)
- WASTE ROCK PILE LOCATION (APPROXIMATE)
- MINE PIT LOCATION
- FAULT
- INFERRED FAULT
- FAULT CONCEALED BY SURFACE DEPOSITS
- MW010 — PROPOSED GROUNDWATER WELL MONITORING LOCATION
- PW023 — GROUNDWATER WELL MONITORING LOCATION
- MDS022 — WASTE ROCK DUMP SEEP
- MSG002 — SPRING STATION
- MST064 — HEADWATER STREAM STATION
- POSTULATED ALLUVIAL FLOW PATH
- NATIONAL FOREST
- BUREAU OF LAND MANAGEMENT

GEOLOGIC KEY

- b — BASALT
- Qal — ALLUVIUM
- Qw — HILL WASH AND OLDER ALLUVIUM
- Trd — DINWOODY FORMATION (WOODSIDE SHALE)
- Pp — PHOSPHORIA FORMATION
- Ppm — MEADE PEAK MEMBER
- PPw — WELLS FORMATION
- Mb — BRAZER LIMESTONE

NOTE:
1. GEOLOGIC MAPPING BY MANSFIELD, ET AL., 1927 USGS PROFESSIONAL PAPER 152.

N

SCALE
600' 0 600' 1200'
CONTOUR INTERVAL 10 FT.

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
2	Issued for Draft Tech Memo Ver4	08/06	D.Brame	S.Farnam	C.Foulk
1	Issued for Draft Tech Memo Rev2	03/06	D.Brame	C.Fowler	C.Foulk
0	Issued for Draft Tech Memo	10/05	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine-Specific Selenium Program

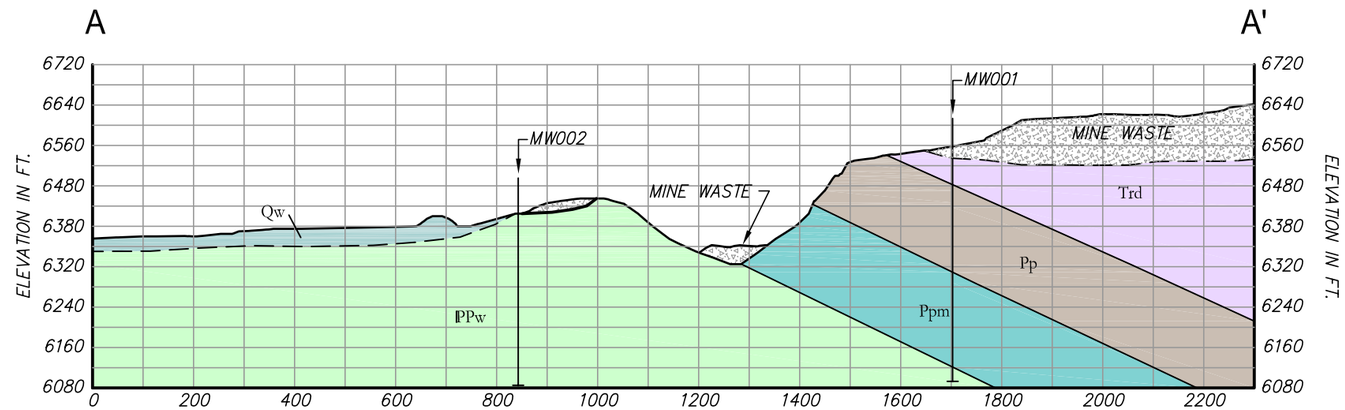
PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
BALLARD MINE DETAIL AND CONCEPTUAL CROSS-SECTION FOR PROPOSED WELL LOCATION MW006

MWH

Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 10

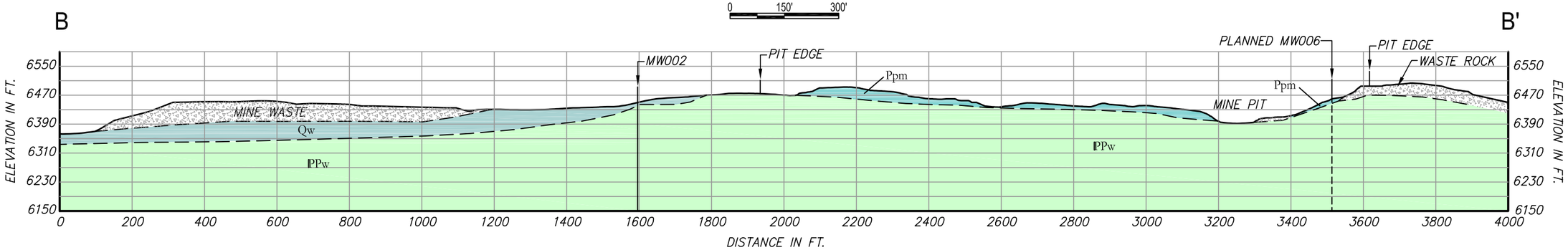
AutoCAD FILE: P2-Dwg_10_Ballard_Det_Xsecs PROJECT NUMBER: 1010076.016G2



CROSS-SECTION A-A'

HORIZONTAL SCALE
0 150' 300'

VERTICAL SCALE
0 150' 300'



CROSS-SECTIONB-B'

HORIZONTAL SCALE
0 150' 300'

VERTICAL SCALE
0 150' 300'

LEGEND

Trd	DINWOODY FORMATION (WOODSIDE SHALE)
Pp	PHOSPHORIA FORMATION
Ppm	MEADE PEAK MEMBER
PPw	WELLS FORMATION
———	MAPPED CONTACT
— — —	INFERRED CONTACT

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
0	Issued for Tech Memo	10/06	P.Anderson	K.Conrath	C.Foulk

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Monitoring Well Installation Tech Memo

DRAWING TITLE:
CONCEPTUAL CROSS-SECTION FOR PROPOSED WELL LOCATION MW006 BALLARD MINE

MWH

Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 11

AutoCAD FILE: Dwg. 1fb. Ballard Geology PROJECT NUMBER: 1010076.016102

Appendix B
Unfiltered Censored Results

Appendix B: Unfiltered Censored Results

Page 1	Table 1:	Domestic and Agricultural Wells – Unfiltered Censored Results: Cd, Cr, Ni, Se, Total Alkalinity, V, Zn
Page 2	Table 2:	Monitoring and Production Wells – Unfiltered Censored Results: Cd, Ca, Cr, Fe, Mg, Mn, Ni, N (as nitrate/nitrite), K
Page 3	Table 3:	Monitoring and Production Wells – Unfiltered Censored Results: Se, Na, Total Alkalinity, V, Zn
Page 4	Table 4a:	Seeps, Springs, and Headwater Streams – Unfiltered Censored Results: Se (1997 – 2002)
Page 5	Table 4b:	Seeps, Springs, and Headwater Streams – Unfiltered Censored Results: Se (2003 - 2004)
Page 6	Table 5:	Seeps Springs, and Headwater Streams – Unfiltered Censored Results: Hg, N (as nitrate/nitrite), P, Total Alkalinity

Table 1
Domestic and Agricultural Wells - Unfiltered Censored Results (mg/L)

Station		Cadmium						Chromium						Nickel						Selenium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	U	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	0.00010	0.00020	U	NS			0.00090			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
(b) (6) ld Well	MAW002	0.00010	0.00020	U	NS			0.00010	0.00020	U	NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
Field Well	MAW003	0.00040			NS			0.0044			NS			0.0028		U	NS			0.00050	0.0010	U	NS		
ield Well	MAW004	0.00010	0.00020	U	NS			0.00020			NS			0.0049			NS			0.00050	0.0010	U	NS		
indmill Field Well	MAW005	0.0016			NS			0.0048			NS			0.0038			NS			0.00050	0.0010	U	NS		
Field Well West	MAW006	NS			0.00010	0.00020	U	NS			0.0031			NS			0.0049			NS			0.00050	0.0010	U
Field Well North	MAW007	NS			0.000050	0.00010	U	NS			0.00070			NS			0.0029			NS			0.00050	0.0010	U
House Well	MDW001	0.00010	0.00020	U	NS			0.00040			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
n House Well	MDW002	0.00010	0.00020	U	NS			0.00060			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
ouse Well	MDW003	0.00010	0.00020	U	NS			0.00070			NS			0.0013	0.0025	U	NS			0.0020			NS		
House Well	MDW004	0.00010	0.00020	U	NS			0.0017			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
Cedar Bay RV Park Well	MDW005	0.00010	0.00020	U	NS			0.00040			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		
(b) House Well	MDW006	0.00010	0.00020	U	NS			0.00090			NS			0.0013	0.0025	U	NS			0.00050	0.0010	U	NS		

Station		Total Alkalinity						Vanadium						Zinc					
		2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	170			NS			0.00073			NS			0.080	0.16	U	NS		
(b) (6) d Well	MAW002	250			NS			0.00050	0.0010	U	NS			0.080	0.16	U	NS		
ield Well	MAW003	110			NS			0.0070			NS			0.30			NS		
eld Well	MAW004	700			NS			0.00070			NS			0.080	0.16	U	NS		
ndmill Field Well	MAW005	150			NS			0.0024			NS			21			NS		
ield Well West	MAW006	NS			120			NS			0.011			NS			0.036		
ield Well North	MAW007	NS			240			NS			0.00090			NS			0.087		
ouse Well	MDW001	190			NS			0.00040			NS			0.080	0.16	U	NS		
House Well	MDW002	150			NS			0.0041			NS			0.080	0.16	U	NS		
use Well	MDW003	190			NS			0.00070			NS			0.080	0.16	U	NS		
ouse Well	MDW004	150			NS			0.0018			NS			0.080	0.16	U	NS		
Cedar Bay RV Park Well	MDW005	460			NS			0.00040			NS			0.080	0.16	U	NS		
(b) House Well	MDW006	150			NS			0.0028			NS			0.080	0.16	U	NS		

Notes:
[a] Average of the QA replicate samples reported for Spring 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 2
Monitoring and Production Wells - Unfiltered Censored Results (mg/L)

Station			Cadmium									Calcium						Chromium			Iron									Magnesium					
			1998[a]						2005			1998[a]						2005			1998[a]						2005			1998[a]					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.0021			-0.0010	0.0020	U	NS			48			46			NS			0.0046			0.095			NS			17			18		
	EVM Shop Well	MPW019	0.0010	0.0020	U	-0.0012	0.0020	U	NS			73			63			NS			0.0073			0.22			NS			9.3			9.0		
	Degerstrom Well at EVM	MPW020	0.0033			0.0013	0.0020	U	NS			60			59			NS			0.00075	0.0015	U	0.089			NS			15			17		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.050	0.10	U	NS			NS			0.050	0.10	U	NS			NS			0.63			NS			NS		
	Henry South Pit Well	MPW022	NS			NS			0.050	0.10	U	NS			NS			0.050	0.10	U	NS			NS			8.1			NS			NS		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.025	0.050	U	NS			NS			0.025	0.050	U	NS			NS			0.12	0.24	U	NS			NS		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.025	0.050	U	NS			NS			0.025	0.050	U	NS			NS			1.0			NS			NS		

Station			Manganese									Nickel									Nitrate/Nitrite as N						Potassium					
			1998[a]						2005			1998[a]						2005			2005						1998[a]					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.28			0.21			NS			0.0050	0.010	U	0.0050	0.010	U	NS			NS			NS			2.0			1.8		
	EVM Shop Well	MPW019	0.040			0.032			NS			0.0050	0.010	U	0.0050	0.010	U	NS			0.060			NS			1.4			0.88		
	Degerstrom Well at EVM	MPW020	0.17			0.11			NS			0.17			0.12			NS			NS			NS			1.1			1.2		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			0.12			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.25	0.50	U	NS			NS			0.30	0.60	U	1.4			1.4			NS			NS		
	Henry South Pit Well	MPW022	NS			NS			0.25	0.50	U	NS			NS			0.30	0.60	U	0.10			0.010	0.020	U	NS			NS		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			0.010	0.020	U	NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.15	0.30	U	NS			NS			0.15	0.30	U	0.33			0.69			NS			NS		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.15	0.30	U	NS			NS			0.15	0.30	U	0.040			0.010	0.020	U	NS			NS		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses*.

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 3
Monitoring and Production Wells - Unfiltered Censored Results (mg/L)

Station			Selenium									Sodium						Total Alkalinity																	
			1998[a]						2005			1998[a]						1998[a]						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.00035	0.00070	U	0.00035	0.00070	U	NS			13			14			180			200			160			170			NS			NS		
	EVM Shop Well	MPW019	0.00082			0.00035	0.00070	U	NS			6.5			6.2			200			190			220			NS			190			NS		
	Degerstrom Well at EVM	MPW020	0.00035	0.00070	U	0.00035	0.00070	U	NS			4.7			4.5			160			190			NS			94			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			NS			120			160			150			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.00050	0.0010	U	NS			NS			NS			NS			140			130			160			170		
	Henry South Pit Well	MPW022	NS			NS			0.00050	0.0010	U	NS			NS			NS			NS			NS			200			180			180		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			NS			NS			190			180			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.069			NS			NS			NS			NS			270			270			240			260		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.022			NS			NS			NS			NS			300			310			280			290		

Station			Vanadium									Zinc								
			1998[a]						2005			1998[a]						2005		
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.021			0.0077			NS			0.14			0.068			NS		
	EVM Shop Well	MPW019	0.011			0.0022	0.0043	U	NS			0.051			0.073			NS		
	Degerstrom Well at EVM	MPW020	0.0092			0.00215	0.0043	U	NS			0.99			0.71			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.10	0.20	U	NS			NS			480		
	Henry South Pit Well	MPW022	NS			NS			0.10	0.20	U	NS			NS			550		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.050	0.10	U	NS			NS			450		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.050	0.10	U	NS			NS			460		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 4a
Seeps, Springs, and Headwater Streams - Unfiltered Censored Results (mg/L)

Station			Selenium																										
			1997			1998[d]						2000			2001			2002											
Mine	Station Name	Station ID	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			0.0026		J	0.00050	0.0010	U	NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			0.049		J	0.12			NS			0.020		J	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			0.0075	0.015	U	NS			0.0042		J	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			NA			NS			0.0075	0.015	U	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NA			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			0.0075	0.015	U	0.0030			0.00050	0.0010	UJ	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			Dry			NS			0.00050	0.0010	UJ	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0011			0.00038			0.00010	0.00020	U	0.0060			0.00050	0.0010	U	0.00050	0.0010	U	NS			0.00050	0.0010	UJ	NS		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			NS			0.00050	0.0010	UJ	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			NS			0.0075	0.015	U	0.0040			0.00050	0.0010	UJ	0.00050	0.0010	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.00050	0.0010	U	NS			0.00050	0.0010	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			NS			0.0075	0.015	U	0.0030			0.0020		J	0.0013		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			0.44		J	0.47			NS			0.42		J	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			NS			0.0080		J	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			NS			0.0030		J	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			NS			NS			0.13			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			NS			0.58			0.49			0.27		J	0.55		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			0.00050	0.0010	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			Dry			NS			0.021			Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.047			NS			0.16			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.098			NS			0.025			Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 5
Seeps, Springs, and Headwater Streams - Unfiltered Censored Results (mg/L)

Station			Mercury			Nitrate/Nitrite as N			Phosphorus			Total Alkalinity														
			2001			2001			2001			2000			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.00025	0.00050	U	0.050	0.10	U	1.7			NS			150			Dry			180			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	0.00025	0.00050	U	0.18		J	0.28			NS			310			290			330			300		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			200			190			200			200		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NS			NS			NS			NA			61			Dry			60			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NA			Dry			Dry			110			Dry		
	Headwaters	MST269	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			150			170			150			180		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			Dry			NA			59			630		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			Dry			Dry			270			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	0.00025	0.00050	U	0.050	0.10	U	0.22			NS			360			530			410			570		
	Taylor Spring	MSG002	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NA			220			310		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			240			230			220			250		
	Below Wooley Valley Mine	MST226	NS			NS			NS			87			NA			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			79			210			190			230		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			280			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			320			300		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			240			230		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			180			320		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			290			Dry		
	Garden Hose Spring	MSG003	0.00025	0.00050	U	5.0		J	0.031			NS			220			270			280			270		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			260			230			250		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			260			260			270		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			230			250		
	Headwaters	MST067	NS			NS			NS			NS			240			Dry			250			Dry		
	Headwaters	MST068	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			180			270			110			300		
	Above Ballard Mine	MST093	NS			NS			NS			NS			78			Dry			98			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			Dry			130			Dry			160			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			160			140			Dry			220			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			180			190			Dry			190			230		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Appendix C
Filtered Censored Results

Appendix C: Filtered Censored Results

Page 1	Table 1:	Domestic and Agricultural Wells – Filtered Censored Results: Ca, Cd, Cl^-, Cr, Mg, Ni, K, Se
Page 2	Table 2:	Domestic and Agricultural Wells – Filtered Censored Results: Na, SO_4^{2-}, V, Zn
Page 3	Table 3:	Monitoring and Production Wells – Filtered Censored Results: Al Ca, Cd, Cl^-, Cr
Page 4	Table 4:	Monitoring and Production Wells – Filtered Censored Results: Fe, Mn, Mg, Ni, K Se, Na
Page 5	Table 5:	Monitoring and Production Wells – Filtered Censored Results: SO_4^{2-}, V, Zn
Page 6	Table 6:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Al, Sb, As, Ba, Be, B, Cl^-
Page 7	Table 7:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Ca
Page 8	Table 8a:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Cd (1998 – 2002)
Page 9	Table 8b:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Cd (2003 – 2004)
Page 10	Table 9:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Cr, Cu, F, Pb, Mn, Mo
Page 11	Table 10:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Mg
Page 12	Table 11a:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Ni (1998 – 2002)
Page 13	Table 11b:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Ni (2003 – 2004)
Page 14	Table 12:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: K, Na
Page 15	Table 13:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Se, Ag, SO_4^{2-}, Tl, U
Page 16	Table 14a:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: V (1998 – 2002)
Page 17	Table 14b:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: V (2003 – 2004)
Page 18	Table 15a:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Zn (1998 – 2002)
Page 19	Table 15b:	Seeps, Springs, and Headwater Streams – Filtered Censored Results: Zn (2003 – 2004)

Table 1
Domestic and Agricultural Wells - Filtered Censored Results (mg/L)

Station		Calcium						Cadmium						Chloride						Chromium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	66			NS			0.00010	0.00020	U	NS			11			NS			0.00010	0.00020	U	NS		
(b) (6) eld Well	MAW002	62			NS			0.00010	0.00020	U	NS			3.2			NS			0.00010	0.00020	U	NS		
Field Well	MAW003	34			NS			0.00010	0.00020	U	NS			4.8			NS			0.0013			NS		
ield Well	MAW004	180			NS			0.00010	0.00020	U	NS			7.5			NS			0.00010	0.00020	U	NS		
indmill Field Well	MAW005	110			NS			0.00060			NS			140			NS			0.00010	0.00020	U	NS		
Field Well West	MAW006	NS			38			NS			0.000050	0.00010	U	NS			9.2			NS			0.00075	0.0015	U
Field Well North	MAW007	NS			58			NS			0.0013	0.0025	U	NS			12			NS			0.038	0.075	U
House Well	MDW001	67			NS			0.00010	0.00020	U	NS			13			NS			0.00010	0.00020	U	NS		
on House Well	MDW002	54			NS			0.00010	0.00020	U	NS			32			NS			0.00060			NS		
ouse Well	MDW003	74			NS			0.00010	0.00020	U	NS			7.8			NS			0.00040			NS		
House Well	MDW004	73			NS			0.00010	0.00020	U	NS			7.8			NS			0.0011			NS		
Cedar Bay RV Park Well	MDW005	150			NS			0.00010	0.00020	U	NS			17			NS			0.00040			NS		
(b) House Well	MDW006	66			NS			0.00010	0.00020	U	NS			58			NS			0.00070			NS		

Station		Magnesium						Nickel						Potassium						Selenium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	12			NS			0.00060			NS			0.57			NS			0.00050	0.0010	U	NS		
(b) (6) eld Well	MAW002	22			NS			0.0012			NS			2.0			NS			0.00050	0.0010	U	NS		
Field Well	MAW003	8.6			NS			0.00020	0.00040	U	NS			0.40			NS			0.00050	0.0010	U	NS		
ield Well	MAW004	61			NS			0.0028			NS			4.8			NS			0.00050	0.0010	U	NS		
indmill Field Well	MAW005	38			NS			0.0019			NS			5.7			NS			0.00050	0.0010	U	NS		
Field Well West	MAW006	NS			10			NS			0.0023			NS			1.6			NS			0.00050	0.0010	U
Field Well North	MAW007	NS			20			NS			0.033	0.065	U	NS			1.5	3.0	U	NS			0.00050	0.0010	U
House Well	MDW001	13			NS			0.0011			NS			0.50			NS			0.00050	0.0010	U	NS		
n House Well	MDW002	19			NS			0.0016			NS			2.4			NS			0.00050	0.0010	U	NS		
ouse Well	MDW003	6.5			NS			0.0012			NS			0.50			NS			0.0010			NS		
House Well	MDW004	20			NS			0.00040			NS			2.2			NS			0.00050	0.0010	U	NS		
Cedar Bay RV Park Well	MDW005	38			NS			0.0016			NS			2.4			NS			0.00050	0.0010	U	NS		
(b) House Well	MDW006	27			NS			0.00060			NS			2.8			NS			0.00050	0.0010	U	NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 2
Domestic and Agricultural Wells - Filtered Censored Results (mg/L)

Station		Sodium						Sulfate						Vanadium						Zinc					
		2004						2004						2004						2004					
Well Name	**Well ID**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**
School Bus Well	MAW001[a]	5.9			NS			11			NS			0.00020			NS			0.017			NS		
(b) (6) eld Well	MAW002	22			NS			0.25	0.50	U	NS			0.00050	0.0010	U	NS			0.026			NS		
Field Well	MAW003	9.0			NS			6.4			NS			0.0017			NS			0.18			NS		
Field Well	MAW004	10			NS			7.7			NS			0.00070			NS			0.0080			NS		
indmill Field Well	MAW005	100			NS			270			NS			0.00020			NS			2.9			NS		
Field Well West	MAW006	NS			8.7			NS			10			NS			0.0081			NS			0.022		
Field Well North	MAW007	NS			160	320	U	NS			24			NS			0.000025	0.000050	U	NS			2.7	5.4	U
House Well	MDW001	5.9			NS			11			NS			0.00020			NS			0.020			NS		
on House Well	MDW002	21			NS			44			NS			0.0039			NS			0.060			NS		
ouse Well	MDW003	6.0			NS			6.4			NS			0.00020			NS			0.0020	0.0040	U	NS		
House Well	MDW004	15			NS			15			NS			0.0018			NS			0.085			NS		
Cedar Bay RV Park Well	MDW005	16			NS			44			NS			0.00050			NS			0.056			NS		
(b) House Well	MDW006	45			NS			100			NS			0.0026			NS			0.033			NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 3
Monitoring and Production Wells - Filtered Censored Results (mg/L)

Station			Aluminum						Calcium												Cadmium											
			2005						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	NS			NS			72			71			NS			NS			0.00010	0.00020	U	0.00010			NS			NS		
	EVM Shop Well	MPW019	0.015	0.030	U	NS			72			NS			71			NS			0.00010	0.00020	U	0.00038	0.00075	U	0.000050	0.00010	U	NS		
	Degerstrom Well at EVM	MPW020	NS			NS			NS			51			NS			NS			NS			0.0013	0.0025	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.015	0.030	U	NS			54			66			62			NS			0.00010	0.00020	U	0.00020			0.000050	0.00010	U	NS		
	Henry North Pit Well N	MMW004[b]	0.015	0.030	U	0.015	0.030	U	76			70			71			77			0.00010	0.00020	U	0.0013	0.0025	U	0.000050	0.00010	U	0.000050	0.00010	U
	Henry South Pit Well	MPW022	0.015	0.030	U	0.015	0.030	U	NS			52			57			50			0	0.00020	U	0.0013	0.0025	U	0.000050	0.00010	U	0.000050	0.00010	U
	Henry Center Pit Well	MPW023	0.015	0.030	U	NS			NS			63			61			NS			NS			0.0013	0.0025	U	0.000050	0.00010	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.015	0.030	U	0.015	0.030	U	120			110			110			110			0.0033			0.0059			0.0061			0.0029		
	Ballard Pit West Well	MMW002[c]	0.015	0.030	U	0.015	0.030	U	78			69			74			73			0.00010	0.00020	U	0.0013	0.0025	U	0.000050	0.00010	U	0.000050	0.00010	U

Station			Chloride																		Chromium											
			1998[a]						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	4.8			5.0			3.9			4.0			NS			NS			0.00010	0.00020	U	0.000050	0.00010	U	NS			NS		
	EVM Shop Well	MPW019	5.7			5.0			6.1			NS			8.0			NS			0.00010	0.00020	U	0.0075	0.015	U	0.0085	0.017	U	NS		
	Degerstrom Well at EVM	MPW020	5.5			5.0			NS			6.2			NS			NS			NS			0.038	0.075	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			34			55			41			NS			0.00010	0.00020	U	0.000050	0.00010	U	0.0085	0.017	U	NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			67			64			57			57		J	0.00010	0.00020	U	0.038	0.075	U	0.0085	0.017	U	0.00055	0.0011	U
	Henry South Pit Well	MPW022	NS			NS			NS			5.8			2.8	5.5	U	5.0			0.00010	0.00020	U	0.038	0.075	U	0.0085	0.017	U	0.00055	0.0011	U
	Henry Center Pit Well	MPW023	NS			NS			NS			6.6			6.8			NS			NS			0.038	0.075	U	0.0085	0.017	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			5.8			6.6			6.6			6.0			0.00010	0.00020	U	0.038	0.075	U	0.0085	0.017	U	0.00055	0.0011	U
	Ballard Pit West Well	MMW002[c]	NS			NS			12			12			15			14			0.00010	0.00020	U	0.038	0.075	U	0.0085	0.017	U	0.00055	0.0011	U

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 4
Monitoring and Production Wells - Filtered Censored Results (mg/L)

Station			Iron						Manganese					
			2005						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	NS			NS			NS			NS		
	EVM Shop Well	MPW019	0.80	1.6	U	NS			0.047			NS		
	Degerstrom Well at EVM	MPW020	NS			NS			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.0050	0.010	U	NS			0.012	0.023	U	NS		
	Henry North Pit Well N	MMW004[b]	0.80	1.6	U	0.010	0.020	U	0.012	0.023	U	0.0028		
	Henry South Pit Well	MPW022	0.80	1.6	U	4.3			0.012	0.023	U	0.23		
	Henry Center Pit Well	MPW023	0.80	1.6	U	NS			0.19			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.0050	0.010	U	0.010	0.020	U	0.031			0.059		
	Ballard Pit West Well	MMW002[c]	0.0050	0.010	U	0.010	0.020	U	0.012	0.023	U	0.0074		

Station			Magnesium											
			2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	28			30			NS			NS		
	EVM Shop Well	MPW019	9.9			NS			10			NS		
	Degerstrom Well at EVM	MPW020	NS			17			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	21			28			25			NS		
	Henry North Pit Well N	MMW004[b]	26			37			26			27		
	Henry South Pit Well	MPW022	NS			12			13			13		
	Henry Center Pit Well	MPW023	NS			24			23			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	22			21			23			22		
	Ballard Pit West Well	MMW002[c]	45			36			40			40		

Station			Nickel											
			2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.0032			0.0072			NS			NS		
	EVM Shop Well	MPW019	0.00020	0.00040	U	0.0045			0.00030	0.00060	U	NS		
	Degerstrom Well at EVM	MPW020	NS			0.033	0.065	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.0045			0.0098			0.0043	0.0085	U	NS		
	Henry North Pit Well N	MMW004[b]	0.00051			0.033	0.065	U	0.0003	0.00060	U	0.00030	0.00060	U
	Henry South Pit Well	MPW022	0.00070			0.033	0.065	U	0.0043	0.0085	U	0.0030	0.0060	U
	Henry Center Pit Well	MPW023	NS			0.033	0.065	U	0.015			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.052			0.033	0.065	U	0.058			0.045		
	Ballard Pit West Well	MMW002[c]	0.0017			0.033	0.065	U	0.0043	0.0085	U	0.0041		

Station			Potassium											
			2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	1.3			1.1			NS			NS		
	EVM Shop Well	MPW019	0.80			NS			0.60			NS		
	Degerstrom Well at EVM	MPW020	NS			1.5	3.0	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	2.2			2.7			2.6			NS		
	Henry North Pit Well N	MMW004[b]	3.6			1.5	3.0	U	3.4			3.6		
	Henry South Pit Well	MPW022	NS			1.5	3.0	U	1.2			1.3		
	Henry Center Pit Well	MPW023	NS			1.5	3.0	U	0.80			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.90			1.5	3.0	U	0.90			0.90		
	Ballard Pit West Well	MMW002[c]	1.9			1.5	3.0	U	1.7			1.6		

Station			Selenium											
			2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.00050	0.0010	U	0.00050	0.0010	U	NS			NS		
	EVM Shop Well	MPW019	0.00050	0.0010	U	0.00050	0.0010	U	0.0010			NS		
	Degerstrom Well at EVM	MPW020	NS			0.00050	0.0010	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.0050			0.058			0.033			NS		
	Henry North Pit Well N	MMW004[b]	0.00050	0.0010	U	0.00050	0.0010	U	0.0013			0.0013		
	Henry South Pit Well	MPW022	0.0030			0.00050	0.0010	U	0.00050	0.0010	U	0.00050	0.0010	U
	Henry Center Pit Well	MPW023	NS			0.00050	0.0010	U	0.00050	0.0010	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.046			0.017			0.067			0.072		
	Ballard Pit West Well	MMW002[c]	0.00050	0.0010	U	0.024			0.031			0.022		

Station			Sodium											
			2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	18			17			NS			NS		
	EVM Shop Well	MPW019	6.9			NS			7.3			NS		
	Degerstrom Well at EVM	MPW020	NS			160	320	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	21			35			36			NS		
	Henry North Pit Well N	MMW004[b]	46			160	320	U	45			45		
	Henry South Pit Well	MPW022	NS			160	320	U	7.4			7.0		
	Henry Center Pit Well	MPW023	NS			160	320	U	9.5			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	10			160	320	U	10			11		
	Ballard Pit West Well	MMW002[c]	9.7			160	320	U	13			17		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 5
Monitoring and Production Wells - Filtered Censored Results (mg/L)

Station			Sulfate																	
			1998[a]						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	20			20			120			170			NS			NS		
	EVM Shop Well	MPW019	8.9			8.0			8.3			NS			8.3			NS		
	Degerstrom Well at EVM	MPW020	43			36			NS			98			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			81			120			99			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			130			140			120			130		
	Henry South Pit Well	MPW022	NS			NS			NS			4.0	8.0	U	3.8	7.5	U	0.25	0.50	U
	Henry Center Pit Well	MPW023	NS			NS			NS			70			63			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			100			99			120		J	98		
	Ballard Pit West Well	MMW002[c]	NS			NS			54			49			50			59		

Station			Vanadium												Zinc											
			2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.0045			0.0022			NS			NS			0.051			0.0075	0.015	U	NS			NS		
	EVM Shop Well	MPW019	0.00020			0.00040	0.00079	U	0.00010	0.00020	U	NS			0.036			0.0075	0.015	U	0.48	0.95	U	NS		
	Degerstrom Well at EVM	MPW020	NS			0.000025	0.000050	U	NS			NS			NS			2.7	5.4	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.00050	0.0010	U	0.00040	0.00079	U	0.00010	0.00020	U	NS			0.0036	0.0040	U	0.0075	0.015	U	0.48	0.95	U	NS		
	Henry North Pit Well N	MMW004[b]	0.0013			0.00059			0.0019			0.00095	0.0019	U	0.0012	0.0040	U	2.70	5.4	U	0.48	0.95	U	0.039		
	Henry South Pit Well	MPW022	0.00030			0.000025	0.000050	U	0.00010	0.00020	U	0.00010	0.00020	U	0.0014	0.0040	U	2.70	5.4	U	0.48	0.95	U	0.13		
	Henry Center Pit Well	MPW023	NS			0.000025	0.000050	U	0.00010	0.00020	U	NS			NS			2.70	5.4	U	0.48	0.95	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.0055			0.011			0.0091			0.0053			0.28			2.70	5.4	U	0.48	0.95	U	0.25		
	Ballard Pit West Well	MMW002[c]	0.00050	0.0010	U	0.000025	0.000050	U	0.0001	0.00020	U	0.00010	0.00020	U	0.0039	0.0040	U	2.70	5.4	U	0.48	0.95	U	0.16		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 6
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Aluminum			Antimony			Arsenic			Barium			Beryllium			Boron			Chloride																	
			2001			2001			2001			2001			2001			2001			2000			2001			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.00050	0.0010	U	0.0013	0.0025	U	0.0081			0.031		J	0.0025	0.0050	U	0.026			NS			5.0			4.6		J	Dry			5.0			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	0.00050	0.0010	U	0.0013	0.0025	U	0.0003	0.00050	U	0.023		J	0.0025	0.0050	U	0.013	0.025	U	NS			7.4			NA			21		J	0.80			6.8		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			NS			NS			11		J	11		J	11			11		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NS			NS			NS			NS			NS			NS			NA			NS			180		J	Dry			160			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			NA			NS			Dry			Dry			5.5			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			NS			NS			Dry			280		J	Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			NS			NS			18		J	13		J	23			23		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			NS			NS			Dry			NA			5.6			37		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			1.3			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0041		J	0.0013	0.0025	U	0.0018			0.015		J	0.0025	0.0050	U	0.013	0.025	U	NS			3.3			12.8		J	7.0		J	3.6			5.5		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			NS			NS			NS			7.0		J	3.3			5.2		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			NS			NS			NS			NS			4.0		J	4.4		J	4.1			4.1		
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			2.0			NS			2.6		J	Dry			D			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			NS			NS			NS			NS			3.3		J	5.3		J	2.4			4.5		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.5			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			3.9			4.9		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			2.9			3.2		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			6.6			7.4		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.1			Dry		
	Garden Hose Spring	MSG003	0.00050	0.0010	U	0.0013	0.0025	U	0.0003	0.00050	U	0.039			0.0025	0.0050	U	0.013	0.025	U	NS			5.7			4.2		J	5.0	10	UJ	4.5			10		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			NS			NS			NS			3.2		J	2.9			3.5		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			NS			NS			NS			3.1		J	3.3			2.8		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.8			4.8		
	Headwaters	MST067	NS			NS			NS			NS			NS			NS			NS			NS			6.2		J	Dry			8.3			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			NS			NS			NS			NS			12		J	20		J	12			17		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			NS			NS			8.4		J	Dry			8.9			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			NS			NS			NS			Dry			NS			1.8		J	Dry			2.2			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			NS			NS			NS			3.0			NS			3.5		J	Dry			4.1			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			NS			NS			NS			3.0			NS			3.9		J	Dry			3.4			4.0		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 7
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Calcium																																										
			2000			2001			2002															2003														2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			250			250		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			240			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			280			160		J	NS			250			NS			NS			NS			NS			NS			NS			NS			360			280		
	Hedin Spring	MSG001[c]	NS			NS			69		J	NS			63			NS			NS			NS			NS			NS			NS			NS			70			69		
	Above Lone Pine Creek	MST059	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	NA			NS			140		J	Dry			Dry			Dry			Dry			Dry			130			130			Dry			Dry			130			Dry		
	Headwaters, below West Pond	MST144	NA			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			150			Dry		
	Headwaters	MST269	NS			NS						NS			48			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			63		J	NA			62			NS			NS			NS			NS			NS			NS			NS			67			70		
	Above East Fork Lone Pine Creek	MST275	NS			NS						NS			NA			NS			NS			NS			NS			NS			NS			NS			16			75		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			280			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			100			120		J	NS			130			NS			NS			NS			NS			NS			NS			NS			120			140		
	Taylor Spring	MSG002	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS						NS			91			NS			NS			NS			NS			64			NS			NS			76			98		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			58		J	81			67			79			74			NA			70			72			75			80			76			76		
	Below Wooley Valley Mine	MST226	33			NS			21		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			69		J	NA			77			79			71			61			57			62			82			84			76			80		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			93			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			160			160		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			140			140		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			230			230		
	Goat Seep	MDS033	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			280			Dry		
	Garden Hose Spring	MSG003	NS			130			140		J	NS			140			NS			NS			NS			NS			NS			NS			NS			140			140		
	Holmgren Spring	MSG004	NS			NS						NS			75			NS			NS			NS			NS			NS			NS			NS			66			78		
	Cattle Spring	MSG005[c]	NS			NS						NS			78			NS			NS			NS			NS			NS			NS			NS			85			84		
	Southeast Spring	MSG006	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			220			210		
	Headwaters	MST067	NS			NS			300		J	Dry			Dry			Dry			Dry			Dry			260			250			Dry			Dry			270			Dry		
	Headwaters	MST068	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			400		J	480			420			430			Dry			Dry			340			380			430			470			240			430		
	Above Ballard Mine	MST093	NS			NS			38		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			24			NS		
	Below Ballard Mine	MST094	Dry			NS			33		J	Dry			Dry			Dry			Dry			Dry			41			Dry			Dry			Dry			66			NS		
	Below Ballard Mine	MST095	7.0			NS			110		J	Dry			Dry			Dry			Dry			Dry			150			120			Dry			Dry			140			Dry		
	Below Ballard Mine	MST096	87			NS			92		J	Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			94			100		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 8a
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Cadmium																							
			1998[d]						2000			2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			0.00080			0.0014			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			0.0048			0.00050			NS			0.00030	0.0011	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			0.000050	0.00010	U	NS			0.000040	0.00010	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			NS			0.00030			Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			0.000050	0.00010	U	NA			0.000050	0.00010	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			Dry			NS			0.00050	0.0010	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0027			0.0010	0.0020	U	NS			0.00017			0.000020	0.00010	U	NS			0.000050	0.00010	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			0.00055	0.0011	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			0.000050	0.00010	U	0	0.00020	U	0.000050	0.00010	U	0.000050	0.00010	U
	Below Wooley Valley Mine	MST226	NS			NS			0.00013	0.00025	U	NS			0.000050	0.00010	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			0.000050	0.00010	U	NA			0.000050	0.00010	U	0.000050	0.00010	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			NS			0.000065	0.00013	U	0.000050	0.00010	U	NS			0.000050	0.00010	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			NS			0.0022			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			0.00011			0.000050	0.00020	U	0.000050	0.00010	U	0.000050	0.00010	U
	Above Ballard Mine	MST093	NS			NS			NS			NS			0.000050	0.00010	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			Dry			NS			0.000050	0.00010	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			0.00013	0.00025	U	NS			0.00020			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			0.00013	0.00025	U	NS			0.000050	0.00010	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 8b
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Cadmium																							
			2003																		2004					
Mine	Station Name	Station ID	Jan	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.00050			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.0017			0.00010		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.00020			0.00020			NS			NS			0.00010			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00010			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.000100	0.00020	U	0.000050	0.00010	U
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.00010	0.00020	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.000050	0.00010	U	NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Above West Fork Lone Pine Creek	MST064[c]	0.000050	0.00010	U	NA			0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.000050	0.00010	U	0.000050	0.00010	U	0.00016			0.000050	0.00010	U	0	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.00025	0.00050	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.00010		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.00020			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U
	Headwaters	MST067	Dry			Dry			0.0017			0.0019			Dry			Dry			0.0013			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.000050	0.00010	U	0.00010			0.000050	0.00010	U
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			0.000100	0.00020	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.000050	0.00010	U	Dry			Dry			Dry			0.000100	0.00020	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.00030			0.00030			Dry			Dry			0.00020			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.000050	0.00010	U	0.000050	0.00010	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 9
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Chromium															Copper			Flouride			Lead			Manganese			Molybdenum		
			2001			2002						2004						2001			2001			2001			2001			2001		
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.019			0.0050	0.010	U	Dry			0.00020			Dry			0.0015			0.51			0.00013	0.00025	U	5.0			0.0033		
	Enoch Valley Mine South Dump Seep	MDS026	0.0085			0.0050	0.010	U	NA			0.00040			0.00075	0.0015	U	0.0018			0.40			0.00013	0.00025	U	0.77			0.00013	0.00025	U
	Hedin Spring	MSG001[c]	NS			0.0050	0.010	U	NA			0.00020			0.00075	0.0015	U	NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST059	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST060	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST061	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST136	NS			0.0050	0.010	U	Dry			0.00010			Dry			NS			NS			NS			NS			NS		
	Headwaters, below West Pond	MST144	NS			Dry			Dry			0.00020			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST269	NS			Dry			NA			Dry			Dry			NS			NS			NS			NS			NS		
	Above Rasmussen Creek	MST274	NS			0.0050	0.010	U	NA			0.00020			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Above East Fork Lone Pine Creek	MST275	NS			Dry			NA			0.00050			0.000050	0.00010	U	NS			NS			NS			NS			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			Dry			Dry			0.00010	0.00020	U	Dry			NS			NS			NS			NS			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0024			0.0050	0.010	U	NA			NA			0.00005	0.00010	U	0.0013			0.17			0.00013	0.00025	U	0.027			0.0086		
	Taylor Spring	MSG002	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.000050	0.00010	U	0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			0.0050	0.010	U	NA			0.000050	0.00010	U	0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Below Wooley Valley Mine	MST226	NS			0.0050	0.010	U	Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST276	NS			0.0050	0.010	U	NA			0.00020			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			0.00020			Dry			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			0.0015			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			0.0011			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			0.00050			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			0.00070			Dry			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	0.023			0.0050	0.010	U	NA			0.00090			0.00075	0.0015	U	0.00058			0.050	0.10	U	0.00013	0.00025	U	0.0010	0.0020	U	0.00013	0.00025	U
	Holmgren Spring	MSG004	NS			NS			NS			0.00060			0.00075	0.0015	U	NS			NS			NS			NS			NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			0.00050			0.00075	0.0015	U	NS			NS			NS			NS			NS		
	Southeast Spring	MSG006	NS			NS			NS			0.00080			0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			0.0050	0.010	U	Dry			0.00060			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST068	NS						Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST069[a]	NS			0.0050	0.010	U	NA			0.00070			0.00075	0.0015	U	NS			NS			NS			NS			NS		
	Above Ballard Mine	MST093	NS			0.0050	0.010	U	Dry			0.000050	0.00010	U	Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST094	NS			0.0050	0.010	U	Dry			NA			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST095	NS			0.0050	0.010	U	Dry			NA			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST096	NS			0.0050	0.010	U	Dry			0.00020			0.000050	0.00010	U	NS			NS			NS			NS			NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2002.

[b] Average of the QA replicate samples reported for Spring 2004.

[c] Average of the QA replicate samples reported for Fall 2004.

[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 10
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Magnesium																																														
			2000			2001			2002												2003																		2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov	RL	Flag	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			64			68			NS			Dry			NS			NS			NS			NS			NS			NS			NS			62			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			79			42			NS			73			NS			NS			NS			NS			NS			NS			NS			83			77		
	Hedin Spring	MSG001[c]	NS			NS			11			NS			31	61	U	NS			NS			NS			NS			NS			NS			NS			10			10		
	Above Lone Pine Creek	MST059	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	NA			NS			24			Dry			Dry			Dry			Dry			Dry			25			23			Dry			Dry			23			Dry		
	Headwaters, below West Pond	MST144	NA			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			36			Dry		
	Headwaters	MST269	NS			NS			Dry			NS			85			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			8.5			NA			31	61	U	NS			NS			NS			NS			NS			NS			NS			9.3			9.9		
	Above East Fork Lone Pine Creek	MST275	NS			NS			Dry			NS			NA			NS			NS			NS			NS			NS			NS			NS			4.1			22		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			52			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			44			43			NS			31	61	U	NS			NS			NS			NS			NS			NS			NS			47			56		
	Taylor Spring	MSG002	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			31	61	U	NS			NS			NS			NS			12			NS			NS			13			18		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			12			19			31	61	U	19			17			NA			16			16			17			80			17			17		
	Below Wooley Valley Mine	MST226	5.0			NS			3.7			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			9.5			NA			31	61	U	12			12			9.9			8.4			9.1			14			84			11			13		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			8.8			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			17			17		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			18			20		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			69			75		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			64			Dry		
	Garden Hose Spring	MSG003	NS			16			16			NS			31	61	U	NS			NS			NS			NS			NS			NS			NS			15			15		
	Holmgren Spring	MSG004	NS			NS			NS			NS			31	61	U	NS			NS			NS			NS			NS			NS			NS			24			26		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			31	61	U	NS			NS			NS			NS			NS			NS			NS			22			22		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			41			42		
	Headwaters	MST067	NS			NS			73			Dry			Dry			Dry			Dry			Dry			68			66			83			470			75			Dry		
	Headwaters	MST068	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			85			100			85			90			Dry			Dry			76			83			NA			NA			87			86		
	Above Ballard Mine	MST093	NS			NS			6.2			NS			Dry			NS			NS			NS			NS			NS			NS			NS			4.0			Dry		
	Below Ballard Mine	MST094	Dry			NS			6.5			Dry			Dry			Dry			Dry			Dry			6.8			Dry			Dry			Dry			11			Dry		
	Below Ballard Mine	MST095	15			NS			32			Dry			Dry			Dry			Dry			Dry			42			31			Dry			Dry			39			Dry		
	Below Ballard Mine	MST096	22			NS			16			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			17			19		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 11a
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Nickel																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.17			0.17			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.021			0.0093		J	NS			0.014	0.028	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.0018	0.0035	UJ	NS			0.014	0.028	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			0.0018	0.0035	UJ	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			0.0018	0.0035	UJ	NA			0.014	0.028	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			Dry			0.014	0.028	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.034			0.018			0.0032			0.0063		J	NS			0.014	0.028	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.014	0.028	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.0018	0.0035	UJ	0.0023	0.0045	U	0.0021	0.028	U	0.045		
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.0018	0.0035	UJ	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0018	0.0035	UJ	NA			0.014	0.028	U	0.037		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.0011			0.0018	0.0035	UJ	NS			0.014	0.028	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.014	0.028	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.014	0.028	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.014		J	Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.027		J	0.018			0.033			0.0066		
	Above Ballard Mine	MST093	NS			NS			NS			0.0018	0.0035	UJ	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			0.0018	0.0035	UJ	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.0074		J	Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.0018	0.0035	UJ	Dry			Dry			Dry		

Notes:

[a] Average of the QA replicate samples reported for Spring 2002.

[b] Average of the QA replicate samples reported for Spring 2004.

[c] Average of the QA replicate samples reported for Fall 2004.

[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 11b
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Nickel																							
			2003																		2004					
Mine	Station Name	Station ID	Jan	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.19			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.014			0.0087		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0020		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.0032			0.0026			Dry			Dry			0.0025	0.0050	U	Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0019		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.0053			0.020		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.013			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.0057			0.0085		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.00075	0.0015	U	NS			NS			0.0025	0.0050	U	0.0032		
	Above West Fork Lone Pine Creek	MST064[c]	0.0028			NA			0.0010	0.0020	U	0.00075	0.0015	U	0.0065	0.013	U	0.0015	0.0030	U	0.0025	0.0050	U	0.0016		
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.0029			0.0019			0.0026			0.0022			0.0020			0.019			0.0025	0.0050	U	0.0020		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0050		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0057		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.0067			0.011		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.011			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0066		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0089		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.00010	0.00020	U	0.0039		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.00010	0.00020	U	0.0072		
	Headwaters	MST067	Dry			Dry			0.010			0.010			Dry			Dry			0.013			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			0.0015	0.0030	U	Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.019			0.020			0.019			NA			0.025			0.037		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.0010	0.0020	U	Dry			Dry			Dry			0.0025	0.0050	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.0093			0.0071			Dry			Dry			0.0068			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.0025	0.0050	U	0.0036		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 12
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Potassium																		Sodium																	
			2000			2001			2002						2004						2000			2001			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			3.0			3.1			Dry			3.4			Dry			NS			12		J	13			Dry			12			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			1.6			0.90			13			5.3			1.8			NS			16		J	8.7			8.5	17	UJ	17			17		
	Hedin Spring	MSG001[c]	NS			NS			0.60			2.3	4.5	U	0.70			0.63			NS			NS			5.5			8.5	17	UJ	5.6			5.7		
	Above Lone Pine Creek	MST059	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NA			NS			2.0			Dry			2.5			Dry			NA			NS			8.0			Dry			8.6			Dry		
	Headwaters, below West Pond	MST144	NA			NS			Dry			Dry			1.4			Dry			NA			NS			Dry			Dry			6.8			Dry		
	Headwaters	MST269	NS			NS			Dry			6.3			Dry			Dry			NS			NS			Dry			8.5	17	UJ	Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			0.50			2.3	4.5	U	0.60			7.8			NS			NS			4.5			8.5	17	UJ	4.9			4.7		
	Above East Fork Lone Pine Creek	MST275	NS			NS			Dry			NA			20			100			NS			NS			Dry			NA			4.6			17		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			Dry			Dry			1.1			Dry			NS			NS			Dry			Dry			9.3			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			0.88			2.7			2.3	4.5	U	1.4			1.9			NS			15		J	18			8.5	17	UJ	14			17		
	Taylor Spring	MSG002	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			2.3	4.5	U	12			3.4			NS			NS			NS			8.5	17	UJ	6.8			9.2		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			0.60			2.3	4.5	U	0.60			0.73			NS			NS			7.1			8.5	17	UJ	9.4			10		
	Below Wooley Valley Mine	MST226	1.0			NS			0.70			Dry			Dry			Dry			3.0			NS			2.5			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			1.0			2.3	4.5	U	0.50			0.70			NS			NS			6.1			8.5	17	UJ	7.0			7.9		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			9.1			Dry			NS			NS			NS			NS			7.0			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			1.0			0.80			NS			NS			NS			NS			11			10		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			1.5			1.7			NS			NS			NS			NS			11			12		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			2.6			9.0			NS			NS			NS			NS			37			38		
	Goat Seep	MDS033	NS			NS			NS			NS			3.0			Dry			NS			NS			NS			NS			28			Dry		
	Garden Hose Spring	MSG003	NS			2.3			0.80			2.3	4.5	U	0.80			0.90			NS			NS			10			8.5	17	UJ	9.5			9.2		
	Holmgren Spring	MSG004	NS			NS			NS			2.3	4.5	U	1.5			1.9			NS			NS			NS			8.5	17	UJ	4.7			4.8		
	Cattle Spring	MSG005[c]	NS			NS			NS			2.3	4.5	U	0.50			0.63			NS			NS			NS			8.5	17	UJ	4.2			4.6		
	Southeast Spring	MSG006	NS			NS			NS			Dry			0.70			1.4			NS			NS			NS			NS			9.0			9.9		
	Headwaters	MST067	NS			NS			2.2			Dry			1.7			Dry			NS			NS			25			Dry			30			Dry		
	Headwaters	MST068	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			3.0			9.2			2.7			3.9			NS			NS			25			25	J		25			24		
	Above Ballard Mine	MST093	NS			NS			0.80			Dry			0.40			Dry			NS			NS			7.6			Dry			7.0			Dry		
	Below Ballard Mine	MST094	Dry			NS			0.60			Dry			1.2			Dry			Dry			NS			2.3			Dry			5.0			Dry		
	Below Ballard Mine	MST095	2.0			NS			0.50			Dry			0.15	0.30	U	Dry			7.0			NS			7.4			Dry			7.7			Dry		
	Below Ballard Mine	MST096	0.37			NS			1.6			Dry			1.2			1.6			6.0			NS			5.6			Dry			5.4			5.7		

Notes:

[a] Average of the QA replicate samples reported for Spring 2002.

[b] Average of the QA replicate samples reported for Spring 2004.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 13
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Selenium						Silver			Sulfate																		Thallium			Uranium		
			2004						2001			2000			2001			2002						2004						2001			2001		
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.013			Dry			0.00013	0.00025	U	NS			700		J	620		J	Dry			590			Dry			0.0013	0.0025	U	0.0023		
	Enoch Valley Mine South Dump Seep	MDS026	0.32			0.0060			0.00013	0.00025	U	NS			645		J	470		J	620		J	810			0.25	0.50	U	0.0013	0.0025	U	0.071		
	Hedin Spring	MSG001[c]	0.00050	0.0010	U	0.00050	0.0010	U	NS			NS			NS			9.8			11		J	10			11			NS			NS		
	Above Lone Pine Creek	MST059	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above Lone Pine Creek	MST060	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above Lone Pine Creek	MST061	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Headwaters	MST136	0.016			Dry			NS			NA			NS			150			Dry			140			Dry			NS			NS		
	Headwaters, below West Pond	MST144	0.18			Dry			NS			NA			NS			Dry			Dry			340			Dry			NS			NS		
	Headwaters	MST269	Dry			Dry			NS			NS			NS			Dry			55		J	Dry			Dry			NS			NS		
	Above Rasmussen Creek	MST274	0.0030			0.00050	0.0010	U	NS			NS			NS			34			18		J	37			16			NS			NS		
	Above East Fork Lone Pine Creek	MST275	0.00050	0.0010	U	0.00050	0.0010	U	NS			NS			NS			Dry			NA			8.6			2.2			NS			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	0.00050	0.0010	U	Dry			NS			NS			NS			Dry			Dry			350			Dry			NS			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	NA			0.00050	0.0010	U	0.00013	0.00025	U	NS			76		J	57		J	38		J	60			49			0.0013	0.0025	U	0.0067		
	Taylor Spring	MSG002	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above West Fork Lone Pine Creek	MST058	0.00050	0.0010	U	0.00050	0.0010	U	NS			NS			NS			NS			13		J	19			34			NS			NS		
	Above West Fork Lone Pine Creek	MST064[c]	0.0030			0.0013			NS			NS			NS			37			27		J	40			39			NS			NS		
	Below Wooley Valley Mine	MST226	Dry			Dry			NS			9.0			NS			8.2			Dry			Dry			Dry			NS			NS		
	Above West Fork Lone Pine Creek	MST276	0.0030			0.0020			NS			NS			NS			59			39		J	40			47			NS			NS		
	Tributary Above Lone Pine Creek	MST277[b]	0.00050	0.0010	U	Dry			NS			NS			NS			NS			NS			3.7			Dry			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	0.42			0.59			NS			NS			NS			NS			NS			140			15			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	0.45			0.43			NS			NS			NS			NS			NS			160			200			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	0.45			0.29			NS			NS			NS			NS			NS			570			440			NS			NS		
	Goat Seep	MDS033	1.4			Dry			NS			NS			NS			NS			NS			720						NS			NS		
	Garden Hose Spring	MSG003	0.39			0.46			0.00013	0.00025	U	NS			160			120			120		J	120			110			0.0013	0.0025	U	0.0022		
	Holmgren Spring	MSG004	0.0090			0.018			NS			NS			NS			NS			45		J	34			46			NS			NS		
	Cattle Spring	MSG005[c]	0.0070			0.0040			NS			NS			NS			NS			31		J	34			30			NS			NS		
	Southeast Spring	MSG006	0.21			0.26			NS			NS			NS			NS			NS			390			440			NS			NS		
	Headwaters	MST067	0.010			Dry			NS			NS			NS			780			Dry			810			Dry			NS			NS		
	Headwaters	MST068	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Below Ballard Mine	MST069[a]	0.64			0.49			NS			NS			NS			1000			NA			1200			760			NS			NS		
	Above Ballard Mine	MST093	0.0010			Dry			NS			NS			NS			18		J	Dry			17			Dry			NS			NS		
	Below Ballard Mine	MST094	0.021			Dry			NS			Dry			NS			7.7		J	Dry			13			Dry			NS			NS		
	Below Ballard Mine	MST095	NA			Dry			NS			69			NS			290		J	Dry			270			Dry			NS			NS		
	Below Ballard Mine	MST096	0.016			0.027			NS			110			NS			110		J	Dry			100			59			NS			NS		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 14a
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Vanadium																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.0028		J	0.0025	0.0050	U	NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.0018		J	0.0025	0.0050	U	NS			0.0025	0.0050	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.0025	0.0050	U	NS			0.0025	0.0050	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			0.0025	0.0050	U	Dry			Dry			NS		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			0.0025	0.0050	U	NA			0.0025	0.0050	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			NS			0.0088			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.023			0.0022	0.0043	U	0.024		J	0.0025	0.0050	U	NS			0.0025	0.0050	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.0025	0.0050	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.0025	0.0050	U	0.00070			0.0025	0.0050	U	0.00074		
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.0025	0.0050	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0025	0.0050	U	NA			0.0025	0.0050	U	0.0010		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.0028		J	0.0025	0.0050	U	NS			0.0025	0.0050	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.0025	0.0050	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.0025	0.0050	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.019			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.0025	0.0050	U	0.0016			0.0025	0.0050	U	0.0019		
	Above Ballard Mine	MST093	NS			NS			NS			0.011			NS			Dry			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			0.0025	0.0050	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.0025	0.0050	U	Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.0025	0.0050	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 14b
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Vanadium																							
			2003																		2004					
Mine	Station Name	Station ID	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.0011			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.0034			0.00089		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.00024	0.00048	U	0.00040	0.00079	U
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.0016			0.0013			Dry			Dry			0.0022			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00058			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.00056			0.00040	0.00079	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.011			0.0034		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.00024	0.00048	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.00024	0.00048	U	0.00003	0.000050	U
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.00060			NS			NS			0.00072			0.0013		
	Above West Fork Lone Pine Creek	MST064[c]	0.0055			NA			0.00069			0.00064			0.00065			0.00093			0.00065			0.00040	0.00079	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.00085			0.00092			0.0014			0.0011			0.0010			0.0014			0.0011			0.00086		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.00015	0.00030	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.00090			0.00040	0.00079	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.00099			0.00040	0.00079	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.0011			0.00081		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.0016			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.0011			0.00087		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.0016			0.0052		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.00024	0.00048	U	0.00040	0.00079	U
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.00073			0.0011		
	Headwaters	MST067	Dry			Dry			0.018			0.013			Dry			Dry			0.0084			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NA			Dry			0.0015			0.0020			0.0015			0.0019			0.0011			0.0011		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NA			0.0062			Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.00080			Dry			Dry			Dry			0.0017			Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.0038			0.0057			Dry			Dry			0.0023			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.00072			0.00040	0.00079	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 15a
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Zinc																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.14		J	0.12			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.047		J	0.0075	0.015	U	NS			0.038	0.075	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.0010	0.0020	U	NS			0.038	0.075	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			0.0010	0.0020	U	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			0.0010	0.0020	U	NA			0.038	0.075	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			NS			0.038	0.075	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0060			0.00055	0.0011	U	0.10			0.0018			NS			0.038	0.075	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.038	0.075	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.0010	0.0020	U	0.035	0.070	U	0.038	0.075	U	0.023	0.045	UJ
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.0075	0.015	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0010	0.0020	U	NA			0.038	0.075	U	0.023	0.045	UJ
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.016		J	0.0010	0.0020	U	NS			0.038	0.075	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.038	0.075	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.038	0.075	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.033			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			NS			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.0075	0.015	U	0.035	0.070	U	0.038	0.075	U	0.023	0.045	UJ
	Above Ballard Mine	MST093	NS			NS			NS			0.0010	0.0020	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			0.0075	0.015	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.016			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.0075	0.015	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 15b
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Zinc																							
			2003																		2004					
Mine	Station Name	Station ID	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS						NS			NS			0.00020	0.00040	U			
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS						NS			NS			0.00020	0.00040	U	0.0075	0.015	U
	Hedin Spring	MSG001[c]	NS			NS			NS						NS			NS			0.00020	0.00040	U	0.0010	0.0020	U
	Above Lone Pine Creek	MST059	NS			NS			NS						NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS						NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS						NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.023	0.045	U	0.035	0.070	U	Dry			Dry			0.0010	0.0020	U	Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00020	0.00040	U	Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.0010	0.0020	U	0.0010	0.0020	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.00020	0.00040	U	0.0075	0.015	U
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS						NS			NS			0.00020	0.00040	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0075	0.015	U
	Taylor Spring	MSG002	NS			NS			NS						NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.035	0.070	U	NS			NS			0.00020	0.00040	U	0.0075	0.015	U
	Above West Fork Lone Pine Creek	MST064[c]	0.033	0.065	U	NA			0.023	0.045	U	0.035	0.070	U	0.040	0.080	U	0.038	0.075	U	0.0010	0.0020	U	0.0010	0.0020	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.033	0.065	U	0.025	0.050	U	0.023	0.045	U	0.035	0.070	U	0.040	0.080	U	0.038	0.075	U	0.0010	0.0020	U	0.0075	0.015	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.0050	0.010	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0010	0.0020	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0075	0.015	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0075	0.015	U
	Goat Seep	MDS033	NS			NS			NS						NS			NS			0.0010	0.0020	U	Dry		
	Garden Hose Spring	MSG003	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0010	0.0020	U
	Holmgren Spring	MSG004	NS			NS			NS						NS			NS			0.0002	0.00040	U	0.0010	0.0020	U
	Cattle Spring	MSG005[c]	NS			NS			NS						NS			NS			0.00020	0.00040	U	0.0010	0.0020	U
	Southeast Spring	MSG006	NS			NS			NS						NS			NS			0.0010	0.0020	U	0.0075	0.015	U
	Headwaters	MST067	Dry			Dry			0.023	0.045	U	0.035	0.070	U	Dry			Dry			0.027			Dry		
	Headwaters	MST068	NS			NS			NS						NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.023	0.045	U	0.035	0.070	U	0.040	0.080	U	0.038	0.075	U	0.0075	0.015	U	0.0010	0.0020	U
	Above Ballard Mine	MST093	NS			NS			NS						NS			NS			0.00020	0.00040	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.023	0.045	U				Dry			Dry			0.00020	0.00040	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.023	0.045	U	0.035	0.070	U	Dry			Dry			0.013			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry						Dry			Dry			0.00020	0.00040	U	0.0075	0.015	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Appendix D
Unfiltered and Filtered Uncensored Results

Appendix D: Unfiltered and Filtered Uncensored Results

Page 1	Table 1:	Domestic and Agricultural Wells – Unfiltered Uncensored Results: Cd, Cr, Ni, Se, Total Alkalinity, V, Zn
Page 2	Table 2:	Monitoring and Production Wells – Unfiltered Uncensored Results: Cd, Ca, Cr, Fe, Mg, Mn, Ni, N (as nitrate/nitrite), K
Page 3	Table 3:	Monitoring and Production Wells – Unfiltered Uncensored Results: Se, Na, Total Alkalinity, V, Zn
Page 4	Table 4a:	Seeps, Springs, and Headwater Streams – Unfiltered Uncensored Results: Se (1997 – 2002)
Page 5	Table 4b:	Seeps, Springs, and Headwater Streams – Unfiltered Uncensored Results: Se (2003 – 2004)
Page 6	Table 5:	Seeps Springs, and Headwater Streams – Unfiltered Uncensored Results: Hg, N (as nitrate/nitrite), P, Total Alkalinity
Page 7	Table 6:	Domestic and Agricultural Wells – Filtered Uncensored Results: Ca, Cd, Cl^-, Cr, Mg, Ni, K, Se
Page 8	Table 7:	Domestic and Agricultural Wells – Filtered Uncensored Results: Na, SO_4^{2-}, V, Zn
Page 9	Table 8:	Monitoring and Production Wells – Filtered Uncensored Results: Al Ca, Cd, Cl^-, Cr
Page 10	Table 9:	Monitoring and Production Wells – Filtered Uncensored Results: Fe, Mn, Mg, Ni, K Se, Na
Page 11	Table 10:	Monitoring and Production Wells – Filtered Uncensored Results: SO_4^{2-}, V, Zn
Page 12	Table 11:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Al, Sb, As, Ba, Be, B, Cl^-
Page 13	Table 12:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Ca
Page 14	Table 13a:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Cd (1998 – 2002)
Page 15	Table 13b:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Cd (2003 – 2004)
Page 16	Table 14:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Cr, Cu, F, Pb, Mn, Mo
Page 17	Table 15:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Mg
Page 18	Table 16a:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Ni (1998 – 2002)
Page 19	Table 16b:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Ni (2003 – 2004)
Page 20	Table 17:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: K, Na

Page 21	Table 18:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Se, Ag, SO_4^{2-}, Tl, U
Page 22	Table 19a:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: V (1998 – 2002)
Page 23	Table 19b:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: V (2003 – 2004)
Page 24	Table 20a:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Zn (1998 – 2002)
Page 25	Table 20b:	Seeps, Springs, and Headwater Streams – Filtered Uncensored Results: Zn (2003 – 2004)

Table 1
Domestic and Agricultural Wells - Unfiltered Uncensored Results (mg/L)

Station		Cadmium						Chromium						Nickel						Selenium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	U	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	0.00014	0.00020	U	NS			0.00090			NS			0.0014	0.0025	U	NS			0.00053	0.0010	U	NS		
(b) (6) ld Well	MAW002	0.000040	0.00020	U	NS			0.000060	0.00020	U	NS			0.0016	0.0025	U	NS			-0.00064	0.0010	U	NS		
Field Well	MAW003	0.00040			NS			0.0044			NS			0.0028		U	NS			-0.00061	0.0010	U	NS		
ield Well	MAW004	-0.000040	0.00020	U	NS			0.00020			NS			0.0049			NS			-0.00094	0.0010	U	NS		
indmill Field Well	MAW005	0.0016			NS			0.0048			NS			0.0038			NS			-0.0002	0.0010	U	NS		
Field Well West	MAW006	NS			0.00016	0.00020	U	NS			0.0031			NS			0.0049			NS			-0.00020	0.0010	U
Field Well North	MAW007	NS			0.000090	0.00010	U	NS			0.00070			NS			0.0029			NS			-0.000080	0.0010	U
House Well	MDW001	0.000050	0.00020	U	NS			0.00040			NS			0.0010	0.0025	U	NS			0.00055	0.0010	U	NS		
n House Well	MDW002	0.000050	0.00020	U	NS			0.00060			NS			0.00090	0.0025	U	NS			-0.00054	0.0010	U	NS		
ouse Well	MDW003	0.000070	0.00020	U	NS			0.00070			NS			0.0013	0.0025	U	NS			0.0020			NS		
House Well	MDW004	0.000020	0.00020	U	NS			0.0017			NS			0.0015	0.0025	U	NS			-0.00020	0.0010	U	NS		
Cedar Bay RV Park Well	MDW005	-0.000030	0.00020	U	NS			0.00040			NS			0.0025	0.0025	U	NS			0.00022	0.0010	U	NS		
(b) House Well	MDW006	-0.000040	0.00020	U	NS			0.00090			NS			0.0011	0.0025	U	NS			-0.00014	0.0010	U	NS		

Station		Total Alkalinity						Vanadium						Zinc					
		2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	170			NS			0.00073			NS			0.024	0.16	U	NS		
(b) (6) ld Well	MAW002	250			NS			0.00010	0.0010	U	NS			0.038	0.16	U	NS		
Field Well	MAW003	110			NS			0.0070			NS			0.30			NS		
ield Well	MAW004	700			NS			0.00070			NS			0.037	0.16	U	NS		
indmill Field Well	MAW005	150			NS			0.0024			NS			21			NS		
Field Well West	MAW006	NS			120			NS			0.011			NS			0.036		
Field Well North	MAW007	NS			240			NS			0.00090			NS			0.087		
House Well	MDW001	190			NS			0.00040			NS			0.021	0.16	U	NS		
n House Well	MDW002	150			NS			0.0041			NS			0.045	0.16	U	NS		
ouse Well	MDW003	190			NS			0.00070			NS			0.0050	0.16	U	NS		
House Well	MDW004	150			NS			0.0018			NS			0.078	0.16	U	NS		
Cedar Bay RV Park Well	MDW005	460			NS			0.00040			NS			0.052	0.16	U	NS		
(b) House Well	MDW006	150			NS			0.0028			NS			0.035	0.16	U	NS		

Notes:
[a] Average of the QA replicate samples reported for Spring 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 2
Monitoring and Production Wells - Unfiltered Uncensored Results (mg/L)

Station			Cadmium									Calcium						Chromium			Iron									Magnesium					
			1998[a]						2005			1998[a]						2005			1998[a]						2005			1998[a]					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.0021			-0.0010	0.0020	U	NS			48			46			NS			0.0046			0.095			NS			17			18		
	EVM Shop Well	MPW019	-0.00030	0.0020	U	-0.0012	0.0020	U	NS			73			63			NS			0.0073			0.22			NS			9.3			9.0		
	Degerstrom Well at EVM	MPW020	0.0033			0.0013	0.0020	U	NS			60			59			NS			-0.0071	0.0015	U	0.089			NS			15			17		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.0029	0.10	U	NS			NS			0.050	0.10	U	NS			NS			0.63			NS			NS		
	Henry South Pit Well	MPW022	NS			NS			0.00085	0.10	U	NS			NS			0.050	0.10	U	NS			NS			8.1			NS			NS		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			-0.027	0.050	U	NS			NS			0.025	0.050	U	NS			NS			0.20	0.24	U	NS			NS		
	Ballard Pit West Well	MMW002[c]	NS			NS			-0.032	0.050	U	NS			NS			0.025	0.050	U	NS			NS			1.0			NS			NS		

Station			Manganese									Nickel									Nitrate/Nitrite as N						Potassium					
			1998[a]						2005			1998[a]						2005			2005						1998[a]					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.28			0.21			NS			0.0095	0.010	U	0.010	0.010	U	NS			NS			NS			2.0			1.8		
	EVM Shop Well	MPW019	0.040			0.032			NS			-0.0084	0.010	U	-0.0027	0.010	U	NS			0.060			NS			1.4			0.88		
	Degerstrom Well at EVM	MPW020	0.17			0.11			NS			0.17			0.12			NS			NS			NS			1.1			1.2		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			0.12			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			0.25	0.50	U	NS			NS			0.30	0.60	U	1.4			1.4			NS			NS		
	Henry South Pit Well	MPW022	NS			NS			0.25	0.50	U	NS			NS			0.30	0.60	U	0.10			0.0098	0.020	U	NS			NS		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			-0.0093	0.020	U	NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.15	0.30	U	NS			NS			0.15	0.30	U	0.33			0.69			NS			NS		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.15	0.30	U	NS			NS			0.15	0.30	U	0.040			0.0076	0.020	U	NS			NS		

Notes:
[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 3
Monitoring and Production Wells - Unfiltered Uncensored Results (mg/L)

Station			Selenium									Sodium						Total Alkalinity																	
			1998[a]						2005			1998[a]						1998[a]						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.00020	0.00070	U	0.00026	0.00070	U	NS			13			14			180			200			160			170			NS			NS		
	EVM Shop Well	MPW019	0.00082			0.0016	0.00070	U	NS			6.5			6.2			200			190			220			NS			190			NS		
	Degerstrom Well at EVM	MPW020	0.00010	0.00070	U	0.0017	0.00070	U	NS			4.7			4.5			160			190			NS			94			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS			NS			120			160			150			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			-0.0012	0.0010	U	NS			NS			NS			NS			140			130			160			170		
	Henry South Pit Well	MPW022	NS			NS			-0.0013	0.0010	U	NS			NS			NS			NS			NS			200			180			180		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS			NS			NS			190			180			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			0.069			NS			NS			NS			NS			270			270			240			260		
	Ballard Pit West Well	MMW002[c]	NS			NS			0.022			NS			NS			NS			NS			300			310			280			290		

Station			Vanadium									Zinc								
			1998[a]						2005			1998[a]						2005		
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.021			0.0077			NS			0.14			0.068			NS		
	EVM Shop Well	MPW019	0.011			-0.0073	0.0043	U	NS			0.051			0.073			NS		
	Degerstrom Well at EVM	MPW020	0.0092			0.0042	0.0043	U	NS			0.99			0.71			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			NS			NS			NS			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			-0.13	0.20	U	NS			NS			480		
	Henry South Pit Well	MPW022	NS			NS			-0.19	0.20	U	NS			NS			550		
	Henry Center Pit Well	MPW023	NS			NS			NS			NS			NS			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			-0.057	0.10	U	NS			NS			450		
	Ballard Pit West Well	MMW002[c]	NS			NS			-0.051	0.10	U	NS			NS			460		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 4a
Seeps, Springs, and Headwater Streams - Unfiltered Uncensored Results (mg/L)

Station			Selenium																										
			1997			1998[d]						2000			2001			2002											
Mine	Station Name	Station ID	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			0.0026		J	0.00060	0.0010	U	NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			0.049		J	0.12			NS			0.020		J	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			0.0010	0.015	U	NS			0.0042		J	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			NA			NS			0.014	0.015	U	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NA			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			0.0040	0.015	U	0.0030			-0.00039	0.0010	UJ	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			Dry			NS			0.00010	0.0010	UJ	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0011			0.00038			-0.00024	0.00020	U	0.0060			0.00071	0.0010	U	0.00047	0.0010	U	NS			-0.0016	0.0010	UJ	NS		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			NS			-0.00079	0.0010	UJ	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			NS			0.0040	0.015	U	0.0040			0.00040	0.0010	UJ	0.000090	0.0010	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			-0.00051	0.0010	U	NS			0.00010	0.0010	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			NS			0.010	0.015	U	0.0030			0.0020		J	0.0013		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			0.44		J	0.47			NS			0.42		J	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			NS			0.0080		J	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			NS			0.0030		J	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			NS			NS			0.13			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			NS			0.58			0.49			0.27		J	0.55		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			0.00070	0.0010	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			Dry			NS			0.021			Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.047			NS			0.16			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.098			NS			0.025			Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 4b
Seeps, Springs, and Headwater Streams - Unfiltered Uncensored Results (mg/L)

Station			Selenium																							
			2003																		2004					
Mine	Station Name	Station ID	Jan	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.016			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.43			0.0060		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.00049	0.0010	U	0.00026	0.0010	U
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.037			0.0070			Dry			Dry			0.016			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.23			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.0030			-0.00069		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.00019	0.0010	U	0.0080		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			-0.00021	0.0010	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			-0.00066	0.0010	U	-0.00034	0.0010	U
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			-0.00059	0.0010	U	NS			NS			-0.00046	0.0010	U	-0.00048	0.0010	U
	Above West Fork Lone Pine Creek	MST064[c]	0.00029	0.0010	U	NA			0.0020			0.0057			0.0030			0.0020			0.0020			0.0020		
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.0023			0.0020			0.0090			0.0030			0.0030			0.0023			0.0030			0.013		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			-0.00065	0.0010	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.52			0.57		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.38			0.38		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.5			0.29		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			1.5			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.47			0.44		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.016			0.031		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.007			0.0040		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.22			0.28		
	Headwaters	MST067	Dry			Dry			0.15			0.052			Dry			Dry			0.029			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.58			0.47			0.51			0.51			0.60			0.48		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			0.00091	0.0010	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.0020			Dry			Dry			Dry			0.023			Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.22			0.080			Dry			Dry			0.059			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.020			0.027		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 5
Seeps, Springs, and Headwater Streams - Unfiltered Uncensored Results (mg/L)

Station			Mercury			Nitrate/Nitrite as N			Phosphorus			Total Alkalinity														
			2001			2001			2001			2000			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.000012	0.00050	U	-0.055	0.10	U	1.7			NS			150			Dry			180			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	0.000013	0.00050	U	0.18		J	0.28			NS			310			290			330			300		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			200			190			200			200		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NS			NS			NS			NA			61			Dry			60			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NA			Dry			Dry			110			Dry		
	Headwaters	MST269	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			150			170			150			180		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			Dry			NA			59			630		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			Dry			Dry			270			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0000060	0.00050	U	-0.014	0.10	U	0.22			NS			360			530			410			570		
	Taylor Spring	MSG002	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NA			220			310		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			240			230			220			250		
	Below Wooley Valley Mine	MST226	NS			NS			NS			87			NA			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			79			210			190			230		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			280			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			320			300		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			240			230		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			180			320		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			290			Dry		
	Garden Hose Spring	MSG003	0.000012	0.00050	U	5.0		J	0.031			NS			220			270			280			270		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			260			230			250		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			260			260			270		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			230			250		
	Headwaters	MST067	NS			NS			NS			NS			240			Dry			250			Dry		
	Headwaters	MST068	NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			180			270			110			300		
	Above Ballard Mine	MST093	NS			NS			NS			NS			78			Dry			98			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			Dry			130			Dry			160			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			160			140			Dry			220			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			180			190			Dry			190			230		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 6
Domestic and Agricultural Wells - Filtered Uncensored Results (mg/L)

Station		Calcium						Cadmium						Chloride						Chromium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	66			NS			0.000060	0.00020	U	NS			11			NS			0.00013	0.00020	U	NS		
(b) (6) d Well	MAW002	62			NS			0.000020	0.00020	U	NS			3.2			NS			-0.000040	0.00020	U	NS		
ield Well	MAW003	34			NS			0.000020	0.00020	U	NS			4.8			NS			0.0013			NS		
ld Well	MAW004	180			NS			0	0.00020	U	NS			7.5			NS			0.00013	0.00020	U	NS		
ndmill Field Well	MAW005	110			NS			0.00060			NS			140			NS			-0.000080	0.00020	U	NS		
ield Well West	MAW006	NS			38			NS			0.000050	0.00010	U	NS			9.2			NS			0.0010	0.0015	U
ield Well North	MAW007	NS			58			NS			0.000010	0.0025	U	NS			12			NS			0.00010	0.075	U
ouse Well	MDW001	67			NS			0.000020	0.00020	U	NS			13			NS			0.00016	0.00020	U	NS		
House Well	MDW002	54			NS			0.000040	0.00020	U	NS			32			NS			0.00060			NS		
use Well	MDW003	74			NS			-0.000020	0.00020	U	NS			7.8			NS			0.00040			NS		
ouse Well	MDW004	73			NS			0.000050	0.00020	U	NS			7.8			NS			0.0011			NS		
Cedar Bay RV Park Well	MDW005	150			NS			0.000020	0.00020	U	NS			17			NS			0.00040			NS		
(b) House Well	MDW006	66			NS			0.000020	0.00020	U	NS			58			NS			0.00070			NS		

Station		Magnesium						Nickel						Potassium						Selenium					
		2004						2004						2004						2004					
Well Name	Well ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
School Bus Well	MAW001[a]	12			NS			0.00060			NS			0.57			NS			0.00020	0.0010	U	NS		
(b) (6) ld Well	MAW002	22			NS			0.0012			NS			2.0			NS			-0.0011	0.0010	U	NS		
Field Well	MAW003	8.6			NS			0.00014	0.00040	U	NS			0.40			NS			-0.00083	0.0010	U	NS		
ield Well	MAW004	61			NS			0.0028			NS			4.8			NS			0.00020	0.0010	U	NS		
indmill Field Well	MAW005	38			NS			0.0019			NS			5.7			NS			-0.00061	0.0010	U	NS		
Field Well West	MAW006	NS			10			NS			0.0023			NS			1.6			NS			-0.00049	0.0010	U
Field Well North	MAW007	NS			20			NS			0.00070	0.065	U	NS			2.8	3.0	U	NS			-0.00042	0.0010	U
House Well	MDW001	13			NS			0.0011			NS			0.50			NS			0.00018	0.0010	U	NS		
n House Well	MDW002	19			NS			0.0016			NS			2.4			NS			-0.00080	0.0010	U	NS		
ouse Well	MDW003	6.5			NS			0.0012			NS			0.50			NS			0.0010			NS		
House Well	MDW004	20			NS			0.00040			NS			2.2			NS			-0.000040	0.0010	U	NS		
Cedar Bay RV Park Well	MDW005	38			NS			0.0016			NS			2.4			NS			0.00019	0.0010	U	NS		
(b) House Well	MDW006	27			NS			0.00060			NS			2.8			NS			-0.00048	0.0010	U	NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 7
Domestic and Agricultural Wells - Filtered Uncensored Results (mg/L)

Station		Sodium						Sulfate						Vanadium						Zinc					
		2004						2004						2004						2004					
Well Name	**Well ID**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**	**Spring**	**RL**	**Flag**	**Fall**	**RL**	**Flag**
School Bus Well	MAW001[a]	5.9			NS			11			NS			0.00020			NS			0.017			NS		
(b) (6) ld Well	MAW002	22			NS			0.091	0.50	U	NS			0.000060	0.0010	U	NS			0.026			NS		
Field Well	MAW003	9.0			NS			6.4			NS			0.0017			NS			0.18			NS		
ield Well	MAW004	10			NS			7.7			NS			0.00070			NS			0.0080			NS		
indmill Field Well	MAW005	100			NS			270			NS			0.00020			NS			2.9			NS		
ield Well West	MAW006	NS			8.7			NS			10			NS			0.0081			NS			0.022		
ield Well North	MAW007	NS			13	320	U	NS			24			NS			-0.0015	0.000050	U	NS			0.053	5.4	U
House Well	MDW001	5.9			NS			11			NS			0.00020			NS			0.020			NS		
n House Well	MDW002	21			NS			44			NS			0.0039			NS			0.060			NS		
ouse Well	MDW003	6.0			NS			6.4			NS			0.00020			NS			0.0022	0.0040	U	NS		
House Well	MDW004	15			NS			15			NS			0.0018			NS			0.085			NS		
Cedar Bay RV Park Well	MDW005	16			NS			44			NS			0.00050			NS			0.056			NS		
(b) House Well	MDW006	45			NS			100			NS			0.0026			NS			0.033			NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 8
Monitoring and Production Wells - Filtered Uncensored Results (mg/L)

Station			Aluminum						Calcium												Cadmium											
			2005						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	NS			NS			72			71			NS			NS			0.000020	0.00020	U	0.00010			NS			NS		
	EVM Shop Well	MPW019	-0.0030	0.030	U	NS			72			NS			71			NS			0.000040	0.00020	U	0.000070	0.00075	U	0.000020	0.00010	U	NS		
	Degerstrom Well at EVM	MPW020	NS			NS			NS			51			NS			NS			NS			0.000050	0.0025	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	-0.0050	0.030	U	NS			54			66			62			NS			0.000040	0.00020	U	0.00020			0.000070	0.00010	U	NS		
	Henry North Pit Well N	MMW004[b]	-0.0090	0.030	U	0.018	0.030	U	76			70			71			77			0.000040	0.00020	U	0.000010	0.0025	U	0.000017	0.00010	U	0.000010	0.00010	U
	Henry South Pit Well	MPW022	-0.015	0.030	U	-0.019	0.030	U	NS			52			57			50			0	0.00020	U	0	0.0025	U	0	0.00010	U	0.000010	0.00010	U
	Henry Center Pit Well	MPW023	-0.0070	0.030	U	NS			NS			63			61			NS			NS			0.000060	0.0025	U	0.000040	0.00010	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.014	0.030	U	0.0090	0.030	U	120			110			110			110			0.0033			0.0059			0.0061			0.0029		
	Ballard Pit West Well	MMW002[c]	0.0090	0.030	U	0.010	0.030	U	78			69			74			73			0.000090	0.00020	U	0.00010	0.0025	U	0.000080	0.00010	U	0.000060	0.00010	U

Station			Chloride																		Chromium											
			1998[a]						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	4.8			5.0			3.9			4.0			NS			NS			-0.000020	0.00020	U	-0.00037	0.00010	U	NS			NS		
	EVM Shop Well	MPW019	5.7			5.0			6.1			NS			8.0			NS			0.00018	0.00020	U	-0.0005	0.015	U	0.00020	0.017	U	NS		
	Degerstrom Well at EVM	MPW020	5.5			5.0			NS			6.2			NS			NS			NS			0.000060	0.075	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			34			55			41			NS			-0.00010	0.00020	U	-0.00040	0.00010	U	0.0014	0.017	U	NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			67			64			57			57		J	0.000070	0.00020	U	0.00020	0.075	U	0.00083	0.017	U	0.00047	0.0011	U
	Henry South Pit Well	MPW022	NS			NS			NS			5.8			2.8	5.5	U	5.0			0.00015	0.00020	U	0.0012	0.075	U	0.0010	0.017	U	0.00010	0.0011	U
	Henry Center Pit Well	MPW023	NS			NS			NS			6.6			6.8			NS			NS			0.000040	0.075	U	0.00010	0.017	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			5.8			6.6			6.6			6.0			0.000020	0.00020	U	0.00047	0.075	U	0.0042	0.017	U	0.00020	0.0011	U
	Ballard Pit West Well	MMW002[c]	NS			NS			12			12			15			14			0.00010	0.00020	U	0.00023	0.075	U	0.0023	0.017	U	0.00020	0.0011	U

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 9
Monitoring and Production Wells - Filtered Uncensored Results (mg/L)

Station			Iron						Manganese						Magnesium												Nickel											
			2005						2005						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	NS			NS			NS			NS			28			30			NS			NS			0.0032			0.0072			NS			NS		
	EVM Shop Well	MPW019	0.16	1.6	U	NS			0.047			NS			9.9			NS			10			NS			0.00033	0.00040	U	0.0045			0.00033	0.00060	U	NS		
	Degerstrom Well at EVM	MPW020	NS			NS			NS			NS			NS			17			NS			NS			NS			0.013	0.065	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.010	0.010	U	NS			0.0056	0.023	U	NS			21			28			25			NS			0.0045			0.0098			0.0045	0.0085	U	NS		
	Henry North Pit Well N	MMW004[b]	0.42	1.6	U	0.0067	0.020	U	0.013	0.023	U	0.0028			26			37			26			27			0.00051			0.0014	0.065	U	0.00056	0.00060	U	0.00026	0.00060	U
	Henry South Pit Well	MPW022	0.13	1.6	U	4.3			0.016	0.023	U	0.23			NS			12			13			13			0.00070			0.0010	0.065	U	0.00070	0.0085	U	0.00023	0.0060	U
	Henry Center Pit Well	MPW023	0.20	1.6	U	NS			0.19			NS			NS			24			23			NS			NS			0.016	0.065	U	0.015			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	-0.0020	0.010	U	-0.0010	0.020	U	0.031			0.059			22			21			23			22			0.052			0.056	0.065	U	0.058			0.045		
	Ballard Pit West Well	MMW002[c]	0.0090	0.010	U	0.0020	0.020	U	0.022	0.023	U	0.0074			45			36			40			40			0.0017			0.012	0.065	U	0.0064	0.0085	U	0.0041		

Station			Potassium												Selenium												Sodium											
			2004						2005						2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	1.3			1.1			NS			NS			-0.00038	0.0010	U	-0.00088	0.0010	U	NS			NS			18			17			NS			NS		
	EVM Shop Well	MPW019	0.80			NS			0.60			NS			0.00083	0.0010	U	0.00094	0.0010	U	0.0010			NS			6.9			NS			7.3			NS		
	Degerstrom Well at EVM	MPW020	NS			1.5	3.0	U	NS			NS			NS			-0.00036	0.0010	U	NS			NS			NS			5.3	320	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	2.2			2.7			2.6			NS			0.0050			0.058			0.033			NS			21			35			36			NS		
	Henry North Pit Well N	MMW004[b]	3.6			1.5	3.0	U	3.4			3.6			-0.00061	0.0010	U	0.00012	0.0010	U	0.0013			0.0013			46			8.6	320	U	45			45		
	Henry South Pit Well	MPW022	NS			1.5	3.0	U	1.2			1.3			0.0030			0.000040	0.0010	U	-0.00038	0.0010	U	-4E-04	0.0010	U	NS			6.4	320	U	7.4			7.0		
	Henry Center Pit Well	MPW023	NS			1.5	3.0	U	0.80			NS			NS			-0.00022	0.0010	U	-0.00029	0.0010	U	NS			NS			9.3	320	U	9.5			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.90			1.5	3.0	U	0.90			0.90			0.046			0.017			0.067			0.072			10			8.9	320	U	10			11		
	Ballard Pit West Well	MMW002[c]	1.9			1.5	3.0	U	1.7			1.6			0.00033	0.0010	U	0.024			0.031			0.022			9.7			8.5	320	U	13			17		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 10
Monitoring and Production Wells - Filtered Uncensored Results (mg/L)

Station			Sulfate																	
			1998[a]						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	20			20			120			170			NS			NS		
	EVM Shop Well	MPW019	8.9			8.0			8.3			NS			8.3			NS		
	Degerstrom Well at EVM	MPW020	43			36			NS			98			NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	NS			NS			81			120			99			NS		
	Henry North Pit Well N	MMW004[b]	NS			NS			130			140			120			130		
	Henry South Pit Well	MPW022	NS			NS			NS			3.1	8.0	U	2.8	7.5	U	0.38	0.50	U
	Henry Center Pit Well	MPW023	NS			NS			NS			70			63			NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	NS			NS			100			99			120		J	98		
	Ballard Pit West Well	MMW002[c]	NS			NS			54			49			50			59		

Station			Vanadium												Zinc											
			2004						2005						2004						2005					
Mine	Name	ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Agrium Production Well	MPW006	0.0045			0.0022			NS			NS			0.051			0.32	0.015	U	NS			NS		
	EVM Shop Well	MPW019	0.00020			0.00018	0.00079	U	-0.0010	0.00020	U	NS			0.036			0.012	0.015	U	0.026	0.95	U	NS		
	Degerstrom Well at EVM	MPW020	NS			-0.0031	0.000050	U	NS			NS			NS			0.0050	5.4	U	NS			NS		
Henry Mine	Henry North Pit Well S	MMW003	0.000010	0.0010	U	0.00071	0.00079	U	-0.00043	0.00020	U	NS			0.0036	0.0040	U	0.010	0.015	U	0.098	0.95	U	NS		
	Henry North Pit Well N	MMW004[b]	0.0013			0.00059			0.0019			0.0018	0.0019	U	0.0012	0.0040	U	0.051	5.4	U	0.072	0.95	U	0.039		
	Henry South Pit Well	MPW022	0.00030			-0.0012	0.000050	U	-0.00087	0.00020	U	-0.00050	0.00020	U	0.0014	0.0040	U	0.10	5.4	U	0.043	0.95	U	0.13		
	Henry Center Pit Well	MPW023	NS			-0.0032	0.000050	U	-0.0011	0.00020	U	NS			NS			0.74	5.4	U	0.59	0.95	U	NS		
Ballard Mine	Ballard Pit East Well	MMW001[c]	0.0055			0.011			0.0091			0.0053			0.28			0.56	5.4	U	0.51	0.95	U	0.25		
	Ballard Pit West Well	MMW002[c]	0.00010	0.0010	U	-0.0014	0.000050	U	-0.00099	0.00020	U	-0.00010	0.00020	U	0.0039	0.0040	U	0.25	5.4	U	0.13	0.95	U	0.16		

Notes:

[a] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

[b] Average of the QA replicate samples reported for Spring 2004 and Spring and Fall 2005.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 11
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Aluminum			Antimony			Arsenic			Barium			Beryllium			Boron			Chloride																	
			2001			2001			2001			2001			2001			2001			2000			2001			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.00086	0.0010	U	0.00012	0.0025	U	0.0081			0.031		J	0.00020	0.0050	U	0.026			NS			5.0			4.6		J	Dry			5.0			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	0.00037	0.0010	U	0.00010	0.0025	U	0.0004	0.00050	U	0.023		J	-0.0030	0.0050	U	0.0052	0.025	U	NS			7.4			NA			21		J	0.80			6.8		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			NS			NS			11		J	11		J	11			11		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NS			NS			NS			NS			NS			NS			NA			NS			180		J	Dry			160			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			NA			NS			Dry			Dry			5.5			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			NS			NS			Dry			280		J	Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			NS			NS			18		J	13		J	23			23		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			NS			NS			Dry			NA			5.6			37		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			1.3			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0041		J	0.00028	0.0025	U	0.0018			0.015		J	0.00020	0.0050	U	0.015	0.025	U	NS			3.3			12.8		J	7.0		J	3.6			5.5		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			NS			NS			NS			7.0		J	3.3			5.2		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			NS			NS			NS			NS			4.0		J	4.4		J	4.1			4.1		
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			2.0			NS			2.6		J	Dry			D			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			NS			NS			NS			NS			3.3		J	5.3		J	2.4			4.5		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.5			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			3.9			4.9		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			2.9			3.2		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			6.6			7.4		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.1			Dry		
	Garden Hose Spring	MSG003	0.000048	0.0010	U	0.00064	0.0025	U	0.00034	0.00050	U	0.039			0.00020	0.0050	U	0.016	0.025	U	NS			5.7			4.2		J	5.0	10	UJ	4.5			10		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			NS			NS			NS			3.2		J	2.9			3.5		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			NS			NS			NS			3.1		J	3.3			2.8		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			4.8			4.8		
	Headwaters	MST067	NS			NS			NS			NS			NS			NS			NS			NS			6.2		J	Dry			8.3			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			NS			NS			NS			NS			12		J	20		J	12			17		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			NS			NS			8.4		J	Dry			8.9			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			NS			NS			NS			Dry			NS			1.8		J	Dry			2.2			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			NS			NS			NS			3.0			NS			3.5		J	Dry			4.1			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			NS			NS			NS			3.0			NS			3.9		J	Dry			3.4			4.0		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 12
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Calcium																																										
			2000			2001			2002															2003														2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			250			250		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			240			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			280			160		J	NS			250			NS			NS			NS			NS			NS			NS			NS			360			280		
	Hedin Spring	MSG001[c]	NS			NS			69		J	NS			63			NS			NS			NS			NS			NS			NS			NS			70			69		
	Above Lone Pine Creek	MST059	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	NA			NS			140		J	Dry			Dry			Dry			Dry			Dry			130			130			Dry			Dry			130			Dry		
	Headwaters, below West Pond	MST144	NA			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			150			Dry		
	Headwaters	MST269	NS			NS						NS			48			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			63		J	NA			62			NS			NS			NS			NS			NS			NS			NS			67			70		
	Above East Fork Lone Pine Creek	MST275	NS			NS						NS			NA			NS			NS			NS			NS			NS			NS			NS			16			75		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			280			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			100			120		J	NS			130			NS			NS			NS			NS			NS			NS			NS			120			140		
	Taylor Spring	MSG002	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS						NS			91			NS			NS			NS			NS			64			NS			NS			76			98		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			58		J	81			67			79			74			NA			70			72			75			80			76			76		
	Below Wooley Valley Mine	MST226	33			NS			21		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			69		J	NA			77			79			71			61			57			62			82			84			76			80		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			93			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			160			160		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			140			140		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			230			230		
	Goat Seep	MDS033	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			280			Dry		
	Garden Hose Spring	MSG003	NS			130			140		J	NS			140			NS			NS			NS			NS			NS			NS			NS			140			140		
	Holmgren Spring	MSG004	NS			NS						NS			75			NS			NS			NS			NS			NS			NS			NS			66			78		
	Cattle Spring	MSG005[c]	NS			NS						NS			78			NS			NS			NS			NS			NS			NS			NS			85			84		
	Southeast Spring	MSG006	NS			NS						NS			NS			NS			NS			NS			NS			NS			NS			NS			220			210		
	Headwaters	MST067	NS			NS			300		J	Dry			Dry			Dry			Dry			Dry			260			250			Dry			Dry			270			Dry		
	Headwaters	MST068	NS			NS						NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			400		J	480			420			430			Dry			Dry			340			380			430			470			240			430		
	Above Ballard Mine	MST093	NS			NS			38		J	NS			Dry			NS			NS			NS			NS			NS			NS			NS			24			NS		
	Below Ballard Mine	MST094	Dry			NS			33		J	Dry			Dry			Dry			Dry			Dry			41			Dry			Dry			Dry			66			NS		
	Below Ballard Mine	MST095	7.0			NS			110		J	Dry			Dry			Dry			Dry			Dry			150			120			Dry			Dry			140			Dry		
	Below Ballard Mine	MST096	87			NS			92		J	Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			94			100		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 13a
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Cadmium																							
			1998[d]						2000			2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			0.00080			0.0014			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			0.0048			0.00050			NS			0.00030	0.0011	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			0.000020	0.00010	U	NS			0.000040	0.00010	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			NS			0.00030			Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			0	0.00010	U	NA			0.000020	0.00010	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			Dry			NS			0.00079	0.0010	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0027			0	0.0020	U	NS			0.00017			0.000020	0.00010	U	NS			0.00010	0.00010	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			NS			0.00020	0.0011	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			NS			-0.000010	0.00010	U	0	0.00020	U	0.000070	0.00010	U	-0.000030	0.00010	U
	Below Wooley Valley Mine	MST226	NS			NS			0.000082	0.00025	U	NS			0.000060	0.00010	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			NS			0.000023	0.00010	U	NA			0.000060	0.00010	U	-0.000040	0.00010	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			NS			0.000041	0.00013	U	0.000020	0.00010	U	NS			0.000020	0.00010	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0	0.00010	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			-0.000040	0.00010	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			NS			0.0022			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			NS			0.00011			0.000050	0.00020	U	0.000060	0.00010	U	-0.000040	0.00010	U
	Above Ballard Mine	MST093	NS			NS			NS			NS			0.000060	0.00010	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			Dry			NS			0.000070	0.00010	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			0.000032	0.00025	U	NS			0.00020			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			0.00015	0.00025	U	NS			0.000050	0.00010	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 13b
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Cadmium																							
			2003																		2004					
Mine	Station Name	Station ID	Jan	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.00050			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.0017			0.00010		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			-0.000010	0.00010	U	0.000013	0.00010	U
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS									Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.00020			0.00020									0.00010			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00010			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.000010	0.00010	U	0.000010	0.00010	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.000050	0.00020	U	0.00025	0.00010	U
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.00010	0.00020	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.000010	0.00010	U	0.000020	0.00010	U
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			-0.000020	0.00010	U	NS			NS			0.000010	0.00010	U	0.000060	0.00010	U
	Above West Fork Lone Pine Creek	MST064[c]	0	0.00010	U	NA			0.000030	0.00010	U	0.000017	0.00010	U	-0.000010	0.00010	U	-0.000010	0.00010	U	0.000010	0.00010	U	0.000010	0.00010	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.000030	0.00010	U	0.000027	0.00010	U	0.00016			0.000010	0.00010	U	0	0.00010	U	-0.0000067	0.00010	U	0.000020	0.00010	U	-0.000010	0.00010	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.0000067	0.00050	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.000040	0.00010	U	0.000030	0.00010	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.000060	0.00010	U	0.000050	0.00010	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.000030	0.00010	U	0.00010		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.00020			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.000010	0.00010	U	-0.000010	0.00010	U
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.000020	0.00010	U	0.000050	0.00010	U
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.000010	0.00010	U	-0.0000067	0.00010	U
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0	0.00010	U	0.000010	0.00010	U
	Headwaters	MST067	Dry			Dry			0.0017			0.0019									0.0013			Dry		
	Headwaters	MST068	NS			NS			NS												Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.00010	0.00010	U	0.000040	0.00010	U	0.000020	0.00010	U	-0.000080	0.00010	U	0.00010			0.000030	0.00010	U
	Above Ballard Mine	MST093	NS			NS			NS												0.000070	0.00020	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.000050	0.00010	U										0.000020	0.00020	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.00030			0.00030									0.00020			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry												0.000050	0.00010	U	0.000010	0.00010	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 14
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Chromium															Copper			Flouride			Lead			Manganese			Molybdenum		
			2001			2002						2004						2001			2001			2001			2001			2001		
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.019			0.0030	0.010	U	Dry			0.00020			Dry			0.0015			0.51			-0.000070	0.00025	U	5.0			0.0033		
	Enoch Valley Mine South Dump Seep	MDS026	0.0085			0.0010	0.010	U	NA			0.00040			0.00012	0.0015	U	0.0018			0.40			-0.000021	0.00025	U	0.77			0.00078	0.00025	U
	Hedin Spring	MSG001[c]	NS			-0.0010	0.010	U	NA			0.00020			-0.0028	0.0015	U	NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST059	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST060	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above Lone Pine Creek	MST061	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST136	NS			-0.0050	0.010	U	Dry			0.00010			Dry			NS			NS			NS			NS			NS		
	Headwaters, below West Pond	MST144	NS			Dry			Dry			0.00020			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST269	NS			Dry			NA			Dry			Dry			NS			NS			NS			NS			NS		
	Above Rasmussen Creek	MST274	NS			0.0010	0.010	U	NA			0.00020			-0.00017	0.00010	U	NS			NS			NS			NS			NS		
	Above East Fork Lone Pine Creek	MST275	NS			Dry			NA			0.00050			-0.0016	0.00010	U	NS			NS			NS			NS			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			Dry			Dry			0.00015	0.00020	U	Dry			NS			NS			NS			NS			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0024			-0.0027	0.010	U	NA			NA			-0.0029	0.00010	U	0.0013			0.17			-0.000060	0.00025	U	0.027			0.0086		
	Taylor Spring	MSG002	NS			Dry			Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.000020	0.00010	U	-0.00011	0.00010	U	NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			0	0.010	U	NA			0.000080	0.00010	U	-0.00010	0.00010	U	NS			NS			NS			NS			NS		
	Below Wooley Valley Mine	MST226	NS			-0.0020	0.010	U	Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST276	NS			0.0050	0.010	U	NA			0.00020			-0.000050	0.00010	U	NS			NS			NS			NS			NS		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			0.00020			Dry			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			0.0015			-0.0024	0.00010	U	NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			0.0011			-0.0023	0.00010	U	NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			0.00050			-0.0028	0.00010	U	NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			0.00070			Dry			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	0.023			0.0060	0.010	U	NA			0.00090			0.00050	0.0015	U	0.00058			0.093	0.10	U	0.000013	0.00025	U	0.00080	0.0020	U	0.00072	0.00025	U
	Holmgren Spring	MSG004	NS			NS			NS			0.00060			0.00030	0.0015	U	NS			NS			NS			NS			NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			0.00050			0.00053	0.0015	U	NS			NS			NS			NS			NS		
	Southeast Spring	MSG006	NS			NS			NS			0.00080			-0.0025	0.00010	U	NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			0.0025	0.010	U	Dry			0.00060			Dry			NS			NS			NS			NS			NS		
	Headwaters	MST068	NS						Dry			Dry			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST069[a]	NS			0.00033	0.010	U	NA			0.00070			0.00020	0.0015	U	NS			NS			NS			NS			NS		
	Above Ballard Mine	MST093	NS			0.0020	0.010	U	Dry			0.00016	0.00010	U	Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST094	NS			0.0030	0.010	U	Dry			NA			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST095	NS			0.0030	0.010	U	Dry			NA			Dry			NS			NS			NS			NS			NS		
	Below Ballard Mine	MST096	NS			0.00050	0.010	U	Dry			0.00020			-0.0028	0.00010	U	NS			NS			NS			NS			NS		

Notes:

[a] Average of the QA replicate samples reported for Spring 2002.

[b] Average of the QA replicate samples reported for Spring 2004.

[c] Average of the QA replicate samples reported for Fall 2004.

[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 15
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Magnesium																																											
			2000			2001			2002												2003																		2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov	RL	Flag	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			64			68			NS			Dry			NS			NS			NS			NS			NS			NS			NS			62			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			79			42			NS			73			NS			NS			NS			NS			NS			NS			NS			83			77		
	Hedin Spring	MSG001[c]	NS			NS			11			NS			10	61	U	NS			NS			NS			NS			NS			NS			NS			10			10		
	Above Lone Pine Creek	MST059	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	NA			NS			24			Dry			Dry			Dry			Dry			Dry			25			23			Dry			Dry			23			Dry		
	Headwaters, below West Pond	MST144	NA			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			36			Dry		
	Headwaters	MST269	NS			NS			Dry			NS			85			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			8.5			NA			8.8	61	U	NS			NS			NS			NS			NS			NS			NS			9.3			9.9		
	Above East Fork Lone Pine Creek	MST275	NS			NS			Dry			NS			NA			NS			NS			NS			NS			NS			NS			NS			4.1			22		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			52			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			44			43			NS			53	61	U	NS			NS			NS			NS			NS			NS			NS			47			56		
	Taylor Spring	MSG002	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			NS			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			20	61	U	NS			NS			NS			NS			12			NS			NS			13			18		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			12			19			16	61	U	19			17			NA			16			16			17			80			17			17		
	Below Wooley Valley Mine	MST226	5.0			NS			3.7			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			9.5			NA			13	61	U	12			12			9.9			8.4			9.1			14			84			11			13		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			8.8			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			17			17		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			18			20		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			69			75		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			64			Dry		
	Garden Hose Spring	MSG003	NS			16			16			NS			14	61	U	NS			NS			NS			NS			NS			NS			NS			15			15		
	Holmgren Spring	MSG004	NS			NS			NS			NS			25	61	U	NS			NS			NS			NS			NS			NS			NS			24			26		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			21	61	U	NS			NS			NS			NS			NS			NS			NS			22			22		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			NS			41			42		
	Headwaters	MST067	NS			NS			73			Dry			Dry			Dry			Dry			Dry			68			66			83			470			75			Dry		
	Headwaters	MST068	NS			NS			Dry			NS			Dry			NS			NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			85			100			85			90			Dry			Dry			76			83			NA			NA			87			86		
	Above Ballard Mine	MST093	NS			NS			6.2			NS			Dry			NS			NS			NS			NS			NS			NS			NS			4.0			Dry		
	Below Ballard Mine	MST094	Dry			NS			6.5			Dry			Dry			Dry			Dry			Dry			6.8			Dry			Dry			Dry			11			Dry		
	Below Ballard Mine	MST095	15			NS			32			Dry			Dry			Dry			Dry			Dry			42			31			Dry			Dry			39			Dry		
	Below Ballard Mine	MST096	22			NS			16			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			Dry			17			19		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 16a
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Nickel																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.17			0.17			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.021			0.0093		J	NS			0.024	0.028	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.0011	0.0035	UJ	NS			0.0034	0.028	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			0.0031	0.0035	UJ	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			0.0014	0.0035	UJ	NA			0.0039	0.028	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			Dry			0.024	0.028	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.034			0.018			0.0032			0.0063		J	NS			0.014	0.028	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.0027	0.028	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.0017	0.0035	UJ	0.00090	0.0045	U	0.0021	0.028	U	0.045		
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.0010	0.0035	UJ	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0025	0.0035	UJ	NA			0.0023	0.028	U	0.037		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.0011			0.0010	0.0035	UJ	NS			0.0068	0.028	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.0086	0.028	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.0052	0.028	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.014		J	Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.027		J	0.018			0.033			0.0066		
	Above Ballard Mine	MST093	NS			NS			NS			0.0016	0.0035	UJ	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			0.00090	0.0035	UJ	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.0074		J	Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.0026	0.0035	UJ	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 16b
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Nickel																							
			2003																		2004					
Mine	Station Name	Station ID	Jan	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.19			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.014			0.0087		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.00050	0.0050	U	0.0020		
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.0032			0.0026			Dry			Dry			0.0031	0.0050	U	Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.0015	0.0050	U	Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.00020	0.0050	U	0.0019		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.0053			0.020		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.013			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.0057			0.0085		
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.0013	0.0015	U	NS			NS			0.00080	0.0050	U	0.0032		
	Above West Fork Lone Pine Creek	MST064[c]	0.0028			NA			0.0018	0.0020	U	0.0013	0.0015	U	0.0012	0.013	U	0.00090	0.0030	U	0.00040	0.0050	U	0.0016		
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.0029			0.0019			0.0026			0.0022			0.0020			0.019			0.0013	0.0050	U	0.0020		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.0013	0.0050	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.0031	0.0050	U	0.0050		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.0011	0.0050	U	0.0057		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.0067			0.011		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.011			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.0025	0.0050	U	0.0066		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.0023	0.0050	U	0.0089		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.00018	0.00020	U	0.0039		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.00010	0.00020	U	0.0072		
	Headwaters	MST067	Dry			Dry			0.010			0.010			Dry			Dry			0.013			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			0.0010	0.0030	U	Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.019			0.020			0.019			NA			0.025			0.037		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NS			0.00080	0.0050	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.0015	0.0020	U	Dry			Dry			Dry			0.00050	0.0050	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.0093			0.0071			Dry			Dry			0.0068			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.00050	0.0050	U	0.0036		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 17
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Potassium																		Sodium																	
			2000			2001			2002						2004						2000			2001			2002						2004					
Mine	Station Name	Station ID	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			3.0			3.1			Dry			3.4			Dry			NS			12		J	13			Dry			12			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			1.6			0.90			13			5.3			1.8			NS			16		J	8.7			17	17	UJ	17			17		
	Hedin Spring	MSG001[c]	NS			NS			0.60			0.70	4.5	U	0.70			0.63			NS			NS			5.5			5.5	17	UJ	5.6			5.7		
	Above Lone Pine Creek	MST059	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Headwaters	MST136	NA			NS			2.0			Dry			2.5			Dry			NA			NS			8.0			Dry			8.6			Dry		
	Headwaters, below West Pond	MST144	NA			NS			Dry			Dry			1.4			Dry			NA			NS			Dry			Dry			6.8			Dry		
	Headwaters	MST269	NS			NS			Dry			6.3			Dry			Dry			NS			NS			Dry			4.5	17	UJ	Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			0.50			1.1	4.5	U	0.60			7.8			NS			NS			4.5			4.1	17	UJ	4.9			4.7		
	Above East Fork Lone Pine Creek	MST275	NS			NS			Dry			NA			20			100			NS			NS			Dry			NA			4.6			17		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			Dry			Dry			1.1			Dry			NS			NS			Dry			Dry			9.3			Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			0.88			2.7			2.5	4.5	U	1.4			1.9			NS			15		J	18			16	17	UJ	14			17		
	Taylor Spring	MSG002	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			7.0	4.5	U	12			3.4			NS			NS			NS			12	17	UJ	6.8			9.2		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			0.60			0.80	4.5	U	0.60			0.73			NS			NS			7.1			10	17	UJ	9.4			10		
	Below Wooley Valley Mine	MST226	1.0			NS			0.70			Dry			Dry			Dry			3.0			NS			2.5			Dry			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	NS			NS			1.0			0.60	4.5	U	0.50			0.70			NS			NS			6.1			7.5	17	UJ	7.0			7.9		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			9.1			Dry			NS			NS			NS			NS			7.0			Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			1.0			0.80			NS			NS			NS			NS			11			10		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			1.5			1.7			NS			NS			NS			NS			11			12		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			2.6			9.0			NS			NS			NS			NS			37			38		
	Goat Seep	MDS033	NS			NS			NS			NS			3.0			Dry			NS			NS			NS			NS			28			Dry		
	Garden Hose Spring	MSG003	NS			2.3			0.80			0.70	4.5	U	0.80			0.90			NS			NS			10			9.2	17	UJ	9.5			9.2		
	Holmgren Spring	MSG004	NS			NS			NS			1.8	4.5	U	1.5			1.9			NS			NS			NS			4.3	17	UJ	4.7			4.8		
	Cattle Spring	MSG005[c]	NS			NS			NS			0.60	4.5	U	0.50			0.63			NS			NS			NS			4.3	17	UJ	4.2			4.6		
	Southeast Spring	MSG006	NS			NS			NS			Dry			0.70			1.4			NS			NS			NS			NS			9.0			9.9		
	Headwaters	MST067	NS			NS			2.2			Dry			1.7			Dry			NS			NS			25			Dry			30			Dry		
	Headwaters	MST068	NS			NS			Dry			Dry			Dry			Dry			NS			NS			Dry			Dry			Dry			Dry		
	Below Ballard Mine	MST069[a]	NS			NS			3.0			9.2			2.7			3.9			NS			NS			25			25	J		25			24		
	Above Ballard Mine	MST093	NS			NS			0.80			Dry			0.40			Dry			NS			NS			7.6			Dry			7.0			Dry		
	Below Ballard Mine	MST094	Dry			NS			0.60			Dry			1.2			Dry			Dry			NS			2.3			Dry			5.0			Dry		
	Below Ballard Mine	MST095	2.0			NS			0.50			Dry			0.20	0.30	U	Dry			7.0			NS			7.4			Dry			7.7			Dry		
	Below Ballard Mine	MST096	0.37			NS			1.6			Dry			1.2			1.6			6.0			NS			5.6			Dry			5.4			5.7		

Notes:

[a] Average of the QA replicate samples reported for Spring 2002.

[b] Average of the QA replicate samples reported for Spring 2004.

[c] Average of the QA replicate samples reported for Fall 2004.

Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

RL - Reporting Limit

NS - Not Sampled

Dry - Station was dry.

NA - Not Analyzed.

Table 18
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Selenium						Silver			Sulfate																Thallium			Uranium		
			2004						2001			2000			2001			2002						2004						2001			2001		
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	0.013			Dry			-0.000012	0.00025	U	NS			700		J	620		J	Dry			590			Dry			0.00029	0.0025	U	0.0023		
	Enoch Valley Mine South Dump Seep	MDS026	0.32			0.0060			-0.000028	0.00025	U	NS			645		J	470		J	620		J	810			0	0.50	U	0.000081	0.0025	U	0.071		
	Hedin Spring	MSG001[c]	0.000060	0.0010	U	0.00078	0.0010	U	NS			NS			NS			9.8			11		J	10			11			NS			NS		
	Above Lone Pine Creek	MST059	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above Lone Pine Creek	MST060	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above Lone Pine Creek	MST061	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Headwaters	MST136	0.016			Dry			NS			NA			NS			150			Dry			140			Dry			NS			NS		
	Headwaters, below West Pond	MST144	0.18			Dry			NS			NA			NS			Dry			Dry			340			Dry			NS			NS		
	Headwaters	MST269	Dry			Dry			NS			NS			NS			Dry			55		J	Dry			Dry			NS			NS		
	Above Rasmussen Creek	MST274	0.0030			0.000040	0.0010	U	NS			NS			NS			34			18		J	37			16			NS			NS		
	Above East Fork Lone Pine Creek	MST275	-0.00030	0.0010	U	-0.00011	0.0010	U	NS			NS			NS			Dry			NA			8.6			2.2			NS			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	-0.00034	0.0010	U	Dry			NS			NS			NS			Dry			Dry			350			Dry			NS			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	NA			0.00044	0.0010	U	-0.000016	0.00025	U	NS			76		J	57		J	38		J	60			49			0.000051	0.0025	U	0.0067		
	Taylor Spring	MSG002	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Above West Fork Lone Pine Creek	MST058	-0.00045	0.0010	U	-0.00093	0.0010	U	NS			NS			NS			NS			13		J	19			34			NS			NS		
	Above West Fork Lone Pine Creek	MST064[c]	0.0030			0.0013			NS			NS			NS			37			27		J	40			39			NS			NS		
	Below Wooley Valley Mine	MST226	Dry			Dry			NS			9.0			NS			8.2			Dry			Dry			Dry			NS			NS		
	Above West Fork Lone Pine Creek	MST276	0.0030			0.0020			NS			NS			NS			59			39		J	40			47			NS			NS		
	Tributary Above Lone Pine Creek	MST277[b]	-0.00088	0.0010	U	Dry			NS			NS			NS			NS			NS			3.7			Dry			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	0.42			0.59			NS			NS			NS			NS			NS			140			15			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	0.45			0.43			NS			NS			NS			NS			NS			160			200			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	0.45			0.29			NS			NS			NS			NS			NS			570			440			NS			NS		
	Goat Seep	MDS033	1.4			Dry			NS			NS			NS			NS			NS			720						NS			NS		
	Garden Hose Spring	MSG003	0.39			0.46			0.0000011	0.00025	U	NS			160			120			120		J	120			110			0.00016	0.0025	U	0.0022		
	Holmgren Spring	MSG004	0.0090			0.018			NS			NS			NS			NS			45		J	34			46			NS			NS		
	Cattle Spring	MSG005[c]	0.0070			0.0040			NS			NS			NS			NS			31		J	34			30			NS			NS		
	Southeast Spring	MSG006	0.21			0.26			NS			NS			NS			NS			NS			390			440			NS			NS		
	Headwaters	MST067	0.010			Dry			NS			NS			NS			780			Dry			810			Dry			NS			NS		
	Headwaters	MST068	Dry			Dry			NS			NS			NS			Dry			Dry			Dry			Dry			NS			NS		
	Below Ballard Mine	MST069[a]	0.64			0.49			NS			NS			NS			1000			NA			1200			760			NS			NS		
	Above Ballard Mine	MST093	0.0010			Dry			NS			NS			NS			18		J	Dry			17			Dry			NS			NS		
	Below Ballard Mine	MST094	0.021			Dry			NS			Dry			NS			7.7		J	Dry			13			Dry			NS			NS		
	Below Ballard Mine	MST095	NA			Dry			NS			69			NS			290		J	Dry			270			Dry			NS			NS		
	Below Ballard Mine	MST096	0.016			0.027			NS			110			NS			110		J	Dry			100			59			NS			NS		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 19a
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Vanadium																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.0028		J	-0.0010	0.0050	U	NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.0018		J	0	0.0050	U	NS			0.0014	0.0050	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.0030	0.0050	U	NS			0.00029	0.0050	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			-0.0010	0.0050	U	Dry			Dry			NS		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			-0.0020	0.0050	U	NA			0.00075	0.0050	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			NS			0.0088			NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.023			0.0040	0.0043	U	0.024		J	0	0.0050	U	NS			0.00016	0.0050	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.00067	0.0050	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.0020	0.0050	U	0.00070			0.00043	0.0050	U	0.00074		
	Below Wooley Valley Mine	MST226	NS			NS			NS			-0.0030	0.0050	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0050	0.0050	U	NA			0.0011	0.0050	U	0.0010		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.0028		J	0.0020	0.0050	U	NS			0.0010	0.0050	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.0016	0.0050	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.00036	0.0050	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.019			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			Dry			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.0010	0.0050	U	0.0016			0.0022	0.0050	U	0.0019		
	Above Ballard Mine	MST093	NS			NS			NS			0.011			NS			Dry			Dry		
	Below Ballard Mine	MST094	NS			NS			NS			-0.0010	0.0050	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.0030	0.0050	U	Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			-0.0010	0.0050	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 19b
Seeps, Springs, and Headwater Streams - Filtered Uncensored Results (mg/L)

Station			Vanadium																							
			2003																		2004					
Mine	Station Name	Station ID	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS			NS			NS			NS			0.0011			Dry		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS			NS			NS			NS			0.0034			0.00089		
	Hedin Spring	MSG001[c]	NS			NS			NS			NS			NS			NS			0.00020	0.00048	U	-0.000057	0.00079	U
	Above Lone Pine Creek	MST059	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.0016			0.0013			Dry			Dry			0.0022			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00058			Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.00056			0.00047	0.00079	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.011			0.0034		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			NS			NS			NS			0.00040	0.00048	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS			NS			NS			NS			0.00013	0.00048	U	-0.00014	0.000050	U
	Taylor Spring	MSG002	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.00060			NS			NS			0.00072			0.0013		
	Above West Fork Lone Pine Creek	MST064[c]	0.0055			NA			0.00069			0.00064			0.00065			0.00093			0.00065			0.00065	0.00079	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.00085			0.00092			0.0014			0.0011			0.0010			0.0014			0.0011			0.00086		
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.00029	0.00030	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			0.00090			0.00054	0.00079	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			0.00099			0.00075	0.00079	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			0.0011			0.00081		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			0.0016			Dry		
	Garden Hose Spring	MSG003	NS			NS			NS			NS			NS			NS			0.0011			0.00087		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			NS			0.0016			0.0052		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			NS			0.00024	0.00048	U	0.00013	0.00079	U
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			0.00073			0.0011		
	Headwaters	MST067	Dry			Dry			0.018			0.013			Dry			Dry			0.0084			Dry		
	Headwaters	MST068	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	NA			Dry			0.0015			0.0020			0.0015			0.0019			0.0011			0.0011		
	Above Ballard Mine	MST093	NS			NS			NS			NS			NS			NA			0.0062			Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.00080			Dry			Dry			Dry			0.0017			Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.0038			0.0057			Dry			Dry			0.0023			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry			Dry			Dry			Dry			0.00072			0.00013	0.00079	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 20a
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

Station			Zinc																				
			1998[d]						2001			2002											
Mine	Station Name	Station ID	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	May	RL	Flag	July	RL	Flag	Sept.	RL	Flag	Nov.	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			0.14		J	0.12			NS			Dry			NS		
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			0.047		J	0.0070	0.015	U	NS			0.023	0.075	U	NS		
	Hedin Spring	MSG001[c]	NS			NS			NS			0.00064	0.0020	U	NS			0.0090	0.075	U	NS		
	Above Lone Pine Creek	MST059	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST060	NS			NS			NS			Dry			NS			Dry			NS		
	Above Lone Pine Creek	MST061	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST136	NS			NS			NS			0.0015	0.0020	U	Dry			Dry			Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			Dry			NS			Dry			NS		
	Headwaters	MST269	NS			NS			NS			Dry			NS			NA			NS		
	Above Rasmussen Creek	MST274	NS			NS			NS			0.00092	0.0020	U	NA			0.011	0.075	U	NS		
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			Dry			NS			0.020	0.075	U	NS		
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS			Dry			NS			Dry			NS		
	South Pit Overburden Limestone Drain	MDS022[a]	0.0060			-0.0010	0.0011	U	0.10			0.0018			NS			0.0080	0.075	U	NS		
	Taylor Spring	MSG002	NS			NS			NS			Dry			NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			NS			NS			0.010	0.075	U	NS		
	Above West Fork Lone Pine Creek	MST064[c]	NS			NS			NS			0.00081	0.0020	U	0.014	0.070	U	0.0070	0.075	U	0.0090	0.045	UJ
	Below Wooley Valley Mine	MST226	NS			NS			NS			0.0030	0.015	U	NS			Dry			NS		
	Above West Fork Lone Pine Creek	MST276	NS			NS			NS			0.0019	0.0020	U	NA			0.0060	0.075	U	0.011	0.045	UJ
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			NS		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS			NS			NS			NS			NS		
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS			NS			NS			NS			NS		
	Goat Seep	MDS033	NS			NS			NS			NS			NS			NS			NS		
	Garden Hose Spring	MSG003	NS			NS			0.016		J	0.00075	0.0020	U	NS			0.0090	0.075	U	NS		
	Holmgren Spring	MSG004	NS			NS			NS			NS			NS			0.011	0.075	U	NS		
	Cattle Spring	MSG005[c]	NS			NS			NS			NS			NS			0.019	0.075	U	NS		
	Southeast Spring	MSG006	NS			NS			NS			NS			NS			NS			NS		
	Headwaters	MST067	NS			NS			NS			0.033			Dry			Dry			Dry		
	Headwaters	MST068	NS			NS			NS			Dry			NS			NS			NS		
	Below Ballard Mine	MST069[a]	NS			NS			NS			0.0073	0.015	U	0.016	0.070	U	0.011	0.075	U	0.013	0.045	UJ
	Above Ballard Mine	MST093	NS			NS			NS			0.0011	0.0020	U	NS			Dry			NS		
	Below Ballard Mine	MST094	NS			NS			NS			0.0020	0.015	U	Dry			Dry			Dry		
	Below Ballard Mine	MST095	NS			NS			NS			0.016			Dry			Dry			Dry		
	Below Ballard Mine	MST096	NS			NS			NS			0.0060	0.015	U	Dry			Dry			Dry		

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Table 20b
Seeps, Springs, and Headwater Streams - Filtered Censored Results (mg/L)

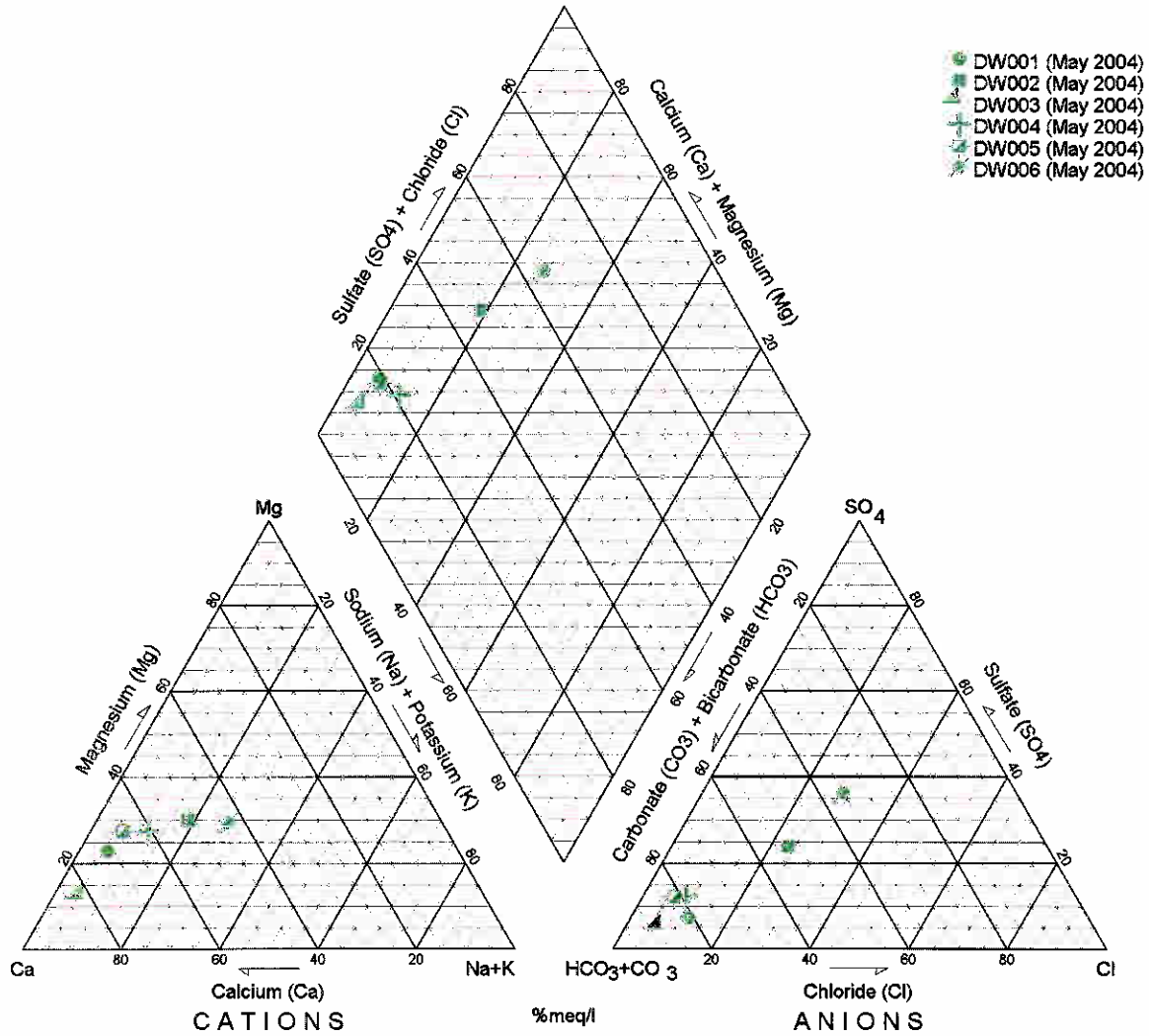
Station			Zinc																							
			2003																		2004					
Mine	Station Name	Station ID	Jan.	RL	Flag	Mar.	RL	Flag	April	RL	Flag	May	RL	Flag	June	RL	Flag	July	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Enoch Valley Mine	Enoch Valley Mine West Dump Seep	MDS025	NS			NS			NS						NS			NS			0.049	0.00040	U			
	Enoch Valley Mine South Dump Seep	MDS026	NS			NS			NS						NS			NS			0.016	0.00040	U	0.0040	0.015	U
	Hedin Spring	MSG001[c]	NS			NS			NS						NS			NS			0.00130	0.00040	U	0.0017	0.0020	U
	Above Lone Pine Creek	MST059	NS			NS			NS						NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST060	NS			NS			NS						NS			NS			Dry			Dry		
	Above Lone Pine Creek	MST061	NS			NS			NS						NS			NS			Dry			Dry		
	Headwaters	MST136	Dry			Dry			0.010	0.045	U	0.014	0.070	U	Dry			Dry			0.0018	0.0020	U	Dry		
	Headwaters, below West Pond	MST144	NS			NS			NS			NS			NS			NS			0.00400	0.00040	U	Dry		
	Headwaters	MST269	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above Rasmussen Creek	MST274	NS			NS			NS			NS			NS			NS			0.00081	0.0020	U	0.00081	0.0020	U
	Above East Fork Lone Pine Creek	MST275	NS			NS			NS			NS			NS			NS			0.0011	0.00040	U	0.0060	0.015	U
Henry Mine	South Pit Overburden Dump Seep	MDS016	NS			NS			NS						NS			NS			0.0080	0.00040	U	Dry		
	South Pit Overburden Limestone Drain	MDS022[a]	NS			NS			NS						NS			NS			0.0012	0.0020	U	0.0020	0.015	U
	Taylor Spring	MSG002	NS			NS			NS						NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST058	NS			NS			NS			0.0090	0.070	U	NS			NS			0.0080	0.00040	U	0.0030	0.015	U
	Above West Fork Lone Pine Creek	MST064[c]	0.0060	0.065	U	NA			0.0080	0.045	U	0.010	0.070	U	0.015	0.080	U	0.012	0.075	U	0.00094	0.0020	U	0.0015	0.0020	U
	Below Wooley Valley Mine	MST226	NS			NS			NS			NS			NS			NS			Dry			Dry		
	Above West Fork Lone Pine Creek	MST276	0.0067	0.065	U	0.0087	0.050	U	0.012	0.045	U	0.013	0.070	U	0.013	0.080	U	0.019	0.075	U	0.0015	0.0020	U	0.00084	0.015	U
	Tributary Above Lone Pine Creek	MST277[b]	NS			NS			NS			NS			NS			NS			0.0016	0.010	U	Dry		
Ballard Mine	Pit #2 Upper Dump Seep	MDS030	NS			NS			NS						NS			NS			0.0030	0.0020	U	0.0011	0.0020	U
	Pit #2 Lower Dump Seep South	MDS031	NS			NS			NS						NS			NS			0.0018	0.0020	U	0.0020	0.015	U
	Pit #2 Lower Dump Seep North	MDS032	NS			NS			NS						NS			NS			0.0040	0.0020	U	0.0060	0.015	U
	Goat Seep	MDS033	NS			NS			NS						NS			NS			0.0070	0.0020	U	Dry		
	Garden Hose Spring	MSG003	NS			NS			NS						NS			NS			0.00084	0.0020	U	0.0014	0.0020	U
	Holmgren Spring	MSG004	NS			NS			NS						NS			NS			0.0030	0.00040	U	0.0015	0.0020	U
	Cattle Spring	MSG005[c]	NS			NS			NS						NS			NS			0.0030	0.00040	U	0.00061	0.0020	U
	Southeast Spring	MSG006	NS			NS			NS						NS			NS			0.00075	0.0020	U	0.0030	0.015	U
	Headwaters	MST067	Dry			Dry			0.031	0.045	U	0.037	0.070	U	Dry			Dry			0.027			Dry		
	Headwaters	MST068	NS			NS			NS						NS			NS			Dry			Dry		
	Below Ballard Mine	MST069[a]	Dry			Dry			0.014	0.045	U	0.014	0.070	U	0.013	0.080	U	0.017	0.075	U	0.0090	0.015	U	0.011	0.0020	U
	Above Ballard Mine	MST093	NS			NS			NS						NS			NS			-0.00023	0.00040	U	Dry		
	Below Ballard Mine	MST094	Dry			Dry			0.012	0.045	U				Dry			Dry			0.0012	0.00040	U	Dry		
	Below Ballard Mine	MST095	Dry			Dry			0.031	0.045	U	0.023	0.070	U	Dry			Dry			0.013			Dry		
	Below Ballard Mine	MST096	Dry			Dry			Dry						Dry			Dry			0.017	0.00040	U	0.0020	0.015	U

Notes:
[a] Average of the QA replicate samples reported for Spring 2002.
[b] Average of the QA replicate samples reported for Spring 2004.
[c] Average of the QA replicate samples reported for Fall 2004.
[d] Data from 1998 are flagged for samples below the detection limit only. Additional flags were not in use in 1998.
Data validation was performed in accordance with *MWH SOP-NW-18.1* and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* .
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.
RL - Reporting Limit
NS - Not Sampled
Dry - Station was dry.
NA - Not Analyzed.

Appendix E
Major Ion Plots

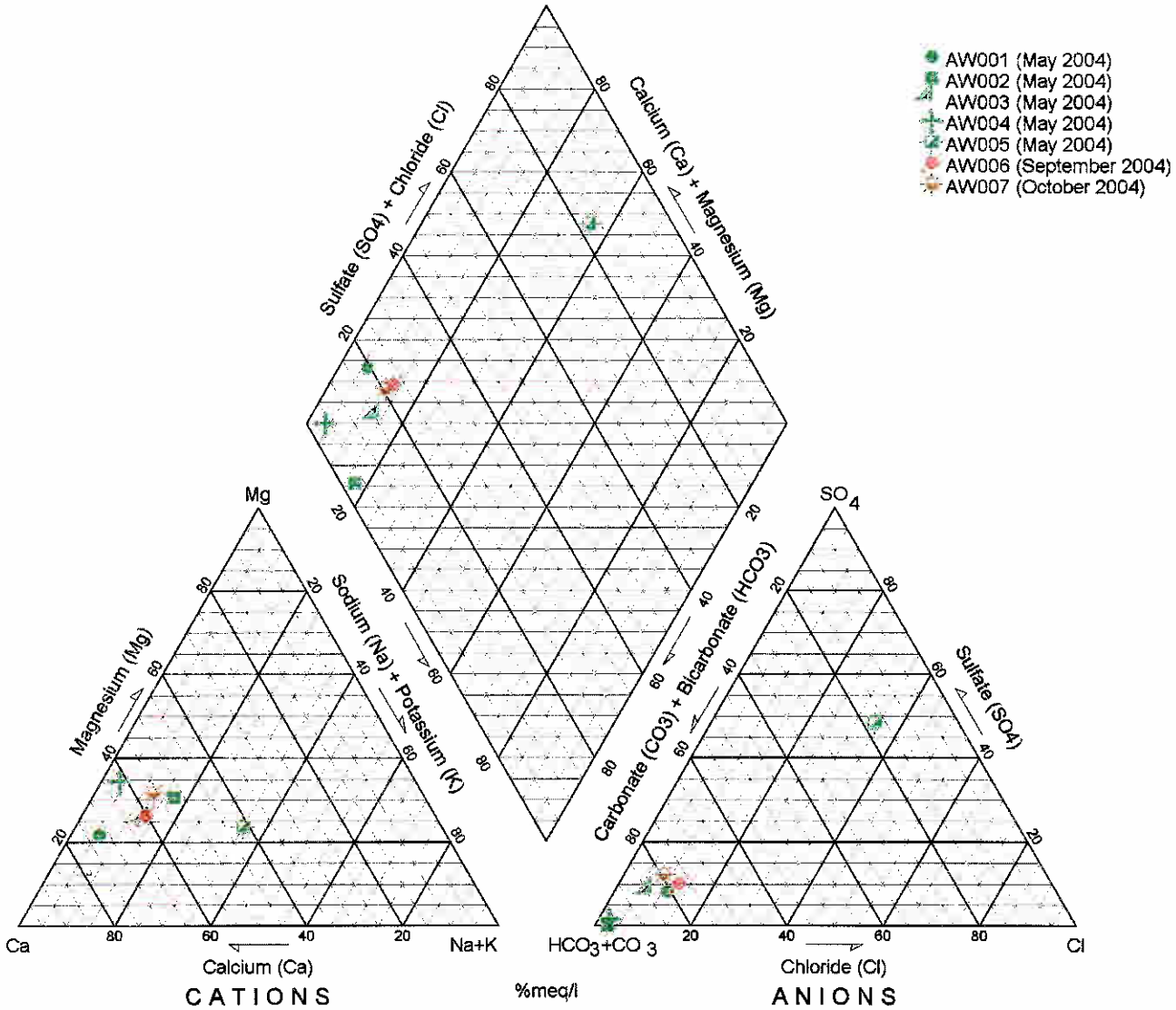
Piper Diagram

Domestic Wells



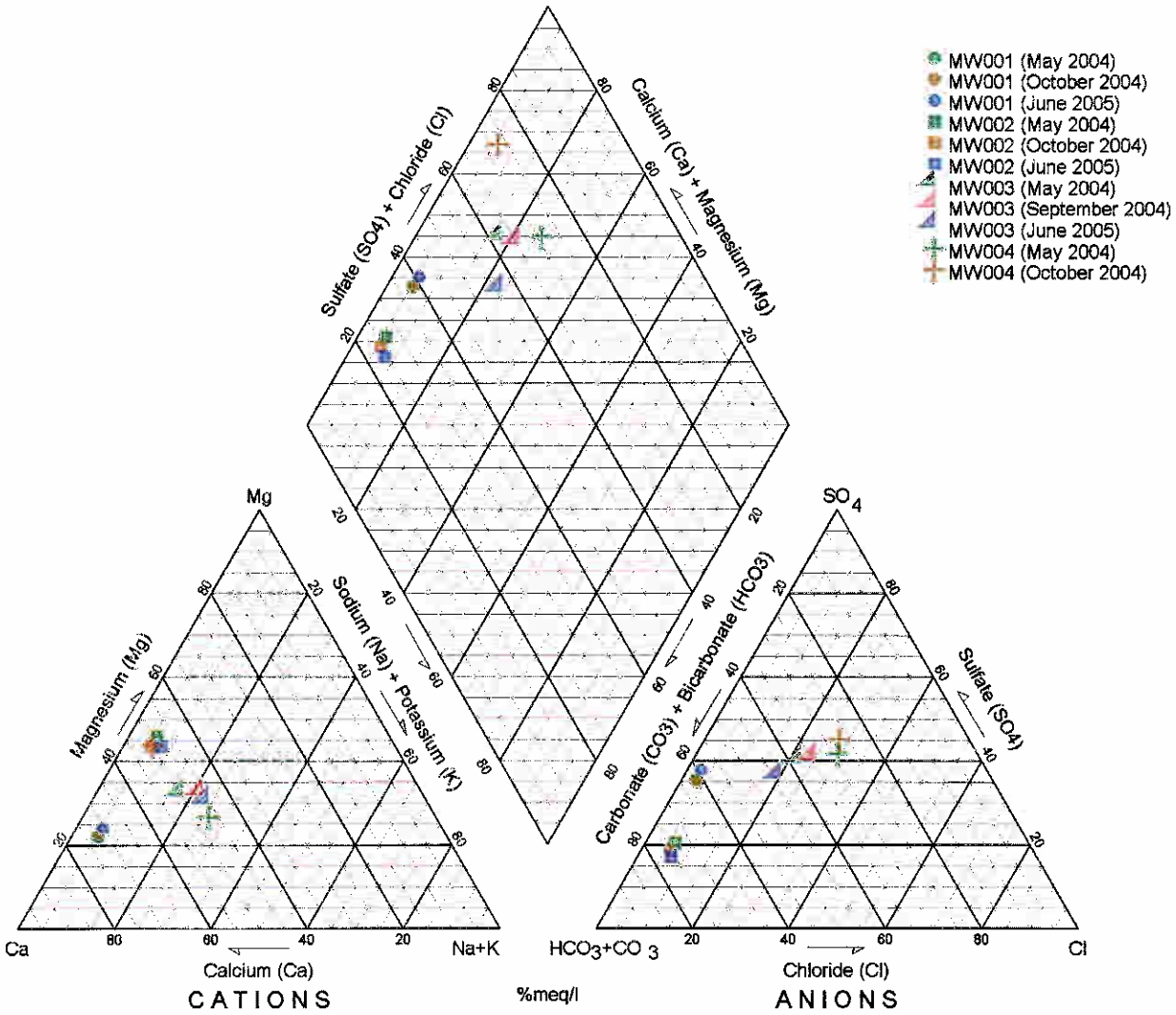
Piper Diagram

Agricultural Wells



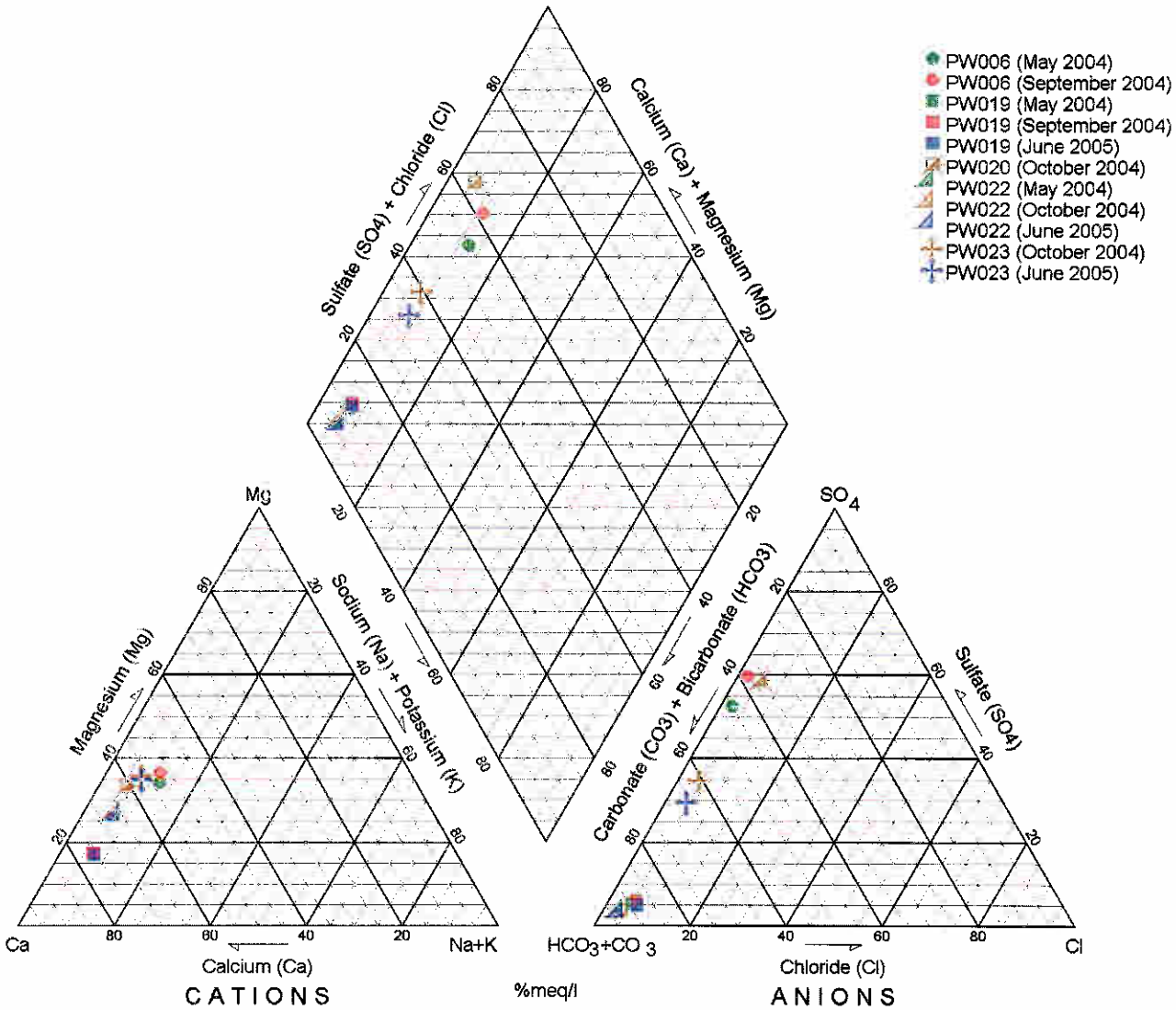
Piper Diagram

Monitoring Wells

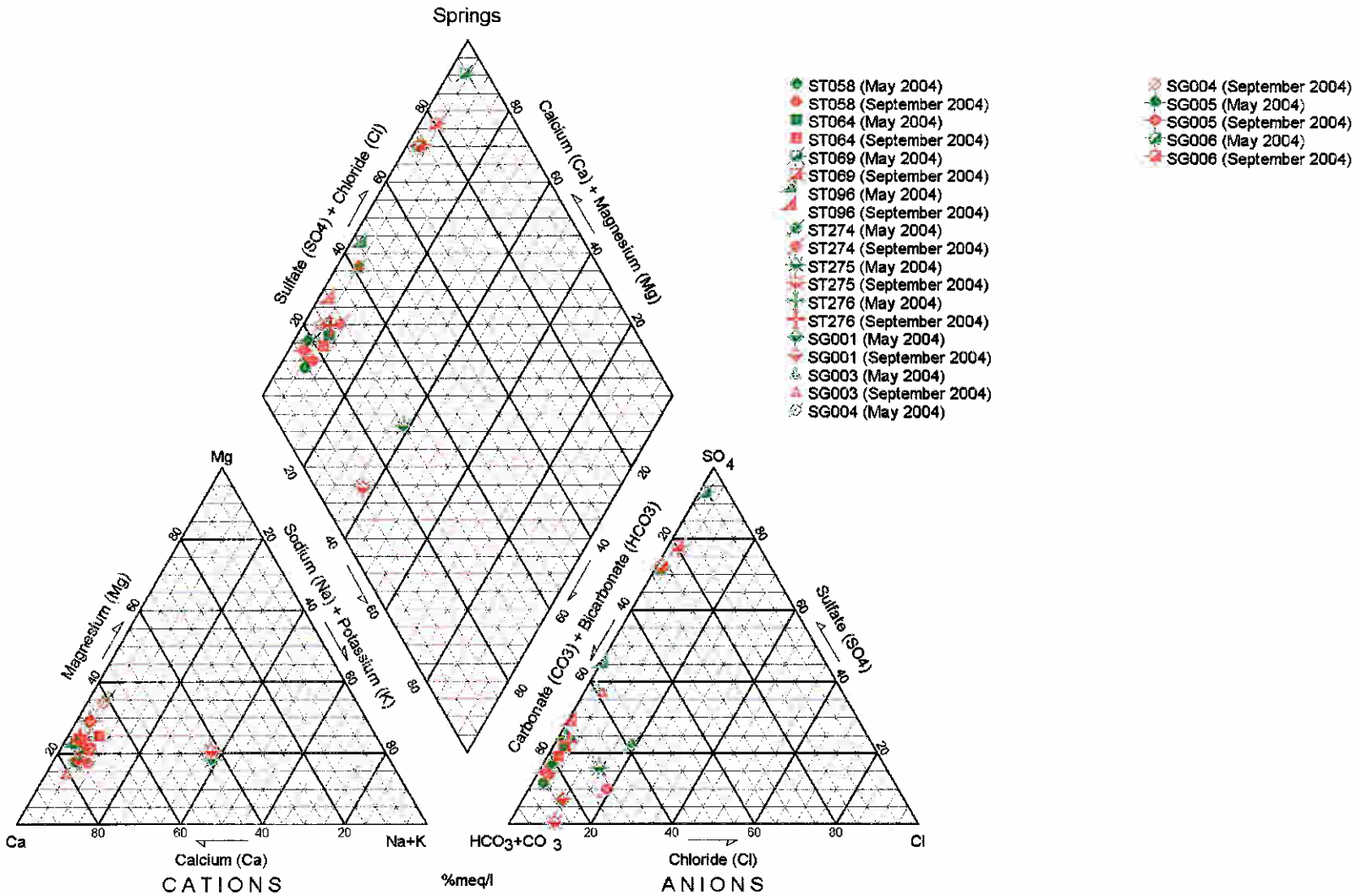


Piper Diagram

Production Wells

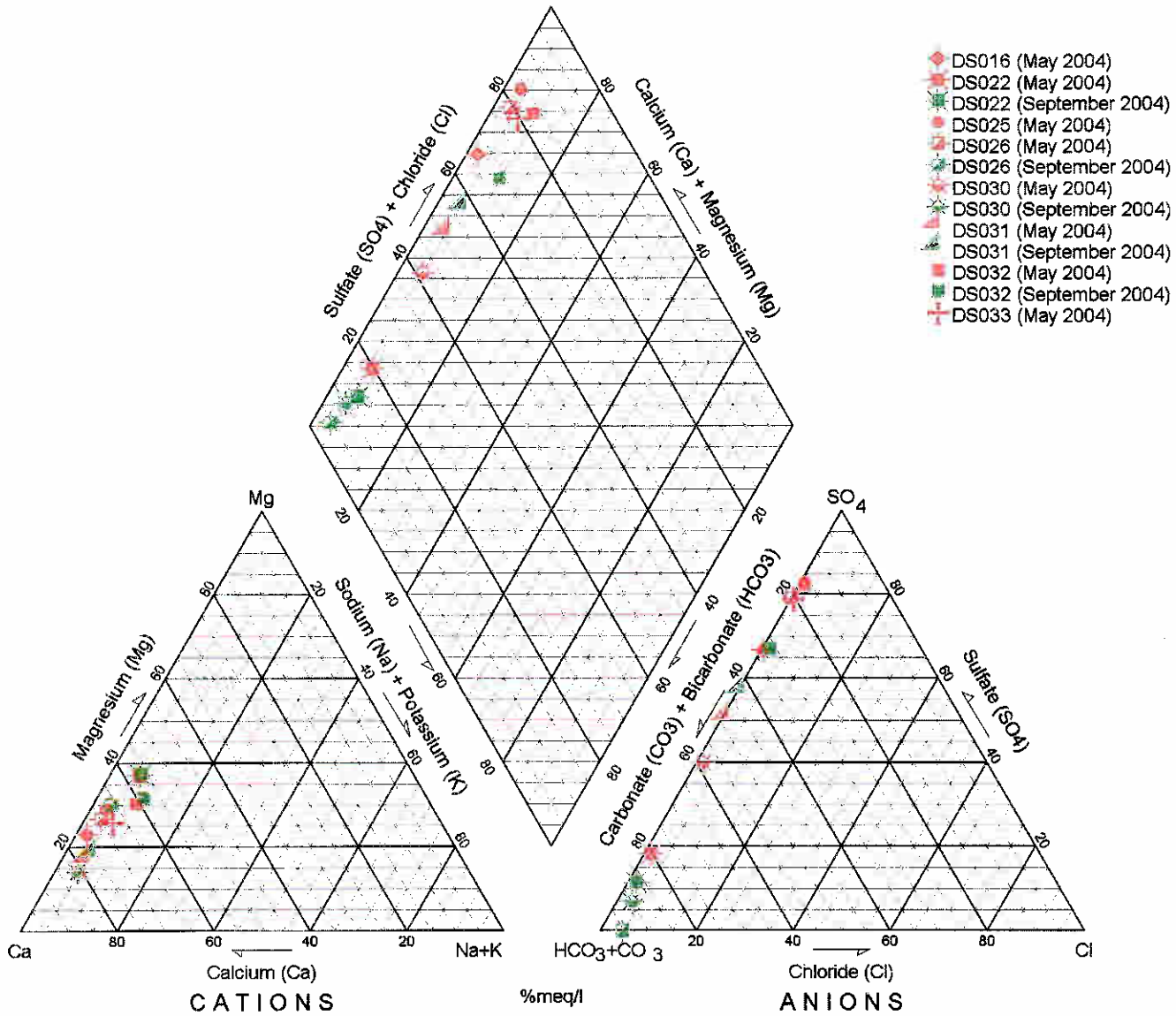


Piper Diagram

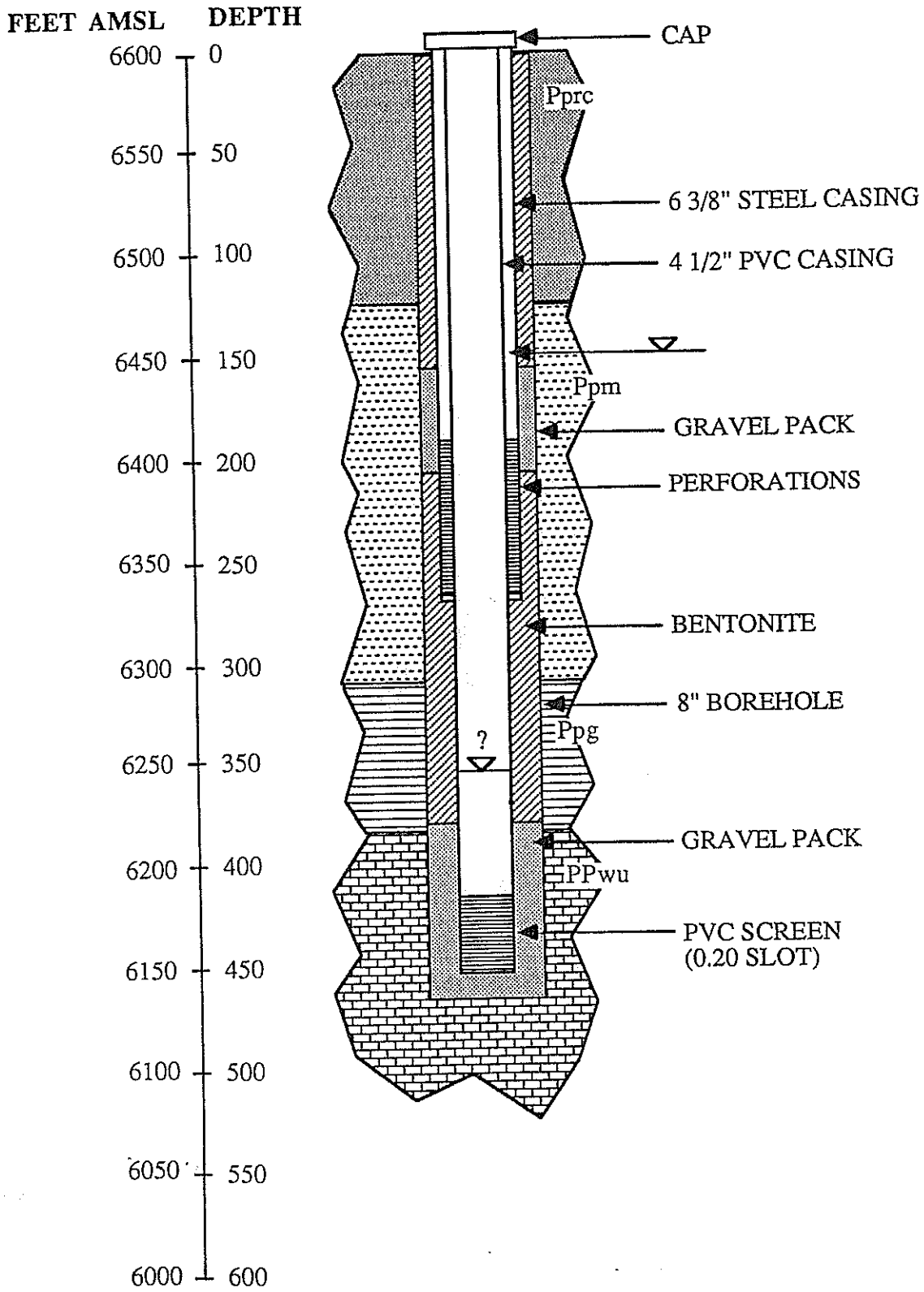


Piper Diagram

Dump Seeps



Appendix F
Well Logs



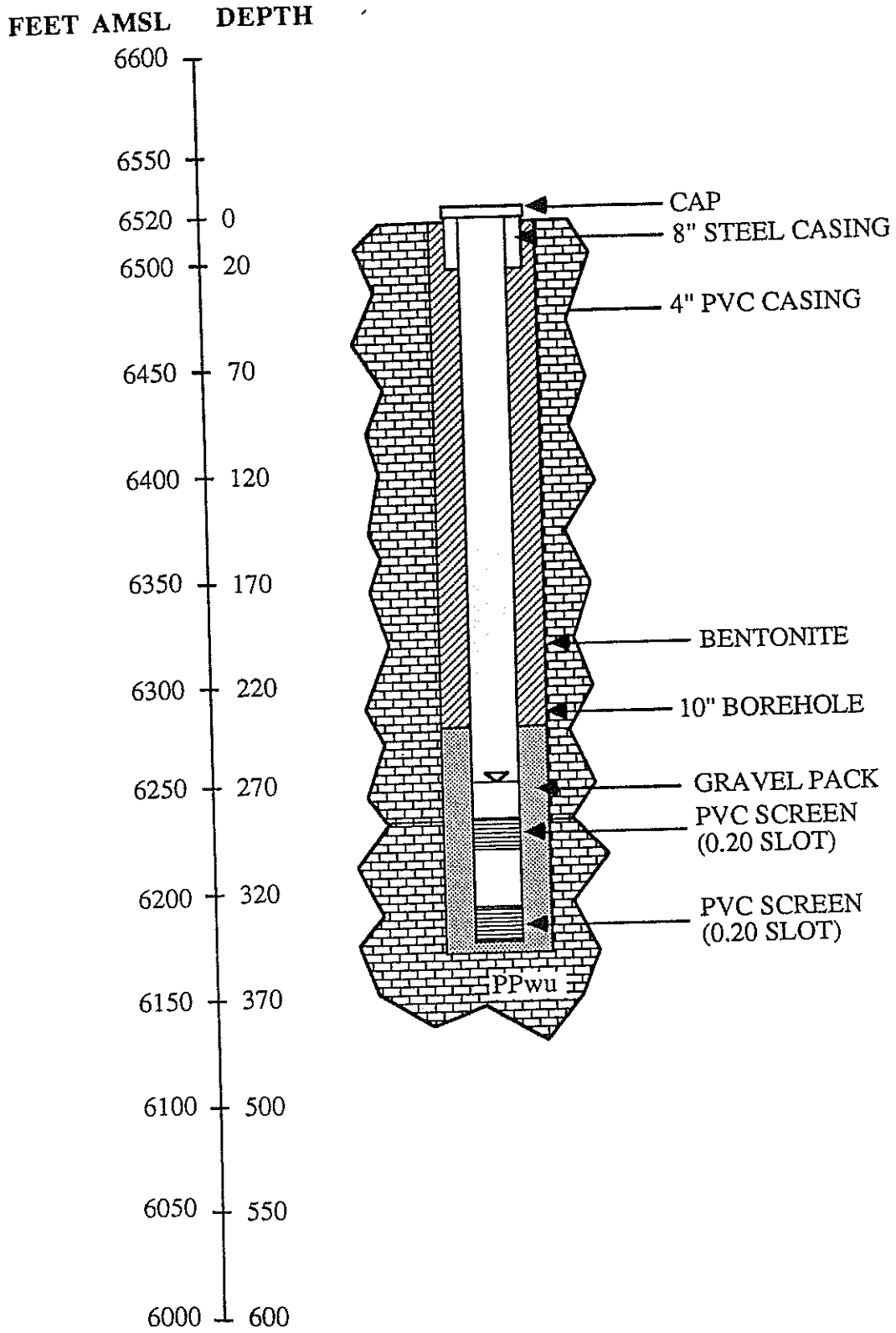
MW001

Geologic Log of Monitor Well #1

HOWARD CONSULTANTS, INC.
CONSULTING GEOTECHNICAL ENGINEERS

DATE ____ BY ____ FILE ____ CHECKED BY ____

PLATE 2



Geologic Log of Monitor Well #2

MW002

HOWARD CONSULTANTS, INC.
CONSULTING GEOTECHNICAL ENGINEERS

DATE
BY
FILE
CHECKED BY

PLATE 3

Form 238-7
8/90

MW-1

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name Monsanto Co. #1 E.

Address Box 816 Soda Springs, Id. 83276

Drilling Permit No. 27-92E-060-001.

Water Right Permit No. _____

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☒ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☒ Other PVC F.J.

Thickness	Diameter	From	To
.250 inches	6 5/8 inches +	2 feet	271 feet
.250 inches	4½ PVC inches +	2 feet	452 feet
inches	inches	feet	feet
inches	inches	feet	feet

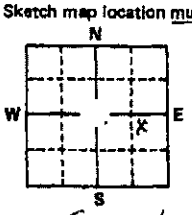
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☒ Yes ☐ No
Perforated? ☒ Yes ☐ No
How perforated? ☒ Factory ☐ Knife ☐ Torch ☐ Gun
Size of perforation .020 inches by 2 inches

		From	To
PVC Size .020	perforations	420 feet	450 feet
	perforations	feet	feet
Steel 80	perforations	191 feet	271 feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☒ Yes ☐ No ☐ Size of gravel 3/8 -
Placed from 380 feet to 450 feet
Surface seal depth _____ Material used in seal: ☐ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ Temp. surface casing (cent)
☒ Overbore to seal depth
Method of joining casing: ☒ Threaded PVC ☒ Welded STEEL ☐ Solvent Weld
☐ Cemented between strata
Describe access port Locking Cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



~~Subdivision Name~~ _____

Collar Elev. _____

Lot No. _____ Block No. _____

County Caribou

NE ¼ SE ¼ Sec. 12, T. 7 N ☐ S ☒, R. 42 E ☒ W ☐

7. WATER LEVEL

Static water level 190 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 49 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
15	210	4

9. LITHOLOGIC LOG 103888

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
12"	0	10	cherty overburden		X
	10	100	Med. Lt. Shale		
	100	130	" Blk. "		
	130	150	" Chert		
	150	170	" Blk. Shale		
	170	190	Phosphate - 15 GPM	X	
	190	212	Med. Blk. shale		X
7 7/8	212	265	" " "	X	
"	265	290	hard ls.		X
6"	290	345	Med. to hard shale		
	345	385	phosphate		
	385	395	fine well silts		
	395	410	Hard ls.		
	410	420	Broken ls.		
	420	460	Hard ls.		

RECEIVED
JAN 01 1993
Department of Water Resources
Eastern District Office

RECEIVED
FEB 22 1993
Department of Water Resources

10.

Work started 11-11-92 finished 12-29-92

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Firm No. 215

Address Soda Springs Date 12-30-92

Signed by (Firm Official) R. Nelson

and

(Operator) [signature]

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
9/90

MW002

USE TYPEWRITER OR BALLPOINT

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name MONSANTO Co. #2 W.

Address Box 816 Soda Springs, Id. 83276

Drilling Permit No. 27-92E-060-002

Water Right Permit No. _____

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☒ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☒ Other PVC F.J.

	Thickness	Diameter	From	To
Steel	.250 inches	8" ID inches	+ 2 feet	20 feet
PVC	.250 inches	4" ID inches	+ 2 feet	348 feet
	inches	inches	feet	feet
	inches	inches	feet	feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☒ Factory ☐ Knife ☐ Torch ☐ Gun
Size of perforation .020 inches by 2 inches

Number	From	To
.020 perforations	328 feet	348 feet
.020 perforations	288 feet	308 feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☒ Yes ☐ No ☐ Size of gravel 3/8 -
Placed from 250 feet to 350 feet
Surface seal depth 20 Material used in seal: ☐ Cement grout ☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ ~~Temp.~~ Perm. surface casing ☒ Overbore to seal depth
Method of joining casing: ☒ Threaded PVC ☒ Welded Steel ☐ Solvent Weld ☐ Cemented between strata

7. WATER LEVEL

Static water level 223 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 49 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
25	330	4

9. LITHOLOGIC LOG

103889

Bore Diam.	Depth From	Depth To	Material	Water Yes
12¼	0	12	overburden	
"	12	19	Med. Sandstone	
7⅞	19	42	" "	
	42	54	Hard limestone	
	54	60	Med. Sandstone	
	60	73	Hard "	
	73	169	Med. "	
	169	178	Hard "	
	178	220	Med "	
	220	259	Med. limestone	
	259	270	Med. Sandstone	
	270	282	Med. limestone 15GPM	X
	282	286	Hard "	
	286	330	Med. " 10GPM	X
	330	400	Hard "	

RECEIVED
JAN 07 1993
Department of Water Resources
Eastern District Office

RECEIVED
FEB 22 1993
Department of Water Resources

Form 238-7
4/92

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

RECEIVED
APR 1 8 1994
Department of Water Resources

USE TYPEWRITER OR BALLPOINT PEN

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

PW006 (2 wells)

0-7539
0-7540
C-025 2/3

1. WELL OWNER

Name Rhone Poulenc

Address P.O. Box 160 Montpelier, ID 83254

Drilling Permit No. 27-92E-054 0080-000 D.W. See Remarks 4-27-95

Water Right Permit No. 27-07540

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase ☐ Modification
☐ Abandoned (describe abandonment or modification procedures such as liners, screen, materials, plug depths, etc. in lithologic log, section 9.)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Monitor
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☒ Other Road Watering (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Auger ☐ Reverse rotary
☐ Cable ☐ Mud ☐ Other _____ (backhoe, hydraulic, etc.)

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.375 inches	10 inches	+ 1 feet	280 feet
.250 inches	8 inches	+ 18" feet	601 feet
inches	inches	feet	feet

Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☐ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☒ Knife ☐ Torch ☐ Gun
Size of perforation? ¼ inches by 2½ inches

Number		From	To
800	perforations	380 feet	280 feet
480	perforations	580 feet	520 feet
	perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer _____ Type _____
Top Packer or Headpipe _____
Bottom of Tailpipe _____

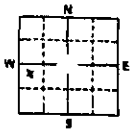
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☐ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet

Surface seal depth 280 Material used in seal: ☐ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit
☒ Temp. surface casing ☐ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded
☐ Solvent Weld ☐ Cemented between strata

Describe access port 1½" Nipple w/cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____
County Caribou
Address of Well Site Rassmuesen Valley (give at least name of road)
NW ¼ SW ¼ Sec. 26, T. 6 N ☐ or S ☒, R. 43 E ☒ or W ☐

MAY 0 8 1995

7. WATER LEVEL

Static water level 267 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature _____ °F. Quality _____
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40	Unknown	8

9. LITHOLOGIC LOG 074862

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
10 3/4	0	5	Top Soil		
10 3/4	5	20	Gravel		x
10 3/4	20	40	Gravel & Clay		x
10 3/4	40	60	Gravel & Clay		x
10 3/4	60	80	Gravel & Clay		x
10 3/4	80	100	Gravel & Clay		x
10 3/4	100	120	Gravel & Clay		x
10 3/4	120	140	Gravel & Clay		x
10 3/4	140	160	Gravel, Clay & Mudstone		x
10 3/4	160	180	Gravel, Clay & Mudstone		x
10 3/4	180	200	Gravel, Clay & Mudstone		x
10 3/4	200	220	Gravel, Clay & Mudstone		x
10 3/4	220	240	Gravel, Clay & Mudstone		x
10 3/4	240	260	Gravel, Clay & Mudstone		x
10 3/4	260	280	Gravel, Clay & Phosphate		x
8 5/8	280	300	Gravel		x
8 5/8	300	320	Gravel		x
8 5/8	320	340	Gravel		x
8 5/8	340	360	Gravel		x
8 5/8	360	380	Gravel		x
8 5/8	380	400	Gravel		x
8 5/8	400	420	Gravel		x
8 5/8	420	440	Gravel	x	
8 5/8	440	460	Gravel	x	
8 5/8	460	480	Sandstone		x
8 5/8	480	500	Sand & Sandstone		x
8 5/8	500	520	Sand Stone & Sand		x
8 5/8	520	540	Sand & SAndstone	x	
8 5/8	540	560	Sand & Sandstone	x	
8 5/8	560	580	SAnd & Sandstone		x
8 5/8	580	590	Limestone		x
8 5/8	590	600	Limestone		x
8 5/8	600	630	Pink Sandstone		x
8 5/8	630	650	Sandstone, & Gravel		x

Wells

RECEIVED
OCT 2 1 1994
Department of Water Resources

RECEIVED
APR 2 5 1994
Department of Water Resources
Eastern District Office

10.

Work started 2-11-93 finished 8-9-93

11. DRILLER'S CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Thomas Drilling, Inc. Firm No. 390
Address Rt. 1 Afton, WY 83110 Date 1-27-94
Signed by Drilling Supervisor _____
and
(Operator) _____
(If different than the Drilling Supervisor)

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
4/92

C

RECEIVED
APR 1 8 1994
Department of Water Resources

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT PEN

PW006 (2 wells)

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name: Rhone Poulenc

Address: P.O. Box 160 Montpelier, ID 83254

Drilling Permit No. 27-92E-054-000 Correct it

Water Right Permit No. 27-07540

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase ☐ Modification
☐ Abandoned (describe abandonment or modification procedures such as liners, screen, materials, plug depths, etc. in lithologic log, section 9.)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Monitor
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☒ Other Road Watering (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Auger ☐ Reverse rotary
☐ Cable ☐ Mud ☐ Other _____ (backhoe, hydraulic, etc.)

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.375 inches	10 inches	+ 1 feet	150 feet
.250 inches	6 inches	+ 18" feet	390 feet
_____ inches	_____ inches	_____ feet	_____ feet

Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☐ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☒ Knife ☐ Torch ☐ Gun
Size of perforation? ¼ inches by 2½ inches

Number		From	To
80	perforations	90 feet	80 feet
320	perforations	385 feet	350 feet
_____	perforations	_____ feet	_____ feet

Well screen installed? ☐ Yes ☒ No
Manufacturer _____ Type _____
Top Packer or Headpipe _____
Bottom of Tailpipe N/A

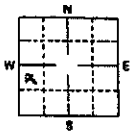
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☐ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet

Surface seal depth 150 Material used in seal: ☐ Cement grout ☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ Temp. surface casing ☐ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld ☐ Cemented between strata

Describe access port 1¼" Coupling w/ plug

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____
County Caribou
Address of Well Site Rasmuessen Valley (give at least name of road)
NW ¼ SW ¼ Sec. 26, T. 6 N ☐ or S ☒, R. 43 E ☒ or W ☐

MAY 0 8 1995

7. WATER LEVEL

Static water level 32 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature _____ °F. Quality _____
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40	Couldn't tell	7

9. LITHOLOGIC LOG 074861

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
10	0	3	Top soil		x
10	3	35	RedClay		x
10	35	45	Tan Clay & Gravel		x
10	45	48	Gravel	x	
10	48	70	Tan Clay & Gravel		x
10	70	80	Tan Clay		x
10	80	90	Gravel	x	
10	90	100	Gravel	x	
83/4	100	130	Gravel & TanClay		x
8 3/4	130	150	Tan Clay, Mud Stone		x
8 3/4	150	230	Tan Clay, Mud Stone		x
8 3/4	230	240	Tan Shale, Mud Stone		x
8 3/4	240	250	Tan Shale, Mud Stone		x
8 3/4	250	260	Tan Shale, Mud Stone		x
8 3/4	260	270	Tan Shale, Mud Stone		x
8 3/4	270	280	Black Shale		x
8 3/4	280	300	Black Shale		x
8 3/4	300	350	Black Shale		x
8 3/4	350	360	Black Shale, Interbed Lime Stone	x	
8 3/4	360	370	Black Shale, Interbed Lime Stone	x	
8 3/4	370	380	~~Black Shale, Interbed Lime Stone~~	x	
8 3/4	380	390	~~Black Shale, Interbed Lime Stone~~	x	

PPC

RECEIVED
APR 25 1994
Department of Water Resources
Eastern District Office

RECEIVED
OCT 21 1994
Department of Water Resources

10. Work started 9-26-92 finished 6-17-93

11. DRILLER'S CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Thomas Drilling, Inc. Firm No. 390
Address Rt. 1 Afton, WY 83110 Date 1-27-94
Signed by Drilling Supervisor _____
and
(Operator) _____ *(if different than the Drilling Supervisor)*

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 6/89

RECEIVED
AUG 24 1990
Department of Water Resources

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

USE TYPEWRITER OR BALLPOINT PEN

PW 19

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name Diamond Soda Springs, Monsanto
Box 975
Address Soda Springs, Id, 83276

Owner's Permit No. _____

2. NATURE OF WORK Drill Permit # 27-90-E-023

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☐ Steel ☒ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	16 inches +	1 feet	20 feet
.250 inches	10 inches +	2 feet	225 feet
inches	inches	feet	feet
inches	inches	feet	feet

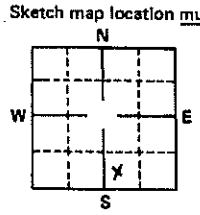
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch ☐ Gun
Size of perforation 1/4 inches by 12 inches

Number	From	To
120 perforations	175 feet	235 feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☒ Yes ☐ No ☐ Size of gravel 3/8" -
Placed from 235 feet to 35 (10 yd) feet
Surface seal depth 20 Material used in seal: ☐ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ ~~Temp.~~ Perm. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port PLUG IN CAP

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____
County _____
SW ¼ SE ¼ Sec. 21, T. 6 N ☐ S ☒ R. 43 E ☒ W ☐

7. WATER LEVEL

Static water level 137 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 50 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
300	235	8

9. LITHOLOGIC LOG 072583

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
20"	0	11	Fill		X
"	11	20	Clay		X
15"	20	96	"		X
"	96	108	" + Rock		X
"	108	189	"		
"	189	217	Broken Rock - May be BASALT	X	
"	217	230	Hard Rock	X	
"	230	234	" Broken Rock	X	
9 7/8	234	255	Hard Rock	X	

RECEIVED
JUN 22 1990
Department of Water Resources
Eastern District Office

10. Work started 5-21-90 finished 6-1-90

11. DRILLERS CERTIFICATION DL

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Drilling Firm No. 215
Address Soda Springs Date 6-16-90
Signed by (Firm Official) R. Nelson
and
(Operator) R. Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 2[illegible]
6/89

RECEIVED
AUG 24 1990
Department of Water Resources

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

RECEIVED
MAY 28 1990
Department of Water Resources
Eastern District Office

PW 20

1. WELL OWNER Monsanto

Name Dravo Soda Springs - Box 975

Address Soda Springs, Id, 83276

Owner's Permit No. 27-07452

2. NATURE OF WORK Drill Permit # 27-90-E-001

☒ New well ☐ Deepened ☐ Replacement
☐ Well diameter increase
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☒ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☐ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	16 inches +	1 feet	22 feet
.250 inches	12 inches +	2 feet	461 feet
inches	inches	feet	feet
inches	inches	feet	feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch ☐ Gun
Size of perforation 1/4 inches by 12" inches

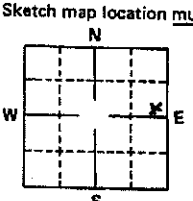
Number	From	To
120 perforations	401 feet	461 feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 22 Material used in seal: ☒ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ ~~Temp.~~ Perm surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port plug in cap

6. LOCATION OF WELL

Sketch map location must agree with written location.

N
W X E
S



Subdivision Name _____

Lot No. _____ Block No. _____

RECEIVED
JUN 27 1991

County Caribou

SE ¼ NE ¼ Sec. 21, T. 6 N ☐ S ☒ R. 43 E ☒ W ☐

7. WATER LEVEL

Static water level 260' feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 49 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
100-150	460	6

9. LITHOLOGIC LOG 072584

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
20"	0	10	Clay		X
"	10	22	Clay + overburden		X
15"	22	50	" "		X
"	50	100	Dynwoody		X
"	100	160	" + Clay		X
"	160	320	"		X
"	320	440	Cherty Shales		X
"	440	510	Hard porous Chert	X	
12"	510	720	Shales + Phosphate		X
"	720	722	Void	X	
"	722	726	Broken limestone	X	
"	726	800	Hard limestone		X
"	800	810	Sandy lse - losing H2O		X

10. Work started 4-4-90 finished 5-16-90

11. DRILLERS CERTIFICATION DL

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Drilling Firm No. 215

Address Soda Springs, Id, Date 5-21-90

Signed by (Firm Official) R. Nelson

and

(Operator) Ray Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT PEN

~~PW 023~~ ?
PW 022 ?

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name Monsanto Hole #504

Address Soda Springs, Idaho

Owner's Permit No. _____

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe method of abandoning) _____

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☒ Test ☐ Municipal
☐ Industrial ☐ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☐ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	6 inches +	1 feet	151 feet
.250 inches	8 inches	1 feet	19 feet
inches	inches	feet	feet
inches	inches	feet	feet

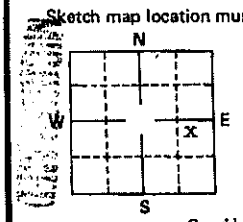
Was casing drive shoe used? ☒ Yes ☐ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☐ Yes ☒ No
How perforated? ☐ Factory ☐ Knife ☐ Torch
Size of perforation _____ inches by _____ inches

Number	From	To
perforations	feet	feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 18' Material used in seal: ☐ Cement grout
Bentonite ☒ Puddling clay ☐ Well cuttings
Sealing procedure used: ☐ Slurry pit ☐ Temp. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port _____

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name So. Henry Mine

Lot No. _____ Block No. _____

County Caribou

NE ¼ SE ¼ Sec. 30, T. 6 N/S, R. 43 E/W

7. WATER LEVEL

Static water level 63' feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature ____ °F. Quality Good

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
8	0	5	Soil		x
8	5	122	Gummy Clay and Gravel		x
8	122	125	Soft Shale-Greenish Gray	x	
8	125	150	Soft Shale " "		x

RECEIVED JAN 19 1981 Department of Water Resources Eastern District Office

10.

Work started 3-20-80 finished 3-26-80

11. DRILLERS CERTIFICATION

Cbdl

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Andrew Well Drilling Contr. Firm No. 5
Address 1268 East 17th Street Idaho Falls, Idaho 83401 Date 5-8-80
Signed by (Firm Official) [signature]
and
(Operator) Alfred High

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
9/82

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

USE TYPEWRITER OR BALL POINT PEN

DEC 16 1988

Department of Water Resources
Eastern District Office

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

RECEIVED DEC 22 1988 Department of Water Resources

DW 001 or ~~MW 003~~

1. WELL OWNER

Name (b) (6)

Address HENRY, IDAHO

Owner's Permit No. 27-88-E-040

2. NATURE OF WORK

☐ New well ☒ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log).

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☐ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
	inches	inches + feet	feet
.250 inches	6" I.D. inches	+ 1 feet	109 feet
.258 inches	5" I.D. inches	97 feet	160 feet
	inches	inches feet	feet

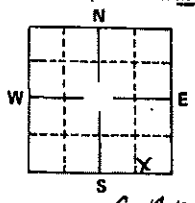
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 3/16 inches by 12 inches

Number	From	To
60 perforations	70 feet	110 feet
33 perforations	139 feet	160 feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☒ Yes ☐ No ☐ Size of gravel + 1/8"
Placed from 110 feet to 20 feet
Surface seal depth 20 Material used in seal: ☐ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☐ Temp. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port plug on cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____

County CARIBOU

SE ¼ SE ¼ Sec. 18, T. 6 S, R. 43 E

7. WATER LEVEL

Static water level 13 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 48 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☐ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
30	160	3

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
			This well was drilled over 30 years ago. was just going to install a pump - but well pumped dry.		
9 7/8	90	110	Brown Clay & gravel		X
6 3/4	110	138	" " " "		X
"	138	142	hard lava		X
"	142	150	broken limestone	X	
"	150	160	hard "	X	

10.

Work started 10-28-88 finished 11-4-88

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Firm No. 215
Address Soda Springs Date 11-9-88
Signed by (Firm Official) R. Nelson
and
(Operator) Ray Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
9/82

NELSON SAYS
His Locations
Correct. HWJ

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

DW002 USE TYPEWRITER OR BALLPOINT PEN

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name (b) (6)

Address Wayan, Idaho

Owner's Permit No. 27-87-E-017

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths; etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☐ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	8" I.D. inches +	1 feet	19 feet
.280 inches	6" I.D. inches +	1 feet	159 feet
inches	inches	feet	feet
inches	inches	feet	feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 1/4" inches by 12" inches

Number	From	To
15 perforations	20 feet	30 feet
30 perforations	160 feet	180 feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 19 Material used in seal: ☒ Cement grout
☐ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ ~~Temp.~~ Perm. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☐ Welded ☐ Solvent Weld

7. WATER LEVEL

Static water level 10 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 48 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40		6

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes
12 1/4	0	5	overburden	
"	5	19	clay	
8 1/2"	19	25	clay	
	25	40	gravel + clay	X
	40	140	" "	
	140	150	Sandstone	
	150	155	gravel	X
	155	159	hard rock	
4 3/4	159	180	hard rock	

RECEIVED
DEC
Department of Water Resources
Eastern District Office

USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Reclamation

WELL DRILLER'S REPORT

State law requires that this report be filed with the State Reclamation Engineer within 30 days after completion or abandonment of the well.

K-4 7-23-6 mw

DW005

1. WELL OWNER

Name (b) (6) [redacted]

Address Henry, Idaho

Owner's Permit No.

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Test

☐ Municipal ☐ Industrial ☐ Stock

4. METHOD DRILLED

☒ Cable ☐ Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 6 inches Total depth 46 feet

Casing schedule: ☒ Steel ☐ Concrete

Thickness	Diameter	From	To
.250 inches	6 5/8 inches	top feet	46-6 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was a packer or seal used? ☐ Yes ☐ No

Perforated? ☒ Yes ☐ No

How perforated? ☐ Factory ☐ Knife ☒ Torch

Size of perforation 5 inches by 1/4 inches

Number	From	To
24 perforations	~~35~~ 40 feet	45 feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☐ No

Manufacturer's name

Type Model No.

Diameter Slot size Set from feet to feet

Diameter Slot size Set from feet to feet

Gravel packed? ☐ Yes ☐ No Size of gravel

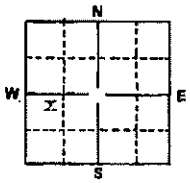
Placed from feet to feet

Surface seal? ☒ Yes ☐ No To what depth 19 feet

Material used in seal ☒ Cement grout ☐ Puddling clay

6. LOCATION OF WELL

Sketch map location must agree with written location.



County Caribou

NW ¼ SW ¼ Sec. 10, T. 6 N/S, R. 42 E/W

27 mw

7. WATER LEVEL

Static water level 6 feet below land surface

Flowing? ☐ Yes ☒ No G.P.M. flow

Temperature ° F. Quality

Artesian closed-in pressure p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☒ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
~~XX~~ 20	8 ft.	30 min.

9. LITHOLOGIC LOG 29712

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
6 in	0	4	Clay		
	4	8	Gravel and sand		
	8	14	White loose rock	X	
	14	29	White crevised rock		
	29	38	White broken rock		
	38	46	White loose rock	X	

10.

Work started May 5, 1969 finished May 10, 1969

11. DRILLER'S CERTIFICATION

This well was drilled under my supervision and this report is true to the best of my knowledge.

Westlake Drilling mw 114

Driller's or Firm's Name Number

P.O.Box 40 Bannington, Idaho 83219

Address

Signed By Bert Westlake Date 7-10-69

USE ADDITIONAL SHEETS IF NECESSARY

USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Reclamation

WELL DRILLER'S REPORT

State law requires that this report be filed with the State Reclamation Engineer within 30 days after completion or abandonment of the well.

RECEIVED
NOV 20 1969
Department of Reclamation

AW002

1. WELL OWNER Enoch Valley Grazing Assn. Inc

Name RAY TAYLOR

Address Grace, Idaho

Owner's Permit No.

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test

☐ Municipal ☐ Industrial ☒ Stock

4. METHOD DRILLED

☒ Cable ☐ Rotory ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 6 inches Total depth 153 feet

Casing schedule: ☒ Steel ☐ Concrete

Thickness	Diameter	From	To
.250 inches	6 5/8 inches	TOP feet	153 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was a packer or seal used? ☐ Yes ☐ No

Perforated? ☒ Yes ☐ No

How perforated? ☐ Factory ☐ Knife ☒ Torch

Size of perforation 6 inches by 1/4 inches

Number	From	To
18 perforations	142 feet	144 feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☐ No

Manufacturer's name

Type Model No.

Diameter Slot size Set from feet to feet

Diameter Slot size Set from feet to feet

Gravel packed? ☐ Yes ☐ No Size of gravel

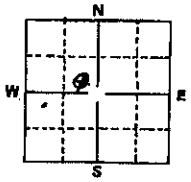
Placed from feet to feet

Surface seal? ☒ Yes ☐ No To what depth 34 feet

Material used in seal ☐ Cement grout ☒ Puddling clay

6. LOCATION OF WELL

Sketch map location must agree with written location.



County Caribou

S.E. ¼ NW ¼ Sec. 17 T. 6 S, R. 43 E

7. WATER LEVEL

Static water level 17'-7" feet below land surface

Flowing? ☐ Yes ☐ No G.P.M. flow

Temperature ° F. Quality

Artesian closed-in pressure p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☒ Bailer ☐ Other

Discharge G.P.M.	Draw Down	Hours Pumped
15	4 FT	30 MIN

9. LITHOLOGIC LOG 29709

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
6	0	8	CLAY TAN		
	8	14	" SOFT + SANDY		
	14	34	" "		
	34	63	" MEDIUM SOFT TAN		
	63	67	BLUE CLAY + GRAVEL		
	67	81	" "		
	81	86	" " + COURSE SAND		
	86	105	" "		
	105	114	" " + COURSE SAND		
	114	138	" " SHELLS		
	138	142	BLACK CINDERS + SILT		
	142	151	" "	✓	
	151	154	BLUE CLAY		

10. Work started Aug 28 1969 finished Aug 29 1969

11. DRILLER'S CERTIFICATION

This well was drilled under my supervision and this report is true to the best of my knowledge.

Bert Westlake Drilling — Driller's or Firm's Name — 114 — Number

Bennington Idaho 83219 — Address

Bert Westlake — Signed By — Sept 6 1969 — Date

USE ADDITIONAL SHEETS IF NECESSARY

Form 238-7
9/82

NELSON SAYS HIS LOCATION CORRECT. HWJ

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

USE TYPEWRITER OR BALLPOINT PEN

~~DW001 or~~ AW003

1. WELL OWNER

Name (b) (6) [redacted]

Address

Owner's Permit No. 27-87-E-017

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☐ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	8" I.D. inches +	1 feet	19 feet
.280 inches	6" I.D. inches +	1 feet	159 feet
inches	inches	feet	feet
inches	inches	feet	feet

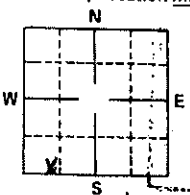
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 1/4" inches by 12" inches

Number	From	To
15 perforations	20 feet	30 feet
30 perforations	160 feet	180 feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 19 Material used in seal: ☒ Cement grout
☐ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ ~~Temp.~~ Perm. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☐ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port plug in cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____

OCT 17 1988

Lot No. _____ Block No. _____

County Caribou

SE 1/4 SW 1/4 SW 1/4 Sec. 8, T. 6 S, R. 43 E

7. WATER LEVEL

Static water level 10 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 48 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40		6

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
12 1/4	0	5	overburden		x
"	5	19	clay		x
8 1/4"	19	25	clay		x
	25	40	gravel + clay	x	
	40	140	" "		x
	140	150	Sandstone		x
	150	155	gravel	x	
	155	159	hard rock		x
4 3/4	159	180	hard rock		x

RECEIVED
DEC
Department of Water Resources
Eastern District Office

10.

Work started 10-20-87 finished 11-5-87

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Drilling Firm No. 215

Address Soda Springs, Id. Date 11-8-87

Signed by (Firm Official) R. Nelson

and

(Operator) Ray Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

rm 238-7
/82

DMD

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

USE TYPEWRITER OR BALLPOINT PEN

AW005

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

1. WELL OWNER

Name (b) (6) [redacted]

Address [redacted] 4542

Owner's Permit No. _____

2. NATURE OF WORK Drill Permit 27-90-E047

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	8" I.D. inches +	1 feet	20 feet
.250 inches	6" I.D. inches +	1.5 feet	239 feet
inches	inches	feet	feet
inches	inches	feet	feet

Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 3/16 inches by 12 inches

Number	From	To
60 perforations	199 feet	239 feet
28 perforations	159 feet	199 feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Diameter ___ Slot size ___ Set from ___ feet to ___ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 20 Material used in seal: ☒ Cement grout ☐ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ Perm. surface casing ☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld ☐ Cemented between strata
Describe access port NONE - CAP Welded ON

6. LOCATION OF WELL

Sketch map location must agree with written location.

N / W / E / S / X

Subdivision Name _____

JUN 21 1991

Lot No. _____ Block No. _____

County CARIBOU

SE ¼ SW ¼ Sec. 26, T. 6 N/S, R. 43 E/W

7. WATER LEVEL

Static water level 220 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 49 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
10	260	3

9. LITHOLOGIC LOG 072585

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
12¼	0	20	Blue Clay		X
7⅞	20	40	" "		
	40	90	Red "		
	90	168	Brown "		
	168	210	Red Clay		
	210	220	Hard limestone		
	220	235	Broken " 1 GPM	X	
	235	245	Hard "		X
6"	245	260	Broken " 3 GPM	X	
	260	271	Hard "		X
	271	280	Broken " 6 GPM	X	

RECEIVED
JAN 03 1991
Department of Water Resources

RECEIVED
DEC 1 2 1990
Department of Water Resources
Eastern District Office

10. Work started 11-19-90 finished 11-28-90

11. DRILLERS CERTIFICATION DL

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Firm No. 215

Address Soda Springs, Id. Date 12-1-90

Signed by (Firm Official) Ray Nelson

and

(Operator) Wyatt B

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
9/82

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

USE TYPEWRITER OR BALLPOINT PEN

RECEIVED OCT 18 1988 Department of Water Resources

AW0016

1. WELL OWNER

Name (b) (6) [redacted]

Address [redacted] Soda Springs Id. 83276

Owner's Permit No. 27-88-E 028

2. NATURE OF WORK

☒ New well ☐ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log).

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	8" ID inches +	1 feet	19 feet
.250 inches	6" ID inches +	1 feet	109 feet
____ inches	____ inches	____ feet	____ feet
____ inches	____ inches	____ feet	____ feet

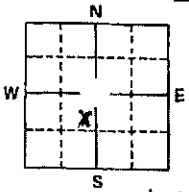
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 3/16" inches by 12 inches

Number	From	To
30 perforations	89 feet	109 feet
____ perforations	____ feet	____ feet
____ perforations	____ feet	____ feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from ____ feet to ____ feet
Surface seal depth 19 Material used in seal: ☒ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ Pump. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port plug in cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____

County Caribou

NW ¼ SW ¼ Sec. 35, T. 6 S/S, R. 42 E/W.

7. WATER LEVEL

Static water level 27 feet below land surface.
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 48 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40	110	3

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
12¼	0	4	overburden		X
"	4	17	Clay		X
"	17	19	Hard lava		X
7⅞	19	27	" "		X
	27	33	" porous lava w/cinder	X	
	33	58	" lava		X
	58	59	Clay seam		X
	59	63	Hard lava		X
	63	69	Hard broken lava	X	
	69	81	" lava		X
	81	87	Brown Clay		X
	87	102	Cinders	X	
	102	110	Hard lava		X
5"	110	120	" "		

OCT 4 1989
Department of Water Resources
Eastern District Office

10. Work started 9-1-88 finished 9-2-88

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Firm No. 215

Address Soda Springs, Id. Date 9-17-88

Signed by (Firm Official) R. Nelson

and

(Operator) Ray Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Form 238-7
9/82

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well.

USE TYPEWRITER OR BALLPOINT PEN

RECEIVED JUL 18 1988 Department of Water Resources

AW007?

1. WELL OWNER

Name (b) (6) [redacted]

Address Soda Springs, Id. 83276

Owner's Permit No. 27-88-E-015

2. NATURE OF WORK

☐ New well ☒ Deepened ☐ Replacement
☐ Abandoned (describe abandonment procedures such as materials, plug depths, etc. in lithologic log)

3. PROPOSED USE

☐ Domestic ☐ Irrigation ☐ Test ☐ Municipal
☐ Industrial ☒ Stock ☐ Waste Disposal or Injection
☐ Other _____ (specify type)

4. METHOD DRILLED

☒ Rotary ☒ Air ☐ Hydraulic ☐ Reverse rotary
☐ Cable ☐ Dug ☐ Other _____

5. WELL CONSTRUCTION

Casing schedule: ☒ Steel ☐ Concrete ☐ Other _____

Thickness	Diameter	From	To
.250 inches	8" Id. inches +	1 feet	119 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

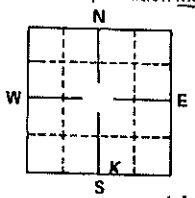
Was casing drive shoe used? ☐ Yes ☒ No
Was a packer or seal used? ☐ Yes ☒ No
Perforated? ☒ Yes ☐ No
How perforated? ☐ Factory ☐ Knife ☒ Torch
Size of perforation 3/16 inches by 12 inches

Number	From	To
45 perforations	59 feet	119 feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No
Manufacturer's name _____
Type _____ Model No. _____
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Diameter ____ Slot size ____ Set from ____ feet to ____ feet
Gravel packed? ☐ Yes ☒ No ☐ Size of gravel _____
Placed from _____ feet to _____ feet
Surface seal depth 20 Material used in seal: ☐ Cement grout
☒ Bentonite ☐ Puddling clay ☐ _____
Sealing procedure used: ☐ Slurry pit ☒ Temp. surface casing
☒ Overbore to seal depth
Method of joining casing: ☐ Threaded ☒ Welded ☐ Solvent Weld
☐ Cemented between strata
Describe access port plug in Cap

6. LOCATION OF WELL

Sketch map location must agree with written location.



Subdivision Name _____
Lot No. _____ Block No. _____

County Caribou

SW ¼ SE ¼ Sec. 23, T. 6 ☒S, R. 42 E/☒.

7. WATER LEVEL

Static water level 60 feet below land surface
Flowing? ☐ Yes ☒ No G.P.M. flow _____
Artesian closed-in pressure _____ p.s.i.
Controlled by: ☐ Valve ☐ Cap ☐ Plug
Temperature 57 °F. Quality Good
Describe artesian or temperature zones below.

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Air ☐ Other _____

Discharge G.P.M.	Pumping Level	Hours Pumped
40	120	2

9. LITHOLOGIC LOG

Bore Diam.	Depth From	Depth To	Material	Water Yes	Water No
10"	0	4	overburden		X
10	4	10	Gray Clay		
10"	10	19	" "		
6¾	19	53			
"	53	57	Sand Stone	X	
"	57	93	Blue Clay		X
"	93	120	Hard Rock (Chert?)	X	

RECEIVED Department of Water Resources Eastern District Office

10. Work started 6-24-88 finished 6-26-88

11. DRILLERS CERTIFICATION

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name Nelson Drilling Firm No. 215
Address Soda Springs Id. Date 82
Signed by (Firm Official) R. Nelson
and
(Operator) Ray Nelson

USE ADDITIONAL SHEETS IF NECESSARY — FORWARD THE WHITE COPY TO THE DEPARTMENT

Appendix G
Standard Operating Procedures

Borehole Drilling and Logging
Monitoring Well Installation

Borehole Drilling and Logging
Monitoring Well Installation
Aquifer Testing

Standard Operating Procedures

June 2004

Prepared by:

MWH
100 S. Broad Street
Globe, Arizona 85501

TABLE OF CONTENTS

Section No. **Page No.**

1.0 INTRODUCTION 1

2.0 DRILLING OPERATIONS 2

2.1 DRILLING METHODS WITHOUT CIRCULATING FLUIDS 2
2.1.1 Hollow-Stem Auger Drilling 2
2.1.2 Rotary-sonic Drilling 3
2.2 DRILLING METHODS WITH CIRCULATING FLUIDS 3
2.2.1 Dual-Tube Percussion Drilling 3
2.2.2 Air Rotary Down-the-Hole Hammer 4
2.3 PERMITTING 5
2.4 SAMPLING METHODS 5
2.4.1 Spoon Samplers 5
2.4.2 Thin-Walled Tube Samplers 6
2.4.3 Continuous Coring 6
2.5 BOREHOLE OR WELL ABANDONMENT 6
2.6 DRILLING EQUIPMENT DECONTAMINATION 7

3.0 BOREHOLE LOGGING - SOILS 8

3.1 GENERAL 8
3.2 GEOLOGIST/HYDROGEOLOGIST 8
3.3 DEFINITIONS 8
3.3.1 Grain Sizes 8
3.3.2 Physical Characteristics 9
3.4 SOIL LOGGING PROCEDURES 9
3.4.1 Field Classification of Soils 10
3.4.1.1 Procedure for Identifying Coarse-Grained Soils (contain less than 50% fines) 10
3.4.1.2 Procedure for Identifying Fine-Grained Soils (contain 50% or more fines) 11
3.4.1.3 Procedure for Identifying Borderline Soils 12
3.4.2 Descriptive Information for Soils 12
3.4.2.1 Color 12
3.4.2.2 Consistency & Density 12
3.4.2.3 Moisture 12
3.4.2.4 Maximum Grain Size 12
3.4.2.5 Odor 13
3.4.2.6 Cementation 13
3.4.2.7 Angularity 13
3.4.2.8 Structure 13
3.4.2.9 Lithology 13
3.4.2.10 Additional Comments 14
3.4.3 Additional Boring Log Information 14

4.0 BOREHOLE LOGGING - BEDROCK 15

4.1 GENERAL 15
4.2 BEDROCK LOGGING PROCEDURES 15
4.2.1 Header Information 15
4.2.2 Drilling Information 16
4.2.3 Rock Type 16
4.2.4 Depth Scale 17
4.2.5 Core Recovery Data 17
4.2.6 Discontinuity Data 17
4.2.7 Strength Data 18
4.2.8 Additional Notes 18
4.3 DRILL CORE PHOTOGRAPHY 18

5.0 MONITORING WELL DESIGN AND INSTALLATION 19

5.1 GENERAL 19

5.2 WELL LOCATIONS 19
5.3 WELL DESIGN 19
5.3.1 Casing Diameter and Screen Length 19
5.3.2 Casing and Screen Materials 19
5.3.3 Decontamination of Casing and Screen Materials 20
5.3.4 Filter Pack and Well Screen Design 20
5.3.5 Annular Seal 21
5.3.6 Surface Completions 22
5.3.7 Summary of Well Design 22

6.0 PIEZOMETER INSTALLATION 23

6.1 BASIC INSTALLATION AND OPERATION OF PIEZOMETERS 23

7.0 WELL DEVELOPMENT 25

7.1 GENERAL 25
7.1.1 Decontamination 25
7.1.2 Documentation 25
7.1.3 Well Purging 25
7.1.3.1 Indicator Parameters 25
7.1.3.2 Purge Volume 26
7.2 WELL DEVELOPMENT 27

8.0 TOPOGRAPHIC SURVEYING 29

9.0 PACKER TESTS 30

9.1 FLOW RATE 30
9.2 TEST SECTION LENGTH 31
9.3 NET PRESSURE 31
9.4 GAUGE PRESSURE 31
9.5 COLUMN PRESSURE 31
9.6 FRICTION LOSS 31
9.7 EQUIPMENT AND MEASUREMENT 31

10.0 PUMPING TESTS 33

10.1 DEFINITIONS 33
10.2 AQUIFER TESTING METHODS 36
10.2.1 Slug Testing 37
10.2.2 Pumping Tests 40
10.2.3 Step-Tests 42
10.2.4 Constant Rate Pumping Tests 44
10.2.5 Recovery Tests 47

11.0 REFERENCES 48

LIST OF ATTACHMENTS

Attachment	Description
A	Glossary of Terms
B	Unified Soil Classification System
C	Criteria for Describing Plasticity
D	Criteria for Describing Density and Consistency
E	Criteria for Describing Structure
F	Soil Boring Log Form
G	Rock Core Log Form
H	Weathering and Intact Rock Strength Classification
I	Typical Monitoring Well Installation Diagram
J	Monitoring Well Construction Form
K	Well Development Record and Well Volume Chart
L	Water Level Readings Form
M	Packer Test Form
N	Time Intervals for Manual and Electronic Measurements of Drawdown
O	Aquifer Test Form

1.0 INTRODUCTION

The purpose of this document is to define the standard procedures for drilling, logging, testing, documentation, and installation of boreholes and monitoring wells. This SOP provides descriptions of equipment, field procedures, and technical procedures necessary to perform the proposed drilling and sampling activity. The procedures described herein are intended to be used with other applicable SOPs, as appropriate.

This SOP describes procedures for conducting the tasks listed below.

- Drilling boreholes
- Sampling soil and bedrock for lithologic description
- Borehole logging
- Equipment decontamination
- Well design and construction
- Well development
- Topographic surveying
- Aquifer testing (sieve, packer and pumping tests)

Many terms included in this SOP may be unfamiliar to the reader. A glossary of terms is included in Attachment A.

2.0 DRILLING OPERATIONS

Drilling methods can be separated into two general types - techniques that do not use circulating fluids and techniques that use circulating fluids. The following sections discuss the drilling methods that fall into each of these two general categories that are most likely to be used for this project.

This section provides a description of the principles of operation and the applicability and implementability of the drilling methods that are proposed for this investigation. It focuses on methods and equipment that are readily available and typically applied. It is not intended to provide an all-inclusive discussion of drilling methods. Drilling will be conducted using air rotary drilling rigs, hollow stem auger (HSA) drilling rigs, and direct push Cone Penetrometer (CPT) rigs. Other alternatives that will be available are dual-tube percussion hammer and Rotary-sonic drilling. These methods are discussed below. All drillers and drilling personnel working onsite will be 40 hour OSHA (CFR 1910) certified and 24 hour MSHA certified. Drillers will also be available to provide additional services for minor repair or servicing of existing wells.

2.1 DRILLING METHODS WITHOUT CIRCULATING FLUIDS

2.1.1 HOLLOW-STEM AUGER DRILLING

Drilling is accomplished by rotating a pipe or rod that has a cutting bit. The common auger drilling method expected to be used is discussed in section.

Hollow-stem augers (H.S.A.) are commonly used in unconsolidated materials up to 150 feet in depth. A key advantage of H.S.A. drilling is that undisturbed soil samples can be collected through the auger, which acts as a temporary outer casing during drilling. The auger also acts as a temporary outer casing during monitoring well installation.

Hollow-stem augers consist of two parts: a tube with flights attached to the outside and connected the lead auger, and an inner pilot or center rod and bit which is removable from the center of the auger. The removable inner plug is the primary advantage of this drilling method. Withdrawing the plug while leaving the auger in place provides an open, cased hole into which soil samplers, down-hole drive hammers, instruments, casing, wire, pipe, or numerous other items can be inserted. Replacing the center bit and plug allows for continuation of the borehole.

Hollow-stem augers are specified by the inside diameter of the hollow stem, not by the hole size it drills. Hollow-stem augers are available in a variety of diameters, such as 2.5, 3.25, 3.375, 4.0, 4.25, 6.25, 6.625, 8.25, and 10.25 inches. The most commonly used sizes are 3.25 inches and 4.25 inches for soil borings that may be completed as 2-inch monitoring wells, and 6.625 inches for soil borings that may be completed as 4-inch monitoring wells.

The rotation of the augers causes the cuttings to move upward and be "smeared" along the borehole walls. This smearing may effectively seal off the upper zones thereby reducing the possibility of cross contamination of the upper zones to the deeper zones but increases the possibility of deep to shallow contamination. Conversely, smearing of clays on the borehole walls may seal off aquifers to be monitored.

Applications

- Suitable for all types of soil investigations.
- Allows good soil sampling with split-spoon samplers or Shelby tubes.
- Monitoring well installation in all unconsolidated formations.
- Can serve as temporary casing.
- Can be used in stable formations to set surface casing.

Limitations

- Difficulty in preserving sample integrity in heaving formations.
- Formation invasion by water or drilling mud if used to control heaving.
- Possible cross contamination of aquifers where annular space not positively controlled by water or drilling mud or surface casing.
- Limited diameter of augers limits casing size.
- Smearing of clays may seal off aquifer to be monitored.

2.1.2 ROTARY-SONIC DRILLING

Rotasonic drilling is a dual-cased drilling system that uses high frequency vibration to take continuous core samples and advance casing into the ground. The hydraulically powered drill head applies vibration to the drill string. This energy is directed down the drill string to the face of the core bit. No mud pump or air compressor is used to force cutting away from the borehole. The inner core barrel is advanced in increments into the formation, and then the outer casing is advanced down over the core barrel. The core barrel is then removed and the sample extruded into a plastic sleeve.

Applications

- Suitable for all types of soil investigations.
- Allows undisturbed soil sampling and recovery with continuous coring.
- Monitoring well installation in all unconsolidated formations.
- Waste minimization.
- Prevents cross contamination and formation mixing.

Limitations

- Slower through hard dense formations.
- Large rig and requires a support vehicle.
- Technique can create high heat, which is a concern if sampling for hydrocarbons.
- Technique is not appropriate for dense, consolidated material (rock).

2.2 DRILLING METHODS WITH CIRCULATING FLUIDS

Many drilling techniques use a circulating fluid, such as water, drilling mud, air, a combination of air and water, or even a surfactant to create foam. Circulation fluids flow from the surface either through the drill pipe, out through the bit, and up the annulus between the borehole wall and the drill pipe (direct rotary) or down the borehole annulus, into the bit, and up the drill pipe (reverse rotary). Generally the up-hole velocity needed to transport cuttings to the surface is between 100 to 150 feet per minute for plain water with no additives, 80 to 120 feet per minute for high-grade bentonite drill muds, 50 to 1,000 feet per minute for foam drilling, and up to 3,000 feet per minute for air with no additives. Additives decrease the required minimum velocity. Excessive velocities can cause erosion of the borehole wall. For this project, air is the expected fluid.

The use of circulating fluids may involve the addition of chemicals to the borehole. Drilling mud utilizes bentonite clay or polymers. Additives to air drilling may include surfactants (detergents) and water mist to generate foam. Compressed air may also contain various amounts of hydrocarbon lubricants. Therefore, attention should be given to the circulating fluids and any possible additives that are used when using drilling methods utilizing circulation fluids.

2.2.1 DUAL-TUBE PERCUSSION DRILLING

Dual-tube percussion drilling is very similar to dual-tube rotary with the exception that the two drive pipes do not rotate during drilling. The two concentric drive pipes are driven into the ground with a

hammer. The hammer is similar to the mechanisms mounted on pile drivers. The typical outside diameter of the outer drive pipe is 7 to 12 inches. The typical inside diameter of the inner pipe, where well materials are normally inserted, is 4.25 to 8 inches. This drilling system is also a center stem recovery system and is used primarily in hazardous waste investigations. It is rapid and effective to depths of about 250 feet.

The outer pipe effectively seals off the formation while drilling, reducing the chance of cross contamination. Air is pumped between the annulus of the two pipes to the bit where it is deflected upward into the inner pipe. Cuttings are transported to the surface through the inner pipe.

In general, three systems are available: 7-inch OD/4.25-inch ID, 9-inch OD/6-inch ID, and 12-inch OD/8-inch ID. A 2-inch diameter monitoring well can be constructed in the 7-inch system, a 4-inch diameter monitoring well can be constructed in the 9-inch system, and a 5- or 6-inch diameter monitoring well can be constructed in the 12-inch system.

Applications

- Very rapid drilling through consolidated formations, especially sands and gravels.
- Allows continuous sampling for lithologic logging in all types of formations.
- Representative samples can be obtained with minimal risk of contamination of sample and/or water bearing zone.
- In stable formations, wells with diameters as large as 6 inches can be installed in open hole completions.
- Soil samples can be easily obtained for chemical analysis.
- Capable of advancing third surface casing.
- Capable of driving 3-inch North American Large Penetration split-spoon sampler, potentially driven with a down hole 300 lb hammer with a wire line winch.

Limitations

- In unstable formations wells are limited to approximately 4 inches.
- Air may modify chemical or biological conditions; recovery time is uncertain.
- Not appropriate for drilling consolidated rock.

2.2.2 AIR ROTARY DOWN-THE-HOLE HAMMER

This method combines percussion and air rotary drilling methods to drill. The borehole is drilled using the air rotary drilling method. A pneumatic drill, "down-the-hole", at the end of the drill pipe strikes the rock while the drill pipe is gradually rotated. Rotation helps to insure even penetration. The air used to run the drill is used to remove cuttings. Casing or drive pipe follows closely behind the rotary bit to prevent the erosion of the borehole wall.

Applications & Advantages

- Rapid drilling of unconsolidated sands, silts, and clays.
- Drilling in alluvial materials (including boulder formations).
- Casing supports borehole thereby maintaining borehole integrity and minimizing inter-aquifer cross contamination.
- Eliminates circulation problems common with direct mud rotary method.
- Good formation samples for stratigraphic evaluation.
- Minimal formation damage as casing is pulled back.

Limitations

- Thin, low pressure water bearing zones easily overlooked if drilling is not stopped at appropriate places to observe whether or not water levels are recovering.
- Samples pulverized as in all rotary drilling.
- Air may modify chemical or biological conditions.
- Difficult to obtain soil samples for chemical analysis.

2.3 PERMITTING

All monitoring wells and piezometers proposed to be installed will be installed and constructed in accordance with all applicable Idaho Department of Water Quality (IDWR) rules and regulations. For each monitoring well a permit to drill, deepen, replace, or modify a Monitoring Well must be filed with IDWR prior to the start of drilling.

A licensed drilling subcontractor registered with IDWR will conduct all drilling and well installation activities.

2.4 SAMPLING METHODS

2.4.1 SPOON SAMPLERS

Split-spoon samplers are the most commonly used samplers for monitoring and geotechnical work and can be applied to a variety of drilling methods. Split-spoon samplers are usually steel or stainless steel, are tubular in shape, and are split longitudinally into two semi-cylindrical halves. They may be lined or unlined. Liners are made of brass, aluminum, stainless steel, or various synthetic materials. Split-spoon samplers are generally available in 2-, 2.5-, 3-, 3.5-, and 4-inch outside diameters (OD). Lengths range between 12 and 60 inches. The 18-inch long sampler is the most commonly used. Three 6-inch liners are generally used with this sampler. Sixty-inch samplers are used when continuous coring is necessary.

Driving (hammering) is the usual method of obtaining split-spoon samples up to 2.5 feet in length. Samples are collected from the split-spoon sampler by driving the sampler into undisturbed material beneath the bottom of the casing or borehole with a weighted hammer. For most sampling, a 140-pound hammer is used. The hammer may either be at the ground surface or in-hole. The number of blow counts per 6-inch increment of total drive is recorded. An estimate of the density and consistency of the subsurface soils can be made from the relationships among the hammer weight, drop, and number of blows required to advance the split spoon in 6-inch increments. The split spoon associated with the North American Large Penetration Test is 3.0 iin outside diameter and is driven by a 300 pound hammer.

If the sampler cannot be advanced 6 inches with a reasonable number of blows (usually about 50), sampler refusal occurs and the sampling effort at that particular interval is terminated. If "auger refusal" has not occurred, the hole is advanced to the next sampling interval where another attempt at sample retrieval is made.

After the split spoon is removed, it is opened for visual inspection and classification. If an adequate volume of sample has not been retrieved, additional sample shall be collected from a second sampler from the interval immediately below the preceding interval.

If VOCs are to be analyzed, the sample is immediately transferred into the appropriate sampling jars upon retrieval of the split spoon from the borehole. Following sample description, sample material for non-VOC analyses may be composited, homogenized, or collected from discrete intervals as provided in the project work plan. Care shall be taken to ensure that the sample collected is

representative of the sample interval of interest, and not slough material. All slough material shall be discarded. If a representative sample is to be retained for future reference, the sample must be stored in a container that is compatible with potential contaminants in the sample and minimizes the potential for accidental spillage.

2.4.2 THIN-WALLED TUBE SAMPLERS

The thin-walled tube (Shelby tube) sampler is a 18-, 30-, or 36-inch long, thin-walled steel, aluminum, brass, or stainless steel tube equipped with a connector head. It is primarily used in soft or clayey formations where it will provide more sample recovery than a split-spoon sampler and when relatively undisturbed samples are desired. The most commonly used sampler has a 3-inch OD and a 2.81-inch cutting diameter, and is 30 inches long.

Pressing or pushing without rotation is the normal mode of advance for the thin-walled sampler. If pressing cannot advance the tube, it may become necessary to drive the sample with drill rods and hammers without rotation. The tubes are generally allowed to stay in the hole 10 to 15 minutes to allow the buildup of skin friction prior to removal. The tube is then rotated to separate it from the soil beneath it, prior to being brought to the surface.

After removal, the sample is inspected to ensure an adequate sample volume has been collected. If an inadequate volume has been collected, the above sampling procedure is repeated.

Upon retrieval, a description of the soil core is recorded in the logbook and any disturbed soil removed from the end of the tube. VOC samples are removed and placed in the appropriate sample containers immediately upon sample retrieval. Thin-walled tubes are capped with non-reactive material for transport.

2.4.3 CONTINUOUS CORING

Continuous coring is usually performed with a 60-inch split-spoon sampler that is advanced by pressing without rotating while the drill bit is rotating. The sampling tube is lowered into and retrieved from the auger or drill stem using wireline or drill rods.

The sampling tube is locked into place so the sampler protrudes slightly ahead of the drill bit. As the bit is advanced, the auger is pressed into the formation. After the hole has been advanced the length of the sampling tube, the full sampler is retrieved and an empty sampler is put down the hole. Sampling procedures will follow those described in Section 4.2.2.

2.5 BOREHOLE OR WELL ABANDONMENT

Any borehole that will not be converted into a well (e.g., soil borings, bedrock boreholes) will be abandoned according to all applicable IDWR rules and regulations. The borehole will be abandoned by pumping cement-bentonite grout to the bottom of the borehole through a tremie pipe until the borehole is filled to the ground surface with undiluted grout. Dry holes less than 15 feet deep can be filled with grout poured from the surface. After 24 hours, the abandoned borehole will be checked for grout settlement. Any settlement will be filled in with grout, using a tremie pipe if it is deeper than 15 feet. This process will be continued until firm grout remains at the ground surface. Under no circumstances, will the borehole be backfilled with the soil removed during drilling and sampling operations.

There are currently no monitoring wells slated for abandonment during this SCP. However, if circumstances develop where a monitoring well needs to be abandoned, the well will be abandoned according to IDWR regulations, and the proper forms will need to be filed with IDWR prior to commencement of abandonment procedures.

2.6 DRILLING EQUIPMENT DECONTAMINATION

The purpose of decontamination and cleaning procedures during excavation, drilling and sampling is to prevent contamination of the samples and cross-contamination between sites. A decontamination area and clean zone will be established for the preparation and breakdown of equipment prior to each sampling task. The decontamination area will be large enough to accommodate equipment to be used for invasive work and that will allow decontamination rinsate to be pumped off for temporary storage and subsequent disposal. Before use and between each site, all equipment and other non-sampling equipment will be decontaminated with high-pressure steam, or scrubbed with a non-phosphate detergent and rinsed with water from an approved water source. If appropriate, equipment will be covered in plastic to protect it from the elements.

All equipment that may directly contact samples, such as split-spoon samples or core barrels, will be decontaminated on-site. The following sampling-specific decontamination procedures will be utilized.

- Wash and scrub with detergent (laboratory grade, non-phosphate detergent)
- Rinse with potable water
- Rinse with deionized water
- Rinse with another batch of deionized water
- Air dry
- Protect from fugitive dust and vapors

3.0 BOREHOLE LOGGING - SOILS

3.1 GENERAL

The procedures described herein are applicable to logging soils and are based on the Unified Soils Classification System (USCS); ASTM Standard D 2488-93, Standard Practice for Description and Identification of Soils (Visual Manual); and ASTM Standard D 5434-93, Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock (ASTM, 1993).

Much of the information described in this section is summarized on several tables and a USCS field guide, as shown in Attachment B. Other field guidance references also may be used according to personal preference, however, such references must be based on the USCS. Note that many references (for example, AGI Data Sheet grain size scales) base soil classifications on the Wentworth Scale. Such scales may vary significantly from the USCS and will lead to inaccurate or inconsistent soil descriptions.

All soil logging will be documented using the *Soil Boring Log Form* included in Attachment F.

3.2 GEOLOGIST/HYDROGEOLOGIST

One or more geologists or hydrogeologist will accompany each operating drill rig for inspection of drilling and borehole testing work. Each individual will be responsible for only one operating rig. Once assigned to an individual borehole, that person will remain as the geologist or hydrogeologist until that borehole is completed, unless approved for replacement. The geologist or hydrogeologist will be present during the entire time that the drill rig is operating and during casing and screen installation, developing and clean-out operations.

The geologist or hydrogeologist will observe and record the drilling operations along with the characteristics of the subsurface materials. This individual will be responsible for the preparation of a separate log for each boring and will sign each log.

3.3 DEFINITIONS

Use of the USCS requires familiarity with the grain size ranges that define a particular type of soil, as well as several other physical characteristics. The grain size definitions and physical characteristics upon which soil descriptions are based are presented below.

3.3.1 GRAIN SIZES

USCS grain sizes are based on U.S. standard sieve sizes, which are listed below.

- Standard sieves with larger openings are named according to the size of the openings in the sieve mesh. For example, a "3-in." sieve contains openings that are 3 inches square.
- Standard sieves with smaller openings are given numbered designations that indicate the number of openings per inch. For example, a "No. 4" sieve contains 4 openings per inch.

The following grain size definitions are paraphrased from the ASTM Standard D 2488-93. Field personnel should familiarize themselves with the grain size definitions.

Boulders - Particles of rock that will not pass a 12-in. (300-mm) square opening.

Cobbles - Particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve.

Gravel - Particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

- *Coarse Gravel* - passes a 3-in. (75-mm) sieve and is retained on a 3/4-in. (19-mm) sieve
- *Fine Gravel* - passes a 3/4-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve

Sand - Particles of rock that will pass a No. 4 (0.19 in. or 4.75-mm) sieve and be retained on a No. 200 (0.003 in. or 75-μm) sieve with the following subdivisions:

- *Coarse Sand* - passes a No. 4 (0.19 in. or 4.75-mm) sieve and is retained on a No. 10 (0.08 in. or 2-mm) sieve
- *Medium Sand* - passes a No. 10 (0.08 in. or 2-mm) sieve and is retained on a No. 40 (0.017 in. or 425-μm) sieve
- *Fine Sand* - passes a No. 40 (0.017 in. or 425-μm) sieve and is retained on a No. 200 (0.003 in. or 75-μm) sieve

Silt - Soil passing a No. 200 (0.003 in. or 75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried. Individual silt particles are not visible to the naked eye.

Clay - Soil passing a No. 200 (0.003 in. or 75-μm) sieve that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air-dried. Individual clay particles are not visible to the naked eye.

3.3.2 PHYSICAL CHARACTERISTICS

The following physical characteristics are used in the USCS classification for fine-grained soils. A brief definition of each physical characteristic is presented below. A determination of the type of fine-grained soil present in the sample can generally be made on the basis of plasticity, as described in Section 3.4.1.2.

Dry Strength - The ease with which a dry lump of soil crushes between the fingers.

Dilatancy Reaction - The speed with which water appears in a moist pat of soil when shaking in the hand and disappears while squeezing.

Toughness - The strength of a soil, moistened near its plastic limit, when rolled into a 1/8-inch diameter thread.

Plasticity - The extent to which a soil may be rolled into a 1/8-inch thread and re-rolled when drier than the plastic limit.

3.4 SOIL LOGGING PROCEDURES

The following aspects of a project must be understood before sampling and soil logging commences.

- Purpose of the soil logging (e.g., initial investigation, subsequent investigation, remediation)
- Known or anticipated hydrogeologic setting including presence of fill material, lithology, physical characteristics of the aquifer, type of aquifer, recharge/discharge conditions, aquifer thickness and ground water/conditions
- Drilling conditions
- Previous soil boring or borehole geophysical logs
- Soil sampling and geotechnical testing program
- Characteristics of potential chemical release(s) (chemistry, density, viscosity, reactivity and concentration)

- Health and Safety protection requirements
- Regulatory requirements

The procedures used to determine the correct soil sample classification are described below. These procedures are presented in Attachment B.

The soils should be described in terms of lithologic units, rather than on a sample-by-sample basis. Thus, a single description may cover several sample intervals, or conversely, several units may occur within a single sample interval. For a specific unit, the primary classification is described and then variations or minor changes are noted below the main description at the depth where they occur.

3.4.1 FIELD CLASSIFICATION OF SOILS

When naming soils, the proper USCS soil group name is given followed by the group symbol. For clarity, it is recommended that the group symbol be placed in parentheses after the written soil group name.

Soil identification using the visual-manual procedures is based on naming the portion of the soil sample that will pass a 3-in. (75-mm) sieve. Therefore, before classifying a soil, any particles larger than 3 inches (cobbles and boulders) should be removed, if possible. Estimate and note the percentage of cobbles and boulders.

Using the remaining soil, the next step of the procedure is to estimate the percentages by dry weight of the gravel, sand and fine fractions (particles passing a No. 200 sieve). The percentages shall be estimated to the closest 5%. In general, the soil is *fine-grained* (e.g., a silt or a clay) if it contains 50% or more fines and *coarse-grained* (e.g., a sand or a gravel) if it contains less than 50% fines. If one of the components is present but estimated to be less than 5%, its presence is indicated by the term *trace*. For example, "trace of fines" would be added as additional information following the formal USCS soil description.

3.4.1.1 Procedure for Identifying Coarse-Grained Soils (contain less than 50% fines)

If it has been determined that the soil contains less than 50% fines, the soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand. The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

If the soil is predominantly sand or gravel but contains an estimated 15% or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "gravel with sand (GP)." If the sample contains any cobbles or boulders, the words "with cobbles" or "with cobbles and boulders" shall be added to group name. For example: "silty gravel with cobbles (GM)."

5% or less fines. The soil is a "clean gravel" or "clean sand" if the percentage of fines is estimated to be 5% or less. "Clean" is not a formal USCS name but rather a general descriptor for implying little to no fines. Clean sands and gravels are given the USCS designation as either *well-graded* or *poorly-graded*, as described below.

Identify the soil as a *well-graded gravel* (GW) or as a *well-graded sand* (SW), if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes. Identify the soil as a *poorly-graded gravel* (GP) or as a *poorly-graded sand* (SP) if it consists predominantly of one grain size (uniformly graded) or has a wide range of sizes with some intermediate sizes obviously missing (gap- or skip-graded).

Note: When using the USCS, keep in mind the difference between grading and sorting. The term grading is used to indicate the range of particles contained in the sample. For example, a poorly-graded sand containing predominantly one grain size would be considered well-sorted and vice-versa.

One notable exception to this general rule is a skip-graded (bimodally distributed) sample: a sand containing two distinct grain sizes would be considered both poorly-sorted and poorly-graded. The USCS uses only the *GRADING* descriptor in soil naming, not the sorting descriptor.

≥ 15% fines. The soil is a *silty* or *clayey gravel* or a *silty* or *clayey sand* if the percentage of fines is estimated to be 15% or more. For example, identify the soil as *clayey gravel* (GC) or a *clayey sand* (SC) if the fines are clayey. Identify the soil as a *silty gravel* (GM) or a *silty sand* (SM) if the fines are silty. The coarse-grained descriptor "poorly-graded" or "well-graded" is not included in the soil name, but rather, should be included as additional information following the formal USCS soil description.

>5% but <15% fines. If the soil is estimated to contain greater than 5% and less than 15% fines, give the soil a dual identification using two group symbols. The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a clayey/silty gravel or sand (GC, GM, SC, SM). The group name shall correspond to the first group symbol and include the words "poorly-graded" or "well-graded", plus the words "with clay" or "with silt" to indicate the character of the fines. For example, "poorly-graded gravel with silt (GP-GM)".

3.4.1.2 Procedure for Identifying Fine-Grained Soils (contain 50% or more fines)

The USCS classifies inorganic fine-grained soils according to their degree of plasticity (no or low plasticity - indicated with an "L", or high plasticity - indicated with an "H"). The field tests used to determine dry strength, dilatancy and toughness are generally too time consuming to be performed on a routine basis. Field personnel should be familiar with the definitions of the physical characteristics and the concepts of the field tests; however, field classifications will generally be based primarily on plasticity, as described in Attachment C.

Lean clay (CL) - soil has medium to high dry strength, no or slow dilatancy and medium toughness and plasticity.

Fat clay (CH) - soil has high to very high dry strength, no dilatancy and high toughness and plasticity.

Silt (ML) - the soil has no to low dry strength, slow to rapid dilatancy and low toughness and plasticity, or is nonplastic.

Elastic silt (MH) - the soil has low to medium dry strength, no to slow dilatancy and low to medium toughness and plasticity; will air dry more quickly than lean clay and have a smooth, silky feel when dry.

Organic soil (OL or OH) - the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, from black to brown, when exposed to the air. Organic soils normally will not have a high toughness or plasticity.

Other Modifiers for Use with Fine-Grained Soils:

15% to 25% coarse-grained material. If the soil is estimated to have 15% to 25% sand or gravel, or both, the words "with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example: "lean clay with sand (CL)" or "silt with gravel (ML)." If the percentage of sand is equal to the percentage of gravel, use "with sand."

≥30% coarse-grained material. If the soil is estimated to have 30% or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be the same or more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy silt (ML)", or "gravelly fat clay (CH)."

3.4.1.3 Procedure for Identifying Borderline Soils

To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example, a soil containing an estimated 50% silt and 50% fine grained sand may be assigned a borderline symbol "SM/ML." Borderline symbols should not be used indiscriminately. Every effort should be made to first place the soil into a single group and then to estimate percentages following the USCS soil description.

3.4.2 DESCRIPTIVE INFORMATION FOR SOILS

After the soil name and symbol are assigned, the soil color, consistency/density and moisture content shall be described in that order. Other information is presented later in the description, as applicable.

3.4.2.1 Color

Describe the color using the Munsell Soil Color Chart (1992). Color is an important property in identifying organic soils and may also be useful in identifying materials of similar geologic or depositional origin in a given location.

When using the Munsell Soil Color Charts, first attempt to assign the soil a general color, such as brown, gray, red, etc. Then go to the correct area in the charts and assign the applicable color name and Munsell symbol. The ability to detect minor color differences varies among people and the chance of finding a perfect color match in the charts is rare. Keeping this in mind should help field personnel avoid spending unnecessary time and confusion going through the chart pages. In addition, attempting to describe detail beyond the reasonable accuracy of field observations could lead to making poorer soil descriptions than by expressing the dominant colors simply (Munsell Soil Color Chart, 1992).

If the color charts are not being used or are unavailable, again attempt to assign general colors to soils. Comparing a particular soil sample to samples from different locations in the borehole will help keep the eye "calibrated." For example, by holding two soils together, it may become evident that one is obviously greenish-brown, while another is reddish.

3.4.2.2 Consistency & Density

For intact fine-grained soil, describe consistency as very soft, soft, medium stiff, stiff, very stiff, or hard, based on the blows per foot using a 140-pound hammer dropped 30", as described in Attachment D. If blow counts are not available, use the thumb test, as described in Attachment D to determine consistency.

For coarse-grained soils, describe density based on blows per foot as very loose, loose, medium dense, dense and very dense, as described in Attachment D. If blow counts are not available, attempt to estimate the soil density by observation, since a practical field test is not available. Be sure to clearly indicate on the field boring log if blow counts could not be obtained.

3.4.2.3 Moisture

Describe the moisture condition of the soil as dry (absence of moisture, dusty, dry to the touch), moist (damp but no visible water, even in interstices) or wet (visible free water, saturated).

3.4.2.4 Maximum Grain Size

Describe the maximum particle size found in the sample in accordance with the information listed below.

- **Sand Size** - If the maximum particle size is a sand size, describe as fine, medium, or coarse.
- **Gravel Size** - If the maximum particle size is a gravel size, describe the diameter of the maximum particle size in inches.
- **Cobble or Boulder Size** - If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle.

For gravel and sand components, describe the range of particle sizes within each component. For example, "about 20% fine to coarse gravel, about 40% fine to coarse sand."

3.4.2.5 Odor

Due to health and safety concerns, NEVER intentionally smell the soil. This could result in exposure to volatile contaminants that may be present in the soil. If, however, an odor is incidentally noticed, it should be described if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation (sometimes a hydrogen sulfide ["rotten egg"] smell). If the odor is unusual (petroleum product, chemical, etc.), it should be described. Organic vapor readings from an OVM or similar instrument should be noted on the field boring log. The project-specific Heath and Safety Plan should then be consulted to determine the appropriate level of protection necessary for the continuation of fieldwork.

3.4.2.6 Cementation

Describe the cementation of intact coarse-grained soils as weak, moderate or strong, in accordance with the criteria listed below.

- **Weak** - Crumbles or breaks with handling or little finger pressure
- **Moderate** - Crumbles or breaks with considerable finger pressure
- **Strong** - Will not crumble or break with finger pressure

The presence of calcium carbonate may be confirmed on the basis of effervescence with dilute hydrochloric acid, HCl, if calcium carbonate or caliche is believed to be present in the soil. Proper health and safety precautions must be followed when mixing, handling, storing, or transporting HCl.

3.4.2.7 Angularity

Describe the angularity of the sand (coarse sizes only), gravel, cobbles and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria listed below.

- **Angular** - Particles have sharp edges and relatively planar sides with unpolished surfaces
- **Subangular** - Particles are similar to angular description but have rounded edges
- **Subrounded** - Particles have nearly plane sides but have well-rounded corners and edges
- **Rounded** - Particles have smoothly curved sides and no edges

A range of angularity may be stated, such as "subrounded to rounded".

3.4.2.8 Structure

Describe the structure of intact soils in accordance with the criteria in Attachment E.

3.4.2.9 Lithology

Describe the primary lithologies (rock or mineral type) of the sand, gravel, cobbles and boulders, if possible. It may be difficult to determine the lithology of fine and medium-grained sand or particles that have undergone alteration.

3.4.2.10 Additional Comments

Additional comments may include the presence of roots or other vegetation, fossils or organic debris, staining, mottling, or oxidation; difficulty in drilling and caving or sloughing of the borehole walls. Also, when drilling in an area known or suspected to contain imported fill material, every effort should be made to identify the contact between fill and native soils. If a soil is suspected to be fill, this should be clearly indicated on the log following the soil description. Stratigraphic units and their contacts should be noted wherever possible.

3.4.3 ADDITIONAL BORING LOG INFORMATION

In addition to soil descriptions, there are several other items that should be included on all *soil boring log forms*, included in Attachment F. Information in the log heading should be complete and accurate. The information listed below should be included, at a minimum.

- Boring or monitoring well number
- Project name and job number
- Site name
- Name of individual who logged the boring
- Drilling contractor
- Drill rig type and method of drilling (for example, "CME 75, hollow stem auger")
- Name of drilling company
- Name of driller and helper
- Borehole diameter and drill bit type
- Type of soil sampler (for example, Modified California, continuous core, etc.)
- Time and date that drilling started and finished
- Time and date that the well was completed or the soil boring backfilled, as appropriate
- Method of borehole abandonment, if applicable
- Sketch map of boring or well location with estimated distances to major site features such as property lines or buildings and north arrow

Soil sample information should include the depth interval that was sampled, the blow counts per six inches, the amount of soil recovered and the portion submitted for analysis or testing, if any. The sample identification number may also be noted on the log.

The degree to which soil samples are collected during a field effort depends on the overall scope and purpose of the investigation, which should be clearly defined before the field effort commences. Additional soil samples may need to be collected if, for example, soils are very heterogeneous or unexpected conditions such as perched water zones or zones of contamination are encountered.

If groundwater is encountered during drilling, the depth to water and the time and date of the observation should be recorded. If the first water encountered is a perched zone, the depth, time and date that any additional groundwater zones are encountered should also be recorded. Depth to water after drilling, the measuring point and the date and time of the measurement(s) must be noted. Additional measurements of depth to groundwater, including depth and time, may be beneficial.

4.0 BOREHOLE LOGGING - BEDROCK

4.1 GENERAL

This discussion has been prepared to assist geologists in the recovery of geologic and hydrogeologic data from boreholes drilled through bedrock. Drilling is expensive and it is therefore appropriate to obtain as much relevant information from each borehole as possible. Core logging is often a slow process; the program described herein has been designed to utilize simple observations and tests in order to keep the effort required to a minimum.

4.2 BEDROCK LOGGING PROCEDURES

A *Rock Core Log Form* is included in Attachment G. This form contains columns for recording virtually all information of geologic or hydrogeologic significance that is available from rock core.

4.2.1 HEADER INFORMATION

Information required at the top of the sheet includes the following.

Date — Date record prepared

Borehole Location — Brief description of physical location of borehole. May be grid coordinates, chainage and offset, or geographical description. Should not simply say "see plan."

Logged by — First initial and surname of logger

Elevation — Reference elevation below which all down-hole depths are measured. This is not always available at the time of drilling.

Ref. Point — The reference point, below which all down-hole depths are measured; normally below ground surface (bgs). If the reference point is not the ground surface, the height of the reference point above the ground surface should be noted.

Datum — The survey datum to which the reference elevation is referred (e.g., State Plane NAD 83).

Drill Rig — Drill rig manufacturer and model number (e.g., Longyear 44).

Inclination — Surveyed inclination from horizontal of borehole at collar (90 degrees for vertical drill hole).

Azimuth — Surveyed azimuth of inclined borehole at collar (use N/A - not applicable for vertical drill holes). (If the drill hole inclination or azimuth are not surveyed, this should be noted and the method of estimating [e.g., with an inclinometer and compass] should be described.)

Bit Type — Brief description of type of diamond core bit used (e.g., "face discharge, surface set").

Flush — Medium used to cool the drill bit and flush cuttings out of the hole (e.g., water, compressed air).

Feed The method by which pressure/force is applied to advance the bit in the hole (e.g., hydraulic, screw).

4.2.2 DRILLING INFORMATION

The first (left-hand) four columns in the data section of the form record pertinent drilling information regarding hole size, casing and water conditions.

Core dia.: Depth This column records the standard core descriptor (e.g., NQ3) over the applicable depth interval shown graphically.

Casing dia.: Depth This column records the standard casing descriptor (e.g., NW) or nominal diameter of steel drill casing (e.g., 4 in.), if used (if none, insert "uncased") and the cased depth interval shown graphically. Any notes on telescoping or withdrawing casing should also be recorded.

Water Notes Any observations related to groundwater conditions in the hole should be noted (e.g., "hole made water at 19 meters [62 ft]," "lost circulation at 14 meters [47 ft.]"). This column should also include an estimate (usually by visual observation) of the flush return, or rate of return of drilling fluid. It is expressed as a percentage of fluid pumped into the hole (100 equals full return; 0 equals total loss of circulation). The depth interval over which the return rate is applicable should be indicated graphically. The color, particularly changes in color, of the return drill fluid should also be noted.

4.2.3 ROCK TYPE

The next three columns on the form present the lithologic information from the drill hole. This description should be complete, although due to lack of space, reference to additional detail found on the geologic log is often appropriate. The rock type should be described in terms of lithologic units rather than on a run-by-run basis. Thus, a single description may cover several runs, or conversely, several rock types may occur within a single run.

Depth The depth below ground surface of all boundaries between lithologic units (rock types). Boundaries should be plotted at scaled depths and should be extended horizontally across the "Description" column, as described below. Identification/recording of boundaries between lithologic units is one of the **primary responsibilities** of the logger.

Description This section of the log provides a complete description of each lithologic unit encountered by the drill hole. Soil, if included in the rock log, or soil infillings should also be described.

Contacts between rock types are represented as listed below.

- *Sharp* - solid horizontal line at contact location
- *Gradational* - solid slanted line from start of gradational change to end of gradational change
- *Inferred contact* - dashed slanted line extending over depth range of inferred contact
- *Erosional* - solid wavy line at contact location (depth)
- *Fault* - heavy solid horizontal line at contact location (depth)

The description should include the items shown in the list below.

- Rock type (e.g., basalt)
- Formation name, if known

- Modifiers (e.g., shaly, calcareous, siliceous, micaceous, vesicular)
- Bedding characteristics (e.g., laminated, thin bedded, massive)
- Color (based on USGS Rock Color Chart)
- Hardness (soft, very hard)
- Degree at cementation (poorly cemented, well cemented)
- Texture (dense, fine-, medium-,or coarse-grained; glassy; porphyritic; crystalline)
- Solution or void conditions (solid, cavernous, vuggy with partial infilling by clay)
- Primary and secondary permeability

4.2.4 DEPTH SCALE

The vertical scale, generally in feet, to which the drilling information, lithologic description and core data are plotted on the log. Typically, the log is set up to handle 8 meters (27.5 ft.) of hole but any scale can be used as long as it is clearly documented. The units to which the scale is plotted (e.g., feet, meters) should always be marked in the space provided in the column header.

4.2.5 CORE RECOVERY DATA

This portion of the form records pertinent data regarding the condition of the recovered core. This information is recorded on a "per run" basis. Accordingly, for each core run, the "run interval" should be indicated by solid horizontal lines plotted at the start and end depths of the run and extending across all of the "Core Recovery Data" columns. The actual cored interval should be indicated on the log, not the length of recovered core.

Details regarding drilling conditions ("hard drilling," "easy drilling," "machine off pressure," etc.), core blockages or any other factors which could effect or indicate the condition of the core should be noted.

For each run the following information should be recorded within the core interval (or immediately above the interval in the case of very short runs).

Run No. Core runs should be numbered consecutively (from-to) with increasing depth. If the overburden portion of the drill hole was sampled, the core runs should be numbered consecutively with the soil samples. The start and end depths of the core run should also be recorded in this column.

T.C.R. The Total Core Recovery of each run should be recorded as both the actual lengths cored and recovered and as the calculated percentage recovery.

R.Q.D. The Rock Quality Designation should be recorded as both the actual lengths cored and recovered and as the calculated percentage recovery.

$$\text{RQD} = \frac{\text{Sum of 10 cm (4 in) Lengths}}{\text{Total Length of Run}} \text{ (expressed as \%)}$$

Fractures This column is used to record the number of natural (not drilling induced) fractures per foot (or other appropriate interval) in a given length of core. If more than ten naturally occurring fractures are counted in the interval, record ">10" in the "Fractures per ____" column.

4.2.6 DISCONTINUITY DATA

This section of the form records information regarding the orientation and physical characteristics of each significant natural discontinuity in the core. When similar natural fractures occur regularly along pre-existing weakness planes such as bedding or foliation, it is not necessary to record the orientation

and characteristics of each fracture individually. An explanatory note such as "unless otherwise noted fractures to 83.5 meters (274 feet), are along foliation; planar; smooth" should be included to eliminate the need to repeat the description for each fracture. With this convention, only fractures that do not meet the stated criteria need to be described individually, although the location and dip of all fractures should be recorded. The following additional information should also be recorded:

- Dip W.R.T - the dip with respect to the core axis of each significant natural discontinuity should be measured and recorded numerically (i.e., 90 degrees for horizontal).
- Type and surface - the type of discontinuity and the surface description characteristics should be determined and recorded using the abbreviations included in the footer section of the log form.

4.2.7 STRENGTH DATA

Weathering Index Weathering Index is recorded in this column. Changes in the Weathering Index are indicated by a solid, horizontal line at the point of change for an abrupt change, or a solid slanting line covering the range of weathering change. The classification scheme for weathering index is shown in Attachment H, *Weathering and Intact Rock Strength Classification.*

Strength Index: Strength Index is recorded in this column. Any change in the Strength Index should be indicated by a solid horizontal line at the point of change. The classification scheme for strength index is shown in Attachment H.

4.2.8 ADDITIONAL NOTES

The final column on the form is used to record any additional notes for performed on the core or in the hole. This might include data such as drilling equipment malfunction, core blockage or data that did not fit in the other columns.

4.3 DRILL CORE PHOTOGRAPHY

Each box of bedrock core will be photographed as soon as possible. Photographic records will be acquired using 35mm slides and/or digital cameras. A separate bound field logbook shall be assigned to each camera for recording the photographer's name, subject matter, borehole identification number, interval and other pertinent information for each frame or digital image. The photography is a routine process and care must be taken to ensure that sharp focus and proper exposure settings are maintained throughout. A setup which utilizes daylight photo flood lamps or sunlight at an appropriate angle (e.g., directly overhead with no shadows) should be used for the best color. A signboard should be included in each picture, which contains identifying information. This would include the project name, borehole number, box number, depth interval and a scale. An engineer's scale or tape and standard Munsell/Geological Society of America (GSA) soil or rock color reference charts will be included in any photographs taken of rock core or soil. Any wasted frames or images in a roll of film or sequence of digital images shall be so noted in the field logbook. The core can be photographed either wet or dry depending on which condition reveals the most detail.

The core photography provides a permanent record of the core condition as it came out of the ground. It is easier to access for review than the core itself and contains information that is otherwise lost as the core is handled for logging, split for assaying, samples taken for testing, etc. It may turn out that the photographic file is the only record behind the logs for a number of reasons, including core storage facilities have collapsed, core has been discarded after the initial logging because storage is expensive, or due to time pressures some core may not be logged at all. When a project changes hands, the new owner or lessor often receives an incomplete collection for one reason or another. In such cases, the photographic record will prove invaluable.

5.0 MONITORING WELL DESIGN AND INSTALLATION

5.1 GENERAL

This guideline is applicable to the design and installation of permanent monitoring wells at CC. Each monitoring well will be designed to suit the hydrogeologic setting of the site, the type of contaminants to be monitored, the overall purpose of the monitoring program and other site-specific variables. During all phases of well design, attention must be given to clear documentation of the basis for design decisions, the details of well construction and the materials to be used. A *Typical Monitoring Well Installation Diagram* is provided as Attachment I and a *Monitoring Well Construction Form* is provided in Attachment J.

5.2 WELL LOCATIONS

The current scope of work entails installing 6 monitoring wells. The locations and rationale of these wells are discussed in the Work Plan. These wells are located as single wells.

5.3 WELL DESIGN

5.3.1 CASING DIAMETER AND SCREEN LENGTH

Monitoring well casing diameter is dependent on the purpose of the well and the amount and size of downhole equipment that must be accommodated. All of the wells are designed to be multipurpose monitoring wells. Therefore, they will all be constructed with 4-inch or 6-inch diameter PVC well casing.

With the exception of any wells specifically designed for accommodating a pumping test, the screen lengths will be 10 feet. Any wells that will be screened near the water table will be screened across the water table. Consideration should be given to seasonal fluctuations in water levels when locating the well screen across the top of the water table.

5.3.2 CASING AND SCREEN MATERIALS

The two most commonly used materials are PVC and stainless steel. PVC is inexpensive, widely available, lightweight and easy to work with. Many studies have been conducted concerning the effect of PVC on water quality data. Adsorption of some chlorinated species to PVC was found to be too slow to effect data quality. Because a sample is generally taken shortly after the purging of stagnant water in contact with the casing, the contaminants in the water will have minimal time to be influenced by sorption or leaching effects. Therefore, potential sample bias effects due to interactions with PVC are negligible (Reynolds, et al, 1990). Consequently, monitoring well casings and screens will be constructed of polyvinyl chloride (PVC). Wells less than 150 feet deep will be constructed of schedule 40 PVC, while deeper wells will be constructed of schedule 80 PVC.

The hydraulic efficiency of a well screen depends primarily upon the amount of open area available per unit length of screen. The two screen types commonly used for monitoring wells are machine-slotted and continuous-slot wire-wound. The continuous-slot, wire-wound screen has a greater area per opening per length and diameter than is available with any other screen type. The percentage of open area in continuous-slot screen is often more than twice that provided by standard slotted well screen. The triangular shaped wire makes these screens non-clogging. The monitoring wells installed at the site will be constructed with machine-slotted PVC screens, except ones installed for conducting pumping tests, which may be installed with continuous-slot wire-wound PVC screen.

Additional construction specifications are listed below.

- Threaded, flush-joint casing

- Well caps that are vented to prevent the accumulation of gases and to allow water levels in the well to respond to barometric and hydraulic pressure changes
- Threaded end-caps

5.3.3 DECONTAMINATION OF CASING AND SCREEN MATERIALS

During the production of PVC casing, a wax layer can develop on the inner wall of the casing; protective coatings may also be added to enhance casing durability. All of these represent potential sources of chemical interference and must be removed with either a laboratory-grade non-phosphate solution or by steam cleaning prior to installation. Factory cleaning of casing and screen in a controlled environment by standard detergent washing, rinsing and air-drying procedures is superior to any cleaning efforts attempted in the field. Factory cleaned and sealed casing and screen that is certified by the supplier will be used if available.

5.3.4 FILTER PACK AND WELL SCREEN DESIGN

A properly designed monitoring well requires that a well screen be placed opposite the zone to be monitored and be surrounded by materials that are coarser and of greater hydraulic conductivity than the natural formation material. Filter packs are installed to create a permeable envelope around the well screen. The selection of the filter pack grain size should be based on the grain size of the finest layer to be screened.

The typical well construction for a monitoring well in average formation materials includes filter pack on the order of #3 Monterey sand size and 0.020 inch slotted screen. A configuration similar to this will be used, unless the materials encountered are radically different than expected. The design of wells to be used for pumping during a pumping test is described in Section 10.2.4.

If conditions warrant, filter pack grain size and well screen slot size should be determined by the grain size distribution of the formation material. The filter pack should be designed first. It is recommended to use a filter pack grain size that is three to five times the average (D50) size of the formation materials. D50 will be estimated based on the lithologic description made by the site geologist or hydrogeologist. However, this method may be misleading in coarse, well graded formation materials. Another way to determine filter pack grain size is to take the D30 grain size of the formation materials and multiplying it by a factor of between 3 and 6, with 3 used if the formation is fine and uniform and 6 used if the formation is coarse and non-uniform. For both methods, the uniformity coefficient of the filter pack materials should be as close to 1.0 as possible to minimize particle size segregation during filter pack installation.

The filter pack will extend from the bottom of the well screen to approximately 3 to 5 feet above the top of the screen to account for settlement of the pack material during development and to act as a buffer between the well screen and the annular seal. Filter pack thickness must be sufficient to surround the well screen but thin enough to minimize resistance to the flow of fine-grained formation material and water into the well during development. Consequently, a filter pack thickness of approximately 2 inches will be used.

The materials comprising the filter pack should be as chemically inert as possible. It should be comprised of clean quartz sand or glass beads. Filter pack materials usually come in 100-pound bags; these materials are washed, dried and factory packaged.

The size of well intake openings can only be selected after the filter-pack grain size is specified. The slot size should be such that 90 percent to 100 percent of the filter-pack material is held back by the well screen.

The casing string should be installed in the center of the borehole. This will allow the filter-pack materials to evenly fill the annular space around the screen and ensure that annular seal materials fill

the annular space evenly around the casing. Where a dual-tube rig is used, the inner tube of the dual tube will adequately centralize the casing string. For other types of drilling, centralizers will be used to ensure the casing string is positioned in the center of the borehole. Centralizers are typically expandable metal or plastic that attach to the outside of the casing and are adjustable along the length of the casing. Centralizers will be attached immediately above the well screen and at 20-foot intervals along the casing to the surface.

Methods for filter pack emplacement normally used for monitoring wells include: 1) gravity (free-fall); and 2) tremie pipe. Gravity emplacement is only possible in relatively shallow wells (less than ~50 feet) with an annular space of more than 2 inches where the potential occurrence of bridging is minimized. Bridging can result in the occurrence of large unfilled voids in the filter pack or the failure of filter pack materials to reach their intended depth. Gravity emplacement may also cause filter pack gradation. Additionally, formation materials from the borehole wall can become incorporated into the filter pack, potentially contaminating it.

With the tremie emplacement method, the filter pack is poured or slurried into the annular space adjacent to the well screen through a rigid pipe, usually 1.5 inches in diameter. Initially the pipe is positioned so that its end is at the bottom of the annulus. If the filter pack is being installed in a temporarily cased borehole (e.g., dual-tube percussion) the temporary casing is pulled to expose the screen as the filter-pack material builds up around the well screen. In unconsolidated formations the temporary casing should only be pulled out 1 to 2 feet at a time to prevent caving. In consolidated or well-cemented formations or in cohesive unconsolidated formations, the temporary casing may be raised well above the bottom of the borehole prior to filter pack emplacement. For deep wells and/or nonuniform filter pack materials, the filter pack may be pressure fed through a tremie pipe with a pump. Emplacement will be continuously monitored with a weighted measuring tape accurate to the nearest 0.1 foot to determine when the filter pack has reached the desired height.

5.3.5 ANNULAR SEAL

Proper annular seal formulation and placement results in the complete filling of the annular space and envelopes the entire length of the well casing to ensure that no vertical migration can occur within the borehole.

Annular seal materials will include bentonite chips or a high solids (approximately 10%) bentonite grout with a weight in the range of eleven to thirteen pounds per gallon of sealant. The grout will be mixed using the manufacturer's directions. A bentonite seal at least 2 feet thick will be emplaced immediately above the filter pack using a side-discharge tremie pipe. The use of bentonite as a sealing material depends on its efficient hydration following emplacement. Expansion of bentonite in water can be on the order of 8 to 10 times the volume of dry bentonite. This expansion causes the bentonite to provide a tight seal between the casing and the adjacent formation. Bentonite pellets, granules, or chip will be used for this seal. Bentonite pellets expand in water at relatively slow rates, thus reducing the potential for bridging compared to chips, chunks, or granules. If the bentonite seal will be above the saturated zone, several gallons of clean distilled water will be poured down the annulus to begin the hydration process. A minimum of 30 minutes should pass to allow for hydration before additional annular seal materials are placed above the bentonite.

The high solids grout will be mechanically blended in an aboveground rigid container and pumped through a tremie pipe to within a few inches of the bottom of the space to be sealed. This allows the grout to displace groundwater and loose formation materials up the hole. The end of the tremie pipe should always remain in the grout without allowing air spaces. After emplacement, the tremie pipe should be removed immediately. The grout should be emplaced in one continuous mass before initial setting of the cement or before the mixture loses its fluidity.

Cement is a highly alkaline substance (pH from 10 to 12) and introduces the possibility of altering the chemistry of the water it contacts. Thinner slurries may infiltrate an unprotected filter pack. After a

borehole annulus is filled with grout a sample of water may be obtained and the pH determined in the field. A pH reading of 12 or higher may indicate an invasion of cement grout into the well.

5.3.6 SURFACE COMPLETIONS

Two types of surface completions will be used: aboveground and flush-mounted. Aboveground completions will be used wherever practical. Flush mounted completions will be used anywhere there may be vehicle traffic or where low visibility is preferred. The primary purpose of either type of completion is to prevent surface runoff from entering and infiltrating down the annulus of the well and to protect the well from accidental damage or vandalism. The surface seal may be an extension of the annular seal installed above the filter pack, or a separate seal emplaced atop the annular seal.

For aboveground completions, a protective steel casing fitted with a locking cover will be set into the uncured cement surface seal. Four guard posts (bollards) will be spaced around each well with above ground completions to afford additional protection.

In a flush-mount surface completion, a water-tight monitoring well Christy box or its equivalent will be set into the cement surface seal before it has cured. This type of completion is used in high-traffic areas. A low, gently sloping mound of cement will discourage surface runoff. A locking well cap will be used to secure the inner well casing.

5.3.7 SUMMARY OF WELL DESIGN

In summary, the filter pack and well design criteria for the investigations are listed below.

- PVC screen and casing
- Schedule 40 casing for wells less than 150 feet deep
- Schedule 80 casing for wells greater than 150 feet deep
- 0.020-inch machine slotted screen
- 4-inch diameter casing
- Threaded flush joint casing and end-caps
- Centralizers in uncased holes
- #3 Monterey sand or equivalent for filter packs up to 3 to 5 feet above the top of the screened interval
- Bentonite plug at least 2 feet thick on top of filter pack
- Annular seal to the surface to consist of neat cement
- Both filter pack and annular seal are to be emplaced using a tremie pipe
- Surface completions will be aboveground stand-pipes with bollards unless in a vehicle traffic right-of-way of area where low visibility is preferred

6.0 PIEZOMETER INSTALLATION

Piezometers are typically installed at investigation sites where permanent groundwater monitoring wells are not required or are not feasible. Piezometers are primarily used for groundwater elevation studies. Piezometers differ from permanent monitoring wells mainly in construction and development standards. However, like permanent monitoring wells, piezometers will be designed to suit the hydrogeologic setting, the types of contaminants to be monitored, the overall purpose of the monitoring program, and other site-specific variables. Clear documentation of design parameters, construction details, and materials used will be maintained. During installation of piezometers, care will be taken to ensure that they do not serve as conduits for surface contaminants to the subsurface. Therefore, surface completions will follow essentially the same standards as outlined for monitoring wells.

6.1 BASIC INSTALLATION AND OPERATION OF PIEZOMETERS

A piezometer is essentially a device used for the measurement of hydraulic head. A piezometer must be sealed along its length, must be open to groundwater flow at the bottom, and be open to the atmosphere at the top. The intake is usually a section of slotted pipe or a commercially available well point. In either case, the intake is designed to allow the inflow of water but not of the sand grains or clay particles that make up the formation. A simple standpipe piezometer may be replaced in some applications by more complex designs utilizing pressure transducers, pneumatic devices, and electronic components.

Piezometers are installed using either direct-push methods or installed through a soil boring. With the use of direct-push methods, the piezometer pipe is attached to the push rods and driven to depth using a hydraulic ram. With use of a drill rig, the pipe is attached to standard soil sampling drill rods and driven to depth using either a standard 140-pound hammer, or hydraulically advanced into the water-bearing zone. Blow counts during advancement of the sampler should not exceed 30 per 6 inches. Piezometers can also be constructed in auger strings within a boring.

Unless otherwise specified in project-specific work plans, piezometers will be completed as naturally developed wells with the formation materials allowed to collapse around the screen. As previously described for monitoring wells, screen slot sizes will be based on grain-size distribution. Surface completions will be constructed in a similar manner as for monitoring wells. However, the protective outer PVC casing will not be installed. The piezometer will instead be fitted with a PVC end cap.

Piezometers will be constructed using one of three common methods:

1. Using the pull-back method

2. Driving the well point beyond the end of the casing into the formation below

3. Construction within drill pipes or augers

Pull-Back Method: In the pull-back method for piezometer installation, the casing is first set to the desired depth. A packer is then threaded to the top of the well point or riser pipe and lowered through the casing. After the well point has been lowered through the casing, the casing is pulled back to expose the screen to the water-bearing sediment. Drill tools (drill stem or driving bar) may be placed on the well point to hold it down as the casing is pulled back. Alternatively, some well points are manufactured with a drive plate mounted just above the point. The driving force is directed at the point, and the screen is pulled into place. However, care should be taken when using this technique

as inside driving may cause severe damage to the bottom of the screen. All points to be driven from the inside should be identified as such when ordered from the manufacturer. Two-inch well points can be set in 4-inch diameter wells using the pull-back method.

Driven Well Point: Occasionally the pull-back method cannot be used because the friction on the pipe is so great that the force required to move the pipe might break it. In this case, a well point can be driven beyond the end of the casing into the sand formation below. All the sediment in the casing is removed to prevent the well point from becoming sand-locked inside the pipe. If the sediment tends to heave, the casing is kept full of water while the screen is set (any water used should be from an approved source and complete records of quantities used should be maintained). A self-sealing packer is attached to the well point, and the well point is dropped through the casing. A driving bar, drill stem, or other similar tool is lowered to the top of the packer and alternately raised and dropped to drive the well point out the bottom of the casing. Careful measurements must be made so the driller knows when the screen has been driven to the correct depth. A riser pipe may be used for this purpose.

Construction within Drill Pipe or Auger: Two-inch well points can be easily set through drill pipes or hollow stem augers once the pipes/auger-flight assembly has reached the desired depth. The screen is attached directly to the casing, and the string is lowered inside the pipes/augers to the bottom of the borehole. The pipes/auger flights are then pulled back to expose the screen and casing. This method is particularly suitable in shallow, caving formations.

7.0 WELL DEVELOPMENT

The goal of monitoring well development is to remove fines and drilling fluid residue from the gravel pack and the natural formation in the vicinity of the screened interval, this will assure good communication between the aquifer and the well. The result of well development is assurance that a sample collected will be a true representative of the quality of water moving through the formation.

The well development process is composed of: (1) the application of sufficient energy in a monitoring well to create groundwater flow reversals (surging) in and out of the well and the gravel pack to release and draw fines into the well; and (2) pumping or bailing to draw drilling fluids out of the borehole and adjacent natural formation along with fines that have been surged into the well.

7.1 GENERAL

The following general guidelines are applicable to well development regardless of method.

7.1.1 DECONTAMINATION

It is essential that every effort be made to avoid outside contamination and the cross-contamination of monitoring wells. This can accomplished by ensuring that all equipment is clean prior to being introduced into a well. Before use and between each site, all equipment and other non-sampling equipment will be decontaminated with high-pressure steam or scrubbed with a non-phosphate detergent and rinsed with water from an approved water source. If appropriate, equipment will be covered in plastic to protect it from the elements.

7.1.2 DOCUMENTATION

A critical part of monitoring well development is recording of significant details and events; a *Well Development Record* is provided in Attachment K. Listed are some important details to document.

- Well identification number
- Installation date
- Date and time of development
- Quantity of drilling fluid lost during well installation
- Measured well depth (pre-development and post-development)
- Water level
- Height of water column
- Pumping rate and water level draw down (if applicable)
- Recharge rate (poor, good, excellent)
- Periodic parameter readings
- Sample observations
- Type of equipment used
- Total amount of water removed
- Completion time

7.1.3 WELL PURGING

The total volume of water purged during the development process will be based on two factors: (1) indicator parameters and (2) minimum purge volume.

7.1.3.1 Indicator Parameters

During the development process, the indicator parameters pH, temperature, electrical conductivity and turbidity will be measured. The parameters pH, temperature and electrical conductivity will be measured with a field meter while turbidity will be described qualitatively. Other observations of the

water, such as color and odor, will also be recorded. Measurement of the indicator parameters will be taken at the beginning and end of the development process and at least once every ½-casing-volume with a minimum of 4 measurements. Once the minimum required volume is reached, as described in Section 6.1.3.2, purging will continue until three consecutive measurements of the stabilization parameters meet the stabilization requirements shown below.

pH	± 0.2 units	
Conductivity	± 3% of span	(i.e., ± 0.03 for span of 0 to 1 mS/cm)
Temperature	± 1° C	
Turbidity	± 10%	

However, if the indicator parameters have stabilized, but there are still significant changes in color or some other qualitative characteristic, purging will continue until it has stabilized, if practical.

7.1.3.2 Purge Volume

Before the development process begins, the minimum number of gallons to be removed will be calculated. The minimum number of gallons to purge will be equal to three casing volumes or one purge volume (described below), whichever is larger.

Information needed to calculate purge volume is listed below.

1. Total depth of well (TD)
2. Measured static water level (WL)
3. Screen length (SL)
4. Well casing inner diameter (ID)
5. Borehole Diameter (BD)
6. Number of gallons of water used during well drilling/construction
7. If the standing water column (SC) is longer then the screen length, you will need to note how many feet of filter pack was installed above the screen.

Calculating one well volume:

- To calculate standing water column (SC), TD - WL = SC
- Use a well volume chart to find a multiplier in the "gallons per foot" column that coincides with the wells ID. This volume chart is located in Attachment K.
- SC x ID multiplier = gallons of water in one well volume

Calculating one annulus volume (2 Options):

Option 1, if SC is shorter then the screen length

- Portion of saturated annulus = SC
- Use a volume chart to find a multiplier in the "Gallons per foot" column that coincides with the wells BD
- BD multiplier - ID multiplier = annulus multiplier
- Feet of saturated annulus x annulus multiplier x 30% (assumed porosity) = gallons of water in one annulus volume

Option 2, if SC is longer then the screen length

- Portion of saturated annulus is = to the screen length + the number of feet of sand above the top of the screen
- Use a volume chart to find a multiplier in the "Gallons per foot" column that coincides with the wells BD

- BD multiplier - ID multiplier = annulus multiplier
- Feet of saturated annulus x annulus multiplier x 30% (assumed porosity) = gallons of water in one annulus volume

Calculating the minimum gallons to be removed: well volume + annulus volume + number of gallons lost during well drilling/construction = one purge volume

Example:

You are to develop a 4-inch well. From the Well Construction Diagram you note_the borehole diameter was 11 inches, the screen is 15 feet long and the driller used 75 gallons of water during well construction. With a water level indicator you measure the static water level at 59.45 feet and with a well tagger you measure the well depth at 71.21 feet.

Record in log book: TD = 71.25'
WL = 59.45'

TD -WL = SC
Log book: SC = 11.8'

From a Volume chart, the "gallons per foot" multiplier for a 4-inch well is 0.653 and 11.8 x 0.653 = 7.71 (gallons of water in one well volume).

Log book, One well vol. = 7.71 gallons

From a Volume chart, the "gallons per foot" for an 11-inch borehole is 4.937. Therefore, 4.937(BD multiplier) - 0.653(ID multiplier) = 4.284(annulus multiplier). And, 11.8 x 4.284 x 30% = 15.17 (gallons of water in one annulus volume).

Log book, One annulus vol. = 15.17 gallons
Drilling fluid lost = 75 gallons

7.71(one well volume) + 15.17(one annulus volume) + 75(fluid lost) = 97.88 gallons (one purge volume). A minimum of 3 well volumes must be removed during development. Additional water may need to be purged to allow the parameters to stabilize and the water to clear up.

Log book, One purge vol. = 97.88 gallons
97.88 x 3 = 293.64 (minimum number of gallons to be purged).
Log book, Min. gal. to be purged = 293.64 gallons

7.2 WELL DEVELOPMENT

Development will be accomplished using surge and bail/pump. In relatively clean and permeable formations where water flows freely into the borehole, bailing, surging and pumping is an effective development technique. First, the bottom of well will be tagged to measure the amount of sand/silt before and after surging that may be present at the bottom of the well. Then a bailer will be lowered down the well to clean out any fines that have settled on the bottom of the well. Then a surge block, slightly smaller than the inside diameter of the well casing, will be used to agitate the water, causing it to move in and out of the screen, thus drawing in fines from the gravel pack and surrounding formation and breaking up any bridges that may have occurred during the placement of the gravel pack. After surging for a few minutes (depending on the height of the water column and length of screen), the bailer will then be lowered again to clean out any fines that were drawn into the casing as a result of surging. This surge/bail technique will continue until minimal fines are being pulled out with the bailer. A submersible pump will then be lowered down the well. Pumping will begin at the top of the saturated portion of the screened interval to prevent sand locking of the pump. The pump

will be lowered at intervals of 5 feet or less until the pump is resting approximately 1 foot off the bottom of the casing. The water level will be monitored continuously during the first few minutes of pumping so as not to draw the water level below the pump intake and break the suction. The discharge flow rate will be increased (if possible) until the well is pumping at its maximum yield without draw down beneath the pump.

Developing low-yield wells is a very lengthy process. If development exceeds five hours, the remaining development will be done in stages (demobilize and remobilize), not to exceed three casing volumes or two return trips to the well. For wells installed in clay or fine-grained silt, the method of development will be bailing only. Surging of such wells has been found to substantially increase the turbidity of the water and does not significantly improve hydraulic well response. These wells will be bailed dry and a record kept on the time it takes for the well to recharge 80 percent.

A *Well Development Record* is provided in Attachment K.

8.0 TOPOGRAPHIC SURVEYING

A licensed surveyor will survey all new monitoring wells. Each point will be surveyed to determine its map coordinates with reference to the State Plane Coordinate System (SPCS), based on North American Datum, 1983 Adjustment (NAD 83) and the local mine coordinate system. The surveys will be connected to SPCS by third order, Class II control surveys in accordance with the Standards and Specifications for Geodetic Control Networks. All points should have a horizontal accuracy of at least ±1 foot.

The elevation of a designated point on the top of the PVC well casing (not protective casing) and/or the ground surface (not the top of the cement well apron) should be surveyed for each monitoring well or soil boring. The elevations should be surveyed to within 0.01 feet and referenced to the National Geodetic Vertical Datum, 1988 Adjustment (NGVD 88).

9.0 PACKER TESTS

Packer tests (borehole pressure tests) will be performed while drilling through saturated bedrock to assess the hydraulic conductivity of the bedrock. A description of the procedures for conducting packer tests is included in the following sections. A form for recording packer test data is included in Attachment M, *Packer Test Form.*

Packer tests will be conducted during drilling using a double-packer system. The borehole will be drilled to total depth and then the most representative interval of the borehole will be tested. The interval to be tested will be determined based on in-field review of the description of the core, as discussed in Section 4.0. Packer tests will generally be performed on one ten-foot interval per borehole that is advanced through bedrock. However, if a specific interval is observed that is not representative of the borehole as a whole, but probably has an unusually high transmissivity that could have a significant impact on groundwater flow through bedrock, it may also be tested. The intervals to be tested will normally be 10 feet long, although some may be from 5 to 20 feet, if conditions warrant (discussed below). Water will be pumped at a constant rate into the test interval, while pressure and flow rate are measured. These parameters will then be used to compute an average hydraulic conductivity value for the tested interval.

The equation used to analyze the packer tests data is (*Bureau of Reclamation, 1963*) shown here.

$$K = \frac{Q}{2\pi LH}\ln\left(\frac{L}{r}\right); L \geq 10r$$

K = hydraulic conductivity
Q = constant rate of flow into the hole
L = length of the portion of the hole tested
H = differential head of water (net pressure)
r = radius of hole tested
ln = natural logarithm

This formula is more accurate when the thickness of the stratum tested is at least 5L and for tests below rather than above the groundwater table.

9.1 FLOW RATE

Two in-line water meters will be used to measure the flow rate: a high-flow meter for measuring flow rates greater than approximately 0.25 gallons per minute (gpm); and a low-flow meter for measuring flow rates from 0.1 to 1 gpm. After flow is initiated at the desired pressure, the high-flow meter will be read at the beginning and end of a specific time interval. Generally, readings will be collected at 2-minute intervals for the first 10 minutes and then at 4- to 5-minute intervals until a constant water loss is observed for three consecutive time periods. For the high-flow meter, the flow rate will be determined by dividing the total flow volume over the interval by the time interval. For example:

$$Q = \frac{62.4\text{gals}}{10\,\text{min}} = 6.24\ \text{gpm}$$

If measured flow rates are less than 1 gpm, then flow will be switched to the low-flow meter. The low-flow meter is a direct reading instrument. Flow rates will be converted from gpm to cubic feet per minute (cfm) using the following conversion:

1 gpm = 1.337 cfm

Based on a comparison of flow measurements within the overlapping flow range of both flow meters and on observations of flow fluctuations during testing at other sites, flow readings are generally accurate to about 5 percent.

9.2 TEST SECTION LENGTH

The test section length will be defined as the current borehole depth (since packer tests are performed as the hole is advanced) minus the depth to the base of the packer. In most cases, this length will be set at approximately 10 feet. If permeable zones are encountered during drilling, as determined by significant loss of circulation water, the bottom 5 feet of borehole will be tested.

9.3 NET PRESSURE

The net pressure applied to the borehole test section (also referred to as the "differential head of water") is the sum of the following three pressure terms:

Net pressure = gauge pressure + column pressure - friction losses

All pressure terms are expressed in units of feet of water. Gauge pressure, column pressure and friction losses are described below.

9.4 GAUGE PRESSURE

The gauge pressure is the water pressure measured on a gauge at or above the ground surface. Gauge pressures are read to +/-1 pound per square inch (psi). However, due to pump vibrations, the gauge pressure may fluctuate up to +/-2 psi. For calculating the net pressure, the gauge pressure is converted from psi to feet of water using the following factor:

Gauge Pressure (psi) x 0.433 = Gauge Pressure (feet of water)

9.5 COLUMN PRESSURE

The column pressure is the static pressure due to the weight of water in the test pipe above the water table. Column pressure is therefore equal to either the depth to the bottom of the packer or the depth to groundwater, whichever is smaller.

Below the water table, the column pressure is always equal to the depth of the water table with respect to the surface reference point. The depth to groundwater is usually measured in the well borehole within a week or two of packer testing.

9.6 FRICTION LOSS

The head loss from friction of the pipe causes a back pressure that is recorded on the pressure gauge but is not applied to the formation. Friction loss is a function of the flow rate and the length of pipe between the pressure gauge and the packer. Friction losses will be obtained from the equipment manufacturer, if available. If they are not available, friction losses will be estimated by performing calibration tests in the field. Flow rates versus head loss are plotted on log-log paper for different lengths of pipe. Values of the gauge pressure (the pressure required to produce a target flow rate) for the target flow rate are then recorded.

9.7 EQUIPMENT AND MEASUREMENT

The basic equipment for packer tests consists of an inflatable wireline packer, ¾-inch galvanized pipe, flexible air and water hoses, water pump, water pressure gauge, water flow meters, water level indicator and stop watch. The water pump will be capable of injecting water at a uniform flow rate.

The basic measurements consist of gauge pressures, flow meter readings, time reading and equipment height and dimension values.

The packer assembly basically consists of two cylindrically shaped, inflatable rubber seals separated by a larger-diameter steel cylinder. The rubber packer is tightened against the borehole walls to prevent water from leaking between the walls of the rock and the rubber seal. The packer is then inflated using compressed nitrogen or other appropriate gas/air.

The packer test is performed using the following procedure (for a typical 10-foot test section).

- The borehole is advanced approximately 10 feet using water rotary.
- After the last core barrel is retrieved from within the drill rods, the entire drill string is raised approximately 12.5 feet from the base of the hole.
- The packer assembly is lowered down the drill string until it rests on the backside of the drill bit. The upper seal of the packer remains inside the drill string, while the lower seal extends 2.5 feet from the bottom of the bit.
- Ten-foot galvanized pipe sections attached to the packer are screwed together as the packer is lowered down the hole. All screwed connections are first wrapped with Teflon tape to minimize leakage at the connections.
- Once the packer is in place, compressed nitrogen is fed to the packer through high pressure air hose until the packers seal against the drill string and the borehole walls. Typical packer inflation pressures range form 120 to 160 psi.
- The water pump, gauging assembly (water pressure and flow gauges) and the uppermost galvanized pipe are connected using flexible hoses.
- After pumping startup, water is allowed to flow through the packer and into the borehole until the desired test pressure is achieved. Typical pressures range from 10 to 30 psi depending on the depth of the packer test.
- Water flow rates are monitored upon initiation of flow down the borehole until steady-state conditions are achieved for a minimum of 5 minutes. Afterward, the pressure is increased 5 to 10 psi and the measurements re-started for an additional test, or the test is terminated.

During a packer test, there is a potential for leakage around the packer. Leakage around the packer is monitored in two ways.

- Leakage moving up through the inside of the drill string is initially monitored using a water level indicator placed down the drill string.
- Leakage moving up along the annular space between the drill string and the borehole walls is visually monitored by watching for return flow into the water circulation pit.

Tests in which leakage is observed will be immediately discontinued.

Calculated hydraulic conductivities below roughly 5×10^{-6} cm/sec, which result from flow rates less than 0.1 gpm, are very approximate due to flow-gauging limitations of the packer test equipment. These conductivity values would represent average values for the interval of borehole being tested.

10.0 PUMPING TESTS

Determining the hydraulic properties of an aquifer is a fundamental component of the site characterization process. This section details aquifer test methods that are commonly implemented to help characterize an aquifer, and evaluate the performance characteristics of a monitoring well.

Aquifer parameters can be determined by employing either ex-situ or in-situ methods. Ex-situ methods involve collecting samples of the aquifer material and testing them in a geotechnical lab. In-situ methods involve determining the hydraulic characteristics of the aquifer by applying a stress to the aquifer and recording the response to that stress over time. In-situ methods are generally considered more representative of aquifer conditions than ex-situ (laboratory) soil permeability testing. As a result, this SOP only describes in-situ aquifer testing. Data resulting from these tests can be used in standard well flow equations to determine the hydraulic parameters of the aquifer and the monitoring/extraction well in which the tests are performed.

Each aquifer test method has certain applications, effort requirements, costs, risks, and limitations, and will be evaluated based on the project goals, design requirements, long-term planning, budget, schedule, and regulatory concerns. In addition, aquifer testing may be conducted in several phases involving one or more of the above methods. This iterative approach may be very effective in that the aquifer-testing program can be tailored to meet the project needs as the site characterization or basin study evolves.

Aquifer tests are typically conducted during the site investigation, although they may also be performed at any phase of an investigation. A great deal of care will be given to data collection methods and data analysis for aquifer tests, as the findings will subsequently be used for long-term resource planning, engineering design, and capitol expenditures. The findings from an aquifer testing program can ultimately be used for several important purposes, including the following:

- Development of the site conceptual hydrogeologic model. Aquifer testing provides the mechanism to quantify and incorporate soil heterogeneity and hydraulic anisotropy into the conceptual model
- Development of analytical groundwater flow solutions (models) such as determination of a groundwater flow velocity
- Evaluation of contaminant fate and transport mechanisms associated with advection
- Generation of parametric data for numerical groundwater flow models and associated solute transport models
- Development of groundwater extraction scenarios for hydraulic containment, collection of contaminants, and aquifer restoration
- Wellhead protection studies (determination of the zone of influence and zone of contribution for production wells) and other groundwater basin studies.

10.1 DEFINITIONS

Various physical properties and hydraulic parameters of aquifers and aquitards are important in describing groundwater flow, and are therefore significant in aquifer testing studies. A thorough understanding of the hydraulic principles involved in aquifer testing is an essential component of aquifer analysis. A brief definition of terms that are used in this section are provided below:

Bailing Line: A line used for rapidly lowering and raising the slug into the water column. Deep wells may require the use of the winch on a drill rig.

Darcy's Law: States that the rate of flow through a porous medium is proportional to the loss of head, and inversely proportional to the length of the flow path, or

(eq. 1) $v = K(dh/dl)$

Where:

v = Q/A, which is the specific discharge, also known as the Darcy velocity or Darcy flux, (length/time),
Q = the volume rate of flow (length^3/time),
A = the cross sectional area normal to flow direction (length^2),
dh/dl = describes the aquifer hydraulic gradient (length/length) and,
K = describes the hydraulic conductivity of the aquifer.

Equation 1 may be rewritten as:

(eq. 2) $Q = K(dh/dl)A$

It should be noted that the specific discharge is in velocity units of length/time. It is important to also note that this is a macroscopic concept, and must be differentiated from microscopic (real) flow velocities, which consider the porosity of the medium, as:

(eq. 3) $$v = \frac{K(dh/dl)}{n}$$

where "n" is the effective porosity of the media.

Data Logger: A small field computer capable of recording a wide range of physical measurements such as pressures, temperatures, electrical conductivities, and flow. For aquifer analysis, pressure is generally the parameter of interest (feet of water in the well). The data logger converts the pressure value sent by the traducer into feet of water above the traducer, and records the values in its memory. The data can then be transferred from the logger to a personal computer via a standard RS-232 port.

Each transducer has specific parameters that must be input to the data logger to make the appropriate conversions from pressure units to feet. It is extremely important that field personnel operating a data logger be properly trained on the use of the instrumentation to ensure proper collection of test data.

Common data logger models are the Hermit 3000 (8-channels plus an internal barometer, very user friendly) and Hermit 2000 (8-channels, less user friendly). The Hermit 3000 data logger also contains a RS-422 communication port.

Drawdown: The amount of water level decline in a well and aquifer due to pumping. Usually measured and reported in terms of feet of drawdown relative to static (non-pumping) conditions ('s' by convention).

Electric Submersible Pump: A pumping device capable of pumping for extended periods of time at a constant discharge rate. Discharge pipe or hose should be fitted with a valve to provide the ability to adjust flow. Adjusting the discharge rate by adjusting the speed of the pump is less desirable than the use of a valve. An exception is the variable-speed 2-inch-OD Grundfos submersible pumps, which are designed for adjustable speed (flow) settings. A shroud is recommended if a 2-inch pump is used in a 4-inch or greater diameter well to ensure long-term cooling of the pump motor. The pump will require a reliable power source.

Flow Gauge: An in-line, "turbine type" flow meter is recommended for most moderate to high flow-rate applications. Other means of gauging flow include the use of calibrated orifice weirs or an orifice bucket. For low flow applications, a container and stopwatch method may be suitable. The container method requires measuring the time it takes to fill a container of known volume, such as a 5-gallon bucket or 55-gallon drum. The flow gauging method should be accurate to +/- 5 percent.

Hydraulic Conductivity: This property is a constant of proportionality that describes fluid flow through a porous media (see Darcy's Law, above). Hydraulic conductivity ("K" by convention) is a function of the permeability of the media and of the physical properties of the fluid. Hydraulic conductivity has the units of length/time. In a normal groundwater setting, where the physical properties of the water are considered relatively constant, hydraulic conductivity can be considered a function of the porous media.

For this reason, the terms permeability and hydraulic conductivity are often used interchangeably for groundwater settings. Because hydraulic conductivity varies over 13 orders of magnitude for earth materials (Freeze and Cherry, 1979), order-of-magnitude approximations are generally considered appropriate for evaluation of aquifer properties.

Potentiometric Surface: An imaginary surface connecting points to which water would rise in cased wells from a given point in an aquifer (Lohman, 1979). It may be above or below the ground surface. The water table is a particular potentiometric surface for unconfined aquifers. "Potentiometric" is preferable to the term "piezometric" used by many in the past.

Pressure Transducer: A device installed in the well below the water surface that is capable of continuously providing very accurate water level measurements. The transducer is connected to a continuous data logger (described above). Transducers are available in different pressure (and accuracy) ranges. The transducers should never be lowered into a water column below the operating pressure range of the transducer. Higher pressure range transducers are less accurate than lower pressure range transducers. As a rule, a multiplier of 2.3 can be used to estimate the maximum total amount of water above a traducer (i.e., a 10-psi transducer can have 23 feet of water above, a 50-psi traducer can have 106 feet of water above, etc.). For example, if a 10-psi traducer is installed at the bottom of the well with 100 feet of water above it, it will no longer function properly, and must be returned to the manufacturer for recalibration.
Please note, the transducer only needs to record the change in water levels, and therefore should be installed immediately below the lowest depth expected. A 10-psi transducer is capable of measuring up to 23 feet of change in water levels to 0.01 foot accuracy, and is therefore the recommended transducer for slug tests. Transducers will operate improperly if lowered into sediment, and therefore should never be lowered to the bottom of the well. The target depth of the transducer should be identified prior to lowering into the well, and then the traducer cable should be marked with duct tape to ensure that the transducer is not lowered too deep.

Residual Drawdown: Once a pump is shut off during a pumping test, water levels in pumping wells, observation wells, or piezometers will rise. This rise in total head results from the principle of superposition, and is commonly known as residual drawdown ('s' by convention). It is expressed as the difference between the static water level and the water level at time t' after the cessation of pumping.

Slug: A solid pipe used to displace water by insertion or withdrawal from a well. Bailers may also be used for slug withdrawal only. The slug volume should be maximized based on field conditions. Different length slugs, capable of threading together, should be brought to the field to provide flexibility to the program. A typical slug used for a 2-inch-diameter monitoring well may be 1.5 inches in diameter and 6 to 10 feet in length. The volume of the slug used for each test must be recorded in the field notes.

Specific Capacity: The specific capacity is defined as the discharge rate per unit length of drawdown for a pumping well. Typically expressed in gallons per minute per foot of drawdown (gpm/ft).

Specific Yield: The specific yield is the volume of water released by gravity drainage from an unconfined aquifer from storage per unit surface area of the aquifer per unit decline in the watertable. Specific yield is also known as unconfined storativity, effective porosity, or drainable pore space. Specific yield is unitless and typically ranges from 0.01 to 0.3 (Kruseman and de Ridder, 1991).

Static Water Level: The non-pumping, stabilized water level in a cased well or piezometer. Usually recorded in the field as depth to water below a datum such as the top of casing. This term is usually reported in feet above mean sea level.

Storativity: The storativity of a confined aquifer is the volume of water released from storage per unit surface area per unit change in head. For confined aquifers, stored water is released via aquifer compression and expansion of water. In an unconfined (watertable) aquifer, the storativity is equivalent to the specific yield and is also known as the storage coefficient. Storativity is dimensionless and typically ranges from $5x10^{-5}$ to $5x10^{-3}$ (Kruseman and de Ridder, 1991).

Total Head: The sum of the elevation head, the pressure head, and the velocity head at any given point in an aquifer.

Transmissivity: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient (Fetter, 1980). This term ("T" by convention) is simply the product of the hydraulic conductivity (K) and the aquifer thickness ("b" by convention).

$$T = Kb \qquad \text{(eq. 4)}$$

Transmissivity may vary significantly due to spatial variations in both the thickness and conductivity of the aquifer. Transmissivity carries the units length^2/time. For aquifers, b is the thickness of the confined aquifer. For unconfined aquifers, b is the thickness of the saturated portion of the aquifer.

Water Level Indicator: A device used to measure static water levels. An electrical conductivity-based water level indicator capable of measuring to 0.01 foot accuracy is required for all measurements.

10.2 AQUIFER TESTING METHODS

All aquifer test methods, such as slug tests, pumping tests, and recovery tests, have unique advantages and limitations. This section describes the principles, methodology, and staffing requirements for various selected slug tests, pump tests, and recovery tests. Several methods are described here, paying attention to the limitations of each.

Pumping tests may be subdivided into two categories:

- short-term, variable rate test (also commonly known as step test)
- long-term, constant rate test

In general, pumping tests and recovery tests require pumping groundwater from an aquifer, and are therefore more suitable for relatively high transmissivity zones, such as alluvial sand and gravel aquifers, or extensively fractured aquifers. In these types of aquifers, a long-term pumping test is the most accurate means of evaluating aquifer properties and other hydrogeologic factors such as boundary conditions, heterogeneity, and anisotropy.

10.2.1 SLUG TESTING

Principle: Slug testing involves either introducing or removing a "slug" of known volume into or from a well and recording the water level changes that result. The rate of recovery observed in the well is a function of the hydraulic properties of the aquifer and of the well itself. The transmissivity of the aquifer can then be estimated using appropriate well-flow equations.

Assumptions and Limitations of Slug Testing: Slug tests stress only a small portion of the aquifer adjacent to the well, and therefore, slug tests are incapable of evaluating hydrogeologic boundary conditions, hydraulic anisotropy, storage coefficients, and pumping characteristics of the well. However, slug tests commonly provide a cost-effective means of gathering "point" transmissivities across a screen interval. Slug tests are commonly considered as a first step in characterizing an aquifer because of the relative low cost and effort requirements. Additionally, slug tests do not generate large volumes of groundwater, and therefore often used to initially characterize water-bearing zones beneath hazardous waste sites, where disposal options of contaminated groundwater may be limited or costly.

It is important to note that slug tests do not provide adequate information regarding the hydraulic characteristics of a pumping well. Additionally, because of the small stress applied to the aquifer, data may be influenced by drilling methods (skin effects), well construction, and development procedures. Slug tests alone cannot provide accurate information regarding boundary conditions, anisotropy, or storage coefficient data, and are therefore not useful for predicting steady-state drawdowns resulting from any given hypothetical pumping scenario. The development of long-term groundwater extraction scenarios, such as in most modeling studies, should therefore not be based solely on slug test data, but require more sophisticated pumping tests, if feasible.

Falling Head Slug Tests: Falling head slug testing involves the insertion of a slug into the well that is screened below the water table. If a slug is rapidly inserted into the water column in a well, it will instantaneously raise the water column in the well. The amount of head change is defined as the instantaneous head (H_O). The water column will then "fall" to the static water level at a rate that is controlled by the hydraulic characteristics of the water-bearing formation and of the well itself. Falling head slug tests are not appropriate for water table wells (i.e., wells in which part of the screen is unsaturated and the screened interval is within the first water encountered).

Rising Head Slug Tests: Rising head slug testing requires submerging the slug under water in a well, and allowing the water level to stabilize to static conditions. The slug is then rapidly withdrawn from the well. After the slug is withdrawn from the well, the instantaneous water level will be at a level that is lower than the static water level. The rate at which the water level recovers to static condition is a function of the aquifer properties and of the well itself.

Both falling and rising head methods can be used in series during a slug testing program. The slug insertion method may be followed by the slug withdrawal with relative ease. However, if a slug insertion method is chosen for unconfined aquifers, groundwater will be displaced above the water table and into the unsaturated sand filter pack of the well and the formation itself. It should be noted that the hydraulic conductivity of the soils overlying the water-bearing zone may differ from those of the aquifer. Additionally, hydraulic conductivity of unsaturated soils varies as a function of moisture content. For these reasons, a slug withdrawal method is generally considered advantageous to slug insertion in unconfined or semiconfined aquifers due to two-phase (air and water) flow. A good rule-of-thumb is that if the static water level is within the screened interval of the well being tested, a slug withdrawal method should be chosen for aquifer analysis.

Selection of the Slug: Several different types of slugs may be used for the test, including:

- Solid pipe fitted with an eye bolt at one end to affix a bailing line
- Stainless steel or Teflon bailers

- A slug of water of known volume.

Introduction of a slug of water (usually distilled, organic-free water) may not be feasible due to regulatory restrictions. In addition, it is generally considered infeasible to "instantaneously" withdraw a slug of water using a pump. The withdrawal of a slug of water is limited to the use of bailers. The most common slug test involves the use of solid pipes (either slug insertion or withdrawal methods), or the use of bailers (slug withdrawal only).

An additional slug testing method involves applying a pressure or vacuum to the well head and measuring changes in water levels that result following the removal of the pressure. This method requires specialized well fittings, generators, and compressors. Details of this method are provided in Kruseman and de Ridder (1991) (Oscillation Method, p.238), and are not included in this SOP.

The remainder of this section focuses on slug tests conducted using a solid slug, although the general methods for slug tests analyses do not vary significantly if other types of slugs are used for the test.
A large slug will stress the aquifer to a greater degree than a small slug, and therefore the size of the slug should be maximized based on field conditions. Three-foot Teflon bailers or sections of solid pipe can be threaded together to optimize slug volume. The size of the slug is limited only by the standing water column in the well and physical limitations in one's ability to instantaneously insert or withdraw the slug.

Slug Insertion (Falling Head) Test Methods: The procedures outlined below will be followed while conducting falling head slug tests.

1. Remove the well head expansion cap and allow the well to equilibrate to atmospheric conditions.

2. Record the static water level using a conductivity-based water level indicator. Measure the total depth of the well. Note: potential sediment at the bottom may have decreased the total depth value recorded during construction.
3. Determine the appropriate depth of 10-psi traducer. This will generally be between 10 and 20 feet below the static water level, or above potential sediment at the bottom of shallow wells. Affix duct tape to traducer cable to indicate the target depth below top of casing.

4. Lower a 10-psi transducer to the target depth. The transducer and transducer cable must hang plumb in the well to minimize entanglement with the slug. Duct-tape the transducer cable to an immovable object, such as the top of casing. Allow the well to equilibrate to static water levels.

5. Connect the pressure transducer to a continuous data recorder. Input the required transducer parameters and other test parameters in the data logger. The data logger will need to be referenced to the top of casing (TOC) or surface (static water level datum). It is recommended that it is "zeroed" to the static water level, and therefore measured water level changes will be relative to static water level. Water levels above static water levels will be recorded as positive, and water levels below static will be recorded as negative values. The slug test requires only measuring the change in head associated with slug insertion or withdrawal. The "surface mode" is therefore the desired data logger "mode" for slug testing. "TOC mode" refers to measuring the absolute value (i.e., total head) of the water level relative to the TOC datum. This is an unnecessary step that may introduce error in the field, and is therefore not recommended for slug testing. An accurate record of all input parameters and field observations will be included in the field logbook.

6. "Zero" the pressure traducer/data logger to static water levels. Confirm static levels with a water level indicator. The data logger should be set to begin the test in the "immediate" mode (i.e., no time delay). The data logger will be set to record water levels as frequently as possible (i.e., using the "log" mode and default settings).

7. Affix a bailing line to the slug. To accurately complete the test, the slug will be completely submerged in the well. Record the volume of the slug in the field log. Determine the total depth required to submerse the slug. A piece of duct tape may be used to identify the desired length of the bailing line. The slug will be lowered to a "ready" position immediately above the static water level. The slug must not be tangled with the transducer cable.

8. ***Critical step.*** On a pre-determined count, ***lower*** the slug rapidly (but gently) to total submersion and trigger the data logger to begin recording water levels. The slug should remain motionless once it has been lowered into the well. The bailing line for the slug will be tied to an immovable object (tailgate of truck, etc.) once the slug is submerged. Allow the data logger to complete it's logarithmic data recording cycle (approximately 2-3 minutes) prior to confirming water levels with a water level indicator. Wells screened within low to moderately transmissive aquifers may require from 30 seconds to several minutes or even hours to recover to static water levels. If the well recovers within a few seconds, it is likely that the well is screened within a moderate to high transmissivity zone, and therefore the slug test method is likely not an appropriate test method for the determination of aquifer properties.

9. The slug injection test is completed when the water level recovers to static water levels. In many instances, the final few tenths of a foot of recovery may require a significant amount of time (hours). The field team will use their best judgement regarding when to terminate the test. It should be noted that for nearly all methods of data analysis, the last data points are equally significant as the initial data points. The validity of the tests will not be compromised due to impatience of field team members. In many cases, the team can be setting up the next test on a different well while the previous well completes its recovery.

10. Once the well has equilibrated to at least 90 to 95 percent of static water level, the test can be terminated by stopping the data logger. However, at this time, it would be advantageous to initiate a slug withdrawal test (see item #6 below). This may be accomplished by either "stopping" the insertion test, or "stepping" the test by using the "Step" function of the data logger. The original input parameters remain unchanged if you choose to use the "Step" function or stop and start function. Both methods involve restarting the "log cycle" for the data logger (highly desirable for the early time data). An accurate record of test numbers and step numbers will be maintained in the field logbook.

Slug Withdrawal (Rising Head) Test Methods: Follow steps 1 through 5 as described above for the falling head slug test. Steps 6 through 8, below, describe the slug withdrawal test method.

6. Lower the slug into the water column so the slug is fully submerged. For this test, tie the slug bailing line to an immovable object and allow the slug to remain motionless in the well. Ensure that the slug is not entangled with the transducer or transducer cable.

7. Allow the well to equilibrate to the static water level. The well recovers most quickly if a bailer is used for the slug. A solid pipe slug requires a longer period of time to recover. Verify that the well has equilibrated to static water level with a water level indicator.

8. ***Critical step.*** On a pre-determined count, one person will rapidly (and in a fluid motion) ***retrieve*** the slug from the well while the second person simultaneously triggers the data logger to begin recording water levels. Remove the slug from the well while making sure not to disturb the transducer cable. As stated above, allow the data logger to complete it's logarithmic data recording cycle (approximately 2-3 minutes) prior to confirming water levels with a water level indicator. Wells screened within low to moderately transmissive aquifers may require from 30 seconds to several minutes or hours to recover to static water levels. If the well recovers within a few seconds, it is likely that the well is screened within a moderate to high transmissivity zone, and therefore the slug test method is likely not an appropriate test method for determination of aquifer properties.

It is recommended that two slug tests be conducted for each well for data verification purposes. Most data loggers allow the user to view the data or download the data to a field personal computer. Data will be reviewed in the field following completion of the test to ensure that the transducers and data logger are functioning properly.

The initial head values (H_O) which result from instantaneous withdrawal or injection of the slug will be evaluated against the maximum theoretical drawdown. This can easily be completed by calculating the volume of the slug and converting volume of the slug to volume of water in a well. The well volume can then be converted to feet of water in the well column. An example calculation is provided below:

Hypothetical slug size:

0.75-inch outer diameter (OD) x 60-inch length = 106.05 in.^{3}

Conversion to gallons:

106.05 in.^{3} x (0.004329 gallons/in.^{3}) = 0.46 gallons

Conversion to feet (assumes a 2-inch inner diameter (ID) well):

0.46 gallons x (1 foot/0.16 gallons) = 2.88 feet

Therefore, using a slug that is 0.75 inches in diameter and 60 inches (5 feet) in length, the maximum anticipated change in water level with respect to static levels (H_O) would be 2.88 feet. This should be evaluated against the maximum head change observed in the field. Significantly different (greater than 20-30 percent) values may indicate that the transducers or data loggers are not functioning properly. Other possibilities are that the slug is not being inserted or withdrawn rapidly enough, or that the timing between the "trigger" operator and the "slug" operator is off. These factors will be evaluated and resolved prior to conducting additional slug tests.

Data loggers generally have sufficient memory to record an entire day of slug testing. The data will be downloaded daily to minimize the risk of loss of data. An electronic and hard copy will be stored.

10.2.2 PUMPING TESTS

This section details the following elements of pumping tests:

- The Principle
- Assumptions and Limitations
- Test Method Selection
- Equipment Requirements
- Personnel Requirements

The Principle - Pumping Tests: Several different types of pumping tests can be conducted to determine aquifer properties, although the fundamental principles of all tests remains similar. The principle of a pumping tests involves applying a stress to an aquifer by extracting groundwater from a pumping well and measuring the aquifer response to that stress by monitoring drawdown as a function of time in the pumping well and/or observation wells or piezometers at known distances from the well. These measurements are then incorporated into an appropriate well-flow equation to calculate the hydraulic characteristics of the aquifer and pumping well.

General Assumptions and Limitations for Pumping Tests: Numerous different types of pumping tests and well-flow equations exist that may be implemented for nearly all hydrogeologic settings. Each method has a different set of limitations and assumptions. For complex hydrogeologic settings, please see Kruseman and de Ridder (1991). Different assumptions and limitations exist for confined, semi-confined (leaky), and unconfined (water-table) aquifers. In general, the following assumptions apply to most well-flow equations and hydrogeologic settings:

- The aquifer is of infinite areal extent
- The aquifer thickness is of uniform over the entire extent
- Prior to pumping, the potentiometric surface is horizontal (or nearly so) over the area that will be influenced by the pumping test
- The aquifer is pumped at a constant discharge rate, or for variable discharge rate tests, the rate is known
- The pumping well fully penetrates the entire thickness of the aquifer and thus receives water by horizontal flow
- The aquifer is considered homogenous and isotropic

Pumping Test Method Selection: Three types of pumping tests are described in this SOP:

- Variable rate tests (step tests)
- Constant rate tests
- Recovery tests

The overall approach for each test, including capabilities, limitations and assumptions are defined below:

Step Tests: Step tests involve pumping from a single well at a relatively low rate until drawdown has stabilized. The pumping rate is then increased to a higher discharge rate until drawdown once again stabilizes. This procedure is continued for at least three additional steps. Each step is typically 20 to 40 percent greater than the previous step, with a duration of typically 30 minutes to 120 minutes (Kruseman and de Ridder, 1991; Driscoll, 1986). In general, step-tests are relatively short duration tests that are capable of providing general well performance characteristics, aquifer transmissivity, and aquifer storativity in the vicinity of the pumping well. A step-test provides specific capacity data, and therefore should always be conducted prior to conducting a long-term pumping test if no previous pumping data for the well exist. Step-tests are generally considered less effective than long-term pumping tests for determining hydraulic anisotropy, leakage between layers, boundary conditions and recharge areas.

Constant Rate Pumping Test: Constant rate pumping tests involve pumping from a well at a continuous, known, constant discharge rate over an extended period of time. This type of test typically involves monitoring drawdown in several observation wells or piezometers, although the test may also be performed as a single-well test. Long-term, constant discharge pumping tests are the most accurate means of evaluating aquifer hydraulic properties. If properly designed and conducted, these types of aquifer tests are capable of evaluating transmissivity, storativity, hydraulic anisotropy, leakage from overlying or underlying layers, boundary effects, recharge areas, etc. Additionally, well

performance characteristics such as well capacity, well yield, and well efficiency may also be determined

Recovery Test: Constant discharge tests and step tests should generally be accompanied by a recovery test. A recovery test measures the residual drawdown (s') following the pumping test. The recovery test provides the data required to calculate the transmissivity of the aquifer, thus providing an independent check on the results of the pumping test at a relatively low cost (Freeze and Cherry, 1979; and Kruseman and de Ridder, 1991). A recovery test is invaluable if the pumping test is performed without the use of piezometers or observation wells to evaluate potential borehole storage effects of the pumping well. Additionally, residual drawdowns are more reliable than drawdowns measured during pumping due to difficulties in the field of maintaining absolutely constant discharge from a pumping well (i.e., all pumps have a level of discharge variability dependent upon the decreasing column of water above the pump).

Personnel Requirements: Most pumping tests initially require a minimum of three people. More staff may be required for long-term constant rate tests than for step tests and recovery tests, which generally can be performed by two field team members.

One person will be responsible for monitoring the flow gauge and adjusting the discharge rate of the pump, and for ensuring that the data logger is triggered and operating. Another team member will be responsible for taking manual (back-up) water level measurements with a conductivity-based water level indicator.

If the observation wells are located at great distances from one another, or if rapid drawdown is anticipated, it may be advantageous to have several field team members on-site to measure and record water levels. This is particularly helpful during the earlier stages of the test when the most rapid change in water levels is anticipated. As water levels reach a pseudo-steady state, fewer team members may be required.

10.2.3 STEP-TESTS

Provided below is a description of the design and field methodology for completion of a step-drawdown test.

Design of the Step Test: The following design components will be evaluated prior to completion of the step-test:

Choice of pumping well: The pumping well will be fully developed and capable of sustained prolonged pumping. Ideally, the well will be located in the geographic center of the area of interest.

Size of pump: The pump size will be based on the estimated specific capacity, desired total drawdowns, and head requirements. If no previous pumping data are available, development logs or other field observation data will be assessed to aid in sizing the pump.

Duration of each step: Ideally, a step-test will consist of a total of four steps of progressively increasing discharge rate, followed by one step for recovery. Each step generally will range from 30 minutes to 2 hours. A step test typically requires one 10-hour field day to complete.

Initial Discharge Rate: The first step discharge rate should produce approximately 25 percent of the maximum anticipated drawdown estimated from the well specific capacity. If a production well is to be used for the step-test, the initial rate should be approximately 25 percent of the pump capacity. The second step should be approximately 50 percent of the anticipated drawdown and so on. An example is provided below:

Example: A 100-foot-deep well is constructed with a screened interval 80 to 100 feet below TOC. The aquifer is confined. The water column in the well is 50 feet (depth to water is 50 feet below TOC). The pump will be set at 90 feet, allowing 40 feet of water column above the pumping level. The specific capacity is estimated from development data to be approximately 5 gpm/foot of drawdown.

The desired drawdown for the first step is:

$$(0.25)(40 \text{ feet}) = 10 \text{ feet of drawdown,}$$

therefore, the desired pumping rate for the first step is:

$$(10 \text{ feet})(5 \text{ gpm/feet of drawdown}) = \textit{50 gpm}$$

The second step would therefore be 100 gpm, the third step would be 150 gpm, etc.

Please note that the above calculation does not consider well losses from turbulent flow that will likely occur at higher flow rates. A factor of safety may therefore be incorporated in the design of the discharge rates for each step. Given the above conditions and assumptions, a first step pumping rate may be 40 gpm, a second step 80 gpm, etc. Flexibility in the design of the step-test is recommended due to uncertainties associated with estimating specific capacity and well efficiency. Pumping rates for the second and successive steps will be based on field observations of drawdown vs. discharge rate.

Step-Testing Methods:
Remove the well head expansion cap and allow the well to equilibrate to atmospheric conditions. Record the static water level using a conductivity-based water level indicator. Sound the well to determine the total depth. Note: potential sediment at the bottom may have reduced the total depth value recorded during construction.

Determine the appropriate depth of the traducer. Generally a 10-psi transducer (capable of measuring 23 feet of head change) or 50-psi transducer (capable of measuring 106 feet of head change) are well suited for step-testing. The transducer will be targeted for a level 3 to 5 feet above the pump, whenever possible, to minimize interference from the operating pump. Affix duct tape to the transducer cable to indicate the target depth below the top of casing.

Set the pump in the well at the desired pumping level. This is usually the screened interval for shallow wells (<100 feet total depth). For deeper wells, the pumping depth only needs to be greater than the anticipated drawdown. In some cases, it may be cost-effective to hire a pumping subcontractor to operate the pumps, discharge lines, etc., especially for high flow-rate, long-term tests. Contaminated groundwater discharged from the well will be collected and disposed of in an appropriate manner.

Lower the transducer to the target depth. The transducer and transducer cable will hang plumb in the well to minimize entanglement with the pump discharge pipe/hose. Duct tape the transducer cable to an immovable object such as the top of casing. Allow the well to equilibrate to static water levels.

Connect the pressure transducer to a continuous data recorder. Input the required transducers parameters and other test parameters to the data logger. The data logger typically prompts the user to record water levels below the top of casing (TOC) or surface. 'Surface' refers to a static water level datum.

The instrument is therefore "referenced" or "zeroed" to the static water level, and therefore measures changes relative to static water level (the desired mode for step-testing). Water levels below static water level will be recorded as negative values. The step-test requires only measuring drawdown relative to static (and residual drawdown during recovery, if desired). TOC refers to measuring the absolute value (i.e., total head) of the water level relative to the TOC datum. This is an unnecessary

step that may introduce error in the field, and is therefore not recommended for step-tests. An accurate record of all input parameters and field observations will be included in a field logbook or on the Aquifer Test Form (see Attachment O).

"Zero" the pressure traducer/data logger to static water levels. Confirm static levels with a water level indicator. The data logger should be set to begin the test in the "immediate" mode (i.e., no time delay). The data logger will be set to record water levels as frequently as possible (i.e., using the "log" mode and default settings).

STEP #1. On a pre-determined count, simultaneously trigger the data logger and the pump. Quickly stabilize the discharge rate to the desired pumping rate. At the same time, begin recording water levels as rapidly as possible in the pumping well (every 15 to 30 seconds for the first 5 minutes). It is usually helpful to have the data table constructed with pre-determined water level time intervals. The water level measuring interval may be lengthened to every minute or every five minutes as the test progresses. Field observations suggest that 70-80 percent of the total drawdown for each step occurs within the first 15 to 20 minutes following commencement of pumping. The data recorded by the transducers and data logger can be viewed following completion of the logarithmic data recording cycle (approximately 2-3 minutes). Water levels recorded by the traducer/data logger system should be similar to the manually recorded water levels. It is always beneficial to plot the time and drawdown data in the field to ensure that the pumping rate and the drawdowns are adequate. Allow the test to run until the water level in the pumping well stabilizes to a steady state (or nearly so). This typically requires 30-120 minutes. Field plotting of data is helpful in determining when pseudo-steady state drawdown is achieved.

STEP #2 through STEP #4. On a pre-determined count, simultaneously step-up the pumping discharge rate to the desired level (usually by opening a control valve located upstream of the flow gauge), and restart the "logarithmic data recording cycle" on the data logger. This is easily done using a Hermit 2000 by using the "STEP" function. Make sure not to draw the water level down to the pumping level. It is more desirable to abbreviate the duration of any step and get accurate recovery data than to draw the water level down to the pumping level.

STEP #5. Critical Step. On a pre-determined count, simultaneously turn off the pump, "Step" the data logger, and manually record recovery (residual drawdown) data. Continue recording the recovery data until the water level returns to static water levels (or nearly so). The test is completed.
Carefully download the field data logger. Obtain a hard copy and retain a master electronic copy.

10.2.4 CONSTANT RATE PUMPING TESTS

A description of the design and field methodology for the completion of a constant rate pumping test is presented below.

Design Considerations for Constant Rate Pumping Tests: It should be noted that a single pumping test may cost several tens, or even hundreds of thousands of dollars to complete. Qualified and experienced personnel will be consulted during the scoping, project planning, and technical design phase to ensure that the test is conducted in a technically sound and cost-effective manner. Key members of the field team will possess extensive experience conducting aquifer tests. The following design components will be evaluated prior to initiating a constant rate pumping test:

Choice of Pumping Well. The well chosen will be designed as a pumping well, although many monitoring wells have been "converted" to pumping wells for use in a pumping test. In either case, the well will be fully developed and capable of sustained prolonged pumping. Ideally, the well will be located in the geographic center of the area of interest, or in a downgradient location (if remediation involves hydraulic containment and collection downgradient). Nearby observation wells or piezometers are required for distance-drawdown calculations. If an existing pumping well is used in the test, the pumping history of the well will be determined.

Choice of Observation Wells. Ideally, water levels will be monitored in as many nearby observation wells as feasible. Wells screened at different depth intervals will also be monitored to evaluate hydraulic communication across aquitards. It may be advantageous to equip observation wells that are located nearby the pumping well with continuous data recording instruments, and manually record water levels for wells located at greater distances. Prior to conducting the pumping test, estimated zones of influence may be completed using well-flow equations to determine which wells are likely to show a drawdown response. It is beneficial to use observation wells located upgradient, downgradient, and cross-gradient from the pumping well to evaluate hydraulic anisotropy.

Size of Pump. Pump size will be based on the drawdown requirements and estimated specific capacity determined from a step-drawdown test or from actual long-term pumping data. Pumping tests will not be conducted without completing a step-drawdown test, particularly without existing knowledge of the pumping characteristics of the pumping well.

Duration of Pumping Test - Confined Aquifer. Confined aquifers respond to pumping relatively quickly due to small storativity values. A pumping test for a confined aquifer will be conducted over a minimum period of 48 hours (two days) to achieve steady state conditions. Preliminary plotting of data in the field may indicate how the aquifer is responding, thus determining the duration of the test.

Duration of Pumping Test - Unconfined Aquifer. The cone of depression that results from pumping expands much more slowly for unconfined aquifers prior to reaching a steady state. The generally accepted minimum duration pumping test for an unconfined aquifer is therefore 72 hours (three days).

Discharge Rate. The discharge rate will be based on the results of the step-drawdown testing program. The specific capacity calculated from the step test will be used to estimate the desired drawdown and pumping rate. Because of the uncertainty in the step test calculations, a level of safety will be factored into the desired drawdown level to ensure that the water level is not lowered to the pumping level. If the water level is lowered to the pumping level, the test will be terminated immediately (although recovery data will be collected until the aquifer recovers to static conditions).

Frequency of Water Level Measurements. Water levels will be recorded electronically using continuous pressure transducers and a data logger, and manually using a conductivity-based water level indicator. Following the "logarithmic data recording cycle", the pressure traducer can be set to record water levels every minute. Suggested time intervals for manual and electronic measurements of drawdown are presented in Attachment N.

Control Points. It is recommended for control purposes that water levels be monitored in a well located at a distance beyond the area of influence of the test. If no such well is available, a common approach is to construct a "stilling basin". The stilling basin can be constructed of 10 to 20 feet of 2-inch class 125 PVC pipe with a cap placed on one end. The basin will be filled to approximately 75 percent of capacity with water and secured in a vertical position. A transducer will be placed in the bottom of the basin as a control point in the test. A V-notch can be cut in a top cap to allow access for the transducer cable while still minimizing evaporation. The basin should be in equilibrium with the atmosphere. All measurements recorded in observation wells will also be taken for the control station to evaluate instrument drift and error.

Background Water Level Data. Prior to conducting the pumping test, it is useful to monitor water levels in the proposed pumping well and observation wells for a week prior to the test. The background data provides the mechanism to evaluate earth tides, barometric influences, temperature influences, etc.

Background Pumping Data. It is important to understand regional or site-specific groundwater pumping to evaluate well interference, relict drawdown, etc. If a production zone is used for the pumping test, a well canvass should be completed to determine aquifer groundwater uses.

Collection of Water Samples. In many cases, groundwater will be collected during the pumping test to gather data required for treatability testing. At a minimum, groundwater will be monitored during pumping for pH, temperature, electrical conductivity, and turbidity.
Miscellaneous. Precipitation events will be recorded in the field notes, including time of onset, duration, and rainfall total. Barometric readings will be checked and recorded hourly. For shallow zone wells, the passing of heavy equipment or trains will be noted on the field logs.

Constant Rate Pumping Test Methods: The description of the pumping test outlined below assumes several observation wells will be used in the test. Continuous data logging equipment will be used wherever possible, although manual backup measurements will also be taken periodically. All of the data loggers will be synchronized to the correct day, date, and time. All project team members will synchronize their watches to the correct time datum.

Remove the well head expansion caps from all observation wells and piezometers, as well as the test well. Allow all wells to equilibrate to atmospheric conditions. Record the static water level in each well using a conductivity-based water level indicator. Sound each well to determine the total depth. Note: potential sediment at bottom may reduce the total depth from the value recorded at time of construction.

Determine the appropriate depth of the transducer for the pumping well. Generally a 50-psi transducer (capable of measuring 106 feet of head change) is well suited for the pumping well. The transducer will be targeted for a level 3 to 5 feet above the pump level, whenever possible, to minimize interference with the pump. In some instances, installation of the transducer below the pump may be required. Care must be taken to not entangle the transducer with the pump, or to lower the transducer into sediment at the bottom of the well. Affix duct tape to traducer cable to indicate the target depth below top of casing.

Set the pump in the well at the desired pumping level. This is usually the screened interval for shallow wells (<100 feet total depth). For deeper wells, the pumping depth only needs to be greater than the anticipated drawdown (it is wise to consider a margin of error - be conservative). In some cases, it may be cost-effective to hire a pumping subcontractor to operate the pumps, discharge lines, etc., especially for high flow-rate, long-term tests. Contaminated groundwater discharged from the well may require storage in portable tanks and/or require treatment prior to disposal. All groundwater generated from the test will be disposed of as specified in the project-specific work plan. Lower the transducer to the target depth in the pumping well. The transducer and transducer cable must hang plumb in the well to minimize entanglement with the pump discharge pipe/hose. Duct tape the transducer cable to an immovable object such as the top of casing, or protective bollard. Allow the well to equilibrate to static water levels.

Install pressure transducers in all of the oberservation wells included in the test in a manner similar to that described above. In nearly all applications, a 10-psi transducer (highly accurate over a 23-foot range) is ideal for monitoring drawdown in observation wells.

Connect the pressure transducers that have been installed in each well to a continuous data recorder. A single, multi-channel data logger may suffice if observation wells are in close proximity to one another, or several "remote" loggers may be required for wells separated by great distances. Input the required transducer parameters and other test parameters in the data logger. The data logger typically prompts the user to record water levels below the top of casing (TOC) or surface. Surface refers to a static water level datum.

The instrument is therefore "referenced" or "zeroed" to either a static water level or to a value input by the operator. Water levels below static water level will be recorded as negative values. For pumping test purposes, water levels can be recorded relative to either "TOC" or "surface". It is noted that referencing to "surface mode" minimizes mistakes in the field. Additionally, nearly all data reduction techniques evaluate drawdown, not absolute water levels. An accurate record of all input

parameters and field observations will be included in a field logbook or on the Aquifer Test Form (see Attachment O).

"Zero" the pressure traducer/data logger to static water levels (or, alternatively, enter the TOC value for each well). Confirm static levels (or TOC-adjusted values) with a water level indicator.
For the pumping well, and for observation wells close by the pumping well, it is advantageous to record the early time data at frequent intervals. This is best accomplished using the "logarithmic data recording mode" for each transducer.

TEST START-UP. On a pre-determined count, simultaneously start the pump and trigger the data logger. Quickly stabilize the discharge rate to the desired value (determined from a step test). At the same time, another team member will begin recording water levels as rapidly as possible in the pumping well (see frequencies above). It usually helps to have the data table constructed with pre-determined time intervals for water level measurements. The data recorded by the transducers and data logger can be viewed following completion of the logarithmic data recording cycle (approximately 2-3 minutes). Water levels recorded by the transducer/data logger system should be similar to the manually recorded water levels. It is always beneficial to plot the time and drawdown data in the field to ensure that the pumping rate and the drawdowns are adequate. The first couple of hours of the pumping test can be hectic. It is recommended that "more" rather than "less" project team staff be on site to assist in the early stages of the test. The size of the field team can generally be greatly reduced following the initial few hours of the test.

Monitoring Water Levels and Discharge Rates. Water levels will be monitored on the frequency detailed above. The discharge rate will be monitored at least every 30 to 60 minutes, and recorded on a field logbook or on the Aquifer Test Form (see Attachment O).

10.2.5 RECOVERY TESTS

A recovery test will be completed following either a step-test or a constant rate pumping test. As stated above, a recovery test is invaluable if the pumping test is performed without the use of piezometers or observation wells to evaluate potential borehole storage effects in the pumping well. Additionally, residual drawdowns are more reliable than drawdowns measured during pumping due to difficulties in the field of maintaining absolutely constant discharge from a pumping well.

The Principle - Recovery Tests: When the pump is shut down following a pumping test, water levels in the pumping well and observation wells begins to rise. This rise is known as residual drawdown, 's'. As with other types of aquifer tests, the relationship between discharge rate, time, and drawdown measured during the step test can be used in well-flow equations and corresponding "recovery equations" to determine the aquifer transmissivity and storage coefficient, and well characteristics.

Recovery Test Methods:
Complete a step-test or constant rate pumping test in the manner detailed above.
On a pre-determined count, simultaneously turn off the pump, "Step" the data logger, and manually record recovery (residual drawdown) data. The early time data will be recorded using the "log" data recording mode (high data logging frequency). Continue recording the recovery data until the water level returns to static water levels (or nearly so). The test is completed.

Important. Carefully download the field data to a PC computer. Obtain a hard copy and a master electronic copy to be stored.

11.0 REFERENCES

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Sedoris, H. and Nielsen, D.M., 1989. Handbook of suggested practices for the design and installation of groundwater monitoring wells, National Water Well Association, Dublin, Ohio, 397 pp.

ASTM, 1990, Standard D 2488-90, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Bouwer, H. and Rice, R.C., 1976. A slug test method for determining the hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

Cooper, H.H. and Jacob, C.E., 1946. A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys. Union Trans. vol 27, pp. 526-534.

Cooper, H.H., Bredehoeft, J.D. and Papadopulos, S.S., 1967. Response of a finite-diameter well to an instantaneous charge of water, Water Resources Research, vol. 3, no. 1, pp. 263-269.

Dansby, D.A. and Price, C.A., 1987. Graphical Well Analysis Package "GWAP" v.2.0, Groundwater Graphics, 5209 Windmill Street, Oceanside, CA 92056. ph. (619) 940-9473.

Driscoll, F.G., 1987. Groundwater and wells; Johnson Division; St. Paul, Minnesota, 1089 pp.

Fetter, C.W., Jr., 1980. Applied Hydrogeology, Charles Merrill Publishing, Columbus, Ohio.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, N.J.

Geraghty and Miller, 1991. Aquifer Test Solver "AQTESOLV" v.1.1, Geraghty and Miller, 10700 Parkridge Blvd., Suite 600, Reston, Virginia, 22091. ph. (703) 758-1200.

Hantush, M.S. and C.E. Jacob, 1955. Non-steady radial flow in an infinite leaky aquifer, Am. Geophys. Union Trans., vol. 36, pp. 95-100.

Hantush, M.S., 1960. Modification of the theory of leaky aquifers, Jour. of Geophys. Res., vol. 65, no. 11, pp. 3713-3725.

Kruseman, G.P. and N.A. de Ridder, 1991. Analysis and Evaluation of Pumping Test Data, 2nd Ed., Nat'l Institute for Land Reclamation and Improvement/ILRI, Wageningen, The Netherlands, 377p. Available through the NWWA Bookstore.

Lohman, S.W., 1979. Ground-Water Hydraulics, USGS Prof. Paper 708. Available through the USGS "Books and Open-File Reports Section, Federal Center, Box 25425 Denver, Colorado 80225.

Macbeth, 1992, Munsell Soil Color Charts.

Neuman, S.P., 1975. Analysis of pumping test data from anistropic unconfined aquifers considering delayed yield, Water Resources Research, Vol 11, No. 2, pp. 329-342.

Neuman, S.P. and P.A. Witherspoon, 1972. Field Determination of Hydraulic Properties of Leaky Multiple-Aquifer Systems. Water Resources Res. Vol. 8, No. 5, October 1972, pp. 1284 - 1298.

Nielsen, D. ed., 1991. Ground-water monitoring; Lewis Publishers, Chelsea, Michigan, 717 pp.

Reynolds, G.W., J.T. Hoff and R.W. Gillham, 1990. Sampling Bias Caused by Materials Used to Monitor Halocarbons in Groundwater. Environmental Science and Technology, Vol. 24, No. 1.

Theis, C.V., 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage, Am. Geophys. Union Trans., Vol. 16, pp. 519-524.

Thiem, G., 1906. Hydrologische Methoden. Gebhardt, Leipzig, 56p.

United States Army Corps of Engineers (USACE), EM 200-1-3, 1998. Requirements for the Preparation of Sampling and Analysis Plans.

USACE, EM 1110-1-4000, 1998. Monitoring Well Design, Installation and Documentation at Hazardous, Toxic and Radioactive Waste Sites.

U.S. Environmental Protection Agency (USEPA), 1987. A Compendium of Superfund Field Operations Methods, EPA/540/p-87/001.

United State Environmental Protection Agency (USEPA), EPA/540/G-89/004, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final.

USEPA, SW846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods Third Edition, 1986.

ATTACHMENTS

ATTACHMENT A

GLOSSARY OF TERMS

Absorption - The penetration or apparent disappearance of molecules or ions of one or more substances into the interior of a solid or liquid.

Adsorption - The process by which atoms, ions, or molecules are held to the surface of a material through ion-exchange processes.

Annular Sealant - Material used to provide a positive seal between the borehole and the casing of the well. Annular sealants should be impermeable and resistant to chemical or physical deterioration.

Annular Space - The space between the borehole wall and the well casing, or the space between a casing pipe and a liner pipe.

Annulus - The gap between the well and borehole where the sand, seal and grout are installed.

Aquifer - A geologic formation, group of formations, or part of a formation that can yield water to a well or a spring.

Backwashing - A method of filter pack emplacement whereby the filter pack material is allowed to fall freely through the annulus while clean fresh water is simultaneously pumped down the casing.

Bentonite - Hydrous aluminum silicate available in powder, granular, or pellet form. It is used to provide a tight seal between the well casing and the borehole.

Bailer - A cylindrical tool designed to remove material, both solid and liquid, from a well or borehole. A valve at the bottom of the bailer retains the material in the bailer. The three types of bailers are flat-valve bailer, a dart-valve bailer and the sand pump with rod plunger.

Blow Counts - Number of hammer blows needed to advance a split spoon sampler. Blow counts are usually counted in 6-inch increments.

Borehole - The hole created by drilling through the subsurface.

Bridge - A wedge or build up of sand that occurs when the driller is pouring the sand pack around the screened interval, thus leaving a gap or "open zone" where the natural formation could possibly clog the screen. Also the development of gaps or obstructions in either grout or filter pack materials during emplacement.

Cone Penetrometer - An instrument used to identify the underground conditions by measuring the differences in the resistance and other physical parameters of the strata. The cone penetrometer consists of a conical point attached to a drive rod of smaller diameter. Penetration of the cone into the formation forces the soil aside, creating a complex shear failure. The cone penetrometer is very sensitive to small differences in soil consistency.

Continuous Slot Wire-Wound Intake - A well intake that is made by winding and welding triangular-shaped, cold-rolled wire around a cylindrical array of rods. The spacing of each successive turn of wire determines the slot size of the intake.

Core Barrel - A steel tube used to collect rock core samples. The core barrel receives the rock core cut by the outer barrel as the borehole is advanced.

Cuttings - Formation particles obtained from a borehole during the drilling process.

Drill Rod - The rigid steel rod used to lower and retrieve cutting, coring and sampling equipment down the borehole.

Draw down - Distance between the static water level and water level while the well is being pumped or bailed at a constant rate.

Drilling Fluids_- A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the inner barrel and the sides of the borehole and to seal the borehole.

Dual-Purpose Well - A well that can be used as both a monitoring and extraction or injection well.

Filter Pack - Sand, gravel, or glass beads that are uniform, clean and well-rounded that are placed in the annulus of the well between the borehole wall and the well intake to prevent formation material from entering through the well intake and to stabilize the adjacent formation.

Fines - Silt, clay, fine sand.

Grout - A fluid mixture of neat cement and water with various additives or bentonite of a consistency that can be forced through a pipe and emplaced in the annular space between the borehole and the casing to form an impermeable seal.

Heaving Formation - Unconsolidated saturated substrate encountered during drilling where the hydrostatic pressure of the formation is greater than the borehole pressure causing the sands to move up into the borehole.

Inner Barrel - The tool lowered through the inside of the outer barrel that can be configured for cutting, coring, or sampling.

Kelly Bar - A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is either square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.

Neat Cement - A mixture of Portland cement and water in the proportion of 5 to 6 gallons of clean water per bag (94 pounds) of cement.

Outer Barrel - The steel piping that serves to both cut downwards and to line the borehole walls to prevent hole collapse.

Overshot Tool - The tool that attaches to the inner barrel so that the barrel may be lowered through the outer barrel to depth on the wireline. The overshot tool is designed to attach to, or release from, the inner tube at depth.

Parameters - Groundwater variables, pH, specific conductivity, temperature, turbidity.

Pitch - The distance along the axis of an auger flight that it takes for the helix to make one complete 360 degree turn.

Purge water - Any water removed from the well via bailing, pumping, or air lift.

Rotary Table - A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.

Saturated annulus - The portion of the annulus that is below the aquifer.

Sieve Analysis - Determination of the particle-size distribution of soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

Split-Spoon Sampler - A thick-walled steel tube split lengthwise used to collect soil samples. The sampler is commonly lined with metal sample sleeves and is driven or pushed downhole by the drill rig to collect samples.

Thin-Walled Sampler - A sampling devise used to obtain undisturbed soil samples made from thin-wall tubing. The sampler is also known as a Shelby tube. The thin-wall sampler minimizes the most serious sources of disturbance: displacement and friction.

Tremie Pipe - A device, usually a small-diameter pipe, that carries grouting materials to the bottom of the borehole and that allows pressure grouting from the bottom up without introduction of appreciable air pockets.

VOCs - Volatile organic compounds.

Wireline - The steel cable used to lower and retrieve cutting, coring and sampling equipment down the borehole.

Yield - The rate at which a well will produce water.

ATTACHMENT B

UNIFIED SOIL CLASSIFICATION SYSTEM

TABLE - A
Unified Soil Classification System

CRITERIA FOR ASSIGNING GROUP SYMBOLS AND NAMES			SOIL CLASSIFICATION	
			GROUP SYMBOL	GENERALIZED GROUP DESCRIPTIONS
Coarse-Grained Soils More Than 50% Retained On No. 200 Sieve	Gravels More Than 50% Of Coarse Fraction Retained On No. 4 Sieve	Clean Gravels Less Than 5% Fines	GW	WELL-GRADED GRAVELS
			GP	POORLY-GRADED GRAVELS
		Gravels With Fines More Than 12% Fines	GM	GRAVEL AND SILT MIXTURES
			GC	GRAVEL AND CLAY MIXTURES
	Sands 50% Or More Of Coarse Fraction	Clean Sands Less Than 5% Fines	SW	WELL-GRADED SANDS
			SP	POORLY-GRADED SANDS
		Sands With Fines More Than 12% Fines	SM	SAND AND SILT MIXTURES
			SC	SAND AND CLAY MIXTURES
Fine-Grained Soils 50% Or More Passes The No. 200 Sieve	Silts And Clays Liquid Limit Less Than 50	Inorganic	CL	NON-PLASTIC AND LOW PLASTICITY CLAYS
			ML	NON-PLASTIC AND LOW PLASTICITY SILTS
		Organic	OL	NON-PLASTIC AND LOW PLASTICITY ORGANIC CLAYS
				NON-PLASTIC AND LOW PLASTICITY ORGANIC SILTS
	Silts And Clays Liquid Limit 50 Or More	Inorganic	CH	HIGH PLASTICITY CLAYS
			MH	HIGH PLASTICITY SILTS
		Organic	OH	HIGH PLASTICITY ORGANIC CLAYS
				HIGH PLASTICITY ORGANIC SILTS
Highly Organic Soils	Primarily Organic Matter, Dark In Color, And Organic Odor		PT	PEAT

TABLE - B
Relative Density Or Consistency
Utilizing Standard Penetration Test Values

NONCOHESIVE SAMPLES (a)		COHESIVE SAMPLES (b)	
Relative Density	No. Blows/PerFt. (c)	Consistency	No. Blows/PerFt.
Very Loose	0 To 4	Very Soft	0 To 2
Loose	4 To 10	Soft	2 To 4
Compact	10 To 30	Firm	4 To 8
Dense	30 To 50	Stiff	8 To 15
Very Dense	Over 50	Very Stiff	15 To 30
		Hard	Over 30

(a) Soils consisting of gravel, sand, and silt, either separately or an combination, processing no characteristics of plasticity, with average particle diameter greater than 0.002 millimeters.

(b) Soils consisting generally of the Clay fraction, possessing the characteristics of plasticity with an average particle diameter of less than 0.002 millimeters.

(c) Refer to text or ASTM D 1586-84 for a definition of N.

TABLE - C
Component Definitions By Gradation

COMPONENT	SIZE RANGE
Boulders	Greater than 12in. (300mm)
Cobbles	12in. to 3in. (300mm to 75mm)
Gravels	3 In. To No.4(4.75mm)
Coarse Gravel	3 In. To 3/4 In. (75mm to 19mm)
Fine Gravel	3/4 In. (19mm) To No.4 sieve (4.75mm)
Sand	No.4(4.75mm) To No.200(0.074mm)
Coarse Sand	No.4(4.75mm) To No.10(2.0mm)
Medium Sand	No.10(2.0mm) To No.40(0.42mm)
Fine Sand	No.40(0.42mm) To No.200(0.074mm)
Silt & Clay	Smaller Than No.200(0.074mm)

TABLE - D
Descriptive Terminology Denoting Component Proportions

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	0-5%
Little	5-12%
Some	12-30%
And	30-50%

TABLE - E
Descriptive Terms Denoting Gradation Of Granular Components

GRADATION DESIGNATION	ABBREVIATION SYMBOLS	DEFINING PROPORTIONS
Coarse To Fine Or Coarse Medium To Fine	C-F C-M-F	(All fractions greater than 10% of the component, but the medium component dominates)
Coarse To Medium	C-M	Less Than 10% Fine
Medium To Fine	M-F	Less Than 10% Coarse
Medium	M	Less Than 10% Coarse & Fine
Fine	F	Less Than 10% Coarse & Medium

TABLE - F
Sample Test Taken

- STANDARD PENETRATION TEST
- SHELBY TUBE
- GRAB SAMPLE
- CUTTINGS
- PENETRATION SAMPLER (3" O.D.)
- SPLIT SPOON SAMPLER (2.5" O.D.)
- WATER LEVEL DURING DRILLING
- MEASURED WATER LEVELS

MWH

AUTOCAD FILE: SOILNDX.DWG

ATTACHMENT C

CRITERIA FOR DESCRIBING PLASTICITY

CRITERIA FOR DESCRIBING PLASTICITY	
Description	**Criteria**
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

ATTACHMENT D

CRITERIA FOR DESCRIBING DENSITY AND CONSISTENCY

DENSITY/CONSISTENCY BASED UPON BLOW COUNTS							
Density (Sand and Gravel) Blows/ft*				Consistency (Silt and Clay) Blows/ft*			
Term	**1.4" ID**	**2.0" ID**	**2.5" ID**	**Term**	**1.4" ID**	**2.0" ID**	**2.5" ID**
very loose	0-4	0-5	0-7	very soft	0-2	0-2	0-2
loose	4-10	5-12	7-18	soft	2-4	2-4	2-4
medium dense	10-29	12-37	18-51	medium stiff	4-8	4-9	4-9
dense	29-47	37-60	51-86	stiff	8-15	9-17	9-18
very dense	>47	>60	>86	very stiff	15-30	17-39	18-42
				hard	30-60	39-78	42-85
				very hard	>60	>78	>85
* 140 lb. hammer dropped 30 inches							

CRITERIA FOR DESCRIBING CONSISTENCY BASED UPON THUMB TEST	
Description	**Criteria**
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about 1/4 in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

ATTACHMENT E

CRITERIA FOR DESCRIBING STRUCTURE

CRITERIA FOR DESCRIBING STRUCTURE	
Description	**Criteria**
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

ATTACHMENT F

SOIL BORING LOG FORM

BORING LOG NUMBER:

LOC. ID: ELEVATION: SHEET ___ OF ___

PROJECT NAME: DATUM:

INCLINATION: AZIMUTH: HAMMER WEIGHT: DRILL DATE:

DATE FINISHED:

LOCATION SKETCH

DEPTH (UNITS)	BORING METHOD	SOIL PROFILE: SOIL DESCRIPTION	GRAPHIC LOG	SAMPLES: USCS	NUMBER	TYPE	BLOW COUNT/6"	RECOVERY	ADDITIONAL COMMENTS
0									
5									
10									
15									
20									
25									
30									
35									
40									
45									

DEPTH UNITS: _____

DRILLING CONTRACTOR: _____

DRILLER: _____

LOGGED BY: _____

CHECKED BY: _____

REV. NO.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND APPROVED BY

MWH

PROJECT No.:

AutoCAD FILE:

SCALE: FIGURE No.:

SOIL BORING LOG FORM

ATTACHMENT G

ROCK CORE LOG FORM

PROJECT NAME: _____ DATE: _____ BOREHOLE NUMBER: _____

BOREHOLE LOCATION: _____ LOGGED BY: _____

ELEVATION: _____ REFERENCE POINT: _____ DATUM: _____ DRILL RIG: _____

INCLINATION: _____ AZIMUTH: _____ FLUSH: _____ FEED: _____

TOTAL DEPTH: _____ BIT TYPE: _____ PAGE ___ OF ___

CORE DIA. / DEPTH (Tick-Mark = 1 Ft.)	CASING DIA. / DEPTH	WATER NOTES	ROCK TYPE		DEPTH SCALE	CORE RECOV. DATA			DISCONTINUITY DATA	STRENGTH DATA		ADDITIONAL COMMENTS
			DEPTH	DESCRIPTION		T.C.R. (Length - %) 25 50 75	R.Q.D. (Length - %) 25 50 75	FRACTURES	TYPE & SURFACE DESCRIPTION	WEATHERING INDEX	STRENGTH INDEX	

ABBREVIATIONS

T.C.R. - Total Core Recovery
R.Q.D. - Rock Quality Description

S - Shear
B - Bedding
FO - Foliation

U - Undulating
ST - Stepped
I - Irregular

SM - Smooth
R - Rough
VR - Very Rough

C - Curved
J - Joint = Fracture
F - Fault

PL - Planar
P - Polished
K - Slickensided

REV. No.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY

ROCK CORE LOG FORM

MWH

PROJECT No.:
AutoCAD FILE:
SCALE: FIGURE No.:

ATTACHMENT H

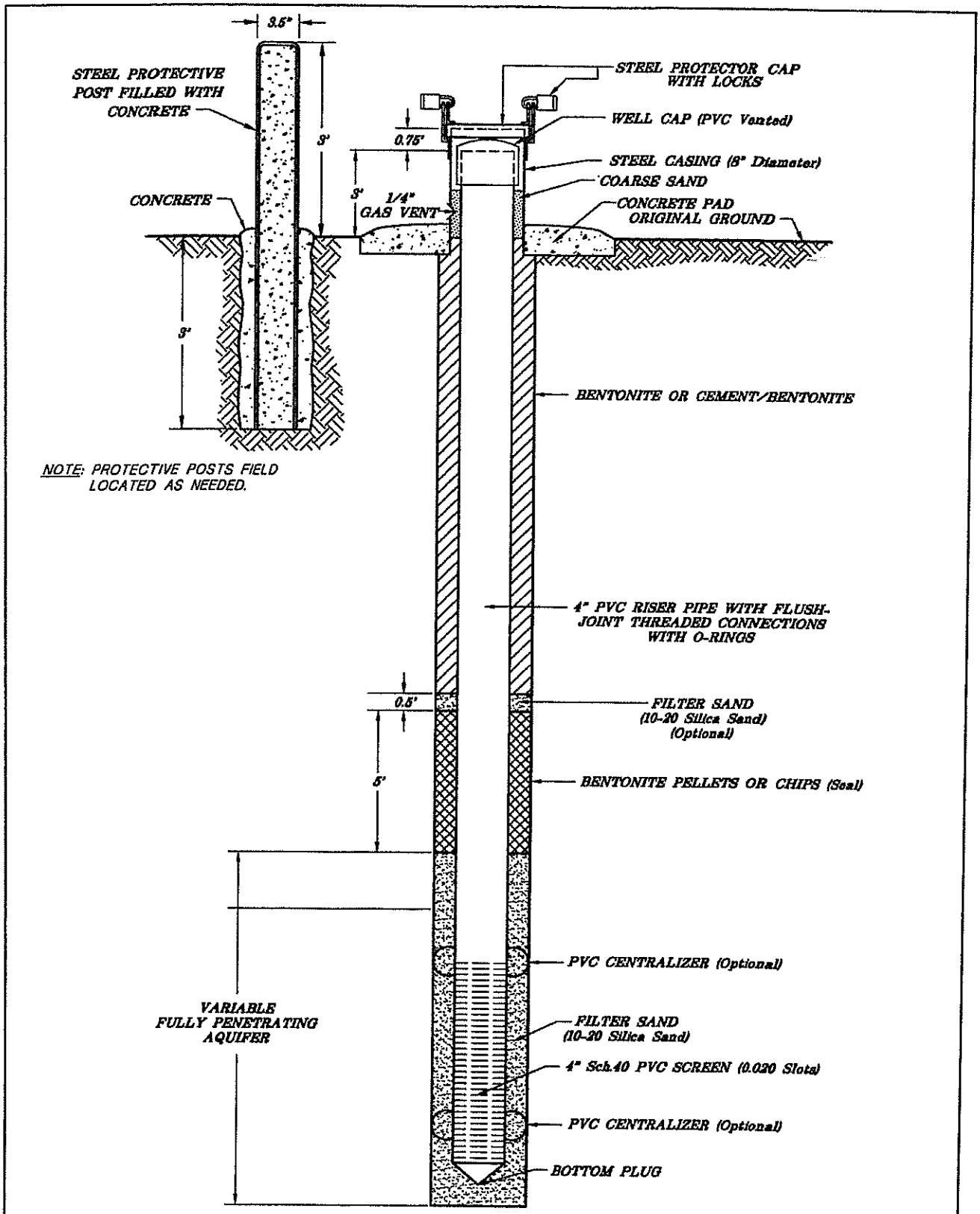
WEATHERING AND INTACT ROCK STRENGTH CLASSIFICATION

WEATHERING CLASSIFICATION		
TERM	**DESCRIPTION**	**SYMBOL**
Fresh	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.	W1
Slightly Weathered	Discoloration indicates weathering of rock material on discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition	W2
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	W3
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.	W4
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	W5

INTACT ROCK STRENGTH CLASSIFICATION		
TERM	**DESCRIPTION**	**SYMBOL**
Extremely Weak Rock	Indented by thumbnail	R0
Very Weak Rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	R1
Weak Rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	R2
Medium Strong Rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of geological hammer to fracture it.	R3
Strong Rock	Specimen requires more than one blow of geological hammer to fracture it.	R4
Very Strong Rock	Specimen requires many blows of geological hammer to fracture it.	R5
Extremely Strong Rock	Specimen can only be chipped with geological hammer.	R6

ATTACHMENT I

TYPICAL MONITORING WELL INSTALLATION DIAGRAM



Project No.:	Design By:	Scale: N.T.S.
File: TYP-WELL.DWG	Drawn By:	Date:

MWH

TYPICAL MONITORING WELL INSTALLATION

ATTACHMENT J

MONITORING WELL CONSTRUCTION FORM

Facility/Project Name: _____ Date Well Installed: From _____ To _____

Well Number: _____ Well Installed By (Person's Name & Firm) _____

Type of Protective Cover: Above-Gound ☐ Flush-To-Ground ☐

NOTE: Use Ground Surface (BGS or AGS) for all depth measurements

(A) - Protective casing _____ ft. BGS ☐ or AGS ☐

(B) - Well casing, top _____ ft. BGS ☐ or AGS ☐

(C) - Surface seal, bottom _____ ft. BGS

(D) - Bentonite seal, top _____ ft. BGS

(E) - Primary filter, top _____ ft. BGS

(F) - Screen joint, top _____ ft. BGS

(G) - Screen joint, bottom _____ ft. BGS

(H) - End cap bottom _____ ft. BGS

(I) - Filter pack, bottom _____ ft. BGS

(J) - Borehole, bottom _____ ft. BGS

(K) - Borehole, diameter _____ in. to _____ ft. BGS
_____ in. to _____ ft. BGS

(L) - O.D. well casing _____ in.

(M) - I.D. well casing _____ in.

(N) - 24 hr. water level after completion _____ ft. BGS _____ ft. TOC

(1) - Cap and Lock? Yes ☐ No ☐

(2) - Protective posts? Yes ☐ No ☐ No. of Posts _____
a. Height AGS: Feet: _____ b. Depth BGS: Feet: _____

(3) - Protective casing:
a. Inside diameter: Inches: _____ b. Depth: Feet: _____

(4) - Drainage port (s)? Yes ☐ No ☐

(5) - Surface seal material a. Cap: _____ b. Annular space seal _____

(6) - Material between well casing and protective casing: _____

(7) - Annular space seal: Mix: _____
- How installed: Tremie ☐ Tremie pumped ☐ Gravity ☐

(8) - Centralizers: No ☐ Yes ☐ Depths (BGS) _____

(9) - Bentonite seal:
a. Bentonite granules ☐ or b. Bentonite pellets 1/4in. ☐ 3/8in. ☐ 1/2in. ☐
c. _____ ☐ other

(10) - Filter pack material: Manufacturer, product name, & mesh size
a. _____
b. Volume added _____ ft./3 _____ Bags/Size

(11) - Well casing: Flush threaded PVC schedule 40 ☐
Flush threaded PVC schedule 80 ☐
_____ Other ☐

(12) - Screen material: _____
a. Screen type: _____
Factory cut ☐ Continuous slot ☐ Other ☐ _____
b: Manufacturer _____
c: Slot size: _____
d: Slotted length: _____

(13) - Backfill material (below filter pack): None ☐
_____ Other ☐

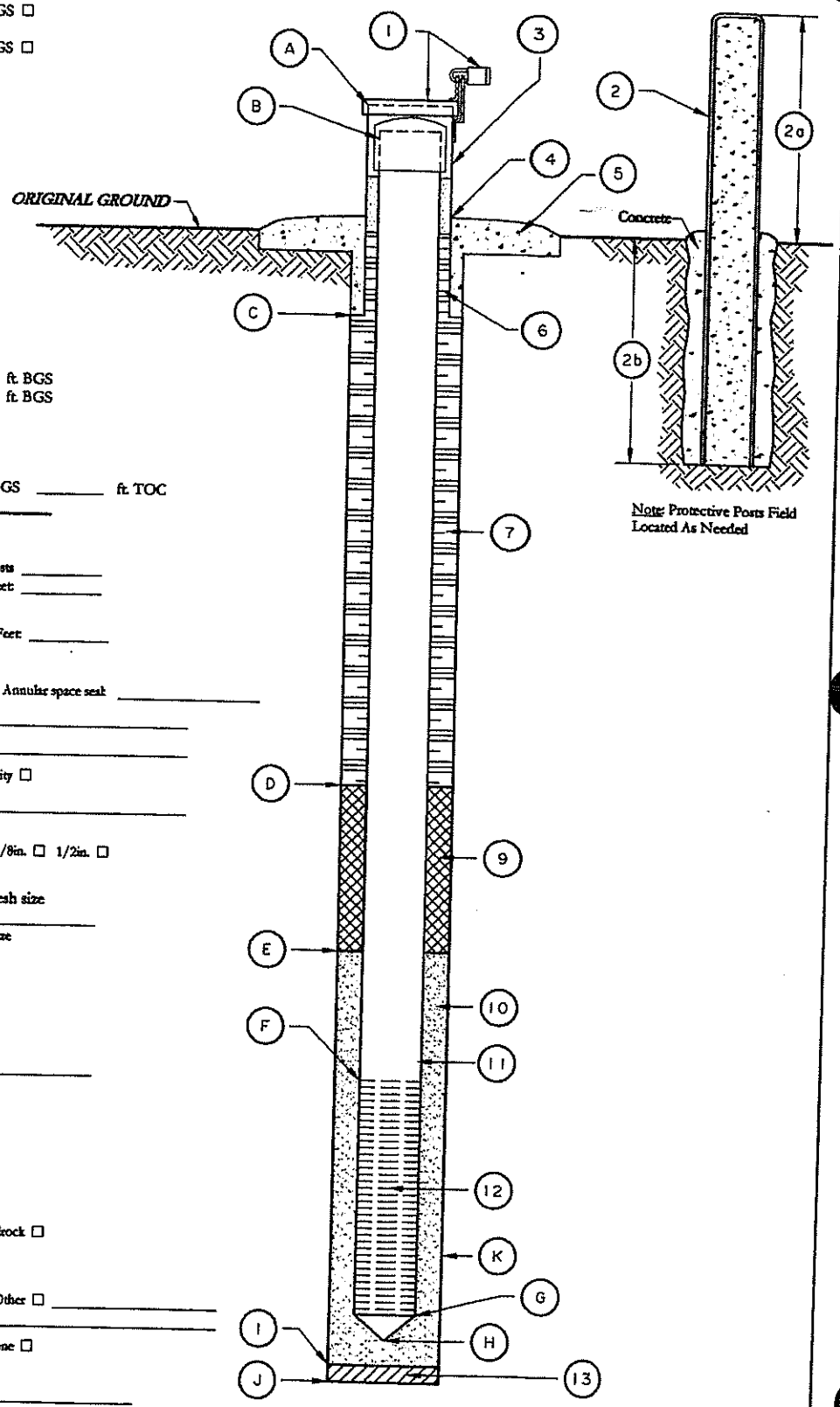
(14) - USCS classification of soil near screen None ☐
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☐
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐ Bedrock ☐

(15) - Sieve analysis attached? Yes ☐ No ☐

(16) - Drilling method used: Rotary ☐ Hollow Stem Auger ☐ Other ☐ _____

(17) - Drilling fluid used: Water ☐ Air ☐ Drilling Mud ☐ None ☐

(18) - Drilling additives used? Yes ☐ No ☐
Describe: _____



REV. No.	REVISIONS	REV. DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY

MWH

PROJECT No.: 100400107803
AutoCAD FILE: Well Construction Form
SCALE: Not To Scale
FIGURE No:

WELL CONSTRUCTION FORM

ATTACHMENT K

WELL DEVELOPMENT RECORD
WELL VOLUME CHART

WELL DEVELOPMENT RECORD

Well Number:

Job No. _____ Project Name: _____ Page: ___ of ___

Date(s): _____

Developed by: _____

Measuring Point (MP) of Well: _____

Screened Interval (ft bgs): _____

Filter Pack Interval (ft bgs): _____

Development Method: _____

Comments: _____

Starting H_2O Level (BMP): _____

Casing Stickup TOC (ft): _____

Casing Diameter (in ID): _____

Casing Volume (gal): _____

QUALITY ASSURANCE

Methods (describe)

Cleaning Equipment:

Development:

Disposal of Purge Water:

Instruments (indicate make, model, id.)

Water Level: Thermometer:

pH Meter: Field Calibration:

Conductivity Meter: Field Calibration:

Turbidity Meter: Field Calibration:

Other: Field Calibration:

DEVELOPMENT MEASUREMENTS

Date/Time	Cumul. Vol. (gal)	Temp. (C)	Field EC (_____)	Color	Turbidity	Other _____	Remarks

Total Discharge (gal): _____ Casing Volumes Purged: _____

Observations/Comments: _____

Abbreviations:

BMP = below measuring point

BGS = below ground surface

Cumul. Vol. = cumulative volume removed

ID = inside diameter

C = Celsius

gal = gallons

ft = feet

in = inches

MWH

Filename: Well-devel.dwg

ATTACHMENT L

WATER LEVEL READINGS FORM

RECORD OF WATER LEVEL READINGS

Job No. _____ Project Name _____ Location _____

Loc. ID	Date	Time	Measuring Device/ Unit Number	Reference Point	Depth to Water	By	Comments

Filename: Wtr_lvl.dwg

MWH

ATTACHMENT M

PACKER TEST FORM

PACKER TEST DATA FORM

Job No. _____ Location _____ Gauge Ht _____ ft Page ____ of ____

Job Name _____ Depth to Groundwater _____ ft bgs Borehole Dia. _____ in

Boring No. _____

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Gauge Pressure (ft water) = Gauge Gressure (psi)/0.433

Column Pressure = Gauge Heigth plus Top Depth or Depth to GW, whichever is smaller.

Net Pressure = Gauge + Column + Frict. Loss

K (cm/s) = K (ft/min) x 0.508

Filename: Packer_test.dwg

MWH

ATTACHMENT N

TIME INTERVALS FOR MANUAL AND ELECTRONIC MEASUREMENTS OF DRAWDOWN

SUGGESTED MANUAL MEASUREMENT FREQUENCY USING CALIBRATED ELECTRONIC WATER-LEVEL INDICATORS

ELAPSED TIME	MEASUREMENT FREQUENCY
0-20 minutes	30 seconds
20-40minutes	2 minute
40-60 minutes	5 minutes
60-120 minutes	10 minutes
2-12 hours	1 hour
12 hours to 3 days	2 hours

LOGARITHMIC TIME INTERVAL SCHEDULE FOR PRESSURE TRANSDUCERS AND DATA LOGGERS

LOG CYCLE	MEASUREMENT INTERVAL	TOTAL DATA POINTS PER CYCLE
0-20 seconds	0.2 second	101
20 -60 seconds	1 second	40
1-10 minutes	12 seconds	45
10-100 minutes	2 minutes	45
100-1,000 minutes	20 minutes	45
1,000-10,000 minutes	200 minutes	45

ATTACHMENT O

AQUIFER TEST FORM

AQUIFER TEST FORM

Well Number ID: _____

Page ____ of ____

Observer's Name: _____

Location: _____

Job No. _____

Pumped/Observation Well (x-out one)

Date Test Started: _____

Total Depth: _____ Blank Casing Length: _____

Date Test Ended: _____

Screened From ____ to ____

Static Water Elevation: _____

Type of Screen/Casing: _____

Static Water Depth: _____

Gravel Pack O.D.: _____

Groundwater Temperature: _____

If observation well, bearing and distance from pumped well: _____

Depth to Aquifer Top: _____

Initial Pumping Rate: _____

Depth to Aquifer Bottom: _____

Saturated Thickness: _____

Additional Well Details or Comments: _____

Constant Discharge Maintained?

Yes ___ No ___

How Measured?: _____

MEASUREMENTS

Time of Day	Elapsed Time (min)	Depth to Water	Drawdown	Remarks (note fluctuation or change in discharge rate, cessation of pumping, etc.)

Additional Comments/Observations: _____

PROJECT NAME:

MWH

Filename: Aquifer-T1.dwg

Appendix H
Standard Operating Procedures

Low Stress Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells

STANDARD OPERATING PROCEDURE

LOW STRESS PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

(Based on EPA Region 1, Revision 2. July 30, 1996.)

1.0 INTRODUCTION

This standard operating procedure (SOP) is intended to serve as a reference for the proper equipment and techniques for collecting groundwater samples by low-stress sampling techniques. The purpose of this SOP is to enable the user to collect representative and defensible groundwater samples, and to plan the field sampling effort. The techniques presented will be followed whenever applicable, although site-specific conditions or project-specific requirements may warrant adjustments in methodology. This SOP is based on EPA Region 1, Low Stress Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Revision 2, July 30, 1996, which is attached as Attachment A.

This SOP describes groundwater sample collection by low-stress sampling methods, only. All other groundwater sampling procedures will be performed in accordance with the Field Sampling Plan of the

MONITORING WELL LOW-STRESS SAMPLING

Monitoring wells can be sampled with bladder pumps using lower flow rates. Studies have shown that groundwater in the screened interval of a standard monitoring well can be representative of groundwater in the formation, even though stagnant water lies above in the casing. This occurs when flow is generally horizontal and naturally purges the screened interval. However, the insertion of a sampling device, such as a bailer or pump, can disrupt this equilibrium and cause mixing of the screened and cased interval waters. The mixture of stagnant and screened interval water can even be forced into the aquifer, resulting in chemical and microbiological effects that may affect data quality. Therefore, low-stress sampling techniques are most accurate using dedicated sampling devices that can be left in place within a monitoring well. Considerations also need to be made for switching between standard purge volume and low-stress sampling methods.

The objective of low-stress sampling is to minimize the velocity/stress on the sample water as it exits the formation into the screened interval of the well and as it enters the

pump. Flow rates from 0.1 to 0.5 liter/minute (l/min) are typical for this sampling procedure. When performed correctly, water sampled using the low-stress technique is produced from the screened interval without disturbing stagnant water in the well casing. By using low flow rates to stabilize drawdown at less than the goal of 0.30 feet, only screened interval water will be sampled. Depth to water measurements during purging are recorded to verify that less than 0.3 feet of drawdown has occurred. In those cases where drawdown is observed to be greater than 0.3 feet, the pumping rate will be reduced by decreasing the pumping rate. If the pumping rate is reduced to less than 0.25 liters per minute and the drawdown still exceeds 0.3 feet after two 2-minute intervals, pumping will be halted. Project-specific work plans should be developed in cases where low-stress sampling with less than 0.30 feet of drawdown can not be achieved. Under these cases, the Project Manager must approve of alternative sampling methods prior to sampling. If drawdown is ever observed to be greater than 0.5 feet, pumping will be halted and the will be allowed to recover before resuming low-stress sampling or purging at a lower pumping rate.

The following procedures will be used while performing low-stress purging and sampling:

1. Install a bladder pump in the well (if one does not already exist). Slowly lower the bladder pump into the well to minimize disturbance of the stagnant water within the well. Place the pump inlet in the screened interval at the appropriate depth, which should be near the midpoint of the screened interval unless site-specific conditions dictate placing the pump at a different point within the screened interval. Wait at least 48 hours after pump installation before purging and sampling.

2. Before initiating purging, place an electric water level indicator down to the top of the static water table and record the depth to groundwater.

3. Begin purging groundwater at a rate between 100 to 500 ml/min, making sure to minimize drawdown to less than 0.3 feet as a goal. Rates up to approximately 1 l/min may be feasible in high hydraulic conductivity formations, only if the

drawdown continues to be less than 0.3 feet. Measure drawdown at intervals of five minutes or less during purging. Adjust the purge rate to balance the desired (low) purge rate and water level drawdown. If the recharge to the well is less than 100 ml/min (i.e., excessive drawdown is occurring), proceed to Step 6.

4. The minimum volume to be purged from the well is two times the volume of the tubing and pump (available from the manufacturer). The tubing volume will be determined by multiplying the volume per foot of tubing (available from the manufacturer) by the total length of tubing.

5. During purging, measure the following groundwater quality parameters: pH, temperature, electrical conductivity, turbidity, DO, and ORP. The parameters will be considered stable when three consecutive readings, collected at intervals of at least five minutes, are within:

Conductivity	±10%
pH	±0.2 units
Temperature	±1 degree Celsius
Dissolved Oxygen	±0.2 mg/l
ORP	±10 millivolts
Turbidity	<5 NTU.

However, if the turbidity is not ≤5 NTU, but is stable (within ± 10 percent between readings) within a four-hour period, and all other parameters are stable, the samples will be collected. Once the parameters have stabilized, collect the samples.

6. If the well produces water at an extremely slow rate and excessive drawdown is occurring (> 0.30 feet.), even at a pumping rate of 100 ml/min, low-stress procedures may not be the best sampling method for the well. It is recommended that the standard practice for sampling low-recharge rate wells using bladder pumps be followed.

ATTACHMENT A

LOW STRESS PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

(Based on EPA Region 1, Revision 2. July 30, 1996.)

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

July 30, 1996
Revision 2

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Use of trademark names does not imply endorsement by U.S.EPA but is intended only to assist in identification of a specific type of device.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permealability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II.EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic “tape”, pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level “tape” at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III.PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and

total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV.PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator

parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values

measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter

size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a “silting” problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII.FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and

detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

EXAMPLE (Minimum Requirements) Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____ Depth to _____/_____ of screen
Well Number_____Date_____ (below MP) top bottom
Field Personnel_____ Pump Intake at (ft. below MP)_____
Sampling Organization_____ Purging Device; (pump type)_____
Identify MP_____

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

Appendix I
Draft 2005 Phase II Supplemental SI Groundwater Health and Safety Plan

M E M O R A N D U M

MWH
2353 130th Avenue N.E., Suite 200
Bellevue, Washington 98005
Phone: (425) 602-4000
Fax: (425) 867-1970

To: Mary Kauffman, IDEQ
Cc: Bob Geddes, P4 Production, LLC
From: Paul Stenhouse, MWH

Date: October 13, 2005

Reference: P4 Production Southeast Idaho Mine-Specific Selenium Program

Subject: Supplemental Health and Safety Plan to Support the Phase II Groundwater Investigation

---

Draft 2005 Phase II Supplemental SI Groundwater Health and Safety Plan

MWH will conduct water well drilling operations at P4 Production, LLC (P4) mines as part of the second phase of the site investigation. Phase II of this site-specific investigation work will focus on groundwater flow characterization, natural attenuation, and chemical speciation. P4 is proposing to install a limited number of monitoring wells on historical phosphate mines to satisfy investigation needs.

The purpose of this memorandum is to supplement the existing project health and safety plan, *Southeast Idaho Mine-Specific Selenium Program Comprehensive Site Investigation Program Health and Safety Plan–Final*, (MWH, 2004), so that well drilling operations and their hazards are well documented. Its purpose is also to provide field crews with guidelines for working safely around water well drilling operations and supports Section 12.2.8.1, *Drilling Operations* of the MWH 2004 program health and safety plan. In addition, the flash freezing process during sample collection was not anticipated while drafting the project health and safety plan (HASP).

Attached to this supplemental HASP memorandum is Attachment 1, *MWH ES&H Procedure No. 811, Drilling Safety*. This procedure outlines health and safety requirement for MWH employees and subcontractors and will be followed by MWH personnel and subcontractors involved in drilling operations as part of the Phase II SI groundwater investigation. This procedure covers topics related to drilling operations, such as OSHA requirements, drilling at hazardous waste sites, safety equipment, subcontractor selection and oversight, and planning activities. Procedures for drilling, including safe work practices, site preparation, drill rig requirements, equipment travel and set-up, equipment operation, drill rig maintenance, and a self-assessment checklist also cover the more specific tasks involved directly with drilling operations. Attachment A of this procedure, *Subcontractor Safety Program Criteria—Drilling Operations* will also be discussed with AK Drilling of Butte, Montana to ensure that the minimum acceptable standards for subcontractors can be met. MWH personnel at each new drill location

shall fill out Attachment B, *Self-Assessment Checklist—Drilling Operations*, as it contains site location criteria, which must be met prior to drilling operations.

SAMPLING HANDLING

MWH will ship samples to a laboratory that can conduct analytical speciation. Speciation analysis requires that groundwater samples be flash frozen in the field (frozen to -70° C). Flash freezing will be facilitated by immersing filled high-density polyethylene (HDPE) water bottles in a dry ice (carbon dioxide)/ethanol slurry. Ethanol will be obtained from a commercial source. Dry ice will be obtained in sufficient quantities from a local source.

MWH personnel will be required to transport quantities of these materials in amounts sufficient to complete the flash freezing process on the days that ground water will be sampled. MWH intends to transport these materials under the materials of trade exemption. The materials of trade exemption for these chemicals is as follows:

- Carbon Dioxide (Dry Ice)—30 kg or 66 lbs.
- Ethanol (Ethyl Alcohol)—30 L or 8 gal.

These materials will be secured and transported in the bed of a pickup, so that inhalation hazards will be minimized.

During the flash freezing process, MWH personnel will minimize the likelihood of cryogenic burns from contact with a dry ice/ethanol slurry. This will be facilitated by immersing water bottles in an insulated cooler with metal tongs, which will be placed on a flat surface, and physically separated from other personnel who may be working in the area. In addition to the level D personal protective equipment (PPE) worn by MWH field personnel and subcontractors while in the field, the following increase in PPE will be worn by MWH personnel when flash freezing samples:

- Protective face shield (with safety glasses) or goggles.
- Loose fitting gloves, such as cryo-gloves.
- Protective apron without pockets.
- Rubber boots.

Material safety data sheets (MSDS) for ethanol and carbon dioxide (dry ice) will be attached to this memorandum as Attachment 2.

Table 1 contains the Activity Hazard Analysis (AHA), which covers drilling operations and flash freezing.

TABLE 1 ACTIVITY HAZARD ANALYSIS FORM		
ACTIVITY: *Flash Freezing Water Samples*	***ANALYZED BY/DATE:*** *Paul Stenhouse, 10-11-05*	***REVIEWED BY/DATE:***
Principal Steps	**Potential Hazards**	**Recommended Controls**
Identify the principal steps involved, <u>including the equipment and machinery to be used</u>, and the sequence of work activities.	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards.	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed. • Specify worker training requirements.
• Transport dry ice and ethanol • Prepare the dry ice/alcohol slurry for flash freezing in a insulated cooler, on a flat, hard surface away from other workers. • Immerse water samples in slurry using metal tongs. • Slowly whirl water samples until sample is frozen (~7 minutes). • Remove water samples and place in cooler.	<u>Chemical/Toxicological Hazards</u>: Carbon dioxide, ethanol. Chemical exposure hazards are listed in Attachment 2. <u>Radiological Hazards</u>: No radiological hazards are anticipated. <u>Biological Hazards:</u> No biological hazards are anticipated. <u>Physical Hazards:</u> 1. Driving Hazards. 2. Cryogenic burns.	<u>Chemical/Toxicological Hazards:</u> 1. Air monitoring is not required for this task; see Attachment 2 for the specific MSDS. Slurry mixture will be prepared in a well ventilated outdoor area. <u>Radiological Hazards:</u> No radiological hazards are anticipated. <u>Biological Hazards:</u> No biological hazards are anticipated. <u>Physical Hazards:</u> Driving hazards are addressed in the SI HASP, section 12.2.4, *Motor Vehicle Hazards*. Dry ice and ethanol will be transported in the bed of a pickup, and secured in a suitable container with straps or chains. First aid for cryogenic burns: 1. Remove from cryogen hazard. 2. Remove any clothing that affects circulation. Frozen clothing should be removed slowly, to prevent skin removal. 3. Immerse affected area in warm water (~105°F) and rewarm slowly (up to 60 minutes). 4. Seek immediate medical attention. 5. Cover thawed area with sterile dressings if thawing occurs prior to medical help. 6. Avoid alcohol and nicotine. Warm drinks and food are acceptable. <u>PPE Required:</u> • Level D as initial level, with supplemental protective garb when flash freezing samples.

TABLE 1 ACTIVITY HAZARD ANALYSIS FORM		
ACTIVITY: *Monitoring Well Installation*	***ANALYZED BY/DATE:*** *Paul Stenhouse, 10-11-05*	***REVIEWED BY/DATE:***
Principal Steps	**Potential Hazards**	**Recommended Controls**
Identify the principal steps involved, <u>including the equipment and machinery to be used</u>, and the sequence of work activities.	Analyze each principal step for its potential chemical/ toxicological, radiological, biological and physical hazards.	Develop specific controls for each potential hazard. Also: • List inspection requirements for the equipment / machinery listed. • Specify worker training requirements.
MWH personnel will observe and assist with the following: Mobilization or drilling rig and support equipment Set up of rig (e.g., brush clearing, leveling) Set up of rods, drill strings, etc. Drill to depth and retract Use borehole to: Install well casing and screen – develop and collect water samples. Complete borehole by: Grouting hole Seal well with sand and grout, may inert depth-discrete sampling sleeve Create surface completion – well stove pipe, marker, cap etc. Document work Make sure site is tidy prior to moving to next work area.	<u>Chemical/Toxicological Hazards</u>: Silica from grout Hydraulic oil spill <u>Radiological Hazards</u>: No radiological hazards are anticipated <u>Biological Hazards:</u> Ticks, mosquitoes, spiders. <u>Physical Hazards:</u> Slip / Trip / Fall on same or lower level Contact with buried or overhead utility • Heat stress, sunburn • Hand injury from hand tools, brush clearing equipment and drilling equipment • Heavy lifting of drilling rods, augers and packed sample coolers, waste containers, and awkward postures while cleaning tools and sampling equipment • Rig tip-over on uneven terrain • Being struck by or caught by / between something – especially if a backhoe is used to clear brush. • Fires from dry brush • Foreign object to eye from rotating equipment and dust • Noise • Spill or damage to equipment not secured in vehicles during travel.	<u>Chemical/Toxicological Hazards:</u> a) Personal Protective Equipment (PPE), Level D b) Review MSDS for grout – stand upwind of the contractor while dry grout is being poured. The drilling subcontractor may wear half-face APR with dust filter while mixing grout. c) Ensure that the driller has the means to contain and handle a hydraulic oil release from the rig. <u>Radiological Hazards:</u> None required. <u>Biological Hazards:</u> • PPE: Long pants, light colored clothing, ankle high boots, Tyvek and gloves optional. • First Aid Kit: Insect repellent with the active ingredient DEET at no more than 30%; bug bite supplies. • Conduct self inspection for ticks or insect bites. <u>Physical Hazards:</u> • Observe terrain for holes and trip hazards. Wear boots with significant tread. Work above six feet over the ground requires fall protection (guard rail, safety net or harness and lanyard). If drill rig mast must be climbed a 5-point harness and lanyard must be worn and tied to an approved anchorage point. Maintain 3 points of contact when mounting the rig. • Prior to drilling an underground utility survey must be completed. Try to allow a five foot clearance to marked underground utilities. Before raising the drill mast or drill string walk around the rig looking up for any overhead lines. If a 20-foot clearance can not be maintained contact the utility and arrange to have the power turned off or insulated. • On hot days (e.g., over 90 degrees F) wear light colored clothing. It is recommended that sunscreen be used if working in direct

		sunlight. • Use heavy work gloves when handling tools or equipment with sharp edges. Select hand tools carefully, considering the relative safety of the tool compared to others (e.g., choose cutters over knives for cutting things). Cut away from the body and be sure that no one else is within two arms' lengths of the tool. • Practice safe lifting. • Ensure that the drilling contractor inspects the rig, keeps a tidy workplace around the rig, and replaces any faulty or suspect items. Stay away from rotating parts (ask driller to identify pinch points – do not touch anything you are not familiar with and know is safe), approach only when the operator knows you are there (e.g., make eye contact). • Never stand underneath a suspended load. Always verify with a rig operator that the drilling platform area is safe to approach. • Be sure that the rig and support vehicles have emergency brakes set and wheels chocked. Use leveling jacks as necessary to stabilize the rig. • Verify that no dry brush is under parked vehicles. • Wear brightly colored safety vest if any moving heavy equipment is on site. Do not stand or get within the swing radius of a backhoe or similar piece of equipment. • Wear safety glasses when in the exclusion zone. • Wear hearing protection when standing within ten feet of the rig while split spoon samplers are driven and within 30 feet of air rotary casing hammer rigs. Hearing protection may be discarded if a noise survey indicates that levels are below 85 dBA. • As a standard rule of practice ensure that items being hauled in vehicles are secured in sturdy containers and held from sliding with bungee cords, ties, or compartments. Any compressed gas cylinders (e.g., for equipment calibration must be secured upright or in a carry case).

Attachment 1
MWH ES&H Procedure No. 811, Drilling Safety

811 DRILLING SAFETY

I. PURPOSE

This procedure provides information on the hazards, regulatory requirements, and safe work practices for using drilling equipment and performing drilling operations. This procedure address all forms of drilling, including cable tool, rotary, geo-probe, rotosonic, and hollow-stem auger drilling used for most geotechnical, investigation, groundwater, and subsurface exploration drilling projects.

II. REGULATORY REVIEW

There are no specific Occupational Safety and Health Administration (OSHA) regulations for drilling activities; however, general guidelines may be found in 29 CFR 1926.800, *Underground Construction,* section (q). In addition, some of the OSHA standards that are applicable to drilling operations include:

29 CFR 1926, Subpart E, *Personal Protective and Lifesaving Equipment*
29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response*
29 CFR 1926.251, *Rigging Equipment for Material Handling*
29 CFR 1926.307, *Mechanical Power-transmission Apparatus.*
29 CFR 1926.550, *Cranes and Derricks*
29 CFR 1926, Subpart Z, *Toxic and Hazardous Substances*

Some state OSHA plans may have additional requirements for drilling. Also, the client may have specific permits or operation practices that will be applicable to MWH drilling operations. Contact the Regional ES&H Manager for additional information.

Additional information may be obtained from the following non-regulatory references:

- ATEC Associates, Inc. 1991. *Drilling Safety: Working in the Danger Zone*.
- Diamond Core Drill Manufacturers Association (DCDMA) and the National Drilling Contractors Association (NDCA). *Drilling Safety Guide*. National Drilling Federation.
- Driscoll, Fletcher. 1989. *Groundwater and Wells*.
- West Hazmat Drilling. 1991. *Workplace Injury & Illness Prevention Program*.
- U S Army Corps of Engineers, EM385-1-1, *Safety and Health Requirements* Chapter 16.

III. ROLES AND RESPONSIBILITIES

A. ES&H Director

The ES&H Director is responsible for establishing a program that provides for the protection of MWH employees and subcontractors and that meets the applicable regulatory requirements for the use of, and work adjacent to, drilling equipment.

B. Regional ES&H Manager

The Regional ES&H Manager is responsible for:

- Ensuring that this procedure is implemented within his or her region.
- Ensuring assessments are completed to verify compliance with regulatory and procedure requirements.

C. ES&H Representative

The ES&H Representative is responsible for the following:

- Evaluating work sites and activities to ensure drilling operations are conducted in compliance with the requirements of this procedure and regulatory standards.
- Verifying that equipment inspections are completed and that equipment used is in serviceable condition.
- Verifying that employees are following safe work practices for work with, and adjacent to, drilling operations.

D. Employee

Each employee is responsible for the following:

- Understanding the hazards and following the required safe work practices for drilling operations.
- Using the personal protective equipment (PPE) specified for the task being performed.

IV. DEFINITIONS

Annulus: The space between the drill string (length of connected drill pipe) or casing and the wall of the borehole or outer casing.

Auger Drilling: A general type of drilling in which the borehole is drilled by rotating augers (either hollow-stem or solid-stem), and cuttings are removed by being pushed up the "flights" (corkscrew-like flanges) of the augers. (Note: the term "flight" is often used to indicate the lengths of hollow-stem or solid-stem augers, as well as the flanges on the augers.) Hollow-stem augers allow drillers to send split-spoon samplers down through the center of the augers, thereby eliminating the need to pull out the augers first. Solid-stem augers are used for smaller-diameter holes and for drilling through formations where more concentrated downward force is necessary.

Bit: The cutting tool attached to the bottom of the drill string. Used in rotary drilling.

Blowout: An uncontrolled escape of drilling fluid, gas, oil, or water from the well caused by the formation pressure being greater than the hydrostatic head of the fluid in the borehole. Also, an uncontrolled escape of grout from the borehole or well caused by malfunctioning pressure grouting apparatus.

Cone Penetrometer Testing (CPT): This was originally a method of performing geotechnical evaluations of subsurface soils, now additionally used to obtain rough estimates of aquifer properties. The CPT rig uses a direct-push method to advance a cone equipped with electronic sensors. As the cone is pushed downward, measurements are collected by the sensor and are recorded on the CPT aboveground equipment. Some CPT rigs are also capable of collecting soil gas, soil and groundwater samples at shallow depths (usually less than 50 feet).

Cuttings: Formation particles obtained from a borehole during the drilling process.

Direct-Push Soil Gas/Soil/Groundwater Sampling: A method of sampling either soil gas, soil, or groundwater by advancing a small sampling probe. The probe is hydraulically pushed downward, generating virtually no cuttings and eliminating waste disposal concerns. Direct-push sampling is applicable where no permanent wells are desired, and/or where sampling is required at relatively shallow depths (usually less than 50 feet). Direct-push equipment may be truck-mounted (on a vehicle), or mounted on a modified hand truck.

Drill Collar: A length of extremely heavy steel tube. It is placed in the drill string immediately above the bit to minimize bending caused by the weight of the drill pipe.

Drill Pipe: A special pipe used to transmit rotation from the rotating mechanism to the bit. The pipe also transmits weight to the bit and conveys air or fluid, which removes cuttings from the borehole and cools the bit.

Drilling Fluid or Mud: A water-based or air-based fluid used in the well drilling operation to remove cuttings from the borehole, to clean and cool the bit, to reduce friction between the drill string and the sides of the borehole, and to seal the borehole.

Grouting: The operation by which grout is placed between the casing and the sides of the borehole to a predetermined height above the bottom of the well. This secures the casing in place and excludes water and other fluids from the borehole. A pressure grouting operation injects grout from the surface under high pressure, in order to move grout laterally in the subsurface and ensure an adequate seal.

Kelly: A hollow steel bar or pipe that is the main section of drill string to which the power is directly transmitted from the rotary table to rotate the drill pipe and bit. The cross section of the kelly is either square, hexagonal, or grooved. The kelly works up and down through drive bushings in the rotary table.

Limited Access Drill Rig: A type of drill rig, usually equipped with solid-stem augers, which allows drilling in tight spaces or in areas with low overhead clearance (less than 12 feet). Limited access drill rigs may be mounted on a small lawnmower-like vehicle, or on a modified hand truck.

Rotary Drilling: A general type of drilling in which the borehole is drilled by rotating a bit, and cuttings are removed by continuous circulation of a drilling fluid (e.g., mud, water, air, foam) as the bit penetrates the formation. The bit is attached to the lower end of a string of drill pipe, which transmits the rotating action from the rig to the bit.

Rotary Table: A mechanical or hydraulic assembly that transmits rotational torque to the kelly, which is connected to the drill pipe and the bit. The rotary table has a hole in the center through which the kelly passes.

Split-Spoon Sampler: A thick-walled steel tube split lengthwise used to collect soil samples. The sampler is commonly lined with metal sample sleeves and is pounded or pushed downhole by the drill rig to collect samples.

V. PLANNING

A. Training

Only trained and experienced personnel who are familiar with the use, limitations, and maintenance requirements of the equipment are permitted

to operate the drill rig. The drill rig must be operated in accordance with the manufacturer's instructions and recommendations.

The drill crew shall be familiar with the hazards associated with the drilling operations, personal protective equipment requirements, location of emergency stops, site-specific safety requirements, and the content of this procedure.

Additional training requirements may be required based on the location of the drilling activities. This training may include:

- Hazardous Waste Operations training if work is conducted at a hazardous waste site.

- Waste management training, where waste streams (e.g., drill cuttings, purge water, decontamination water, contaminated personal protective equipment) will be generated.

Site-specific training requirements will be outlined in the project-specific HASP.

B. Medical Surveillance

There are no medical surveillance requirements specific to drilling activities. However, drilling at hazardous waste sites that involve toxicological hazards may require medical surveillance.

Medical surveillance requirements will be addressed in the Project HASP.

MWH drilling subcontractors are responsible for ensuring that their employees receive medical surveillance as required.

C. Safety Equipment

MWH will provide required PPE and safety equipment for its employees and operations. Subcontractors are responsible for providing all PPE and safety equipment necessary for safe operation. Safety equipment will be provided by the subcontractor as delineated in the subcontract and referenced documents. The minimum safety equipment for drilling activities includes safety-toed boots, hard hats, and safety glasses with side shields. Other safety equipment that may be required for drilling operations includes:

- Hearing protection when working in proximity to drilling machinery.

- Body protection (e.g., gloves and protective coveralls) when chemical hazards exist.

- Detection equipment shall be provided if the exact location of underground utilities cannot be determined.

- Air monitoring instruments shall be provided if the potential for a hazardous atmosphere exists in the drilling location.

- High-visibility warning vests are to be worn by all workers exposed to vehicle traffic.

- Fall protection equipment is required if working from unprotected platforms or surfaces greater that 6 feet above the lower level.

D. Subcontractor Selection and Oversight

The *Subcontractor Safety Program Review Criteria—Drilling Operations*, Attachment A, provides the minimum criteria for subcontractor drilling safety procedures. These criteria will be used by the ES&H Representative or ES&H Staff to review subcontractor programs and procedures

Responsibilities for environment, safety and health are expressly defined in the subcontract terms and conditions, and MWH's ES&H practices in the field are determined based on these defined responsibilities. MWH employees shall not direct the means and methods of the subcontractor's operations or direct the details of corrective actions except when MWH employees are responsible for the work activity by contract.

E. Planning Activities

Depending on the contract with the client, the subcontract with a drilling subcontractor, and the physical location of the drilling operation, MWH, may be responsible for some of the following functions to support drilling operations. The responsible party for these items should be clearly defined in the contract and subcontract requirements and included in the Project ES&H Plan.

1. Utility Location

The location of underground utilities, such as electric, fuel, water, cable, telephone, and sewer (either in service or abandoned), and underground installations such as foundations, underground storage tanks, piping, and any other structures need to be identified before drilling is permitted. Utility companies and/or installation owners shall be contacted to provide exact locations of their equipment or structures. Some states have a one-call phone number for locating underground utilities. Most utilities and call

centers require a minimum 48-hour-notice (excluding Saturdays, Sundays, and holidays) to identify utilities before drilling work can begin.

If underground utilities cannot be positively located, or where drilling is performed in areas known or suspected to contain buried objects (e.g. drums, tanks, or cylinders), the area will be surveyed with the aid of audio and radio frequency transmitters and receivers, ground penetrating radar, ultrasonic testing, metal detectors, or other means necessary to ensure safe drilling operations.

Overhead electrical transmission and communication lines also need to be identified. If any portion of the drill rig will be within: 10 feet of electrical lines up to 50kV or 10 feet plus 4 inches for every 10 kV over 50 kV, the utility or other facility operating the system will be contacted to have the lines de-energized.

Access to the work location will also be evaluated. Where rigs must travel under energized electrical lines, clearance will be 4 feet for voltages up to 50kV; 10 feet for voltages over 50kV and up to 345kV; and 16 feet for voltages from 345kV up to 750kV.

2. Permits

The following permits and notifications may be required, depending on state, local, and client requirements. The Regional ES&H Manager should be contracted for assistance in determining applicability.

- Well driller license/certification or Professional Geologist requirements: MWH subcontractors will be required to submit licenses or certifications before subcontract award, where applicable.

- Well installation or abandonment notification: Submittal of a well log or inventory may be required after installation or abandonment.

- A groundwater withdrawal permit may be required for large water withdrawals in some states.

- A “drilling permit” may be required at certain client facilities.

3. Waste Management

Drill cuttings and purge water from uncontaminated soil or ground water shall be appropriately.

When drilling is conducted at hazardous waste sites, the Regional ES&H Manager or designee may be consulted on the proper evaluation, disposal, and decontamination procedures involving potential hazardous waste.

- All waste generated shall be evaluated for appropriate disposal and handled in accordance with the appropriate waste management procedure.

- If drilling involves hazardous waste, MWH decontamination procedures shall be followed. No potentially contaminated equipment shall be permitted to leave the work site.

4. Drilling at Ordnance Explosives (OE) or Unexploded Ordnance (UXO) Sites

If the project site is suspected of OE contamination, the requirements of the ES&H procedure for *Unexploded Ordnance, Open Firing Ranges, and Chemical Warfare Agents,* shall be followed. The following procedures will be implemented, at a minimum:

- Drilling operations on OE sites will not be conducted until a complete plan for the site is prepared and approved by MWH ES&H, and the UXO Safety Officer. OE/UXO avoidance must be conducted during drilling operations on known or suspect OE sites.

- The UXO team will identify and clearly mark the boundaries of a clear approach path for the drilling crews, vehicles, and equipment to enter the site. This path will be, at a minimum, twice the width of the widest vehicle. No personnel will be allowed outside any marked boundary.

- If OE is encountered on the ground surface, the UXO team will clearly mark the area where it is found, report it to the proper authorities, and divert the approach path around it.

- The UXO team will conduct an access survey using the appropriate geophysical instrument over the approach path for avoidance of OE that may be in the subsurface. If a magnetic anomaly is encountered, it will be assumed to be OE and the

approach path will be diverted around the anomaly. Only UXO personnel will operate the appropriate geophysical instrument and identify OE.

- An incremental geophysical survey of the drill hole location(s) will be initially accomplished by the UXO team using a hand auger to install a pilot hole. If OE is encountered or an anomaly cannot be positively identified as inert material, Hazardous Toxic Radiological Waste sampling personnel will select a new drill hole location.

- Once a drilling site has been surface cleared and a pilot hole established as described above, the drilling crew or subcontractor will be notified that the site is available for subsurface drilling.

VI. PROCEDURE

A. Safe Work Practices

Only authorized or licensed personnel, based on applicable state or local requirements, shall be permitted to operate drill rigs.

When moving large equipment in a confined area, spotters shall be used. The spotter and equipment operator must use standard hand signals for communication. Spotters shall never place themselves between equipment and fixed structures or equipment.

Drill site work areas shall be demarcated to deter unauthorized individuals from entering the work area.

Personnel not involved in equipment operation shall remain clear of drill rigs.

Personnel shall stay clear of the rotating augers and other rotating components of drill rigs at all times. Stand to the side while tripping and tailing rods and augers. Never stand under the rod/auger or between the rig and service truck while tripping rods or augers.

Stay as clear as possible of all hoisting operations. Loads shall not be hoisted over personnel. Never work around or under drilling rods or augers being hoisted.

Keep footwear and work area free of mud and drilling fluids. Maintain 3 points of contact when mounting and dismounting a drill rig. Do not climb the drill rig mast without the use of fall protection.

Augers shall not be stored standing up and shall be secured from rolling.

Hand tools shall be inspected before use. Wrench jaws must be periodically inspected and replaced when necessary.

Understand and be aware of all pinch points including breakout wrenches, pull down cables, and pulling jacks. These points should be color-coded. Experienced employees must show new employees these pinch points on the first day of work.

Good housekeeping shall be maintained at all times. Litter will be properly stored, and hand tools and other hardware will be properly secured on the drill rig. Before moving a drill rig, a check shall be made for loose tools and hardware.

All work areas, platforms, walkways, scaffolding, and other accessways should be maintained free of materials, debris, obstructions, and substances, such as ice, grease, or oil.

Drill rods and augers should be placed on dunage and secured to prevent movement. Always use a sling or strap while manually handling rods and augers.

Be aware of your footing to prevent slips, avoid stepping between rods and augers to prevent crushed ankles from their movement.

Do not wear loose-fitting clothing or other items, such as rings or watches, that could get caught in moving parts. Individuals with long hair should have it restrained.

Personnel shall not smoke around drilling operations.

Personnel shall wear the appropriate PPE. Minimum protection includes safety-toed boots, hard hats, safety glasses, and hearing protection.

A daily safety briefing shall be conducted with all work site personnel to discuss the work planned for the day and the ES&H requirements.

Unattended boreholes shall be covered or protected to avoid the possibility of animals or people accidentally falling into them.

Wellheads on roads and parking lots should be flush-mounted.

B. Site Preparation

Verify that underground utilities and structures have been located and marked, and overhead utilities de-energized as required.

As applicable, the drilling site shall be prepared, cleared, and leveled, particularly on steep slopes or areas that are covered with dry dead grass and weeds. Care should be taken in constructing pads if extensive cutting into existing slopes or surfaces is required to level the area. Areas where extensive fill is required should be avoided. Compaction is recommended if significant amounts of fill are needed; the ground must be capable of supporting the impact imposed by the drill rig and associated equipment. Clean fill or gravel can be brought in to cover areas with surface contamination.

Before drilling equipment is mobilized to the drilling pad, the travel route shall be surveyed for overhead and terrain hazards. Access roads shall be designed, constructed, and maintained to safely accommodate the movement of the drill rig and other equipment.

Material Safety Data Sheets (MSDSs) shall be available for all drilling fluids, grout, bentonite, or other substances used in the drilling process.

C. Drill Rig Requirements

All self-propelled drill rigs shall be equipped with the following safety features:

- Seatbelts,
- Multipurpose dry chemical fire extinguisher rated at not less that 2A:10B:C
- Multidirectional alarm
- Operator's Manual
- Horn
- Lights
- Other warning devices specified by the manufacturer

Self-propelled off-road drill rigs will be equipped with roll-over protective structures (ROPS) meeting Society of Automotive Engineers requirements.

The drilling equipment shall be equipped with two easily accessible emergency shutdown devices.

Control levers on the drill rig shall be clearly labeled indicating the function and direction of the movement.

All machine guards shall be in place while the rig is in operation.

Where drill rigs are equipped with a platform, the platform shall be constructed from material strong enough to support the weight of the load that will be placed on the platform. The platforms shall be accessed using a ladder or steps. Platforms over 6 feet above ground surface shall be equipped with a guardrail system that includes a toeboard.

The drill rig and associated equipment shall be inspected each day before use by a qualified mechanic or an operator knowledgeable of the specific equipment. Inspections and tests will be conducted in accordance with the manufacturer's recommendations. A written record of the inspections shall be kept on the equipment or in a project file. Consideration shall be given to the following items in the performance of equipment inspections.

- Missing nuts, bolts, pins, loose fittings and couplings.
- Cracked paint, frayed cables and hoses, evidence of fluid leakage on equipment or ground, and loose tracks and pads.
- Fluid levels in the battery, hydraulic system, brake system, and cooling systems; engine lubrication; and fuel supply. CAUTION: Never use your hands to check for hydraulic leaks. An open flame shall not be used to check fluid levels or look for leaks.
- Condition of glass in cab clean and not broken, gauges checked for proper function and readings; test of brake lights, horn, backup alarm, steering, and other controls.
- All emergency shutdown and warning systems to ensure that they are working correctly.

When deficiencies that affect the safe operation of equipment are identified, the equipment will be immediately taken out of service until unsafe conditions are corrected. A "DO NOT OPERATE" tag indicating that the equipment is not to be operated will be placed on the operator controls. When required or necessary, lockout procedures will be used. When corrections are made, the equipment will be re-tested for safe use before being returned to service.

D. Equipment Travel and Set-up

Safe clearances from overhead electrical transmission lines shall be maintained.

The operator shall ensure ground is stable and that grades, especially side traverses, are within the operating limits of the vehicle.

The mast shall be lowered and rig placed in appropriate configuration for travel. Drilling equipment shall not be transported for even a short distance with the mast up.

The drill rig must be leveled and stabilized with leveling jacks. Cribbing shall be used as necessary. Outriggers shall be extended per the manufacturer's specifications. Cribbing materials should be made from materials that are capable of supporting the weight of the rig. Care should be taken in muddy, soggy soils, or partially frozen areas. In addition to cribbing, guy wires should be used as required by the manufacturer to improve stability if the rig is located on wet, partially frozen ground, or in areas with loose, caving soil, or in an area subject to frequent gusty winds.

Prior to raising the mast (derrick) the operator shall look up for overhead obstructions. The drill rig operator shall verify that all personnel are cleared from the area immediately to the rear and the side of the mast.

Unsecured equipment shall be removed from the mast and cables; mud lines and cat line rope must be secured before raising the mast.

Before starting drill operations, the mast shall be secured and locked in accordance with the manufacturer's recommendations.

E. Equipment Operation

The drill rig shall be provided with a "kill" switch that, when activated, will shut down the rig. The switch should be clearly identified and tested daily to confirm operational status. All drilling crew members should be made aware of the location and purpose of this switch.

The rope, wire rope, or cable on the drill rig should never be wrapped around any part of the body.

The drill rig should not be operated during severe inclement weather, such as lightning storms, high winds, or severe rain. The mast should be lowered during these conditions.

Before starting, the operator shall verify that all gear boxes are in neutral; all hoist levers are disengaged; hydraulic levers are in the correct non-actuating positions; and the cathead rope is not on the cathead.

The operator shall verbally alert workers and visually verify that workers are clear from the dangerous parts of equipment before starting the equipment.

Drill crew members shall not wear loose clothing or clothing with loose ends, straps, drawstrings, belts, or otherwise unfastened parts that might catch on rotating or translating components of the drill rig. Rings and jewelry shall not be worn during a work shift.

The drill rig shall always be operated from the control panel. The operator must never leave the control panel while the drill is in operation. Only one person should operate the machine. If the operator must leave the area of the controls, the operator must shift the transmission controlling the rotary drive into neutral and place the feed control level in neutral. The drill rig shall be shut down before he operator leaves the vicinity of the drill.

Pressurized lines, such as airlines, mud hose, etc. shall be equipped with safety-type couplings and secured with wire or chain at each coupling to prevent whipping in the event of failure. Lines and safety connection shall be inspected daily. Pressurized lines shall not be disconnected until shut off and bled to reduce the pressure.

Drilling fluid discharges shall be channeled away from the work area to prevent the accumulation of water. Mud pits and drainage channels should be safely sloped and located to provide minimum interference with the work. Where necessary, suitable barricades or temporary fencing should be provided to protect the work area and reduce the possibility of injury to persons.

Where compressed air drilling is conducted, the exhaust shall be directed into an approved dust collection system. The cuttings shall be directed to the side away from employees. Workers shall be required to use protective clothing and respiratory protection, when required.

1. Tool Handling – Hoist Line

All wire ropes and rigging hardware shall be thoroughly inspected before use. Defective equipment shall not be used. Shop fabricated rigging or hooks without latches are not permitted. Where a chain sling is used, it shall be an alloy chain and shall be properly labeled.

Hoist and rigging hardware shall be used only for their designated intent and shall not be loaded beyond their rated capacity. Steps shall be taken to prevent two-blocking of hoist.

The tool handling hoist shall only be used for vertical lifting of tools. The tool hoist must not be used to pull on objects away from the drill rig, unless specifically designed for that purpose.

Drill rods shall be neither run nor rotated through rod slipping devices: no more than 1 foot of drill column shall be hoisted above the top of the drill mast. Drill rod joints shall not be made up, tightened, or loosened while a rod-slipping device supports the rod column.

Chuck jaws shall not be used to brake a string of drill rods while being lowered into the hole. A cat line or hoisting cable or plug should be used for braking before tightening the chuck.

- Drilling rods shall not be lowered into the hole with a pipe wrench.

- When stuck tools or similar loads cannot be raised with a hoist, disconnect the hoist line and connect the stuck tool directly to the feed mechanism of the drill. Do this only when the rope is secured with a wrench or dog collar. Do not use hydraulic leveling jacks for added pull to the hoist line or feed mechanism of the drill.

Loads shall not be hoisted over the head, body, or feet of any person. Loads shall not be left suspended when the hoist is unattended. Work is not permitted under a suspended load.

Hoist lines shall not be used to ride up the mast of a drill rig.

When wire rope hoist lines are used, the following precautions shall be followed:

- Wire rope must be properly matched with each sheave. (If too large, the rope will pinch; if too small, the sheave will groove. Once a sheave is grooved, it will pinch and damage the larger rope.)

- Most sheaves on rigs are stationary and designed for a single-part line. Never increase the number of sheaves, winch lines, or part lines unless approved by the drill manufacturer.

- Minimize the shock to wire rope. Pull loads smoothly and steadily, especially in cold weather. Never use frozen ropes.

- Protect wire rope from sharp corners and edges. Replace faulty guides and rollers.

- When handling wire rope, always wear gloves. Do not guide rope onto hoist drums with your hands. Replace the wire rope

according to manufacturer's specifications. When new rope is installed, first lift a light load to allow the rope to adjust.

2. Auger Drilling

Use an auger guide to facilitate the starting of a straight hole through hard ground or pavement, as applicable. Apply an adequate amount of down pressure before rotation to seat the auger head below the ground surface.

The operator and tool handler shall establish a system of responsibility for the series of activities required for auger drilling, such as connecting and disconnecting auger sections, and inserting and removing auger fork.

The operator shall verify that the tool handler and others are clear from the auger column and that the auger fork is removed before starting rotation.

The manufacturer's recommendations must be followed for securing the auger to the power coupling. Workers shall not touch the coupling or the auger with their hands, a wrench, or any other tools during rotation.

Only tight-fitting pins designed for the auger shall be used to secure auger flights. The use of mismatched augers shall be avoided.

Augers shall be cleaned only when the rotating mechanism is in neutral and the auger stopped. Long-handled shovels may be used to move auger cuttings away from the auger.

Workers shall not place their hands or fingers under the bottom of auger section when hoisting the auger over the top auger section in the ground or over hard surfaces such as drill rig platform.

Workers shall, stay clear of the rotating auger and other rotating components of the drill rig. Never reach behind or around a rotating auger for any reason.

3. Cathead Operations

The cathead shall be inspected before use. Inspection shall be made with the engine off. The cathead shall be kept clean and free of rust, oil, and grease. When 1/8-inch or greater rope groves form, the cathead should be replaced. In wet or icy conditions, a cathead cannot be used.

Always use a clean, dry rope. An oily rope may grab on the cathead. Never use a rope that is longer than necessary.

If the rope grabs or tangles, alert personnel to back away and stay clear. If tools are suspended, carefully shutdown the drill and back away. Once you have resolved the situation, the drill may be restarted and the tools lowered to safety.

Hoist lines shall be positioned to prevent contact with the cathead rope.

The following precautions shall be used to prevent cathead incidents:

- The operator should be on a level surface with firm footing.
- Do not wear loose clothing or gloves with loose straps or cuffs.
- Never wrap the rope around your hand, wrist, arm or other body parts. Never stand on the end of the cathead rope.
- Maintain a distance of 18 inches clearance between operating hand and drum.
- Be aware, the rope advances with each hammer blow.
- Do not leave a cathead unattended with the rope wrapped on the drum.

4. Rotary and Core Drilling

Water swivels, hoist plugs, rod chuck jaws etc. shall be inspected before use. Defective equipment shall not be used.

Only the operator of the drill rig shall brake or set a manual chuck so that rotation of the chuck will not occur before removing the wrench from the chuck.

Chuck jaws shall not be used to brake drill rods while lowering rods into hole. Drill rods shall not be held or lowered into the hole with pipe wrenches. If a string of drill rods are accidentally or inadvertently released into the hole, no attempt shall be made to grab the falling rods with hands or a wrench.

When drill rods are hoisted from the hole, they shall be cleaned to facilitate safe handling. The hand should not be used to clean drilling fluids from drill rods.

Drill rods shall never be lifted and leaned unsecured against the mast. Drill rods shall be secured to the upper ends of the drill rod sections for safe vertical storage or shall be laid horizontally.

In the event of a plugged bit or other circulation blockage, the pressure in the piping and hose between the pump and the obstruction should be relieved or bled down before breaking the first tool joint.

The spinning chain is very powerful and must be treated with respect. Spinning chains must have a rope tail. Communication between the driller and tool handler is required for safe operation of the spinning chain.

If freezing weather is expected, all air and water lines should be drained when not in use.

F. Drill Rig Maintenance

Components found to be in defective condition, either during inspections or during rig operation, should be repaired immediately.

Rig maintenance shall only be performed after appropriate lockout/tagout procedures have been implemented.

The cathead should be kept clean and free of rust, oil, and grease. The cathead should be cleaned with a wire brush if it becomes rusty.

Drilling operations may require repair or disentanglement of wire rope on the mast while it is raised. Fall protection shall be used when personnel are exposed to a fall of 6 feet or greater.

Augers should be cleaned only when the drill rig is in neutral and the augers have stopped rotating. Hands or feet should not be used to move cuttings away from the auger.

G. Self-Assessment Checklist

The *ES&H Self-Assessment Checklist – Drilling* provides a method of verifying compliance with established regulations, safe work practices, and industry standards pertaining to drilling operations. The MWH ES&H Representative or ES&H staff may use this checklist when MWH

employees and/or MWH Subcontractors are performing drilling operations or are exposed to the hazards of activities involving drilling.

VII. ATTACHMENTS

Attachment A: *Subcontractor Safety Program Criteria – Drilling Operations*
Attachment B: *ES&H Self-Assessment Checklist – Drilling Operations*

Drilling Operations
ES&H Procedure – 811
Attachment A

Subcontractor Safety Program Criteria – Drilling Operations

MWH

ATTACHMENT A

Subcontractor Safety Program Criteria – Drilling Operations

The following criteria are not intended to be all-inclusive, but are provided as a tool to facilitate review of subcontractor safety procedures. Subcontractors are expected to address the following items, at a minimum, in their safety procedures.

Minimum Acceptable Criteria for Subcontractor Drilling Safety Procedures:

1. Provide name and qualifications of the drilling "competent person" responsible for drilling (years and type of experience, training background, etc.).
2. Describe drill rig and equipment inspection criteria or procedures (frequency of inspections, visual vs. written inspections, items that are inspected).
3. Describe methods of identifying underground utilities (contacting utility companies, detection equipment).
4. Describe methods of avoiding contact with overhead power lines (de-energizing and grounding, insulating, safe clearance distances).
5. Describe methods to identify hazardous atmospheres and controls used to eliminate (detection equipment and controls).
6. Describe leveling and stabilizing methods for drill rig (drilling pad, jacks, cribbing, guy wires).
7. Verify that rig equipment is in good operational condition (including "kill" switch, cathead, ropes, pressurized hoses and lines, operator controls, machine guards, and drilling tools).
8. Describe procedures for operating in inclement weather, including lightning, high winds, and severe rain storms.
9. Describe other safe work practices for equipment operation (drill rig, equipment, tools, rig transportation, rig travel).
10. Describe on-the-job maintenance procedures, including lockout/tagout.
11. Describe safe work practices for other activities to be performed during this project (use of ladders, fall protection, electrical power tools, personal protective equipment, etc.).
12. Describe methods for disposal of non-hazardous drill cuttings and purge water (including accumulation, transport, and disposal).
13. If hazardous waste project, provide documentation of hazardous waste worker training and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training) and describe methods of hazardous waste management (including accumulation, transport, and disposal).
14. Submit a copy of drilling license/certification and drill rig permit.
15. Describe methods and responsibilities for submittal of notifications and logs.
16. Complete the Waste Subcontractor Qualification form for each proposed transport and disposal facility.
17. Describe procedures for drilling site cleanup upon job completion.

<u>If drilling in areas with known or potential Ordance Explosives (OE)/Unexploded Ordnance (UXO) hazards:</u>

18. Provide documentation of UXO qualifications, hazardous waste worker training, and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training).
19. Describe procedures for OE avoidance, identification and marking the boundaries of a clear approach path and work site for the sampling crews, vehicles, and equipment to enter the site.
20. Describe the procedures for drilling and monitoring and the process for encountered OE.

Drilling Operations
ES&H Procedure – 811
Attachment B

ES&H Self-Assessment Checklist – Drilling Operations

MWH

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

This checklist shall be used by MWH personnel only and may be completed at the frequency specified in the Project HASP or by the ES&H Representative.

This checklist is to be used at locations where (1) MWH employees and/or (2) MWH subcontractors are working on projects involving drilling operations.

During evaluation of MWH subcontractors, the ES&H Representative may consult with subcontractors when completing this checklist, but shall not direct the means and methods of operations nor direct the details of corrective actions unless provided for by contract requirements. Subcontractors shall determine how to correct deficiencies.

If deficiencies are identified that are considered imminent danger (possibility of serious injury or death) hazards, they shall be corrected immediately or all exposed MWH and MWH subcontract personnel shall be removed from the hazard until corrected.

Completed checklists shall be maintained in project ES&H Files.

Project Name: _____ Project No.:_____

Location: _____ PM: _____

Evaluator: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate MWH employee compliance with requirements

☐ Evaluate an MWH subcontractor's compliance with requirements

Check "Yes" if an assessment item is complete/correct.

Check "No" if an item is incomplete/deficient, section 2 must be completed for all items checked "No."

Subcontractor deficiencies shall be brought to the immediate attention of the subcontractor.

Check "N/A" if an item is not applicable
Check "N/O" if an item is applicable, but was not observed during the assessment

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

	Yes	No	N/A	N/O
Section 1				
SAFE WORK PRACTICES				
1. Only authorized, licensed operators meeting local requirements.	☐	☐	☐	☐
2. Spotters used for equipment in constricted areas.	☐	☐	☐	☐
3. Drill site work area demarcation in place.	☐	☐	☐	☐
4. Personnel cleared during rig startup.	☐	☐	☐	☐
5. Personnel clear of rotating parts.	☐	☐	☐	☐
6. Personnel not positioned under hoisted loads.	☐	☐	☐	☐
7. Augers and drill strings stored properly.	☐	☐	☐	☐
8. Good Housekeeping maintained on rig and work site.	☐	☐	☐	☐
9. Loose clothing and jewelry removed.	☐	☐	☐	☐
10. Smoking is prohibited around drilling operation.	☐	☐	☐	☐
11. Personnel wearing appropriate personal protective equipment (PPE).	☐	☐	☐	☐
12. Daily safety meeting completed.	☐	☐	☐	☐
13. Traffic control in place, where required.	☐	☐	☐	☐
Site Preparation				
14. Underground utilities & structures identified.	☐	☐	☐	☐
15. Drill site prepared for rig.	☐	☐	☐	☐
16. Travel routes surveyed for obstruction.	☐	☐	☐	☐
17. Required MSDSs on site.	☐	☐	☐	☐
Drill Rig Requirements				
18. Drill rig equipped with emergency stop controls.	☐	☐	☐	☐
19. Drill rig inspected daily, deficiencies corrected.	☐	☐	☐	☐
20. All machine guards are in place.	☐	☐	☐	☐
21. Platforms are properly constructed and accessible.	☐	☐	☐	☐
Equipment Travel and Set-up				
22. Safe clearance from overhead electrical maintained.	☐	☐	☐	☐
23. Mast lowered and equipment secure during travel.	☐	☐	☐	☐
24. Drill rig level and stabilized, proper cribbing used.	☐	☐	☐	☐
25. Mast secured before drilling.	☐	☐	☐	☐
Equipment Operation				
26. Personnel remain clear of cables and ropes.	☐	☐	☐	☐
27. Drilling operations suspended in inclement weather.	☐	☐	☐	☐
28. All gearboxes in neutral before starting.	☐	☐	☐	☐
29. Drill rig is always operated from control panel. Operator never leaves control panel while drill is in operation.	☐	☐	☐	☐
30. Pressurized lines are equipped with safety cables.	☐	☐	☐	☐
31. Drilling discharges channeled away from work area.	☐	☐	☐	☐
32. Compressed-air exhaust is controlled.	☐	☐	☐	☐
33. Wire ropes are inspected before use.	☐	☐	☐	☐
34. Hoist and hardware used only for designed purpose.	☐	☐	☐	☐
35. No more than one foot of drill column hoisted above mast.	☐	☐	☐	☐
36. Chuck jaws are not used as drill rod brake.	☐	☐	☐	☐
37. Wire ropes are properly matched to sleeves and are protected from sharp edges.	☐	☐	☐	☐
38. Operators are not guiding wire ropes with hands.	☐	☐	☐	☐
39. Auger guides are used to start auger in hard surfaces.	☐	☐	☐	☐

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

	Yes	No	N/A	N/O
40. Operator and tool handler have established responsibilities.	☐	☐	☐	☐
41. Augers are attached to power coupling per Manufacturer's instructions.	☐	☐	☐	☐
42. Auger flights are connected only by pins designed for such use.	☐	☐	☐	☐
43. Workers remain clear of auger and other rotating parts.	☐	☐	☐	☐
44. Cathead inspected before use.	☐	☐	☐	☐
45. Clean dry rope is used on cathead.	☐	☐	☐	☐
46. Proper actions are followed for cathead operations.	☐	☐	☐	☐
47. Drill rods are not leaned unsecured against mast.	☐	☐	☐	☐
48. Prior to disconnection plugged core drill rods, pressure source is isolated and pressure is bled off.	☐	☐	☐	☐
Drill Rig Maintenance				
49. Defects identified during inspection or operation are corrected before continuing operation.	☐	☐	☐	☐
50. Fall protection is used while climbing mast and for other unprotected elevated work.	☐	☐	☐	☐
51. Augers are cleaned only when drill is in neutral and auger has stopped.	☐	☐	☐	☐

ATTACHMENT B

Self-Assessment Checklist – Drilling Operations

SECTION 2

Complete this section for all items checked "No" in Sections 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Evaluator:_____ Project Manager:_____

Attachment 2
Material Safety Data Sheets

DRY ICE
MATERIAL SAFETY DATA SHEET

NSN: 685000F002383
Part Number/Trade Name: **CARBON DIOXIDE/DRY ICE**
==========

General Information
==========
Date MSDS Prepared: 01JUN90
Safety Data Review Date: 06APR94
Preparer's Company: AIR PRODUCTS AND CHEMICALS INC.
Preparer's St Or P. O. Box: 7201 HAMILTON BLVD
Preparer's City: ALLENTOWN
Preparer's State: PA
Preparer's Zip Code: 18195-1501
MSDS Serial Number: BBKVW
==========

Ingredients/Identity Information
==========
Proprietary: NO
Ingredient: CARBON DIOXIDE
Ingredient Sequence Number: 01
Percent: 100
NIOSH (RTECS) Number: FF6400000
CAS Number: 124-38-9
OSHA PEL: 5000 PPM
ACGIH TLV: 9000 MG/CUM
Other Recommended Limit: 10000 PPM
==========

Physical/Chemical Characteristics
==========
Appearance And Odor: COLORLESS, ODORLESS
Boiling Point: -109.3F
Melting Point: -69.9F
Vapor Pressure (MM Hg/70 F): 831 PSIA
Vapor Density (Air=1): 0.115
Specific Gravity: 1.56
Solubility In Water: APPRECIABLE
==========

Fire and Explosion Hazard Data
==========
==========

Reactivity Data
==========
Stability: YES

Conditions To Avoid (Stability): MOISTURE
Materials To Avoid: CARBONIC ACID/SALT/CORROSIVE CHEMICALS
Hazardous Polymerization Occurrence: NO
==========

Health Hazard Data

==========
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: NO
Route Of Entry - Ingestion: NO
Health Hazard Acute and Chronic: CONCENTRATION IN EXCESS OF 1.5% CARBON DIOXIDE MAY
CAUSE DEATH. AT HIGHER CONCENTRATIONS, DISPLACES OXYGEN IN AIR BELOW LEVELS
NECESSARY TO SUPPORT LIFE.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NONE
Signs/Symptoms Of Overexposure: AT CONCENTRATIONS >1.5%: HYPERVENTILATION/HEADAHCES/
DYSPNEA/PERSPIRATION. AT 6-10%:
HEADAHCES/DYSPNEA/PERSPIRATION/TREMORS/VISUAL
DISTURBANCES. >10%: UNCONSCIOUSNESS W/OUT WARNING. CRYOGENIC BURNS.
Emergency/First Aid Procedures: INHALATION: REMOVE TO FRESH AIR. ASSISTED RESPIRANT
& SUPPLEMENTAL OXYGEN SHOULD BE GIVEN IF NOT BREATHING. FROZEN TISSUES SHOULD BE
FLOODED/SOAKED W/TEPID WATER. DON'T USE HOT WATER. OBTAIN MEDICAL ATTENTION IN ALL
CASES.
==========

Precautions for Safe Handling and Use

==========
Steps if Material Released/Spill: VENTILATE INDOOR AREAS WELL TO AVOID HAZARDOUS CO2
CONCENTRATIONS. VENTILATE AREA WELL & AVOID CONTACT W/COLD VAPORS/DRY ICE. CO2 IS
HEAVY GAS & WILL REMAIN IN LOW SPOTS W/OUT ASSISTED VENTILATION.
Waste Disposal Method: DON'T ATTEMPT TO DISPOSE OF RESIDUAL CO2 IN
COMPRESSED GAS CYLINDERS. RETURN CYLINDERS TO AIR PRODUCTS W/RESIDUAL PRESSURE,
CYLINDER VALVE TIGHTLY CLOSED/THE VALVE CAP IN PLACE. DISPOSE OF IAW/LOCAL/STAT/
FEDERAL REGULATIONS. NONFLAMMABLE GAS. UN1013.
Precautions-Handling/Storing: COMPRESS GAS CYLINDERS CONTAIN GASEOUS/LIQUID CO2 AT
EXTREMELY HIGH PRESSURE/SHOULD HANDLED W/CARE. KEEP CYLINDERS AWAY FROM HEAT.
Other Precautions: PREVENT CONTACT OF CO2 ON SKIN. USE PRESSURE-REDUCING REGULATOR
WHEN CONNECTING TO LOWER PRESSURE PIPING SYSTEMS. SECURE CYLINDERS WHEN IN USE. KEEP

FROM COMBUSTIBLES. AVOID EXPOSURE TO AREAS WHERE SALT/OTHER CORROSIVE MATERIALS ARE
PRESENT.
==========

Control Measures
==========
Respiratory Protection: SCBA IN OXYGEN DEFICIENT ATMOSPHERES/WHERE CO2 >1.5%.
DON'T USE AIR PURIFYING RESPIRATORS.
Ventilation: LOCAL EXHAUST: AT POINT SOURCES OF CO2 VAPORS.
MECHANICAL(GENERAL): LOW
LYING AREA ARE NOT NATURALLY VENTILATED.
Protective Gloves: IMPERMEABLE/LOOSE FITTING (LEATHER)
Eye Protection: SAFETY GLASSES
Supplemental Safety & Health Data: CO2 IS STORED IN CONTAINERS UNDER ITS OWN VAPOR
PRESSURE. IF THE PRESSURE IS SUDDENLY RELIEVED, THE LIQUID RAPIDLY COOLS AS IT
EVAPORATES & SUBLIMES, FORMING DRY ICE AT -109.3F.
==========

Transportation Data
==========
==========

Disposal Data
==========
Disposal Data Review Date: 89018
Record # For This Disp Entry: 01
Total Disp Entries Per NSN: 001
Landfill Ban Item: YES
Disposal Supplemental Data: BOX 538/ALLENTOWN, PA 18105. ITEM NOT REGULATED AS A
RCRA HAZARDOUS WASTE BY THE FEDERAL EPA, BUT MAY BE REGULATED IN CERTAIN STATES.
1st EPA Hazardous Waste Name New: NOT REGULATED
1st EPA Hazardous Waste Char New: NOT REGULATED BY RCRA
1st EPA Acute Hazard New: NO
==========

Label Data
==========
Label Required: YES
Technical Review Date: 06APR94
Label Date: 06APR94
Label Status: F
Common Name: CARBON DIOXIDE/DRY ICE
Chronic Hazard: YES
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Slight: X
Fire Hazard-Severe: X

Reactivity Hazard-None: X
Special Hazard Precautions: CONCENTRATION IN EXCESS OF 1.5% CARBON DIOXIDE MAY CAUSE
DEATH. AT HIGHER CONCENTRATIONS, DISPLACES OXYGEN IN AIR BELOW LEVELS NECESSARY TO
SUPPORT LIFE.
TARGET ORGANS: RESPIRATORY SYSTEM, SKIN.
CARCINOGEN: FORMALDEHYDE.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y

Material Safety Data Sheet
May be used to comply with
OSHA's Hazard Communication Standard
29 CFR 1910.1200. Standard must be
consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

Identity *(As Used on Label and List)*
ETHANOL (ETHYL ALCOHOL) DENATURED, 190 PROOF

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section 1

Manufacturer's Name THOMAS SCIENTIFIC	Emergency Telephone Number **Call Chemtrec - 800-424-9300 (24 hours a day)**
Address (Number, Street, City, State and Zip Code) P.O. BOX 99	Telephone Number for Information 856-467-200
SWEDESBORO, NJ 08085	Date Prepared 1/3/2005
	Signature of Preparer (Optional

Section II – Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Names(s))		OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Ethyl Alcohol	CAS 64-17-5	1000ppm	1000ppm	N/A	87
Methyl Alcohol	CAS 6756-1	200ppm	200ppm	N/A	5
Ethyl Acetate	CAS 141-78-6	400ppm	400ppm	N/A	1
Methyl Isobutyl Ketone	CAS 108-10-1	50ppm	50ppm	N/A	1
Hydrocarbon Solvent	N/A	N/A	N/A	N/A	1
Water	CAS 7732-18-5	N/A	N/A	N/A	5

Section III – Physical/Chemical Characteristics

Boiling Point	79.4 Degrees (C)	Specific Gravity (H_20 = 1)	0.81
Vapor Pressure (mm Hg.) 19 Degrees (C)	40	Melting Point	N/A
Vapor Density (AIR = 1)	1.59	Evaporation Rate (Butyl Acetate = 1)	3.3

Solubility in Water
Miscible

Appearance and Odor
Colorless liquid, characteristic odor

Section IV – Fire and Explosion Hazard Data

Flash Point (Method Used) 57 degrees Fahrenheit (CC)	Flammable Limits	LEL 3.3	UEL 19

Extinguishing Media
Carbon Monoxide, dry chemical

Special Fire Fighting Procedures
Wear self contained breathing apparatus and protective clothing.

Unusual Fire and Explosion Hazards
Vapors can travel to ignition sources and flash back.

Section V – Reactivity Data

Stability	Unstable		Conditions to Avoid Heat, Sparks, Open flame
	Stable	X	

Incompatibility (Materials to Avoid)
Oxidizers, Nitric and Sulfuric Acids, Halogens

Hazardous Decomposition or Byproducts
Carbon Monoxide

Hazardous Polymerization	May Occur		Conditions to Avoid N/A
	Will Not Occur	X	N/A

Section VI – Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
	X	X	X

Health Hazards (Acute and Chronic)
Acute- Headache, Nausea, Dizziness, Narcosis; Ingestion can be fatal or cause blindness.
Chronic- Damage to Gastro intestine. Tract liver, Kidneys, Cardiovascular System.
Contact- Irritation to skin and eyes.

Carcinogenicity:	NTP?	IARC Monographs?	OHSA Regulated?

Test on laboratory animals may cause tumors , produce adverse mutagenic and reproductive effects.

Signs and Symptoms of Exposure
Ingestion or inhalation – headache, nausea, dizziness, narcosis.
Contact- irritation to skin and eyes.

Medical Conditions Generally Aggravated by Exposure
Kidney, liver, heart and GI conditions.

Emergency and First Aid Procedures
Skin- Wash with soap and water. Eyes- Flush with water for 15 minutes. Inhalation- Remove to fresh air.
Ingestion- If conscious, induce vomiting.

Section VII – Precautions for Safe Handling and Use.

Steps to Be Taken in Case Material Is Released or Spilled
Dike spill, take up with absorbent, containerize for disposal.

Waste Disposal Method
To be performed in compliance with all local, State and Federal regulations.

Precautions to Be Taken in Handling and Storing
Electrically ground all equipment when handling, residue may make empty container hazardous.

Other Precautions

Section VIII – Control Measures

Respiratory Protection (Specify Type)
Self contained breathing apparatus

Ventilation	Local Exhaust X	Special
	Mechanical (General) X	Other

Protective Gloves	Eye Protection
Neoprene or equivalent	X

Other Protective Clothing or Equipment
As indicated depending on volume being handled.

Work/Hygienic Practices
Avoid breathing vapor; ingesting and all contact with liquid.