2017 Multi-Media Investigation Work Plan
Mayflower Tailings Impoundments Area

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ARSG	Animas River Stakeholders Group
bgs	below ground surface
CDWR	Colorado Department of Water Resources
DQO	Data Quality Objective
EPA	United States Environmental Protection Agency
HASP	Health and Safety Plan
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SGC	Sunnyside Gold Corporation
SOP	Standard Operating Procedure
TA	Target Analyte

1.0 INTRODUCTION

This Multi-Media Investigation Work Plan (Work Plan) was prepared on behalf of Sunnyside Gold Corporation (SGC) to investigate surface water, groundwater, and solid phase media in the Animas River Valley in the area at and adjacent to the Mayflower Tailings Impoundments Area near Silverton, Colorado (Figure 1-1). The Work Plan presents the sampling and analysis plan (SAP) for data collection planned for 2017. SGC is collecting and analyzing these multi-media samples to update the current site conceptual model and address data gaps. The initial site conceptual model for the study area is presented in the *Supplemental Information and Data Interpretation Report* (Formation Environmental, 2016a)

Aside from this introductory section, the structure of this Work Plan is as follows. Section 2.0 identifies the data needs, intended data uses, and data quality objectives (DQOs) for the investigation. The SAP for 2017 multi-media investigation is presented in Section 3.0 along with a list of Target Analytes (TAs). Reporting of the results for the multi-media sampling effort is described in Section 4.0. References cited in this Work Plan are provided in Section 5.0. Appendices to this Work Plan are listed below:

- Appendix A: Quality Assurance Project Plan (QAPP), and
- Appendix B: Health and Safety Plan (HASP).

1.1 Study Area

The study area is located in the Animas River valley and extends from just upstream of the confluence of the Animas River and Arrastra Creek downstream to the 14th Street bridge crossing in Silverton (Figure 1-2). The study area encompasses the four Mayflower Tailings Impoundments and the surrounding areas as reflected in Figure 1-2. The Mayflower Tailings Impoundments define the site boundaries and thus, they are collectively referred to as “the Site” herein. The Howardsville station, which is located on the Animas River approximately one mile upstream from the study area, is also shown on Figure 1-2 because it has been routinely used for comparison with water quality data in the study area.

Both the right bank and left bank of the Animas River are included in the study area, and the right bank and left bank designations are based on the perspective viewed in the downstream direction. As such, the right bank is on the north side of the river and the left bank is on the south side of the river.

1.2 Background

The following is a summary of the background information provided in the *Supplemental Information and Data Interpretation Report* (Formation Environmental, 2016a). Refer to that report for detailed information on the Mayflower Tailings Impoundment Area.

The study area is located in the Animas River basin. Volcanic rocks within the basin are intensely mineralized. Natural weathering of mineralized rocks contributes to metals loading in the basin's surface water quality. Streams within the basin that are considered representative of natural background conditions (i.e., unaffected or minimally affected by mining activity) can be acidic (pH <3.0) with elevated metals concentrations, including zinc, copper, and manganese, above aquatic life standards (Church and others, 2007). Environmental conditions in the Animas River basin also reflect influences from the extensive historical mining and milling activities that occurred over the past 150 years, including mining in areas upstream of the Mayflower Tailings Impoundments Area and on the left bank of the Animas River (opposite the tailings impoundments). Mine adits and mine waste rock piles are present at numerous locations in the Animas River basin, and historically mills discharged tailings to the Animas River and its tributaries. Currently, there are no active mine or mill sites within the study area.

The Mayflower Tailings Impoundments are located approximately one mile to the northeast and upstream of Silverton on the right bank of the Animas River (Figure 1-2). Tailings Impoundment No. 1 is the most upstream and subsequent impoundments 2 through 4 are numbered consecutively in the downstream direction. These tailings impoundments are referenced as TP-1 through TP-4 hereafter.

Tailings in TP-1 through TP-4 were produced by flotation milling at the Mayflower Mill. Thus, the impoundments consist of relatively fine-grained material, with sand-sized particles predominating near the impoundment embankments and finer silts and clays predominating nearer the native hillsides where settling ponds were maintained during operation and from which clarified water was decanted for reuse at the mill. TP-1 and TP-2 operated from 1936 to 1975. TP-3 operated from 1976 to 1977 while TP-4 was being constructed. TP-4 operated from 1977 to 1991, when the Sunnyside Mine ceased operation. TP-1 and TP-2 were reclaimed between 1991 and 1992. TP-3 was reclaimed in 1992 and TP-4 was reclaimed between 2004 and 2006, although the majority of the top cover was completed in 2004. In general, reclamation of the tailings impoundments was accomplished by regrading the side slopes to achieve a stable configuration, where required, and by covering the slopes and top surfaces with locally derived growth medium.

2.0 DATA QUALITY OBJECTIVES AND DATA NEEDS

This section identifies the data needs, intended data uses, and DQOs for the 2017 multi-media investigation of the study area shown by Figure 1-2. The TAs for the multi-media investigation are described in Section 3.0.

This section is organized to be generally consistent with the Environmental Protection Agency's (EPA) guidance for application of its DQO process (EPA, 2006), which includes the seven steps listed below.

1. State the Problem
2. Identify the Goals of the Study
3. Identify Information Inputs
4. Define the Boundaries of the Study
5. Develop the Analytic Approach
6. Specify Performance and Acceptance Criteria
7. Develop the Plan for Collecting Data

Application of the DQO process results in identification of the specific types and quality of data needed to support the goals of the multi-media investigation.

The DQOs listed below are intended to address the current data gaps in the site conceptual model.

2.1 DQO Step 1 - State the Problem

The current site conceptual model for the study area is presented in two separate reports. The *DRAFT Supplemental Information and Data Interpretation Report* (Formation Environmental, 2016a) describes the initial site conceptual model based on the data collected by SGC in 2015 and the spring of 2016. The *DRAFT 2016 Investigation Summary and Data Interpretation* provides updates to the site conceptual model based on the data collected by SGC from the fall of 2016 (Formation Environmental, 2017).

A number of potential sources may contribute metals to the water in the Animas River as it flows through the study area. The potential sources are both naturally occurring and mining related. However, the magnitude of their contributions to groundwater and surface water in the study area remain uncertain. In addition, many potential sources have not been fully characterized, such as areas of mining disturbance that are within the study area on the left bank of the river. Upstream of the study area, there are numerous legacy mill sites and related tailings deposits and mine sites with flowing mine adits that potentially contribute metals to the Animas River. Thus, multiple sources potentially contribute to the elevated concentrations of metals in the river water that flows into and through the study area. Several of these potential sources require further characterization, including the naturally occurring sources of metals.

Temporal and spatial metals concentration trends have been identified in the Animas River and these trends appear to be related to various groundwater transport pathways in addition to other environmental factors such as river stage, dilution effects, and surface water/groundwater mixing effects in the river. The groundwater transport pathways are controlled by two distinct yet related groundwater systems present in and around the study area. An alluvial aquifer system is generally present on the valley floor and is bound by the bedrock on the valley walls. The fractured bedrock system is present throughout the groundwater basin and is coincident with major bedrock structural features such as faults, veins, and fissures. The fractured bedrock system can discharge groundwater directly to the river and to the alluvial aquifer, which discharges directly to the river along the majority of the reach of interest.

Additional data are needed to better understand the relationship, if any, between the Mayflower Tailings Impoundments Area and metals concentrations in the groundwater underlying the impoundments that discharges to the river. Data are also needed to better understand the groundwater flow paths in the fractured bedrock system and the relationship between metals potentially sourced in the fractured bedrock and the groundwater that discharges to the river. Finally, additional data are needed to better understand the groundwater flow paths and the source(s) of metals in the groundwater on the left bank of the river and in the groundwater downgradient of the Mayflower Mill and downgradient of TP-4.

Additional areas outside of the study area may be investigated, as directed by SGC. Investigations in these areas would be conducted in accordance with the data-collection procedures specified in this Work Plan.

2.2 DQO Step 2 - Identify the Goals of the Study

Several of the key study questions listed herein were identified previously for the 2015 multi-media and subsurface investigations (Formation Environmental, 2015a; Formation Environmental, 2015b). Since preparation of the 2015 work plan and collection of data from the study area in 2015 and 2016, those study questions have been refined. Based on review and evaluation of existing and relevant data, as recently presented by Formation Environmental (2017), the key questions to be answered by the 2017 multi-media investigation are as follows. Data gaps related to these key questions will be identified following the completion of the 2017 investigation.

- How do the concentrations of the TAs change in surface water in response to varying discharge rates in the Animas River, including winter low-flow, spring high-flow, and summer/fall low-flow conditions?

- How do the concentrations of the TAs change in surface water both temporally and spatially along the reach of interest in the study area?

- What are the concentrations of TAs in right- and left-bank inflows, and how do the concentrations of the TAs change in surface water in relation to right- and left-bank inflows, along the reach of interest in the study area?

- Are there additional left bank inflows that have not been identified in areas where concentrations of TAs change in the river?

- Does the alluvial aquifer underlying TP-1, TP-2, TP-3, and TP-4 receive recharge from infiltration through the overlying tailings, and if so, how much?

- What are the groundwater conditions (i.e., water bearing zones, depth, flow direction, and hydraulic gradient) in the alluvial aquifer and fractured bedrock systems, where present, to the south of the Mayflower Mill?

- Is the storm water retention basin located to the south of the Mayflower Mill hydraulically connected to the shallow groundwater system, and what are the sources of water to the basin?

- What are the groundwater conditions (i.e., water bearing zones, depth, flow direction, and hydraulic gradient) in the alluvial aquifer and fractured bedrock systems to the north, south, west and southwest of TP-4?

- What is the downstream extent for groundwater discharging to the river that originates from the portion of the alluvial aquifer that underlies TP-4?

- What are the concentrations of TAs in groundwater upgradient (to the north) of the Mayflower Tailings Impoundments Area, in both the fractured bedrock and alluvial aquifer systems, where present?

- What are the concentrations of TAs in groundwater to the north, south of the Mayflower Mill, including the hillside seepage below the mill, and what are the sources of TAs in that groundwater?

- What are the concentrations of TAs in groundwater to the south (e.g., in the iron-rich right bank seepage area), west and southwest (e.g, in the iron bog and wetland area) of TP-4, and what are the sources of TAs in that groundwater?

- What are the concentrations of TAs in groundwater in the alluvial aquifer underlying TP-3, and how do those concentrations vary seasonally and with changes in groundwater elevations?

- What are the groundwater conditions (i.e., water bearing zones, depth, flow direction, and hydraulic gradient) in the alluvial aquifer on the left bank of the Animas River, including in the former Silver Lake Mill area?

- What are the concentrations of TAs in groundwater in the alluvial aquifer on the left bank of the Animas River including the area underlying the former Silver Lake Mill and the left bank area adjacent to the western half of TP-4?

- How do the concentrations of metals in the Animas River sediments and pore water change with location, and over time, along the reach of interest in the study area?

- What are the concentrations of the TAs in the soil and mine wastes in the Mayflower Mill area, and how do those concentrations change with location and depth?

- How does the metals leaching potential vary among the mine wastes and the native materials underlying the Mayflower Mill area?

- What is the approximate volume of tailings present on the hillside below the Mayflower Mill and TP-1?

- What is the nature and extent of metals contamination in soil, mine waste, and/or tailings in selected locations within the study area that have yet to be characterized?

- What are the meteorological conditions at the Site and how do they influence water movement?

2.3 DQO Step 3 - Identify Information Inputs

Previous investigations conducted by the USGS provided preliminary characterization of the surface water flow conditions and surface water quality in the study area in 2002 and 2003 (Kimball et al., 2010). Surface water samples have also been routinely collected by the EPA and others from several stations (e.g., A56, A60, A61, A64, A65, A66, and A68) in the segment of the Animas River in the study area since this investigation and before. In 2015 and 2016, SGC conducted additional multi-media investigations to further characterize the metals concentrations in surface water, pore water, sediment, groundwater, soil/alluvial deposits, and tailings in the study area.

The following types of information are needed to address the 2017 study goals listed in DQO Step 2. Some of the inputs described below were identified and characterized during previous investigations conducted by SGC under separate work plans (Formation Environmental, 2015a; Formation Environmental, 2015b) and some inputs are from data collected by others; thus, these data will be combined with new data and incorporated into the iterative investigation approach described herein.

- Concentrations of the surface water TAs at multiple locations on the Animas River reach of interest, including right and left bank inflows along that reach, during varying flow conditions, including late-winter, pre-snowmelt conditions.

- Concentrations of sediment and pore water TAs at multiple locations on the Animas River reach of interest (Note: these data are needed primarily for use with surface water TA concentrations in evaluating potential risks to aquatic receptors).

- Concentrations of groundwater TAs at multiple locations within the study area to represent a range of seasonal conditions.

- Concentrations of TAs in soil and mine waste and the acid-generating potential and metals leaching potential of these solid-phase media at locations where new groundwater monitoring wells will be installed within the study area and at near-surface soil sample locations along the former railroad line within and upstream of the study area.

- Physical characteristics (e.g., thickness, texture, and moisture conditions) and vertical extent of the Mayflower tailings and the native materials underlying the impoundments.

- The available flow and water chemistry data collected by others for the Animas River and the tributaries in the study area and upstream of the study area.

- River discharge records from the USGS Animas River gauging station 0935800 in the study area and the Colorado Department of Water Resources (CDWR) gauging station at Howardsville, approximately one mile upstream from the study area throughout the period of 2017 surface water data collection.

- Groundwater elevations (above mean sea level), flow directions, and hydraulic gradients for the bedrock fracture and alluvial groundwater systems in the study area during a range of seasonal conditions (wet vs. dry seasons).

- Field water quality parameters, observations, and measurements recorded during surface water and groundwater sampling activities.

- Subsurface geophysical investigation data collected in the study area to better define groundwater flow paths in the alluvial aquifer and/or fractured bedrock systems.

- Mapped locations of bedrock outcrops and geologic structures, including faults, veins, and fissures, and depth to bedrock information from boreholes in the study area.

- Mapped locations of unconsolidated deposits and thickness information from boreholes in the study area.

- Mapped and surveyed topographic-surface elevations in the study area.

2.4 DQO Step 4 – Define the Boundaries of the Study

The spatial boundaries for the study area for the 2017 investigation are shown on Figure 1-2 and extend along the river and the floodplain from just upstream of the confluence of the upper Animas River and Arrastra Creek downstream to the 14th Street bridge crossing in Silverton. The spatial boundaries of the study area also include the Howardsville station (A55), which is located approximately 1-mile upstream of the study area. This station is used as an upstream point of comparison for locations within the study area.

The temporal boundaries for this study begin in 2002 with the low-flow sampling event conducted by the USGS and end with the final sampling event proposed for the summer/fall of 2017. Depending on the necessity, scope, and types of future data collection activities, any later investigations will be conducted under agreed to amendments to this work plan or in accordance with separate agreed to work plans.

2.5 DQO Step 5 – Develop the Analytic Approach

The following approach will be used to collect the specific types of new data needed to address the goals of the 2017 multi-media investigation. Several synoptic surface water sampling events will be conducted within the reach of the Animas River in the study area and the identified right and left bank inflows to the river. The events are to be conducted during winter low-flow, spring high-flow and summer/fall low-flow conditions. During the winter low-flow conditions, surface water samples will be collected at selected stations in the study area during the months of February, March, and April. A pre-peak flow sampling event in May will also be conducted. Groundwater monitoring wells will be sampled during spring and fall conditions during the 2017 investigation. Sediment and sediment pore water will be sampled in the Animas River during summer/fall low-flow conditions. Various solid phase media (e.g., soil, tailings, mine waste, mineralized rock, etc.) will be sampled at selected locations in the study area. Exploration boreholes and the installation of one or more monitoring wells in the alluvial aquifer and fractured bedrock groundwater systems are also planned for the 2017 investigation. Sampling of materials encountered during the subsurface investigation will allow for analysis of TAs and description of physical, textural, and lithologic characteristics. Finally, subsurface geophysical investigation(s) may be conducted in the study area to characterize areas of saturation that may affect groundwater transport pathways. Section 3.4 of this plan provides a general schedule for implementing this investigation approach.

The data analyses that will be performed as part of the multi-media investigation are as follows:

1. Compare surface water monitoring results collected during seasonally distinct flow conditions (e.g., winter low-flow, spring high-flow, and summer/fall low-flow) to evaluate and describe observed differences in TA concentrations both temporally and spatially. The temporal evaluation will include new data collected in 2017, data collected by SCG in 2015 and 2016, and data collected by others prior to 2015.

2. Compare the Animas River data collected during this investigation to historical data published by others (e.g., USGS, Animas River Stakeholders Group [ARSG], and EPA) and data collected by SGC (e.g., 2015-2016).

3. Compare metals contents of soil, mine waste, and tailings in the study area to water quality and sediment data in the Animas River to evaluate the contribution, if any, from suspected source areas on both the right and left bank of the Animas River.

4. Use depth-to-water data to estimate groundwater flow direction(s) and hydraulic gradient(s) within the study area. Evaluation of these data, in conjunction with geophysical data, will help support the interpretation of how surface water and groundwater interact.

5. Evaluate the concentrations of TAs in groundwater and their spatial distribution both laterally and vertically, and utilize groundwater TA data, along with groundwater flow directions and locations of groundwater discharge, to evaluate potential sources of TAs to surface water in the study area.

6. Use geophysical methods (to be determined) to evaluate preferential groundwater flow pathways in the alluvial aquifer system and fractured bedrock system in the vicinity of and underlying the Mayflower Tailings Impoundment Area. Evaluation of these data will support the interpretation of groundwater transport pathways to the Animas River.

A detailed description of the sampling and analysis methods selected to address these data needs is included in Section 3.0 of this plan and the QAPP (Appendix A). Measurement errors (field and laboratory) and related uncertainties for the data collected and the results of the data-analyses described above will be evaluated and documented. The uncertainties associated with field and laboratory measurements obtained for this investigation will be identified through a review of data quality indicators, such as precision and accuracy. Measurement uncertainties will be documented and described in accordance with the data-quality review and validation procedures specified in Section 4.0 of the QAPP.

The measurement data obtained through this investigation will not be used as the sole basis for risk-based (or other) decision making, and therefore, this plan does not specify the uncertainty level considered acceptable for statistically based decision making. In short, statistical evaluation of the 2017 data is not planned; instead, the 2017 data will be incorporated with other data collected in 2015-2016 to support statistical analyses for the study area investigation (and ecological risk assessment, as appropriate).

2.6 DQO Step 6 – Specify Performance or Acceptance Criteria

Performance and acceptance criteria are defined and controlled through implementation of sampling and analytical methodologies that are designed to ensure that the data generated are of adequate quality for project decision-making purposes. If the quality assurance activities for sample collection and analysis specified in project documents are met, and the analytical precision and accuracy requirements specified in the QAPP (Appendix A) are met, the resulting data will be usable for characterizing the conditions in the study area and addressing the study goals stated herein.

The laboratory analysis methods need to provide quantitative data at concentrations low enough for meaningful comparison to applicable regulatory standards and/or thresholds (e.g., surface water quality standards, etc.). The proposed analytical methods and the target method detection limits and reporting limits typically achieved using the analysis method are specified in the QAPP (Appendix A).

2.7 DQO Step 7 – Develop the Plan for Obtaining Data

The basic sampling and analysis approach described in DQO Step 5 will be implemented in accordance with the more detailed plans presented in Section 4.0. The plans developed for data collection are considered resource effective approaches that provide the quantities and quality of data needed to answer the subsurface investigation questions consistent with the analytical approach (Step 5) and performance criteria (Step 6) described above.

3.0 SAMPLING AND ANALYSIS PLAN

This section presents the SAP for the 2017 multi-media investigation that has been developed to characterize the study area (Figure 1-2). Additional areas outside of the study area may be investigated, as directed by SGC. Investigations in these areas would be conducted in accordance with this Work Plan.

An adaptive management approach will be employed for this study. As such, the investigation(s) will rely on an iterative methodology that allows for modification to the SAP as warranted by study area conditions.

The QAPP is provided in Appendix A. Standard operating procedures (SOPs) that describe the various multi-media investigation procedures and methodologies are provided in Attachment A-1 of Appendix A. The health and safety plan (HASP) for the field investigations described in this work plan is provided in Appendix B.

3.1 Target Analytes

The TAs for surface water, pore water and groundwater are summarized in Table 3-1. The TAs for sediment are summarized in Table 3-2 and the TAs for soil/tailings are summarized in Table 3-3. These TAs are inclusive of those presented in the SAP/QAPP developed by the EPA for the 2016 sampling events in the Bonita Peak Mining District (EPA, 2016). Additional TAs have been added to those listed by the EPA, as needed, to achieve the DQOs described in Section 2.0.

Table 3-1 summarizes all TAs including tritium and stable isotopes of oxygen, hydrogen, and sulfur ($\delta^{18}O$ and $\delta^{2}H$ in water and $\delta^{18}O$ and $\delta^{34}S$ in dissolved sulfate). However, analysis of tritium and stable isotopes will only be performed for a subset of the surface water and groundwater samples collected during the 2017 multi-media investigation. Surface water and groundwater samples will be selected, as needed, to achieve the DQOs. The isotopic analyses will be performed by Isotope Tracer Technologies, Waterloo, Ontario, as specified in the QAPP (Appendix A).

3.2 Sampling Design

The following describes the sampling design for the various media. The multi-media network of stations in the study area that is included in the sampling design is summarized by Table 3-4 and shown on Figure 3-1. Several areas of interest have also been identified for surface water, groundwater, and soil. The areas of interest are summarized in Table 3-5 and are shown on Figure 3-2. Two areas of interest on the left bank of the Animas River will be investigated and stations may be added to the surface water sampling design in one or more of these areas to achieve the DQOs. Ten areas of interest on the right bank and one area of interest on the left bank of the Animas River are being considered for the subsurface investigation described in Section 3.3. Stations for collection of solid phase and groundwater samples will be added to the subsurface sampling design in one or more of these areas to achieve the DQOs. Finally, the soils along a former railroad grade are an area of interest that will be investigated in 2017.

3.2.1 Surface Water Sampling

A network of surface water stations have been established for the study area as summarized by Table 3-4 and shown on Figure 3-1. A brief description of each sample location is also presented in Table 3-4. Many of these stations have been historically sampled by the EPA, USGS, and others. Additional opportunistic samples may be added to the sampling design during the field investigation program, as directed by SGC. Two areas of interest on the left bank of the Animas River are summarized in Table 3-5 and shown on Figure 3-2. These areas will be investigated and, based on field observations including field water quality measurements, surface water stations may be added to the sampling design in one or more of these areas to achieve the DQOs.

Surface water samples will be collected during the synoptic spring high-flow and summer/fall low-flow sampling events described in Section 3.4. Access to left bank inflows during high-flow conditions is limited at several locations due to the fast moving water in the Animas River. Thus, left bank stations listed in Table 3-4 will be sampled where possible during these conditions. Samples will not be collected from any of the surface water stations listed in Table 3-4 if they are dry or are not connected to the Animas River via a surface flow.. Surface water samples will also be collected during the synoptic winter low-flow and pre-peak discharge sampling events described in Section 3.4. During these events, samples will only be collected from the Animas River at selected stations including Howardsville (A55), 4023 (A56), 4581 (A61), 4916, 5938 (A65), 6724, 6528, 6768 (A66), 7688 and 7858 (A68). If open water is not present due to ice then an alternative sample location may be selected or the sample location will be omitted until open water is present.

The surface water samples will be analyzed for the full suite of TAs listed in Table 3-1, including laboratory analytes and field water quality parameters, to evaluate the water chemistry in the Animas River from upstream to downstream during varying flow conditions. At selected locations noted in Table 3-4, samples will also be analyzed for tritium and stable isotopes ($\delta^{18}O$ and $\delta^{2}H$ in water and $\delta^{18}O$ and $\delta^{34}S$ in dissolved sulfate). An unfiltered and a field filtered sample will be collected at each of the sampling locations for analyses of metals/metalloids. If sample volumes are limited due to environmental conditions and the related sampling method selected during the winter low-flow sampling events, the analysis of total metals may be omitted. Sample filtration methods are described in the surface water sampling SOP (refer to Attachment A-1 of Appendix A for SOPs).

During the study, data from USGS gauging station 09538000 will be used to document the stream discharge in the Animas River. Manual field discharge measurements will be performed at selected locations to the extent practical. Field discharge measurement methods are described in the QAPP (Appendix A).

The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A for SOPs.

3.2.2 Pore Water Sampling

Pore water samples will be collected during the synoptic low-flow surface water sampling event, where possible. The data will be used along with other available pore water data collected prior to 2017 for evaluating potential ecological impacts of any existing contaminants in the hyporheic zone of the streambed.

The network of pore water stations for the study area are summarized by Table 3-4 and shown on Figure 3-1. The pore water stations are co-located with surface water stations and a brief description of each of the sample locations is presented in Table 3-4. Many of these stations have been historically sampled by the EPA, USGS and others. Additional, opportunistic, samples may be added to the sampling design during the field investigation program, as directed by SGC.

If the collection of pore water is not possible due to field conditions (e.g., rocky stream bed surface) then an alternative sample location will be selected or the pore water sample location will be omitted from the sampling plan if a suitable alternative location cannot be identified.

The pore water samples will be analyzed for the full suite of TAs listed in Table 3-1, including laboratory analytes and field water quality parameters. An unfiltered and a field filtered sample will be collected at each of the sampling locations. The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A.

3.2.3 Groundwater Sampling

A network of groundwater stations, including monitoring wells and piezometers, has been established for the study area as summarized by Table 3-4 and shown on Figure 3-1. A brief description of each of the monitoring well locations is also presented in Table 3-4. The piezometers were present prior to SGC's initial groundwater characterization in 2015 and the piezometer construction details are uncertain. The groundwater monitoring wells were completed and developed by SGC in the summer/fall of 2015. The installation and construction details are summarized in the *2015 Investigation Summary Report* (Formation Environmental, 2016b).

Ten areas of interest on the right bank and one area of interest on the left bank of the Animas River are being considered for the subsurface investigation described in Section 3.3. Groundwater monitoring wells for collection of groundwater samples will be added to the subsurface sampling design in one or more of these areas to achieve the DQOs.

Groundwater samples will be collected from the existing wells and piezometers during the synoptic spring and fall sampling events described in Section 3.4. It is unlikely that the spring event will include any of the new proposed groundwater monitoring wells in the areas of interest since these will not be installed until mid summer 2017. The fall groundwater monitoring event will include the additional proposed monitoring wells. Samples will not be collected from any of the monitoring wells and/or piezometers listed in Table 3-4 that are dry or have insufficient water for sampling.

The groundwater samples will be analyzed for the full suite of TAs listed in Table 3-1, including laboratory analytes and field water quality parameters, to evaluate the groundwater quality at and downgradient of the Mayflower Tailing Impoundments Area during the spring and fall conditions. At selected locations, the samples will also be analyzed for tritium and stable isotopes ($\delta^{18}O$ and $\delta^{2}H$ in water and $\delta^{18}O$ and $\delta^{34}S$ in dissolved sulfate). An unfiltered and a field-filtered sample will be collected at each of the sampling locations for analyses of metals/metalloids. The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A. Groundwater purged from the monitoring wells will be discharged to the surface of the impoundments and will not be allowed to run-off the impoundment area.

3.2.4 Sediment Sampling

Sediment samples will be collected during to the synoptic low-flow surface water sampling event. The network of sediment stations for the study area is summarized by Table 3-4 and shown on Figure 3-1. Sediment samples will be collected primarily to evaluate potential source contributions from metals sourced in stream bed sediments to surface water and from metals sourced in the surface water to the stream bed sediments. The sediment stations are co-located with surface water stations and a brief description of each of the sample locations is presented in Table 3-4. Many of these stations have been historically sampled by the EPA, USGS, and others. Additional opportunistic samples may be added to the sampling design during the field investigation program, as directed by SGC.

The sediment samples will be analyzed for the full suite of TAs listed in Table 3-2 and field water quality parameters will be measured prior to sample collection. Data will be used for determination of contaminant concentrations in streambed sediments.

The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A.

3.2.5 Soil/Tailings

Soil and/or tailings samples will be collected in 2017 from the near surface (less than 6 inches below ground surface [bgs]) and subsurface materials (greater than 6 inches bgs) to support the characterization of potential sources of metals in the study area.

Near surface samples will be collected from within the soil area of interest located along a former railroad grade that traverses the study area along the north (right) bank of the Animas River as shown on Figure 3-2. Soils along this corridor may include material spilled from rail cars in the past. Near-surface samples will be collected every 200 meters along the area of interest as shown on Figure 3-2 and opportunistic samples may be collected as directed by SGC.

Subsurface samples will be collected from the proposed boreholes described in Section 3.3. Ten areas of interest on the right bank and one area of interest on the left bank of the Animas River are being considered for the subsurface investigation. Boreholes for collection of solid phase samples and well installation will be added to the subsurface sampling design in one or more of these areas to achieve the DQOs.

The TAs for soil/tailings are summarized in Table 3-3. The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A.

3.2.6 Opportunistic Samples

In addition to the multi-media stations describe above, opportunistic surface water, groundwater, pore water, sediment, and other solid phase media samples (e.g., soils, mine waste, mineralized rock) may also be collected, at the direction of SGC, to evaluate TA concentrations.

The opportunistic surface water and pore water samples will be analyzed for the full suite of TAs listed in Table 3-1. The opportunistic sediment samples will be analyzed for the full suite of TAs listed in Table 3-2, and other solid phase media samples will be analyzed for the full suite of TAs listed in Table 3-3.

The sample collection methods and sample handling, preservation, and custody procedures are described in the QAPP (Appendix A) and the SOPs are included in Attachment A-1 of Appendix A.

3.3 Drilling and Monitoring Well Installation

Ten areas of interest on the right bank and one area of interest on the left bank of the Animas River are being considered for the subsurface investigation to achieve the DQOs. These areas are summarized in Table 3-5 and shown on Figure 3-2. The number and location of additional borings and monitoring wells depends on a number of factors including property access, drill rig access, drilling method, and other environmental conditions.

To better define groundwater levels and flow directions in the alluvial aquifer system within the study area, it is anticipated that at least one monitoring well will be competed to the south of the Mayflower Mill, one monitoring well will be completed at TP-1 to the south of existing well MTMW-12, one monitoring well will be completed at TP-3 (screened below the level of the existing well MTMW-9), one monitoring well will be completed to the south of TP-4 between the impoundment and the river, and two monitoring wells will be completed to the west and southwest of TP-4. Additional monitoring wells are also proposed to investigate the bedrock facture system on the hillside upgradient of the Site and on the hillside to the south of the Mayflower Mill; however, the anticipated number of wells is uncertain at this time given the potential limitations for drill rig access due to the steep terrain. Finally, one or more groundwater monitoring wells may be completed in the southern lobe of the alluvial aquifer on the left bank of the river, in the area of the former Silver Lake Mill, depending on property access and drill rig access. The characterization of groundwater depth, flow direction, and chemistry will be based on an iterative process and will evolve based on the data collected during the proposed investigation herein, as needed.

Between November 1 and 2, 2016, 31 pressure transducers were deployed in selected monitoring wells and piezometers in the study area. The pressure transducers were installed to monitor groundwater elevations through time and were programmed to collect data at a minimum frequency of 3 times daily and additional measurements will automatically be recorded if the groundwater level changes by +/- 0.1 feet.

All monitoring wells installed by SGC in 2015 at the Mayflower Tailing Impoundment Area were instrumented with pressure transducers, except for MTMW-15, which has been dry since installation. Existing piezometers PZ-SS-1 and PZ-SS-15 (upgradient of TP-1), PZ-SS-11 (upgradient of TP-2), PZ-SS-23 and PZ-SS-24 (upgradient of TP-3), PZ-SS-01, PZ-SS-02, and PZ-SS-07 (upgradient of TP-4), and PZ-SS-06 (western toe of TP-4) were also instrumented with pressure transducers. Additional pressure transducers were deployed in selected existing piezometers and monitoring wells located outside of the Mayflower Tailings Impoundment Area, which included SV-1 and SV-2 (downgradient of TP-4) and PZ-27 (downgradient of TP-2 and

TP-3). A barometer (In-Situ, Inc. Level BaroTroll ®) was also installed at TP-1 to measure the barometric pressure of the atmosphere through time. These instruments will be operated through 2017 and may continue under agreed to amendments to this work plan or in accordance with separate agreed to work plans.

As described in Section 3.4, the schedule of drilling is uncertain and SGC will direct the 2017 monitoring well installation program using a phased approach. The following describes general drilling, core sampling, and well installation procedures anticipated for the 2017 subsurface investigations. Supplemental planning information will be prepared, including drilling, coring, and well construction methods, once the drilling program has been further defined and before any drilling activities commence in 2017.

3.3.1 General Drilling Procedures

Boreholes may be advanced through unconsolidated materials and/or bedrock. Where unconsolidated materials are encountered, boreholes will be advanced through these materials to bedrock (if possible).

It is anticipated that eight-inch diameter boreholes will be advanced using the most suitable drilling method to meet the DQOs. Smaller diameter boreholes may be advanced on the hillside upgradient of the impoundments. The rotosonic drilling method will likely be used as the primary drilling method. Drilling waste including all cuttings and fluids will be temporarily disposed of on-Site near each borehole location, as deemed appropriate by the field staff. At selected borehole locations drilling waste may be temporarily containerized, as needed, based on site conditions. Following the completion of the drilling program, all drilling waste will be permanently disposed of at Tailings Impoundment 4. The drilling waste will be covered with growth medium.

3.3.2 Unconsolidated Materials Core Sampling

The core sampling plan for the unconsolidated materials is described below and the sample collection methods are described in the QAPP (Appendix A). The textural and lithological characteristics of the core will be described in accordance with the visual and manual methods described in the QAPP.

The following sampling approach will be used to provide a sufficient number of samples for characterization of unconsolidated materials. An approximate one-kilogram sample will be collected from the upper portion of each ten-foot interval at each drilling location. Additional samples may be collected to represent any visually distinctive materials encountered during drilling. The samples will be submitted to the laboratory for analysis (refer to the QAPP in Appendix A for a description of laboratory methods associated with these preliminary analyses).

Decontamination procedures for the core barrel are described in SOP No. 7, Equipment Decontamination (Refer to Attachment A-1 of Appendix A for SOPs). Decontamination waste water will be discharged to the surface of the impoundments and the water will not be allowed to runoff the impoundment area.

3.3.3 Bedrock Core Sampling

It is anticipated that one or more bedrock core holes will be advanced within the groundwater areas of interest shown on Figure 3-2 and summarized in Table 3-5. The drilling and coring methods are uncertain at this time and will be determined during the drilling services bidding process. The proposed geophysical investigation described in Section 3.5 will likely guide the location of bedrock boreholes.

The objectives of the proposed bedrock coring are to investigate the fractured bedrock groundwater system and to identify groundwater transport pathways from the fractured bedrock system to the Animas River. The degree and orientation of the fractures and lithology of the bedrock will be recorded in accordance with the visual and manual methods described in the QAPP.

3.3.4 Abandonment of Borings

Abandonment of boreholes that are not selected for completion as monitoring wells will be conducted by filling the boreholes with bentonite chips or pellets and then introducing water to hydrate the chips or pellets. This abandonment method meets or exceeds the abandonment requirements of Rule 16 (Standards for Plugging, Sealing, and Abandoning Wells and Boreholes) of the Colorado “Water Well Construction Rules” (CODWR, 2016).

3.3.5 Monitoring Well Construction

Boreholes to be completed as monitoring wells will be selected in the field. The basic criteria for completion includes the presence of saturated native alluvial materials with a thickness of 5 feet or greater in the unconsolidated zones and water bearing bedrock fractures. In the unconsolidated materials, the target zone for well completion is the native alluvial materials for the characterization of water quality and piezometric heads in the alluvial aquifer.

4-inch diameter schedule-40 polyvinyl chloride (PVC) wells will be completed with 10-foot screened intervals, unless longer or shorter screened intervals are appropriate to achieve the DOQs. Water bearing zones will be identified during drilling and logging. Final well construction details will be determined in the field. The wells will be completed with a sand filter pack extending above and below the well screen followed by a transition seal and an annular seal to the surface in conformance with Colorado “Water Well Construction Rules,” effective date

January 1, 2005. All wells will be completed at the surface with a locking steel casing monument and concrete pad to direct runon away from the borehole annulus.

Monitoring wells installed under this Work Plan will be developed and sampled after a minimum of 24 hours have elapsed following well construction to allow grout to set and bentonite to fully hydrate. Well development will be conducted in accordance with SOP No. 8, *Monitoring Well Development* (Refer to Attachment A-1 of Appendix A for SOPs). Waste water generated during well development will be discharged to the surface of the impoundments, if on the impoundments, and will be temporarily stored, if not on the impoundments. If development water is temporarily stored in a drum or tank, the water will later be discharged to surface of the impoundments. Waste water will not be allowed to runoff the impoundment area.

3.4 Schedule

The anticipated schedule for the 2017 multi-media sampling plan discussed above is as follows:

- Winter Low-Flow Surface Water Sampling – February, March and April 2017
- Pre-Peak Discharge Surface Water Sampling – May 2017
- Spring Groundwater Sampling – May 2017
- High-Flow Surface Water Sampling – June 2017 (conducted concurrent with the EPA sampling event)
- Drilling, core sampling, and monitoring well installation and development (Summer of 2017)
- Geophysical investigation (Spring and/or Fall 2017)
- Low-Flow Surface Water, Pore Water, and Sediment Sampling – September 2017 (conducted concurrent with the EPA sampling event)
- Fall Groundwater Sampling – October 2017

The above schedule is only for those activities planned in 2017 and is subject to change based on field conditions and other factors to be considered by SGC for a sampling plan of this magnitude. Changes to the schedule will be communicated to the EPA and others, as needed. Additional multi-media investigation activities within the Study Area in 2017, as determined by SGC, which are not included in the schedule above will also be communicated to the EPA and others, as needed. Any additional multi-media investigation activities undertaken post-2017 will be conducted under agreed to amendments to this work plan or in accordance with separate agreed to work plans.

3.5 Geophysical Investigation

The objectives of the proposed geophysical investigation are to evaluate potential groundwater transport pathways in the alluvial aquifer and fractured bedrock groundwater systems to the Animas River. Geophysical methods may also be used to map the bedrock surface and/or to identify major structural features such as faults and fracture zones.

It is anticipated that a subsurface geophysical investigation will be conducted in the study area. The approach and geophysical methods are uncertain at this time and will be determined during the geophysical bidding process. Supplemental planning information will be prepared as an addendum to the QAPP and will be submitted to the EPA for review once the investigation program has been further defined and before geophysical studies commence in 2017. This information will include the geophysical methods and data-collection locations.

3.6 Sample Labeling

Each sample that is collected in the field will be labeled for future identification. Sample labels may be filled out as completely as possible by a member of the sampling team prior to the start of the day's field sampling activities. Samples will be labeled with all necessary information on pre-printed waterproof labels using waterproof ink. At a minimum, each sample label shall contain the following information:

- location identification;
- sample identification number (including codes for site location, sample matrix, and sample type, described in further detail below);
- date and time of sample collection;
- analyses required;
- method of preservation, if used;
- sample matrix;
- sample depth, if applicable.

Each sample shall be assigned a unique sample identification number. These numbers are required for tracking the handling, analysis, and verification or validation status of all samples collected during monitoring. Each sample identification number will identify the sampling location and type of sample. Samples to be collected will include planned soil phase media samples and quality control samples.

3.6.1 Surface Water, Pore Water and Sediment

For the planned surface water, pore water and sediment samples, sample identification numbers will be assigned using several codes as follows with the appropriate media type:

Sampling Event - Location – Media Type

SS0815-4023-SW

The first field in the identification number identifies the project location and event month and year. This example includes the project location, “SS” (Sunnyside) and an event month and year of “0815” (August 2015).

The second field in the identification number identifies the location of the sample. In this example, “4023” indicates the sampling location ID. Location identifiers have already been established and are included in Tables 3-4 and 3-5.

The third field identifies the sample matrix type. The matrix type is defined as “SW” to designate the matrix is surface water. The matrix type for pore water will be defined as “PW”. The matrix type for sediment will be “SED”.

Note that additional codes may be added as the project proceeds. The additions will be communicated to the field staff and data management team.

The required QC samples are described in the QAPP (Appendix A). For QC samples, sample identification numbers will be assigned using the same coding described above, but also including information needed by the Formation project team to recognize the field QC samples, for example:

Sampling Event – Location - Matrix

SS0815-8000-SW

[where 8000 is for a non-existent sample location]

For multiple QC samples, the location ID will be numbered sequentially for each sample (e.g., rinsate blank = 8001, duplicate = 8002, etc.)

Field personnel will record the sample identification code with the type of QC sample (e.g., rinsate blank) and the time of sample collection in field log books.

Samples will be immediately labeled in the field and sample numbers shall be recorded at the time of sampling in field notes and on field data collection forms.

3.6.2 Groundwater

For the planned groundwater samples, sample identification numbers will be assigned using several codes as follows with the appropriate media type:

Sampling Event - Location – Media Type

SS0815-MW1-GW

The first field in the identification number identifies the project location and event month and year. This example includes the project location, “SS” (Sunnyside) and an event month and year of “0815” (August 2015).

The second field in the identification number identifies the location of the sample. In this example, “MW1” indicates the sampling location monitoring well ID. Location identifiers have already been established and are included in Tables 3-4 and 3-5.

The third field identifies the sample matrix type. The matrix type is defined as “GW” to designate the matrix is groundwater.

Note that additional codes may be added as the project proceeds. The additions will be communicated to the field staff and data management team.

The required QC samples are described in the QAPP (Appendix A). For QC samples, sample identification numbers will be assigned using the same coding described above, but also including information needed by the Formation project team to recognize the field QC samples, for example:

Sampling Event – Location - Matrix

SS0815-MW100-SW

[where MW100 is for a non-existent sample location]

For multiple QC samples, the location ID will be numbered sequentially for each sample (e.g., rinsate blank = MW100, duplicate = MW101, etc.)

Field personnel will record the sample identification code with the type of QC sample (e.g., rinsate blank) and the time of sample collection in field log books.

Samples will be immediately labeled in the field and sample numbers shall be recorded at the time of sampling in field notes and on field data collection forms.

3.6.3 Other Solid Phase Media

For other planned solid phase media samples, sample identification numbers will be assigned using several codes as follows:

Sampling Event – Location - Depth – Matrix Type

SS0815-01-05-SO

The first field in the identification number identifies the project location and event month and year. This example includes the project location, “SS” (Sunnyside) and an event month and year of“0815” (August 2015).

The second field in the identification number identifies the location of the sample. In this example, “01” indicates the sample location.

The third field identifies the sample depth. The depth is indicated in feet bgs and in this example “05” indicated 5 feet bgs.

The fourth field identifies the sample matrix type. The matrix type is defined as “SO” to designate the matrix is solid.

Note that additional codes may be added as the project proceeds. The additions will be communicated to the field staff and data management team.

The required QC samples are described in the QAPP (Appendix A). For QC samples, sample identification numbers will be assigned using the same coding described above, but also including information needed by the Formation project team to recognize the field QC samples, for example:

Sampling Event – Location - Depth - Matrix

SS0815-100-01-SO

[where 100 and the depth are for a non-existent sample location]

For multiple QC samples, the depth field will be numbered sequentially for each sample (e.g., rinsate blank = 01, duplicate = 02, etc.)

Field personnel will record the sample identification code with the type of QC sample (e.g., rinsate blank) and the time of sample collection in field log books.

Samples will be immediately labeled in the field and sample numbers shall be recorded at the time of sampling in field notes and on field data collection forms.

3.6.4 Opportunistic

For opportunistic samples, sample identification numbers will be assigned using the following codes:

Sampling Event - OP - Number

SS0815-OP-01

For opportunistic surface water samples, the first field in the identification number identifies the project location and event month and year. This example includes the project location, “SS” (Sunnyside) and an event month and year of “0815” (August 2015).

The second field in the identification number identifies the sample as an opportunistic sample and the third field identifies the opportunistic sample. Opportunistic samples will be numbered consecutively starting with 1 and once a number is used it will not be re-used during the same event or during future events. Field personnel will record the actual sample location and time in field log books.

4.0 REPORTING

An annual report will be prepared which will summarize the findings from all phases of investigation conducted during 2017. This report will include updates to the site conceptual model and recommendations for additional investigative work, if needed. It is anticipated that the annual report will be submitted to the EPA and other interested parties on or before March 15, 2018.

5.0 REFERENCES

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TABLES

Table 3-1
Target Analytes for Surface Water, Pore Water, and Groundwater Samples

Target Analyte	Total Recoverable (Y/N)	Dissolved (Y/N)	Laboratory Analytical Method	MDL[10] (µg/L)	PQL[10] (µg/L)	Maximum Hold Time (days)	Sample Volume	Preservative
Laboratory Parameters								
Metals								
Aluminum	Y	Y	200.7	30	150	180	250 mL	HNO_3
Antimony	Y	Y	200.8	0.4	2			
Arsenic	Y	Y	200.8	0.2	1			
Barium	Y	Y	200.8	0.5	2.5			
Beryllium	Y	Y	200.7	10	50			
Cadmium	Y	Y	200.8	0.1	0.5			
Calcium	Y	Y	200.7	100	500			
Chromium	Y	Y	200.7	10	50			
Cobalt	Y	Y	200.8	0.05	0.25			
Copper	Y	Y	200.8	0.5	2.5			
Iron	Y	Y	200.7	20	100			
Lead	Y	Y	200.8	0.1	0.5			
Lithium	Y	Y	200.7	8	40			
Magnesium	Y	Y	200.7	200	1000			
Manganese	Y	Y	200.7	5	25			
Molybdenum	Y	Y	200.8	0.5	2.5			
Mercury	Y	Y	245.1	0.2	1			
Nickel	Y	Y	200.8	0.6	3			
Potassium	Y	Y	200.7	200	1000			
Selenium	Y	Y	200.8	0.1	0.5			
Silica	Y	Y	200.7	428	2140			
Silver	Y	Y	200.8	0.05	0.25			
Sodium	Y	Y	200.7	200	1000			
Strontium	Y	Y	200.7	5	25			
Thallium	Y	Y	200.8	0.1	0.5			
Vanadium	Y	Y	200.8	0.2	1			
Zinc	Y	Y	200.7	10	50			
Anions								
Bromide	N	Y	300.0	50	250	28	250 mL	None
Chloride	N	Y	300.0	500	2500			
Sulfate	N	Y	300.0	500	2500			
Flouride	N	Y	300.0	100	500			
Misc.								
Hardness	Y	--	SM2340B	1,500	7,500	180	250 mL	HNO_3
Alkalinity	Y	--	SM2320B	2,000	10,000	14	500 mL	None
TSS	Y	--	SM2540D	5,000	25,000	7	500 mL	None
TDS	Y	--	SM2540C	10,000	50,000			
Field Parameters								
Temperature	--	--	--	--	--	--	--	--
Turbidity	--	--	--	--	--	--	--	--
pH	--	--	--	--	--	--	--	--
Specific Conductance	--	--	--	--	--	--	--	--
DO	--	--	--	--	--	--	--	--
ORP	--	--	--	--	--	--	--	--

Notes:
1. -- = not applicable
2. Y = Yes
3. N = No
4. DO = dissolved oxygen
5. ORP = oxidation reduction potential
6. TSS = Total suspended sediments
7. TDS = Total dissolved solids
8. MDL = Method detection limit
9. PQL = Practical quantitation limit
10. Targeted MDLs and PQLs are listed. Laboratories routinely adjust these values, and therefore, reported MDLs and PQLs may differ here slightly from those listed
11. mL = mililiter

Table 3-2
Target Analytes for Sediment Samples

Target Analyte	EPA Method Number	MDL[6] (mg/kg)	PQL[6] (mg/kg)	Maximum Hold Time (days)	Sample Volume	Preservative
Laboratory Parameters						
Metals						
Aluminum	6010	3	15	180	Collect 200 grams	None
Antimony	6020	0.2	1			
Arsenic	6020	0.1	0.5			
Barium	6010	0.3	1.5			
Beryllium	6010	1	5			
Cadmium	6010	0.5	2.5			
Calcium	6010	10	50			
Chromium	6020	0.25	1.25			
Cobalt	6010	1	5			
Copper	6010	1	5			
Fluoride (Soluble)	D3761	0.1	0.5	--		
Iron	6010	2	10	180		
Lead	6010	3	15			
Lithium	6010	0.8	4			
Magnesium	6010	20	100			
Manganese	6010	0.5	2.5			
Mercury	7471	0.002-0.005	0.01-0.025	28		
Molybdenum	6010	2	10	180		
Nickel	6010	0.8	4			
Selenium	6020	0.05	0.25			
Silica	6010	42.8	214			
Silver	6010	1	5			
Strontium	6010	0.5	2.5			
Thallium	6020	0.5	2.5			
Vanadium	6020	0.1	0.5			
Zinc	6010	1	5			
Other						
SPLP extraction and analysis for metals listed above	1312/6020 and 7470[1]	--	--	180	100 grams	None
Acid-Base Accounting (ABA)	600/2-78-054	--	--	--	10 grams	None

Notes:

1. -- = not applicable
2. SPLP = Synthetic Precipitation Leaching Procedure
3. Leachate solution analyzed for metals/metalloids by EPA Methods 6020 and 7470
4. MDL = Method detection limit
5. PQL = Practical quantitation limit
6. Targeted MDLs and PQLs are listed. Laboratories routinely adjust these values, and therefore, reported MDLs and PQLs may differ slightly from those listed here

Table 3-3
Target Analytes for Soil/Tailings Samples

Target Analyte	EPA Method Number	MDL[8] (mg/kg)	PQL[8] (mg/kg)	MaximumHold Time (days)	Sample Volume	Preservative
Aluminum	6010	3	15	180	10 grams	None
Antimony	6020	0.2	1			
Arsenic	6020	0.1	0.5			
Barium	6010	0.3	1.5			
Beryllium	6010	1	5			
Cadmium	6010	0.5	2.5			
Calcium	6010	10	50			
Chromium	6020	0.25	1.25			
Cobalt	6010	1	5			
Copper	6010	1	5			
Fluoride (Soluble)	D3761	0.1	0.5	--	25 grams	
Iron	6010	2	10	180	10 grams	
Lead	6010	3	15			
Lithium	6010	0.8	4			
Magnesium	6010	20	100			
Manganese	6010	0.5	2.5			
Mercury	7471	0.0002	0.001	28		
Molybdenum	6010	2	10	180		
Nickel	6010	0.8	4			
Selenium	6020	0.05	0.25			
Silica	6010	42.8	214			
Silver	6010	1	5			
Strontium	6010	0.5	2.5			
Thallium	6020	0.05	0.25			
Vanadium	6020	0.1	0.5			
Zinc	6010	1	5			
Other						
SPLP extraction and analysis for metals listed above	1312/6020[3]	--	--	180	100 grams	None
Acid-Base Accounting (ABA)	600/2-78-054	--	--	--	10 grams	None
Net Acid Generation (NAG)	VOL[4]	--	--	--	--	--

Notes:

1. -- = not applicable
2. SPLP = Synthetic Precipitation Leaching Proceedure
3. Multi-element analysis by ICP-MS following aqua regia digestion
4. pH 4.5 to 7 end points
5. MDL = Method detection limit
6. PQL = Practical quantitation limit
7. Targeted MDLs and PQLs are listed. Laboratories routinely adjust these values, and therefore, reported MDLs and PQLs may

Table 3-4
Multi-Media Stations in the Study Area

Station ID	Alias	X	Y	Sample Media Type				Source Type	Source Name	Location Description
		UTM		SW	PW	SED	GW			
Surface Water Stations										
Howardsville	A55	271230.9261	4190459.243	x[9]	x	x	--	S	Animas River	At EPA Location A55; right bank access via gravel road; at USGS gauging station
4023	A56	269050.435	4189934.865	x[9, 10]	x	x	--	S	Animas River	At EPA location A56; right bank access via gravel road
4033		268979.8442	4189977.341	x[9]	--	--	--	RBI	Waterfall	Waterfall immediately upstream of Arrastra Creek confluence; right bank access via gravel road.
4166		268868.384	4189929.03	x	--	--	--	S	Animas River	At Kimball et. al (2010) low-flow and high-flow in-stream sample location 4166; Kimball et. al (2010) Transport site T1; upstream from Arrastra Creek; right bank access via gravel road; limited left bank access
A58-SS	A58	268932.569	4189836.753	x	x	x	--	LBI	Arrastra Creek	At EPA location A58; in Arrastra Creek approximately 70 feet downstream from the road culvert.
4220	A60	268828.166	4189890.512	x	x	x	--	S	Animas River	At EPA location A60; right bank access via boat ramp immediately downstream of bridge on County Road 52; left bank access by crossing the bridge
4300		268752.5701	4189906.342	x	--	--	--	RBI	Spring	At Kimball et. al (2010) low-flow sample location 4300; small spring upstream from pipe bridge; right bank access via gravel road
4353A		268729.773	4189910.536	x	--	--	--	RBI	Pipe	Inflow from pipe on right bank; right bank access via gravel road
4353B		268725.911	4189909.58	x	--	--	--	S	Animas River	In stream sample; Immediately downstream of pipe inflow and seep inflow; right bank access via gravel road; limited left bank access
4353C		268725.863	4189909.661	x	--	--	--	RBI	Spring	Stream level spring, At Kimball et. al (2010) right bank inflow sample location 4353; aluminum oxide colored water; right bank access via gravel road
4520		268599.016	4189819.023	x	--	--	--	RBI	Seep	At Kimball et al. (2010) low-flow sample location 4520; right bank inflow from seep that crosses gravel road.
4520B		268593.6929	4189804.795	x	--	--	--	S	Animas River	Immediately downstream of RBI sample location 4520; sample if 4520 RBI is not observed
4581	A61	268560.187	4189782.005	x[9]	x	x	--	S	Animas River	At EPA location A61; upstream of Boulder Creek; right bank access via gravel road; limited left bank access
4656		268463.119	4189773.57	x	--	--	--	S	Animas River	Upstream for Pinnacle Gap; right bank access via gravel road; limited left bank access
4734		268416.084	4189774.348	x	--	--	--	Adit	Mine Adit	At observed mine adit; access via gravel road
4737	OP-79	268395.0000	4189762.0000	x[9]	--	--	--	LBI	--	Left bank inflow adjacent to former Silver Lake Mill area; left bank access requires crossing Animas River
4749		268378.424	4189757.965	x	--	--	--	S	Animas River	Immediately downstream of observed mine adit; right bank access via gravel road; limited left bank access
4916		268284.3982	4189652.885	x[9]	--	--	--	S	Animas River	At Kimball et. al (2010) low-flow and high-flow in-stream sample location 4916; Kimball et. al (2010) Transport site T2 (low flow)/T3 (high-flow); immediately upstream from the road culverts for Boulder Creek; right bank access via gravel road; limited left bank access
4951	A62	268202.577	4189647.58	x	--	--	--	RBI	Boulder Creek	At Kimball et. al (2010) low-flow right bank sample location 4951 and EPA location A62; on right bank of the Animas River; at confluence of Boulder Creek and Animas River; immediately downstream of where boulder creek flows across gravel road; access via gravel road
4951B	OP-86	267979.069	4190045.14	x	--	--	--	RBI	Boulder Creek	Boulder Creek, upstream of TP-1 and TP-2; access via TP-1 or TP-2.
5000		268155.103	4189588.578	x[9]	--	--	--	RBI	Spring	At observed right bank inflow; red colored water; access via gravel road
5038B		268163.9071	4189516.09	x	--	--	--	S	Animas River	Immediately downstream of Kimball et. al (2010) low-flow RBI sample location 5038; right bank access via gravel road
5306	A64	268068.6541	4189433.518	x[9]	x	x	--	S	Animas River	At EPA location A64. At USGS in-stream low-flow sample location 5306; Adjacent to Tailings Impoundment 2 and immediately upstream of the temporary tailings; right bank access via gravel road; limited left bank access
5221		268041.0816	4189427.495	x	--	--	--	LBI	Aspen Mine Drainage	Aspen mine drainage waterfall; at Kimball et al (2010) low-flow sample location 5221; left bank access requires crossing Animas River
5356B		267936.8894	4189433.067	x	--	--	--	S	Animas River	Immediately downstream of RBI sample location 5356; sample if 5356 RBI is not observed; right bank access via gravel road
5608		267702.127	4189335.244	x	--	--	--	RBI	Ditch	At right bank inflow; drainage ditch from Tailings Impoundment 2 area; right bank access via County Road 2

Table 3-4
Multi-Media Stations in the Study Area

Station ID	Alias	X	Y	Sample Media Type				Source Type	Source Name	Location Description
		UTM		SW	PW	SED	GW			
5756		267583.9812	4189253.453	x	--	--	--	S	Animas River	At USGS low-flow sample location 5756; Upstream from right bank drainage ditch behind power plant
5858B		267522.5569	4189215.853	x	--	--	--	S	Animas River	Immediately downstream of Kimball et. al (2010) low-flow RBI sample location 5858; right bank access via County Road 2
5938	A65	267453.831	4189171.261	x[9]	x	x	--	S	Animas River	At EPA location A65; downstream of temporary tailings impoundment area; right bank access via County Road 2; limited left bank access
6013		267403.415	4189127.235	x	--	--	--	RBI	Spring	Downstream of spring near metal building; access via County Road 2; on private property
6150		267292.383	4189054.525	x[9, 10]	--	--	--	RBI	Seep	At USGS low-flow sample location 6150; Red stained right bank discharge
6215		267234.117	4189017.174	x	--	--	--	RBI	Seep	Right bank inflow seep; red stained water, right bank access via County Road 2
6274		267186.697	4188989.154	x[9, 10]	--	--	--	S	Animas River	In Animas river immediately downstream of right bank inflow seep with red stained water; right bank access via County Road 2
6528		266986.295	4188864.368	x[9]	--	--	--	S	Animas River	Upstream from former Lacawana Bridge; right bank access via County Road 20; limited left bank access
Pond-4	OP-80	266851.1471	4188974.2300	x[9]	--	--	--	Pond	Pond	Apparent iron bog on right bank of Animas River. Near power substation, across the road from Silverton trash transfer station and the western toe of TP-4; access via County Road 2.
Pond-1		266752.12	4188826.24	x	--	--	--	Pond	Pond	In pond upgradient of reactive treatment wall; right bank access via County Road 20
6768	A66	266788.978	4188751.872	x[9, 10]	x	x	--	S	Animas River	Near Kimball et. al (2010) low-flow and high-flow in-stream sample location 6745 and EPA location A66 (approx. 20 feet downstream); at former Lacawana Bridge; right bank access via County Road 20; limited left bank access
6879		266641.287	4188733.554	x	--	--	--	RBI	Wetland	Right bank inflow at wetland near campground
7049		266511.807	4188670.608	x[9]	--	--	--	RBI	Braid	At Kimball et. al (2010) low-flow sample location 7049; in braid of Animas River during April 29, 2015 recon; right bank access via gravel road; limited left bank access
7688		266002.52	4188360.347	x[9]	--	--	--	S	Animas River	At USGS sample location AMIN-7688; right bank access via E 16th Street; limited left bank access
7690		265996.937	4188351.183	x	--	--	--	RBI	Ditch	Approx. 60 meters upstream from Kimball et. al (2010) right bank inflow low-flow sample location 7750; during 4/30/2015 recon event 7750 was part of the main Animas River channel; ditch draining from pond; right bank access via Animas Street; left bank access via CO Road 32
7858	A68	265905.498	4188192.675	x[9, 10]	x	x	--	S	Animas River	At Kimball et. al (2010) low-flow and high-flow sample location 7858 and EPA location A68; Kimball et. al (2010) Transport site T3 (low flow)/T7 (high flow) – at 14th Street bridge with Kimball et. al (2010) stream gauge
AMIN-7103		266466.681	4188599.392	x	--	--	--	LBI	--	Go over 14th st. bridge, turn left and continue left around what appears to be ice rink, follow road to gate, turn right to park, walk 0.2 miles to location. at USGS sample location AMIN-7103 which is described as discharge from Lackawanna tailings; left bank access requires crossing Animas River
AMIN-7163		266435.2968	4188576.056	x	--	--	--	LBI	Swansea Gulch	At Swansea Gulch and Animas River confluence; at USGS sample location AMIN-7136; left bank access requires crossing Animas River
Pond-3	OP-15	268655.8063	4189977.18	x[10]	--	--	--	Pond	Pond	Mayflower Mill storm water retention pond; access via Mayflower Mill.
Seep-1	OP-76	268724.0000	4189972.0000	x[10]	--	--	--	RBI	Seep	Hillside seepage below Mayflower Mill. Seepage coming out of hillside tailings and bedrock fractures; access via County Road 52.
Seep-2	OP-77	268707.3979	4189948.3660	x	--	--	--	RBI	Seep	Hillside seepage below Mayflower Mill, near the gravel road. Seepage may be coming out of the hillside tailings and bedrock fractures; access via County Road 52.
Seep-3	OP-78	268686.7911	4189945.5030	x[10]	--	--	--	RBI	Seep	Hillside seepage below Mayflower Mill, near the gravel road. Seepage may be coming out of bedrock fractures; access via County Road 52.

Table 3-4
Multi-Media Stations in the Study Area

Station ID	Alias	X	Y	Sample Media Type				Source Type	Source Name	Location Description
		UTM		SW	PW	SED	GW			
Groundwater Stations										
MTMW-1		267018.4269	4189198.211	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-2		267021.8231	4189128.08	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-3		267195.0375	4189117.31	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-4		267173.4129	4189312.908	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-5		267202.3035	4189201.022	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-6A		267244.4161	4189262.15	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-6B		267230.1981	4189252.68	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-7		267308.5819	4189211.896	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-8		267334.6934	4189304.329	--	--	--	x[9]	GW	Alluvial Aquifer	TP-4 monitor well
MTMW-9		267773.3905	4189551.694	--	--	--	x[9]	GW	Alluvial Aquifer	TP-3 monitor well
MTMW-10		267916.1608	4189745.729	--	--	--	x[9]	GW	Alluvial Aquifer	TP-2 monitor well
MTMW-11		267970.884	4189811.749	--	--	--	x[9]	GW	Alluvial Aquifer	TP-2 monitor well
MTMW-12		268171.8592	4189987.485	--	--	--	x[9]	GW	Alluvial Aquifer	TP-1 monitor well
MTMW-13		268375.0187	4189963.244	--	--	--	x[9]	GW	Alluvial Aquifer	TP-1 monitor well
MTMW-14		268554.4852	4190062.157	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-1 monitor well
MTMW-15		268777.8046	4190108.676	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-1 monitor well
MTMW-16		268781.8718	4190107.586	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-1 monitor well
MTMW-17		268678.4684	4190120.06	--	--	--	x[9, 10]	GW	Alluvial Aquifer	TP-1 monitor well
PZ-SS-02		267098.8642	4189316.254	--	--	--	x[9]	GW	Alluvial Aquifer	Piezometer on hillside above TP-4
PZ-SS-15		268054.7385	4190060.207	--	--	--	x[9]	GW	Alluvial Aquifer	Piezometer on hillside above TP-1
PZ-SS-21		268649.3601	4190137.848	--	--	--	x[9]	GW	Alluvial Aquifer	Piezometer on hillside above Mayflower Mill
PZ-SS-24		267707.1981	4189616.811	--	--	--	x[9]	GW	Alluvial Aquifer	Piezometer on hillside above TP-3
SV-1		266809.6273	4188843.163	--	--	--	x	GW	Alluvial Aquifer	Monitoring well near Pond-1; on east side of Country Road 20; access via gravel road.
SV-2		266679.3815	4188755.537	--	--	--	x	GW	Alluvial Aquifer	USGS monitoring well near campground; on west side of Country Road 20; access via gravel road.

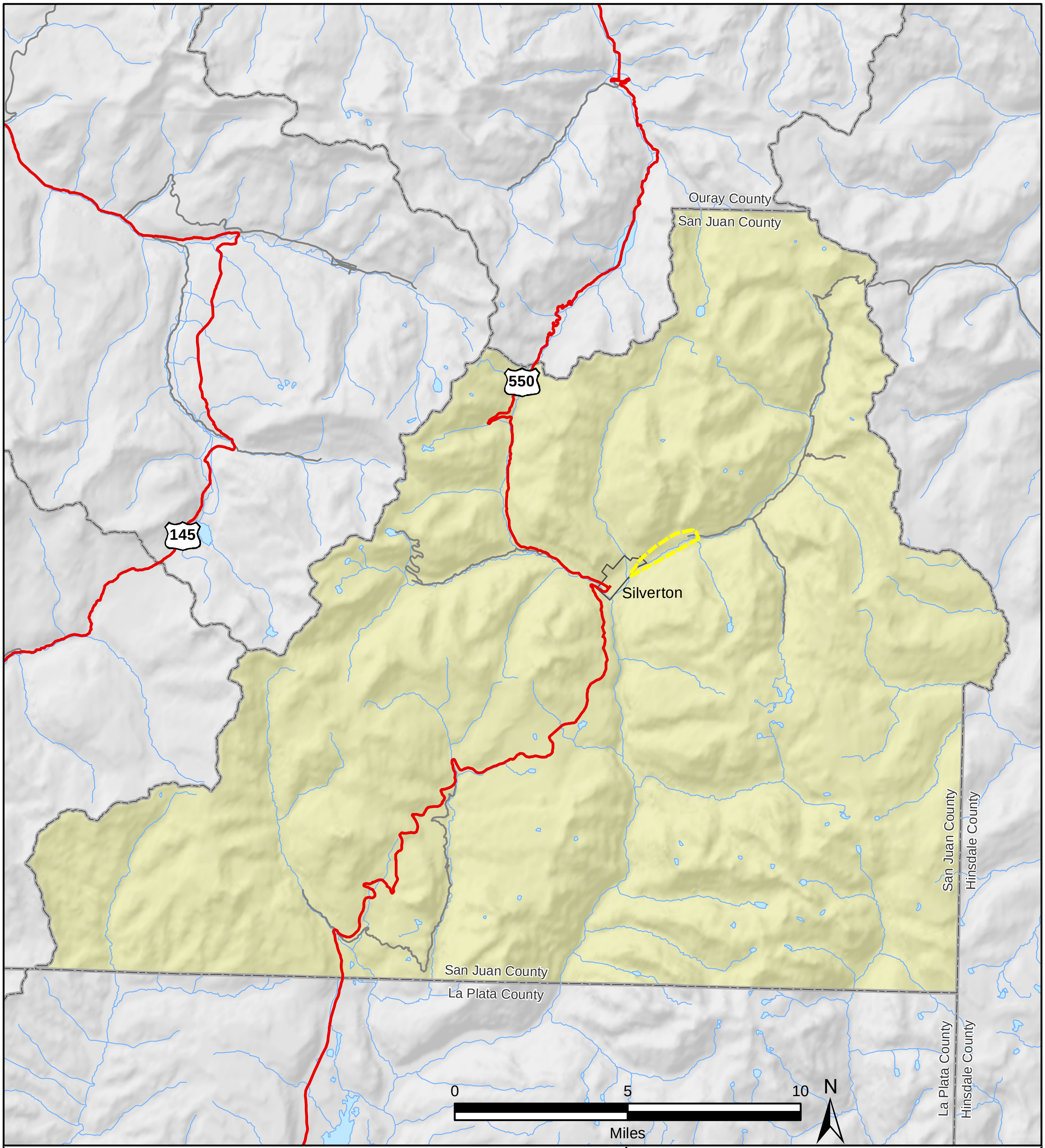
NOTES:

1. -- = not applicable
2. S = Stream
3. RBI = Right Bank Inflow to Animas River
4. LBI = Left Bank Inflow to Animas River
5. SW = Surface Water
6. PW = Pore Water
7. SED = Sediment
8. GW = Groundwater
9. Stable isotopes of oxygen and hydrogen in water.
10. Additional isotopic analyses (tritium, stable isotopes of oxygen and sulfur in sulfate).

Table 3-5
Areas of Interest

Areas of Interest	Location Description
Surface Water	
SW-1	Left bank between stations 6150 and 6528
SW-2	Left bank between stations 4220 and 4749
Groundwater	
GW-1	Right bank, to the west/southwest of TP-4
GW-2	Right bank, to the southeast of TP-4 between stations 6150 and 6528
GW-3	Upgradient of TP-4
GW-4	Upgradient of TP-3
GW-5	TP-3
GW-6	Upgradient of TP-2
GW-7	Upgradient of TP-1
GW-8	Upgradient of Mayflower Mill
GW-9	Downgradient of Mayflower Mill, storm water retention basin area
GW-10	Right bank, hillside seepage
GW-11	Left bank, former Silver Lake Mill area
Soil	
Railroad Line	Former railroad line along the right bank of the river. Proposed soil sample locations are on 200 meter centers.

FIGURES



Legend

Roads

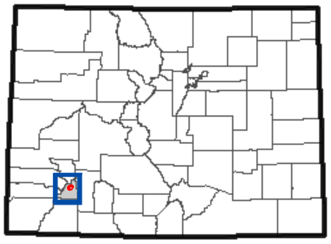
Highways

Counties

Silverton, CO

Study Area

Location of Study Area
In San Juan County



SUNNYSIDE GOLD

SILVERTON, CO

FIGURE 1-1

STUDY AREA LOCATION MAP

DATE: APR 13, 2017

BY: DKG

FOR: NBB

FORMATION ENVIRONMENTAL

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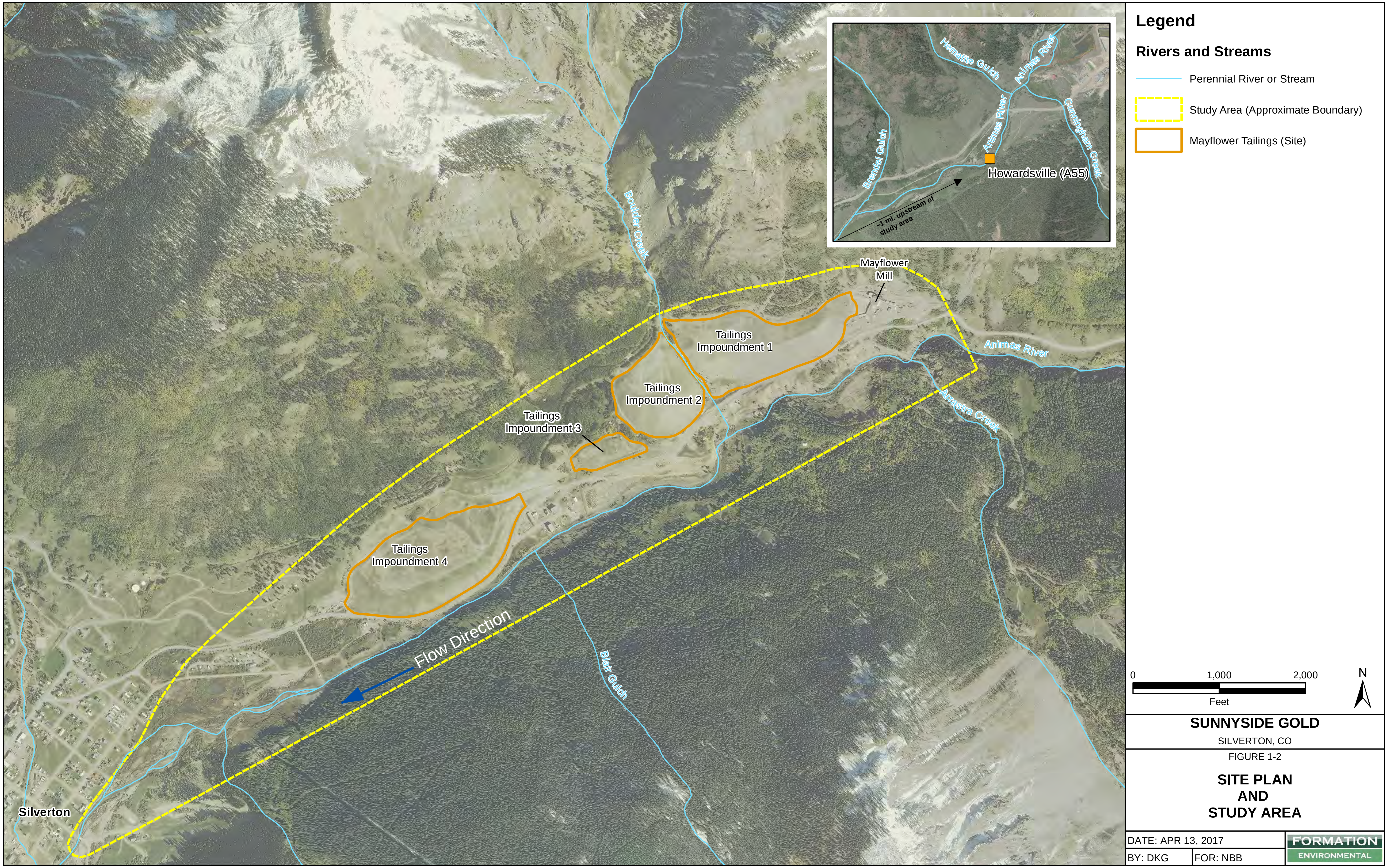


SUNNYSIDE GOLD

SILVERTON, CO

FIGURE 1-2

SITE PLAN AND STUDY AREA

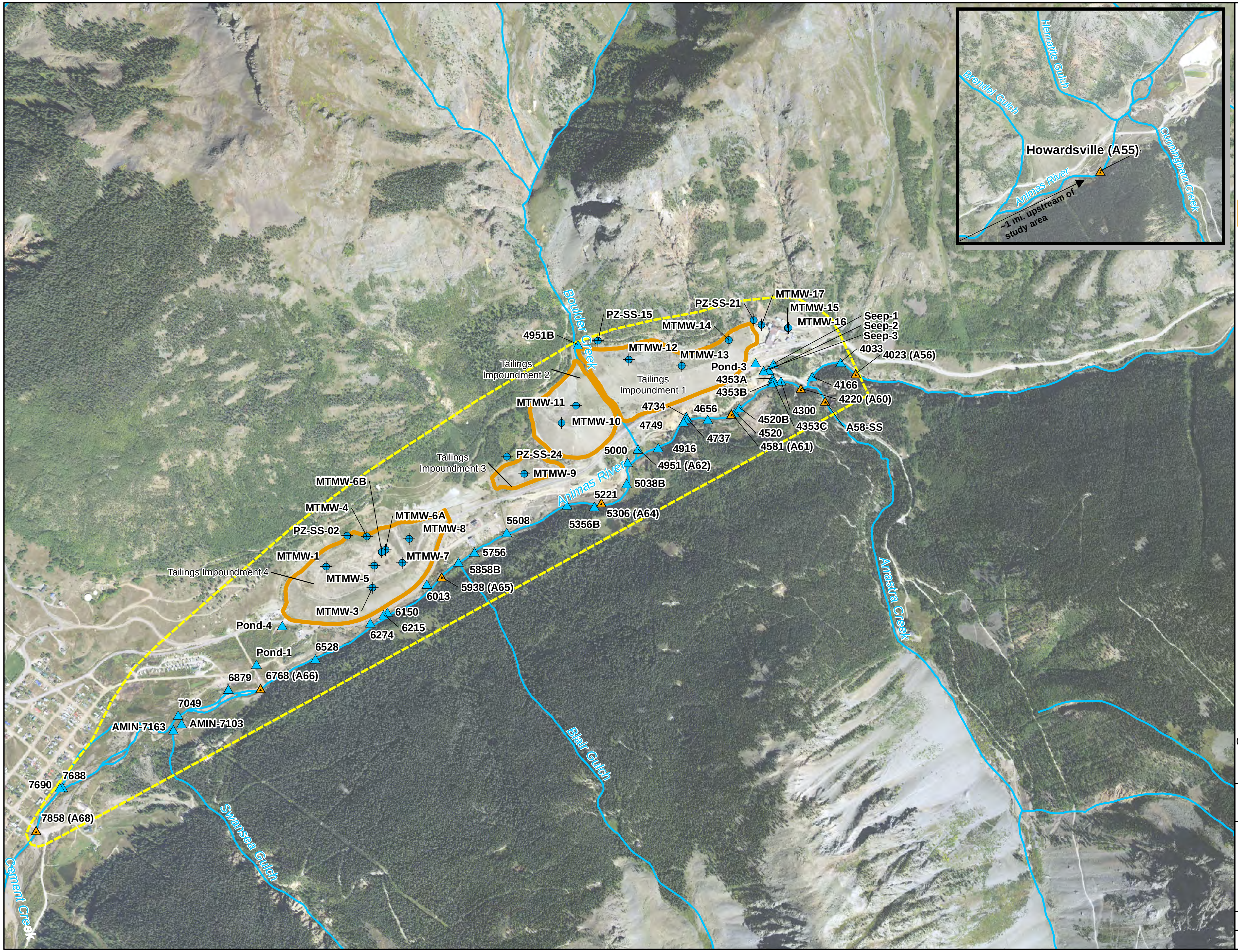
DATE: APR 13, 2017

BY: DKG

FOR: NBB

FORMATION ENVIRONMENTAL

S:\GIS\a5\065-001-Sunnyside-UpperAnimas\plt\WorkPlan_2017\Fig_1-02_SitePlanStudyArea.mxd



Legend

Multi-Media Stations

- Surface Water
- Surface Water, Pore Water, Sediment
- Groundwater

Mine Features

- Mayflower Tailings (Site)
- Study Area (Approximate Boundary)

Rivers and Streams

- Perennial Stream
- Ephemeral
- Braided

0 1,000 2,000
Feet

N

SUNNYSIDE GOLD

SILVERTON, CO

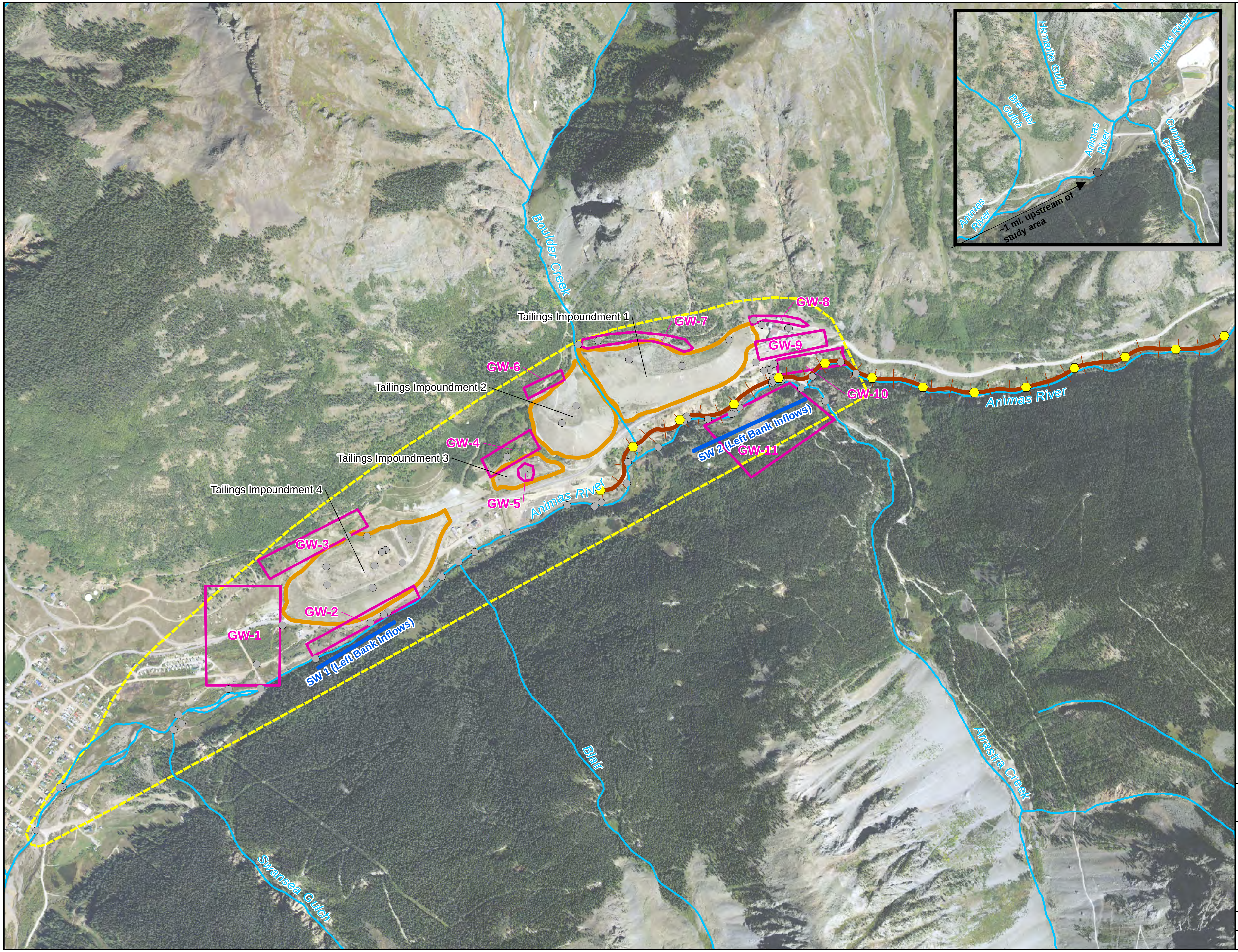
FIGURE 3-1

MULTI-MEDIA SAMPLE LOCATIONS

DATE: APR 13, 2017
BY: DKG
FOR: NBB

FORMATION ENVIRONMENTAL

S:\GIS\a5\065-001-Sunnyside-UpperAnimas\plt\WorkPlan_2017\Fig_3-01_MultiMediaSampLocs.mxd



Legend

- ⬢ Proposed Sample Locations (200m spacing)
- ● Existing Multi-Media Stations
- ━ Surface Water Areas of Interest
- ┼ Railroad Area Of Interest
- ☐ Groundwater Areas Of Interest

Rivers and Streams

- ─ Perennial Stream
- ‐·‐ Ephemeral
- ┄ Braided

Mine Features

- ☐ Mayflower Tailings (Site)
- ☐ Study Area (Approximate Boundary)

SUNNYSIDE GOLD

SILVERTON, CO

FIGURE 3-2

AREAS OF INTEREST

DATE: APR 13, 2017

BY: DKG

FOR: NBB

FORMATION ENVIRONMENTAL

S:\GIS\a5\065-001-Sunnyside-UpperAnimas\plt\WorkPlan_2017\Fig_3-02_AreasOfInterest.mxd

2017 Multi-Media Investigation Work Plan

Mayflower Tailings Impoundments Area

APPENDIX A - Quality Assurance Project Plan (QAPP)

May 2017

Prepared for:

Sunnyside Gold Corporation
5075 South Syracuse Street
Suite 800
Denver, CO 80237

Prepared by:

FORMATION
ENVIRONMENTAL
2500 55th Street, Suite 200
Boulder, Colorado 80301

APPROVAL PAGE

QUALITY ASSURANCE PROJECT PLAN FOR
2017 MULTI-MEDIA
INVESTIGATION WORK PLAN
MAYFLOWER TAILINGS IMPOUNDMENT AREA

Approved: ______________________ Date: 5-10-17

Pat Maley, Sunnyside Gold Program Manager

Approved: Brian G. Hansen Date: 5-10-17

Brian Hansen, Formation Environmental Project Manager

Approved: ______________________ Date: 5-10-17

Kathy Tegtmeyer, Formation Environmental Project QA Manager

Approved: ______________________ Date: 5-10-17

Nat Beal, Formation Environmental Field Investigations Manager

Plan is effective on date of last signature above.

EPA REGION 8 QA DOCUMENT REVIEW CROSSWALK

QAPP/FSP/SAP for: *(check appropriate box)* **GRANTEE** **CONTRACTOR** **EPA** X **Other**	**Entity** *(grantee, contract, EPA AO, EPA Program, Other)* Prepared by Formation Environmental for Sunnyside Gold Corp. and provided to EPA Region 8 for review and comment	**Regulatory Authority** **and/or** **Funding Mechanism**	**___40 CFR 31 for Grants** **___48 CFR Part 46 for Contracts** **___ Interagency Agreement** **___ EPA Administrative Order** **___ EPA Program Funding** **___ EPA Program Regulation** **___ EPA CIO 2105**
Document Title ***[Note: Title will be repeated in Header]***	2017 Multi-Media Investigation Work Plan – Mayflower Tailings Impoundments Area		
QAPP/FSP/SAP Preparer	Formation Environmental		
Period of Performance *(of QAPP/FSP/SAP)*	**CY 2017**	**Date Submitted for Review**	
EPA Project Officer **EPA Project Manager**	Rebecca Thomas	**PO Phone #** **PM Phone #**	
QA Program Reviewer or Approving Official		**Date of Review**	

Documents to Review:

1. QAPP written by Grantee or EPA must also include for review: N/A
   Work Plan(WP) / Statement of Work (SOW) / Program Plan (PP) / Research Proposal (RP)

2. QAPP written by Contractor must also include for review: N/A
   a) Copy of signed QARF for Task Order
   b) Copy of Task Order SOW
   c) Made available hard or electronic copy of approved QMP
   d) If QMP not approved, provide Contract SOW

3. For a Field Sampling Plan (FSP) or Sampling & Analyses Plan (SAP), the Project QAPP must also be provided.
   OR
   The FSP or SAP must be clearly identified as a stand-alone QA document and must contain all QAPP required elements (Project Management, Data Generation/Acquisition, Assessment and Oversight, and Data Validation and Usability).

Documents Submitted for QAPP Review:

1. QA Document(s) submitted for review:

QA Document	**Document Date**	**Document Stand-alone**	**Document with QAPP**
QAPP	**tbd**	Yes / No	
~~FSP~~		~~Yes / No~~	~~Yes / No~~
SAP	**tbd**	Yes / No	Yes / No
SOP(s)			Yes / No

2. WP/SOW/TO/PP/RP Date _______NA____
WP/SOW/TO/RP Performance Period __NA___________

3. QA document consistent with the:
WP/SOW/PP for grants? _Yes / No/ N/A
SOW/TO for contracts? _Yes / No/ N/A

4. QARF signed by R8 QAM Yes / No / N/A
Funding Mechanism ______________________
Amount _____________

Summary of Comments *(highlight significant concerns/issues)***:**

Element	**Acceptable** *Yes/No/NA*	**Page/ Section**	**Comments**
A. Project Management			
A1. Title and Approval Sheet			
a. Contains project title		QAPP title and approval pages; QAPP header (each page)	
b. Date and revision number line (for when needed)			
c. Indicates organization=s name			
d. Date and signature line for organization’s project manager			
e. Date and signature line for organization’s QA manager			
f. Other date and signatures lines, as needed			
A2. Table of Contents (TOC)			
a. Lists QA Project Plan information sections		QAPP TOC	
b. Document control information indicated		QAPP TOC	
A3. Distribution List			
Includes all individuals who are to receive a copy of the QA Project Plan and identifies their organization		Cover letter transmitted with Work Plan	
A4. Project/Task Organization			
a. Identifies key individuals involved in all major aspects of the project, including contractors		QAPP Section 2.3	
b. Discusses their responsibilities			
c. Project QA Manager position indicates independence from unit generating data			
d. Identifies individual responsible for maintaining the official, approved QA Project Plan			
e. Organizational chart shows lines of authority and reporting responsibilities			

A5. Problem Definition/Background			
a. States decision(s) to be made, actions to be taken, or outcomes expected from the information to be obtained		QAPP Section 2.1	
b. Clearly explains the reason (site background or historical context) for initiating this project			
c. Identifies regulatory information, applicable criteria, action limits, etc. necessary to the project		See comments.	Regulatory criteria for surface water are included in prior data reports (Formation, 2016 and Formation, 2017) and were referred to in development of these planning documents; no other regulatory standards apply; no action levels for project at this time.
A6. Project/Task Description			
a. Summarizes work to be performed, for example, measurements to be made, data files to be obtained, etc., that support the project=s goals		Work Plan Section 3.0	
b. Provides work schedule indicating critical project points, e.g., start and completion dates for activities such as sampling, analysis, data or file reviews, and assessments	N/A		No critical project dates. A general schedule is provided to meet the data needs identified in Section 2.0 of the Work Plan.
c. Details geographical locations to be studied, including maps where possible		Work Plan Figures 1-1, 1-2, 3-1, 3-2	
d. Discusses resource and time constraints, if applicable	N/A		
A7. Quality Objectives and Criteria			
a. Identifies - performance/measurement criteria for all information to be collected and acceptance criteria for information obtained from previous studies, - including project action limits and laboratory detection limits and - range of anticipated concentrations of each parameter of interest		Tables A2-2-A2-11; Tables A3-2 – A3-3	Acceptance criteria for information obtained from previous studies apply to data that will be used for quantitative risk assessment.
b. Discusses precision		QAPP Section 2.4	
c. Addresses bias			
d. Discusses representativeness			
e. Identifies the need for completeness			
f. Describes the need for comparability			

g. Discusses desired method sensitivity		QAPP Tables A2-10, A2-11, A3-2 and A3-3	
A8. Special Training/Certifications			
a. Identifies any project personnel specialized training or certifications		QAPP Section 2.5	
b. Discusses how this training will be provided			
c. Indicates personnel responsible for assuring training/certifications are satisfied		QAPP Section 2.5	
d. identifies where this information is documented			
A9. Documentation and Records			
a. Identifies report format and summarizes all data report package information		QAPP Section 2.6	
b. Lists all other project documents, records, and electronic files that will be produced			
c. Identifies where project information should be kept and for how long			
d. Discusses back up plans for records stored electronically			
e. States how individuals identified in A3 will receive the most current copy of the approved QA Project Plan, identifying the individual responsible for this		QAPP Section 2.3	
B. Data Generation/Acquisition			
B1. Sampling Process Design (Experimental Design)			
a. Describes and justifies design strategy, indicating size of the area, volume, or time period to be represented by a sample		Work Plan Sections 2.0 and 3.0	
b. Details the type and total number of sample types/matrix or test runs/trials expected and needed		Work Plan Section 3.0; Tables 3-4 and 3-5	

c. Indicates where samples should be taken, how sites will be identified/located		Work Plan Section 3.0; Tables 3-4 and 3-4; Figures 3-1 and 3-2	
d. Discusses what to do if sampling sites become inaccessible		Work Plan Section 3.0	
e. Identifies project activity schedules such as each sampling event, times samples should be sent to the laboratory, etc.		Work Plan Section 3.4 and QAPP Section 3.0	
f. Specifies what information is critical and what is for informational purposes only		Work Plan Section 2.0	
g. Identifies sources of variability and how this variability should be reconciled with project information			
B2. Sampling Methods			
a. Identifies all sampling SOPs by number, date, and regulatory citation, indicating sampling options or modifications to be taken		QAPP Attachment A-1, Standard Operating Procedures (SOPs)	
b. Indicates how each sample/matrix type should be collected			
c. If in situ monitoring, indicates how instruments should be deployed and operated to avoid contamination and ensure maintenance of proper data			
d. If continuous monitoring, indicates averaging time and how instruments should store and maintain raw data, or data averages			
e. Indicates how samples are to be homogenized, composited, split, or filtered, if needed			
f. Indicates what sample containers and sample volumes should be used		Work Plan Tables 3-1 and 3-2; QAPP Tables A2-10 and A3-1	
g. Identifies whether samples should be preserved and indicates methods that should be followed			

h. Indicates whether sampling equipment and samplers should be cleaned and/or decontaminated, identifying how this should be done and by-products disposed of		QAPP Attachment A-1 (SOPs)	
i. Identifies any equipment and support facilities needed		Work Plan Section 3.0 and QAPP Attachment A-1 (SOPs)	
j. *Addresses actions to be taken when problems occur*, identifying individual(s) responsible for corrective action and how this should be documented		QAPP Section 5.3, and Tables A2-2 through A2-9 for laboratory analyses.	
B3. Sample Handling and Custody			
a. States maximum holding times allowed from sample collection to extraction and/or analysis for each sample type and, for in-situ or continuous monitoring, the maximum time before retrieval of information		Work Plan Tables 3-1 – 3-2; QAPP Tables 2-10 and Table A3-1	
b. Identifies how samples or information should be physically handled, transported, and then received and held in the laboratory or office (including temperature upon receipt)		Work Plan Section 3.6; QAPP Section 3.2 and Attachment A-1 (SOPs)	
c. Indicates how sample or information handling and custody information should be documented, such as in field notebooks and forms, identifying individual responsible			
d. Discusses system for identifying samples, for example, numbering system, sample tags and labels, and attaches forms to the plan			
e. Identifies chain-of-custody procedures and includes form to track custody			

B4. Analytical Methods			
a. Identifies all analytical SOPs (field, laboratory and/or office) that should be followed by number, date, and regulatory citation, indicating options or modifications to be taken, such as sub-sampling and extraction procedures		QAPP Section 3.3.2 and Tables A3-2 and A3-3	
b. Identifies equipment or instrumentation needed		QAPP Attachment A-2. See comments.	Samples will be analyzed by contract laboratories in accordance with the referenced method numbers (EPA SW-846 methods, EPA drinking water methods, Standard Methods, ASTM Methods, etc.). In addition, each laboratory maintains internal SOPs on file. Laboratory-specific SOPs are available for review by the project team at any time.
c. Specifies any specific method performance criteria		QAPP Tables A2-2 through A2-10, and Attachment A-2.	
d. Identifies procedures to follow when failures occur, identifying individual responsible for corrective action and appropriate documentation			
e. Identifies sample disposal procedures		QAPP Attachment A-2.	
f. Specifies laboratory turnaround times needed		N/A	Each laboratory's standard turn-around times (3 to 5 weeks) are expected to meet this project's needs.
g. Provides method validation information and SOPs for nonstandard methods		QAPP Table A2-10.	
B5. Quality Control			
a. For each type of sampling, analysis, or measurement technique, identifies QC activities which should be used, for example, blanks, spikes, duplicates, etc., and at what frequency		QAPP Table A3-4 and Table A3-5	
b. Details what should be done when control limits are exceeded, and how effectiveness of control actions will be determined and documented		QAPP Section 3.4 and Tables A2-2 through A2-9	
c. Identifies procedures and formulas for calculating applicable QC statistics, for example, for precision, bias, outliers and missing data		QAPP Table A2-1	

B6. Instrument/Equipment Testing, Inspection, and Maintenance			
a. Identifies field and laboratory equipment needing periodic maintenance, and the schedule for this		QAPP Attachments A-1 (SOPs) and A-2 (laboratory Quality Management Plan)	See also comments at B4.b. regarding laboratory SOPs.
b. Identifies testing criteria			
c. Notes availability and location of spare parts			
d. Indicates procedures in place for inspecting equipment before usage			
e. Identifies individual(s) responsible for testing, inspection and maintenance			
f. Indicates how deficiencies found should be resolved, re-inspections performed, and effectiveness of corrective action determined and documented			
B7. Instrument/Equipment Calibration and Frequency			
a. Identifies equipment, tools, and instruments that should be calibrated and the frequency for this calibration		QAPP Attachments A-1 (SOPs) and A-2 (laboratory Quality Management Plan)	See also comments at B4.b. regarding laboratory SOPs.
b. Describes how calibrations should be performed and documented, indicating test criteria and standards or certified equipment			
c. Identifies how deficiencies should be resolved and documented			
B8. Inspection/Acceptance for Supplies and Consumables			
a. Identifies critical supplies and consumables for field and laboratory, noting supply source, acceptance criteria, and procedures for tracking, storing and retrieving these materials		QAPP Section 3.6	
b. Identifies the individual(s) responsible for this			
B9. Use of Existing Data (Non-direct Measurements)			
a. Identifies data sources, for example, computer databases or literature files, or models that should be accessed and used		QAPP Section 3.7	
b. Describes the intended use of this information and the rationale for their selection, i.e., its relevance to project			
c. Indicates the acceptance criteria for these data sources and/or models			
d. Identifies key resources/support facilities needed	N/A		No key resources associated with the types of non-direct measurements identified in the QAPP, Section 3.7.

e. Describes how limits to validity and operating conditions should be determined, for example, internal checks of the program and Beta testing	N/A		No operational elements identified in Non-direct Measurement section of QAPP (Section 3.7).
B10. Data Management			
a. Describes data management scheme from field to final use and storage		QAPP Section 3.8	
b. Discusses standard record-keeping and tracking practices, and the document control system or cites other written documentation such as SOPs			
c. Identifies data handling equipment/procedures that should be used to process, compile, analyze, and transmit data reliably and accurately			
d. Identifies individual(s) responsible for this		QAPP Section 3.8	
e. Describes the process for data archival and retrieval			
f. Describes procedures to demonstrate acceptability of hardware and software configurations	N/A		
g. Attaches checklists and forms that should be used		QAPP Attachment A-1 (SOPs)	Various SOPs include forms to be used to document field data collection and data validation.
C. Assessment and Oversight			
C1. Assessments and Response Actions			
a. Lists the number, frequency, and type of assessment activities that should be conducted, with the approximate dates		QAPP Section 5.0	
b. Identifies individual(s) responsible for conducting assessments, indicating their authority to issue stop work orders, and any other possible participants in the assessment process			
c. Describes how and to whom assessment information should be reported			
d. Identifies how corrective actions should be addressed and by whom, and how they should be verified and documented			

C2. Reports to Management			
a. Identifies what project QA status reports are needed and how frequently		QAPP Section 5.0	
b. Identifies who should write these reports and who should receive this information			
D. Data Validation and Usability			
D1. Data Review, Verification, and Validation			
Describes criteria that should be used for accepting, rejecting, or qualifying project data		QAPP Section 4.4	
D2. Verification and Validation Methods			
a. Describes process for data verification and validation, providing SOPs and indicating what data validation software should be used, if any		QAPP Section 4.4	
b. Identifies who is responsible for verifying and validating different components of the project data/information, for example, chain-of-custody forms, receipt logs, calibration information, etc.			
c. Identifies issue resolution process, and method and individual responsible for conveying these results to data users			
d. Attaches checklists, forms, and calculations		QAPP Attachment A-1, SOP No 20	
D3. Reconciliation with User Requirements			
a. Describes procedures to evaluate the uncertainty of the validated data		QAPP Sections 4.4, 4.5 and 4.6	
b. Describes how limitations on data use should be reported to the data users			

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LIST OF ACRONYMS

ACZ	ACZ Laboratories
ASTM	American Society for Testing and Materials
amu	Atomic Mass Unit
CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CLP	EPA Contract Laboratory Program
COC	Chain of Custody
DO	Dissolved Oxygen
DQOs	Data Quality Objectives
EDD	Electronic Data Deliverable
EDITQ	Equal Discharge Increment Technique
EPA	(United States) Environmental Protection Agency
FISP	Federal Interagency Sedimentation Project
HASP	Health and Safety Plan
HDPE	High Density Polyethylene
ICB	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICP-MS	Inductively Coupled Plasma-Mass Spectrometer
ICV	Initial Calibration Verification
JSA	Job Safety Analysis
LCS	Laboratory Control Sample
LCSD	Duplicate Laboratory Control Sample
LFB	Laboratory Fortified Blank
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Not Detected
NFGs	National Functional Guidelines
ORP	Oxidation-Reduction Potential
PARCC	Precision, Accuracy, Representativeness, Comparability, and Completeness
PQV	Practical Quantitation Verification
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control

QL	Quantitation Limit
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SAP	Sampling and Analysis Plan
SGC	Sunnyside Gold Corporation
SOP	Standard Operating Procedure
TA	Target Analyte
USCS	United Soils Classification System

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) comprises Appendix A of the *2017 Multi-Media Investigation Work Plan for the Mayflower Tailings Impoundments Area* (Work Plan). The purpose of this QAPP is to describe the quality assurance and quality control (QA/QC) policies and procedures that will be used during data collection and evaluation conducted in support of the multi-media investigation proposed for the study area defined in the Work Plan. Additional areas outside of this study area may be investigated, as directed by the Sunnyside Gold Corporation (SGC). Investigations in these areas would be conducted in accordance with this QAPP.

The QAPP describes the measures that shall be employed during the multi-media investigation to assure that data generated are of a known and defensible quality in relation to the overall objectives of the investigation. These measures will assure that the precision and accuracy of program data are known and documented; sample collection, analysis, and reporting are complete; and samples are representative of tested environmental media. This plan also provides guidance for documentation of information collected in the field, including field quality control data; maintenance of documented sample custody and laboratory analytical procedures; and quality control data for data verification and validation.

The QAPP was prepared in accordance with United States Environmental Protection Agency (EPA) guidance on Quality Assurance Project Plans (EPA, 2002; EPA QA/G-5) and EPA Requirements for Quality Assurance Project Plans (EPA, 2001; EPA QA/R-5). It is comprised of the following four basic project plan elements:

- project management;
- data generation and acquisition;
- data review, validation, and usability; and
- data assessment and oversight.

The subsections that follow provide the four EPA project plan elements (EPA, 2002), and each presents the topics applicable to that element with appropriate Site-specific content, as needed for planning the investigation of environmental media in the study area.

2.0 PROJECT MANAGEMENT

This section addresses project administrative functions and project concerns, goals, and approaches to be followed during implementation of the surface water, groundwater, and solid phase media investigation.

2.1 Problem Definition and Background

The study area is located in the Animas River basin. Volcanic rocks within the basin are intensely mineralized. Natural weathering of mineralized rocks degrades the basin's surface water quality. Streams within the basin that are considered representative of natural-background conditions (i.e., unaffected or minimally affected by mining activity) can be acidic (pH <3.0) with elevated metals concentrations, including zinc, copper, and manganese, above aquatic life standards (Church and others, 2007). Environmental conditions in the Animas River basin also reflect influences from the extensive historical mining and milling activities that occurred over the past 150 years, including mining in areas upstream of the Mayflower Tailings Impoundments Area and on the left bank of the Animas River (opposite the tailings impoundments). Mine adits and mine waste rock piles are present at numerous locations in the Animas River basin, and historically mills discharged tailings to the Animas River and its tributaries. Currently, there are no active mine or mill sites within the study area.

Additional data are needed to better understand the relationship, if any, between the Mayflower Tailings Impoundments Area and metals concentrations in the groundwater underlying the impoundments that discharges to the river. Data are also needed to better understand the groundwater flow paths in the fractured bedrock system and the relationship between metals potentially sourced in the fractured bedrock and the groundwater that discharges to the river. Finally, additional data are needed to better understand the groundwater flow paths and the source(s) of metals in the groundwater on the left bank of the river and in the groundwater downgradient of the Mayflower Mill and downgradient of TP-4.

2.2 Project Description

The Work Plan presents the rationale and scope of data collection and monitoring activities planned to achieve the investigation objectives described above. The data collection activities associated with the multi-media investigation are described in detail in Section 3.0 of the Work Plan.

2.3 Project Organization

The multi-media investigation is being conducted by SGC.

SGC's responsibilities include preparation of project planning documents, collection of data needed to complete the surface water, groundwater, and solid media investigation and data analysis and interpretation as needed to complete the investigation.

- An organization chart for this project is shown by Figure A2-1 and the SGC project team and responsibilities are described below. Formation Environmental LLC (Formation), Boulder, CO (environmental services contractor); and
- ACZ Laboratories (ACZ), Steamboat Springs, CO (analytical laboratory contractor); and
- Isotope Tracer Technologies, Waterloo, Ontario (analysis and testing laboratory contractor)

SGC Program Manager (Pat Maley, Sunnyside Gold Corporation)

Oversees scheduling and management of all technical and non-technical aspects of the project (e.g., field activities, data collection, data analysis, report preparation, scheduling, costing) and serves as primary point of contact with agency representatives.

SGC Site Manager (Larry Perino, SGC).

Reports to SGC's Program Manager and serves as the local liaison and provides access and historical knowledge for the mine site.

SGC Field Representative (Terry Turner, SGC).

Reports to SGC's Program Manager and oversees all field aspects of the project, including sample collection, measurements, and data collection**.**

Formation Project Manager (Brian Hansen, P.E., Formation)

Oversees scheduling and management of all technical and non-technical aspects of the project (e.g., field activities, data collection, data analysis, report preparation, scheduling, costing) and reports to the SGC Program Manager. Directs the Field Investigations Manager and Project QA Manager. Ensures that all field personnel understand the scope of work including QA/QC requirements. Responsible for ensuring that the sampling methods and data analyses reflected in the Sampling and Analysis Plan (SAP) meet the objectives of the Work Plan. Reviews and approves project plans and all project deliverables.

Field Investigations Manager (Nat Beal, P.G., Formation)

Plans and supervises sampling and other field activities and coordinates acquisition of any necessary permits. Schedules and manages various field tasks (e.g., sample collection, measurements, data collection) and is responsible for sample transport to the laboratory.

Responsible to the SGC and Formation Project Managers for implementation of field sampling activities, QA/QC measures, and health and safety program requirements defined in the Appendix B of the Work Plan. The Field Investigations Manager is also responsible for ensuring that field staff have appropriate, hands-on training and properly utilize the project Standard Operating Procedures (SOPs; Attachment A-1). The Field Investigations Manager is also responsible for informing field staff when water samples are to be collected and analyzed for isotopic compositions.

Project QA Manager (Kathy Tegtmeyer, Ph.D., Formation)

Responsible for coordinating the development and approval of the QAPP and its supporting procedures and for maintaining the current, approved version of the QAPP for use on the project. Assures that all personnel on the distribution list receives the most current copy of the QAPP. The QA Manager participates in the review and approval of all project deliverables, assists with establishing laboratory contracts, acts as a day-to-day liaison with the laboratories, directs field and laboratory audit activities, coordinates any subsequent corrective and preventive actions, if needed, and communicates regularly with the Formation Project Manager and Field Investigations Manager regarding any laboratory or data validation concerns. The QA Manager will also oversee data validation efforts and coordinate the resolution of any necessary corrective actions resulting from data validation activities, including any quality issues that may be resolved during field activities (i.e., resampling to replace unusable samples).

Contracted Laboratories - ACZ Laboratories Project Manager and Isotope Tracer Technologies Project Manager

Reviews QAPP and ensures laboratory resources are available for the requested work, reviews final analytical reports produced by the laboratory, coordinates scheduling of laboratory analyses, and supervises in-house chain-of-custody and reporting procedures.

2.4 Quality Objectives and Criteria for Measurement Data

This section describes the data needed to address the study objectives as well as the measurement performance criteria established to assess the field and laboratory data quality. Measurement performance criteria are established by defining acceptance criteria and quantitative or qualitative goals (e.g., control limits) for precision, accuracy, representativeness, comparability, and completeness (PARCC). The definitions of PARCC are provided below along with the acceptance criteria for data collected in support of this investigation.

The range of anticipated concentrations for the various media that will be sampled in 2017 has been established through review of existing chemical data from similar samples collected from within the study area over time. Historical surface water data from the study area were considered when selecting the laboratory analytical methods. Historical data for pore water, sediment, and soils in the study area were also available for estimating a range of anticipated concentrations.

2.4.1 Data Quality Objectives

The data quality objectives (DQOs) for this program are presented in Section 2.0 of the Work Plan. Consistent with EPA guidelines (EPA, 2006a), the DQOs describe the systematic planning of data collection activities to assure that the proper type, quality, and quantity of data are collected. The DQOs will be fulfilled by implementation of these QA and QC activities during data collection in support of the investigation:

- Following specific sampling designs (refer to the Work Plan);
- Adherence to standardized procedures for field measurements, sampling, sample handling, and sample chain of custody (COC) procedures;
- Collection and analyses of field and laboratory QC samples, as discussed in Section 3.4.1 and in Section 3.4.2, respectively;
- Analyses of samples in accordance with standard method protocols selected to meet the project's measurement performance goals (Section 2.4.3) and detectability requirements (Section 3.4.2);
- Adherence to the laboratory analysis methods, and their associated quality control steps, specified for analyses of environmental samples (Section 3.4.2);
- Implementation of laboratory-specific preventative maintenance measures;
- Data review and reduction by the laboratories;
- Data validation; and
- Quality auditing and corrective/preventative action processes, as described in this QAPP.

2.4.2 Measurement Performance Criteria - Definitions

The definitions of PARCC are provided below along with the acceptance criteria for data collected in support of the investigation. Equations for calculation of precision, accuracy, and completeness are also provided in Table A2-1.

Precision

Precision is the level of agreement among repeated measurements of the same characteristic. There are two general forms of uncertainty. The first is the random error component of the data collection process. The second is inherent stochastic variability, which cannot be eliminated but can be described.

Data precision is assessed by determining the agreement between replicate measurements of the same sample and/or measurements of duplicate samples. The overall random error component of precision is a function of the sampling and analytical precision and is assessed by the analysis of field duplicates. The analytical precision is determined by the analysis of field duplicates by laboratories and by replicate analyses of the same sample. An analytical duplicate is the preferred measure of analytical method precision. When analytes are present in samples at concentrations below or near the quantitation limit (QL), precision may be evaluated using duplicate analyses of laboratory prepared samples such as duplicate laboratory control samples (LCS/LSCD) and duplicate laboratory matrix spike samples (MS/MSD).

Precision can be measured as relative percent difference (RPD) or as relative standard deviation (RSD; also known as a coefficient of variation). Formulae for both are presented in Table A2-1.

Accuracy

Accuracy is the degree of difference between the measured or calculated value and the true value. It is a measure of the bias or systematic error of the entire data collection process. Potential sources of systematic errors include:

- sample collection methods;
- physical or chemical instability of the samples;
- interference effects during sample analysis;
- calibration of the measurement system; and
- contamination.

Data accuracy or analytical bias may be evaluated by the analysis of laboratory control samples (LCS) and/or matrix spike (MS) samples, with results expressed as a percentage recovery measured relative to the true (known) concentration (refer to Table A2-1 for percent recovery calculations).

Field equipment and laboratory blanks may be analyzed to assess artifacts introduced during sampling, transport, and/or analysis that may affect the accuracy of the data. In addition, initial calibration verification samples and continuing calibration verification samples (ICV and CCV) and initial calibration blanks and continuing calibration blanks (ICB and CCB) may be used to verify that the sample concentrations are accurately measured by the analytical instrument throughout the analytical run.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental conditions. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program. Representativeness of samples shall be achieved through the careful selection of sampling locations and methods. The sampling program described in Section 3.0 of the Work Plan has been designed to provide samples that are representative of the medium being sampled as well as a sufficient number of samples to meet the project DQOs.

Comparability

Data comparability is defined as the measure of the confidence with which one data set can be compared to another. Comparability is a qualitative parameter but must be considered in the design of the sampling plan and selection of analytical methods, quality control protocols, and data reporting requirements.

Completeness

Completeness refers to the amount of useable data produced during a sampling and analysis program. The procedures established in this QAPP are designed to ensure, to the extent possible, that data shall be valid and usable. To achieve this objective, every effort shall be made to collect each required sample and to avoid sample loss.

2.4.3 Measurement Performance Goals for Target Analytes

This section identifies numerical goals for precision, accuracy, and completeness for analyses of the various environmental media. Failure to meet these goals shall be considered in the data validation process described in Section 4.0. Measurement performance goals for the target analytes listed in the Work Plan are described below and also provided in Tables A2-2 through A2-9.

Precision

Precision shall be determined on field data and laboratory analysis data by the analysis of field duplicates, laboratory replicates, matrix spike and matrix spike duplicate results and evaluation of the RPD for these various paired measurements. The RPD goals for measures of precision associated with the analytical methods are presented in Tables A2-2 through A2-9.

Accuracy

Sampling accuracy shall be determined by the collection and analysis of equipment blanks, at the frequencies described in Section 3.4.

Laboratory accuracy is determined by the analysis of calibration and method blanks, calibration verification samples, laboratory control samples or standard reference materials, and matrix spike samples. Method blank goals shall be that blanks contain less than the quantitation limit for each target parameter. Accuracy goals for the specific laboratory analysis methods that will be relied on to generate data for the investigation are summarized in Tables A2-2 through A2-9.

Representativeness

Representativeness is addressed by the description of the sampling techniques and the rationale used to select the sampling locations. Sampling methods are established by the SOPs provided in Attachment A-1. Sample representativeness is also evaluated using the RPDs for field duplicate results and by a review of the results of field blanks (i.e., equipment blanks as appropriate to sampling methods).

Representativeness of individual sample analyses will be described on the basis of results obtained from associated laboratory quality control samples. The representativeness of sample analyses will be considered acceptable as long as any detectable concentrations of analytes in associated field and method blanks are less than the quantitation limit.

Comparability

Comparability shall be ensured by analyzing samples obtained in accordance with appropriate SOPs and the referenced standard laboratory analysis methods. All data should be calculated and reported in units consistent with standard reporting procedures so that the results of the analyses can be compared with those of other laboratories, if necessary. In general, data shall be reported in µg/L for water matrices.

Completeness

The project's completeness goals are 95 percent for analyses of each sample type (i.e., surface water/pore water, groundwater, sediment, and other solid media).

2.4.4 Measurement Performance Goals for Isotope Analyses

The laboratory-analysis methods and associated accuracy and precision goals for analysis of stable isotopic ratios and tritium abundance in water samples are provided in Table A2-10. Analysis results reported within the specifications noted on Table A2-10 will be considered usable for characterizing isotopic compositions of oxygen and hydrogen in water and oxygen and sulfur in dissolved sulfate.

2.4.5 Measurement Performance Goals for Meteorological Monitoring

The measurement performance objectives for on-site meteorological monitoring are presented in Table A2-11 and defined in the EPA's *Meteorological Monitoring Guidance for Regulatory*

Modeling Applications (EPA, 2000b; Sections 3 and 5). Data completeness will be assessed by dividing the number of valid hourly averages by the number of hours available during the monitoring period, and then multiplying that number by 100. The DQO for data completeness is 90 percent for the quarter.

2.5 Training Requirements

Field personnel shall be trained in the requirements of the Work Plan and this QAPP at a project meeting prior to the initiation of field activity. All personnel shall read the Work Plan documents, including this QAPP, prior to the start of field work and shall acknowledge that they have read the documents at the time of the project meeting. In addition, prior to conducting sampling activities, the Field Investigations Manager, or designee, shall review field procedures and sampling requirements in order to better ensure that samples are collected and handled according to Work Plan and QAPP requirements. Field personnel will also be trained in the use of field equipment, decontamination procedures, and COC procedures in accordance with SOPs used for this project (Attachment A-1). One hard copy of the current approved version of the Work Plan shall be maintained for ready-reference purposes in the field vehicle or field office. All field team members shall have access to *.pdf format files of the complete Work Plan through their personal laptop computers. The Field Investigations Manager will be responsible for assuring that field personnel have the appropriate training for the task and will maintains training records for each employee.

2.6 Documentation and Records

This section describes the management of project documents and records, including this QAPP. All field documentation will be conducted in accordance with the procedures described in SOP No. 1, *Field Documentation* (Attachment A-1).

2.6.1 Field Logbooks

Documentation of observations in the field provides information on conditions at the time of sampling and a permanent record of field activities. Field observations and data collected during sampling activities will be recorded with waterproof ink in a permanently bound weatherproof field log book with consecutively numbered pages, or on field forms associated with the individual SOPs found in Attachment A-1 of the Work Plan. Field forms for recording various types of sampling and measurement activities. The appropriate field forms are located in the applicable SOP (Attachment A-1). The SOPs also provide instructions for recording field activities at the time of field measurements or sample collection.

Field notebook and data sheet entries will, at a minimum, include the information listed below:

- Project name and number;
- Sample location;

- Data and time of sample collection;
- Sample identification numbers;
- Description of sample (sample matrix or species);
- Number of samples collected;
- Field measurements;
- Field observations and weather conditions;
- Personnel present;
- Sampler's signature; and
- Field filtration activities and equipment, if performed.

In addition, other ancillary information shall be recorded, including:

- personnel and/or other visitors to the sampling site(s);
- weather conditions;
- presence of livestock or wild game; and
- any unusual events.

Changes or deletions in the field book or on the data sheets will be recorded with a single strike mark through the changed entry, with the sampler’s initials and the date recording the new entry. All entries must remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without having to rely on the sampler’s memory.

Completed field forms and logbooks will be copied to the project’s quality records (refer to Section 2.6.4) in addition to copies of outgoing COCs and sample shipping documents.

2.6.2 Chain of Custody Records

Documentation of sample custody must be maintained. Information on the custody, transfer, handling, and shipping of samples shall be recorded by field personnel on a COC form as specified in SOP No. 2 (Attachment A-1), and as described in greater detail in Section 2.6.2 below.

A COC form shall be completed for each set of samples collected daily and shall contain the following information:

- sampler's signature and affiliation;
- program name and identification number;
- date and time of collection;
- sample identification number and matrix;

- analyses requested;
- number of containers;
- signature of persons relinquishing custody, dates, and times;
- signature of persons accepting custody, dates, and times;
- method of shipment; and
- shipping papers/waybill identification number (as appropriate).

A copy of each as-transmitted COC form shall be retained in the program quality records (refer to Section 2.6.4).

2.6.3 Analytical Laboratory Records

Results received from the laboratory will be documented both in report form and in electronic format. Original hard copy and/or electronic reports and data files received from laboratories will be maintained with the program quality records, as described below. Section 4.0 presents the project's laboratory reporting requirements in detail. The final deliverable ("data package" or "report") issued to SGC and Formation will include data necessary to complete validation of laboratory results in accordance with specifications included in Section 4.0.

2.6.4 Program Quality Records

Program quality records are defined as completed, legible documents that furnish objective evidence of the quality of items or services, activities affecting quality, or the completeness and quality of data. These records shall be organized and managed by Formation and shall include, at a minimum:

- copies of all bound field logbooks;
- copies of all field documentation forms;
- copies of all electronic files from field data loggers or other in situ instrumentation;
- field copies and original (laboratory) copies of all COC forms;
- incoming and outgoing program correspondence (letters, telephone conversation records, and e-mail messages);
- copies of all laboratory agreements and amendments thereto;
- as-received laboratory data packages (hard copy and/or electronic);
- complete laboratory data validation packages;
- documentation of field and/or laboratory audit findings and any corrective actions;
- draft and final versions of all monthly and quarterly reports; and

- draft and final delivered versions of the investigation report(s) and supporting procedures such as statistical analyses, numerical models, etc.

The other documentation included in the program's quality records include the approved Work Plan and QAPP, any approved revisions or addendums to the Work Plan and QAPP, and SOPs referred to for field data collection with any updates, revisions, or addendums to those SOPs approved by the Project Managers and Field Investigations Manager to address specific conditions encountered during the field investigation.

Formation Environmental will maintain project information for as long as they are under contract to SGC to do so. SGC will be responsible for maintaining project information thereafter.

3.0 DATA GENERATION AND ACQUISITION

The elements in this section address management of data generation and acquisition activities.

3.1 Sampling Design

The Work Plan provides a detailed description of the multi-media sampling design. Below is a description of the investigation methods. The SOPs included in Attachment A-1 provide a more detailed description of those procedures, and they also provide information on field documentation and QA activities for the sampling team.

3.1.1 Sampling Locations and Frequencies

Comprehensive sampling activities, including sampling locations, are summarized in the Work Plan. The number and types of samples that will be collected and sampling locations are detailed in Section 3.0 of the Work Plan.

3.1.2 Surface Water Sampling Methods

Surface water samples will be collected in accordance with methods specified in SOP No. 5, *Surface Water Sampling* (Attachment A-1). One or more of the eight sampling methods described in the SOP will be used for the collection of the surface water samples.

During high-flow conditions, it is anticipated that the majority of the surface water samples will be collected using the “Dipper Method”. The Dipper Method utilizes a sample container attached to a pole that is then dipped into the water body and the sample is collected as a “grab sample” from just below the surface of the water. At the seeps and springs and other features that do not have adequate water for the dipper method the direct method will be used.

During low-flow conditions, it is anticipated that majority of the surface water samples will be collected using the “Dipper Method”. At the seeps and springs and other features that do not have adequate water for the dipper method the direct method will be used. The Equal Discharge Increment Technique (EDITQ) may be used, as needed, and will require protocols specified in the *“Operators Manual for the US DH-81 Depth-Integrated Suspended-Sediment Sampler”* (Federal Interagency Sedimentation Project (FISP), Undated). This technique will be employed during the low-flow event at all locations that warrant its use. It will be at the discretion of the field team lead to determine if the sampling location is suitable to perform this type of sampling using the DH-81. This process of using EDITQ will provide equal sample volumes at each stream vertical sample taken from the cross-section of the stream or river.

An adequate sample volume will be collected from each sample location to meet the required volume for the various laboratory analyses described in Section 3.3 of the QAPP. Depending on the sample collection method used, multiple aliquots may need to be collected to form a composite sample of adequate volume for laboratory analysis. Composite samples will be temporarily contained in an inert disposable container. A portion of the sample collected at each location will be field filtered with a 0.45 micron filter and containerized in the appropriate sample bottles. The non-filtered portion of the sample will then be containerized in the appropriate sample bottles. The remainder of the sample will be used for measurement of field parameters. Field parameters will be measured with a water quality instrument(s) in accordance with the procedures described in SOP No. 5, *Water Quality Sampling* (Attachment A-1). Field parameters include: temperature, turbidity, pH, specific conductance, dissolved oxygen (DO), and oxidation reduction potential (ORP). Calibration of the instrument(s) used to measure the field parameters is described in Section 3.6.1 of this QAPP. The water quality meter(s) will be calibrated in accordance with SOP No. 31, *Water Quality Meter Calibration* (Attachment A-1).

During sample collection, care will be taken to minimize disturbance of sediment at the bottom of the water body. Samples will be collected in sequential order from the furthest downstream location to the furthest upstream location, unless the sampler does not enter the water, in which case samples can be collected in the order selected by the sampling team(s) based on field logistics. All non-dedicated sampling equipment will be decontaminated between each sample location in accordance with the procedures described SOP No. 7, *Equipment Decontamination* (Attachment A-1). Documentation for field sampling is described in Section 2.6 of this QAPP and sample, handling, preservation and custody procedures are described below.

Manual stream discharge measurements will be conducted, where feasible, in accordance with the methods described in SOP No. 6, *Surface Water Discharge Measurement* (Attachment A-1). The selection of a discharge measurement method depends on stream flow rate and/or specific channel characteristics.

During high-flow conditions, it may be unsafe for personnel to enter the stream at a particular sample location. The health and safety plan (HASP) for this investigation is included in Appendix B of the Work Plan that includes a job safety analysis (JSA) that describes recommended safe job procedures for stream monitoring. If it is determined, based on the JSA, that conditions are unsafe then a measurement will not be taken.

3.1.3 Pore Water Sampling Methods

Pore Water samples will be collected by inserting a PushPoint® sampler into the hyporheic zone and purging until the pore water runs clear in accordance with *Pore Water Sampling*, SOP No. FLD-10 (ESAT, 2012a; Attachment A-1). The syringe used to extract the pore water will be rinsed three times prior to sample collection with water from the location.

An adequate sample volume will be collected from each sample location to meet the required volume for the various laboratory analyses described in Section 3.3 of the QAPP. Given the limited volume of the syringe, multiple aliquots will be collected to form a composite sample of adequate volume for laboratory analysis. Composite samples will be temporarily contained in an inert disposable container. A portion of the sample collected at each location will be field filtered with a 0.45 micron filter and containerized in the appropriate sample bottles. The non-filtered portion of the sample will then be containerized in the appropriate sample bottles. The remainder of the sample will be used for measurement of field parameters. Field parameters will be measured with a water quality instrument(s) in accordance with the procedures described in SOP No. 5, *Water Quality Sampling* (Attachment A-1). Field parameters include: temperature, turbidity, pH, specific conductance, DO, and ORP. Calibration of the instrument(s) used to measure the field parameters is described in Section 3.5.1 of this QAPP. The water quality meter(s) will be calibrated in accordance with SOP No. 31, *Water Quality Meter Calibration* (Attachment A-1).

During sample collection, care will be taken to minimize disturbance of sediment at the bottom of the water body. Samples will be collected in sequential order from the furthest downstream location to the furthest upstream location, unless the sampler does not enter the water, in which case samples can be collected in the order selected by the sampling team(s) based on field logistics. All non-dedicated sampling equipment will be decontaminated between each sample location in accordance with the procedures described SOP No. 7, *Equipment Decontamination* (Attachment A-1). Documentation for field sampling is described in Section 2.6 of this QAPP and sample, handling, preservation and custody procedures are described below.

Pore water samples will not be collected during high-flow conditions because of health and safety dangers related to entering fast moving water. Therefore, these samples will only be collected during low-flow conditions. The HASP for this investigation is included in Appendix B of the Work Plan and includes a JSA that describes recommended safe job procedures for stream monitoring.

3.1.4 Groundwater Sampling Methods

Groundwater samples and water level measurements will be collected in accordance with methods specified in SOP No. 4, *Groundwater Sampling and Water Level Measurements at Monitoring Wells and Piezometers* (Attachment A-1). Field parameters will be measured with a water quality instrument(s) in accordance with the procedures described in SOP No. 4, *Groundwater Sampling and Water Level Measurements at Monitoring Wells and Piezometers* (Attachment A-1). Field parameters include: temperature, turbidity, pH, specific conductance, DO, and ORP. Calibration of the instrument(s) used to measure the field parameters is described in Section 3.5.1 of this QAPP. The water quality meter(s) will be calibrated in accordance with SOP No. 31, *Water Quality Meter Calibration* (Attachment A-1). All non-dedicated sampling equipment will be decontaminated between each sample location in accordance with the procedures described SOP No. 7, *Equipment Decontamination*

(Attachment A-1). Documentation for field sampling is described in Section 2.6 of this QAPP and sample, handling, preservation and custody procedures are described below.

3.1.5 Sediment Sampling Methods

Sediment samples will be collected using dedicated Teflon scoops and placed in high density polyethylene (HDPE) containers based on the protocols outlined in *Shallow Stream Sediment Sampling* SOP No. FLD-06 (ESAT, 2012b; Attachment A-1). Several sediment subsamples may be collected to achieve the required sample volume. These samples may be collected from a stretch of creek that is upstream and downstream of the actual sampling location. These subsamples will then be combined and homogenized back at the laboratory. No sampling equipment needs to be decontaminated since the Teflon scoops are not re-used across sampling locations.

Sediment samples will not be collected during high-flow conditions because of health and safety dangers related to entering fast moving water. Therefore, these samples will only be collected during low-flow conditions. The HASP for this investigation is included in Appendix B of the Work Plan and includes a JSA that describes recommended safe job procedures for stream monitoring.

3.1.6 Other Solid Phase Media Sampling Methods

Surface or near-surface opportunistic solid phase media samples, including but not limited to soils, mine waste, and mineralized rock, will be collected in accordance with methods specified in the *Standard Operating Procedures for Soil Sampling*, FLD-05 (ESAT, 2012c; Attachment A-1). Samples will be collected using dedicated Teflon scoops. It is expected that no sampling equipment will need to be decontaminated since the Teflon scoops are not re-used across sampling locations. In the event non-dedicated equipment is needed, all non-dedicated sampling equipment will be decontaminated between each sample location in accordance with the procedures described SOP No. 7, *Equipment Decontamination* (Attachment A-1).

3.1.7 Core Sampling Methods

Solid-phase media samples will be collected in accordance with methods specified below. Following sample collection, all equipment will be decontaminated in accordance with the procedures described in SOP No. 7, *Equipment Decontamination* (Attachment A-1). Composite samples will be collected using the following methods.

Samples of unconsolidated tailings and alluvium will be collected during borehole advancement. The time of collection will be noted, along with any water or problems associated with recovery of the core. The core will be labelled as it is brought to the logging station noting the borehole ID, depth, and orientation of the core, and placed onto a clean sheet of plastic at the logging station. Each interval will be photographed. The color, moisture content, texture, primary and secondary minerals will be recorded.

For each interval to be sampled for geochemistry, a minimum of 1.5 kilograms (approximately 1 quart) of sample will be removed from the upper portion (6 inches of the interval) using a clean and dry scoop, trowel, or gloved hand. This volume should be confirmed using a scale for the initial samples. For geochemical samples, a fresh gallon sized zip-lock bag will be used to collect this sample. If encountered, oversized (larger than fist sized) clasts will be excluded from this sample.

3.1.8 Core Logging Methods

The core will be logged in accordance with SOP No. 12, *Drilling and Installation of Shallow Monitoring Wells* and SOP No. 23 *Installation of Deep Bedrock Monitoring Wells* (Attachment A-1). Lithological and textural descriptions will be noted on a borehole log in accordance with the Unified Soils Classification System (USCS) and appropriate American Society for Testing and Materials (ASTM) guidance. Bedrock fractures may be documented using the discrete fracture network logging approach or a similar method (Golder Associates, 2010).

3.2 Meteorological Data Collection

Meteorological parameters (wind direction and speed, temperature, relative humidity, barometric pressure, precipitation, solar radiation) will be collected in a manner consistent with the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements (EPA, 2006b), and as provided in the Multi-Media Work Plan.

The sensors to be used for the horizontal wind speed, horizontal wind direction, ambient temperature, barometric pressure, solar radiation, and precipitation will be acquired through Campbell Scientific and will meet the specifications stated in the *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA, 2000b; EPA-454/R-99-005) and the EPA QA Handbook Volume IV. These sensors will be continuously operated throughout the planned field investigations.

3.3 Sample Handling, Preservation, and Custody

This section describes sample handling requirements and COC procedures from the sample collection step through laboratory analysis and ultimate disposal. Sample custody, packaging, and shipment procedures are described in SOP No. 2, Sample Custody, Packaging and Shipment (Attachment A-1).

3.3.1 Sample Containers, Preservation, and Holding Times

Sample Containers

The laboratory will provide new, certified pre-cleaned, prepared sample containers for aqueous sample matrices (i.e., surface water, rinsates, etc.), appropriate to the list of analyses specified on Table A3-1. Solid-phase samples will be contained in sealable, plastic storage bags (e.g., Wirrl Paks or freezer-type Ziplock bags). After the well-mixed sample material has been transferred to the plastic bag, the bag will be sealed and labeled and then placed into a second, sealable plastic bag to protect the label.

The mass of material collected and contained for shipping to the laboratory will be sufficient for the list of solid-phase analyses listed in Table A3-1.

Sample Preservation and Storage

Samples are preserved in order to prevent or minimize chemical changes that could occur during transit and storage. Sample containers containing appropriate preservative are used to ensure preservation immediately upon sample collection. The contracted laboratories will provide containers and appropriate preservatives (i.e., “pre-preserved” containers), as needed for the analyses to be requested.

Aqueous samples (e.g., surface water, equipment rinsates, etc.) submitted for metals/metalloids analyses require preservation upon collection, as specified in Table A3-1. Preservation requirements are associated with the individual analyses to be performed and the referenced analytical methods.

Solid-phase samples will not require chemical preservation, but they will be maintained at low temperature during storage, handling, and shipping to the laboratory. Sample storage requirements are listed in Table A3-1.

Sample Holding Times

Sample holding times are established to minimize chemical changes in a sample prior to analysis and/or extraction. A holding time is defined as the allowable time between sample collection and analysis recommended to ensure accuracy and representativeness of analysis results, based on the nature of the analyte of interest and chemical stability factors.

Immediately after collection, samples shall be placed in field coolers with wet ice and/or blue ice. If there is no likelihood that a holding time will be violated, samples may be transferred to a locked refrigerator for one or more days of storage prior to shipping to a laboratory. Transfer to the laboratory for analysis should be prompt to minimize the possibility of exceeding holding times.

Holding times for the chemical constituents for which samples will be analyzed are summarized in Table A3-1. Failure to conduct analyses within the required holding times may result in qualification of associated analytical results and shall prompt appropriate corrective and preventive action measures as outlined in Section 4.4.

3.3.2 Sample Handling and Chain of Custody

Sample Handling and Shipping

After collection, sample labels will be completed and the samples will be placed on ice in an insulated cooler. After labeling, each individual sample will be placed in re-closeable freezer-type plastic storage bags. Each sample container will be carefully packaged in a shipping container, typically an ice chest, with Styrofoam® peanuts or other packing material to prevent breakage during shipment. Ice placed in the cooler will be double-bagged to prevent leakage of water. The coolers will be taped shut and the tape will be placed over the custody seal (see below).

Chain of Custody

After samples have been collected, they will be maintained under strict COC protocols. The field sampling personnel will complete a COC form (refer to SOP No. 2, Attachment A-1) for each shipping container (i.e., cooler, ice chest or other container) of samples to be delivered to the laboratory for analysis. The sampler is responsible for initiating and filling out the COC form. The COC for a shipping container will list only those samples in that shipping container. Information contained on the triplicate, carbonless COC form will include the following:

- Project number;
- Date and time of collection;
- Sample identification number;
- Sample matrix;
- Analyses requested;
- Number of containers/bags for each sample;
- Sample preservation;
- Field filtration, if applicable;
- Sampler's signature and affiliation;
- Signature of persons relinquishing custody, dates, and times;
- Signature of persons accepting custody, dates, and times;
- Method of shipment;
- Shipping air bill number (if the samples are shipped);

- Condition of samples and cooler temperature upon receipt by laboratory; and
- Any additional instructions to the laboratory.

Any documentation, including COCs, placed inside the cooler during sample shipment, should be placed inside a re-closeable plastic bag.

The sampling personnel whose signature appears on the COC is responsible for the custody of the samples from the time of sample collection until custody of the samples is transferred to a designated laboratory, a courier, or to another project employee for the purpose of transporting the sample to the designated laboratory. The sample is considered to be in custody when the sample is: (1) in the direct possession of the sample custodian; (2) in plain view of the sample custodian or (3) is securely locked in a restricted-access area by the sample custodian. Custody is transferred when both parties to the transfer complete the portion of the COC under "Relinquished by" and "Received by." Signatures, printed names, company names, dates and times are required. Upon transfer of custody, the sampling personnel who relinquished the samples will retain the third sheet (pink copy) of the COC. When the samples are shipped by a common carrier, a Bill of Lading supplied by the carrier will be used to document the sample custody, and its identification number will be entered on the COC. Copies, receipts and carbons of Bills of Lading will be retained as part of the permanent documentation in the project file. It is not necessary for courier personnel to sign the COC.

When the analytical laboratory receives the samples, the COC will be immediately signed along with the date and time of receipt. The top sheet (white copy) or a copy of the COC may be returned with the final analytical report. The laboratory will follow appropriate chain-of-custody procedures when shipping any samples to a subcontracted laboratory for analysis. A copy of all inter-lab COCs will be included with the final analytical report.

Laboratory Sample Handling and Storage

Upon receipt by the laboratory, the samples will be inspected for sample integrity and proper preservation, including temperature. The COC will be reviewed to verify completeness. Any discrepancies between the COC and sample labels and any problems or questions noted upon sample receipt will be communicated immediately to the Formation QA Manager. The laboratory shall provide the Formation QA Manager with a copy of the COC, and associated sample-receipt information, within 2 working days of receipt of samples. The sample-receipt information routinely provided will include: sample receipt date, sample IDs transcribed from the COCs, sample matrix type, list of analyses to be performed for each sample, and verification of sample temperatures and preservation requirements. Broken custody seals, damaged sample containers, sample labeling discrepancies between container labels and the COC form, and analytical request discrepancies shall be noted on the COC form. The Formation QA Manager shall be notified of any such problems; discrepancies or non-conformances shall be resolved and addressed prior to the samples being released to the laboratory for analysis.

The laboratory will store the samples in a specially designated area, which is clean and maintained at the appropriate preservation temperature, if necessary. The laboratory will be responsible for following their internal custody procedures from the time of sample receipt until sample disposal. At a minimum, the following procedures shall also be in place for laboratory storage of samples:

- samples and extracts shall be stored in a secure area controlled by the laboratory's designated sample custodian;
- samples shall be removed from the shipping container and stored in their original containers unless damaged; damaged samples shall be disposed in an appropriate manner after notifying the Formation QA Manager, and authorization to dispose is received and documented;
- whenever samples are removed from storage, removal shall be documented;
- sample transfers shall be documented on internal COC records;
- samples and extracts shall be stored after completion of analyses in accordance with contractual requirements; and
- Samples shall not be stored with standards or sample extracts.

Samples will be properly disposed by the contracted laboratories in accordance with their own operating procedures, or the samples will be returned to SGC to archive for possible future analyses or testing. SGC is responsible for notifying the laboratories if any of the samples are to be retained and/or returned to SGC.

3.4 Analytical Methods

Samples will be prepared and analyzed using standard laboratory procedures and methods according to performance criteria identified in the following sections. Project goals will be met by the laboratories' standard turn-around-time of 2 to 3 weeks.

3.4.1 Sample Preparation

The laboratory analytical parameters and targeted method detection limits and/or quantitation limits and analytical methods for the laboratory analyses of water samples are specified in Table A3-2. The laboratory analytical parameters and targeted method detection limits and/or quantitation limits and analytical methods for analyses of solid-media samples are specified in Table A3-3.

Preparation of water samples shall be in accordance with the method specifications included in Table A3-1, or method 200.2 for total recoverable metals, as well as standard laboratory practices. Preparation of solid-phase samples, including sediment and soil, shall be in accordance with the method specifications included in Table A3-1.

3.4.2 Target Analyses and Methods

The target analytes (TAs) include both laboratory and field parameters and are described in detail in Section 3.1 of the Work Plan. Laboratory parameters for aqueous and solid-phase sample types are listed in Tables A3-2 and A3-3 of this QAPP, respectively. The laboratory will have discretion in determining when the change from multi-element to element-specific methods are necessary to achieve the target detectability and other QC limits established for the target anions. EPA method numbers and other standard methods are listed in Work Plan Tables 3-1 through 3-3 and in Tables A2-2 through A2-9 of this document.

The laboratories maintain internal SOPs on file for each of the referenced methods, and these SOPs will be referred to by the laboratory during analyses of samples collected for this project. The SOPs for sample preparation and analytical method has been provided by ACZ laboratories and will be available at Formation for review by the project team upon request.

Isotope ratios and activities are not considered project TAs, but isotopic analyses will be conducted on selected water samples. The analysis methods for isotopic analysis of water samples are specified in Table A2-10. These are considered non-standard analytical methods, and additional specifications for performance of each of the methods listed in Table A2-10 are available in the laboratory SOPs (Isotope Tracer Technologies, Waterloo, ON). These SOPs can be provided to data users upon request.

A copy of the appropriate sample-analysis and method table, by sample type, will be included in each batch of samples submitted to the laboratory for analyses to accurately document the analyses being requested.

3.5 Quality Control

There is potential variability in any sample collection, analysis, or measurement activity. This section describes checks that will be performed to evaluate that variability.

3.5.1 Field Quality Control Samples

Field quality control samples are introduced into the measurement process to provide information on transport, storage and field handling biases and on field sampling precision. Field blank samples and field duplicate samples will be collected. Field blank samples may be identified to the laboratory so that they are not used for preparation of an analytical duplicate or matrix spike sample. Descriptions and frequencies of these QC samples are provided below. Table A3-4 summarizes the minimum required frequencies for the field QC samples.

Equipment-Rinsate Blanks

Analyses of equipment-rinsate blanks quantify artifacts introduced into the sample during collection. Potential sources of bias or cross-contamination include sampling gloves and sampling equipment that may incidentally come into contact with the sample. An equipment rinsate blank consists of analyte-free, reagent-grade water (e.g., ASTM Type II) poured through the sampling equipment, collected in a clean suite of sample bottles, and preserved as needed.

Equipment rinsates shall be collected whenever sampling equipment is reused (and decontaminated) between sampling locations. In such cases, equipment rinsates will be collected at rate of 1 per 10 field samples (see Table A3-4). The equipment rinsate blanks will be analyzed for total metals analyses as well as the other parameters listed in Table A3-4. Equipment rinsates collected with solid-phase samples will be analyzed for parameters listed in Table A3-4.

Filter Blanks

A filter blank quantifies any artifacts that could be introduced into the sample during filtration. One filter blank will be collected during each separate sampling event at a rate of one filter blank for each batch of filters used during collection of aqueous samples. The blank sample will consist of one container of filtered water and one container of unfiltered water so that the analysis results can be compared. Analyte-free, reagent-grade water will be poured directly into the sample container for the unfiltered portion, and analyte-free, reagent-grade water will be passed through an unused filter into a separate container for the filtered portion. Both containers will be sent to the laboratory for analyses specified in Table A3-4.

Field Duplicates

Field duplicates are collected to measure the combined sampling and analytical variability associated with the sample results. Duplicate samples are usually collected simultaneously with or immediately after the corresponding original samples have been collected, depending on the sample type and medium and consistent with detailed instructions in the relevant SOPs for sample collection. In all cases, the same sampling protocol is used to collect the original sample and the field duplicate sample. The field duplicate is analyzed for the same suite of analytical parameters as the original sample.

There are no EPA-recommended criteria for evaluation of field duplicate sample comparability; however, the RPD between the original sample and field duplicate can be calculated for each parameter and compared to the project's precision goal. The TA concentrations reported for the field duplicate pairs will be qualified based on the field duplicate RPD results. Possible causes for the observed variability in duplicate samples should be evaluated and explained in the investigation report.

For aqueous samples, field duplicates will be collected at a rate of 1 per 10 samples. These samples will be analyzed for the TAs listed in Table A3-4. The field-duplicate pairs with RPDs greater than 30% (if sample and duplicate concentrations are ≥ 5X QL) will be qualified as estimated ("J" detects and "UJ" for nondetects) and professional judgment will be used regarding flagging other samples in the data set.

For solid-phase media, field duplicates will be collected at a rate of 1 per 10 samples. These samples will be analyzed for the TAs listed in Table A3-4. For the solid media samples, field-duplicate pairs with RPDs greater than 50% will be qualified as estimated.

3.5.2 Laboratory Quality Control Samples

Laboratory quality control samples are introduced into the measurement process to evaluate laboratory performance and sample measurement bias. Control samples may be prepared from environmental samples or be generated from standard materials in the laboratory. The appropriate type and frequency of laboratory QC samples will be dependent on the sample matrix, analytical method, and the laboratory's SOP. Laboratory QC samples will be analyzed in addition to the calibration samples with each QC batch.

Table A3-5 summarizes the minimum required frequencies for the laboratory QC samples. A laboratory method blank, laboratory control sample, analytical duplicate, and a pair of matrix spike samples should be run in each laboratory QC batch at a frequency of 1 each per 20 field samples shown in Table A3-5. Field staff responsible for collection and shipping of samples to the laboratory shall designate the samples to be used for laboratory QC analyses on the COC forms. In the event that such instructions are not included, the laboratory shall always utilize samples submitted from the investigation for preparation of laboratory duplicates and matrix spike samples used for batch QC analyses.

<u>Method Blanks</u>

Method blanks shall be used for the laboratory processes. A method blank is a volume of deionized water that is carried through the entire sample preparation and analysis procedure. The method blank volume or weight shall be approximately equal to the sample volumes or sample weights being processed. Method blanks are used to monitor interference caused by constituents in solvents and reagents and on glassware and other sampling equipment.

Project target analytes must not be detected in laboratory method blanks at concentrations greater than the QL. Method blank contamination, if found, will be addressed in accordance with the response actions given in Tables A2-2 through A2-9, as appropriate to the analytical methods. Method blanks will be evaluated during the data validation process, and associated sample results may be qualified on the basis of blank contamination.

<u>Laboratory Control Samples</u>

A laboratory control sample (LCS)/laboratory fortified blank (LFB), or a blank spike, is an aqueous or solid control sample of known composition that is analyzed using the same sample preparation, reagents, and analytical methods employed for the program samples. An LCS/LFB is obtained from an outside source or is prepared in the laboratory by spiking reagent water or a clean solid matrix for a stock solution that is different than that used for the calibration standards. The LCS/LFB is the primary indicator of process control used to demonstrate whether the sample preparation and analytical steps are in control, apart from sample matrix effects. LCS/LFB samples will be run with all samples at the frequencies specified herein.

Analytical Duplicates

Analytical duplicates are samples that are split at some step in the measurement process and then carried through the remaining steps of the process. Duplicate analyses provide information on the precision of the operations involved.

- Analytical duplicates are a pair of subsamples from a field sample that are taken through the entire preparation and analysis procedure; any difference between the results indicates the precision of the entire method in the given matrix.

- Under certain method protocols (refer to Tables A2-2 through A2-9), the matrix spike is duplicated, to provide a matrix spike duplicate, and serves as the analytical duplicate sample.

Analyses of analytical duplicates and/or matrix spike duplicates monitor the precision of the analytical process.

Matrix Spikes

A matrix spike is prepared by adding an analyte to a subsample of a field sample before sample preparation and analysis. For multi-analyte methods, a representative suite of the analytes is used in the matrix spike. From the concentrations of the analyte in the spiked and unspiked samples, a percent recovery is calculated. Many samples show matrix effects in which other sample components interfere with the determination of the analyte. The value of the percent recovery indicates the extent of the interference.

Laboratory matrix spike samples are used to evaluate potential sample matrix effects on the accurate quantitation of an analyte using the prescribed analytical method. Percent recoveries of target analytes from matrix spike samples should fall within the prescribed control limits. Matrix interference and other effects may cause low or high percent recoveries in investigative samples; matrix effects may be noted at the same time that recoveries from laboratory control samples indicate acceptable method performance.

Site-specific samples shall be used to prepare the MS/MSD samples. Field sampling personnel will collect extra volume and designate on the COC forms the samples that are to be used for the MS/MSD. Every effort will be made to ensure that these samples are representative of the general sample matrix of samples collected on that sampling data. Equipment rinsates and filter blanks are not designated for MS/MSD.

The laboratories will be instructed to use spike concentrations that are consistent with criteria provided in the National Functional Guidelines for Inorganic Data Validation (EPA, 2016) and any specific instructions provided in the referenced analytical methods.

Performance Evaluation Samples

Program-specific laboratory performance evaluations via performance evaluation samples are not anticipated as part of this investigation, but may be included later if analytical or validation exercises indicate the presence of potential laboratory QA issues.

3.6 Instrument/Equipment Calibration and Maintenance

In order to ensure continual quality performance of any instruments or equipment, calibration and maintenance shall be performed and recorded as described in this section.

3.6.1 Field Equipment

Preventative maintenance of field equipment will include routine inspection and calibration and/or testing, as specified in the relevant SOP or manufacturer’s instructions.

All field equipment will be cleaned and safely stored between each use, and any routine maintenance recommended by the equipment manufacturer will also be performed. Equipment will be inspected and the calibration checked (if applicable) before it is transported to a field setting for use. Equipment will be inspected before use and field instruments that fail calibration requirements will be tagged as “nonfunctional” or “defective” and returned to the manufacturer or other supplier for repair or replacement.

The meteorological station installed at the Mayflower Impoundments was visually inspected before deployment for damage, and none was found. After installation at the site and before data collection, all sensors and systems were calibrated according to manufacturer’s specifications. During use of the instrumentation, site checks will be performed each week for the duration of monitoring. Routine maintenance will also be performed in accordance with the manufacturer’s recommendations.

3.6.2 Laboratory Equipment

Instruments used by the laboratory will be maintained in accordance with the laboratory's Quality Assurance Plan (Attachment A-2) and method requirements. All analytical measurement instruments and equipment used by the laboratories shall be controlled by a formal calibration and preventive maintenance program. In addition, each laboratory's preventive maintenance program shall include the following, as a minimum:

- a listing of the instruments and equipment;
- the frequency of maintenance considering manufacturer's recommendations and previous experience with the equipment; and
- a file for each instrument containing a list of spare parts maintained, external contracts, and a listing of the items to be checked or serviced during maintenance.

The laboratory will keep maintenance records and make them available for review, if requested, during laboratory audits. Laboratory preventative maintenance will include routine equipment inspection and calibration at the beginning of each day or each analytical batch, per the laboratory's internal SOPs and method requirements.

Calibration Methods

Physical and chemical calibrations shall be performed within each laboratory as specified by the EPA Methods, instrument manufacturer's guidelines, and this project's calibration requirements for the requested EPA methods, which are summarized in Tables A2-2 through A2-9. When laboratory measurement instruments do not meet the calibration criteria of the laboratory's Quality Assurance Plan and/or EPA method, then the calibration data will be reviewed using the NFGs (EPA, 2016) and will be qualified accordingly. Calibration records and demonstration of acceptable calibration results will be required elements of the laboratory's data reporting. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing QC activities. These records will be filed at the location where the work is performed and will be subject to QA audit.

Calibration procedures for a specific laboratory instrument will consist of initial calibration (blank and standards), initial calibration verification, and continuing calibration verification. All analyses will be governed by the appropriate laboratory SOPs, and appropriate calibration procedures and frequencies can be found in each SOP.

For a summary of the calibration procedures for individual methods, refer to Tables A2-2 through A2-9. Calibration and quality control sample procedures for aqueous samples are summarized in Tables A2-2 through A2-9. Calibration and quality control sample procedures for solid samples are summarized in Tables A2-7 through A2-9.

3.7 Acceptance Requirements for Supplies and Consumables

All supplies and consumables received for a project (e.g., sample bottles, calibration standards) will be checked for damage and other deficiencies that would affect their performance. The Field Investigations Manager will be responsible for ensuring that supplies have been inspected and these inspections will be documented and a copy of the inspection kept in the project's file.

3.8 Criteria for Use of Existing, Non-Direct Measurement Data

Previous reports prepared by SGC, EPA, USGS, and other published studies are potential sources of non-direct measurement data that are relevant to characterization of the study area. The EPA's SCRIBE database is another source of non-direct measurement data that can be used to address certain project DQOs. These data will be used to the fullest extent practicable in the on-going investigation and considering the data quality.

The Project Quality Assurance Manager will be responsible for overseeing data quality evaluations related to existing data and determination of appropriate uses of such data.

3.9 Data Management

The program quality records will be maintained by SGC's contractor, Formation, in its Boulder, CO office. The Project Manager for Formation will be responsible for ensuring that the data management specifications of the QAPP are met. The program quality records, either electronic or hard copy in form, shall include:

- Project work plans, including this QAPP, with any approved modifications, updates, and addendums;
- Field documentation (including well logs, GPS data on monitoring locations including surveyed elevations of monitoring wells);
- Electronic data files downloaded from continuous-reading field instruments (e.g., pressure transducers, weather station sensors, etc.) and any related calculations (and record of peer review) performed to obtain final measurement values;
- COC records;
- Laboratory documentation (results received from the laboratory will be documented both in report form and in an electronic format);
- Data validation reports;
- Data Summary Reports; and
- Final project reports/deliverables.

No checklists or forms are required for this aspect of the project.

Hard-copy field and laboratory records shall be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records are also scanned to produce electronic copies in *.pdf format. The electronic versions of these records are maintained on Formation's central server system with backup scheduled on a daily basis.

A key element of the project's data management process is maintenance of an electronic database that is used to store relevant environmental sampling data, including existing data considered usable to support the investigation (i.e., non-direct measurement data), in a consistent, readily retrievable format. Microsoft® Access will be used for the data structure and query support. A designated Database Manager will ensure the security and integrity of electronically stored data and will also notify the QA manager if any problems are encountered with the database. The project's electronic database will be maintained on a central server system with data backup scheduled on a daily basis. Updated databases are also stored off-site on a monthly basis. The software will be upgraded when updates are available by Formation's Information Technology Officer.

The project database will serve as a source of data for the data presentation and analysis tasks performed to support the multi-media investigation. The database will incorporate, at a minimum, sample collection information (e.g., sample identification, location, date and time of sample collected, matrix) and laboratory analytical fields specified in the project EDD requirements (Table A3-6).

Prior to incorporation of field and laboratory data into the project database, the data and supporting documentation shall be subject to appropriate review, as described below in Section 4.0, to ensure the accuracy and completeness of original data records. Field data that has been reviewed in a hard-copy format will be entered into electronic data files for upload to the project database. All manual data entry into an electronic format will be reviewed by a separate party before such data are incorporated into the project's database (see Section 4.1). Laboratory EDDs and related data packages will be reviewed as part of the data validation process, as described in Sections 4.2 and 4.4.

Following these review steps, field and laboratory electronic data files will be imported to the project database. The data validator(s) (refer to Section 4.4) will add qualifiers and related information to the EDD file/database, for reference by all data users. The EPA flags, Reason Codes, and final, qualified data will be uploaded from electronic files that the data validators populate and return to SGC/Formation, as discussed in Section 4.0. Standardized data import formats and procedures will be used to upload both field and laboratory data into the electronic database. At this time, standardized station identifiers, parameter names, numerical formats, and units of measure are applied to the original information to facilitate comparability across all datasets and within the database.

4.0 DATA REVIEW, VALIDATION AND USABILITY

The following sections address the final project checks conducted to confirm that the data obtained meet the project objectives and to estimate the effect of any deviations on data usability.

4.1 Field Data Review

Raw field data shall be entered in field notebooks and/or sample collection record forms, or if received via automated data loggers, into appropriate electronic data files (e.g., spreadsheets, data forms, etc.). Manually entered field records shall be reviewed for completeness by the Field Investigations Manager, or his/her designated Field Supervisor, at the end of each day of field data collection. The overall quality of the field data from any given sampling round shall be further evaluated during the process of data reduction and reporting.

Typical field-data-reduction procedures will be minimal in scope compared to those implemented in the laboratory setting. Calculations relying on data downloaded from field-deployed data loggers will be recorded and subject to peer review before resultant values are accepted for use as valid measurements. Peer review shall be conducted and documented by a qualified engineer or scientist before values calculated from raw instrument readings are accepted for use as valid measurements.

Field data review will include verification that QC checks are recorded properly in the field logbooks and/or data sheets and that any necessary and appropriate corrective actions were implemented and recorded. Such data will be written into field logbook and/or data sheets immediately after measurements are taken. If errors are made, results will be legibly crossed out, initialed and dated by the field member, and corrected in a space adjacent to the original (erroneous) entry. Later, the appropriate Field Supervisor will proof the field logbooks and/or data sheets to determine whether any transcription errors have been made by the field crew. If transcription errors have been made, the appropriate Field Supervisor and field crew will address the errors to provide resolution.

Field measurement data will be entered into electronic files for import to the project’s database. Data entries will be made from the reviewed field data sheets or logbooks, and all data entries will be reviewed by a separate party before the electronic file is provided to the database manager. Electronic files of field measurement data will be maintained as part of the project’s quality records.

4.2 Laboratory Data Review

Internal, laboratory-data reduction procedures will be according to the laboratory's Quality Management Plan. At a minimum, paper records shall be maintained by the analysts to document sample identification number and the sample tag number with sample results and other details, such as the analytical method used (SOP #), name of analyst, the date of analysis, matrix sampled, reagent concentrations, instrument settings, and the raw data. These records shall be signed and dated by the analyst. Copies of any strip chart printouts (such as gas chromatograms) will be maintained on file. Periodic review of these records by the laboratory QA Manager takes place prior to final data reporting to SGC.

QC data (e.g., laboratory duplicates, LCS/LFB, MSs, and MSDs) will be compared to the method and project-specific acceptance criteria. Data considered to be acceptable will be entered into the laboratory computer system. Data summaries will be sent to the laboratory QA Officer for review. If approved, data are logged into the project database format. The laboratory shall appropriately flag unacceptable data in the data package.

4.2.1 Laboratory Data Reporting Requirements – Target Analytes

The laboratories shall prepare complete data packages for transmittal of results and associated quality control information to SGC and Formation in general accordance with the following instructions, which are based on the EPA's contract laboratory program (CLP) Statement of Work. Deviations from these specifications may be acceptable provided the report presents all of the requested types of information in an organized, consistent, and readily reviewable format. Laboratories providing data packages for this project shall be responsible for reviewing the following requirements, notifying Formation of any differences between their reports and these requirements, and confirming the acceptability of their intended report content and format with Formation before any laboratory data reports are generated for this project.

Each report will be paginated and organized with a table of contents. A cross reference that correlates the client or field identification as provided on the chain-of-custody document with the laboratory's sample identification will be included.

For each batch of sample results consisting of 20 or fewer samples analyzed together and sharing common QC data, the laboratory data will be presented on a form equivalent to the EPA CLP "Form 1" (see below). Case narratives will be prepared which will include information concerning data that fell outside laboratory acceptance limits, and any other anomalous conditions encountered during sample analysis.

CLP Form 1 contains all required data for field samples. The Form 1 (or equivalent reporting mechanism) will provide the following information:

- Field sample identification;

- Laboratory sample identification;
- Sample result, with appropriate units, MDL, and QL. [analyte concentrations equal to or greater than the method detection limit (MDL) will be reported. Concentrations between the MDL and QL will be flagged as an estimated value (“J”) by the laboratory. Parameters that are not detected (ND) or not present at concentrations equal to or greater than the MDL are flagged by the laboratory as “U” and interpreted to be not detected at a value equal to or greater than the MDL. Any non-detected value (“U” flagged) will be reported with its QL and MDL.];
- Sample collection and receipt dates;
- Sample preparation date/time;
- Analysis date/time;
- Dilution factor;
- Preparation batch number or identification;
- Analysis batch number or identification;
- Sample matrix and instrument;
- Percent moisture determination; and
- For solid-matrix samples, identify basis of reporting (i.e., wet-weight or dry-weight basis).

The following additional information will be provided with the Form 1s, as applicable for the reported analytical methods. QC batch will be clearly associated with each sample (on the CLP Form specified, or an equivalent reporting mechanism):

- Case narrative;
- Chain-of-custody;
- Summary of all field sample results (Form 1s, or equivalent, as described above);
- Sample results and preparation blank;
- Initial calibration verification (ICV), and continuing calibration verification (CCV);
- Initial calibration blanks (ICB), continuing calibration blank (CCB), and preparation blanks;
- Low-Level Calibration Check Sample Summary, if necessary
- Inductively coupled plasma (ICP) interference check sample or spectral interference check sample (CLP Form IVA-IN);
- Matrix spike (MS) or analytical spike, and when applicable matrix spike duplicate (MSD) or analytical spike duplicate, sample recovery and, when applicable, MS/MSD relative percent difference (RPD);
- Laboratory duplicate precision, where applicable;

- Laboratory control sample (LCS)/laboratory fortified blank (LFB) recovery;
- MDLs;
- ICP interelement correction factors;
- ICP and inductively coupled plasma-mass spectrometer (ICP-MS) linear ranges;
- Preparation log;
- Analysis run Log;
- ICP-MS tunes;
- ICP-MS internal standards relative intensity summary;
- Sample log-in sheet; and
- Deliverables inventory sheet.

In addition to this standard data package, the laboratory may be requested to deliver a “Level 4” data package, as detailed below. When requested by the Project Manager, the laboratory’s Level 4 Data Package is to include all items specified above plus instrument raw data and/or documentation of the following additional information:

- Calibration standards (including source, preparation date).
- Blanks (ICB, CCB, and preparation).
- ICV, CCV standards.
- Low-Level Calibration Check Sample or Practical Quantitation Verification Standards.
- Interference check samples.
- LCS/LFB.
- Diluted and undiluted samples.
- Dilution factors.
- Sample volumes.
- Laboratory duplicates.
- Matrix spikes (source, concentration, volume).
- Method of standard addition results.
- Instrument identification.
- Analysis date and time.
- All inorganic methods: full raw data printouts from instruments.
- Full run log for each analysis. and
- ICP-MS to include: internal standard recoveries, tune data (atomic mass unit [amu] and peak width), and molecular interference check data.

4.2.2 Laboratory Electronic Data Deliverable – Target Analytes

Each data package, as described above, shall be accompanied by an electronic data deliverable (EDD) prepared by the laboratory. The content and format of laboratory EDDs are specified in Table A3-6. Additional laboratory QC data can be included in the EDD as long as the data fields specified in Table A3-6 are also maintained. The last six fields in the table are to be entered by the data validator.

EDDs will be cross checked against corresponding hard-copy data reports to confirm consistency in results reported in these two separate formats. This cross check will take place as part of the data quality review and validation process described in Section 4.4.

4.3 Specific Quality Control Assessment Procedures

The accuracy, precision, completeness, and representativeness of analytical data will be described relative to the project’s control limits through a process of field and laboratory data quality review and data validation. Results from these reviews will be documented in routine Data Summary Reports prepared for all data users, and any qualification of the data resulting from that review will also be incorporated into the project's electronic database so that all data users are aware of any uncertainties associated with individual results.

4.4 Data Quality Review and Validation – Target Analytes

Data validation is the process of verifying that qualitative and quantitative information generated relative to a given sample is complete and accurate. Data validation procedures shall be performed for both field and laboratory operations as described below and in SOP No. 20, *Data Review and Validation* (Attachment A-1).

4.4.1 Evaluating Field Data

The results of field quality control sample analyses associated with each laboratory data package will be reviewed to allow for evaluation of equipment blanks and other field QC samples and further indications of the data quality. If a problem is identified through the review of field QC data, all related field samples will be identified, and if possible, corrective actions can be instituted and documented. If data are compromised due to a problem identified via field QC sample review, appropriate data qualifications will be used to identify the data for future data users.

The handling, preservation, and storage of samples collected during the sampling program will be monitored on an on-going basis. The project laboratories will document sample receipt including proper containers and preservation at the time samples are logged into their individual laboratory. The sample receipt records (a required data package deliverable) as well as the COC documentation will also be assessed during data validation. Sample handling, storage or preservation problems identified during data validation will result in appropriate qualification of data.

4.4.2 Evaluating Laboratory Chemistry Data for the Target Analytes

The purpose of chemistry data-quality review and validation is to verify that the data are of known quality, technically valid, defensible, and usable for their intended purpose. The objectives of the data validation process will be to:

- Verify completeness of data packages and corresponding EDDs;
- Assess compliance to project specific procedures and programs;
- Evaluate system process control through review of control charts (if applicable);
- Verify that no systematic errors exist within the data sets;
- Assess field QC samples to determine if sampling has adversely impacted the reported results and, therefore, usability;
- Assess both method and laboratory performance through tabulation of QC outliers; and
- Provide measures of data quality in terms of precision, accuracy, and completeness so that overall usability can be determined.

Data validation will be performed using the general protocols and processes described in the following documents and in SOP No. 20, *Data Review and Validation* (Attachment A-1), as applicable to the method calibration and QC limits specified on Tables A2-2 through A2-9 and to the extent possible when non-CLP methods are used:

- Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (National Functional Guideline (NFG); EPA, 2016); and
- Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (EPA, 2009).

The data packages will be evaluated and qualified for quantitative QC elements (e.g., spike recoveries, method and field blank contamination, initial and continuing calibration blanks, instrument tunes, interference check samples, duplicate sample %RSD, and instrument stability and performance [e.g., initial and continuing calibration results, instrument tuning and internal standard areas]) using summary forms (described above). This validation procedure is equivalent to a “Stage 2B Validation,” as defined in the EPA guidance for labeling externally validated data (EPA, 2009).[1] Specific QC elements that will be reviewed include:

- Presence and completeness of COC and sample receipt documentation;

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[1] EPA, 2009. Page 6: “A verification and validation based on completeness and compliance checks of sample receipt conditions and BOTH sample-related and instrument-related QC results…”

- Sample Index (correlation of field sample ID to laboratory sample ID);
- Laboratory Case Narrative (method deviations and QC anomalies);
- Analytical holding times;
- Method blank;
- Matrix spike recoveries;
- Matrix spike/matrix spike duplicate RPD values;
- Field duplicate RPD values;
- Laboratory duplicate RPD values;
- Summaries of initial and continuing calibration;
- Summaries of instrument blanks (e.g., initial calibration blank, CCB, if specified in method);
- Review of reagent/preparation blanks (inorganics);
- Review of LCS;
- Instrument stability and performance (e.g., serial dilution);
- Summaries of internal standards;
- Completeness of laboratory documentation for sample receipt, sample analysis, and sample result reporting;
- Interference check samples (ICP analysis); and
- Serial dilutions (ICP analysis), if any.

Formation will indicate data qualifiers applied to individual results and reasons for application of those qualifiers. Definitions of the data qualifiers that may be applied to individual results as a result of data validation are as follows:

U	The analyte was analyzed for, but was not detected above the level of the reported sample QL.
J	The result is an estimated quantity. The associated numerical value is the approximated concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
R	The result is unusable. The sample result is rejected due to serious deficiencies in meeting quality control criteria. The analyte may or may not be present in the sample.

UJ The analyte was analyzed for, but was not detected. The reported QL is approximate and may be inaccurate or imprecise.

Formation will add the following data to that EDD upon completion of validation:

Field Header “Validation Qualifier”: Populate with validation qualifiers specified above and in template reports.

Field Header “Validation Qual Reason”: Populate with a specific reason for qualification if EPA codes are not used.

Field Header “Val Status”: Populate with a code to indicate if the data has been validated or not.

Field Header “Val Person”: Populate with a code to specify the validation contractor and validator.

Field Header “Val Protocol”: Populate with a code to refer to for validation procedures (QAPP or NFG, etc.) used.

Field Header “Val Notes”: Populate with additional information that is specific to a sample.

Formation will perform a Manual Validation, as defined in the EPA guidance for labeling externally validated data (EPA, 2009), on the data packages generated by the laboratories. The QA manager will document any corrective actions taken.

4.5 Data Usability

Laboratory packages summarizing the data generated for this investigation will be validated as described above. Once validated, the data will be loaded into a project database managed by Formation. Data usability will be determined by Formation based on the results of data validation and overall comparison to DQOs.

Laboratory results for isotopic analyses that are reported within the accuracy and precision specifications listed in Table A2-10 will be considered usable for characterizing the isotopic compositions of water samples.

4.6 Measurement Data Analysis and Reporting

Measurement data will be reported in consistent units for each sample matrix to maintain comparability and facilitate data analyses. For example, concentrations in liquid samples shall be expressed in terms of weight per unit volume such as milligram per liter (mg/L). The number of significant figures in the field and laboratory data presented in the final report shall be consistent with the limits of uncertainty inherent in the measurement or analytical method.

Statistical analyses and other evaluations may be performed that consider the validated data set. The original detected values for parameters with results below the QL may be used as appropriate to the selected statistical methods. Statistical methods may include published methods found in statistical handbooks, textbooks, and EPA or other agency statistical guidance documents.

5.0 ASSESSMENT AND OVERSIGHT

Assessments of data collection and reporting activities are designed to verify that sampling and analyses are performed in accordance with the procedures established in the Work Plan and QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits. Internal audits will be performed by SGC, Formation, or a contracted laboratory. External audits may be performed by the Lead Agency or supporting agencies. Procedures used to conduct internal and external audits shall be consistent with those described in *EPA Guidance on Technical Audits and Related Assessments* (EPA QA/G-7; EPA, 2000a).

Performance and systems audits of field and laboratory data collection and reporting procedures are described in this section. Data assessments, such as data verification and validation, were presented in Section 4.0.

5.1 Field Performance and System Audits

Formation's QA Manager, or designee, may conduct an onsite systems and performance audit of field sampling practices at any time during the field data collection activities. Any non-conformances observed in the audit shall be documented and resolved. Additional systems audits or surveillance may be conducted during the remaining field investigations at the discretion of the Formation Project Manager or Formation QA Manager. One field audit per field season is recommended but not required.

5.1.1 Internal Field Audits

Internal audits of field activities including sampling and field measurements, will be conducted by the Formation QA Manager, or designee. These audits will verify that procedures established in the Work Plan and QAPP, including referenced SOPs (Attachment A-1), are being followed.

The internal field audits (systems and performance audits) will include examination of field measurement and sampling records and field instrument operating records; sample collection, handling, decontamination, and packaging activities; and documentation of sampling activities in compliance with the established procedures for each field activity audited. Follow-up audits may be conducted to correct deficiencies, and to verify that QA procedures are maintained throughout the investigation. The results of field audits will be documented. The completed field audit report will be kept on file by the Formation QA Manager. After a field audit is conducted, the results of the audit will be shared by the auditor with the field teams prior to additional sampling to enhance sampling performance where applicable.

Findings of these audits will be summarized in an audit report that is given to the Formation Project Manager, Field Investigations Manager, and appropriate Field Supervisor in charge of the audited activities. The audited party will submit a reply addressing each finding cited in the report, the corrective action (if necessary) to be taken, and a schedule for implementation. The Field Investigations Manager is responsible for ensuring that corrective actions are taken.

5.1.2 External Field Audits

External field audits may be conducted by representatives from the Agencies. External field audits may be conducted at any time during the field operations. These audits may or may not be announced and are at the discretion of the Agencies.

External field audits will be conducted according to the field activity information presented in the field SOPs or in the sampling procedures outlined in the Work Plan. Results of the external field audit may document the need for a change to procedures in the Work Plan and/or QAPP and result in the need for an amendment to the Work Plan and/or QAPP.

5.2 Laboratory Performance and Systems Audits

5.2.1 Internal Laboratory Audits

The internal laboratory audit will be conducted by the QA Officer at each laboratory utilized for the investigation. Audits will be performed in accordance with the laboratory's Quality Management Plan.

The internal laboratory system audits will be conducted on an annual basis while the internal lab performance audits will be conducted on a quarterly basis, or as specified in the laboratory's Quality Management Plan (Attachment A-2).

The internal laboratory system audits will include an examination of laboratory documentation on sample receiving, sample log-in, sample storage, COC procedures, sample preparation and analysis, instrument operating records, etc. The performance audits will involve preparing blind QC samples and submitting them along with project samples to the laboratory for analysis throughout the project. The QA Officer from each laboratory utilized for this investigation will evaluate the analytical results of these blind performance samples to ensure the laboratory maintains acceptable QC performance.

5.2.2 External Laboratory Audits

An external laboratory audit may be conducted by representatives from the Agencies at any time. An external laboratory audit may be conducted prior to the initiation of the sampling and analysis activities. These audits may or may not be announced, may be conducted at any time and are at the discretion of the Agencies.

External laboratory audits will include (but not be limited to) review of laboratory analytical procedures, laboratory on-site audits, and/or submission of performance evaluation samples to the laboratory for analysis. Typically, the external laboratory audit will be conducted in the lab so that the staff may be questioned regarding laboratory procedure. A recently produced sample data package will be compared with their SOP to ensure compliance with applicable standards.

5.3 Corrective Actions

Corrective action is the process of identifying, recommending, approving and implementing measures to counter unacceptable procedures or out-of-QC performance which can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation and data assessment.

Non-conforming equipment, items, activities, conditions and unusual incidents that could affect data quality and attainment of the project's quality objectives will be identified, controlled and reported in a timely manner. For the purpose of this QAPP, a nonconformance is defined as a malfunction, failure, deficiency, or deviation that renders the quality of an item unacceptable or indeterminate in meeting the project's quality objectives.

Corrective action in the laboratory may occur prior to, during and after initial analyses. If the analytical results from laboratory QC samples fall outside of the measurement performance criteria, the laboratory should initiate corrective actions immediately. If the laboratory cannot correct the situation that caused the nonconformance and an out-of-control situation continues to occur or is expected to occur, then the laboratory will immediately contact the Formation QA Manager and request instructions regarding how to proceed with sample analyses. A number of conditions such as broken sample containers, multiple phases, low/high pH readings and potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with lab analysts and section leaders, it may be necessary for the Laboratory Project Manager (or designated QA Officer) to approve the implementation of corrective action. These conditions may include dilution of samples, additional sample extract cleanup, automatic re-injection/re-analysis when certain QC criteria are not met, etc.

Completion of any corrective action should be evidenced by data once again falling within prescribed measurement performance criteria. If an error in laboratory procedures or sample collection and handling procedures cannot be found, the results will be reviewed by the Formation QA Manager and Formation Project Manager to assess whether reanalysis or re-sampling is required.

Any corrective actions taken will be documented in writing by either the Laboratory Project Manager or the Formation QA Manager, as appropriate, and reported to the Formation Project Manager. Corrective action records will be included in the program's quality records.

5.4 Corrective Action during Data Validation and Data Assessment

The Formation QA Manager may identify the need for corrective action during either the data validation or later data assessment/analysis activities. Potential types of corrective action may include re-sampling by the field team, reanalysis of samples by the laboratory, or re-submission of data packages with corrected clerical errors. The appropriate and feasible corrective actions are dependent upon the ability to mobilize the field team and whether the data to be collected is necessary to meet the required QA objectives (e.g., the holding time for samples is not exceeded, etc.). Corrective actions of this type will be documented by the Formation QA Manager.

5.5 Quality Assurance Reports to Management

The deliverables associated with the tasks identified in the Work Plan will contain QA discussions of data quality information collected during the task is summarized. Those reports will be the responsibility of the Formation Project Manager and QA Manager.

The QA discussions will contain, on a routine basis, the results of field and laboratory audits, information generated on the achievement of specific DQOs and a summary of any corrective actions that were implemented and their immediate results on the project. Detailed references to any QAPP modifications will also be highlighted.

6.0 QAPP REFERENCES

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QUALITY ASSURANCE PROJECT PLAN

TABLES

Table A2-1
Precision, Accuracy and Completeness Equations

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{\lvert x_i - x_j \rvert}{\left(\frac{x_i + x_j}{2} \right)} \times 100$	x_i, x_j: replicate values of x
Precision (as relative standard deviation, RSD, otherwise known as coefficient of variation)	$RSD = \frac{s}{\bar{x}} \times 100$	s: sample standard deviation x: sample mean
Accuracy (as percent recovery, R, for samples without a background level of the analyte, such as reference materials, laboratory control samples, and performance evaluation samples)	$R = \frac{x}{t} \times 100$	x: sample value t: true or assumed value
Accuracy (as percent recovery, R, for measurements in which a known amount of analyte, a spike, is added to an environmental sample)	$R = \frac{x_s - x}{t} \times 100$	x_s: value of spiked sample x: value of unspiked sample t: true or assumed value
Completeness (as a percentage, C)	$C = \frac{n}{N} \times 100$	n: number of valid data points produced N: total number of samples taken

Table A2-2
Summary of Calibration and QC Procedures for EPA Method 200.7 (Metals/Metalloids by ICP) – Aqueous-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample holding time is 180 days for aqueous samples preserved to pH < 2 with nitric acid.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
AMU Check Tune	Prior to initial calibration solution as specified by lab's standard operating procedure (SOP).	Mass calibration < 0.1 amu from the true value; Stability: RSD < 5% for at least five replicate analyses. Peak resolution < 0.75 AMU at 5% peak height.	Retune instrument then reanalyze tuning solution.
Initial calibration (ICAL) for all target analytes (minimum one standard and a blank)	Daily initial calibration prior to sample analysis.	Calibration blank plus 4 non-zero standards. ICAL must be repeated for each batch unless CCV is used for continuing calibration. If the correlation coefficient for the element of interest is not greater than 0.995, then the instrument must be recalibrated and all of the associated samples for that element must be reanalyzed.	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	Immediately after ICAL, before beginning a sample run and from a second source.	All analytes within ± 10% of expected value.	Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	Immediately after ICV.	< 2.2X the Method Detection Limit (MDL) for dissolved 200.8 analyses or < 3X the MDL of the associated analyte.	Recalibrate if ICB is outside of acceptance criteria. Reanalyze all associated samples that are < 10X the blank and > zero since the last compliant CCB.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence.	The analyte concentration within ± 10% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV. If CCV recovery was high, "U" samples can be qualified and passed.
Continuing Calibration Blank (CCB)	Immediately after ICB, after every 10 samples, and at the end of the analytical sequence (after every 20 samples for dissolved analyses)	< 3X MDL	Correct problem then reanalyze calibration blank and previous 10 samples. Reanalyze all associated samples that are < 10X the blank and > zero since the last compliant CCB.
Laboratory Reagent Blank	One per analytical batch of 20 or fewer samples of the same matrix	< 2.2X MDL	Correct problem and reanalyze. Recalibrate if ICB is outside of acceptance criteria.
Laboratory Fortified Blank (LFB)	One LFB per analytical batch of 20 or fewer samples	85-115%	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LFB and all samples in the preparation batch. If the LFB recovery is high, "U" samples may be qualified and passed.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 10 samples per matrix - not to be performed using a field blank.	Percent recovery should be within ± 30% and Relative Percent Difference (RPD) should be < 20%. If sample is spiked post digestion, percent recovery should be ± 15%. MS/MSD recoveries are not applicable if the sample concentration is >4x the spike concentration.	Qualify associated sample results
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable
Internal Standards (IS)	Every sample; internal standards as specified by method and lab's SOP.	60% - 125% of intensity in the calibration blank.	Dilute by a factor of two and re-analyze. If IS recoveries still out, report undiluted results.
Concentrations between the MDL and QL	All samples	Not applicable	Qualify to indicate value is between MDL and QL.

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
Approximate analyte concentrations are discussed in the Work Plan.
AMU - Atomic Mass Unit
MDL - Method detection limit
QL - Quantitation Limit. May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.
ppb - parts per billion
RSD - Relative Standard Deviation

Table A2-3
Summary of Calibration and QC Procedures for EPA Method 200.8 (Metals/Metalloids by ICP-MS) – Aqueous-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample holding time is 180 days for aqueous samples preserved to pH ≤ 2 with nitric acid.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
Initial calibration (ICAL) for all target analytes (minimum one standard and a blank)	Daily initial calibration prior to sample analysis	Calibration blank plus 1 or more non-zero standards. When 3 or more points are used, the criteria is $r^2 > 0.995$.	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	After ICAL, before beginning a sample run (at a concentration other than used for calibration and from a second source)	All analytes within ± 5% of expected value. When 3 or more points are used, the criteria is $r^2 > 0.995$.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	After ICV	< 3X Method Detection Limit (MDL)	Correct problem and reanalyze. Sample values > 10X ICB may be accepted and qualified if ICB fails high.
Practical Quantitation Verification (PQV)	Daily, after ICAL and before samples are run.	The analyte concentrations within ±30% of expected value.	Correct problem then reanalyze.
Spectral Interference Check Sample	Immediately after PQV.	Recovery must be within ± 20% of expected value.	Correct problem and reanalyze.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence (at a mid-calibration range concentration).	The analyte within ± 10% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV. Samples < MDL may be accepted and qualified if CCV fails high.
Continuing Calibration Blank (CCB)	Immediately after CCV and after every 10 samples, and at end of the analytical sequence.	<3X MDL	Correct problem then reanalyze calibration blank and previous 10 samples. Sample values > 10X CCB or < MDL may be accepted and qualified if CCB fails high.
Laboratory Reagent Blank (LRB) / Method Blank	One per analytical batch of 20 or fewer samples of the same matrix.	< 2.2X MDL	Correct problem and reanalyze. Samples values > 10X LRB or < MDL may be accepted and qualified LRB fails high.
Laboratory Fortified Blank (LFB)/Laboratory Control Sample (LCS)	One LFB per analytical batch of 20 or fewer samples	85-115%	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LFB and all samples in the preparation batch. If LFB fails high, samples < MDL may be accepted and appropriately qualified.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 10 samples per matrix - field blanks may not be used.	Percent recovery should be within ± 30% and Relative Percent Difference (RPD) should be < 20%. If sample is spiked post digestion, percent recovery should be ± 15%. MS/MSD recoveries are not applicable if the sample concentration (used for spiking) is >4x the spike concentration.	Flag associated sample results. If the RPD ≥ 20% samples must be repepped and reanalyzed. Ag must have passing RPD in digested samples.
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable
Concentrations between the MDL and QL	All samples	Not applicable	Qualify to indicate value is between MDL and QL.

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
Approximate analyte concentrations are discussed in the Work Plan
MDL - Method detection limit
QL - Contract Required Quantitation Limit. May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.

Table A2-4
Summary of Calibration and QC Procedures for EPA Method 245.1 (Mercury by CVAA) – Aqueous-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Initial calibration (ICAL) for all target analytes (minimum five standards including a blank)	Daily initial calibration prior to sample analysis	Blank plus 4 or more calibration concentrations, correlation coefficient (r) ≥ 0.995	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	After ICAL, before beginning a sample run (at a concentration other than used for calibration and from a second source)	All analytes within ± 20% of expected value	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	After ICV	Absolute value ≤ 2x MDL for each analyte. If (2x MDL) > QL, then use the absolute value ≤ QL as the criteria instead.	Correct problem and reanalyze.
CRQL Check Standard (CRI)	Daily, after ICAL, after every 20 samples and at end of each analysis run.	Within ± 30% of expected value.	Correct problem then reanalyze.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence (at a mid-calibration range concentration)	The analyte within ± 20% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV.
Continuing Calibration Blank (CCB)	Before beginning a sample run, after every 10 samples, and at end of the analytical sequence	Absolute value ≤ 2x MDL for each analyte. If (2x MDL) > QL, then use the absolute value ≤ QL as the criteria instead.	Correct problem then reanalyze calibration blank and previous 10 samples.
Method Blank (or preparation blank)	One per analytical batch	Absolute value ≤ QL	If absolute value is >QL all sample results (excluding field blanks) must be ≥10x the blank concentration. Otherwise, all samples associated with the blank and <10x blank concentration must be redigested and reanalyzed.
LCS	One LCS per analytical batch.	Vendor-specified control limits.	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LCS/SRM and all samples in the
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 20 samples per matrix - field blanks may not be used.	Laboratory-determined control limits (but not wider than 75-125% recovery and RPD < 20). MS/MSD recoveries are not applicable if the sample concentration (used for spiking) is >4x the spike concentration.	Flag associated sample results.
Analytical duplicate sample	One duplicate per every 20 samples per matrix	RPD <20% if sample and duplicate concentrations ≥5xQL. If sample and/or duplicate concentration <5xQL the control limit will be a difference of ±QL.	Flag associated sample results.
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable
Concentrations between the MDL and QL	All samples	Not applicable	Flag as estimated value ("B" flag)

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
Approximate analyte concentrations are discussed in the Work Plan
MDL - Method detection limit
QL - Quantitation Limit May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.

Table A2-5
Summary of Calibration and QC Procedures for SM 2320B (Alkalinity) – Aqueous-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample collected and sent to lab at 0 to 6°C and analyzed within 14 days of collection.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
Practical Quantitation Verification	1 per analytical batch	within ± 50%	Correct problem prior to continuing analysis. Otherwise, recalibrate system.
Prep Blank Water (PBW)/Method Blank	1 per batch of 20 or less samples	< PQL	All samples affected by high method blanks (sample < 10X the highest (PBW) must be qualified accordingly.
Laboratory Control Standard Water (LCSW)	Analyze 1 LCSW at the beginning of the run, 1 after every 20 samples (or less), and 1 at the end of the analysis.	90-110% recovery	Correct problem then reanalyze.
Analytical Duplicate	1 analytical duplicate per every 10 samples - field blanks may not be used.	RPD ≤ 20%	If RPD above control limit, reanalyze associated samples.
Field duplicate sample	1 field duplicate per every 10 samples, per matrix	Not applicable	Not applicable

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
Approximate analyte concentrations are discussed in the Work Plan
PQL - Practical Quantitation Limit
RPD - Relative percent difference

Table A2-6

Summary of Calibration and QC Procedures for EPA Method 300.0 (Anions) – Aqueous-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample collected and sent to lab unpreserved at 0 to 6°C . Samples analyzed 28 days from collection.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
Calibration Standards	Daily(first batch of the day) or when ICV/CCV fail	$r^2 \geq 0.995$	Reanalyze suspect calibration standard. If criteria still not met, then remake standards and recalibrate the instrument.
Initial Calibration Verification (ICV)	One per analytical batch. Immediately following calibration.	Aqueous: 90-110%	If ICV does not meet criteria, retest one time, if problem persists, recalibrate the instrument.
Continuing Calibration Verification (CCV)	Before beginning a sample run if using a continuing calibration, 1 every 10 samples, and 1 at the end of each batch.	Aqueous: 90-110%	Rerun CCV to see if within limits. If both attempts fail, recalibration or two consecutive passing CCVs are required.
Initial Calibration Blanks (ICB)	Immediately following calibration after ICV.	< ± 3X (Method Detection Limit) MDL	Rerun ICB to see if it meets criteria. If not, then recalibrate instrument.
Continuing Calibration Blank (CCB)	Before beginning a sample run, after the CCV, if using a continuing calibration, after every 10 client samples, and at end of the analytical sequence	< ±3X MDL	Correct problem then reanalyze. Samples < MDL can be accepted and reported with the appropriate qualifier if bracketing CCB(s) fails high.
Laboratory Fortified Blank (LFB)/Laboratory Control Sample (LCS)	One per every 20 or fewer client samples.	90-110%	One re-test OK, then, if not within limits, reanalyze all samples. Recalibrate if necessary.
Analytical Spike (Matrix Spike)	One per every 10 analytical samples	90-110%	If instrument QC for other QC samples is within limits, sample results are qualified. If other instrument QC is out of limits, reanalyze samples.
Analytical Duplicate	One per every 10 analytical samples	RPD < 20% /for duplicate concentrations > 10 times MDL	Reanalyze and if within limits, then no impact. It reanalysis results not within limits, then reanalyze associated samples. If duplicate results < 10X MDL, qualify sample results. If the LFB & associated instrument QC pass, then accept qualify the data.
Field duplicate sample	1 field duplicate per every 20 samples per matrix	Not applicable	Not applicable

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
Approximate analyte concentrations are discussed in the Work Plan

Table A2-7

Summary of Calibration and QC Procedures for EPA Method 6020 (ICPMS) – Solid-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample holding time is 180 days for aqueous samples preserved to pH < 2 with nitric acid.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
AMU Check Tune	Prior to initial calibration solution as specified by lab's standard operating procedure (SOP).	Mass calibration < 0.1 amu from the true value; Stability: RSD < 5% for at least five replicate analyses. Peak resolution < 0.75 AMU at 5% peak height.	Retune instrument then reanalyze tuning solution.
Initial calibration (ICAL) for all target analytes (minimum one standard and a blank)	Daily initial calibration prior to sample analysis.	Calibration blank plus 4 non-zero standards. ICAL must be repeated for each batch unless CCV is used for continuing calitbration. If the correlation coefficient for the element of interest is not greater than 0.995, then the instrument must be recalibrated and all of the associated samples for that element must be reanalyzed.	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	Immediately after ICAL, before beginning a sample run and from a second source.	All analytes within ± 10% of expected value.	Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	Immediately after ICV.	< 2.2X the Method Detection Limit (MDL) for dissolved 200.8 analyses or < 3X the MDL of the associated analyte.	Recalibrate if ICB is outside of acceptance criteria. Reanalyze all associated samples that are < 10X the blank and > zero since the last compliant CCB.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence.	The analyte concentration within ± 10% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV. If CCV recovery was high, "U" samples can be qualified and passed.
Continuing Calibration Blank (CCB)	Immediately after ICB, after every 10 samples, and at the end of the analytical sequence (after every 20 samples for dissolved analyses)	< 3X MDL	Correct problem then reanalyze calibration blank and previous 10 samples. Reanalyze all associated samples that are < 10X the blank and > zero since the last compliant CCB.
Laboratory Reagent Blank	One per analytical batch of 20 or fewer samples of the same matrix	< 2.2X MDL	Correct problem and reanalyze. Recalibrate if ICB is outside of accpetance criteria.
Laboratory Fortified Blank (LFB)	One LFB per analytical batch of 20 or fewer samples	85-115%	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LFB and all samples in the preparation batch. If the LFB recovery is high, "U" samples may be qualified and passed.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 10 samples per matrix - not to be performed using a field blank.	Percent recovery should be within ± 30% and Relative Percent Difference (RPD) should be < 20%. If sample is spiked post digestion, percent recovery should be ± 15%. MS/MSD recoveries are not applicable if the sample concentration is >4x the spike concentration.	Qualify associated sample results
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable
Internal Standards (IS)	Every sample; internal standards as specified by method and lab's SOP.	60% - 125% of intensity in the calibration blank.	Dilute by a factor of two and re-analyze. If IS recoveries still out, report undiluted results.
Concentrations between the MDL and CRQL	All samples	Not applicable	Qualify to indicate value is between MDL and QL.

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
AMU - Atomic Mass Unit
MDL - Method detection limit
QL - Quantitation Limit. May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.
ppb - parts per billion
RSD - Relative Standard Deviation

Table A2-8
Summary of Calibration and QC Procedures for EPA Method 6010 (ICP) – Solid-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Sample preservation and holding time	Not applicable	Sample holding time is 180 days for aqueous samples preserved to pH ≤ 2 with nitric acid.	Laboratory will note sample condition on receipt and notify client if criteria are not met.
Initial calibration (ICAL) for all target analytes (minimum one standard and a blank)	Daily initial calibration prior to sample analysis	Calibration blank plus 1 or more non-zero standards. When 3 or more points are used, the criteria is $r^2 > 0.995$.	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	After ICAL, before beginning a sample run (at a concentration other than used for calibration and from a second source)	All analytes within ± 5% of expected value. When 3 or more points are used, the criteria is $r^2 > 0.995$.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	After ICV	< 3X Method Detection Limit (MDL)	Correct problem and reanalyze. Sample values > 10X ICB may be accepted and qualified if ICB fails high.
Practical Quantitation Verification (PQV)	Daily, after ICAL and before samples are run.	The analyte concentrations within ±30% of expected value.	Correct problem then reanalyze.
Spectral Interference Check Sample	Immediately after PQV.	Recovery must be within ± 20% of expected value.	Correct problem and reanalyze.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence (at a mid-calibration range concentration).	The analyte within ± 10% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV. Samples < MDL may be accepted and qualified if CCV fails high.
Continuing Calibration Blank (CCB)	Immediately after CCV and after every 10 samples, and at end of the analytical sequence.	<3X MDL	Correct problem then reanalyze calibration blank and previous 10 samples. Sample values > 10X CCB or < MDL may be accpeted and qualified if CCB fails high.
Laboratory Reagent Blank (LRB) / Method Blank	One per analytical batch of 20 or fewer samples of the same matrix.	< 2.2X MDL	Correct problem and reanalyze. Samples values > 10X LRB or < MDL may be accepted and qualified LRB fails high.
Laboratory Fortified Blank (LFB)/Laboratory Control Sample (LCS)	One LFB per analytical batch of 20 or fewer samples	85-115%	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LFB and all samples in the preparation batch. If LFB fails high, samples < MDL may be accepted and appropriately qualified.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 10 samples per matrix - field blanks may not be used.	Percent recovery should be within ± 30% and Relative Percent Difference (RPD) should be < 20%. If sample is spiked post digestion, percent recovery should be ± 15%. MS/MSD recoveries are not applicable if the sample concentration (used for spiking) is >4x the spike concentration.	Flag associated sample results. If the RPD ≥ 20% samples must be represented and reanalyzed. Ag must have passing RPD in digested samples.
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable
Concentrations between the MDL and CRQL	All samples	Not applicable	Qualify to indicate value is between MDL and QL.

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
MDL - Method detection limit
QL - Quantitation Limit. May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.

Table A2-9
Summary of Calibration and QC Proedures for EPA Method 7471 (Mercury by CVAA) – Solid-Media Samples

Quality Control Check	Frequency	Lab Acceptance Criteria	Corrective Action/Lab Flagging Criteria
Initial calibration (ICAL) for all target analytes (minimum five standards including a blank)	Daily initial calibration prior to sample analysis	Blank plus 4 or more calibration concentrations, correlation coefficient (r) ≥ 0.995	Correct problem then repeat initial calibration.
Initial Calibration Verification (ICV)	After ICAL, before beginning a sample run (at a concentration other than used for calibration and from a second source)	All analytes within ± 20% of expected value	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.
Initial Calibration Blank (ICB)	After ICV	Absolute value ≤ 2x MDL for each analyte. If (2x MDL) > QL, then use the absolute value ≤ QL as the criteria instead.	Correct problem and reanalyze.
CRQL Check Standard (CRI)	Daily, after ICAL, after every 20 samples, and at the end of each analysis run.	Within ± 30% of expected value.	Correct problem then reanalyze.
Continuing Calibration Verification (CCV)	After every 10 samples and at the end of the analysis sequence (at a mid-calibration range concentration)	The analyte within ± 20% of expected value	Correct problem then repeat CCV and reanalyze all samples since last successful CCV.
Continuing Calibration Blank (CCB)	Before beginning a sample run, after every 10 samples, and at end of the analytical sequence	Absolute value ≤ 2x MDL for each analyte. If (2x MDL) > CRQL, then use the absolute value ≤ CRQL as the criteria instead.	Correct problem then reanalyze calibration blank and previous 10 samples.
Method Blank (or preparation blank)	One per analytical batch	Absolute value ≤ CRQL	If absolute value is >QL all sample results (excluding field blanks) must be ≥10x the blank concentration. Otherwise, all samples associated with the blank and <10x blank concentration must be redigested and reanalyzed.
LCS	One LCS per analytical batch (1/20 samples).	Aqueous LCS: 80-120% or vendor-specified or laboratory-determined control limits (but not wider than 80-120% recovery). Solid LCS/SRM: vendor-specified control limits.	Correct problem then reanalyze. If still out, re-prepare and reanalyze the LCS/SRM and all samples in the preparation batch.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	One MS/MSD per every 20 samples per matrix - field blanks may not be used.	Laboratory-determined control limits (but not wider than 75-125% recovery and RPD < 20). MS/MSD recoveries are not applicable if the sample concentration (used for spiking) is >4x the spike concentration.	Flag associated sample results and perform post-digestion spike.
Analytical duplicate sample	One duplicate per every 20	RPD <20% if sample and	Flag associated sample results.
Field duplicate sample	1 field duplicate per every 10 samples per matrix	Not applicable	Not applicable

Notes:
Specific QC procedures may vary based on the laboratory that performs the analyses.
MDL - Method detection limit
QL - Quantitation Limit. May be referred to as "PQL" - Practical Quantitation Limit or "RL" - Reporting Limit.

Table A2-10
Isotope Analysis Methods and Quality Control Checks (for Selected Aqueous Samples)

Parameter	Analysis Method	Accuracy Measure	Accuracy Goal	Precision Measure	Precision Goal	Container and Preservation	Target Hold Time
$\delta^{18}O$ (in H_2O)	cavity ring down spectroscopy	repeat analyses of VSMOW (or other IAEA) standard	+/- 0.1 per mil	Analytical duplicates	+/- 0.2 per mil, st dev	30 mL, glass, Polyseal caps	4 weeks
$\delta^{2}H$ (in H_2O)			+/- 1 per mil		+/- 0.5 per mil, st dev		
^{3}H - Tritium	electrolytic enrichment and direct counting	repeat analyses of standard	1 σ st dev	Analytical duplicates	15% relative percent difference (RPD)	500 mL to 1000 mL , plastic	4 weeks
$\delta^{18}O$ (in SO_4)	isotope ratio mass spectrometry	repeat analyses of IAEA/NBS standards	+/- 0.5 per mil	Analytical duplicates	+/- 0.5 per mil		
$\delta^{34}S$ (in SO_4)			+/- 0.5 per mil		+/- 0.5 per mil		

Notes:
VSMOW = Vienna standard mean ocean water
IAEA = International Atomic Energy Association
NBS = National Bureau of Standards

Table A2-11
Summary of Meteorological Accuracies and Resolution

Parameter	Sensor	Range	Accuracy	Standard	Measurement Resolution
Wind Direction	R.M. Young 05305	0 to 360 degrees	± 3 degrees	Accuracy: ± 5 degrees	1.0 degree
Wind Speed	R.M. Young 05305	0.4 to 45 m/s	± 0.2 m/s	Accuracy: ± 0.25 m/s up to speeds of 5 m/s and ± 5% thereafter	0.1 m/s
Temperature	AdvM2 T/RH	-30 °C to +80 °C	± 0.2 degrees Celsius	± 0.5 degrees Celsius	0.2 °C
Relative Humidity	AdvM2 T/RH	10 to 100 percent	± 3 percent	1.5 °C dew point temperature error	0.4 percent
Solar Radiation	Hukseflux LP-02	0 to 2,000 W/m^2	± 1%	± 5%	10 W/m^2
Barometric Pressure	Vaisala PT110B	600 to 1,060 mb	± 0.5 mb	± 3 mb	± 0.1 mb
Precipitation	Ott Pluvio	N/A	± 5%	± 10% of observed or ± 0.5 mm	0.01 inch

Notes:
1. m/s = Meters per second
2. °C = Degrees Celsius
3. W/m^2 = Watts per square meter
4. mb = Millibars

Table A3-1
Sample Mass, Sample Preservation and Preparation Techniques, Sample Volumes, and Holding Times

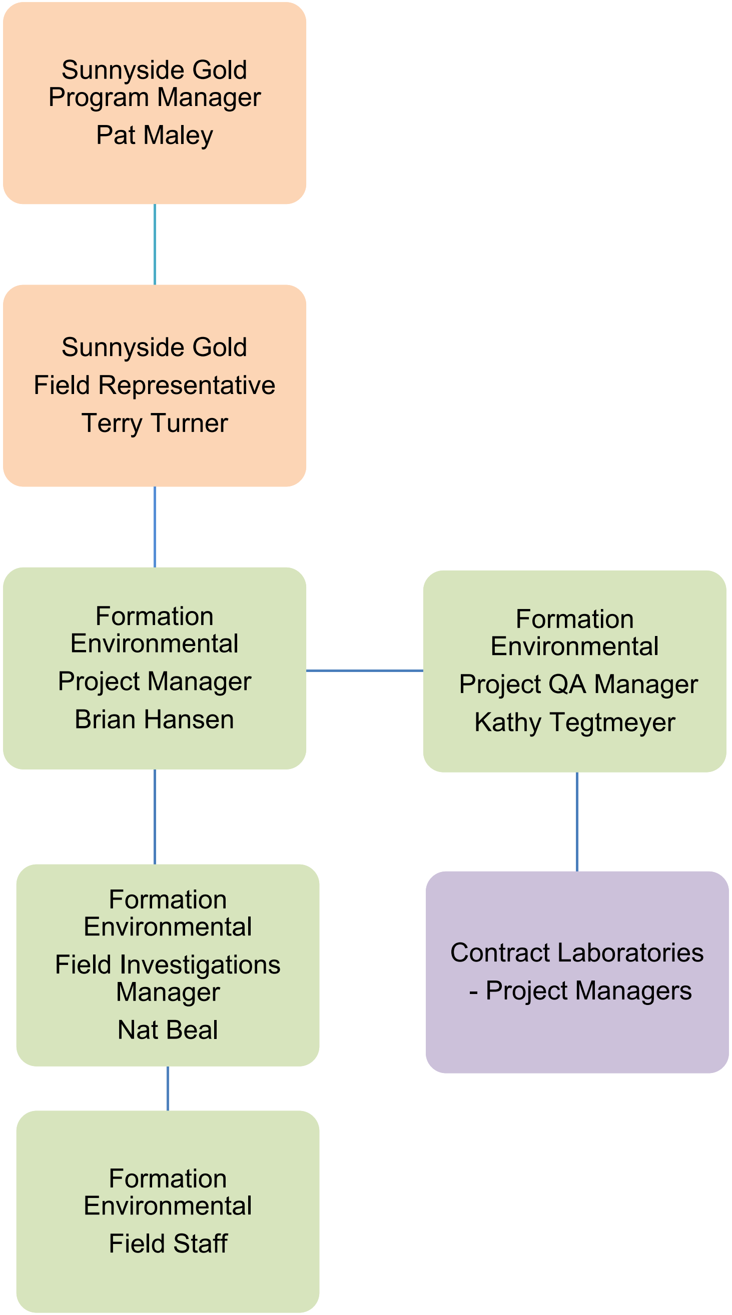
Sample Type	Parameters	Laboratory Analytical Method	Sample Preparation Method	Preservative^1	Minimum Sample Volume or Mass	Bottle Type	Maximum Holding Time (Days)
Aqueous	Metals and metalloids and Hardness	EPA 200.7 and 200.8 (ICP and ICP-MS) and SM2340B (hardness) by calculation	Field filtered (dissolved), Hot Plate Digestion 200.2 (200.7 and 200.8)	HNO_3	250 mL	HDPE	180
			Unfiltered (total); Hot Plate Digestion 200.2 (200.7 and 200.8)	HNO_3	250 mL	HDPE	180
	Mercury	EPA 245.1	Field filtered (dissolved), preparation in accordance with Method 245.1	HNO_3	250 mL	HDPE	28
			Unfiltered (total); preparation in accordance with Method 245.1	HNO_3	100 mL	HDPE	28
	Chloride	EPA 300.0	None	None	250 mL	HDPE	28
	Bromide	EPA 300.0	None				
	Fluoride	EPA 300.0	None				
	Sulfate	EPA 300.0	None				
	Alkalinity^2	SM2320B	None	None	500 mL	HDPE	14
	TSS	SM2540D	None	None			7
	TDS	SM2540C	None	None			7
Solid	Metals and metalloids	6010 6020	Method 3050B Hot plate/acid digestion	None	Collect 250 grams	Plastic bag or glass jar	180
	Mercury	7471	Preparation per Method 7471				28
	Fluoride (soluble)	ASTM D 3761	Preparation per Method 7471				Not defined

Notes
1. In addition to the preservation listed, all samples shall be placed in a cooler with ice that is maintained at temperatures < 6ºC but >0ºC (40 CFR 136) following collection and during shipment to the lab.
2. The holding time for alkalinity is 14 days.
3. HDPE = High-density polyethylene
4. Field filtered samples will be filtered with a 0.45 micron filter.
5. HNO_3 = Nitric acid
6. mL = milliliter

QUALITY ASSURANCE PROJECT PLAN

FIGURES

Sunnyside Gold
Surface Water, Groundwater, and Solid Phase Media Investigation Organization



Sunnyside Gold Corporation

Figure A2-1

2017 Multi-Media Investigation

PROJECT ORGANIZATION CHART

PRJ: 065-001	DATE: March 2017	
REV: 0	BY: KJT	FOR: NBB

FORMATION ENVIRONMENTAL

ATTACHMENT A-1

STANDARD OPERATING PROCEEDURES

Attachment A-1 – Standard Operating Procedures (SOPs)

LIST OF SOPS

SOP No.	Title
1	Field Documentation
2	Sample Custody, Packaging and Shipment
4	Groundwater Sampling and Water Level Measurements at Monitoring Wells and Piezometers
5	Surface Water Sampling
6	Surface Water Discharge Measurements
7	Equipment Decontamination
8	Monitoring Well Development
9	Sediment Sampling for Chemical Analyses
12	Drilling and Installation of Monitoring Wells
20	Data Review and Validation
23	Installation of Deep Bedrock Monitoring Wells
31	Water Quality Meter Calibration
FLD#-5	Standard Operating Procedure for Soil Sampling
FLD#-10	Pore Water Sampling

SOP No. 1 Field Documentation

STANDARD OPERATING PROCEDURE No. 1

FIELD DOCUMENTATION

1.0 SCOPE AND APPLICABILITY

The following Standard Operating Procedure (SOP) describes the protocol for documenting field monitoring activities. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate modifications to the procedures may be made to accommodate project-specific protocols when approved in writing or via email by the Project Manager or detailed in a project work plan, sampling plan, or quality assurance project plan.

The objective of this SOP is to establish a consistent method and format to document daily field activities. The resultant field notes and records are intended to provide sufficient information that can be used to recreate the field activities and the collection of environmental data.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- ANSI/ASQC E-4 (1994) American National Standards Institute/American Society for Quality Control Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs.

- ASTM D 6089 (2010) American Society for Testing and Materials (ASTM) ASTM D 6089 Standard Guide for Documenting a Ground-Water Sampling Event.

- EPA QA/G6 (2007) U.S. Environmental Protection Agency Guidance for Preparation of Standard Operating Procedures (SOPs). EPA/600/B-07/001. Office of Environmental Information, Washington, DC, April.

- EPA QA/G5 (2002) U.S. Environmental Protection Agency EPA Guidance for Quality Assurance Project Plans. EPA/240/R-02/009. Office of Environmental Information, Washington, DC, December.

3.0 PROCEDURES

3.1 Daily Field Activities

The field representative actually performing the environmental monitoring or sampling will record all field activities in the field notebook for each day of field work.

Documentation will include:

A. Project identification;

B. Date;

C. Time on job (beginning and ending time);

D. Weather conditions;

E. Activity description;

F. List of personnel and visitors on site;

G. Safety equipment used and monitoring performed;

H. Waste storage inventory (if any);

I. Chronological record of activities and events;

J. Comments and variances from project work plan;

K. Content of telephone conversations;

L. Calibration parameters; and

M. Signature of the field representative.

The field representative will document all details that would be necessary to recreate the day's activities and events at a later time. The field notebook will be used to document field activities and information that may not be specified on other field record forms. Other activity-specific documentation requirements to be recorded on field record forms are discussed in the Standard Operating Procedure for each activity.

4.0 DOCUMENTATION

4.1 Field Record Forms

In addition to the field notebook, field personnel will complete specific field record forms (which may be in paper or electronic format) applicable to the field activities being conducted. The procedures for completion of activity-specific field record forms are presented in the applicable Standard Operating Procedures. Additional field record forms and applicable procedures may be created for project-specific activities, as necessary.

4.2 Records Management

All original field forms and copies of field notebooks will be filed with the appropriate project records in the project files. Specific field record forms filled out using an electronic device will be printed and filed with the appropriate project records.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

All completed field forms will be reviewed by the Project Manager or project-designated reviewer. Any necessary corrections will be made in pen with a single-line strike out that is initialed and dated.

6.0 REFERENCES

American National Standards Institute/American Society for Quality Control, 1994. Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs. ANSI/ASQC E-4.

American Society for Testing and Materials (ASTM), 2010. ASTM D 6089-97. Standard Guide for Documenting a Ground-Water Sampling Event. American Society for Testing and Materials available online at http://www.astm.org/

U.S. Environmental Protection Agency (USEPA), 2007. EPA QA/G6, Guidance for Preparing Standard Operating Procedures (SOPs). EPA/600/B-07/001. Office of Environmental Information, Washington, DC, April. Available online at http://www.epa.gov/QUALITY/qs-docs/g6-final.pdf

U.S. Environmental Protection Agency (USEPA), 2002. EPA QA/G5, EPA Guidance for Quality Assurance Project Plans. EPA/240/R-02/009. Office of Environmental

Information, Washington, DC., December. Available online at http://www.epa.gov/QUALITY/qs-docs/g5-final.pdf

SOP No. 2 Sample Custody, Packaging and Shipment

STANDARD OPERATING PROCEDURE No. 2

SAMPLE CUSTODY, PACKAGING, AND SHIPMENT

1.0 SCOPE AND APPLICABILITY

The following Standard Operating Procedure (SOP) describes the protocol for sample custody and packaging and shipment of samples. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate modifications to the procedures may be made when approved in writing or via email by the Project Manager.

This SOP applies to any liquid or solid sample that is being transported by the sampler, a courier, or an overnight delivery service.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- 49 CFR 173. Shippers – Shippers – General Requirements for Shipping. United States Code of Federal Regulations available online at http://www.gpoaccess.gov/cfr/index.html
- 49 CFR 178. Specifications for Packaging. United States Code of Federal Regulations available online at http://www.gpoaccess.gov/cfr/index.html
- ASTM D 4220-95 (2000). Standard Practices for Preserving and Transporting Soil Samples, American Society for Testing and Materials available online at http://www.astm.org/
- ASTM D 4840-99 (2010). Standard Guide for Sampling Chain-of-Custody Procedures. American Society for Testing and Materials available online at http://www.astm.org/

3.0 PROCEDURES

The objectives of this packaging and shipping SOP are to minimize the potential for sample breakage, leakage, or cross contamination; to provide for preservation at the proper temperature; and to provide a clear record of sample custody from collection to analysis.

3.1 Packaging Materials

The following is a list of materials that will be needed to facilitate proper sample packaging:

- Chain-of-Custody (COC)/Request for Analysis (RA) forms;
- Analyte List;
- Coolers (insulated ice chests) or other shipping containers as appropriate to sample type;
- Transparent packaging tape;
- Duct tape or similar (for sealing cooler drain);
- Zip-lock type bags (note: this is used as a generic bag type, not a specific brand name);
- Large garbage bags;
- Protective wrapping and packaging material;
- Contained ice (packaged and sealed to prevent leakage when melted) or “Blue Ice”; and
- Chain-of-Custody seals.

3.2 Sample Custody from Field Collection to Laboratory

After samples have been collected, they will be maintained under chain-of-custody procedures. These procedures are used to document the transfer of custody of the samples from the field to the designated analytical laboratory. The same chain-of-custody procedures will be used for the transfer of samples from one laboratory to another, if required.

The field sampling personnel will complete a COC/RA form and provide an Analyte List for each separate container of samples to be shipped or delivered to the laboratory for chemical or physical (geotechnical) analysis. Information contained on the form will include:

1. Project identification;
2. Date and time of sampling;
3. Sample identification;
4. Sample matrix type;
5. Sample preservation method(s);
6. Number and types of sample containers;
7. Sample hazards (if any);
8. Requested analysis(es);
9. Method of shipment;
10. Carrier/waybill number (if any);
11. Signature of sampling personnel;
12. Name of Project Manager;
13. Signature, name and company of the person relinquishing and the person receiving the samples when custody is being transferred;
14. Date and time of sample custody transfer;
15. Condition of samples upon receipt by laboratory; and
16. Chain of Custody identification number.

The samples will be carefully packaged into shipping containers/ice chests.

The sampling personnel whose signature appears on the COC/RA form is responsible for the custody of a sample from the time of sample collection until the custody of the sample is transferred to a designated laboratory, a courier, or to another employee for the purpose of transporting a sample to the designated laboratory. A sample is considered to be in their custody when the custodian: (1) has direct possession of it; (2) has plain view of it; or (3) has securely locked it in a restricted access area.

Custody is transferred when both parties to the transfer complete the portion of the COC/RA form under "Relinquished by" and "Received by." Signatures, printed names, company or organization names, and date and time of custody transfer are required. Upon transfer of custody, the sampling personnel who relinquished the samples will retain a copy of the COC/RA form.

3.3 Sample Custody within Laboratory

The designated laboratory will assume sample custody upon receipt of the samples and COC/RA form. Sample custody within the analytical laboratory will be the responsibility of designated laboratory personnel. The laboratory will document the transfer of sample custody and receipt by the laboratory by signing the correct portion of the COC/RA form. Upon receipt, the laboratory sample custodian will note the condition of the samples, by checking the following items:

1. Agreement of the number, identification and description of samples received by comparison with the information on the COC/RA form; and
2. Condition of samples (any bottle breakage; leakage, cooler temperature, etc.).

If any problems are discovered, the laboratory sample custodian will note this information on the "Laboratory Comments/Condition of Samples" section of the COC/RA form, and will notify the sampling personnel or Project Manager immediately. The Project Manager will decide on the final disposition of the problem samples.

The laboratory will retain a copy of the COC/RA form and return an electronic copy to the originator with the final laboratory report of analytical results. The original of the COC/RA form will be retained as part of the permanent documentation in the project file. A record of the history of the sample within the laboratory containing sample status and storage location information will be maintained in a logbook, or a computer sample tracking system, at the laboratory. The following information will be recorded for every sample access event:

1. Sample identification;
2. Place of storage;
3. Date(s) and time(s) of sample removal and return to storage;
4. Accessor's name and title;
5. Reason for access; and
6. Comments/observations (if any).

The laboratory will provide a copy of the logbook or computer file information pertaining to a sample upon request.

3.4 Sample Custody during Inter-Laboratory Transfer

If samples must be transferred from one laboratory to another, the same sample custody procedures described above will be followed. The designated laboratory person (sample custodian) will complete a COC/RA form and sign as the originator. The laboratory relinquishing the sample custody will retain a copy of the completed form. The laboratory receiving sample custody will sign the form, indicating transfer of custody, retain a copy, and return the original record to the originator with the final laboratory report of analytical results. The COC/RA form will be retained as part of the permanent documentation in the project file.

3.5 Packaging and Shipping Procedure

All sample containers will be properly labeled and all samples will be logged on the COC/RA form in accordance with the procedures explained.

All samples will be packed in the cooler so as to minimize the possibility of breakage, cross-contamination, and leakage. Before placing the sample containers into the cooler, all sample bottle caps will be checked and tightened if necessary. A large garbage bag will be placed as a liner inside the cooler and duct tape (or similar) will be used to seal off any drain openings on the inside and/or outside of the cooler. Bottles made of breakable material (e.g., glass) will also be wrapped in protective material (e.g., bubble wrap, plastic gridding, or foam) prior to placement in the cooler. Each sample set or soil tube liner (for a California, Shelby Tube or Split-spoon Sampler) will be placed into a zip-lock bag to protect from cross-contamination and to keep the sample labels dry. Sample containers will be placed upright in the cooler. Stacking glass sample bottles directly on top of each other will be avoided.

If required by the method, samples will be preserved to 4°C prior to the analysis. Water ice or “blue ice” will be used to keep the sample temperatures at 4°C. The ice will be placed in two zip-lock bags if the samples are to be transported by someone other than the sampler (e.g., a courier or overnight delivery service). The zip-lock bags of ice will be placed in between, on the bottom, and/or on top of the sample containers so as to maximize the contact between the containers and the bagged ice. If the sampler is transporting the samples to the laboratory shortly after sample collection, the water ice may be poured over and between the sample bottles in the cooler.

If there is any remaining space at the top of the cooler, packing material (e.g., Styrofoam pellets or bubble wrap) will be placed to fill the open space of the cooler. After filling the cooler, the garbage bag will be sealed, a copy of the COC/RA form and Analyte List will be placed in a zip-lock bag and taped to the inside of the cooler lid, the top of the cooler will be closed, and the cooler will be shaken to verify that the contents are secure. Additional packaging material will be added if necessary.

When transport to the laboratory by the sampler is not feasible, sample shipment will occur via courier or overnight express shipping service that guarantees shipment tracking and next morning delivery (e.g., Federal Express Priority Overnight or UPS Next Day Air). The same procedures will be followed to pack and fill the cooler and provide the COC/RA form and Analyte List, as if the sampler were transporting the samples to the laboratory. The cooler will be taped shut with packaging tape. Packaging tape will completely encircle the cooler, and chain-of-custody seals will be signed and placed across the front and side of the container opening.

Copies of all shipment records provided by the courier or overnight delivery service will be retained and maintained in the project file.

4.0 DOCUMENTATION AND RECORDS MANAGEMENT

Daily Field Records or a field notebook with field notes will be kept describing the packaging procedures and the method of shipment. Copies of all shipping records and chain-of-custody records will be retained in the project file.

5.0 QUALITY ASSURANCE

The Project Manager or designated reviewer will check and verify that documentation has been completed and filed per this procedure.

6.0 REFERENCES

49 CFR 173. Shippers – General Requirements for Shipments and Packagings. United States Code of Federal Regulations. Available online at http://www.gpoaccess.gov/cfr/index.html

49 CFR 178. Specifications for Packaging. United States Code of Federal Regulations. Available online at http://www.gpoaccess.gov/cfr/index.html

ASTM D 4220-95 (2000). Standard Practices for Preserving and Transporting Soil Samples, ASTM International, West Conshohocken, PA, 2000. Available online at http://www.astm.org/

ASTM D 4840-99 (2010). Standard Guide for Sampling Chain-of-Custody Procedures, ASTM International, West Conshohocken, PA, 2010. Available online at http://www.astm.org/

ACZ Laboratories, Inc.

2773 Downhill Drive Steamboat Springs, CO 80487 (800) 334-5493

CHAIN of CUSTODY

Report to:

Name:	Address:
Company:	
E-mail:	Telephone:

Copy of Report to:

Name:	E-mail:
Company:	Telephone:

Invoice to:

Name:	Address:
Company:	
E-mail:	Telephone:

If sample(s) received past holding time (HT), or if insufficient HT remains to complete analysis before expiration, shall ACZ proceed with requested short HT analyses? YES ☐ NO ☐

If "NO" then ACZ will contact client for further instruction. If neither "YES" nor "NO" is indicated, ACZ will proceed with the requested analyses, even if HT is expired, and data will be qualified

Are samples for SDWA Compliance Monitoring? **Yes** ☐ **No** ☐

If yes, please include state forms. Results will be reported to PQL for Colorado.

Sampler's Name: ______________ **Sampler's Site Information** **State**______________ **Zip code**___________ **Time Zone**________

***Sampler's Signature:** ______________________

*I attest to the authenticity and validity of this sample. I understand that intentionally mislabeling the time/date/location or tampering with the sample in anyway, is considered fraud and punishable by State Law.

PROJECT INFORMATION

ANALYSES REQUESTED ***(attach list or use quote number)***

Quote #:

PO#:

Reporting state for compliance testing:

Check box if samples include NRC licensed material? ☐

SAMPLE IDENTIFICATION	DATE:TIME	Matrix	# of Containers								
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐
				☐	☐	☐	☐	☐	☐	☐	☐

Matrix: SW (Surface Water) · GW (Ground Water) · WW (Waste Water) · DW (Drinking Water) · SL (Sludge) · SO (Soil) · OL (Oil) · Other (Specify)

REMARKS

Please refer to ACZ's terms & conditions located on the reverse side of this COC.

RELINQUISHED BY:	DATE:TIME	RECEIVED BY:	DATE:TIME

FRMAD050.06.14.14 White - Return with sample. Yellow - Retain for your records.

SOP No. 4 Groundwater Sampling and Water Level Measurements at Mentoring Wells and Piezometers

STANDARD OPERATING PROCEDURE No.

4

GROUNDWATER SAMPLING AND WATER LEVEL MEASUREMENTS AT MONITORING WELLS AND PIEZOMETERS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during measurement of water levels and depths of monitoring wells and piezometers, and for water quality sampling from monitoring wells. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate modifications to the procedures may be made to accommodate project-specific protocols when approved in writing or via email by the Project Manager.

The objectives of the groundwater sampling procedures are to minimize changes in groundwater chemistry during sample collection and to maximize the probability of obtaining a representative, reproducible groundwater sample.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- USEPA Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Ground-Water Sample from Monitoring Wells for Site Characterization.

- USEPA Region 1 (2010) Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells. EQASOP-GW-001. Region 1 Low-Stress (Low-Flow) SOP, Revision Number 3, July 30, 1996, Revised January 19, 2010.

- USEPA (2002) Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, Ground Water Forum Issue Paper. U.S Environmental Protection Agency, Technology Innovative Office, Office of Solid Waste and Emergency Response, Washington D.C., EPA 542-S-02-001.

- U.S. Geological Survey (USGS) (variously dated) National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Chapters A1-A9.

3.0 WATER LEVEL AND WELL DEPTH MEASURMENT PROCEDURES

Prior to performing water level and well depth measurements, the construction details and previous measurements for each well or piezometer shall be reviewed by the field geologist or other field personnel so any anomalous measurements may be identified. Well construction details and previous measurements shall be available in the field for review.

In general, water-level measurements shall be performed before groundwater is removed from the well by purging or sampling.

3.1 Equipment

Equipment that may be necessary to perform measurements (depending on measurements to be performed):

- Well/piezometer construction details;
- An electronic water-level meter with accuracy of 0.01 foot;
- Water Level Monitoring Record Sheet, Groundwater Sampling Record or field notebook; and
- Weighted surveyor's rope (measured to the nearest 0.1 foot).

3.2 Measuring Point

A measuring point (MP) shall be selected and marked for each monitoring well and piezometer in which water level measurements will be made. Generally, the MP will be on the north side of the top of the well casing. The MP will be permanently marked using an indelible marker or a notch cut into the PVC casing. When the top-of-casing elevation of a monitoring well or piezometer is surveyed, the licensed surveyor shall measure the MP elevation and reference this measurement to an appropriate datum (such as feet above mean sea level).

3.3 Water Level Measurements

When water levels are measured to describe the groundwater potentiometric surface, the water level will be measured prior to purging. All wells to be gauged during a monitoring event and used to construct the potentiometric surface should have water levels measured within the same 24-hour period, as practical. All water level measurements will be recorded to the nearest 0.01 foot. Instruments used for each measurement will be noted on the Groundwater Sampling Record (attached form or similar). Water levels are measured using the electronic probe method, as discussed below.

An electronic probe consists of a contact electrode attached to the end of an insulated electrical cable, and a reel which houses an ammeter, a buzzer, or other closed circuit indicator. The indicator shows a closed circuit and flow of current when the electrode touches the water surface.

The procedure for measuring water levels with an electric probe is as follows:

1. Switch on and test that the battery is charged and set the sensitivity dial to the middle position.
2. Lower the probe into the well until the ammeter or buzzer indicates a closed circuit. Raise and lower the probe slightly until the shortest length of cable that gives the maximum response on the indicator is found.
3. With the cable in this fixed position, note the depth to water from the Measuring Point (MP).
4. Repeat as necessary until at least two identical duplicate measurements are obtained.

Calibration of the electronic probe will be checked at regular intervals as part of regular maintenance measuring the position of the electrode to check that the calibration marks on the electronic probe correspond to those on a weighted surveyor’s rope or other suitable measuring device.

3.4 Well Depth Measurements

The total depth of a well shall be measured by sounding with a weighted surveyor's rope or other suitable measuring device. For shallow wells, the electronic water-level probe may also be used as a measuring device. Procedures to be followed are specified below.

A. For calibration, measure the distance between the zero mark on the end of the measuring tape and the bottom of the weight to the nearest 0.1 foot at the beginning of each well depth measurement activity day, and whenever the apparatus is altered.

B. To measure well depth, lower a weighted tape into the well until the tape becomes slack or there is a noticeable decrease in weight, which indicates the bottom of the well. Care should be taken to lower the tape slowly to avoid damage to the bottom of the well by the weight. Raise the tape slowly until it just becomes taut, and with the tape in this fixed position, note the tape reading opposite the MP to the nearest 0.1 foot. Add the values from the distance from the end of the tape to the end of the weight together, round this number to nearest 0.1 foot, and record the resulting value as "Total Depth (feet [ft], below measuring point [BMP])" on the Groundwater Sampling Record or field notebook.

3.5 Documentation and Records Management

Water levels observed in wells selected for the groundwater level monitoring program will be tabulated on the Groundwater Sampling Record form during each monitoring period (in print or electronic format – see attached form) or in the field notebook. The date and time of each measurement will also be recorded in the field. All water level measurements shall be recorded to the nearest 0.01 foot, and all depth measurements shall be noted to the nearest 0.1 foot.

Water level data will be recorded as feet BMP so that water level elevations may be calculated from the depth-to-water measurement (from the MP) and the surveyed elevation of the MP at each well or piezometer. The MP will also be described and documented in the Groundwater Sampling Record and/or field notebook (i.e., top of PVC casing, top of protective casing, or below ground surface).

Well depth measurements may also be recorded on the Groundwater Sampling Record.

4.0 GROUNDWATER SAMPLE COLLECTION PROCEDURES

4.1 Low Flow Sample Collection

For wells that are sampled for regulatory compliance, a low flow sample collection technique shall be employed whenever possible to ensure that representative groundwater samples are collected from each well. Additionally, low flow sampling is to be the preferred method for groundwater sampling unless site specific conditions warrant a volume-based approach or a non-purge approach such as a HydraSleeve^{TM} (as discussed in Sections 4.2 and 4.3, respectively).

A. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference MP on the well casing with an electronic water level indicator or steel tape and recorded.

B. For wells with non-dedicated equipment (i.e., no dedicated tubing, pump, or docking station), place the pump at the wellhead and slowly lower the pump and tubing down into the well until the location of the pump intake is set to the midpoint of the screened interval, unless otherwise specified in the monitoring plan. Care should be taken to minimize disturbance to the water column during insertion of the pump. A variable rate submersible centrifugal or positive displacement type pump (i.e., bladder or piston pump) will be used for purging and sampling; however, if the water table is less than 20 ft below ground surface (bgs) a peristaltic pump may be employed as long as the constituents measured are not influenced by negative pressures. The pump and associated tubing used shall be constructed of inert materials and compatible with the parameter(s) to be collected. The placement of the pump intake should be positioned with a calibrated sampling pump hose, sounded with a weighted-tape or using a pre-measured hose. Refer to the available well information to determine the depth and length of the screened interval. The pump should be adequately supported once it has been lowered to ensure that it will not shift during purging. Record the depth of the pump intake after lowering the pump into location. For wells with dedicated pumping equipment, pump depth should be confirmed and equipment condition recorded.

C. Measure the water level (nearest 0.01 feet) and record the information on the Groundwater Sampling Record and/or in the field notebook. The water level indicator should remain in the well to allow for periodic measurement of the water level during purging.

D. Connect the discharge line from the pump to a flow-through cell to measure field water quality parameters. If turbidity measurements are to be collected using a separate instrument from that employed to monitor water quality in the flow through cell, a “T” connection is needed prior to the flow-through cell to allow for the collection of water for turbidity measurements. The discharge line from the flow-through cell must be directed to a container to hold the purge water during the purging and sampling of the well.

E. Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Adjust pump speed until little or no drawdown is evident (less than 0.33 ft). If the minimal drawdown that can be achieved exceeds 0.33 feet but remains stable, continue purging until field parameters stabilize. Typically flow rates should be within 0.1 L/min to 0.5 L/min; however highly productive aquifers may allow for higher flow rates to be used. Adjustments to the flow rate to achieve stabilization should be made as quickly as possible to minimize agitation of the water column. It should be noted that this goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on well-specific conditions and site experience.

F. Measure the discharge rate of the pump using a calibrated discharge volume measurement and stopwatch. Also, measure the water level and record both flow rate and water level on the Groundwater Sampling Record and/or in the field notebook. Continue purging, monitor and record water level and pump rate every three to five minutes during purging.

G. During purging, a minimum of one tubing volume (including the volume of water in the pump and flow-cell) must be purged prior to recording the water-quality indicator parameters. Then monitor and record the water-quality indicator parameters every three to five minutes. The water-quality indicator field parameters are turbidity, dissolved oxygen, specific conductance, pH, ORP, and temperature. The parameters are considered to have stabilized if on three successive readings of the water quality field parameters meet the following criteria:

- pH +/- 0.1 S.U.
- Specific Conductance 3% difference
- Temperature +/- 1ºC
- ORP +/- 10 mV
- Turbidity 10% difference for values greater than 10 NTU
- Dissolved Oxygen 10% difference

H. If a stabilized drawdown in the well can't be maintained at 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Begin pumping at a lower flow rate, if the water draws down to the top of the screened interval again, turn pump off and allow for recovery. If two tubing volumes (including the volumes of water in the field pump and flow-cell) have been removed during purging, then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or Groundwater Sampling Record.

I. If specified in the monitoring plan, a clean plastic disposable apron may be placed adjacent to or around the well to prevent equipment and sample containers from coming into contact with surface materials, prior to collecting samples from a well. Alternatively, a clean field table may be set up near the well. If used, the table will be cleaned (Section 5.1) before and after use at each well.

J. During sampling, maintain the same pumping rate or reduce slightly for sampling in order to minimize any additional disturbance of the water column. Samples should be collected directly from the discharge port of the pump tubing prior to passing through the flow-cell. The sequence of the sampling is immaterial unless filtered (dissolved) samples are collected which must be done last. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. In the event that the groundwater is turbid (greater than 10 NTUs) a filtered metals sample may be collected. If a filtered metals sample is to be collected, then an in-line filter is fitted at the end of the discharge tubing and the sample is collected after the filter.

   Sample bottles that do not contain preservative should be rinsed with the sample water prior to filling.

K. Remove the pump from the well. Decontaminate the pump and tubing if non-dedicated equipment is used.

L. Where more than one well within a specific field or site is to be sampled, the sampling sequence should begin with the well having the lowest suspected level of contamination, if known. Successive samples should be obtained from wells with increasing suspected contamination. If the relative degree of suspected contamination at each well cannot be reasonably assumed, sampling should proceed from the perimeter of the site towards the center of the site. The sampling sequence should be arranged such that wells are sampled in order of increasing proximity to the suspected source of contamination, starting from the wells upgradient of the suspected source.

M. Sampling activity for each monitoring well will be recorded on a Groundwater Sampling Record and the stabilized field parameters may also be recorded in the field notebook.

4.2 Volume-Based Sample Collection

In instances where low-flow sampling is not possible based on site-specific conditions (a minimum and stable drawdown cannot be maintained) samples from wells will be collected using a volume-based approach, if the yield of the well is sufficient, as follows:

A. The depth to water in a well and the total depth will be measured using the procedures discussed in Section 3, above.

B. A positive displacement pump, submersible pump, and/or bailer will be used for removing the groundwater from the monitoring wells (purging). Equipment used for purging and sampling may be permanently installed (dedicated) in the monitoring wells. Care must be taken that bailers and/or tubing are constructed from materials that will not affect the sample analyses. The well pump intake is to be set at the midpoint of the screened interval, unless otherwise specified in the monitoring plan in a manner consistent with that specified for the low-flow sampling above. Pumping is to be performed in such manner as to remove stagnant water while trying to minimize exposing the screened interval to atmospheric conditions and obtain the most representative sample.

C. Wells will be pumped or bailed until at least the volume of water removed is equal to three well casing volumes (volume of standing water in the well based upon total depth of well, the depth to water, and the well casing diameter). The purge rate must not reach a point where the recharge water is entering the well in an agitated manner (cascading water over the screen interval) and the water level in the well during purging should not be allowed to drop below the pump intake. During pumping, water level measurements will be collected (as described for low-flow sampling) and the purging rate adjusted to ensure that these conditions do not occur.

D. To ensure that the water samples are representative of the water-yielding zone, periodic measurements of the temperature, pH, dissolved oxygen, ORP, specific conductance and turbidity will be made. A flow-through cell may be used if purging with a pump. Measurements will be recorded for the initial water removed at a minimum following each well volume purged. Note that indicator parameters dissolved oxygen and ORP cannot be accurately measured using discrete samples obtained during bailing (due to exposure to the atmosphere and entrained air becoming trapped in the sampling probe). These parameters will only be collected using a flow-through cell. The sample will be collected only when the indicator parameters have stabilized (as discussed above in Section 4.1). No more than six well volumes should be removed to prevent the effects of over pumping. If the indicator parameters have not stabilized following six well volumes the field instruments will be recalibrated and checked for possible malfunction. If no problems are found, sampling can be conducted; however, the Project Manager will be notified and all information will be recorded in the field notebook and/or Groundwater Sampling Record. If the yield of the well is low such that it can be bailed or pumped dry, then the recharged groundwater in the well will be considered representative regardless of the number of casing volumes of groundwater removed, since all standing water in the well has been replaced by recharge from the water-yielding zone. If a well is purged dry, the well can be sampled upon 90% recovery or after two hours, whichever occurs first.

E. If specified in the monitoring plan, a clean plastic disposable apron may be placed adjacent to or around the well to prevent equipment and sample containers from coming into contact with surface materials, prior to collecting samples from a well. Alternatively, a clean field table may be set up near the well. If used, the table will be cleaned (Section 5.1) before and after use at each well.

F. Sample containers prepared specifically for the required analyses by the analytical laboratory or their supplier will be used for sample collection. Glass sample bottles should be filled to near the top. To account for slight expansion due to temperature changes, leave headspace approximately equivalent to the volume of liquid which would fill the bottle's cap. Plastic sample bottles should be filled completely. Splashing of the water in the sample container and exposure to the atmosphere shall be minimized during sampling. The container cap will be screwed on tightly immediately after filling the sample container. Under this protocol, samples should be collected in order of decreasing volatility (i.e., most volatile samples will be collected first). Sample filtration, if necessary, is discussed in Section 4.5 of this SOP.

Sample bottles that do not contain preservative should be rinsed with the sample water prior to filling.

G. Where more than one well within a specific field or site is to be sampled, the sampling sequence should begin with the well having the lowest suspected level of contamination, if known. Successive samples should be obtained from wells with increasing suspected contamination. If the relative degree of suspected contamination at each well cannot be reasonably assumed, sampling should proceed from the perimeter of the site towards the center of the site. The sampling sequence should be arranged such that wells are sampled in order of increasing proximity to the suspected source of contamination, starting from the wells upgradient of the suspected source.

H. Sampling activity for each monitoring well will be recorded on a Groundwater Sampling Record and the stabilized field parameters may also be recorded in the field notebook.

4.3 Non-Purge Sample Collection Using a HydraSleeve^{TM}

In monitoring wells with very low yield and/or where low-flow sampling or volume-based purging is not practical, a non-purge method, sampling using a HydraSleeve^{TM}, may be used to collect groundwater samples by the following procedure:

A. The depth to water in a well and the total well depth will be measured using the procedures discussed in Section 3, above. This measurement can be used to determine the preferred position of the HydraSleeve within the well screen.

B. Determine the necessary length of HydraSleeves needed for the specific well screen length and/or water column height to recover the necessary sample volume. HydraSleeves are manufactured in standard lengths of 30, 36, and 60 inches. However, up to three 30-inch HydraSleeves may be installed in series on a single tether (using plastic cable ties) to achieve more volume. Alternatively, a TurboSleeve may be used, which is a larger HydraSleeve that allows recovery of more sample volume. Per manufacturer's recommendations, the TurboSleeve should be allowed to equilibrate in the well for 24 hours before retrieval to allow for full compression of the sleeve for full sample recovery (see step G below).

C. Measure the correct amount of tether cord needed to suspend the HydraSleeve in the well so the weight will not rest on the bottom of the well and the desired depth is achieved.

D. Remove the HydraSleeve from its packaging, unfold and hold it by its top. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.

E. Attach the spring clip to the holes to ensure the top of the HydraSleeve will remain open until the sampler is retrieved. Attach the tether to the spring clip with a strong knot (or tether can be attached to one of the holes at the top of the HydraSleeve).

F. Fold the flaps with the two holes at the bottom of the HydraSleeve together and slide the weight clip through the holes. Attach the weight to the bottom of the weight clip to ensure the HydraSleeve will descend to the desired depth.

G. To deploy the HydraSleeve, carefully lower the HydraSleeve on its tether to the desired depth in the water column. Hydrostatic pressure will keep the self-sealing check valve at the top of the HydraSleeve closed and ensure that it remains flat and empty and will only fill with groundwater from the desired interval when it is retrieved.

H. To retrieve the HydraSleeve to collect groundwater samples, pull up the tether 30 to 45 inches (36 to 54 inches for longer HydraSleeves) in one smooth motion at a rate of about one inch per second or faster. This motion will open the top check valve and allow the HydraSleeve to fill. When the HydraSleeve is full, the top check valve will close and the full weight of the HydraSleeve can be felt by the sampler. Continue to pull the HydraSleeve upward to the top of the well to retrieve. Two persons are needed to retrieve a TurboSleeve, if used, due to its length and flexibility.

I. Once recovered, decant and discard the small volume of water trapped in the HydraSleeve above the top check valve.

J. To fill sample bottles, remove the discharge tube from its sleeve. While holding the HydraSleeve at the check valve, puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube. Discharge the water into the sample bottles as needed.

K. Any leftover water from the HydraSleeve can be poured into a separate vessel for the measurement of groundwater field parameters as needed.

L. Dispose each used HydraSleeve after use at an individual well.

4.4 Non-Purge Sample Collection by Bailer

In monitoring wells with very low yield where low-flow sampling or volume-based purging is not practical and sampling with HydraSleeves^{TM} is not feasible, sampling by bailer without purging the well may be used to collect groundwater samples.

Sampling by bailer may be used by the following procedure:

A. The depth to water in a well and the total depth will be measured using the procedures discussed in Section 3, above. This measurement can be used to determine the height of water and the volume of groundwater within the well screen.

B. A clean, sufficiently weighted PVC or polyethylene bailer will be used attached to a pre-measured length of either coated stainless steel cable or nylon rope tether for each well to be sampled by bailing.

C. The bailer will be slowly lowered through the water column to the well screen interval on the pre-measured tether. Slow and consistent movement of the bailer downward through the well allows the water within the well to pass through the bailer.

D. When the desired depth within the well screen interval is reached, the downward movement of the bailer will immediately be reversed and the bailer slowly retrieved to the surface. This action allows the bailer to collect water representative of conditions within the well screen interval while minimizing generation of turbid conditions within the well.

E. Steel cable or rope will not be allowed to touch the ground surface during retrieval. A reel, tub, tarp, or plastic sheeting can be used to prevent contact with the ground.

F. Upon retrieval of the bailer, sample bottles for total and dissolved metals analysis will be filled first, followed by the remaining sample bottles for other parameters. If more sample volume is needed, the bailer will again be slowly lowered to the screen interval and retrieved as necessary until required sample bottles have been filled.

G. If a filtered metals sample is to be collected, the necessary volume can be filtered from one clean, non-preserved sample bottle as needed.

H. Field parameters will be measured in the instrument cup or other rinsed container following collection of sample bottles. A small aliquot of sample volume will be poured from the bailer for the collection of field parameters.

I. If the well bails dry but additional sample volume is required, the volume will be removed from the well via bailer if such recharge occurs in the well within 24 hours.

4.5 Sample Filtration

When required, a field-filtered water sample will be collected using a disposable, in-line 0.45 micron (µm) filter. The water sample will be pumped through the filter attached directly to the discharge tubing. A peristaltic pump and a clean section of Tygon (polyvinylchloride) tubing, silicone tubing, or other appropriate method may be used if the sample is collected via bailer. The filter cartridge will be rinsed according to the manufacturer's recommendations. If there are no recommendations available, for rinsing pass through a minimum aliquot of 100 ml of sample water prior to collection of sample in to the containers. Both the filter and tubing will be disposed between samples.

4.6 Sample Containers and Volumes

The sample containers will be appropriate to the analytical method and will be obtained from the water analysis laboratory or other approved source. Different containers will be required for specific groups of analytes in accordance with USEPA Methods, project-specific requirements, and/or other local jurisdictional guidance. The sampler will confirm with the laboratory performing the analyses that appropriate bottleware and preservatives are used and ensure that a sufficient volume of sample is collected.

4.7 Sample Labeling

Sample containers will be labeled with self-adhesive tags. Each sample will be labeled with the following information using waterproof ink:

- Project identification;
- Lab Name;
- Sample identification;
- Date and time samples were obtained;
- Matrix;
- Requested analyses and method;
- Bottle type;
- Treatment (preservative added, filtered, etc.);
- Lab QC (if applicable); and
- Initials of sample collector(s).

4.8 Sample Preservation and Storage

If required by the project or analytical method, water samples submitted for chemical analysis will be stored at 4 ºC in ice-cooled, insulated containers immediately after collection. Preservation and storage methods depend on the chemical constituents to be analyzed and should be discussed with the laboratory prior to sample collection. USEPA and/or other local jurisdictional requirements and/or the requirements of a project-specific plan (e.g., sampling and analysis plan, work plan, quality assurance project plan, etc.) shall be adhered to in preservation and storage of water samples.

4.9 Sample Custody

Samples shall be handled and transported according to the sample custody procedures discussed in SOP No. 2 (SAMPLE CUSTODY, PACKAGING, AND SHIPMENT). Sampling personnel shall document each sample on the Chain-of-Custody Record

4.10 Field Measurements

Specific conductance, pH, dissolved oxygen, ORP, temperature, and turbidity measurements will be performed on water samples at the time of sample collection. The only exceptions will be for DO and ORP when the samples are collected via bailer or in those instances where a flow-through cell cannot be used. Data obtained from these (or other) field water quality measurements will be recorded on the appropriate sampling records or in the field notebook. Separate aliquots of water shall be used to make field measurements (i.e., sample containers for laboratory analysis shall not be reopened).

For groundwater samples, field measurement intervals will be as presented above. If the parameters have not stabilized, check to insure that the field instruments are operating correctly and remain calibrated. Recalibrate the instruments if needed, if an instrument cannot be calibrated it will be labeled needing repair and removed from service. Field measurements and purging will continue until three consecutive readings have stabilized to within the following limits or until a maximum of six casing volumes have been removed:

- pH +/- 0.1 S.U.;

- Specific Conductance 3% difference;
- Temperature +/- 1ºC;
- ORP +/- 10 mV;
- Turbidity 10% difference for values greater than 10 NTU; and
- Dissolved Oxygen 10% difference.

4.10.1 Temperature Measurement

Temperature will be measured directly from the water source or from a separate sample aliquot. Temperature measurements will be made with a mercury-filled thermometer, bimetallic-element thermometer, or electronic thermistor. All measurements will be recorded in degrees Celsius (°C). When a flow-through cell is used the temperature can be measured directly via a multi-parameter instrument as per the manufacturer's instructions.

4.10.2 pH Measurement

A pH measurement will be made by dipping the probe directly into the water source or into a separate sample aliquot. Prior to measurement, the container in which the field parameter sample will be collected will be acclimated to the approximate temperature of the sample. This can be accomplished by immersing the container in water removed from a well during the purging process. The pH measurement will be made as soon as possible after collection of the field parameter sample, preferably within a few minutes, using a pH electrode. The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated range, then the pH meter will be recalibrated using the appropriate buffer solutions. When a flow-through cell is used, the pH can be measured directly via a multi-parameter instrument as per the manufacturer's instructions.

4.10.3 Dissolved Oxygen

Dissolved oxygen (DO) will be measured by using a suitable multi-parameter meter that can be placed into a flow-through cell and sealed such that exposure to the atmosphere is prevented. DO measurements will be reported in milligrams per liter (mg/L). The instrument will be calibrated in accordance with SOP No. 31 (WATER QUALITY METER CALIBRATION).

4.10.4 Oxidation Reduction Potential

Oxidation Reduction Potential (ORP) will be measured by using a suitable multi-parameter meter that can be placed into a flow-through cell and sealed such that exposure to the atmosphere is prevented. ORP measurements will be reported in mV. The instrument will be calibrated in accordance with SOP No. 31 (WATER QUALITY METER CALIBRATION).

4.10.5 Specific Conductance Measurement

Specific conductance will be measured by dipping the probe directly into the water source or into a separate sample aliquot. The probe must be immersed to the manufacturer's recommended depth. Specific conductance will be reported in micromhos/cm or microsiemens/cm at 25 ºC. If the meter is not equipped with an automatic temperature compensation function, then the field value will be adjusted at a later time using the temperature data and the following formula:

$$SC_{25} = SC_T / [1 + \{(T - 25) \times 0.025\}]$$

where: SC_{25} = specific conductance at 25 °C
SC_T = specific conductance measured at temperature T (°C)
T = sample temperature (°C)

The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated "range" set by the range dial on the instrument, then the range setting will be changed to a position that gives maximum definition. If the specific conductance value falls outside of the calibrated range of the conductivity standard solution, then the instrument will be recalibrated using the appropriate standard prior to measurement. When a flow-through cell is used the specific conductance can be measured directly via a multi-parameter instrument as per the manufacturer’s instructions.

4.10.6 Turbidity

Turbidity will be measured by using a field portable nephlometer separate from the multi-parameter meter used for DO and ORP and capable of reading down to 0.1 NTU. Turbidity will be measured directly from the water source or from a separate sample aliquot. The instrument will be calibrated at least daily prior to initiating field activities and periodically throughout the day or as recommended by the instrument manufacturer. Turbidity measurements will be reported in nephlometric turbidity units (NTU). When a flow-through cell is used, the turbidity can be measured directly via a multi-parameter (e.g., YSI Sonde 6920) instrument, if so equipped, as per the manufacturer's instructions.

4.10.7 Equipment Calibration

Equipment used to measure field parameters will be calibrated daily in the field in accordance with SOP No. 31 (WATER QUALITY METER CALIBRATION) prior to any measurements being taken.

5.0 DOCUMENTATION

5.1 Groundwater Sampling Record

Each sampling event for each monitoring well will be recorded on a Groundwater Sampling Record form (which may be in paper or electronic format) or in the field notebook.

The documentation should include the following:

- Project identification;
- Location identification;
- Sample identification(s) (including quality control samples);
- Date and time of sampling;
- Purging and sampling methods;
- Sampling depth;
- Name(s) of sample collector(s);
- Inventory of sample bottles collected including sample preservation (if any), number, and types of sample bottles;
- Total volume of water purged;

- Results of field measurements and observations (time, cumulative purge volume, temperature, pH, specific conductance, turbidity, sediment, color, purge rate);
- Equipment cleaning record;
- Description and identification of field instruments and equipment; and
- Equipment calibration record; and
- Number of photos (if any were taken).

When the sampling activity is completed, the Groundwater Sampling Record (whether in print or electronic format) will be checked by the Project Manager or his/her designee, and the original record will be placed in the project file.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

6.1 Equipment Decontamination/Cleaning

Steel surveyor's tapes, electric well probes, and other measuring tapes shall be cleaned prior to use and after measurements in each well are completed. Cleaning shall be accomplished by either: (1) washing with a laboratory-grade detergent/water solution, rinsing with clean, potable, municipal water, final rinsing with distilled or deionized water, or (2) steam cleaning followed by rinsing with distilled or deionized water.

Sample bottles and bottle caps will be pre-cleaned and prepared by the analytical laboratory or their supplier using standard USEPA-approved protocols. Sample bottles and bottle caps will be protected from dust or other contamination between time of receipt by the sampler(s) and time of actual usage at the sampling site.

Groundwater sampling equipment may be dedicated to a particular well at a project site. Prior to installation of this equipment, all equipment surfaces that will be placed in the well or may come in contact with groundwater will be cleaned to prevent the introduction of contaminants.

Sampling equipment that will be used at multiple wells or sampling locations will be cleaned after sampling at each location is completed in accordance with the SOP entitled EQUIPMENT DECONTAMINATION (SOP No. 7).

Equipment such as submersible electric pumps, which cannot be disassembled for cleaning, will be cleaned by circulating a laboratory-grade detergent (e.g., Alconox) and potable water solution through the assembly, followed by clean potable water from a municipal supply, and then by distilled or deionized water. Equipment cleaning methods will be recorded on the Groundwater Sampling Record.

6.2 Technical and Records Reviews

The Project Manager or designated reviewer will check and verify that documentation has been completed and filed per this procedure.

In addition, all calculations of water-level elevations must be reviewed before they are submitted to the project file and used to describe site conditions. The calculation review should be performed by technical personnel familiar with this procedure. Evidence of the completed review and any necessary corrections to calculations should also be submitted to the project file.

7.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), Region 9. Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Ground-Water Sample from Monitoring Wells for Site Characterization. Available online at: www.epa.gov/region9/qa/pdfs/finalgwsamp_sop.pdf.

USEPA, 2010. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells._EQASOP-GW-001 Region 1 Low-Stress (Low-Flow) SOP, Revision Number 3, July 30, 1996, Revised January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf

USEPA, 2002, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, Ground Water Forum Issue Paper. U.S Environmental Protection Agency, Technology Innovative Office, Office of Solid Waste and Emergency Response, Washington D.C., Douglas Yeskis, EPA Region 5, Chicago IL, and Bernard Zavala, EPA Region 10, Seattle, WA, EPA 542-S-02-001. May 2002. http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf

U.S. Geological Survey (USGS), variously dated. National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9. Available online at http://pubs.water.usgs.gov/twri9A.

SOP No. 5 Surface Water Sampling

STANDARD OPERATING PROCEDURE No. 5

SURFACE WATER SAMPLING

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during sampling of surface water. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate modifications to the procedures may be made to accommodate project-specific protocols when approved in writing or via email by the Project Manager.

The objectives of the water quality sampling procedures are to minimize changes in surface water chemistry during sample collection and to maximize the probability of obtaining a representative, reproducible surface water sample.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- U.S. Geological Survey (USGS) (variously dated) National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Chapters A1-A9.
- U.S. Environmental Protection Agency (USEPA) (2003) USEPA Region 8 SOP EH-#1 Technical Standards Operating Procedure – Surface Water Sampling East Helena Site, Montana.

3.0 PROCEDURES

3.1 Sample Collection

Individual samples from surface water sampling stations will be collected as follows:

A. Where multiple sampling stations exist along a moving water source (i.e., a creek or drainage channel), the downstream station will be sampled first. A moving water sample will be taken from the portion of the water with maximum flow at any given sampling station unless otherwise specified. If the sampling point is inaccessible from shore, the sampling personnel will enter the water from a point downstream of the sampling point, taking care not to disturb the water.

B. A standing water sample will be taken at a point in the body of water at least three feet from the shore, if possible, or unless otherwise specified.

C. A surface water sample will be collected according to one of the following, or similar, techniques.

   1. Direct Method -- Sample bottle or disposable container (e.g., cubitainer) is uncapped and inverted, submerged to the specified depth, turned upright pointing upstream, removed from the water, and then capped (if actual sample bottle used). Add preservative, if any, after sample collection.

   2. Dipper Method -- Sample bottle or container attached to a pole is dipped in the water, raised above the water, and then capped (if actual sample bottle used).

   3. Bailer Method -- An appropriate sampling bailer with a ball check valve is submerged to the desired sample depth, either directly or by suspending the bailer on a rope from a pole.

   4. Syringe Method (for very shallow water) -- A disposable plastic filtering syringe may be used to collect very shallow surface water without disturbing the sediment. The syringe will be disposed of after each use.

   5. Peristaltic Pump Method -- The sample is collected through a section of new, clean, flexible Tygon (polyvinylchloride) or silicone tubing. The tubing intake will be secured manually or by attaching weights. This procedure may be modified to collect the sample through a Teflon tube into a sample flask by running the pump on a vacuum.

   6. Kemmerer Bottle -- Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the upper and lower stoppers are pulled away from the body, allowing water to enter the tube. Lower the pre-set sampling device to the predetermined depth. Avoid disturbing the bottom. Once at the required depth, send the weighted messenger down the suspension line, closing the device. Retrieve the sampler and discharge the first 10-20 mL from the drain to clear water that may not be representative of the sample. Repeat as needed to collect the needed volume.

7. Van Dorn Sampler -- Set the device so that the end stoppers are pulled away from the body allowing surface water to enter the tube. Lower the sampler to the predetermined depth. Once at the required depth send the weighted messenger down the suspension line, closing the sampling device. Retrieve the sampler and decant the first 10-20 mL from the drain to clear water that may not be representative of the sample from the valve. Repeat as needed until the required volume to fill sample bottles is collected.

8. Bacon Bomb Sampler -- Lower the bacon bomb sampler carefully to the desired depth, allowing for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taught. This will allow the sampler to fill. Release the trigger line and retrieve the sampler. Decant the first 10-20 mL from the drain to clear water that may not be representative of the sample from the valve. Repeat as needed until the required volume to fill sample bottles is collected.

9. Sampling Using an Unmanned Aerial System (UAS [drone]) -- The drone will be flown according to all local, state, and federal guidelines by a pilot with an appropriate Federal Air Administration certificate. The drone will be affixed with a small container (e.g. 250 ml flask) that will be carefully lowered into the desired portion of the stream. The container is connected to the drone with a safety breakaway, in case the water is moving too quickly. Once filled the container will be returned to shore and decanted for parameters and sample collection. Repeat as needed until the required volume to fill sample bottles is collected.

D. For the direct and dipper methods, the mouth of the sample collection container will be oriented downstream. The first collected water will be used to rinse the sampling equipment. Sample bottles that do not contain preservative should be rinsed with the sample water prior to filling. Subsequent water collected will be used to fill the analytical sample bottles until all bottles are filled. Field measurement of parameters will be taken once for each sampling station at the time of sample collection. Field parameters (pH, specific conductance, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), odor, turbidity, and/or sediment) will be measured from a separate container (instruments will not contact the analytical samples) or directly from the water body sampled downgradient of the sample collection location.

E. To mark the exact sampling location, either: (1) a stake or pole identifying the sampling station should be placed at or near the sampling station for future identification of the location, or (2) the sample location will be recorded in a Global Positioning System (GPS) device and coordinates will be downloaded at the end of the field event. Personnel will record a brief description of the stake or pole location in relation to permanent landmarks, and the sampling location in relation to the stake or pole (example: stake is approximately 100 feet west along Markley Creek from Somersville Road, on north-side shore. Sampling point is 25 feet south of stake, in middle of Markley Creek), or the GPS coordinates of the location. Personnel will include a sketch map of the sampling station in the Surface Water Sampling Record (attached form or similar).

3.2 Sample Filtration

When required, a field-filtered water sample will be collected using a disposable, in-line 0.45 micron (μm) filter. The water sample will be pumped through the filter attached directly to the discharge tubing. A peristaltic pump and a clean section of Tygon (polyvinylchloride) tubing, silicone tubing, or other appropriate method may be used. The filter cartridge will be rinsed according to the manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum aliquot of 100 ml of sample water prior to collection of sample into the containers. Both the filter and tubing will be disposed between samples.

3.3 Sample Containers and Volumes

The sample containers will be appropriate to the analytical method and will be obtained from the water analysis laboratory or other approved source. Different containers will be required for specific groups of analytes in accordance with U.S. EPA Methods, project-specific requirements, and/or other local jurisdictional guidance. The sampler will confirm with the laboratory performing the analyses that appropriate bottleware and preservatives are used and ensure that a sufficient volume of sample is collected.

3.4 Sample Preservation and Storage

If required by the project or analytical method, water samples submitted for chemical analysis will be stored at 4ºC in ice-cooled, insulated containers immediately after collection. Preservation and storage methods depend on the chemical constituents to be analyzed and should be discussed with the water analysis laboratory prior to sample collection. EPA and/or other local jurisdictional requirements and/or the requirements of a project-specific plan (e.g., sampling and analysis plan, work plan, quality assurance project plan, etc.) shall be adhered to in preservation and storage of water samples.

3.5 Field Measurements

Specific conductance, pH, turbidity, DO, ORP, and temperature measurements will be performed on water samples at the time of sample collection. Data obtained from these (or other) field water quality measurements will be recorded on the appropriate sampling records and/or in the field notebook. Separate aliquots of water shall be used to make field measurements (i.e., sample containers for laboratory analysis shall not be reopened). For surface water sampling, the parameters will be measured once and recorded.

3.5.1 Temperature Measurement

Temperature will be measured directly from the water source or from a separate sample aliquot. Temperature measurements will be made with a mercury-filled thermometer, bimetallic-element thermometer, multiprobe, or electronic thermistor. All measurements will be recorded in degrees Celsius (^{o}C) after the reading has stabilized.

3.5.2 Turbidity

Turbidity will be measured by using a field portable nephlometer or integrated turbidity sensor on a multi-parameter meter (e.g., YSI Sonde 6920) capable of reading down to 0.1 NTU. The instrument will be calibrated at least daily or according to the manufacturer’s recommendations prior to initiating field activities and periodically throughout the day or as recommended by the instrument manufacturer. Turbidity measurements will be reported in nephlometric turbidity units (NTU).

3.5.3 pH Measurement

A pH measurement will be made by dipping the probe directly into the water source or into a separate sample aliquot. Prior to measurement, the container in which the field parameter sample will be collected will be acclimated to the approximate temperature of the sample. This can be accomplished by immersing the container in water collected from the sampling location. The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated range, then the pH meter will be recalibrated using the appropriate buffer solutions.

3.5.4 Specific Conductance Measurement

Specific conductance will be measured by dipping the probe directly into the water source or into a separate sample aliquot. The probe must be immersed to the manufacturer's recommended depth. Specific conductance will be reported in micromhos/cm at 25 ºC. If the meter is not equipped with an automatic temperature compensation function, then the field value will be adjusted at a later time using the temperature data and the following formula:

$$SC_{25} = SC_T / [1 + \{(T - 25) \times 0.025\}]$$

where:
SC_{25} = specific conductance at 25 ºC
SC_T = specific conductance measured at temperature T (ºC)
T = sample temperature (ºC)

The value displayed on the calibrated instrument will be recorded after the reading has stabilized. If the value falls outside of the calibrated "range" set by the range dial on the instrument, then the range setting will be changed to a position that gives maximum definition. If the specific conductance value falls outside of the calibrated range of the conductivity standard solution, then the instrument will be recalibrated using the appropriate standard prior to measurement.

3.5.5 Dissolved Oxygen

Dissolved oxygen measurements taken from surface water locations should be representative of the conditions being monitored. For example, if a sample is to be collected from the middle of a stream cross-section, that is also where the DO measurement should be taken.

The dissolved oxygen probe should be fully immersed in the water body being monitored. If the DO measurement is taken from a stream, the probe should be elevated above the stream bed to minimize disturbance of channel sediments. If DO measurements are taken from a water body that is not flowing, the probe should be slowly raised and lowered so that water is moving past the DO probe membrane.

Dissolved oxygen readings should be recorded after allowing sufficient time for the probe to equilibrate and the readings to stabilize. For surface water measurements, the DO reading will typically stabilize as soon as the probe has equilibrated. The value displayed on the calibrated instrument will be recorded after the reading has stabilized.

3.5.6 Oxidation-Reduction Potential

Oxidation-Reduction potential will be measured by dipping the probe directly into the water source or into a separate sample aliquot. The probe must be immersed to the manufacturer's recommended depth. ORP will be reported in mV. Readings should be recorded after allowing sufficient time for the probe to equilibrate and the readings stabilize.

3.5.7 Equipment Calibration

Equipment used to measure field parameters will be calibrated in the field daily in accordance with SOP No. 31 (WATER QUALITY METER CALIBRATION) by field personnel prior to the collection of any samples

4.0 DOCUMENTATION

Each sampling event for each surface water sampling station will be recorded in the field notebook and/or on a separate Surface Water Sampling Record form (in print or electronic format – see attached). The documentation should include the following:

A. Project identification;
B. Location identification (sampling station);
C. Sample identification(s) (including quality control samples);

D. Date and time of sampling;
E. Weather conditions;
F. Description of sampling location;
G. Sampling method;
H. Description of flow measurement method, if applicable, and any flow data;
I. Instrument calibration and cleaning record;
J. Results of field measurements and observations (time, temperature, pH, specific conductance, turbidity, DO, ORP);
K. Name(s) of sample collector(s);
L. Sketch map showing location of sampling station and permanent landmarks and/or GPS coordinates (if GPS coordinates do not already exist for the sampling station); and
M. Number of photos (if taken).

When the sampling activity is completed, the Surface Water Sampling Record will be checked by the Project Manager or his/her designee, and the original record will be placed in the project file.

5.0 QUALITY CONTROL

5.1 Equipment Decontamination/Cleaning

Sample bottles and bottle caps will be cleaned and prepared by the analytical laboratory or their supplier using standard EPA-approved protocols. Sample bottles and bottle caps will be protected from dust or other contamination between time of receipt by the sampling personnel and time of actual usage at the sampling site.

Sampling equipment that will be used at multiple sampling locations will be cleaned after sampling at each location is completed in accordance with the SOP No. 7 (EQUIPMENT DECONTAMINATION).

Equipment such as submersible electric pumps, which cannot be disassembled for cleaning, will be cleaned by circulating a laboratory-grade detergent (e.g., Alconox) and potable water solution through the assembly, followed by clean potable water from a municipal supply, and then by distilled or deionized water. Equipment cleaning methods will be recorded in the field notebook and/or on the Surface Water Sampling Record.

5.2 Records Review

The Project Manager or designated reviewer will check and verify that documentation has been completed and filed per this procedure.

6.0 REFERENCES

U.S Environmental Protection Agency (USEPA), 2003. USEPA Region 8 Technical Standard Operating Procedure, Surface Water Sampling (SOP #EH-01, East Helen Site, Montana). September 2003. Adapted from ERT/REAC SOP 2013 Rev 1.0. Available online at http://nctc.fws.gov/resources/course-resources/pesticides/Monitoring/Surface%20Water%20Sampling_EPA.pdf

U.S. Geological Survey (USGS), variously dated. National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Chapters A1-A9. Available online at http://pubs.water.usgs.gov/twri9A.

SURFACE WATER SAMPLING RECORD

LOCATION ID:

Date: __________ Time: ________ Weather: _____________________________________ Page _____ of ______

Weather Past 48 hours: ____________________________ Personnel: ____________________________________

Location Description: ____

Water Body Type: __________Water Present (Y/N)________Depth____________ Flow Meas (Y/N)__Reason if N__________

QUALITY ASSURANCE

Sampling Equipment:

Decontamination: Alconox, Distilled Water, Rinse

Method of Sampling:

FIELD PARAMETER INSTRUMENTS

pH Meter: Model: YSI-556 Calibration: 4.00/7.00 pH Buffers

After Calibration Meter Read: ____

Conductivity Meter: Model: YSI-556 Calibration: 1,413 *u*S/cm Conductivity Standard

After Calibration Meter Read: ____

Temperature Meter: Model: YSI-556

ORP Meter: Model: YSI-556 Calibration: YSI Zobell Solution

Turbidity Kit: Model: HF Scientific MicroTPW Turbidity Meter; Calibration: ____________________

SAMPLING MEASUREMENTS

Sample Collection Time	Depth (ft)	pH	Specific Conductance (µmhos/cm)	Temp. (°C)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	ORP (mV)

SAMPLE INVENTORY

Sample Type (circle one): Primary Sample Duplicate Equipment Rinsate Blank

SAMPLE ID: ____

Sample Processing		Container Type	Volume (mL)	Number of Bottles	Filtered	Preservative	Comments
Date	Time						

MAP / COMMENTS **UTM Coordinates (NAD83):**

SIGNATURE: ____

SOP No. 6 Surface Water Discharge Measurements

STANDARD OPERATING PROCEDURE No. 6

SURFACE WATER DISCHARGE MEASUREMENT

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol for collecting discharge measurements in streams, ditches, springs, seeps, etc. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate revisions may be made to accommodate site-specific conditions or project-specific protocols when approved in writing or via email by the Project Manager.

The objective of this SOP is to provide a consistent method for describing a current, and three methods for measuring discharge: (1) volumetric method, (2) area-velocity method, and (3) flume method. Discharge is defined as the volume rate of water flow, including any substances suspended or dissolved in the water. Discharge will be expressed in cubic feet per second (cfs) or gallons per minute (gpm). Note that the protocol for collection of surface water samples is included in SOP No. 5 (WATER QUALITY SAMPLING).

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- Rantz, S.E. et al. (1982) Measurement and Computation of Streamflow: Volume 1, Measurement of Stage and Discharge, U.S. Geological Survey Water Supply Paper 2175. U.S. Government Printing Office, Washington, D.C.
- U.S. Department of the Interior Geological Survey (USGS) (1977) National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, U.S. Geological Survey, Reston, VA.
- U.S. Environmental Protection Agency (USEPA) (1986) Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. Environmental Services Division, Region IV, Athens, GA.

- Oberg, K. A., Morlock, S. E., & Caldwell, W. S., 2005, Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers. (available online at https://pubs.usgs.gov/sir/2005/5183/SIR_2005-5183.pdf

3.0 PROCEDURES

The selection of an appropriate method for discharge measurement depends on the flow conditions within the stream reach. In some conditions, the flow measurement methods described here may be impossible to implement (e.g., extreme high or turbulent flow conditions). If flow cannot be measured at a specific location, then field personnel will attempt to measure flow at a point upstream or downstream of the sample site. The field personnel will also note the conditions that inhibited measurement at the designated measurement location.

3.1 Current Description

In cases where a discharge measurement is not required but a description of the direction and relative rate of flow is useful, the following method for current measurement may be used.

> The current within a moving body of water and its direction is variable by location and depth. Current measurement may be used to define the movement of water at a specified location and depth where a sample is collected. Qualitative measurement of current is made by using a strip of soft tape or cloth attached to the end of a pole. The strip will indicate the presence of water flow and direction of flow at the location and depth. The diameter of the pole should be sufficiently small to prevent directional error.

3.2 Discharge Measurement

The selection of discharge measurement method depends on streamflow rate and/or specific channel characteristics. For pipes, drain system outfalls, and cases where flows are too small or stream gradients are too high, the volumetric method may be appropriate. In cases where water depth is greater than 0.3 feet or the channel cross section is wide, discharge should be measured using the area-velocity method. Where flows are below the practical limit that can be measured with the area-velocity method, the flume method is best. Where the total discharge is conveyed through multiple channels or differing types, a combination of these methods may be appropriate.

3.3 Volumetric Method

The volumetric method is a simple and accurate method for measuring flow from small discharges such as gravity flow discharged from pipe outlets. This method involves observing the time required to fill or partly fill a calibrated container to a known volume. Alternatively, in the case of measuring discharge remotely in a sump or standpipe setting, the volumetric method may be performed by capturing flow in a container for a set period of time, no less than 10 seconds, if possible. This volume of water is then measured and discharge is determined and divided by the elapsed fill time.

3.3.1 Equipment

The volumetric method is particularly useful for the measurement of small flows. Equipment required to make this measurement includes a calibrated container and a stopwatch. Calibrated containers of varying sizes include: 5-gallon bucket, 2-liter graduated cylinder, 1-liter graduated cylinder, 1-liter bucket, etc. Extension rods will be used to hold a container for capturing flow in enclosed areas containing discharging pipes.

3.3.2 Maintenance and Calibration Procedures

Graduated cylinders are incremented in terms of milliliters and can be easily converted to gallons. The incremental volume of a 5-gallon bucket can be determined by adding known volumes of water and recording the depth after each addition.

3.3.3 Field Procedures

Upon arrival at the site, the field personnel will evaluate the flow conditions to select the appropriate method for flow measurement. If the flow conditions meet those outlined in Section 3.3, then field personnel will observe and use judgment in approximating the flow volume and will select an appropriately sized volumetric container to use the volumetric method of flow measurement.

Field personnel will use a stopwatch to measure the time required to fill a volumetric container. This is done by timing flow into the container for a minimum of 10 seconds, if possible. A minimum of five consecutive measurements will be made and noted, and the results will be averaged to determine the discharge.

If remote measurement is necessary, a container will be attached to an extension rod. The field personnel will time flow for a minimum of 10 seconds, if possible. The volume of water will then be poured into a calibrated container, measured, and recorded. A minimum of five such measurements will be made, noted, and the results averaged to determine the discharge.

3.3.4 Discharge Calculations

Discharge will be determined initially in gallons per second (gal/s) or in milliliters per second (ml/s). These values will be noted, but the averaged value will be reported in cubic feet per second (cfs). Calculations will be performed as follows:

- Record each of the measurements in terms of gallons per second or milliliters per second, depending on the volumetric container.
- If one of the measurements is different from the other measurements by 50 percent or more, then this value will not be used. Instead, five additional measurements will be taken and, provided that none of these measurements differs by greater than 50 percent from the other measurements, these values will be used.
- Calculate the average of the measured values.
- Leakage around the discharge pipe, if any, will also be estimated and noted.
- Convert the averaged value to cfs as follows:
  - o to convert ml/s to cfs, multiply by 3.53×10^{-5}
  - o to convert gal/s to cfs, multiply by 0.134
- Record discharge in cfs.

3.4 Velocity-Area Method

A vertical axis current meter (e.g., Hach FH950, Sontek FlowTracker 2, or equivalent) may be used to perform velocity-area method discharge measurements. These instruments use electromagnetic induction or acoustic doppler to determine the velocity of water. Electromagnetic current meters produce a magnetic field around the sensor head and measure changes in the electric potential produced by flow velocity. The change in electric potential is processed by the instrument which presents the output as a linear measurement of velocity. Acoustic Doppler current meters measure water velocities adjacent to or beneath the sensor using the Doppler effect which presents an output as a linear measurement of velocity. These units are used in conjunction with either a top setting wading rod or wading rod and can be used at any depth greater than 0.15 feet.

3.4.1 Introduction

The current meter measures velocity in flowing water at a point. The velocity-area method requires measurement of the mean velocity in selected subsections of the stream cross-section. By dividing the stream width into subsections, discharge becomes the total of discharges measured in each subsection. Velocity (V) is measured at each subsection, and discharge becomes the sum of the products of each velocity point and the cross-sectional area of each subsection:

$$Q = \sum(A_i * V_i)$$

where: Q = Streamflow in cfs,
A = Area of stream subsection in square feet, and
V = velocity in feet per second.

A cross section is defined by the depths at vertical points (i = 1, 2, 3, ...n) where the average velocity is measured. Velocity will be measured by the current meter at each point, and recorded when the meter stabilizes (see Section 3.4.4).

3.4.2 Required Measurement Conditions

To make an area-velocity discharge measurement, the following conditions are required:

1. The stream must be in a straight, channelized reach, and exhibit laminar flow parallel to the bank.
2. Depth must be greater than 0.15 ft across the cross-section .

The ideal channel cross-section is uniform, trapezoidal in shape, completely smooth in boundary materials (i.e., devoid of large cobbles and boulders or obstructions that visibly alter the surface flow dynamics of the stream), and possesses a laminar velocity distribution. Such an ideal condition is rarely observed. Therefore, minor modifications to the stream channels can and will be used to optimize measurement conditions. These modifications may include removal of aquatic vegetation, ice, and moving small stones that impact velocity upstream or downstream of the cross-section. However, modifications should only be made before the measurement has taken place.

If the stream is able to be waded then a discharge measurement will be made by wading. To determine if the stream is safe to wade the ‘Rule of 10’ may be applied; by multiplying the depth and velocity of the thalweg, the equated value should not exceed 10 (For example: if the velocity is 2 ft/s and the depth is 5 ft then the equated numerical value is 10 and therefore the channel is safe to wade). When using a current meter (configured with a top setting wading rod the operator should always stand offset and downstream to the rod at arm’s length away. Additionally, the rod should always be kept vertical (perpendicular to the stream surface) and the sensor should be in parallel with flow.

Under open channel laminar flow conditions, the effect of fluid contact with the bed of a stream channel and the air is a vertical distribution of velocities. Consistent with this velocity distribution, actual observation and mathematical theory has demonstrated that a single measurement of velocity taken at 0.6-depth, or the average of two point velocities taken at 0.2 and 0.8, of the depth below the surface accurately results in mean velocity through the verticle profile (USGS Water-Supply Paper 2175, pages 133-134).

If the sub-section is less than 2.5 feet deep, the six-tenths (0.6) method will be used. If the stream sub-section is greater than 2.5 feet, the two- and eight-tenths (0.2 and 0.8) method, also known as the two-point method, will be used. A complete discussion concerning how to set the wading rod to place the current meter at proper depths is contained in Section 3.4.5, Field Procedures.

In the 0.6-depth method, an observation of velocity made at 0.6 of the depth below the surface is used as the mean velocity in the vertical. In the two-point method of measuring velocities, observations are made at 0.2 and 0.8 of the depth below the surface. The average of the two observations is taken as the mean velocity.

3.4.3 Equipment

Current meters and depth and width measuring devices are needed for measurement of discharge. The equipment includes:

- Top-setting wading rod or wading rod and current meter
- Width-measuring devices; either engineer's tape or tagline
- Stakes to secure width-measuring devices
- Calculator
- *Water quality meter (when using the Sontek FlowTracker 2 only)*

Top-Setting Wading Rod. The depth-measuring device that will be used is the top setting wading rod. The current meter is attached to the a 3/8-inch diameter round rod for setting the position of the current meter which travels vertically on a 1/2-inch hexagonal main rod for measuring depth. This allows the operator to set the depth of the current meter without removing the rod from the stream.

Current Meter. Vertical axis current meter, for example: Hach FH950, or Sontek FlowTracker 2.

Engineer's Tape or Tagline. Tape measures or premarked taglines are used for stream width measurements. Orientation normal to the flow patterns of the stream (end [0] of tape should be placed on the right bank [facing downstream]) and elimination of most of the sag, through support or tension, is recommended.

Water quality meter (when using the Sontek FlowTracker 2 only). In freshwater streams salinity is typically 0. However, if this is questioned, a water quality meter should be used to record salinity specified in the Practical Salinity Scale (PSS) and input into the equipment settings. For every 12 PSS there will be a 2% error in the velocity data from acoustic Doppler instruments such as the FlowTracker 2. Maintenance and Calibration Procedures

The Sontek FlowTracker2 and Hach FH950 will have a zero check performed on the sensor to ensure accurate readings are obtained. First clean the sensor. Then place the sensor in a five gallon bucket of water. Keep it at least three inches away from the sides and bottom of the bucket. To make sure the water is not moving. wait at least 10 minutes after positioning the sensor and before taking any zero readings. If needed, follow the manufacturer recommendations to zero adjust the sensor. In addition, the SonTek FlowTracker2 utilizes ADCP technology which is affected by salinity within the stream. While using this instrument, a salinity measurement should be taken in the stream and input into the unit.

To ensure reliable observations of velocity, it is necessary that the current meter be kept in good condition. Before and after each discharge measurement, the meter will be examined for damage, wear, or faulty alignment. During measurements, the meter will be observed periodically when it is out of the water to be sure that the sensor is free of debris.

Meters will be cleaned daily when in use. If measurements are made in sediment-laden water, the meter will be cleaned immediately after each measurement.

3.4.4 Field Procedures

Upon arrival at the site, field personnel will evaluate the flow conditions to determine which measurement method is appropriate. If flow conditions allow for a flow meter (e.g., Hach FH950, or Sontek FlowTracker 2) to be used, then one will be used to perform an area-velocity measurement.

At each measurement point (or section) across the stream cross-section, depth is measured prior to measurement of velocity. Place the wading rod adjacent to the tagline. Place the wading rod in the stream so the base plate rests flat on the streambed. The depth of water is read from the graduated main rod. The main rod is graduated into 0.1-foot increments. These increments are indicated by a single score in the rod. Subsequently half-foot increments are marked by two scores, and each foot is marked by three scores. A vernier scale on the upper handle of the rod corresponds to 0.1-foot increments, and is numbered 0 through 9. A sliding, adjustable rod, known as the setting rod, to which the meter is attached, has single scored marks that are aligned with values on the vernier scale and position the meter at a desired depth relative to the surface of the water

In high-velocity areas, it is recommended that depth be read as the value between depth on the upstream side of the rod and depth on the downstream side of the rod. In certain instances, turbulence in stream may require the operator to average the fluctuation (max and min) in depth on the rod. Depth is measured to the nearest 0.02 foot. This depth is used to set the vertical location of the current meter relative to the surface of the water.

The setting rod is then adjusted downward so that the scored mark of the setting rod that corresponds to the range of depth in feet (e.g., if depth = 0.46, range in feet = 0; or if depth = 1.72, range in feet = 1) is aligned with the stream depth value transposed to the vernier scale. This automatically positions the meter at six-tenths (0.6 method) of the total depth from the surface of the water.

For using the two-point method of velocity measurement, the depth of water is multiplied by 0.5. This will set the meter at eight-tenths of the total depth from the surface of the water. The depth of water is then multiplied by two. The meter will then be at two-tenths of the total depth from the surface of the water. These two positions represent the conventional 0.2- and 0.8-depth positions.

If water quality or sediments are sampled in conjunction with discharge measurement, samples will be collected prior to making discharge measurements.

The following steps are to be followed in discharge measurement:

- Evaluate the measurement location. Choose a location where flow is laminar and has minimal turbulence. If the prescribed location does not exhibit appropriate flow conditions, select a location immediately upstream or downstream, if possible (care should be taken to note any tributaries in the direct vicinity). Eddies and slack water must not be present in the chosen cross-section.

- Remove rocks, wood, aquatic vegetation, ice, or other minor flow impediments. When such modifications are made, exercise great care to avoid unnecessary movement of sediments and allow flow to stabilize before the current meter measurement begins.

- Position tape approximately 1 foot above the surface of the water. Secure the tape so that it remains taut and perpendicular to the channel and flow direction. Place the end (0) of the tape on the right bank facing downstream.

- Select a starting point at either the left bank (left edge of water, LEW) or the right bank (right edge of water, REW), preferably the REW. LEW and REW are refer to position in relation to flow downstream.

- Note the distance in feet that the selected cross-section lies from the prescribed location. For example, the note may read "25 feet downstream" or "15 feet upstream" of the sample location.

- Measure the width of the stream. Select the number of subsections in which to measure velocity such that no more than 5 percent of the total discharge is in any one section, if possible.

- After determining the distance desired between measuring points, commonly referred to as subsections, measurement can begin. Record the bank at which measurements start on the discharge measurement notes as "REW ", using REW or LEW depending upon whether starting at the right or left edge of the water.

- Note the distance to the beginning edge of water from the initial point. The initial point is an arbitrary point on the tape which lies on the bank (edge of water) of the stream. All station locations are recorded as points on the tape.

- Proceed to the first station beyond the edge of water. Record the distance from the initial point on the discharge measurement notes. Place the wading rod into the stream so the base plate rests flat on the stream bed.

- Stand downstream and to the side of the top setting rod. Do not stand directly behind or close to the meter as this could alter the flow characteristics around the probe.

- Measure stream depth at the measurement point as indicated on the wading rod. Record the stream depth to the nearest 0.02 foot (for example 0.32 feet or 1.54 feet).

- Lower the meter to the required depth and record the observation depth. The observation depth as a fraction of total depth is 0.6 or 0.2 and 0.8.

- Field personnel will stand downstream and adjacent to the current meter such that their position least affects the velocity of the water passing the current meter. That position is usually obtained by facing upstream with the arm fully extended. The person(s) will stand at about a 45-degree angle downstream from the wading rod. The wading rod is held in a vertical position, perpendicular to the stream surface with the meter parallel to the direction of flow.

- Field personnel will wait (at least 45 seconds) for the velocity displayed on the meter to stabilize and then record. The flow meter must be aligned parallel to the direction of flow and be kept still for the entirety of the measurement period.

- Proceed to the next station. Record the position on the tape. Repeat measurements of depth and velocity. Repeat these steps across the remainder of the stream. In streams where the majority of the flow exists within a small subset of the channel cross section the subsection width may be reduced. This will lower the chance that the percentage of overall discharge within a subsection exceeds 5%.

- After recording the distance measurement at the last station, record the ending edge of water that is reached (e.g., LEW [or REW]).

- Note velocity and depth at the edge of water as zero.

- Evaluate and record flow characteristics, weather conditions, air temperature, water temperature, observer(s), type of meter, and remarks.

- If an insufficient number of subsections have been used for the measurement, adjust the number of subsections and repeat the measurement steps. Begin from the opposite bank from where the previous measurement began.

3.4.5 Discharge Calculations

- Calculate discharge on the discharge notes as follows: Use the distances from initial point to compute width for each subsection. The first width is computed by subtracting the first distance (edge of water) from the second distance and dividing this quantity by two. The second width will be the difference between the third distance and the first distance divided by two. For each subsequent width, subtract the previous station distance from the following station distance and divide this quantity by two. The final width is calculated as the difference between the final distance and the second-to-last distance divided by two. Sum the width column and check to ensure that the calculated width equals the distance between the REW and LEW.

- Multiply the width by the depth for each station to determine the area of each subsection. Sum the areas to determine total area.

- Multiply the velocity by the area for each station to obtain the discharge for each subsection.

- Sum the discharges for each subsection to determine total discharge and record the value.

- If two sets of discharge measurements beginning at opposite banks were taken, repeat the discharge calculations for the second set of data. Average the total discharges for the two measurements. Record the average value and report it for input into the database.

3.5 Control Structures

Control structures, such as flumes, can be used to determine discharge. These structures have regular dimensions that allow for a consistent relationship between water level and discharge. This section describes use of Parshall flumes to measure discharge.

3.5.1 Introduction

A calibrated constriction placed in a stream channel changes the level of the water in or near the constriction. Flumes are constructed so that a restriction in the channel causes the water to accelerate, producing a corresponding change (drop) in the water level. When the physical dimensions of the flume constriction are known, discharge through constriction may be determined from measurement of depth. See below for a description of discharge measurement for Parshall flumes.

Typical flumes consist of three sections:

- A converging section to accelerate the approaching flow;
- A throat section, whose width is used to designate flume size; and
- A diverging section, designed to ensure that the level downstream is lower than the level in the converging section.

The stage of a stream is the height of the water surface above an established elevation. Stage is usually expressed in feet. The Parshall flume consists of a converging section with a level floor, a throat section with a downward sloping floor, and a diverging section with an upward sloping floor. The principal feature of the Parshall flume (developed by R. Parshall in 1922) is an approach reach having converging sidewalls and a level floor, the downstream end of which is a critical depth cross-section. The primary stage measurement is made in the approach reach at some standard distance upstream from the critical-depth cross-section.

The flumes are designated by the width (w) of the throat. Flumes having throat widths from 3 inches (in.) to 8 feet (ft.) have a rounded entrance whose floor slope is 25 percent. Smaller and larger flumes do not have that feature.

3.5.2 Required Measurement Conditions

Ideally, flow rate through a flume may be determined by measurements at a single point some distance downstream from the inlet and above the throat.

3.5.3 Equipment

The following equipment will be needed:

- Current meter
- Carpenter's level
- Framing square
- Measuring tapes
- Staff gauge

3.5.4 Maintenance and Calibration Procedures

All flumes will be inspected to determine that entrance conditions provide a uniform influent flow distribution, the converging throat section is level, and that the throat section walls are vertical. The flume will be closely examined to determine that it is discharging freely. Any problems observed during the inspection will be noted and reported to the field manager.

3.5.5 Procedures

Steps to be followed in measuring discharge:

- Remove any material that may have accumulated in the flume or on the weir;
- If the station includes a chart recorder, inspect the strip chart on the recorder to verify that it is operating;
- Note any deterioration of the station; report these conditions to the field manager at the conclusion of daily data collection activities;
- Measure and record the throat width (W) to the nearest 1/10 of an inch;
- Use the staff gauge to measure the gauge height (H) to the nearest 0.02 foot;
- Calculate discharge as described in Section 3.4.6; and
- Record the calculated discharge and the time and date of the site visit.

3.5.6 Discharge Calculations

A set of flume tables is necessary for calculating flows. The flume tables are specific to the type and size of flume and are usually supplied by the flume manufacturer. Based on the gauge height (head, H, in feet) and the throat width of the flume (size of flume, W), the discharge is read directly from the table provided from the manufacturer. Note that the approximate values of discharge for heads other than those shown may be found by direct interpolation in the table. The following equation and table gives calculation coefficients for discharge calculations with Parshall flumes.

The free-flow discharge equations for the standard Parshall flume sizes are of the form:

$$Q = Ch_a{}^n$$

where:

h_a = measuring head (ft)
Q = discharge (ft^3/s)
C and n = coefficients specific to flume size

Coefficients (*C*) and exponents (*n*) for Parshall flume discharge calculations are listed in the following table:

Throat width	Coefficient (*C*)	Exponent (*n*)
1 in	0.338	1.55
2 in	0.676	1.55
3 in	0.992	1.55
6 in	2.06	1.58
9 in	3.07	1.53
1 ft	3.95	1.55
2 ft	8.00	1.55
3 ft	12.00	1.57
4 ft	16.00	1.58
5 ft	20.00	1.59
6 ft	24.00	1.59
7 ft	28.00	1.60

8 ft	32.00	1.61
10 ft	39.38	1.60
12 ft	46.75	1.60
15 ft	57.81	1.60
20 ft	76.25	1.60
25 ft	94.69	1.60
30 ft	113.13	1.60
40 ft	150.00	1.60
50 ft	186.88	1.60

3.6 Documentation

Information required by this SOP will be documented in detail in a field notebook and/or on a Surface Water Flow Record form (attached form or similar available in paper or electronic format). This information includes the calibration data for flow measurement devices and field discharge measurement data.

Documentation will also include the type of flow measurement device, including a model number; a detailed description of measurement location and weather conditions during the measurement; and calculations.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

4.1 Calculation Check

All calculations will be reviewed for accuracy and conformance with these procedures. The calculation review will be performed by a technically qualified individual before results are reported or interpreted. The calculation check shall be documented by recording the reviewer’s initials and date of review on the calculation sheet. A copy of the reviewed calculations should be included in the project file.

4.2 Records Review and Management

The Project Manager or designated reviewer will verify that documentation has been completed and filed per this procedure.

5.0 REFERENCES

Rantz, S.E. et al., 1982. Measurement and Computation of Streamflow: Volume 1, Measurement of Stage and Discharge, U.S. Geological Survey Water Supply Paper 2175. U.S. Government Printing Office, Washington, D.C.

U.S. Department of the Interior Geological Survey (USGS), 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, U.S. Geological Survey, Reston, VA.

U.S. Environmental Protection Agency (USEPA), 1986. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. Environmental Services Division, Region IV, Athens, GA.

SOP No. 7 Equipment Decontamination

STANDARD OPERATING PROCEDURE No. 7

EQUIPMENT DECONTAMINATION

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the methods to be used for decontamination of all reusable field equipment that could become contaminated during use and/or sampling. Field equipment may include split spoons, reusable bailers, trowels, scissors, shovels, hand augers, or any other type of equipment used during field activities. Decontamination is performed as a quality assurance measure and a safety precaution; it prevents cross contamination between samples and also helps to maintain a clean working environment. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate revisions may be made to accommodate site-specific conditions or project-specific protocols when approved in writing or via email by the Project Manager.

Decontamination is achieved primarily by rinsing with liquids which may include: steam, soap and/or detergent solutions, potable water, distilled weak acid solution, and/or methanol or other solvent. Equipment may be allowed to air dry after being cleaned or may be wiped dry with chemical-free towels or paper towels if immediate re-use is necessary.

At most project sites, decontamination of equipment that is re-used between sampling locations will be accomplished between each sample collection point. Waste produced by decontamination procedures, including waste liquids, solids, etc., will be discharged to the land surface and will not be allowed to runoff into any water body.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- ASTM D5088. Standard Practice for Decontamination of Field Equipment

Used at Waste Sites. American Society for Testing and Materials (ASTM) International, West Conshohocken, PA, 2008.

- Parker and Ranney, 1997a. Decontaminating Ground Water Sampling Devices, CRREL Special Report 97-25, U.S. Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.
- Parker and Ranney, 1997b. Decontaminating Materials Used in Ground Water Sampling Devices, CRREL Special Report 97-24, U.S. Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.

3.0 PROCEDURES

3.1 Responsibilities

It is the responsibility of the field sampling supervisor to ensure that proper decontamination procedures are followed and that all waste materials produced by decontamination are properly managed. It is the responsibility of the project safety officer to draft and enforce safety measures that provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (e.g., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the Site-Specific Health and Safety Plan. It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and ensure that any contaminants are not negligently introduced to the environment.

3.2 Supporting Materials

Materials needed for equipment decontamination include:

- Cleaning liquids: laboratory grade soap and/or detergent solutions (Alconox, etc.), potable water, distilled water, methanol, weak nitric acid solution, etc.
- Personal protective safety gear as defined in the Site-Specific Health and Safety Plan
- Chemical-free towels or paper towels

- Disposable nitrile gloves
- Cleaning containers: plastic and/or stainless steel pans and buckets
- Cleaning brushes
- Steam cleaner

3.3 Methods

The extent of known contamination will determine the degree of decontamination required. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated. Decontamination procedures should account for the types of contaminants known or suspected to be present. In general, high levels of organic contaminants should include an organic solvent wash step, and high levels of metals contamination should include a weak acid rinse step.

The procedures listed below constitute the full field decontamination procedure. If different or more elaborate procedures are required for a specific project, they may be specified in the project planning documents. Such variations in decontamination protocols may include all, part, or an expanded scope of the decontamination procedure stated herein.

1. Remove gross contamination from the equipment by dry brushing, and rinse with potable water.
2. Wash with laboratory-grade detergent solution or steam cleaner.
3. Rinse with potable water or steam cleaner.
4. Rinse with methanol (optional, for equipment potentially contaminated by organic compounds).
5. Rinse with acid solution (optional, for equipment potentially contaminated by metals).
6. Rinse with distilled or deionized water or steam cleaner.
7. Repeat entire procedure or any parts of the procedure as necessary.
8. Air dry.

4.0 DOCUMENTATION

Field notes will be kept describing the decontamination procedures followed. The field notes will be recorded according to procedures described in SOP No. 1 (FIELD DOCUMENTATION).

5.0 QUALITY CONTROL

To assess the adequacy of decontamination procedures, field rinsate blanks may be required. The specific number of field rinsate blanks will be defined in the project-specific Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP).

Rinsate blanks with elevated or detected contaminants will be evaluated by the Project Manager, who will relay the results to the field personnel. Such results may be indicative of inadequate decontamination procedures that require corrective actions (e.g., retraining).

6.0 REFERENCES

ASTM D5088-02 (2008). Standard Practice for Decontamination of Field Equipment Used at Waste Sites. American Society for Testing and Materials (ASTM) International, West Conshohocken, PA, 2008. Available online at http://www.astm.org/

Parker and Ranney, 1997a. Decontaminating Ground Water Sampling Devices, CRREL Special Report 97-25, U.S. Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.

Parker and Ranney, 1997b. Decontaminating Materials Used in Ground Water Sampling Devices, CRREL Special Report 97-24, U.S. Army Engineer Cold Regions Research and Engineering Laboratory, Hanover, NH.

SOP No. 8 Monitoring Well Development

Formation Environmental

STANDARD OPERATING PROCEDURE No. 8

MONITORING WELL DEVELOPMENT

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during the development of groundwater monitoring wells. Monitoring wells must be developed before they are used to collect groundwater samples. The procedures presented are intended to be general in nature. As site-specific conditions become known, appropriate modifications of the procedures may be made and will be documented in the well development field log.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:

- ASTM D5521-05. Standard Guide for Development of Groundwater in Granular Aquifers. American Society for Testing and Materials available online at http://www.astm.org.
- SESD, 2008. Design and Installation of Monitoring Wells, SESDGUID-101-R0.
- USACE, 1998. Engineering and Design – Monitoring Well Design, Installation, and Documentation at Hazardous Toxic, and Radioactive Waste Sites, EM 1110-4000, Washington, DC.
- USEPA and NWWA, 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, EPA 160014-891034.

3.0 PROCEDURES

3.1 Development Procedure

After construction of the monitoring well is complete, the well will be developed by air lifting, surging, bailing and/or pumping (e.g., positive displacement hand pump, electric pump or pneumatic pump). At least 24 hours must pass between completion of grouting of the monitoring well and development to allow sufficient curing of the grout.

The total depth of the well will be measured with a weighted tape. The presence of sediment at the bottom of the well will be checked using a stainless steel bailer or positive displacement hand pump. Water and sediment will first be removed from the bottom of the well to ensure that the entire screened interval is open for water to flow into the well. The well should be bailed or pumped until the water removed from the bottom of the well is relatively free of sediment. If a bailer is used, care must be taken to avoid breaking the bottom cap on the well casing.

After most of the sediment has been removed from the bottom of the well, a well development pump (positive displacement hand pump, electric pump or pneumatic pump) should be used to remove water from the well. Initially, the intake of the pump should be at the bottom of the well. The pump intake should be raised in two- to three-foot increments to the top of the water column after approximately one-half of a casing volume of water has been removed from each interval.

Next, a surge block constructed of non-reactive material (usually stainless steel or PVC) should be used to develop the well screen by forcing water in and out of the screened area. The surge block should be moved up and down in one-to two-foot increments creating a suction action on the upstroke and a pressure action on the downstroke. Development should begin at the top of the water column and move progressively downward to prevent the surge block from becoming sand locked. After surging to the bottom of the well, the surge block should be moved progressively upward to the top of the water column. Jetting with water from an approved source may also be used as an alternative method to develop the well.

If necessary, water may be added to the well to facilitate surging. This water should be distilled deionized or “clean” potable municipal water. The volume of de-ionized water added to the well should be noted on the Well Development Record form (attached).

After surging, the surge block should be removed and replaced with the pump or bailer. The intake of the pump or bailer should be at the bottom of the well to remove any sediment that may have collected in the bottom of the well. The pump intake should again be raised in two- to three-foot increments to the top of the water column after approximately one-half of a casing volume of water has been removed from each interval.

During development, the pH, specific conductance and temperature of the purge water should be periodically measured and documented on a Well Development Record form (attached). Parameter readings should be collected and noted for every casing volume of water removed from the well.

The well should be alternately surged and pumped until the field water quality parameters have stabilized to within 10% for specific conductance, 0.05 pH units for pH, and 1° C for temperature, and the water is relatively clear and free of sediment with a turbidity of as low as reasonably achievable given the well conditions (e.g., <50 NTU).
Water removed during well development will be discharged to the surface of the impoundments near each well head and will not be allowed to run-off the impoundment area.

3.2 Documentation and Records Management

A Well Development Record will be filled out for each well developed. Also, the daily events and other items not covered in the Well Development Record will be entered on a Daily Field Record.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

4.1 Equipment Cleaning

All reusable equipment used in developing the monitoring well should be cleaned prior to and following use. Cleaning shall be accomplished by either (1) washing with a laboratory-grade detergent/water solution, rinsing with clean, potable, municipal water, then rinsing with distilled or deionized water; or (2) steam cleaning followed by rinsing with distilled or deionized water. An acid rinse (0.1 N HCl) or solvent rinse (i.e., hexane or methanol) may be used to supplement these cleaning steps if tarry or oily deposits are encountered. The acid or solvent rinse will be followed by thoroughly rinsing with water. After final cleaning, equipment will be packaged and sealed in plastic bags or other appropriate containers to minimize contact with dust or other contaminant when not in use.

4.2 Records Review

The Project Manager or designated QA reviewer will check and verify that documentation has been completed and filed per this procedure.

SOP No. 9 Sediment Sampling for Chemical Analyses

STANDARD OPERATING PROCEDURE No. 9

SEDIMENT SAMPLING FOR CHEMICAL ANALYSES

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocols to be followed when sediment samples are collected for physical or chemical analysis. The procedures presented herein are intended to be general in nature and are applicable to sediment sampling in surface waters, wetlands, ponds, drainage structures, etc., when referenced by site-specific or project-specific planning documents. Appropriate revisions may be made to accommodate site-specific conditions or project-specific protocols when approved in writing or via email by the Project Manager.

The objectives of the sediment sampling procedures are to obtain representative, reproducible sediment samples for chemical analyses. The procedures identified in this SOP for sediment sampling have been designed to supporting data needs as defined in the Work Plan.

2.0 BASIS FOR METHODOLOGY

The methodology for sediment sampling is from this source:

- U.S. Environmental Protection Agency (USEPA) (1994) Sediment Sampling, USEPA Environmental Response Team SOP# 2016, Rev# 0, November 17, 1994.

3.0 PROCEDURES

This section describes sediment sampling from the bottom of a surface water drainage course or pond. Details of sample collection will be described on the attached sediment sampling form (either in paper or electronic format) and/or in a field notebook.

3.1 Sampling Equipment and Methods

Sediment in a surface water course with little or no free water may be sampled by directly scooping the sample with a stainless steel or, as appropriate, plastic instrument (e.g., trowel, scoop). All sediments, including sediment submerged under water, may be sampled using the following methods:

A. Direct Sampling Method – In quiet depositional areas sediment may be collected directly using the sample container or scoop. If sampled under water, the container will be capped in place to avoid disturbance while surfacing. If a scoop is used, care should be taken to minimize the loss of fines while lifting the sample from the water. In faster flowing waters, a two foot section of 18-inch diameter polyvinyl chloride (PVC) pipe will be placed in the stream to isolate sediments present. Larger substrates within the pipe enclosure will be rinsed and manually brushed within the pipe and then discarded. Fine materials remaining will be suctioned off into a sample container for compositing with subsamples collected across the channel. After the fine materials are suctioned off, a scoop will be used to collect any larger, but fine materials remaining within the isolation tube. Sediment sampling at each location will continue within and adjacent to the habitat until adequate sample volume has been collected. The composited sample will be allowed to settle and if excess water is present, it will be carefully decanted to minimize loss of any fine materials.

B. Manual Core Sampler Method -- A slide-hammer core sampler with stainless steel liners may be used to recover a relatively undisturbed core sample of the sediment. An extension section may be added to reach sediment intervals in deeper waters.

C. Remote Scoop Method -- A sampling cup or container attached to a pole may be used to collect a sediment sample in deeper water or where a longer reach is needed.

D. Bottom Sampling Dredge Method -- A sampling dredge attached to a cable also may be used to recover sediment samples in deeper waters.

3.1.1 Stream Sediment Sample Collection

Stream sediment will be collected from the surface of the stream bed to a depth of 4 inches (which is the most biologically active sediment zone) in the active channel at each sampling location. Each sample will consist of a mixture, or composite, of five grab samples collected from random locations along the creek channel within 50 feet of the specified location. The five subsamples will be collected from the areas inundated by creek water at the time of sampling. If sufficient sediment mass is not available from the inundated areas, sediment will be collected from within the active high-flow channel (no sediments will be collected from overbank areas).

Based on the location conditions, one of the four methods identified above will be used to collect approximately 200 grams of sediment from each subsampling location. If sediment contains a range of grain sizes, then the subsample will be collected to represent the sand-size and finer materials present (i.e., gravel, cobbles, and boulders would not be collected). The sediment collected for each subsample used to generate a single composite sample will be approximately the same mass, which may be estimated by visual assessment of sediment volume.

To create each composite sample, the five subsamples will be placed together in a water-tight plastic bag (e.g., Ziplock or WhirlPack bags). Excess water may be decanted from the sample bag, if necessary, after the five subsamples have been collected and allowed to settle for a short time. If water is decanted, care will be taken to avoid decanting fine sediment at the same time. Any coarse organic debris, such as sticks, leaves or aquatic vegetation, will be selectively removed from the composite sample. Such debris may be removed by hand, using gloves, or with a plastic or stainless steel scoop or spoon. Larger gravels can be removed from the sample using a No. 10 sieve (2 millimeter). This fraction best represents the sands and finer substrate size particles.

The remaining sediment will be thoroughly homogenized within the sealed bag by massaging and rotating the sealed bag for a minimum of 2 minutes or within the sieve pan via stirring. For duplicates, the sample will be split into two aliquots after homogenization, and each aliquot will be placed directly into a new sample bag.

After homogenization, the composite sample will be double bagged, labeled, and placed in a cooler for storage and later shipping (see SOP No. 2 SAMPLE CUSTODY, PACKAGING, and SHIPMENT).

Sampling equipment will be decontaminated after use at each of the sampling locations in accordance with SOP No. 7 (EQUIPMENT DECONTAMINATION).

3.1.2 Storm Water Detention Pond Sediment Sample Collection

Composite sediment samples will be collected at each of the storm water detention ponds. Each sample will consist of a homogeneous mixture of five grab samples collected at different locations within the pond and will include the top 4 inches of sediment encountered at each of those locations.

Sediments collected from dry ponds will be collected using a stainless steel or disposable plastic scoop to remove the top 4 inches of sediment from each subsampling location. Sediment will be collected from the bottom surface, not from the side slopes, of the pond in areas that would most frequently contain storm water.

If storm water is present at the time of sampling, then procedures for collecting subaqueous sediment cores from a lake or a pond will be adopted. Subaqueous sediment cores will be collected from ponds that contain water. The water in these detention ponds is not expected to be deeper than 3 to 4 feet and may be accessed for sampling by wading. When cores are collected in this manner, the sampler will proceed in a circular direction around the pond to collect the five subsamples and avoid disturbing sediments at the subsampling locations prior to use of the coring device. A core sample will be collected at each subsample location using a Wildco® K-B Corer or similar device. A core barrel long enough to collect 12 inches or more of sample will be used. The core barrel will be advanced a minimum of 6 inches or to the depth of refusal. Clear plastic liners with end caps will be used. Once collected, each sediment core will be capped (with top and bottom marked), labeled and then transported to a clean and flat area for processing into composite samples.

The shallowest 4 inches will be cut away from the core and extruded into a large capacity, water-tight plastic bag for homogenization with the other subsamples from the same pond. Excess water may be decanted from the composite sample bag, if necessary, after the five subsamples have been collected and allowed to settle for a short time. If water is decanted, care must be taken to avoid decanting fine sediment at the same time. Any coarse organic debris, such as sticks, leaves, or aquatic vegetation, will be selectively removed from the composite sample. Such debris may be removed by hand, using gloves, or with a plastic or stainless steel scoop or spoon. The remaining sediment will be thoroughly mixed within the sealed bag by massaging the sediment together and rotating the sealed bag for a minimum of 2 minutes. For duplicates, the sample will be split into two aliquots after homogenization, and each aliquot will be placed directly into a new sample bag.

After homogenization, the composite sample will be double bagged, labeled, and placed in a cooler for storage and later shipping SAMPLE CUSTODY, PACKAGING, and SHIPMENT (SOP No. 2).

Sampling equipment will be decontaminated between uses at different detention ponds in accordance with procedures in SOP No. 7 (EQUIPMENT DECONTAMINATION).

3.2 Sample Designation

Sediment samples will be assigned a unique sample number in accordance with procedures identified in the project-specific Quality Assurance Project Plan (QAPP). Samples will be immediately labeled in the field and sample numbers shall be recorded at the time of sampling in field notes and on the sediment sampling record (attached or similar).

3.3 Sample Preservation

The composited sediment sample will be inspected for color, appearance, and composition, and then sealed in a second plastic bag for storage and transport to the laboratory. The sample will be stored in an ice-cooled, insulated chest at 4 degrees Celsius (+/- 2 degrees) until delivery to the laboratory.

3.4 Sample Handling and Analysis

Sediment samples will be handled in accordance with the SOP for SAMPLE CUSTODY, PACKAGING, and SHIPMENT (SOP No. 2). Composite sediment samples will be stored on ice in coolers prior to and during shipping.

The laboratory procedure will include producing a representative composite sample by drying and then passing the sample materials through a No. 2 sieve to remove gravel and plant debris and homogenize the remaining sediment, if not previously sieved in the field.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

4.1 Equipment Cleaning

Cleaning procedures will be consistent with the SOP for EQUIPMENT DECONTAMINATION (SOP No. 7).

When sampling equipment is re-used at different sample locations, the equipment, and any tools used in assembly and disassembly of the equipment, will be cleaned before and after each use; decontamination between subsampling sites will not be required.

Equipment will be cleaned by scrubbing with a stiff brush using a laboratory-grade detergent/water solution, followed by rinsing with clean, potable, municipal water, then rinsing with distilled or deionized water. After cleaning, equipment will be packaged and sealed in plastic bags or other appropriate containers to minimize contact with dust or other contaminants.

4.2 Records Review

The Field Supervisor or designated QA reviewer will check and verify that field documentation has been completed per this procedure and the other procedures referenced herein.

5.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), 1994. Sediment Sampling, USEPA Environmental Response Team SOP# 2016, Rev# 0, November 17, 1994.

SEDIMENT SAMPLING RECORD

SAMPLE LOCATION:

Project No:___________________ Project Name: ____ Page _____ of: _______

Sampled by:____ Date: _____________________

Sampling
Location (description): __________________________________

UTM Coordinates:
NAD83 Datum
____

Weather (during sampling and past 48 hrs): ____

Sample Collected from (circle one): Subaqueous Saturated-Subareal Bank Saturated-Subareal Marsh Dry-Subareal

Depth Intervals Sampled (inches):____

Sample Description (color, texture, grain size)

QUALITY ASSURANCE

METHODS (describe):

Cleaning Equipment: _If needed, Alconox and Distilled water rinse____

Sampling:__Disposable Trowel____

Grab Sample (Y/N): ________ Composite Sample (Y/N): _________ Number of Locations for Composite: _______________

INSTRUMENTS (indicate make, model, i.d.):

Sediment Corer: ____________________________________ Sieves:____

pH Meter: ____ Field Calibration: ____________________________________

Conductivity Meter: ______________________________ Field Calibration: ____________________________________

Temperature Meter: ______________________________ Other:

SAMPLING MEASUREMENTS OF OVERLYING WATER

Time	Total Water Depth (ft.)	Water Quality Data			Appearance		Remarks (debris, sheen, etc.)
		Temp. (°C)	pH	Specific Conductance (μmhos/cm)	Color	Turbidity & Sediment	

SAMPLE INVENTORY

Sample Type (circle one): Primary Sample Duplicate Equipment Rinsate Blank

Bottles/Bags Collected				Depth Interval (inches)	Remarks (natural, dups, blanks)
Date/Time	Sample ID	Container (glass, plastic)	Quantity/ Volume		
				”	

SAMPLING LOCATION MAP

(reference permanent landmarks, indicate scale, approx. North, direction of flow, locations of sediment collection)

ABBREVIATIONS:
ft. – feet, C – Celsius, cfs – cubic feet per second, gal. – gallons, gpm – gallons per minute

Signature

Chain-of-Custody Record No.

Revision 04/17

SOP No. 12 Drilling and Installation of Monitoring Wells

FORMATION ENVIRONMENTAL

STANDARD OPERATING PROCEDURE No. 12

DRILLING AND INSTALLATION OF SHALLOW MONITORING WELLS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed during drilling and installation of shallow monitoring wells.

The procedures presented herein are intended to be general in nature. As site-specific conditions become known, appropriate modifications of the procedures may be made when approved in writing by the Project Manager.

2.1 PROCEDURES

This SOP addresses shallow monitoring wells (collectively referred to herein as wells) to be constructed to with a single well casing generally intersecting the water table. The following subsections provide a general summary of monitoring well design and construction techniques. The actual design, installation, development, and abandonment of any monitoring well will be documented in the Site records.

2.2 Equipment

The following lists the equipment anticipated to be needed for well installation:

- Schedule 40 PVC well casing and screen materials (of appropriate diameter, length and slot size as specified in the work plan);
- Medium bentonite chip for annular seal;
- Filter pack (appropriately sized unless otherwise indicated);
- Cement and powdered bentonite for grouting (sulfate-resistant Portland Cement Type V, if appropriate);
- Stainless-steel centralizers (depending on well installation method);
- Protective surface casing with lockable steel cap;
- Steel or concrete guard posts;

- High-pressure steam cleaner;
- Long-handled bristle brushes;
- Wash/rinse tubs;
- Alconox detergent;
- Location map;
- Drill rig capable of installing wells to the desired depth in the expected formation materials and conditions;
- Sealable bags or chip boxes;
- Self-adhesive labels;
- Deionized water;
- Appropriate health and safety equipment;
- Daily drilling summary forms;
- Drilling log forms; and
- Well installation report forms.

2.3 Drilling Procedures

The drilling process will minimally alter subsurface conditions, and proper assurances will be in place to prevent the drilling process from introducing foreign substances into the borehole or creating conduits that facilitate the spread of existing contaminants.

2.2.1 Drilling Techniques

Wells typically installed using this SOP will be less than 180 feet deep and consist of single wells with screens intersecting the water table. The typical drilling methods appropriate for installing wells at these depths include:

- Rotosonic (unconsolidated materials)
- Down hole hammer (most appropriate for very hard to hard rock types, but depth may be limited by hydrostatic pressures)
- Rotary drilling with air, water or foam (most appropriate for hard to soft rock, mud may be needed in unconsolidated formations)
- Direct push (unconsolidated materials)

Discussion of these drilling methods are given in “Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices” by American Society for Testing and Materials (ASTM) D6914-04 (ASTM, 2010); “Groundwater and Wells” by Driscoll, 1986; Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells” EPA, March 1991 (EPA/600/4-89/034); “RCRA Ground-Water Monitoring, Technical Guidance” EPA; and “Geoprobe Dual Tube Soil Sampling System” Geoprobe Systems. Specialized methods may be combined with the drilling methods listed above, such as casing advancement while drilling (e.g., ODEX or TUBEX method), or reverse circulation. The method chosen for shallow well installation will depend largely on factors such as relative cost, sample reliability, availability, Site accessibility, and ability to reach desired depths.

For any site or drilling location, the selection of drilling methods will be based on: (1) availability and cost of the method; (2) suitability for the type of geologic materials at the site (e.g., consolidated, unconsolidated); and (3) potential effects on sample integrity (influence by drilling fluids and potential for cross contamination between aquifers). Drill bit (hole) size shall be sufficient to permit efficient installation of the specified well materials. Any drilling fluids needed, will be used in accordance with manufacturer’s specifications.

2.2.2 Decontamination

At contaminated sites, equipment will need to be decontaminated. Drilling equipment will be decontaminated prior to arrival on site. Drill bits, the downhole hammer and drill strings will be decontaminated between boreholes. Heavy equipment, depending on the extent of contamination and the cleaning requirements, will be decontaminated at each sampling and/or excavation site or at the designated decontamination area. Sampling equipment (California tubes, stainless-steel or brass liners, bailers, etc.) will be decontaminated between sampling points to minimize potential cross-contamination. Coring equipment will be decontaminated between holes. All drilling equipment will be decontaminated at the conclusion of well installation, prior to leaving the site. Decontamination will be completed according to SOP entitled Equipment Decontamination. Drilling foam may be used to facilitate drilling and will be properly contained per SOP entitled Storage and Disposal of Soil, Drilling Fluids, and Water Generated during Field Work. All well materials (i.e., casing, screen, centralizers) will be decontaminated by steam cleaning prior to installation except materials that can be certified clean (e.g., new materials in original packaging).

2.3 Borehole Logging

Borehole geology will be logged by examination of the drill cutting samples or core samples according to American Society for Testing and Materials (2000), *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, ASTM Vol. 04.08, 320-329. If coring is not conducted, the drill cuttings should be logged considering the lag time associated with depth of drilling.

All boreholes shall be continuously logged to ensure stratigraphic control by an experienced geologist. Samples should be collected at all suspected changes in lithology and from the screened interval. All confining layer intervals should be classified and the nature of the contacts documented. The data will be recorded on a borehole drilling log form or similar (attached), and will include the following information:

- Project name and number;
- Geologist's or engineer's name;
- Borehole number and location;
- Surface elevation (if available);
- Drilling company and driller's name;
- Date drilling started and finished;
- Drilling equipment and method;
- Drill bit type and size;
- Total borehole depth;
- Sample depths and times;
- Geologic conditions with depth, such as lithology, texture, structure, bedding, color, alteration, mineralization, gouge zones, moisture content, and the Unified Soil Classification (if in unconsolidated materials);
- Core data;
- Hydrogeologic conditions with depth, such as water producing zones, flow rates, pH, specific conductance, and fluid description;
- Presence and/or frequency of fractures;
- Water levels;
- Lost circulation zones; and
- Drilling observations.

2.4 Monitoring Well Installation

Shallow monitoring wells will consist of a single well casing within one borehole. Each shallow monitoring well will be designed to intersect the water table and to permit groundwater sampling of that interface. Separate monitoring wells may be completed, as necessary, in the different water-yielding zones underlying the site (see SOP entitled, Drilling and Installation of Deep Multi-Level Monitoring Wells). The field geologist, in consultation with the Project Manager, will specify the exact depths of screened intervals using the lithologic log and geophysical log (if performed) for control. Construction and completion of all monitoring wells will be in general conformance with the following procedures.

2.4.1 Well Screens and Riser Casing

Each well casing shall extend at least 24 inches above ground surface to facilitate groundwater sampling. The inside diameter of both the well screen and casing will be sufficiently large to permit easy passage of all in-well gauging, development, and sampling equipment, typically two-inch inside diameter casings are satisfactory. The monitoring well assembly shall consist of flush joint, threaded casing composed of polyvinyl chloride (PVC) Schedule 40 (minimum) able to withstand the physical forces expected. The threaded joints will have O-ring seals.

Well screens will consist of 0.020-in factory continuous slot or similar size, depending on geologic conditions, with a maximum length of 15 feet for the shallow interval intersecting the water table

Prior to well construction, the field geologist will inspect the blank and slotted casing delivered to the job site to verify that it meets the project specifications. When the total depth of a boring has been reached, and prior to installation of the well casing, the field geologist will measure and record the depth to water in the borehole.

Upon completion of drilling and/or geophysical logging, the monitoring well casing and screen will be assembled and lowered to the bottom of the boring. The monitoring well assembly will be designed so that the well screen is approximately adjacent to the water-yielding zone that is to be monitored. The bottom of the screen will be approximately flush with the bottom of the well and will be closed with a threaded PVC cap or plug, or a slip cap secured with stainless steel screws. No PVC cement or other solvents are permitted to be used to fasten the joints of the casing or screen. Centralizers spaced at the top and bottom of the screened interval may be used to center the well assembly in the borehole, unless the boring is drilled by a low annular space method and the well is installed with the drill casing in place. Wells installed prior to pulling low annular space drill casing will be centered by the inside walls of the drill casing.

If well casing assembly is being performed by a drilling subcontractor, the field geologist will observe and inspect the assembly, insuring that the bottom cap is threaded or secured with stainless steel screws, O-rings are properly placed in the joints, the joints are completely tightened, and the blank and screen intervals are constructed as specified. The field geologist will measure the location of the top and bottom of the perforated interval by measuring the distances from the joint above the perforated interval to the top slot and from the base of the bottom cap to the bottom slot.

If a mud rotary drilling technique is used and the monitoring well assembly has been lowered to the specified depth, clean water may be circulated downward through the well casing and upward through the annular space between the borehole wall and the monitoring well casing. Circulation will continue until the suspended sediment in the return fluid has been thinned. If the well is greater than 50 feet deep, the casing assembly will be held under tension prior to and during emplacement of the filter pack and seal.

2.4.2 Filter Pack

The annular space between the borehole wall and the screen will be filled with clean filter pack material. Filter pack material will be well-graded, clean sand with less than 2 percent by weight passing a No. 200 sieve and less than 5 percent by weight of calcareous material. At least two inches of filter pack material shall be installed between the well screen and the borehole wall. Filter pack will likely be 8-12 mesh silica sand (0.093-0.055 in), or 10-20 Colorado Silica Sand, although the possibility of using a different mesh sizes appropriately matched to the screen slot size remains.

The filter pack shall be installed in a manner that prevents bridging and particle-size segregation. The filter pack will be added to a minimum of 2 feet above the top of the screen to a maximum of 5 feet. The depth to top of filter pack will be measured with a weighted tape after each lift.

2.4.3 Annular Well Seal

The well casing shall be sealed to prevent possible preferential downward pathways from the surface to the saturated zone. Once the depth to the top of the filter pack has been verified the remaining open annulus will be backfilled using of medium bentonite chip (1/4-in to 3/8-in). The bentonite seal will be placed to approximately 5 feet below ground surface. Annular materials will be placed as advance casing or hollow stem augers are removed from the borehole.

2.4.4 Surface Completion and Capping

Upon completion of the annular seal, a suitable protective casing with lockable lid will be placed around the well casing. The protective casing will extend to a minimum depth of 2 feet below the ground surface. The upper 5 feet of the borehole annulus will be backfilled with concrete. A concrete surface pad measuring 4 feet square and 6 inched thick will be constructed around the well protective casing.

To protect above-ground completions in traffic areas, 3-inch diameter steel posts may be installed radially from the well casing at a distance of approximately 4 feet. They will be placed approximately 2 feet below the ground surface and have a minimum of 3 feet above the ground surface. The posts may be flagged in areas of high vegetation.

2.4.5 Measurements

Measurements collected during drilling and well construction, including the well construction materials, will be measured to the nearest 0.1 foot. Following well completion, the well location will be surveyed by a licensed surveyor. The horizontal location will be measured to 0.1 foot and will be tied to the local, documentable coordinates. A survey reference mark for the vertical elevation will be placed on top of the well casing, for use as a measuring point. The height of the top of the well casing and the ground surface should be determined within ± 0.01 feet relative to mean sea level.

2.5 Documentation and Records Management

General field documentation procedures are described in SOP entitled Field Documentation. Observations and data acquired in the field during drilling and installation of wells will be recorded daily by the onsite geologist or engineer to provide a permanent record of these activities. These observations will be recorded with waterproof ink in a field book. The recorded information will include the following as a minimum:

- Project name and number;
- Observer's name;
- Drilling company name;
- Type of drill rig;
- Date drilling started and finished;
- Type of bit and size;
- Casing sizes and depths;
- Driller' s name;
- Drilling and well installation observations;
- Presence and/or frequency of fractures and any lost circulation zones (to aid in identifying zones of potential hydrostatic head problems associated with placement of the grout seal);
- Daily progress;
- Geophysical log runs, calibration performed, and measurements collected;
- Problems encountered and resolution;
- Decontamination observations; and
- Weather conditions.

At the end of each day the onsite geologist or engineer will complete the field book notes and make two copies, if practicable: one for the task management files and one for the field flies. In addition, daily drilling summary forms will be provided by the drilling contractor and will be approved by the onsite geologist or engineer. A copy will be included in the task management and field files.

A well construction summary form will be completed for each monitoring well or piezometer. Each well report form will include the following (denoted by depth from ground surface):

- Bottom of the borehole;
- Casing types and sizes;

- Screen (perforation) type and interval;
- Coupling/joint locations ;
- Filter pack type, size, and interval;
- Bentonite seal interval;
- Cave-in locations;
- Centralizer types and locations;
- Height of riser without cap (above ground surface); and
- Protective surface casing detail.

Additional documentation for well construction that will be recorded daily in the field book and/or appropriate forms will include the following:

- Sand, and bentonite volume calculations prior to well installation;
- The quantity and composition of the seals and filter pack actually used during construction;
- Screen slot size (in inches), slot configuration, total open area per foot of screen, outside diameter, nominal inside diameter, schedule and/or thickness and composition;
- Coupling/joint design and composition;
- Centralizer design and composition;
- Surface casing composition and nominal inside diameter;
- Start and completion date;
- Discussion of all procedures and any problems encountered during drilling and well construction; and
- Surface completion information and date.

3.0 QUALITY ASSURANCE

Field notes and field forms completed by the field geologist shall be reviewed by the field supervisor and the Project Manager or other designated QA officer before they are placed into project files. Deviations from this SOP or a project-specific work plan shall be identified and described in field notes. The QA review will be recorded on the reviewed originals by initials of reviewer and date.

SOP No. 20 Data Review and Validation

STANDARD OPERATING PROCEDURE No. 20

EVALUATION AND DOCUMENTATION OF LABORATORY DATA QUALITY [INORGANIC CHEMICAL ANALYSES]

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedures for the evaluation of data generated through inorganic laboratory analysis of samples collected for environmental assessment and characterization. These procedures apply to three distinct levels of data-quality evaluation: (1) data completeness check, (2) data-quality review and (3) data validation.

The QAPP, Sampling and Analysis Plan (SAP) and/or any other relevant site-specific or project-specific documents must be reviewed before this SOP is used to evaluate data.

In addition, the individual performing the data evaluation shall be familiar with the analytical methods and other procedures used for the project. Familiarity with project and laboratory quality control requirements is critical to appropriate use of this procedure. A general description of the different levels of data evaluation is provided below and discussed in detail in Section 4.0 of this SOP.

1.1 Data Completeness Check

Data completeness checks may be performed on both Level 2 standard data reports and Level 4 USEPA Contract Laboratory Program (CLP)-like laboratory reports as specified in the project planning documents and/or by the project team or regulatory agencies. These completeness checks may be performed as part of a data-quality review or data validation or may be performed as a stand-alone evaluation. Completeness checks only document the presence or absence of applicable QC data in the laboratory data package, and no qualification of sample results is necessary based on this data evaluation.

1.2 Data-Quality Review

Data-quality review includes a review of laboratory quality assurance (QA) and quality control (QC) sample results provided in Level 2, or equivalent, standard laboratory reports. Data-quality review can also be performed on CLP-like Level 4 data packages if required. In addition to sample results, Level 2 laboratory reports provide QA/QC summaries that typically include results for method blanks, laboratory control samples (LCS), matrix spike (MS) samples, and duplicates, as well as the review of field QC samples (e.g., field blanks and field duplicates). Data-quality review is differentiated from data validation because the review consists of an assessment of the laboratory QA/QC summary reports only.

1.3 Data Validation

Data validation includes the evaluation of the QA/QC results described above as well as an evaluation of additional validation of calculations, calibrations, internal standards, tunes, etc. provided in Level 4 CLP-like data reports. A minimum of 10% of the data reports produced annually by each laboratory analyzing environmental monitoring samples will be reported as CLP-like data reports and validated according to the data validation procedures described in this SOP (Section 4.3). Data validation of the CLP-like data reports will be performed using the general protocols and processes described in this SOP, as applicable to the method calibration and QC limits specified on Tables 2-2 through 2-6 of the QAPP, the Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review (NFG; USEPA, 2010) and to the extent possible when certain non-CLP methods are used, laboratory SOPs.

The following table summarizes the common elements and differences between a data completeness check, data-quality review and data validation.

Scope of Reviews

Item	(1) Data Completeness Check	(2) Data Quality Review	(3) Data Validation
Review of Work Plan, SAP and/or QAPP	Presence only	X	X
Review of Chain-of-Custody Records	Presence only	X	X
Review of Case Narrative	Presence only	X	X

Verify that preservation and holding time requirements met.	Presence only	X	X
Verify that the required frequency of field QC samples was met.	Presence only	X	X
Verify that ICP/MS tune analyses were performed at the required frequency and that results are within control limits.			X
Verify that all instrument calibration were performed at the required frequency and concentrations and that results are within control limits.			X
Verify that laboratory blanks were performed at the required frequency and that results are within the control limits.	Presence only	X	X
Verify that field blank results are within the control limits.	Presence only	X	X
Verify that all Laboratory Control Sample (LCS) were performed at the required frequency and that results are within control limits.	Presence only	X	X
Verify that matrix spike (MS) sample were performed at the required frequency and that results are within control limits.	Presence only	X	X
Verify that analytical duplicates were performed at the required frequency and that RPDs are within control limits.	Presence only	X	X
Verify that ICP Serial Dilutions were performed at the required frequency and that results are within control limits.			X
Verify that ICP/MS internal standards were included with each sample and that results are within control limits.			X
Verify that field duplicate measurements are within the control limits.	Presence only	X	X
Verify sample calculations.			X
Verify that project completeness goals were met.		X	X

2.0 BASIS FOR METHODOLOGY

The data evaluation procedures described in this SOP are based on the guidance specified in the QAPP and the protocols specified in the USEPA Contract Laboratory

Program (CLP) National Functional Guidelines (NFGs) for Inorganic Superfund Data Review (USEPA, 2010). The data evaluation procedure described in this SOP may be used for the evaluation of standard laboratory data reports (Level 2 reports) or CLP-like/Level 4 laboratory data reports. CLP-like/Level 4 data reports are needed in order to complete the validation procedure described in this SOP. It is not meant to replace or incorporate all of the procedures and protocols necessary to complete data validation per the USEPA NFGs. Data qualification may or may not be performed for data-quality review, however data validation will include data qualification.

3.0 DEFINITIONS

Definitions of accuracy, precision, and completeness and methods for computing their measures are provided below. Descriptions of the contents of Level 2 Standard data packages and Level 4 CLP-like data packages are provided in Section 4.2 of this SOP.

a. Accuracy

Accuracy is the degree of difference between the measured or calculated value and the true value. Data accuracy and analytical bias are often evaluated by the analysis of LCS and MS samples, with results expressed as a percentage recovery measured relative to the true (known) concentration.

The percentage recovery for LCS samples is given by:

$$\text{Recovery (\%)} = \frac{A}{T} \times 100$$

where: A = measured concentration of the surrogate or LCS; and
T = known concentration.

The percentage recovery for MS samples is given by:

$$\text{Recovery (\%)} = \frac{A - B}{T} \times 100$$

where: A = measured concentration of the spiked sample;
B = concentration of unspiked sample; and
T = amount of spike added.

Laboratory blanks, and often, field blanks are analyzed to quantify artifacts introduced during sampling, transport, or analysis that may affect the accuracy of the data.

b. Precision

Precision is the level of agreement between duplicate measurements of the same characteristic. Laboratory precision, or analytical error, is assessed by determining the agreement of results for replicate measurements of the same sample. Field precision is assessed by determining the agreement for results for two independent samples collected from the same site at the same time. Precision may be evaluated using LCS/LCSD samples, MS/MSD samples, analytical duplicate samples and/or field duplicate samples. The comparison is made by calculating the relative percent difference (RPD) as given by:

$$\text{RPD (\%)} = \left| \frac{2\,(S1 - S2)}{S1 + S2} \right| \times 100$$

where: S1 = measured sample concentration; and
S2 = measured duplicate concentration.

c. Completeness

Completeness is the percentage of usable data measurements obtained, as a proportion of the number of data measurements planned for the project. Completeness is affected by such factors as sample bottle breakage and acceptance/non-acceptance of analytical results. Percentage completeness (C) is given by:

$$\text{C (\%)} = \frac{V}{P} \times 100$$

where: V = number of usable data measurements obtained; and
P = number of data measurements planned.

d. Data Qualifier Flags

As a result of the data-quality review or data validation procedures (but not data completeness checks), data qualifier flags may be applied to individual analytical results if qualification for project data usability is appropriate. Definitions of the flags applied for data qualification are as follows:

Flag	Definition
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
U	The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

An explanation regarding the assignment of qualifiers in accordance with the review procedures is detailed below in Section 4.2.

4.0 PROCEDURES

The data evaluation documentation requirements and procedures for data completeness checks, data-quality review, and data validation are described below in the following sections.

4.1 Data Completeness Check Procedure

Data completeness checks can be performed as a stand-alone evaluation or as part of a full data-quality review or validation. A data completeness check is performed to verify that the laboratory data provided are complete. The following shall be reviewed for Level 2 Standard data reports and Level 4 CLP-like data reports.

Level 2 Standard data reports shall include the following information for each sample:

- Field and laboratory sample identification;
- Sample result, method detection limit, and reporting limit, with appropriate units;
- Dilution factor
- Sample collection, receipt, and analysis dates;
- Analytical method(s) references; and
- Laboratory qualifiers and definitions.

In addition, Level 2 Standard data reports shall include the following information in a QA/QC summary:

- Method blank results for each analyte;
- LCS results and laboratory control limits for each analyte;
- MS results and laboratory control limits for each analyte, if applicable;
- Analytical duplicate results and laboratory control limits for each target analyte (LCSD and/or MSD results may be provided instead of analytical duplicate results); and
- Confirmation of instrument calibration; and
- Copies of the signed COCs.

Level 4 CLP-like laboratory reports shall include the following information for each sample, at a minimum:

- Field and laboratory sample identification;
- Sample result, method detection limit, and reporting limit, with appropriate units;
- Sample collection and receipt dates;
- Sample preparation and analysis date/time;
- Dilution factor;
- Preparation and analysis batch numbers or identification;

- Sample matrix;
- Analytical method(s) references;
- Percent moisture determination; and
- For solid-matrix samples, identify basis of reporting (i.e., wet-weight or dry-weight basis).

The following additional information will also be provided in Level 4 CLP-like data reports, as applicable for the reported analytical methods:

- Case narrative;
- Copies of the signed COCs;
- Laboratory method/preparation blank;
- Initial calibration verification (ICV), and continuing calibration verification (CCV);
- Initial calibration blanks (ICB), and continuing calibration blank (CCB);
- Interference check sample, if applicable;
- Matrix spike (MS), and when applicable matrix spike duplicate (MSD), sample recovery and, when applicable, MS/MSD relative percent difference (RPD);
- Post-digest spike sample recovery;
- Laboratory duplicate;
- Laboratory control sample (LCS) recovery;
- ICP and ICPMS serial dilution percent differences;
- MDLs;
- ICP inter-element correction factors;
- ICP and ICPMS linear ranges;
- Preparation log;
- Analysis run log;
- Instrument raw data for verification;
- ICPMS tunes;
- ICPMS internal standards relative intensity summary;
- Sample log-in sheet; and
- Deliverables inventory sheet.

4.2 Data-Quality Review Procedure

The procedure for review of a Level 2 Standard data report is as follows. Data may or may not be qualified during data-quality review, depending on the project specifications.

A. Review copies of the Chain-of-Custody records (COCs). Verify that all necessary information was provided on each COC and that all necessary signatures are present. Review laboratory records of sample temperature upon receipt and preservation information, if available, to verify that samples were properly preserved. Professional judgment may be used to determine if data qualification is necessary due to temperature exceedances and/or preservation deviations. Verify that all samples listed on the COCs were analyzed for the appropriate parameters. Note any problems documented on the COCs by either the laboratory or the sampler.

B. Briefly review and summarize the laboratory case narrative, if present. Note any data that are indicated as outside of control limits.

C. For each sample and each parameter, verify that the analyses were performed within the recommended holding time. For sample analyses performed outside the recommended holding times, sample results may be qualified as described in the QAPP or USEPA NFGs (2010), though professional judgment and project-specified requirements should be used.

D. Identify any field QC samples and verify that the field QC samples specified in the Work Plan, QAPP or other relevant project documents have been collected at the correct frequency.

E. Review the results of all field/equipment blanks and the laboratory method blanks. If an analyte was detected in a blank, the corresponding sample concentrations will be compared to the blank concentrations. Sample results may be qualified as described in the QAPP or USEPA NFGs (2010), though professional judgment should be used to carefully evaluate the effect of blank concentrations on the sample data.

F. Check the matrices, units, detection limits and reporting limits to verify that they are reported correctly and meet the project-specific requirements, if provided.

G. Review all LCS (and LCSD, if available) recoveries and verify that they were within the project-specified control limits. If project-specific control limits are not provided, use the laboratory's control limits. LCS materials may not be available for all matrices. Sample results may be qualified as described in the QAPP or USEPA NFGs (2010), though professional judgment and project-specified requirements should be used.

H. Review all MS (and MSD, if available) recoveries and verify that they were within the project-specified control limits. If project-specific control limits are not provided, use the laboratory's control limits. If analyzed and reported, post-digestion spike information should also be reviewed. Sample results may be qualified as described in the QAPP or USEPA NFGs (2010), though professional judgment and project-specified requirements should be used. For MS results that do not meet the control limits, the reviewer may choose to apply qualifiers to all samples of the same matrix associated with the MS, if the reviewer considers the samples sufficiently similar.

If an analytical duplicate was analyzed, compare the laboratory calculated RPD and compare this to the project-specified control limits. If a project-specific control limit is not available, use the laboratory's control limits. However, if one or both of the results are less than five times the PQL, use ± PQL as the control limit for aqueous samples and 2x ± PQL as the control limit for non-aqueous (i.e., soil, sediment, tissue) sample matrices unless project-specific control limits are provided. If the analytical duplicate results fall outside of the control limits, sample results may be qualified as described in the QAPP or USEPA NFGs (2010), though professional judgment and project-specified requirements should be used, LCS/LCSDs and/or MS/MSDs may be analyzed in place of, or in addition to, an analytical duplicate. The RPDs for LCS/LCSD and MS/MSD pairs shall be evaluated in the same manner as described above for analytical duplicates.

I. If field duplicates were analyzed, calculate the RPD for each parameter and compare the RPDs to project-specified control limits. If project-specific control limits are not available, use 30 percent for aqueous samples and 50 percent for soil/solid/vegetation tissue samples. However, if one or both of the results are less than five times the PQL, use ± PQL as the control limit for aqueous samples and 2x ± PQL as the control limit for non-aqueous (i.e., soil, sediment, tissue) sample matrices unless project-specific control limits are provided. If the field duplicate results fall outside of the control limits, the associated field duplicate results should be qualified in the same manner described above for analytical duplicates as described in the QAPP or USEPA NFGs (2010), though professional judgment and project-specified requirements should be used. Professional judgment will be used to determine whether additional sample results, in addition to the field duplicate sample results, should also be qualified.

J. Determine whether the project's analytical completeness goal was met. Note any rejected data.

The data reviewer may also provide a brief summary of the accuracy, precision and completeness of the data set. The qualifier flags assigned to the data will be summarized in a table and/or entered into the electronic data deliverable, as specified in the project's QAPP or SAP.

4.3 Data Validation Procedure

The data validation procedure shall include all of the above steps in the data-quality review procedure (Section 4.2) with additional steps as outlined below. These additional steps include the recalculation of instrument and sample results from the laboratory instrument responses for a subset of the data. These recalculated results are compared to the laboratory reported results to confirm that the instrument outputs were correctly reported. Also, additional QC summary reports will be reviewed including the ICP/MS tune summary, the instrument calibrations, the interference check sample summary, the serial dilution sample summary, and the internal standard relative intensity summary. Data will be qualified during the data validation procedure with the appropriate qualifiers as specified in the QAPP and consistent with USEPA's NFG (2010). A more complete description of the additional steps to be followed in data validation is presented below.

A. Verify sample calculations for a few of each sample results and identify and document any calculation errors if any are present. The raw instrument output will be reviewed to confirm that the analyte concentrations were reported correctly.
B. Verify that the ICP/MS tune analysis data requirements were met and results were within QC limits. Review the raw data for a subset of the tune results and confirm that the raw data matches the results summarized on the ICP-MS Tune summary form. If the ICP/MS tune analysis results fall outside of the control limits, the associated sample results should be qualified as described in the QAPP or USEPA NFGs (2010).
C. Verify that the instrument calibration was performed at the required frequency, that results are within QC limits, and review associated standards, including initial and continuing calibration standards and blanks. For a subset of the analytes, recalculate the percent recoveries for calibration standards using the data on the Initial and continuing calibration verification summary form and verify that the concentrations reported on this form are consistent with those in the instrument output. For ICVs/CCVs that have percent recoveries outside of control limits and for calibration blanks for which analytes are detected, review the run logs to confirm which samples were affected by out of control CCVs and CCBs. Associated sample results should be qualified as described in the QAPP or USEPA NFGs (2010) though professional judgment and project-specified requirements should be used.
D. Verify that Interference Check Sample data requirements were met and results are within QC limits. Recalculate a subset of the percent recoveries and review the raw data to verify that the results from the instrument output match those reported on the Interference Check Sample summary form. If the interference check sample results fall outside of the control limits, the associated sample results should be qualified as described in the QAPP or

USEPA NFGs (2010).

E. Verify that ICP serial dilutions requirements were met and results are within QC limits. Recalculate percent differences for a subset of the results and verify that instrument outputs match values reported in the summary form. Where percent differences exceed the control limit and sample results are greater than 50 times the method detection limit, the associated sample results should be qualified as described in the QAPP or USEPA NFGs (2010).
F. Verify that ICP/MS internal standard requirements were met and results within QC limits. Review raw data and recalculate a subset of the relative intensities of the internal standards and compare them to those reported on the internal standard relative intensity summary form. The associated sample results should be qualified as described in the QAPP or USEPA NFGs (2010).

Qualify all sample data associated with QC or calibration that do not meet the project specifications or QC limit using the appropriate qualifiers as defined in Section 3.4 Data Qualifiers. Use the guidance for data qualification from the project specific guidelines in the QAPP or guidance in the USEPA NFG (2010).

5.0 DOCUMENTATION

The data evaluation procedures and results will be documented through completion of a checklist (refer to Attachment A), worksheet, spreadsheet, or a written summary of findings, subject to acceptance by the appropriate project representative(s). The data evaluation documents prepared by the reviewer will be provided to the Project Manager, and project Quality Assurance Manager if applicable, and included in the project file containing the associated laboratory result reports.

All documentation must include the Formation’s project name, Formation’s project number, laboratory name, laboratory-assigned project number, field sample IDs, sample matrix, and analytical parameters and methods used on the data evaluation documentation forms. Documentation must also identify the relevant project-planning documents and reference the protocol for the data evaluation (e.g., this SOP, a project-specific protocol, or EPA's National Functional Guidelines for Inorganic Data Validation).

The checklist and form provided in Attachment A, or similar, can be used to document the results of these review procedures. The table in Section 1.3 or the list of laboratory report contents in Section 4.1 can be used as the basis for a documenting a data completeness check.

6.0 DATA USE

Qualifier flags are assigned to describe the degree to which individual values provide accurate and precise results. The general criteria for assigning flags and their meaning in terms of future data use are as follows:

- Values assigned J flags (J, J+, or J-) are considered estimated results. QC data supplied with those values indicate that they may not be accurate or precise within the limits specified in the QAPP or a project-specific document, but that the magnitude of the potential imprecision or inaccuracy is not great enough to reject the value for project data uses.
- Values assigned R flags do not meet the requirements for accuracy, precision, representativeness, or reproducibility specified to provide quantitative data for the project data uses. The R flag indicates that serious deficiencies were encountered preventing the generation of usable data for the project objectives.
- Values assigned U flags indicate that a concentration of the analyte cannot be confirmed due to the presence of an interferant or the presence of the analyte in associated blanks. UJ flags may be applied to indicate that the presence of the analyte cannot be confirmed and the value of the reported quantitation limit for the sample may not be accurate or precise. Values flagged with U or UJ are fully usable and should be considered undetected.
- Values without flags assigned have met all of the project data quality objectives and are suitable for all project data uses.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

The data evaluation documents will be reviewed internally for conformance to the procedures described herein. Once any questions or comments resulting from that review have been resolved, the data evaluation documents will be considered final and any data qualifiers will be assigned to the results that are ultimately included in the project's electronic database.

8.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), 2010. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. EPA 540-R-10-011. January.

Formation Environmental SOP No. 20
DATA VALIDATION CHECKLIST

Formation Project Name:
Formation Project No.:

Laboratory Name:
Laboratory Project No.:

Field Sample IDs:

Sample Matrix:
Chemical Parameter(s)/Analytical Method(s):

Formation Environmental SOP No. 20
DATA VALIDATION CHECKLIST

	YES	NO
1. Is a Work Plan, SAP or QAP available?		
Title and date of applicable planning document(s):		
2. Chain-of-Custody (COC) Records:		
Are the COCs present?		
Are the COCs complete and signed off?		
Were the samples received at the proper temperature (4^{o}±2^{o}C), if applicable?		
Were all samples on the COCs analyzed?		
Were any problems noted on the COC?		
3. Were any problems noted by the laboratory in the narrative?		
4. Were all preservation and holding time requirements met?		
5. Was the frequency of field QC sample collection met?		
6. Was the ICP-MS tune analysis performed within limits?		
7. Were all calibration requirements met?		
8. Were all lab blanks non-detect?		
9. Were all field blanks non-detect?		
10. Were Interference Check Sample (ICS) requirements met?		

Formation Environmental SOP No. 20
DATA VALIDATION CHECKLIST

	YES	NO
11. Were Laboratory Control Sample (LCS) requirements met?		
12. Were duplicate sample requirements met?		
13. Were Matrix Spike (MS) sample requirements met?		
14. Were ICP Serial Dilution requirements met, if applicable?		
15. Were ICP-MS Internal Standard requirements met, if applicable?		
16. Were field duplicate RPDs within the project's control limits?		
17. Was the project's completeness goal met?		

Formation Environmental SOP No. 20
DATA VALIDATION CHECKLIST

Additional Comments:

Summary of Findings and Qualifiers Assigned:

Reviewed by:
Reviewed on: [date]

DATA VALIDATION QUALIFIERS
LAB JOB No.

FIELD SAMPLE ID	LAB SAMPLE ID	ANALYTE	LAB QUALIFIER	VALIDATION QUALIFIER	REASON FOR VALIDATION QUALIFIER

Note: When 2 qualifiers are assigned, only the flag higher in the data quality hierarchy was assigned.
The data quality hierarchy is R>UJ>U>J>J+>J-

SOP No. 23 Installation of Deep Bedrock Monitoring Wells

Formation Environmental

STANDARD OPERATING PROCEDURE No. 23

INSTALLATION OF DEEP BEDROCK MONITORING WELLS

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) has been refined to make it applicable for well installation in areas where deeper bedrock wells will be installed. The purpose of this SOP is to define the procedures for installing deep monitoring wells (and piezometers) in bedrock.

The user of this SOP must also refer to any specific instructions for well design and construction included in relevant work plans, field sampling plans, or well installation plans, and the procedures ultimately used to install deep bedrock wells must be consistent with those specifications in addition to this SOP. All drilling and well construction requirements outlined in Idaho Code will be followed as will any well abandonment that could occur.

This SOP outlines the necessary equipment and procedures for deep monitoring well installation. This procedure is intended to be used together with the other SOPs referenced herein.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from these sources:.

- ASTM D5092 – 04(2010)e1. Standard Practice for Design and Installation of Groundwater Monitoring Wells. American Society for Testing and Materials available online at http://www.astm.org.
- ASTM D5872 – 95(2006). Standard Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and

Installation of Subsurface Water-Quality Monitoring Devices. American Society for Testing and Materials available online at http://www.astm.org.

- SESD, 2008. Design and Installation of Monitoring Wells, SESDGUID-101-R0.
- USACE, 1998. Engineering and Design – Monitoring Well Design, Installation, and Documentation at Hazardous Toxic, and Radioactive Waste Sites, EM 1110-4000, Washington, DC.
- USEPA and NWWA, 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, EPA 160014-891034.

3.0 PROCEDURES

This SOP addresses the monitoring wells to be constructed in bedrock at depths greater than 400 feet. Special conditions such as karst terrain, underground mine workings, and/or artesian conditions, may require additional procedures. [However, such conditions are not expected at the Smoky Canyon Mine site.]

3.1 Equipment

The following lists the equipment anticipated to be needed for well installation:

- Stainless-steel or low-carbon steel casing and stainless-steel screen (other types of well material may be used, but the appropriateness of material should be evaluated based on the depth and any special installation methods clearly documented)
- Bentonite (powder, granules, high solids or pellets) for well seal
- Filter pack (8-12 mesh, unless otherwise indicated)

- Cement and powdered bentonite for grouting (sulfate-resistant [Type V] Portland cement, if appropriate)
- Stainless-steel centralizers (depending on well installation method)
- Protective surface casing with lockable steel cap
- Steel or concrete guard posts
- High-pressure steam cleaner
- Long-handled bristle brushes
- Wash/rinse tubs
- Alconox detergent
- Location map
- Drill rig capable of installing wells to the desired depth in the expected formation materials and conditions (e.g., air rotary, percussion hammer)
- Sealable bags or chip boxes
- Self-adhesive labels
- Deionized water
- Appropriate health and safety equipment
- Daily drilling summary forms
- Drilling log forms
- Well installation report forms

3.2 Drilling and Well Installation Procedures

3.2.1 Drilling Techniques

The typical drilling methods appropriate for installing wells at depths of 400 feet or more in bedrock include:

- Down-hole hammer (most appropriate for very hard to hard rock types, but depth may be limited by hydrostatic pressures)

- Rotary drilling with air, water, or foam (most appropriate for hard to soft rock, mud may be needed in unconsolidated formations)
- Cable tool (more common in eastern U.S.; slow but easier well installation)

Discussion of these drilling methods is provided in "*Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*" (EPA, March 1991 [EPA/600/4-89/034]) and other commonly available references. Specialized methods may be combined with the drilling methods listed above, such as casing advancement while drilling (e.g., ODEX or TUBEX method), or reverse circulation. A common method for drilling in faulted hard rock terrain is reverse circulation utilizing a down-hole hammer and dual-wall steel drill pipe. Air (or air with added water) can be used as the primary drilling fluid. With this method, a drill bit and percussion hammer are attached to the leading joint of drill pipe. Compressed air (or air with added water) is routed down-hole between the two walls of the drill pipe exiting at the bit. Rock cuttings and formation water are forced up the borehole through the bit and the inner drill pipe. An advantage of using this method is that fluid circulation can generally be maintained in difficult drilling situations (such as zones of fractures, larger voids, or caving ground) where other methods may fail or require drilling mud to proceed. In addition, semi-quantitative estimates of water production can be made as various geologic formations are penetrated.

For any site or drilling location, the selection of drilling methods will be based on: (1) availability and cost of the method; (2) suitability for the type of geologic materials at the site (e.g., consolidated, unconsolidated); and (3) potential effects on sample integrity (influence by drilling fluids and potential for cross contamination between aquifers). Drill bit (hole) size shall be sufficient to permit efficient installation of the specified well materials.

Surface casing (or conductor casing) will commonly be needed with most of the methods. This casing should consist of the appropriate inside diameter (ID) low-carbon steel for the bit sizes to be used during drilling. The casing should be installed to a depth of 5 to 10 feet below the top of bedrock. The surface casing may be installed with a mud rotary drilling method using bentonite mud. The casing will be pressure grouted if subsurface conditions allow. The surface casing will project approximately 1 foot above the ground surface.

After the surface casing is set, drilling will proceed. If bedrock conditions result in impaired circulation, it may be necessary to use additives with the air or air-water mist to maintain circulation. Additives such as foam or foam with filler, such as cottonseed hulls, will be used, if necessary, and as approved by Formation Environmental.

In some cases where intermediate aquifers or unstable rock are encountered, it may be necessary to install intermediate steel casing to reduce the borehole flooding or to stabilize the borehole. This may require that the casing and borehole size be telescoped, whereby progressively smaller diameter casings are set with depth (one inside the other) as the borehole is advanced. Bentonite mud may be used as the drilling fluid while drilling or reaming the borehole for placement of an intermediate casing. The mud will be flushed from the borehole prior to drilling beyond the intermediate cased intervals. The intermediate casing will be pressure grouted, if subsurface conditions allow.

A variety of geophysical logs can also be run in the uncased borehole or in sections of the borehole to aid in geologic characterization and location of fault/fracture zones by pulling back the drill string prior to well installation.

3.2.2 Disposal of Cuttings and Fluids

If drill cuttings need to be contained, the following method may be used. Where space is available, a basin will be excavated adjacent to the drill pad in a location approved by appropriate agencies. The basin will be located so as not to hamper the drilling operations or cause unsafe conditions at the well site. A physical barrier, meeting MSHA/OSHA standards will be constructed around the basin. Topsoil may be stockpiled for covering the basin after well completion, if appropriate. Cuttings and water produced during drilling will be collected in the containment pit. If appropriate, groundwater produced by drilling operations will be monitored for pH and conductivity using field test methods. Upon completion of drilling, the basin may be drained, regraded, covered with topsoil, and reseeded. Where adequate space is not available, cuttings can be collected in portable containers and disposed at a site specified by appropriate parties. In some cases, large volumes of water may be produced during drilling. Under such conditions, it may be most practical to discharge the water after the solids have settled. The discharge should not go directly to surface water and proper approval may need to be obtained before the water is discharged.

3.2.3 Decontamination

At contaminated sites, drilling equipment will need to be decontaminated. Such equipment will arrive on-site decontaminated. Drill bits, the down-hole hammer and drill strings will be decontaminated between all boreholes. Heavy equipment (backhoes, etc.), depending on the extent of contamination and the cleaning requirements, will be decontaminated at each sampling and/or excavation site or at the designated decontamination area. Unless dedicated sampling equipment is used, all sampling equipment (California tubes, stainless-steel or brass liners, bailers, etc.) will be decontaminated between all sampling points to minimize potential cross-contamination. All drilling equipment will be decontaminated at the conclusion of well installation, prior to leaving the site. Decontamination will be completed according to JRS SOP No.7. All well materials (i.e., casing, screen, centralizers) will be decontaminated by steam cleaning prior to installation except materials that can be certified clean (e.g., new materials). The Smoky Canyon Mine wash bay may be used as a steam cleaning station.

3.2.4 Geologic Logging

Borehole geology will be logged by examination of the drill cutting samples or core samples according to American Society for Testing and Materials (2000), "*Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)"*, ASTM D 2488-90. Bedrock cores will be logged in accordance with the guidance provided in ASTM (2014) *"Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration",* ASTM D 2133-14. If coring is not conducted, the drill cuttings should be logged considering the lag time associated with depth of drilling.

The data will be recorded on a borehole drilling log form (Figure SOP23-1) and will include the following information:

- Project name and number;
- Geologist's or engineer's name;
- Borehole number and location;
- Surface elevation (if available);
- Drilling company and driller's name;
- Date drilling started and finished;
- Drilling equipment and method;
- Drill bit type and size;
- Total borehole depth;
- Sample depths and times;
- Geologic conditions with depth, such as lithology, texture, structure, bedding, color, alteration, mineralization, gouge zones, moisture content, and the Unified Soil Classification (if in unconsolidated materials);
- Core data;
- Hydrogeologic conditions with depth, such as water producing zones, flow rates, pH, specific conductance, and fluid description;

- Presence and/or frequency of fractures;
- Water levels;
- Lost circulation zones; and
- Drilling observations.

Samples of materials encountered while drilling will be collected using the method outlined below.

A. Collecting Cuttings -- A field geologist may collect cuttings from the drilling return fluid, air return for every five-foot (or more frequent) increment or at changes in lithology. Sampling and logging should be performed in accordance with the following procedures:

1. The height of the drilling table above ground surface, lengths of the drill bit, sub and drill collars, and length of drill rods or augers should be taken into account in calculating the depth of penetration.

2. A small-diameter, fine-mesh hand screen or a shovel may be used to obtain a sample of the cuttings from the boring by holding the sampling device directly in the flow of the drilling return fluid or cyclone separator.

3. A sample will be obtained from the drilling return fluid or cyclone separator by leaving the sampling device in place only for the brief period required to collect an adequate sampling volume.

4. The most representative cuttings samples are usually obtained whenever the driller stops advancing the hole and circulates drilling fluid or air prior to adding another joint of drill rod.

5. Keep in mind that the deeper the hole, the longer cuttings at the drill bit take to reach the surface. The travel time for cuttings to reach the surface may be estimated each time the driller adds a new length of drill rod by timing the first arrival of cuttings after fluid or air circulation is resumed. This travel time should be used along with the depth of penetration to estimate the start and finish of each sampling interval.

6. In hydraulic rotary drilling, carefully wash the cutting sample in a bucket of fresh water by slowly shaking the screen while the sample is submerged, to wash away the drilling fluid.

7. A portion of each sample will be archived in sealed and labeled bags or chip boxes. If coring is conducted, the cores will be collected in

intervals of 10 feet or less as determined by the field geologist or engineer. All cores will be archived in labeled cardboard core boxes.

Well completion overview will be documented in the field notebook and/or appropriate forms by the on-site geologist or engineer. Information to be documented is detailed in Section 3.3-Documentation.

3.2.5 Geophysical Logging

Geophysical logging of the borehole may be implemented to collect supplemental subsurface information. The type of logs to be developed will depend on borehole conditions and will be decided by geologist or engineer on a hole-by-hole basis. Logs run may include some or all of the following methods:

- Spontaneous potential (SP)
- Gamma ray
- Electrical resistivity
- Borehole deviation
- Caliper
- Temperature
- Neutron porosity
- Full wave form sonic (variable density)
- Acoustic televiewer
- Hydrophysical
- Gamma-gamma
- Optical televiewer

Logging tool calibrations will be checked before and after each run according to manufacturer specifications. Logging speeds will also follow manufacturer recommendations. Records of geophysical logging operations will be documented by the field geologist or engineer. The field geologist or engineer will supervise the logging subcontractor and will document the logging activities in a field notebook.

3.2.6 Well Materials Specifications Well Casing/Riser Pipe

Materials to be used for the well casing will depend on the conditions encountered in the borehole. A common, 4-inch diameter, steel casing construction is described here.

Casing will be installed in every well. The casing shall extend at least 12 inches above land surface and to a minimum depth of 38 feet below ground, as required by the IDAPA 37.03.09 *Well Construction Standards Rules*.

Well casing would consist of new, 4-inch, threaded, flush-jointed, Schedule 10 stainless steel, or a combination of stainless steel and threaded, Schedule 80 carbon steel, or low-carbon steel if appropriate. Well casing will be stainless steel from total depth to a point 60 feet above the well screen. Carbon steel casing would be used from a point 60 feet above the well screen to the ground surface. Joints within the stainless steel portion of the casing string will be threaded. Joints within the carbon steel portion of the casing string will be threaded or welded. The top of all well casings will be fitted with caps that can be easily removed by hand. If the well cannot be constructed inside the drill string, then stainless-steel centralizers will be used to center the well casing in the borehole. Centralizers will be firmly attached to the casing at the base and top of the screen and at minimum 50-foot intervals on the casing as warranted by the conditions and the well design.

Well Screens and Filter Pack

Well screens will consist of new, threaded, flush-jointed, screen. Well screens will have an inside diameter equal to that of the well casing and the same thread size as that of the well casing. All screen bottoms will be fitted with a sump and bottom cap. Screen slot size will be selected that are appropriate for the geologic conditions. For some piezometers and wells, open-hole construction may be appropriate. The well screen will be factory continuous-slot, V-notch screen. Geologic logs or geophysical investigation of the screened interval may be used to help select the screen slot size. The slot size will be compatible in size with the selected filter material. Based on well installation experience at Smoky Canyon Mine with similar hydrogeologic characteristics, the slot size will likely be 0.020” factory slot, although the possibility of using a different slot size remains. These slotted casing sections are generally not intended to provide optimum flow but only to provide hydraulic connection between the pervious material in the water-yielding zone and the monitoring well. Screen lengths will be kept to the minimum length appropriate for intercepting potential contamination. Actual screen length will depend on the geologic conditions encountered in the target zone.

Where the screen is installed in a highly fractured zone or weakly consolidated materials, installation of a filter pack will typically be needed. If conditions are very poor, then pre-packed screens may be used. The annular space between the borehole wall and the screen will be filled with clean filter pack material. Filter pack material will be well-graded, clean sand with less than 2 percent by weight passing a No. 200 sieve and less than 5 percent by weight of calcareous material. At least two inches of filter pack material shall be installed between the well screen and the borehole wall. Based on well installation experience at Smoky Canyon Mine, filter pack will likely be 8-12 mesh silica sand (0.093-0.055 in), or 10-20 Colorado Silica Sand, although the possibility of using a different mesh sizes appropriately matched to the screen slot size remains.

The filter pack shall be installed in a manner that prevents bridging and particle-size segregation. Filter sand will be tremied into the annular space using a one-inch diameter (or larger) pipe, in a calculated quantity sufficient to fill the annular space to a level of about ten feet above the top of the perforated casing. The depth to top of filter pack will be measured with a weighted tape after each lift.

Bentonite Seal

The well casings shall be sealed to prevent possible preferential downward pathways between water bearing zones, as well as upward movement in artesian conditions. A commercially available bentonite seal shall be installed above the filter pack. The bentonite seal will consist of either bentonite pellets or granular bentonite. The bentonite seal will be at least 10 feet thick. For nested wells, the seal will extend to the bottom of the next saturated interval. The bentonite seal will be allowed to set for 12 hours prior to placement of the annular seal. Because of the proposed depths of the deeper holes, the bentonite seal will be tremied to ensure proper placement of the seal. The depth to the top of the bentonite seal will be measured with a weighted tape after each lift.

The bentonite seal will be placed above a packer, clay ring, or similar device in boreholes where it is not possible to place filter pack in the annulus or a filter pack is not used. The packer, clay ring or similar device will be set at least 10 feet or more above the screened interval to ensure isolation of the screen and bentonite seal. To prevent intrusion of bentonite in the filter, bentonite slurry will not be used immediately above the filter pack or packer device.

If a fracture zone is encountered immediately above the target zone for the screened interval, the filter pack and/or packer device will be extended or placed above the fracture zone to prevent excursion of bentonite into the formation. If the bentonite seal is to be placed within a fracture zone (where it is not appropriate to bring the filter pack beyond the fracture zone) pellets, chips or granular bentonite will be used for the seal to minimize losses to the formation.

Potable water may be added to transport the chips or pellets through the tremie pipe. However, only the minimum amount of water necessary to place the chips or pellets will be used. If a significant depth of water is present in the borehole, bentonite pellets or chips will be used, and granular bentonite will not be used. If the bentonite seal is to extend above the water table, water will be added to provide for adequate hydration of the bentonite.

Annular Seal

The annular space between the well casing and the borehole will be sealed with bentonite chips or grout. Grout will consist of either a high solids bentonite grout or a cement grout. Bentonite grout will not be used above the water table or within 40 feet of the ground surface. The upper 40 feet of the annulus will be grouted with cement. Grout additives that aid in the grout hardening time or minimize losses to the fracture zones may be used with the approval of Formation Environmental.

Grout will be placed in the well annulus with a tremie pipe. The grout will be pumped through the pipe, which will be pulled up incrementally so that the borehole will be filled from the bottom upward. The annular space will be grouted in stages to reduce the potential problems related to the hydrostatic head on the grout and to provide a better seal. The quantity of grout used in each stage will be estimated from the annulus volume prior to emplacement. The first grout stage will be allowed to set for 24 hours prior to the emplacement of a subsequent stage. Grout stages emplaced after the initial grout stage will be allowed to set 12 hours before placement of subsequent stages. The depth to the top of each grout stage will be measured with a weighted tape after the grout has set.

Samples of grout will be collected at the surface during placement of each lift to provide an indication of whether the grout has set up. In addition, the top of the grout will be tagged to determine whether it has hardened during the allowed set up time. If the sample or tag test does not indicate that the grout has sufficiently set up, additional time will be allowed.

Above-Ground Surface Completion

The surface casing installed during drilling will serve as the protective surface casing. The surface casing will project approximately 1-2 foot above the ground surface. Following well completion, the surface casing will be fitted with a lockable steel cap. An internal mortar collar will be placed within the protective casing annulus from ground surface to 0.5 foot above ground surface. The mortar mix should consist of one part cement to two parts sand, by weight, with minimal water for placement.

A 6-inch, thick coarse gravel (3/4-inch to 3-inch particle size) blanket will extend approximately 4 feet radially from the protective casing to provide an effective surface protection in areas were frost heaving may be an issue. Otherwise, a concrete well pad may be placed. Four 3-inch diameter steel posts will be installed radially from the well casing at a distance of approximately 4 feet. They will be placed approximately 3-4 feet below the ground surface and have a minimum of 3 feet above the ground surface. The posts will be flagged in areas of high vegetation.

3.2.7 Borehole Abandonment

It may be necessary to abandon a borehole without completing a well. If abandonment is necessary, the borehole will be grouted in stages as described in Section 3.2.6.

3.2.8 Measurements

Measurements collected during drilling and well construction, including the well construction materials, will be measured to the nearest 0.1 foot. Following well completion, the well location will be surveyed by a licensed surveyor. The horizontal location will be measured to 0. 1 foot and will be tied to the local, documentable coordinates. The elevation of the top of the protective casing, ground surface, and water level measuring point will be measured to 0.01 foot and will be tied to a documentable benchmark.

3.2.9 Well Installation Procedure

The conditions and monitoring requirements for wells installed under this SOP may vary widely. Therefore, the procedures listed below will need to be adapted to the specific drilling and well construction methods used. The data needs and quality from the well will affect the installation procedure. For example, piezometer construction may require less strict decontamination and well construction procedures. The general procedure for well installation is as follows.

1) Decontaminate all drilling equipment prior to drilling the first borehole according to procedures outlined in JRS SOP No.7.

2) Advance borehole through surficial weathered material to bedrock; collect and log cuttings at 5-foot intervals.

3) Set surface casing to 5 to 10 feet below top of bedrock and grout the annular space using a pressure grouting method (if subsurface conditions allow).

4) Allow grout to harden. See Section 3.2.6-Well Materials Specifications for proper grout set up time.

5) Advance borehole to planned total depth. Collect and log drill cuttings at intervals of approximately 5 feet. If needed, ream and set intermediate casing using pressure-grouting method (if subsurface conditions allow).

6) Measure depth of completed borehole using a weighted tape or measured drill pipe, sub, and bit.

7) Measure depth to water using an electronic water level probe.

8) Run the appropriate geophysical logs, if any, using logging tools and cable that were decontaminated according to JRS SOP No.7.

9) Determine screen length and screened interval using collected geological, geophysical and water level information.

10) Plug borehole back to desired total depth, only if necessary, using grout tremied into the borehole. Allow grout to harden. Measure depth to top of grout. Place a several-foot thick transition seal between the cement and the well screen. The transitional seal could be very fine sand, or bentonite overlain by very fine sand.

11) Decontaminate all well materials (i.e., casing, screen. centralizers) according to JRS SOP No.7 unless materials are delivered to the site clean and packaged in boxes or wrapped in plastic.

12) Measure each joint of casing, screen, and sump to nearest 0.1 foot. Attach packer device at appropriate interval if a filter pack will not be used.

13) Assemble screen and casing as it is lowered into the borehole attaching centralizers as required.

14) Lower screen and casing until sump extends to bottom of borehole. The casing should be maintained in tension, suspended from the drill rig until well materials are placed and grout seal sets.

15) Record the level of the top of casing and calculate the depth of the screened interval. If necessary, adjust the screened interval by raising assembly to desired interval.

16) Calculate and record volume of filter pack, bentonite seal and grout required for existing borehole conditions.

17) Begin adding filter pack around the annulus of the casing by tremie pipe in 5-foot increments. Repeated depth soundings shall be taken to monitor the level of the top of the sand in the borehole.

18) Allow sufficient time for the filter pack to settle through the water column outside the casing before measuring the sand level.

19) Extend the filter pack in the annulus to approximately 10 feet above the top of the well screen.

20) Following filter pack placement, install the bentonite seal (coated pellets or slurry) through an appropriately sized tremie pipe to minimize bridging inside the pipe. If filter pack is not used in the well annulus, establish the bentonite seal above a packer, clay ring or similar device at least 10 feet above the screened interval. The depth to the top of the completed bentonite seal shall be measured using a weighted tape. The bentonite seal will be 100 feet thick for deep wells; shallower wells will be sealed to

10 feet below the top of bedrock. Grouting operations can commence 12 hours after placement of the bentonite seal if granular bentonite is used. If bentonite slurry is used, a minimum of 24 hours will be allowed prior to grouting. The depth to the top of the bentonite seal will be measured before grout placement to confirm top elevation and thickness of the seal.

21) Grout the remaining annulus in stages from the top of the bentonite seal to the ground surface. Other additives (such as polymers to aid in the grout hardening time or bridging polymers to minimize losses to the fracture zones), to be blended with the cement/bentonite mixture, may be used with the approval of Formation Environmental. These additives may be used in an effort to control loss of grout into fracture zones thereby limiting the potential for grout contamination in the piezometer/well. The base of the tremie pipe should be placed approximately 10 feet above the bentonite seal and incrementally pulled up as grouting proceeds. After the first stage of grout (to 25 feet above the bentonite seal) is emplaced and allowed to set 24 hours, additional grout stages will be tremied into the borehole. Additional grout stages will be approximately 100 to 300 feet thick and will be allowed to set 12 hours prior to emplacement of each subsequent stage. (If any PVC well material is used, grout lifts should be less than 100 feet thick.) If the zone above the screened interval is highly fractured, subsequent stages will be limited to 100 feet until competent bedrock is reached or the level of the grout is 300 feet above the filter pack. Measure the depth to the top of each grout stage before placing subsequent stages.

22) Check well straightness by passing a 10- to 15-foot-long, bailer through the entire length of casing. Size of bailer should be appropriate to size of well casing (e.g., 1.75-inch diameter bailer for 2-inch well casing).

23) Install the lockable steel cap on the protective surface casing and lock.

24) After the last stage of grout sets for 24 hours, it will be checked for settlement. Additional grout will be added to top off the annulus, if necessary.

25) After 24 hours, install the mortar collar, gravel blanket, and guard posts according to specifications in Section 3.2.7.

26) Place the well number, depth, and date on the well casing and cap. Paint the protective casing and posts fluorescent orange; label the casing, using white paint, with the well designation.

27) Decontaminate all drilling equipment after drilling program is completed according to procedures outlined in JRS SOP No.7.

3.3 Documentation

Observations and data acquired in the field during drilling and installation of wells will be recorded daily by the onsite geologist or engineer to provide a permanent record of these activities. These observations will be recorded with waterproof ink in a field book. The recorded information will include the following as a minimum:

- Project name and number
- Observer's name
- Drilling company name
- Type of drill rig
- Date drilling started and finished
- Type of bit and size
- Casing sizes and depths
- Driller' s name
- Drilling and well installation observations
- Presence and/or frequency of fractures and any lost circulation zones (to aid in identifying zones of potential hydrostatic head problems associated with placement of the grout seal)
- Daily progress
- Geophysical log runs, calibration performed, and measurements collected
- Problems encountered and resolution
- Decontamination observations
- Weather conditions

At the end of each day the onsite geologist or engineer will complete the field book notes and make two copies, if practicable: one for the task management files and one for the field flies. In addition, daily drilling summary forms will be provided by the drilling contractor and will be approved by the onsite geologist or engineer. A copy will be included in the task management and field files.

A well installation report form (Figure SOP23-2) will be completed for each monitoring well or piezometers. Each well report form will include the following (denoted by depth from ground surface):

- Bottom of the borehole
- Casing types and sizes
- Screen (perforation) type and interval
- Coupling/joint locations
- Filter pack type, size, and interval
- Bentonite seal interval
- Cave-in locations
- Centralizers
- Height of riser without cap (above ground surface)
- Protective surface casing detail

Additional documentation for well construction that will be recorded daily in the field book and/or appropriate forms will include the following:

- Grout, sand, and bentonite volume calculations prior to well installation:
- The quantity and composition of the grout, seals and filter pack actually used during construction.
- Screen slot size (in inches), slot configuration, total open area per foot of screen, outside diameter, nominal inside diameter, schedule and/or thickness and composition.
- Coupling/joint design and composition
- Centralizer design and composition
- Surface casing composition and nominal inside diameter

- Start and completion date
- Discussion of all procedures and any problems encountered during drilling and well construction.
- Surface completion information and date.

4.0 QUALITY ASSURANCE

Field notes and field forms completed by the field geologist shall be reviewed by the field supervisor and the Formation Environmental Project Manager or other designated QA officer before they are placed into project files. Deviation from this SOP or a project-specific well installation plan shall be identified and described in field notes. The QA review will be recorded on the reviewed originals by initials of reviewer and date.

SOP No. 31 Water Quality Meter Calibration

STANDARD OPERATING PROCEDURE No. 31

WATER QUALITY METER CALIBRATION

1.0 SCOPE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the protocol to be followed for calibration of the field water quality sampling multi-parameter instrument used during environmental monitoring and sampling activities. The procedures presented herein are intended to be general in nature and are applicable when referenced by site-specific or project-specific planning documents. Appropriate modifications to the procedures may be made to accommodate project-specific protocols when approved in writing or via email by the Project Manager or detailed in a project work plan, sampling plan, or quality assurance project plan.

The objective of calibrating field instruments is to establish the accuracy and reliability of the instrument and to ensure that field readings are consistent with other measurements.

2.0 BASIS FOR METHODOLOGY

The methods and procedures described in this SOP were developed from this source:

- U.S. Geological Survey (USGS) (variously dated) National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Chapters A1-A9.

3.0 EQUIPMENT AND SUPPLIES

3.1 Multi-Parameter Sensors

Multi-parameter sensors can vary between manufacturers of instruments and as technology advances. The following are the sensors generally used on multi-parameter instruments for collecting water quality parameters: water temperature, pH, specific electrical conductance (SC), oxidation-reduction potential (ORP), and dissolved oxygen (DO). Turbidity is generally measured using a separate meter, but there are some instruments for which the turbidity sensor is included with the multi-meter sensor cluster.

- pH – sensor has a range between 2 to 12, or 0 to 14 pH units
- Water Temperature – sensor has a range of at least -5 to +45 degrees Celsius
- SC – sensor is temperature compensating, and measures in microsiemens per centimeter (uS/cm) or mS/cm
- DO – 2 types of sensors (polarographic and optical) both sensors range from 0.05 to 20 milligrams per liter (mg/L)
- ORP – sensor uses a platinum electrode, and measures in millivolts (mV)

3.2 Calibration Supplies

The following supplies are needed to calibrate a multi-parameter instrument: specific sensor buffers, standards, and calibration solutions, field notebooks, deionized water, bucket(s), disposable gloves, scrub brushes, and paper tissues.

4.0 CALIBRATION PROCEDURE

The multi-parameter instrument will be calibrated in the field once daily by personnel according to manufacturer's instructions prior to the collection of any samples. All calibration details will be recorded in a field notebook including, but not limited to: instrument type, instrument serial number, readings prior to calibration, buffers used, readings after calibration, names of personnel calibrating, and date and time of calibration. The following are general guidelines to follow when calibrating a multi-parameter instrument:

A. Follow the manufacturer instructions;
B. Set the meter to the correct measurement units;
C. Allow the meter to warm up (at least 10 minutes or according to manufacturer recommendation);
D. Calibrate the instrument in a temperature-stable environment;
E. Use the calibration cup for calibration;
F. Use the recommended volume of calibration solution during calibration;
G. Do not over tighten the calibration cup;
H. Rinse the sensor with deionized water prior to the use of calibration solution, then rinse with a small amount of the calibration solution to be used before calibrating; and
I. Calibrate the meter sensors in the following order: water temperature, SC, DO, pH, and ORP.

4.1 Multi-Point Calibration

4.1.1 Water Temperature

Check to ensure the accuracy of the temperature sensor at least every 3 months if the multi-parameter instrument is in frequent use or according to the manufacturer's recommendations. The accuracy of the temperature sensor will be verified against a certified NIST-traceable digital or liquid-in-glass thermometer. Completely submerge the multi-parameter meter temperature sensor and allow at least 1 minute for the temperature to equilibrate and stabilize. Record the temperature value in degrees Celsius (°C). If the difference between the readings does not fall within the manufacturer-specified accuracy, contact the supplier or manufacturer for the next steps.

4.1.2 Specific Conductance (SC)

Calibration for SC is performed using a one-point calibration. Use the standard recommended by the manufacturer or a standard that is similar in conductivity to the sample water. The calibration cup and sensor will first be rinsed using a small amount of calibration solution prior to the start of calibration. Next the calibration cup will be filled with the recommended volume of calibration solution and the sensor completely submerged. When the readings stabilize save the calibration point and record in the field notebook the readings before and after calibration in uS/cm.

4.1.3 Dissolved Oxygen (DO)

Follow the manufacturer's guidelines for care, proper setup, and calibration of the DO sensor for the instrument in use. Whenever possible, ensure that the DO sensor has been appropriately calibrated by the instrument supplier or party responsible for maintenance prior to using the instrument in the field.

4.1.4 pH

Calibration of the pH sensor is performed using a two-point calibration. Select the pH 7 buffer as well as a second pH buffer (pH 4 or pH 10) that brackets the expected range of sample water pH. A calibration check using a third buffer can be performed at the end of calibration. To start, the calibration cup and sensor will be rinsed with deionized water and then with a small amount of the first buffer. Next the calibration cup will be filled with enough of the first buffer to completely cover the pH and temperature sensors (the pH value is temperature dependent). Wait for the pH and temperature sensors to equilibrate to the temperature of the buffer and record the temperature reading after stabilization. Adjust the calibration reading (to the true pH value at that temperature) using the chart provided by the buffer manufacturer. Record the temperature and pH readings before and after calibration of the first buffer in the field notebook. Follow the same steps starting with the rinsing of the calibration cup and sensor for the second buffer. If a third buffer is used to check the calibration, follow the same steps, but do not lock in a calibration point.

4.1.5 Oxidation-Reduction Potential (ORP)

Calibration of the ORP sensor is generally performed using a one-point calibration at a known temperature. The manufacturer's recommendation will be followed for calibration. The calibration cup and sensor will first be rinsed with a small amount of the solution. Next fill the calibration cup with enough of the solution to completely submerge the ORP sensor. Wait for the readings to stabilize and then enter the correct value of the solution at the current temperature. Record the ORP readings before and after calibration in mV, as well as the solution values used in the field notebook.

4.2 One-Point Calibration

Calibration may be performed using the In-Situ Quick Cal Solution when an In-Situ smarTROLL^{TM} MP handheld water quality meter is used. The Quick Cal Solution performs a one-point calibration of all smarTroll^{TM} MP sensors (pH, ORP, SC, and DO) at the same time. The manufacturer's recommendations will be followed for calibration as well as the following use and storage guidelines:

- Shake well before use;
- Allow to warm to room temperature before using;
- Store in refrigerator (needs to be stored in dark and cool environment);
- Use within three weeks after opening (document on bottle and calibration records when opened);
- Unopened shelf life is six months (check and document expiration date of bottle); and
- One-time use only (i.e. solution should not be re-used following single calibration).

5.0 DOCUMENTATION

The Project Manager or designated reviewer will check and verify that documentation of instrument calibration has been completed and the calibration records are filed in the project records.

6.0 REFERENCES

U.S. Geological Survey (USGS), variously dated. National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Chapters A1-A9. Available online at http://pubs.water.usgs.gov/twri9A.

EPA SOP FLD#-5 Standard Operating Procedure for Soil Sampling

Soil Sampling

APPROVED:

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This document has been prepared for the Environmental Protection Agency by the TechLaw, Inc. ESAT Region 8 Team and is intended to provide documentation of administrative, analytical and quality control procedures used in the daily performance of EPA and ESAT support services.

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide a guideline for the collection of representative soil samples in the field. The collection and analysis of soil samples serves to establish whether pollutants are present in the soils and helps determine the required action level(s) with regard to public and environmental health and welfare.

2.0 SCOPE AND APPLICATION

These are standard operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and included with the final report. Mention of trade names or commercial products does not constitute Techlaw, inc. endorsement or recommendation for use.

3.0 SUMMARY OF METHOD

Soil samples may be collected using a variety of methods and equipment. The methods and equipment used are dependent on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type. Near-surface soils may be easily sampled using a spade, trowel, and scoop. Sampling at greater depths may be performed using a hand auger, continuous flight auger, a trier, a split-spoon, or a backhoe if necessary.

4.0 ACRONYMS AND DEFINITIONS

COC	Chain of Custody
GPS	Global Positioning System
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
OSHA	Occupation Safety and Health Administration
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
EPA	United States Environmental Protection Agency
ESAT	Environmental Services Assistance Team

Chain of Custody (COC) – A chronological document that tracks transfer of samples between entities from collection to disposal

Composite Sampling – Sampling from several points or intervals and consolidating them into a larger sample

Discrete Sampling - Sampling from a single location

Health and Safety Plan (HASP) – A site-specific plan that outlines potential hazards and procedural/equipment recommendations

Standard Operating Procedure (SOP) - A set of written instructions that document a routine or repetitive activity followed by an organization (EPA, 2007)

5.0 HEALTH AND SAFETY

When working with potentially hazardous materials or in hazardous situations, personnel must understand and comply with the site-specific Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) and Health and Safety Plan (HASP) before the sampling event begins. More specifically, when sampling waste rock piles or fluvial deposit zones containing known or suspected hazardous substances, adequate personal protective equipment such as nitrile gloves, safety glasses, and protective footwear are necessary to prevent exposure.

When traversing tailings piles, hazardous situations exist that require the sampling personnel to wear adequate safety equipment including gloves and non-slip footwear. Never perform sampling activities if it cannot be done so in a safe manner (tailing piles are too steep, lightning is occurring, etc).

6.0 CAUTIONS

There are cautions to be considered before deployment on a soil sampling event. If the samples are to be collected in an urban area at depth, the underground utility lines must be identified. In addition, if sampling at a remote waste rock pile, always use the buddy system when traversing steep gradients that may present fall hazards. Always review the site-specific HASP for potential safety hazards.

7.0 INTERFERENCES

There are two primary interferences or potential problems associated with soil sampling. These include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection can involve disturbance of the matrix (i.e. walking on specific areas that will ultimately be sampled) resulting in compaction of the sample or inadequate homogenization of the samples where required, resulting in variable, non-representative results.

8.0 PERSONNEL QUALIFICATIONS

Any personnel involved with field sampling activities must be cleared for health and safety. Clearance includes medical monitoring, respirator fit testing, and Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour training. Personnel who will be collecting soil samples should familiarize themselves with this and other pertinent SOPs such as the Sample Equipment Decontamination SOP FLD 02.00, the Sample Preservation SOP FLD 03.00, the Sample Custody and Labeling SOP FLD 11.00, and the General Field Sampling Protocols SOP FLD 12.00.

9.0 EQUIPMENT

Equipment needed for collection of soil samples may include:

HASP Gear - Gloves, proper footwear, safety glasses, etc.

Mapping and Location Tools – Global Positioning System (GPS) units, site/local area maps, compass, tape measure, survey stakes, pin flags, camera, 2-way radios

Documentation Tools – Field log book, field data sheet, COC(s), labels, clear tape, pens, permanent marker, waterproof paper

Sampling Tools – Plastic, Teflon^{TM}, or other appropriate composition scoop (analysis dependent), shovel, spade, trowel, measuring cup or graduated cylinder, field scale, bucket auger, post hole auger, homogenization container w/ mixing tool, bucket, rinse bottle, purified water, paper towels

Sample Containers – Ziploc™ baggies, glass jars, labels, clear tape, pens, permanent marker, cooler(s), ice, thermometer

See Appendix A for a detailed list of soil sampling equipment.

10.0 STANDARDS AND REAGENTS

Reagents are not used for the preservation of soil samples. Decontamination solutions are specified in the Sampling Equipment Decontamination SOP# FLD-02 and the site-specific work plan.

11.0 PROCEDURES

11.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies required.
2. Obtain the necessary sampling and monitoring equipment.
3. Decontaminate or pre-clean equipment, and ensure that it is in working order.
4. Prepare schedules, and coordinate with staff, client, and regulatory agencies where necessary. It is also important to obtain access agreements if sampling is to occur on private property.
5. Perform a general site survey prior to site entry in accordance with the site-specific HASP.
6. Use stakes, flagging, or buoys to identify and mark all sampling locations followed by a GPS point (see GPS Trimble® GeoXT 2008 series SOP FLD 07.00). Specific site factors, including extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner

prior to soil sampling. It is the responsibility of the sampler to verify with the property owner that utility lines have been marked. If there is no property owner and there is concern for underground utility lines, it is the responsibility of the samplers to contact the state agency or contractor that can provide a marking service.

11.2 Sample Collection

In general, there are two primary ways to collect a soil sample. Composite sampling involves taking several subsamples from a designated sample location and consolidating into one larger sample. Discrete sampling is defined as taking one sample from a single location. Composite and discrete sampling can be achieved by the sample techniques listed below.

11.2.1 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, shovels, trowels, and scoops. Remove surface material to the required depth and use a stainless steel or plastic scoop to collect the sample.

This method can be used in most soil types but is limited to sampling near-surface areas. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel scoop, lab spoon, or plastic spoon will suffice in most other applications. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. Care should be exercised to avoid use of devices plated with chrome or other materials. Plating is particularly common with garden implements such as potting trowels. There are four depth classes that are typically used in Region 8: 0-2” range, 0-6” range, 6-12” range, and 12-18” range. The 0-2” and 0-6” range can usually be sampled with one of the tools listed above, but the deeper ranges generally require the use of one the tools described in sections 11.2.2 and 11.2.3.

The following procedure is used to collect surface soil samples:

1. Carefully remove the top layer of soil or debris to the desired sample depth with a pre-cleaned spade.

2. Using a pre-cleaned, stainless steel scoop, plastic spoon, or trowel, remove and discard a thin layer of soil from the area which came in contact with the spade.

3. If volatile organic analysis is to be performed, transfer the sample directly into an appropriate, labeled sample container with a stainless steel lab spoon or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval or location into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the

caps tightly.

4. Due to data quality requirements, some soil sampling events may require that each sub-sample of a composite be measured. This can be achieved two ways: by mass or by volume. Due to the remote nature of the sites in Region 8, it is recommended that composite samples are measured by volume. This requires the use of a measuring cup or graduated cylinder (of appropriate composition), placing the material into the measuring device to the desired volume, then adding the sub-samples to a larger sample container (plastic baggie for metals, glass jar for organics). Overall volume of sample will be dictated by analytical requirements.

11.2.2 Sampling at Depth with Augers and Thin Wall Tube Samplers

This system consists of an auger, or a thin-wall tube sampler, a series of extensions, and a "T" handle (Figure 1, Appendix B). The auger is used to bore a hole to a desired sampling depth and is then withdrawn from the hole. The sample may be collected directly from the auger. If a core sample is to be collected, the auger tip is then replaced with a thin wall tube sampler. The sampling assembly is then lowered down the borehole, and driven into the soil to the completion depth. The system is withdrawn and the core is collected from the thin wall tube sampler.

Several types of augers are available; these include: bucket type, continuous flight (screw), and post-hole augers. Bucket type augers are better suited for direct sample recovery since they provide a large volume of sample in a short time. When continuous flight augers are used, the sample can be collected directly from the auger flights. The continuous flight augers are satisfactory for use when a composite of the complete soil column is desired. Post-hole augers have limited utility for sample collection as they are designed to cut through fibrous, rooted, swampy soil and cannot be used below a depth of three feet.

The following procedure is used for collecting soil samples with the auger:

1. Attach the auger bit to a drill rod extension, and attach the "T" handle to the drill rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first three to six inches of surface soil for an area approximately six inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole, and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 10.

5. Remove the auger tip from drill rods and replace with a pre-cleaned thin wall tube

sampler. Install the proper cutting tip.

6. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring as the vibrations may cause the boring walls to collapse.

7. Remove the tube sampler, and unscrew the drill rods.

8. Remove the cutting tip and the core from the device.

9. Discard the top of the core (approximately 1 inch), as this possibly represents borehole debris material collected before penetration of the layer of concern. Place the remaining core into the appropriate labeled sample container. Sample homogenization is not required.

10. If volatile organic analysis is to be performed, transfer the sample into an appropriate, labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

11. If another sample is to be collected in the same hole, but at a greater depth, reattach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

12. Abandon the hole according to applicable State regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

11.2.3 Sampling at Depth with a Trier

The system consists of a trier, and a "T" handle. The auger is driven into the soil to be sampled and used to extract a core sample from the appropriate depth. The following procedure will be used to collect soil samples with a sampling trier:

1. Insert the trier (Figure 2, Appendix B) into the material to be sampled at a 0 to 45 angle from horizontal. This orientation minimizes the spillage of sample.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. If volatile organic analysis is to be performed, transfer the sample into an appropriate,

labeled sample container with a stainless steel lab spoon, or equivalent and secure the cap tightly. Place the remainder of the sample into a stainless steel, plastic, or other appropriate homogenization container, and mix thoroughly to obtain a homogenous sample representative of the entire sampling interval. Then, either place the sample into appropriate, labeled containers and secure the caps tightly; or, if composite samples are to be collected, place a sample from another sampling interval into the homogenization container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.

11.2.4 Sampling at Depth with a Split Spoon (Barrel) Sampler

The procedure for split spoon sampling describes the collection and extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted.

When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved 1974). The following procedures will be used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a well ring, drive the tube. Do not drive past the bottom of the head piece (past the full length of the sample barrel) or compression of the sample will result.

4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.

5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 2 and 3 1/2 inch diameters. However, in order to obtain the required sample volume, use of a larger barrel may be required.

6. Without disturbing the core, transfer it to appropriate labeled sample container(s) and seal tightly.

11.3 Sample Sieving

Analytical methods may require that a sample be separated by particle size. A sieve is the most effective method of separating coarse and fine material from a soil sample. Sieving and random sampling is also an effective method for soil sample homogenization (Schumacher et al, 1990). The site-specific SAP should be consulted when deciding what particle size of a soil sample should be submitted for analysis. Note that saturated soil samples should not be sieved. Those samples must first be dried before processing. Sieving procedures:

- Place sample in appropriate sized sieve (dry samples are optimal; wet samples will stick to the grid of a sieve).
- Use a catch pan that is of a material that won’t compromise the integrity of the sample.
- Place lid on the sieve and shake vigorously to separate particle sizes.
- Transfer desired sample fraction to labeled container.
- Decontaminate thoroughly with brushes and/or compressed air before use on next sample.

12.0 DATA RECORDS AND MANAGEMENT

Once collected, samples are preserved, labeled, and stored for transport. A COC must accompany all samples during transport and transfer between entities. Sample labels should contain the following information:

- Site Identification
- Date sampled
- Sampler initials
- Time
- Analysis to be performed

In addition, soil characteristics may need to be documented when sampling. Below is a standardized list of soil characteristics and their corresponding Unified Soil Classification System identifiers.

- GW – well-graded gravels, gravel and sand mixtures, little or no fines
- GP – poorly graded gravels, gravel and sand mixtures, little or no fines
- GM – silty gravels, gravel, sand, silt mixtures
- GC – clayey gravels, gravel, sand, clay mixtures
- SW – well-graded sands, little or no fines
- SP – poorly-graded sands, little or no fines
- SM – silty sands, sand-silt mixtures
- SC – clayey sands, sand-clay mixtures
- ML – inorganic silts and very fine sands
- CL – inorganic clays of low to medium plasticity
- OL – organic silts and organic silty clays
- MH – inorganic silts, micaceous or diatomaceous fine sandy or silty soils
- CH – inorganic clays of high plasticity
- OH - organic clays of medium to high plasticity, organic silts
- Pt – highly organic soils

13.0 QUALITY CONTROL AND ASSURANCE

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. An instruction manual for the operation of the hand auger equipment is provided in Appendix C of this SOP. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.
3. Always consult the SAP for duplicate sample frequency requirements.
4. Document any deviations from SOP’s, work plan, SAP/QAPP, etc.

14.0 REFERENCES

EPA Guidance for Preparing Standard Operating Procedures, EPA QA/G-6, April 2007.

Mason, B.J., Preparation of Soil Sampling Protocol: Technique and Strategies. 1983 EPA-600/4-83-020.

Barth, D.S. and B.J. Mason, Soil Sampling Quality Assurance User's Guide. 1984 EPA-600/4-84-043.

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EPA SOP FLD#-10 Pore Water Sampling

Pore Water Sampling

APPROVED:

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6/6/12
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TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures, methods, and considerations to be used when obtaining a pore water sample using PushPoint® samplers.

2.0 SCOPE AND APPLICABILITY

This document describes procedures for pore water sampling using PushPoint® samplers and is based on the Operators Manual and Applications Guide provided by MHE Products (Ver. 2.01,2/15). It is intended to be used by field personnel when collecting and handling samples in the field. All deviations from this SOP must be noted in the site-dedicated field logbook.

3.0 SUMMARY OF METHOD

Sediment pore water is collected using a pore water extractor, called a PushPoint® (Figure 1) which is made out of stainless steel tubing developed by MHE Products. The sampling end of the PushPoint® is inserted into the sediment to the desired depth, and pore water is extracted using a syringe or peristaltic pump.

4.0 ACRONYMS AND DEFINITIONS

COC	Chain of Custody
DOC	Dissolved Organic Compounds
DOT	United States Department of Transportation
DQO	Data Quality Objective
EPA	United States Environmental Protection Agency
ESAT	Environmental Services Assistance Team
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IATA	International Air Transportation Association
OSHA	Occupational Safety and Health Administration
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SVOC	Semi-Volatile Organic Compound
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

Health and Safety Plan (HASP): A site-specific document outlining potential safety hazards and hazard mitigation techniques.

Occupational Safety and Health Administration (OSHA): An agency that regulates health and safety standards in the United States.

Standard Operating Procedure (SOP): A set of written instructions that document a routine or repetitive activity followed by an organization (EPA, 2007).

5.0 HEALTH AND SAFETY

Proper safety precautions must be observed when collecting pore water samples. Refer to Environmental Services Assistance Team (ESAT) site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When following this SOP, minimize exposure to potential health hazards in the field by using personal protective equipment (protective clothing, eye wear and gloves). Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

6.0 SAMPLE MANAGEMENT

The following precautions should be considered when collecting pore-water samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.

- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party (see SOP FLD-11.00, or current version, “Sample Custody and Labeling”).

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.

- Shipped samples must conform to all United States Department of Transportation (DOT) and/or International Air Transportation Association (IATA) hazardous materials shipping requirements.

- Documentation of field sampling is done in a bound logbook.

- Chain of custody (COC) documents must be filled out and remain with the samples until custody is relinquished until analysis is complete (or samples are disposed).

- All shipping documents, such as bills of lading, etc., shall be retained by the project leader and stored in a secure place.

7.0 INTERFERENCES

The following sections describe potential interferences when sampling for trace level contaminants. For decontamination procedures, see the Sampling Equipment Decontamination SOP FLD 02.00.

7.1 Potential Volatile Organic Analysis (VOA) Sampling Interferences

Pore water samples for volatile organic compound (VOC) and semi-volatile organic compounds (SVOC) analysis must be collected in 40-ml amber glass vials with Teflon® septa. The vials may be preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two week holding time, whereas, unpreserved samples have only a seven day holding time. Normally, either preserved or unpreserved vials can be used, but there are instances where the use of unpreserved vials is preferred. For example, if the surface water sample contains a high concentration of dissolved calcium carbonate, there may be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

Samples for VOC and SVOC analysis must be collected using either stainless steel or Teflon® equipment. Samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial, and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be refilled. Care should be taken not to flush any preservative out of the vial during topping off. If bubbles are still present after attempting to refill and cap the vial, a new vial should be obtained and the sample re-collected.

7.2 Potential Dissolved Metals or Dissolved Organic Compound Sampling Interferences

If a dissolved metals or Dissolved Organic Compounds (DOC) pore water sample is to be collected, in-line filtration or post-collection filtrations are acceptable approaches. The in-line filter apparatus uses disposable, high capacity filter cartridges (barrel-type) or membrane to filter the sample. The high capacity, barrel-type filter works well due to the higher surface area associated with this configuration. Post-collection filtration involves two approaches. The first approach is to take the sample water and filter it through a .45 micron filter apparatus. The second approach involves the use of a syringe with a .45 micron acrodisc filter attached to end of syringe.

Potential differences could result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations, including filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency of sample technique and filter characteristics is critical in the comparison of short-term and long-term results.

7.3 Special Precautions for Trace Contaminant Pore Water Sampling

1. A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled, and the gloves should be donned prior to handling sampling equipment and sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.

2. Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately from samples suspected of only having trace levels of contaminants.

3. All background or control samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.

4. Samplers must use new, verified, certified clean disposable equipment, or pre-cleaned non-disposable equipment.

8.0 PERSONNEL QUALIFICATIONS

Any personnel involved with field sampling activities must be cleared for health and safety. Clearance includes medical monitoring, respirator fit testing, and Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) 40-hour training. Personnel who will be collecting pore water samples must be familiar with this SOP and any other relevant SOPs, including the Sample Equipment Decontamination SOP FLD 02.00, Sample Preservation SOP FLD 03.00, Water Quality Measurements with the In-Situ® Multi-Parameter Meter SOP FLD 09.00, Sample and Labeling SOP FLD 11.00, and General Field Sampling Protocols SOP FLD 12.00.

9.0 EQUIPMENT AND SUPPLIES

The PushPoint® sampler consists of a tubular 3/16 stainless steel body with a screened zone at one end and a sampling port at the other. It comes with a guard rod that is nested in the tube during deployment in order to provide structural support and to prevent plugging and deformation of the screened zone (Figure 1). The screened zone consists of a series of interlaced machined slots that form a short screened zone with approximately 20% open area. Additional filters can be placed over the screened zone if additional screening is needed. Pore water is collected through the opposite end of the PushPoint® sampler through peristaltic flexible tubing using a syringe through the sampling port. Tygon® tubing is the preferred tubing to be used with PushPoint® samplers. However, other tubing can be used, if allowed by data quality objectives (DQOs) for the specific application. PushPoint® samplers can be custom made to any width or length.

There are many modifications that can be incorporated into the procedure to satisfy DQOs for a specific application. The procedures discussed in the following sections provide guidance on the basic operation of the PushPoint® and issues to consider when deploying the PushPoint® sampler to collect pore water.

Other equipment used in the process of pore water sample collection includes syringes, flanges, tubing, sample bottles or containers, and filters.

10.0 STANDARDS AND REAGENTS

Reagents will be used for preserving samples and for decontaminating sampling equipment (refer to the Sampling Equipment Decontamination SOP FLD 02.00 and Sample Preservation SOP FLD 03.00). The preservatives required are determined by the analysis to be performed and will be specified in the Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP), but usually include nitric acid (total recoverable and dissolved metals samples), hydrochloric acid (VOC samples), and phosphoric acid (DOC samples). The sampler should also be aware of any special sampling considerations, contamination issues, and sample compositing and mixing methods that could affect their sampling efforts. Appropriate regional guidance and procedures should be consulted for detailed sample collection, preservation, handling and storing, equipment decontamination, and quality assurance/quality control (QA/QC) procedures. The sampler should preserve and immediately cool all water samples to 4°C (±2°C) upon collection and samples should remain cooled until the time of analysis (do not freeze water samples).

11.0 PROCEDURES

It is critical in the collection of pore water to avoid surface water intrusion. Water will flow in a path of least resistance. If space is created around the sides of the PushPoint® sampler during deployment, surface water may flow down the outside of the tube to the screened area and into the intended sample. Therefore, the PushPoint® can be used with a sampling platform or flange (Figure 2), especially when collecting pore water near the sediment-surface water interface. However, if pore water is collected from deep in the sediments or in cobble-bottom streams, a flange may not be necessary. Additionally, it is important to note that a platform is only useful in specific situations when you are sampling multiple holes and specific depths and when sampling at shallow depths where the integrity of the hole may be a concern. It is critically important to collect samples from the hyporheic zone, or the area beneath the streambed where shallow groundwater is mixed with surface water (this area is critical to benthic macro-invertebrates and fish spawning activity). When inserted though the sampling platform, or flange, the flange should fit securely around the PushPoint® to eliminate surface water intrusion from around the PushPoint® body during sample collection.

The flange can be made of any material that will not cross contaminate the intended sample. If full scan analytical analysis is required, the flange should be made of inert material such as stainless steel or Teflon®. The size of the flange depends on the volume of pore water to be collected. If large volumes of pore water are to be collected, use a large flange size. If it is not practical to use a large flange, then multiple PushPoints® with smaller flanges can be deployed and smaller volumes can be collected from several PushPoints® for a composite sample. If multiple PushPoints® are deployed, they should be spaced at least 30 cm apart.

11.1 PushPoint® Sampler Basic Operation

The PushPoint® sampler should be inserted into the sediment as carefully as possible (Figure 2). When deploying the PushPoint®, care must be taken not to disturb the sampling area. If the sampler is wading in the water body, the sampler should lean out and insert the PushPoint® as far as possible away from where he/she is standing in order to reduce potential effects of the sampler on the integrity of the pore water sample. Depth of penetration of the PushPoint® into the sediment depends on the objectives of the specific investigation. Once depth is established for sample collection, be sure to measure and record the sampling depth in the logbook.

After the PushPoint® has been deployed, carefully remove the guard rod and attach the sample tubing (Figure 3). The other end of the sample tubing can be connected to the sample withdrawing device, such as a peristaltic pump or syringe (Figure 4). Before collecting a pore water sample, be sure to purge out all air and surface water from the PushPoint® sampler and sample tubing with the appropriate amount of pore water. At least three volumes of pore water (until water is clear) should be purged before sample collection.

11.2 Peristaltic Pump/Vacuum Jug Collection

The peristaltic pump/vacuum jug can be used for sample collection because it allows for sample collection without the sample coming in contact with the pump head tubing. This is accomplished by placing a Teflon® transfer cap assembly onto the neck of a clean standard 1-liter amber glass container. Teflon® tubing (3-inch outside diameter) connects the container to both the pump and the sample source. The pump creates a vacuum in the container, thereby drawing the sample into the container without it coming into contact with the pump head tubing.

Because the sample is exposed to a vacuum and is agitated as it enters the vacuum jug, this method cannot be used for collection of VOC samples. An alternative method for collecting VOC samples involves filling the Teflon® tubing with sample by running the pump for a short period of time. Once the tubing is full of water, the tubing is removed from the PushPoint® and, after the tubing is disconnected from the pump head tubing, the water is allowed to drain, by gravity, into the sample vials. Alternatively, without disconnecting the tubing from the pump head, the contained sample can be pushed out of the tubing and into the sample vials by reversing the peristaltic pump at low speed.

For samples that are collected for metals analyses, or other analysis not affected by the silastic tubing, it is permissible to collect the sample directly from the discharge of the pump head tubing after an adequate purge has been completed. When collecting samples in this manner, there are several considerations to be aware of. The pump head tubing (silastic, etc.) must be changed after each sample and a rinsate blank must be collected from a representative piece of the pump head tubing (only one blank per investigation). Also, precautions must be taken to ensure that the end of the discharge tubing is not allowed to touch the ground, or other surface, in order to maintain the integrity of the sample when it is collected in this manner.

11.3 Syringe

Syringes, in conjunction with PushPoint® samplers, can be used to collect pore water samples if the integrity of the sample analysis will not be compromised. The tubing from the sampling port of the PushPoint® can be directly attached to a syringe and a pore water sample can be manually withdrawn from the sediment. The syringe can be used as the final sample container or the pore water can be transferred to another container, depending on project objectives and analytical requirements.

11.4 Sample Handling and Preservation Requirements

1. Pore water will typically be collected from sediments using a PushPoint® and placed directly into the sampling containers. A syringe may then be used to transfer the sample from the sampling container into the appropriate container.

2. When transferring the pore water sample from a collection device, make sure that the device does not come in contact with the final sample containers. The syringe used in the sample transfer is the only piece of equipment that should be in contact with the transfer vessel and the final sample container.

3. Place the sample into the appropriate labeled container. Samples collected for VOC

analysis must not have any headspace (see Section 7.1). All other sample containers must be filled with an allowance for ullage.

4. All samples requiring preservation must be preserved as soon as practically possible after sample collection. If preserved VOA vials are used, these will be preserved with concentrated hydrochloric acid prior to departure for the field investigation. All other chemical preservatives required for the remaining suite of analytes will be specified in the site-specific SAP. The adequacy of sample preservation will be checked after the addition of the preservative for all samples, except for the samples collected for VOC analysis. If it is determined that a sample is not acceptably preserved, additional preservative should be added to achieve adequate preservation. Preservation requirements for surface water samples will be specified in the site-specific SAP/QAPP and the Sample Preservation SOP FLD 03.00.

12.0 DATA RECORDS AND MANAGEMENT

Once collected, samples are preserved, labeled, and stored for transport. A chain of custody form must accompany all samples during transport and transfer between entities. Sample labels should contain the following information:

- Site identification
- Date sampled
- Location identification
- Sampler initials
- Time
- Analysis to be performed
- Preservative

Any other pertinent data should be recorded in the site dedicated field logbook.

13.0 QUALITY CONTROL AND ASSURANCE

The following general QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.

2. In general, concurrent (duplicate) sample collection at a frequency of 10% is required for most sampling activities. Field blanks at a frequency of one per day are also generally required. Consult the corresponding SAP/QAPP for specific QA/QC sampling frequency. Below is a list of usual pore water QA/QC sample types and the inaccuracy they are intended to detect:

   - Duplicate sample – two samples collected at the same location at the same time, intended to detect variability inherent in collection, processing, and handling procedures
   - Field blank – checks cross-contamination during sample collection, preservation, and shipment as well as in the laboratory.
   - Rinsate blank – detects equipment contamination due to inadequate decontamination

procedures

3. All instrumentation should be operated in accordance with operating instructions as supplied by the manufacturer unless otherwise specified in the work plan or SAP/QAPP. Equipment calibration activities should be conducted and documented prior to sampling and/or operation of equipment.
4. Document any deviations from SOPs, work plan, SAP/QAPP, etc.

14.0 REFERENCES

EPA Guidance for Preparing Standard Operating Procedures, EPA QA/G-6, April 2007.

MHE Products, PushPoint® Sampler (US Pat. # 6,470,967), Operators Manual and Applications Guide, Ver. 2.01, 2/15.

15.0 FIGURES

Figures 1-4 show equipment operation and basic sampling techniques.

Figure 1 - Pore Water PushPoint®

Figure 1. Pore Water PushPoint

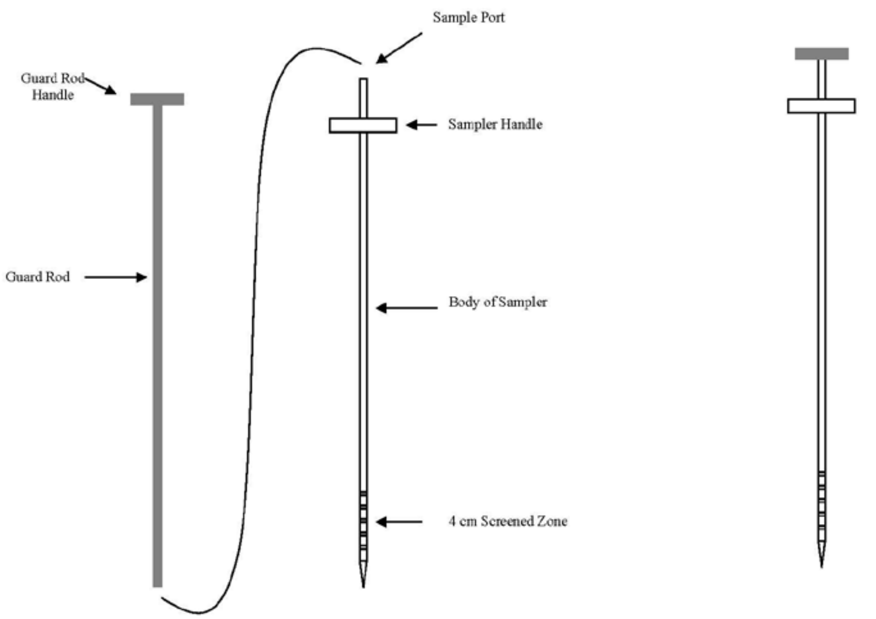


Figure 1A. Disassembled PushPoint

Figure 1B. Assembled PushPoint

Actual length and width of PushPoints will vary, depending on sampling needs and site conditions.

Figure 2 - PushPoint® deployed with a Sampling Platform

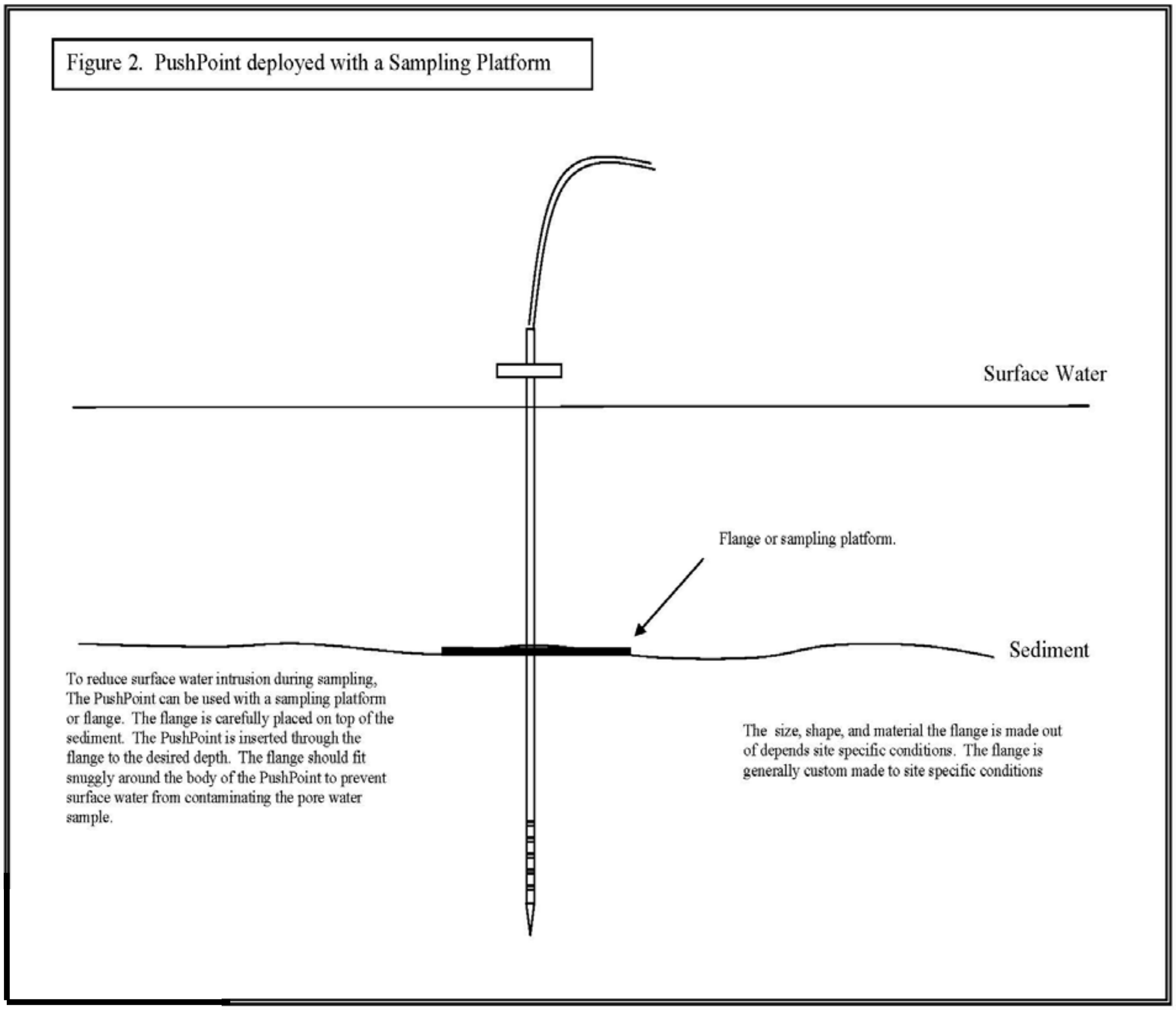


Figure 2. PushPoint deployed with a Sampling Platform

To reduce surface water intrusion during sampling, The PushPoint can be used with a sampling platform or flange. The flange is carefully placed on top of the sediment. The PushPoint is inserted through the flange to the desired depth. The flange should fit snuggly around the body of the PushPoint to prevent surface water from contaminating the pore water sample.

The size, shape, and material the flange is made out of depends site specific conditions. The flange is generally custom made to site specific conditions

Figure 3 - PushPoint® Being Deployed into the Sediment

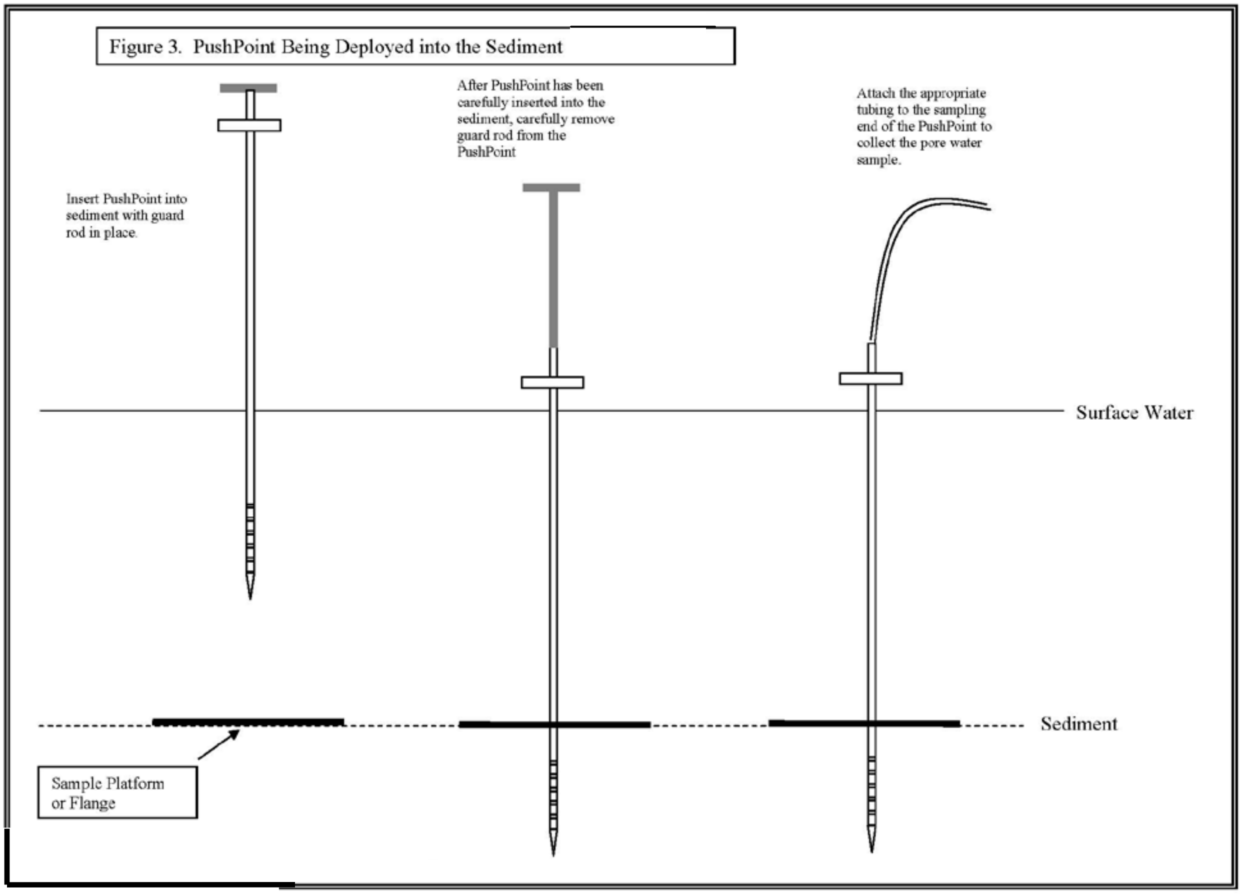
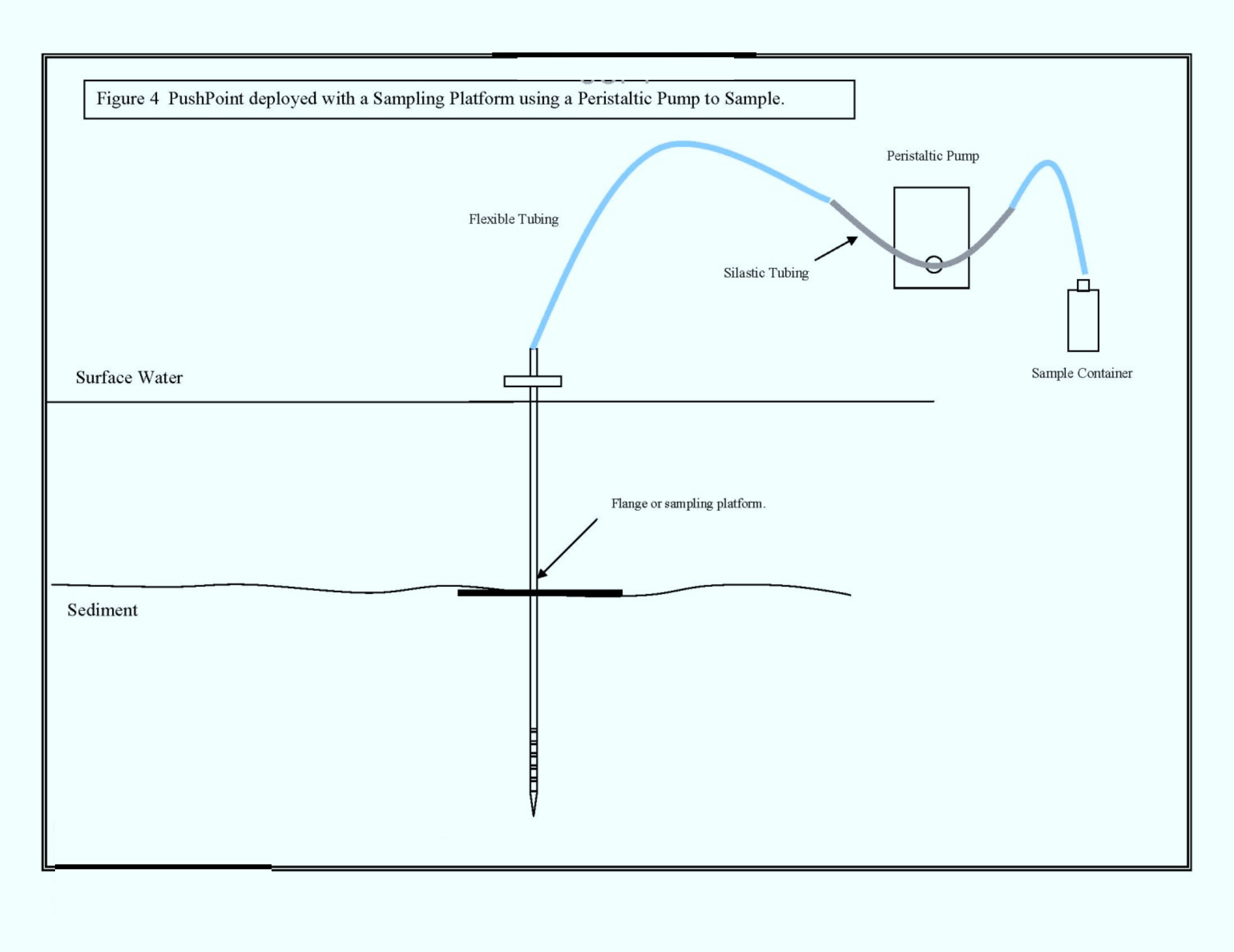


Figure 4 - PushPoint® deployed with a Sampling Platform using a Peristaltic Pump to Sample



ATTACHMENT A-2

ACZ QUALITY MANAGEMENT PLAN

ACZ Laboratories, Inc.

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Quality Assurance Plan v.23

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Table of Contents

1 INTRODUCTION

ACZ Laboratories, Inc. is an environmental testing laboratory that provides data to clients primarily for regulatory purposes. Samples are analyzed for compliance with federal programs including the Resource Conservation Recovery Act (RCRA), Safe Drinking Water Act (SDWA), and Clean Water Act (CWA). Environmental compliance and management decisions are based on the analytical data provided, which are critical to the expenditure of large amounts of money; are important to public health safety; are important in evaluating, monitoring, and protecting the environment; and may be essential in litigation. ACZ's data must be of known and documented quality to support sound decisions and withstand adversarial inquiry.

An effective Quality Management System is the cornerstone of the generation of reliable analytical data. ACZ's Quality Assurance Plan (QAP) outlines the quality assurance and quality control objectives, policies, and procedures determined to be necessary to meet the requirements of the EPA, federal government entities, state agencies, other regulatory authorities, and our clients. This document provides the framework to ensure all ACZ employees have sufficient knowledge and training to perform their job responsibilities in a manner that assures all data reported to ACZ's clients is accurate, reliable, technically sound, legally defensible, and impartial.

For data to be useful, it must be of known and documented quality. The word "quality" has many different meanings, but for the purposes of environmental testing activities can be stated simply as "conformance to requirements." Conforming to requirements allows objective measurements to be applied, rather than subjective opinions, to determine when work is of good quality. *Quality control* refers to all activities that measure conformance (i.e. good quality) of the data. It requires action(s) to be taken and is typically included as part of the procedure. *Quality assurance* provides the records of the results obtained from the required action(s) and refers to the ability of the laboratory to demonstrate or prove to an outside party that the quality of the data is what the laboratory states it is. Quality assurance relies heavily on documentation, and to be effective, the documentation must: (1) assure the quality control procedures are being implemented as required; (2) assure the reported data reflect the sample as it was received, meaning sample mix-up was avoided, the sample was properly preserved prior to analysis, etc.; (3) facilitate traceability of an analytical result; and (4) be subjected to reasonable precautions to protect data from loss, damage, theft, and internal or external tampering.

Quality Policy Statement: To maintain an effective QA program, continually improve the quality of our environmental testing services, and consistently provide clients with technically sound and legally defensible data in a timely manner, the management of ACZ recognizes the importance of its commitment to:

- Ensuring good professional practice by well-trained and qualified employees with the necessary experience and skills to carry out their organizational functions and to meet or exceed ACZ's standards for the quality and reliability of its testing services.

- Ensuring the data provided to our clients is of known and documented quality, and is accurate and impartial.

- Ensuring that all quality assurance and quality control policies and procedures are communicated to and understood by all employees, and that they are implemented by all employees in their work.

- Ensuring that all aspects of the business operations are conducted in a manner that adheres to the TNI Standards and all of ACZ's policies and procedures documented in the QAP, SOPs, emails, memos, etc.

- Upholding the spirit and intent of ACZ's Data Integrity Program and implementing the requirements of the program.

2 QUALITY SYSTEM OBJECTIVES & COMPONENTS

ACZ's QAP provides a framework that guides all technical staff and administrative personnel. The information presented is necessary to ensure all employees perform their duties in a manner that allows the company to achieve its objectives, thereby ensuring the precision, accuracy, completeness, and consistency of the analytical data reported to our clients. This framework is referred to as the Quality System. The Quality System encompasses every documented quality assurance (QA) and quality control (QC) policy and procedure and guides all business functions and laboratory operations by specifying standardized protocols to control both the short-term and long-term activities that influence the quality and defensibility of our testing services.

The Quality System is designed to be appropriate to the type, range, and volume of the environmental testing undertaken. The Quality System is not a static entity and must function in a manner that allows for continuous evolution of all aspects of ACZ's business when improvements have been identified and have been determined to be necessary or beneficial. ACZ management recognizes that the staff is comprised of people who possess varied experience and knowledge and can contribute valuable insight and suggestions regarding these improvements. All employees are encouraged to be involved in this process. The following six (6) key elements form the foundation of ACZ's Quality System:

- Documents & Records
- SOPs
- Training
- Audits
- Corrective Actions
- Management Review of the Quality System

2.1 Documents & Records

The entire history of any sample must be readily understood through the associated documentation. To this extent, a formal and systematic control of documents and records is necessary for accurately reconstructing all events pertaining to any sample and for guaranteeing the quality and defensibility of the data. All information relating to the laboratory facility's equipment, analytical test methods, and related laboratory activities (such as sample receipt, sample preparation, data verification and data reporting) must be documented, and all records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained. Documents and records must be safely stored (protected against fire, theft, loss, deterioration, and vermin), and must be held secure and in confidence to the client for a minimum of 10 years. Refer to §10 for details regarding the storage and control of ACZ's documents and records.

2.1.1 Documents

All official documents are reviewed for accuracy, approved for release by authorized personnel, and distributed through ACZ's LabWeb intranet. LabWeb is a computerized document control system based in HTML that can be accessed from any network computer within the facility. For printed documents to be considered controlled, the header must be in sync with the header on LabWeb. Obsolete or invalid SOPs retained for knowledge preservation or other reasons must be clearly marked to identify their purpose.

All documents are categorized by department and are assigned a unique document ID that is displayed in either the header or footer section. The ID nomenclature starts with either SOP (procedure) or FRM (form), followed by the 2-letter department code, the unique document number, the month and year of issue, and the revision. The effective date for any SOP or other document is included on the title page and header section of each subsequent page and indicates the implementation date.

The QA Officer has full responsibility of the Document Control System. Only employees with the appropriate computer access (IT and QA staff) can upload documents to LabWeb. A new or revised document is reviewed, and following approval, the document control number is updated and the SOP or form is uploaded to Labweb. When a new version of an SOP is added to Labweb, the previous version is removed from the active list, date-stamped and electronically archived in a designated location on the network. This automatic process guarantees that ACZ can retrieve the version that was in effect at any given time.

2.1.2 Records

A record is any information or data on a particular subject that is collected and preserved. Records are produced on a daily basis and contain original, factual information from an activity or study. For ACZ's purpose, this information may be recorded by the following means: LIMS database, logbooks, raw instrument data, worksheets, and notes (or exact copies thereof) that are necessary for the reconstruction and evaluation of the report of the activity or study. The record management system provides control of records for data reduction, validation, reporting and storage, and also provides control of all laboratory notebooks and logbooks. The system must allow for historical reconstruction of all laboratory activities that produced analytical data, must document the identity of personnel involved in sample receipt, preparation, calibration, and testing; and must facilitate the retrieval of all working files and archived records for inspection and verification purposes. At a minimum, the following criteria for records must be met:

1) Instrument logbooks must be kept up-to-date on a daily basis. Document all relevant activities when the event occurs or as soon as practical thereafter.

2) Dilution factors and observations must be recorded at the time they are made, and notes regarding samples or analyses must be identifiable to the specific task.

3) A detailed description of any departure from a documented procedure, and the reason for the departure, must be provided at the time it is performed.

4) All generated data must be recorded either by an automated data collection system or must be recorded directly, promptly and legibly in permanent ink (blue or black is preferred).

5) Erroneous entries (hard copy or electronic) cannot be destroyed by methods such as erasures, overwritten files or markings. Refer to §16 for ACZ's error correction protocol.

6) Any changes to hard copy records must be clearly initialed and dated by the responsible staff. Changes to electronic records must also be traceable to the individual who made the change, and the reason for the change must be provided.

7) Records generated by computers must have hard copy or write-protected backup copies.

2.2 Standard Operating Procedures

A documented procedure is required for all phases of ACZ's business operations, from sample log-in through sample disposal. A Standard Operating Procedure (SOP) is a written document that details the manner in which an operation, analysis, or action is performed and thoroughly prescribes the techniques and procedures, which are the accepted process for performing certain routine or repetitive tasks. Analytical SOPs must be written with adequate detail to allow someone similarly qualified, other than the analysts who routinely performs the procedure, to reproduce the procedure used to generate the test result. To the extent possible, administrative SOPs [non-technical] must include specific requirements pertaining to the process; however, the procedure itself may be a more general description so as to lend a degree of necessary flexibility to account for client requests and other circumstances which may be outside of ACZ's control.

Proposed revisions to any test SOP shall be submitted by the pertinent department supervisor (exceptions may be granted on a case by case basis) and be reviewed and approved by QA prior to implementation. Changes to provide additional clarification, correct typographical errors, etc. do not require formal approval and/or training. Analytical SOPs must be reviewed annually using the SOP Review Form (FRMQA035), and Administrative SOPs must be reviewed regularly and revised if necessary to ensure the information is accurate and reflects current practice. Documenting changes in the controlled copy of any SOP is prohibited. Refer to §10.5.1 for additional information on SOPs.

SOPs are proprietary documents and ACZ does not distribute them freely. Any copy sent electronically or otherwise to an outside party is considered uncontrolled, and the recipient understands that additional changes can be made without prior notification. Excluding method development, the use of uncontrolled copies of SOPs is not permitted.

Unless the reference method is followed exactly and contains sufficient detail to ensure consistent application, an SOP must be developed before a new procedure, application, or instrument can be implemented. The introduction of a new method must be a planned activity directed by the Production Manager, assigned to the appropriate technical director(s), and overseen by QA staff. Exceptions may be made when the client provides specific procedural instructions. In this event, the client's instructions must be followed exactly and appended to ACZ's test report package. Exceptions are primarily related to the preparation of solid materials for analytical testing (refer to SOPAD043 for additional details). An SOP template (SOPAD025) may be obtained from QA. If a client requests a procedure for which there is no published method or existing SOP, ACZ will utilize the process described in the SOP *Client Service Policies and Procedures* (SOPAD043). Analytical SOPs are written in accordance with the TNI Standards and must include or reference the following items, where applicable:

1) identification of the test method
2) summary, scope & application of the test method, including matrices & parameters to be analyzed
3) references, including documents provided by instrument / equipment manufacturer
4) sample collection, preservation, & storage
5) equipment & supplies
6) reagents & standards, including storage conditions & shelf-life for each
7) safety
8) interferences
9) complete procedure, including details and acceptance criteria for initial & continuing calibration
10) data review & assessment, including protocols for handling out-of-control or unacceptable data
11) quality control, including acceptance criteria & corrective action for handling failed quality control
12) calculation equations (dilution factors, RPD, % recovery, etc.) & calibration formulas
13) method detection limit & quantitation limit
14) method performance, including Demonstration of Capability and Method Detection Limit procedures
15) pollution prevention & waste management
16) definitions
17) tables, diagrams, flowcharts

2.3 Training

It is the responsibility of ACZ's management to ensure the competence of all employees who perform environmental tests and other specific duties, operate equipment or instrumentation, give opinions and interpretations, evaluate results, and sign test reports. Additionally, ACZ management is responsible for formulating the goals and policies with respect to the necessary education, training, and skills of all personnel and for providing training that is relevant to the company's present and anticipated tasks.

Employees must possess the appropriate combination of education, experience, and skills to adequately demonstrate a specific knowledge of their particular functions and to carry out those functions in a manner that meets ACZ's standards and expectations. Additionally, each staff member must demonstrate an understanding of laboratory operations, test methods, related quality assurance and quality control procedures, and management of records and documents to the extent necessary to successfully perform their job duties.

All full-time and part-time personnel must complete a formal training process for Safety, Ethics, Quality Assurance / Quality Control, Quarantined Materials, and Sexual Harassment on the first day of hire and are subsequently responsible for complying with all requirements that pertain to their job duties. For all technical staff, training for analytical procedures must be completed prior to independent generation of client data. In general, any staff member who is undergoing training must be provided with appropriate supervision. It is the responsibility of each supervisor or manager to ensure personnel within his or her department are supervised, competent, and working in accordance with ACZ's Quality System.

2.3.1 Safety Training

Safety training is scheduled with ACZ's Chemical Hygiene Officer (CHO) and includes viewing a video of general laboratory safety, a complete review of ACZ's Chemical Hygiene Plan, and a building tour to identify the location of Safety Data Sheets, emergency showers, eye wash stations, and emergency exits. Following completion of the training, the employee takes an exam, which allows the CHO to evaluate their understanding of the material covered.

2.3.2 Data Integrity Training

ACZ is committed to fostering and enforcing an ethically sound work environment that encourages the conscientious production of accurate, technically sound, and legally defensible data. Data integrity training is required for all full-time and part-time employees (permanent or temporary) as described in ACZ's SOP *Data Integrity Principles & Policies* (SOPAD039). Initial training provides an orientation of ACZ's Ethics program, ACZ's Code of Conduct, Code of Ethics, and zero-tolerance policy. Each new employee is introduced to the company's Ombudsman. Data integrity training is provided for all current employees on an annual basis. At a minimum, employees must review ACZ's Data Integrity Principles & Policies (SOPAD039) and provide documented testimony indicating they have read, understood, & agree to adhere to them.

2.3.3 QA Training

All full-time and part-time employees attend an initial orientation session which is based on the most current version of ACZ's Quality Assurance Plan [QAP] and focuses on the relationship between quality control, quality assurance, environmental testing, and environmental monitoring.

2.3.4 Sexual Harassment Training

Sexual Harassment training is required for each new employee and includes viewing a video that demonstrates the identification, reporting, and remediation of harassment issues in the work place. Any complaints of sexual harassment must be brought to the attention of ACZ's EVPs as soon as possible.

2.3.5 Technical personnel must be thoroughly trained in the analytical techniques and operating principles for all pertinent method procedures. Under no circumstances may any analyst independently generate or review client data for a test procedure before completing the required training and receiving the explicit approval of the technical director overseeing the analysis. §5 provides details of ACZ's technical training program.

2.3.6 Employees may be authorized to perform AREV or SREV for a procedure by the pertinent department supervisor or the QAO. Authorization indicates the employee has been trained on applicable QC requirements, corrective actions, and data qualification. AREV & SREV shall be performed in accordance with effective version of the associated test SOP. Authorization is tracked in an excel spreadsheet located on a network drive. Computer permissions are configured so that all employees may view the spreadsheet but only QA staff may edit it.

2.3.7 Training is required for all employees whose activities are affected by any procedural change(s) to an SOP and is considered to be complete once each employee has submitted documentation attesting they have read, understand, and agree to follow the revised policy.

2.3.8 ACZ recognizes the benefit of continuing education and encourages employee participation in advanced training courses, seminars, and professional organizations and meetings.

2.4 Audits

The purpose of an audit is to verify conformance to documented Quality Assurance and Quality Control policies and procedures, and to identify discrepancies when they exist. In the latter case, any problems shall be addressed and resolved in an appropriate manner to assure the Quality System is continuously improved on all levels.

2.4.1 External Audits

External audits are conducted to ascertain compliance with rules, regulations, and additional criteria for certification, and will have a higher degree of formality than internal audits. Where records are required, compliance will be critically evaluated. Issues of non-compliance identified in previous audits are usually reviewed to verify the laboratory has remediated them effectively. The ease with which important records and information can be retrieved is a criterion for judgment of the management practices of a laboratory and may dictate the depth of the audit. Individual state agencies, laboratory Accrediting Bodies, and current and potential clients routinely audit ACZ.

The on-site assessment is generally a two to four day process during which the regulating agency conducts an entrance interview and tours the facility before performing an in-depth review of documents, workgroups, reports, electronic data files, etc. A critical aspect of the on-site assessment is review and verification of bench-level documentation and analyst interviews to determine actual laboratory practices. ACZ's policy is to always have QA personnel present during an interview. If necessary, the EVP, may attend the interview. An exit interview is conducted upon completion of all on-site assessments, during which observations and findings are reviewed. The agency will submit a final report to ACZ, generally within 30 days, detailing all pertinent findings and recommendations.

Upon receipt and review of the agency's report, the QA department will meet with department managers to develop a corrective action plan, which must be submitted to the agency by the date indicated in their report. Each finding or group of similar findings is addressed as a major corrective action as described in §2.5.2. Employees shall not make changes to any laboratory or other practice based on comments or opinions expressed by the regulating agency during an interview or any other stage of the on-site assessment without first obtaining approval from QA. ACZ will revise policies and procedures as necessary as part of the major corrective action process.

2.4.2 Internal Audits

ACZ is responsible for the quality of its data and must take reasonable efforts to assure itself and all interested parties confidence can be placed in it. ACZ shall conduct internal audits of its activities to verify compliance with the Quality System. It is the responsibility of the QA Officer (QAO) to plan, direct, and organize internal audits; however, a trained and qualified individual, independent from the area or system being audited, may be designated by the QAO to conduct an internal audit. The area of activity audited, the audit findings, and subsequent corrective actions shall be documented.

The internal audit program shall address all elements of the management system. At least one test method shall be audited annually for each analytical laboratory division. Method audits encompass both qualitative evaluation of the operational details of the QA program and quantitative evaluation of the accuracy of data generated by the laboratory staff. Test method audits include step by step witnessing of the procedure. Laboratory Divisions:

- Wet Chemistry (Prep and Analytical)
- Metals (Instrument & Prep)
- Soils
- Radiochemistry (Prep and Analytical)
- Organics (Prep and Analytical)

When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of the laboratory's test or calibration results, the laboratory shall take timely corrective action, and shall notify
customers in writing if investigations show that the laboratory results may have been meaningfully affected. Client contact should be initiated within two months of discovering the error(s). If data impact assessment cannot be completed in this timeframe management shall set a deadline commensurate to the demands of the assessment.

More frequent internal audits may be scheduled depending on the following criteria:

- Number and type of corrective actions filed for a method or activity
- Client complaints
- Continued failure to achieve acceptable results for a Proficiency Testing sample
- Findings from an external audit
- Request from management

All findings from internal audits are directed through ACZ's corrective action system. Each finding is assigned a corrective action number (similar findings may be combined). A general description of the process is as follows:

1) Findings and observations are summarized in a report.

2) The report is distributed to the department supervisor, Production Manager, and EVPs.

3) The supervisor reviews the report and composes a plan of corrective action (POC) and projected completion dates for each finding. The POC should be proportional to the finding and the projected completion date commensurate with the demands of the tasks required for the corrective action.

4) The supervisor submits the plan of corrective action to the QAO or designee for review and approval.

5) The QAO or designee reviews the plan of corrective action for each internal audit finding. Once the plan of corrective action is accepted, a major corrective action number is assigned to each planned corrective action or group of similar corrective actions.

6) The supervisor negotiates the corrective action and submits a Corrective Action Report (FRMQA001) for each major corrective action number to the QA department for final review.

7) Once all corrective actions associated with the internal audit have been completed and approved, the internal audit process is complete.

An in-depth review will be conducted if there is any evidence of inappropriate actions or vulnerabilities related to data integrity. This review shall be handled in a confidential manner until a follow up evaluation, full investigation, or other appropriate actions have been completed and the issue(s) clarified. Refer to ACZ's SOP *Data Integrity Policies & Procedures* (SOPAD039).

2.4.3 Proficiency Testing (PT) Program

ACZ is required to participate in a formal Proficiency Testing Program at the frequency stipulated by regulating agencies. These "performance evaluations" are facilitated through the introduction of blind samples, purchased from approved vendors. ACZ analyzes PT samples for most accredited parameters twice in a calendar year, with each study being approximately six (6) months apart. These tests are matrix, technology, and analyte specific, and provide useful information regarding the accuracy of the analytical data being produced. At a minimum, ACZ participates in the Water Supply (WS) study for SDWA, the Water Pollution (WP) study for CWA, a Soil study for RCRA, and a Radiochemistry PT study for Drinking Water. Refer to SOPAD011 for additional details.

2.5 Corrective Action

Corrective action shall be performed when any aspect of ACZ's testing and/or calibration work, or the results of this work, do not conform to established procedures or the agreed requirements of the customer. Corrective actions are a fundamental element of ACZ's QA Program, as a successful Quality System requires the identification of deficiencies and depends on the development, implementation, and documentation of effective contingency plans and resolutions to effectively remediate the deficiencies. Corrective actions are classified as minor, major, or technical.

2.5.1 Minor Corrective Action

Minor corrective actions address problems or issues isolated to a specific data set or group of data sets that do not meaningfully impact reports *already* issued to clients. The minor corrective action report (FRMQA001) allows for complete documentation of any temporary deviation from the SOP or other protocol. The employee who initiates the corrective action will complete Section 1 of the report. Documentation must be accurate and must provide a complete detailed explanation of the situation for future reference. The need to qualify data shall be critically assessed and appropriately addressed. The department supervisor should always be informed of the need for a minor corrective action and may provide additional information in the appropriate section. The project manager may also provide additional information in the appropriate section if necessary. QA does not need to close a minor corrective action; however, the employee may review the report with QA personnel and request their signature in the appropriate section. Minor corrective actions do not require follow-up.

Complete documentation may be provided either on the workgroup bench sheet or on the data review checklist in lieu of using FRMQA001. Use FRMQA001 if the deviation applies to many workgroups and attach a copy of the completed form to each workgroup before the workgroup is scanned. If the report is generated after the workgroups have been scanned, then the workgroup must be retrieved and rescanned with the report included as part of the data package. In this case, a note is made on the front page of the workgroup package indicating the reason the workgroup was rescanned (i.e. “CAR attached, WG rescanned”).

2.5.2 Major Corrective Action

Major corrective actions address problems which are systematic or meaningfully impact reports which have been issued to clients. It is the responsibility of the QAO to notify laboratory management in writing of departures from the Quality System, and it is the responsibility of the laboratory management to ensure remediation is completed by the assigned due date or to negotiate an extended deadline.

A major corrective action is initiated whenever a system failure has been identified or whenever an audit finding or other circumstance casts doubt on the correctness or validity of the analytical results. The client must be notified in writing if their work is significantly affected. The QA department will work with the Project Manager to determine if a revised report must be issued to the client. See ACZ’s SOP *Client Service Policies and Procedure* (SOPAD043) for details. A major corrective action may also be initiated when the need for preventive action has been identified (refer to §2.5.4).

Only QA department personnel may open and close a major corrective action. When opened, the corrective action shall be assigned a unique tracking number (referred to as the CAR number) to ensure that ACZ maintains a complete and accessible record of all Quality System deviations or failures, root cause determinations and subsequent resolutions, and preventive actions. A remediation deadline shall be assigned for all major corrective actions.

Examples of circumstances requiring a major corrective action include, but are not limited to:

- Contamination trends as indicated by blanks routinely above acceptable levels
- Spikes, surrogates and lab control samples continually outside acceptance limits
-
- “Not Acceptable” Proficiency Testing results
- Findings from internal or external audits
- Discrepancies between what was reported to clients and what should have been reported to clients due to equation errors or incorrect LIMS configuration.
- Hold times or deadlines routinely missed
- Evidence of insufficient or inadequate training

Following initiation, the procedure for a major corrective action proceeds to an investigation by the assigned individual to determine the root cause of the problem and identify possible resolutions to rectify the problem. The action(s) most likely to eliminate the problem and prevent recurrence of the problem must be selected, documented and implemented, and pertinent staff members must be trained, if necessary. Changes resulting from the corrective action will be monitored, if necessary, to ensure the resolution(s) are effective. A general outline of the procedure is as follows:

1) Initiation: Any employee may initiate a corrective action by notifying QA. The department manager should be notified first so that they can assess the need for a major corrective action. If determined to be necessary, QA personnel will open a corrective action, assign a unique tracking number, and a deadline for remediation. Deadlines shall be assigned based on the anticipated demands of remediation and potential threat posed to data integrity.

2) Assignment: QA assigns the corrective action to the person(s) responsible for problem characterization, Root Cause Analysis (RCA), Data Impact Assessment (DIA), corrective (including preventive) actions. Sections 1 and 2 of FRMQA001 shall be completed by the assignee(s).

3) Immediate action shall be taken to eliminate propagation of errors. Stopgap measures may be employed, including but not limited to: subcontracting analyses, imposing a moratorium on data reporting, manual data transformation. Immediate action shall be to a degree commensurate with the magnitude and risk of the problem.

4) Investigation and Action: Must be completed by the assigned deadline. Deadline extensions shall be negotiated with the QA department.

    a. The assigned individual(s) launch an investigation of the problem. There are three major components of the investigation
        1) Characterization of the problem: A thorough, but succinct, description of the problem must be composed. Whenever possible, this includes determination of the exact timeframe during which the error was present and what workgroups and samples were affected.
        2) Root Cause Analysis (RCA): Focuses on establishing the sequence of events or causal chain leading up to the problem, identifying contributing factors and elucidating relationships between them, and determining where intervention could be reasonably implemented to change performance and prevent an undesirable outcome. The depth of the RCA shall be commensurate with the risk and magnitude of the problem.
        3) Data Impact Assessment (DIA): Once the problem has been fully characterized, it shall be evaluated to determine whether client data may have been significantly impacted by the error. The DIA shall be commensurate with the risk and magnitude of the problem.

    b. A resolution to correct the problem and prevent its recurrence must be determined & implemented. Resolution may be done solely by the person(s) who investigated the root cause or it may require input from one or more additional departments.

        1) Conduct additional training if necessary. Training must be documented using the appropriate form and must include a description provided by the person who conducts the training. All trainees are required to sign and date the form to acknowledge he/she has received training, understands the change(s) and agrees to adhere to any change(s) in a policy or procedure.
        2) Revise SOP(s) as necessary. Proposed revisions must be approved by QA prior to implementation.
        3) Configure or enhance automated systems (e.g. LIMS) to correct problems or support preventive measures.
        4) Correct data in ACZ's LIMS as deemed necessary by Technical Directors, QA Staff, & Project Managers.
        5) Perform additional measures (e.g. instrument or support equipment purchase, etc.) as necessary.

    6) Document implementation dates for each corrective action.
    7) Attach or reference all supporting documentation in the corrective action report.

5) Project Manager Review: If necessary, the PM will determine whether affected data will be accepted or rejected, contact the client, and issue revised reports accordingly. Project Manager review may not be required for every major corrective action.

6) QA reviews the corrective action. If satisfactory, the corrective action is approved and closed.

7) If deemed necessary, QA conducts follow-up. Follow-up is scheduled after sufficient time has elapsed to observe the efficacy of the corrective action and may need to be done multiple times. If the corrective action is determined to be ineffective, a new major corrective action will be initiated and the process repeated. QA follow-up may be documented on the corrective action report or the CAR spreadsheet located on ACZ's network.

2.5.3 Technical Corrective Actions

Technical corrective actions apply to departures or deviations from the quality control parameters stated in individual test SOPs. Each test SOP must include all required quality control that applies to the procedure (as stipulated by the method and other regulatory agencies) as well as the performance frequency, acceptance criteria and corrective action for handling failed quality control measurements. Each SOP must describe the procedures to be followed for reviewing and assessing data, including corrective action for handling out-of-control or unacceptable data. The required protocol for technical corrective actions is summarized below.

1) Identify the individual responsible for assessing each nonconformance and initiating or recommending corrective action [analyst who performs AREV]

2) Define how the analyst must treat data if associated quality control measurements are unacceptable [section 12 of SOP]

3) Specify how non-conformance and subsequent corrective actions are to be documented [data review checklist]

4) Specify how management reviews the corrective actions [reviewed during SREV]

To the extent possible, samples shall be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control then the corrective action described in the SOP must be performed. Alternatively, report data with the appropriate qualifier if reprocessing and reanalysis is not possible. The qualifier must be assigned to any sample associated with the failed quality control measure. A current list of all extended qualifiers is available in the LIMS database and may be accessed by all employees.

2.5.4 Preventive Action

Preventive action is a pro-active process to identify opportunities for improvement rather than reacting to the identification of problems or complaints. Needed improvements and *potential* source(s) of any nonconformance, either technical or concerning the Quality System, must be identified and addressed. Examples of preventive action include but are not limited to: maintaining a cross-trained staff; maintaining a supply of spare consumable parts; monitoring the performance of support equipment; performing routine maintenance on instruments; maintaining an adequate supply of standards/reagents; ordering supplies before running out; completing log-in review in a timely manner; ensuring ACZ can perform work before samples are accepted; correcting quotes before samples are logged in; and analyzing samples by the appropriate method.

2.6 Management Review of the Quality System

At least once per calendar year, ACZ's management conducts a review of its Quality System and all activities related to its environmental testing services to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. At a minimum, the review must take the following into account:

- Suitability of policies and procedures.
- Manager and supervisor reports
- Review of internal audits
- Status, review, and discussion of major corrective actions
- Review of recent external audits
- Results of recent PT studies and corrective actions initiated / completed
- Changes in the volume and type of work undertaken
- Customer feedback
- Complaints
- Recommendations for improvement
- Status of state certifications
- Ethics and Data Integrity
- Other pertinent issues
- Resources and training.

2.6.1 Department Reports

Each department manager completes a Department Report (FRMQA041 or FRMQA042) prior to the Management Review meeting. Each item on the report is to be evaluated as it pertains to the individual department.

2.6.2 Management Review Report

The completed department reports are submitted to ACZ's EVPs. At a time specified by the EVPs management meets as a group to discuss the reports. All reviews shall be appropriately documented.

2.6.3 Customer Feedback

ACZ solicits customer feedback on an annual basis through the use of a client survey distributed and received via email. The survey asks for feedback regarding customer service, data quality, staff, value, timeliness, and laboratory standing compared to other labs. Feedback is compiled by the CEO and discussed during management review of the quality system.

2.6.4 When a finding is identified through the management review process ACZ's corrective action protocol shall be initiated.

3 ETHICAL AND LEGAL RESPONSIBILITY

All ACZ employees have an ethical and legal responsibility to produce data that is accurate, reliable, and legally defensible. ACZ's proactive program for the prevention and detection of improper, unethical, or illegal actions includes an Ombudsman who acts as a neutral party and serves as a confidential liaison between ACZ employees and management regarding questions, problems, complaints, suggestions, or ethical dilemmas.

Initial employee orientation includes ACZ's Code of Conduct, Code of Ethics, and zero-tolerance policy. Employees are informed of the processes in place to ensure employees are free from undue internal or external commercial, financial, or other pressures that may adversely affect the quality of an employee's work, endanger the trust in the independence of ACZ's judgment, or compromise the integrity of ACZ's environmental testing activities. A more detailed description of all aspects of the ethics program is provided in ACZ's SOP *Data Integrity Principles & Policies* (SOPAD039).

ACZ will not tolerate unethical or improper activities or behavior. Violation of company policies may lead to repercussions ranging from a warning to termination and possible criminal prosecution if warranted by the situation. ACZ has access to many resources that may be utilized at any time to help clarify any situation determined to be a "gray area." Employees are strongly encouraged to seek further guidance from a supervisor, ACZ's Ombudsman, EVPs, or QA staff whenever doubt is raised. Activities that will not be tolerated include, but are not limited to:

- **Misrepresentation of a procedure or documentation** – Intentionally performing a job duty in a manner that does not comply with a documented procedure, including but not limited to a test SOP or method used for sample analysis; providing inaccurate and misleading documentation associated with a data package or failing to provide the necessary documentation as part of a data package.

- **Falsifying Records** – Providing false information on personal credentials, resumes or educational transcripts, logbooks, raw data and client reports, or creating data without performing the procedure (also known as dry labbing).

- **Improper peak integration** – Intentionally performing improper integration of data chromatograms so quality control samples meet acceptance criteria. This is also known as peak shaving or peak enhancing.

- **Improper clock setting** – Readjusting the computer clock so that it appears samples were analyzed within hold times. Also referred to as time traveling.

- **Improper representation of Quality Control samples** – Failing to treat batch quality control samples in the same manner as client samples (including Proficiency Testing samples) or misrepresenting any type of quality control sample associated with the preparation batch and/or analytical batch.

- **Improper calibration** – Intentionally performing improper manipulation of calibration data or forging tune data so that it meets acceptance criteria.

- **File Substitution** – Replacing invalid data with valid data from a different time so the analysis appears to be successful.

4 PERSONNEL AND RESPONSIBILITIES

ACZ Laboratories, Inc. is an S corporation with two owners.

Refer to FRMAD072 for ACZ's current organizational chart.

It is the responsibility of management to document company policies, objectives, systems, programs, procedures, and instructions to the extent necessary to assure the quality and defensibility of all data.

ACZ's Executive Vice Presidents (EVP) are responsible for the overall management of the laboratory. On an operational level, one EVP is the appointed Lab Director with a focus on Production, Sales, & Marketing. The other EVP is the appointed Quality Assurance Officer with a focus on Quality, Compliance, Information Technology, and Project Management. On a tactical level, the focus on these divisions is less acute, and on a strategic level the EVPs focus on all divisions. Finance shares equal focus across all levels. The President/Owner is the ultimate authority at ACZ but has no formal responsibilities beyond those required by law.

It is the responsibility of all managers to ensure that all documented ACZ policies and procedures, including those in the QAP and associated SOPs, are communicated to, understood by, made available to, and implemented by ACZ personnel.

ACZ only uses personnel who are employed by or under contract to the laboratory.

4.1 Executive Vice President (EVP)

The EVP is ultimately responsible for all analytical and operational activities of the laboratory and must ensure that 1) the laboratory carries out all environmental activities in such a way as to meet the requirements of the TNI Standards and 2) the laboratory satisfies the needs of the client and the regulatory authorities. General duties involve budgeting for all departments, making decisions on capital equipment and automation; developing company policies and benefits; addressing personnel issues such as hiring, firing, and promotions; and working with clients on various matters. Day-to-day responsibilities include providing direction to all laboratory departments including laboratory operations, accounting, marketing, QA, and client services. Additional responsibilities are as follows:

- Work directly with ACZ's Ombudsman to provide and maintain a mechanism for confidential reporting of ethical/data integrity issues as well as issues that may directly affect current ACZ policies.
- Define the minimal level of qualification, experience, and skills necessary for all laboratory positions.
- Provide the QA department with defined responsibility and authority for ensuring the successful development, implementation, and management of ACZ's Quality System.
- Provide the Production with defined responsibility and authority for ensuring the technical operations and provision of resources needed to maintain the required quality of laboratory operations.
- Provide adequate supervision of environmental staff by persons familiar with methods and procedures, purpose of each test, and assessment of the test results.
- Ensure all technical staff has demonstrated capability in the activities for which they are responsible and ensure that the training of each member of the technical staff is kept up-to-date.
- Ensure the QA department has access to the highest level of management at which decisions are made on laboratory policy or resources.
- Provide managerial staff the authority and resources needed to discharge their duties.
- Provide technical personnel the resources needed to discharge their duties.
- Specify and document the responsibility, authority, and interrelationship of all personnel who manage, perform or verify work affecting the quality of calibrations and tests.
- Implement appropriate and current guidelines for all lab methods and procedures to ensure data quality and efficiency of analyses. Ensure all method protocols utilized by ACZ meet the QC requirements as established by EPA or other governing agency.
- Document all policies and procedures related to the analytical and operational activities of the laboratory.
- Provide support to technical staff to ensure timely completion of all laboratory work, and develop contingency plans to ensure workflow progresses as planned.
- Meet quarterly (or more often) with department leaders reporting directly to the EVPs.

4.2 QA Officer (QAO)

The QA Officer reports directly to the President; however, the QA department is considered a separate entity from operations in order to ensure data is evaluated objectively. The QAO has direct access to the President, and is therefore able to discuss and/or resolve all concerns, policies, etc. related to quality assurance or quality control. The primary responsibility of the QAO is to develop, implement, and manage all aspects of ACZ's Quality System, and he/she may take any action necessary to ensure all ACZ employees adhere to all policies, procedures, and objectives documented in ACZ's QAP, SOPs, memorandums, emails, etc. If warranted, the QAO has the authority to halt the performance of a single method or the production of a department, and if necessary, the operations of the entire laboratory, and will grant permission to resume when satisfied that the issue(s) have been resolved. Additional responsibilities include but are not limited to those stated in FRMAD060 and the following:

- Review and revise ACZ's QAP and provide training for all employees following approval of a new version.
- Provide QA orientation to new employees.
- Meet quarterly (or more often) with EVP/Lab Director and Laboratory Department Supervisors.
- Work with department managers to develop and improve training protocols.
- Conduct department training sessions as needed to address specific problems and questions.
- Arrange for or conduct internal audits; notify management of deficiencies; and track corrective actions.
- Organize all external audits; notify management of deficiencies; and assign and track corrective actions.
- Review and approve SOPs.
- Meet at least quarterly with Laboratory department supervisors to provide information, respond to questions, etc.
- Manage Proficiency Testing (PT) program.
- Coordinate and maintain all regulatory and client certification programs.
- Review and validate a determined percentage of all data packages from Log-in to Reporting.
- Work with marketing/client service representatives on QA aspects of proposals.
- Work with Project Managers and the Production Manager to resolve client feedback regarding data quality.
- Review and maintain records and documentation for audits, certifications and all other QA issues.

  Qualifications:

  - General knowledge of the analytical test methods
  - Documented training and/or experience in QA procedures
  - Knowledge of the Quality System as defined under TNI

4.3 QA Coordinator

The QA Coordinator reports directly to the QAO and assists with the development, implementation, and management of the Quality System. Primary job responsibilities are as follows:

- Review and maintain records/documentation for employee training including DOCs, MDLs, etc.
- Provide initial QA orientation to new employees.
- Coordinate annual data integrity training.
- Schedule analyses and compile and report data for Proficiency Testing (PT) program, including DMRQA.
- Initiate and track corrective actions related to PT samples and manage all documentation associated with analyses.
- Review and approve SOPs.
- Conduct internal audits, notify management of deficiencies; and track corrective actions.
- Conduct department training sessions as needed to address specific problems and questions.
- Update control chart-generated QC limits in the LIMS database as needed.
- Monitor control & calibration of support equipment
- Assist QAO with management of certifications.
- Manage ACZ's resume compilation.
- Update ACZ organizational chart as necessary.

  <u>Qualifications:</u>

  - General knowledge of the analytical test methods
  - Documented training and/or experience in QA procedures
  - Knowledge of the Quality System as defined under TNI

4.5 Laboratory Department Supervisor

Each Laboratory Department Supervisor is a full-time employee who reports to the EVP/Lab Director and exercises day-to-day oversight of laboratory operations for their specific area(s) of expertise. Each supervisor must be familiar with the test methods and related theory and instrumentation, as well as the assessment of results. In addition to monitoring the standards of performance, validity of all analyses, conformance to documented requirements, and quality of all data generated in their respective department(s), each supervisor is also responsible for ensuring that a new analyst has successfully completed all training requirements and is adequately prepared to commence work on client samples. Additional responsibilities are described in FRMAD060. If any supervisor is absent for more than 15 consecutive calendar days then another full-time staff member meeting the required qualifications will be assigned to perform the supervisor's duties.

Required Qualifications for a Laboratory Department Supervisor:

1) Chemical analyses (Organics & Metals): BS or BA in chemical, environmental, biological sciences, physical sciences or engineering, with a minimum of 24 college semester credit hours in chemistry and at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for which the laboratory seeks or maintains accreditation. A masters or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

2) Inorganic Chemical analyses (other than Metals): At least an earned associate's degree in the chemical, physical, or environmental sciences, or two (2) years of equivalent and successful college education, with a minimum of 16 college semester credit hours in chemistry and at least two (2) years of experience performing such analyses.

3) Radiological analyses: BS or BA in chemistry, environmental, biological sciences, physical sciences, or engineering, with at least 24 college semester credit hours in chemistry and at least two (2) years of experience in the radiological analyses of environmental samples. A masters or doctoral degree may be substituted for one (1) year of experience.

   The minimum requirements may be relaxed if the Laboratory Department Supervisor is not the appointed technical director of the laboratory division.

4.6 Business Development Manager

ACZ's Business Development Manager reports directly to the EVP/Lab Director and supervises all Client Service Representatives, each of who conducts marketing and sales efforts on behalf of ACZ with potential, new and existing clientele, and develops and maintains long-term relationships with customers by working with Project Managers when necessary. Additional responsibilities of the Business Development Manager are described in FRMAD060. ACZ's Client Service staff is authorized to review all contractual agreements with clients, review all proposals and develop price quotations for routine and non-routine analytical projects.

4.7 Project Manager Supervisor

The Project Manager Supervisor reports directly to the EVP/QAO and is responsible for overseeing the PM department. Additional responsibilities of the Project Manager Supervisor are described in FRMAD060. Each Project Manager serves as the primary laboratory contact for each ACZ client, handles all client service requests, and investigates and resolves any problem brought to ACZ's attention by the customer. In order to provide consistency, each PM is assigned a list of clients, and it is the primary responsibility of each PM to ensure all of their client project needs are managed on a day-to-day basis and met in a timely manner and that all data submitted to the client is of high quality. All PMs work directly with the Laboratory Department Supervisors regarding client data issues (due dates, hold times, retests, data quality, etc.), with Document Control regarding client reports, and with the QA department regarding data quality questions or concerns. The Project Manager Supervisor directly oversees Reporting and the Front Office.

4.8 Instrument Operator

Instrument operators report directly to the respective Laboratory Department Supervisor. The position involves the analysis of various matrices for trace level contaminants using specialized and technical instrumentation. Each operator must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee’s personnel file. Experience is verified by ACZ’s CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The operator must demonstrate understanding of related theory, mathematics, analytical instrumentation, and data interpretation. This work is predominantly intellectual and involves the continuous use of professional and sound judgment. The employee must meet or exceed all requirements for generation of litigation-quality data and must also continue to demonstrate increased proficiency regarding the interpretation of the data as well as the operation and troubleshooting of the assigned instrument(s). These improvements should be attainable through ongoing efforts in-house as well as through specialized instruction at off-site locations. Exceptions pertaining to experience or education will be made on a case-by-case basis.

<u>Qualifications:</u>

- BA or BS in Chemistry or related science or a minimum of 3 years of relevant experience in lieu of degree
- Prior laboratory experience is preferred but is not required.
- Successful completion of training by supervisor or proficient instrument operator

4.9 Laboratory Analyst [Technician]

The laboratory technician reports directly to the respective Laboratory Department Supervisor. The position involves analysis of various matrices using appropriate analytical techniques and support equipment as well as preparation of samples for instrument analyses. Each technician must be capable of performing all job duties in an accurate and proficient manner. Education will be verified by providing a copy of a college transcript or diploma, which is maintained in the employee’s personnel file. Experience is verified by ACZ’s CFO prior to completing the hiring process (verbal or documented verification provided by each reference listed on a resume or application is acceptable). The technician must demonstrate understanding of related principles and mathematics, must possess common sense and mechanical skills, and must seek professional judgment from the supervisor as necessary. The employee must meet or exceed all requirements for generation of litigation-quality data as well as sample preparation tasks and routine analyses, and must also continue to demonstrate continuous improvements. These improvements should be attainable through ongoing training efforts in-house as well as through training opportunities at off-site locations. Exceptions pertaining to experience or education will be made on a case-by-case basis.

<u>Qualifications:</u>

- BA or BS in Chemistry or related science is preferred but is not required
- Prior laboratory experience is preferred but is not required
- Successful completion of training period by supervisor or proficient technician

4.10 Information Technology (IT) Manager

The Information Technology Manager reports directly to the EVP/QAO and is responsible for the oversight of the IT department regarding the installation and maintenance of ACZ’s computer network and all hardware and software and related equipment deployed on the premise. Additional responsibilities are described in FRMAD060. The department is also responsible for developing, maintaining, and improving custom written applications for laboratory automation and efficiency as well as for ACZ’s LIMS, Intranet (Labweb), Internet and electronic data deliverables (EDDs).

4.11 Chemical Hygiene Officer (CHO)

The Chemical Hygiene Officer is responsible for oversight of ACZ's documented Chemical Hygiene Plan, conducting initial and refresher safety training for all employees, monitoring exposures, and maintaining records for Safety Data Sheets, injury reports, chemical exposure reports, etc. Additional responsibilities include working with management to develop and implement policies to improve the program. The person designated as CHO must have completed at least one basic laboratory safety course and have one year of experience performing laboratory work, preferably with responsibility for at least one area of laboratory safety.

4.12 Hazardous Waste Officer (HWO)

The HWO is responsible for managing and, with the collaboration of management, enforcing all aspects of ACZ's Hazardous Waste Management Plan (SOPAD007). The HWO must insure the HWP is compliant with relevant requirements in the US Code of Federal Regulations as well as any additional state regulations. Additional duties include bulking and labeling hazardous materials, filling out required documentation, and arranging for disposal; these activities may be delegated to qualified individuals under the supervision of the HWO. The HWO must know and understand the specific waste streams that ACZ uses and be able to determine how to dispose of unknown chemicals. This is best done by attending a training course on "Laboratory Waste Management." The individual responsible for hazardous waste disposal and signing the waste manifest must maintain HAZWOPER and DOT hazmat certification.

4.13 Radiation Safety Officer (RSO)

ACZ's Radioactive Materials License (RML) requires the laboratory have an RSO. The EVP/QAO appoints a Radiation Safety Officer to act as his/her representative in implementing the Radiation Safety Program. The RSO's responsibilities include developing radiation safety guidelines in accordance with Nuclear Regulatory Commission (NRC) and Colorado state rules and regulations, and for assuring compliance with those guidelines by ACZ personnel. The RSO will work with ACZ's administration to implement policies and seek ways to improve the safety program. The person designated as RSO must have completed a Radiation Safety Course or have at least 3 years of experience prior to being officially designated as the RSO. The RSO reports directly to the EVP/QAO of ACZ.

4.14 Chief Financial Officer (CFO)

ACZ's Chief Financial Officer is primarily responsible for all financial matters including payroll, accounts receivable, accounts payable and financial statements; monthly and annual balance and profit and loss statements; and assisting with annual budget preparation. In addition, the CFO maintains and monitors the security system and electronic time clock; invoices client projects from the database; updates customer account information; acts as the administrator for 401k/Profit Sharing Plan; maintains and executes the Employee Benefits Manual; and assists in hiring process by posting job openings, scheduling qualified candidates for interviews, checking references, and ensuring a new employee provides proof of education.

5 TECHNICAL TRAINING

Prior to the independent generation or review of data for client samples (including PT samples), all analysts must undergo a formal, documented training process. Technical personnel must be thoroughly trained in the analytical techniques and operating principles and procedures for the methods utilized by ACZ. This process includes but is not limited to: reading the associated published method, reading all related SOPs, improving laboratory skills, learning troubleshooting, maintenance, calibration and operating procedures for pertinent equipment and instruments, and creating workgroups and reviewing data through the LIMS database.

It is the responsibility of the department supervisor to determine that a new analyst is properly trained, has successfully completed all initial training requirements and is prepared to commence work on client samples. Under no circumstances may an analyst independently generate client data before receiving the explicit approval of the technical director overseeing the analysis.

5.1 The effective version of the test SOP provides the training framework for all sample preparation and analysis. The SOP is typically based on published approved methodologies (EPA or other) and incorporates any necessary activities and protocols not included in the published method(s) as well as requirements stipulated by other regulatory agencies.

5.2 Training for data AREV or SREV only must be documented as specified in §2.3.6. For analysts, approval to perform a procedure includes approval to perform AREV for the procedure. For supervisors and technical directors, approval to perform a procedure includes both AREV and SREV approval. SREV-specific authorization is required for analysts.

5.3 Each employee must be trained either by the department supervisor or by an analyst within the department who is proficient in the area of testing and has been designated by the supervisor. Whenever possible, anyone performing training must meet the following requirements:

1) Documentation of training on the effective version of the test SOP.
2) Documented approval for the analysis.
3) A current IDOC or CDOC.

Exceptions may be granted on a case-by-case basis as approved by the QAO.

5.4 Initial training is documented using the Initial Method Training form (FRMQA004). The General Lab Practice Training Form (FRMQA047) is also required for an analyst’s first procedure. Once training has been completed, the trainee and the instructor fill out the form together to ensure all pertinent information has been addressed and to ensure the trainee comprehends the material and is provided an opportunity to ask questions or request additional training. The trainee’s signature is an attestation that he/she has read, understands, and agrees to follow the effective version of the SOP.

5.5 To demonstrate an aptitude for the procedure, the analyst must perform a successful Initial Demonstration of Capability (IDOC) prior to independent preparation and/or analysis of client samples. Performance is documented using FRMAD023. The data is reviewed initially by the trainee (AREV). SREV is performed by the pertinent technical director or designee. A new IDOC is required if an analyst does not perform the method within 12 months.

5.6 Prior to performing an IDOC, a new analyst should be provided sufficient opportunity to practice the procedure. This confirms the analyst understands the procedure and feels comfortable performing the procedure independently. Data associated with any practice is not submitted to QA.

5.7 It is not necessary for the first IDOC attempt to pass; however, the supervisor needs to review the analyst’s techniques if multiple attempts do not pass.

5.8 A thorough review of the raw data is performed as part of initial method training and should include particular attention to details not presented in LIMS or on the final report, such as generating final sample concentration from the instrument response provided in the raw data (if applicable), verifying correct standard and reagent traceability.

5.9 Where specified by the method or a regulating entity, and as stated in the test SOP, successful demonstration of performance such as Linear Calibration Range determination (LCR) or Method Detection Limit (MDL) study must be completed prior to independent analysis of client samples.

5.10 All initial training documentation must be submitted to the QA department as a complete package. At a minimum, the package must include:

1) Initial Method Training form (FRMQA004), signed by the trainee and instructor (or department supervisor).

2) IDOC documentation:
   - ✓ Completed and signed certification statement (FRMAD023)
   - ✓ Workgroup bench sheet, raw data, and all supporting documentation

3) If applicable, an MDL study. Complete FRMAD031 and attach all related raw data and supporting documentation.

4) If applicable, calibration range study. Complete FRMQA029 and attach all related raw data and supporting documentation.

5) For all determinative methods utilizing a calibration curve or average response factor, the Method Calibration Form (FRMQA050).

NOTE: For those test methods for which no spiking solution is available only an Initial Method Training form (FRMQA004) is required.

5.11 Following review of all pertinent training documentation, the pertinent technical director will issue procedure-specific clearance for the trainee to independently generate and review data for client samples. This permission is tracked and may be viewed on a designated location on the public network drive.

1) Approval for preparation procedures is granted after the instrument data has been reviewed and approved.

2) An unapproved analyst who is “shadowing” the trainer (observing, learning the organization of the lab, reagent room, etc.) may not assist with the procedure, and the workgroup documentation must bear only the initials of the trainer, who is fully responsible for the data.

3) If the analyst has successfully completed training for a procedure and generates client data or reviews client data prior to the technical director’s approval, then any workgroups or data review checklist must also bear the initials of a proficient analyst, with current approval for the method, who oversees the analyst’s work for the procedure and assumes full responsibility for the data. The primary analyst must always be aware that he/she is responsible for the workgroup. The use of another employee’s initials without their explicit approval is expressly prohibited.

5.12 The supervisor is responsible for ensuring the training of each analyst is kept up-to-date. Each analyst must read, understand, and agree to follow the effective version of the SOP and continued proficiency must be demonstrated and documented annually for each analyst. A one month grace period is allowed for submitting CDOC documentation. Thereafter, the analyst is prohibited from performing the procedure until a successful CDOC or IDOC is submitted to QA.

5.13 Each Laboratory Department Supervisor routinely conducts department meetings to discuss procedures, work schedules, resources, questions and concerns, problems, QA, etc.

6 SAMPLE COLLECTION AND HOLDING TIMES

Sample collection procedures are well documented by the EPA and other agencies. ACZ's clients are instructed to provide representative samples whenever possible. ACZ supplies its clients with the containers and other materials necessary to maintain sample integrity (to the extent possible) from the time of collection through analysis. Although ACZ does not perform sample collection activities, each project manager or client service representative will assist a client with specific sampling requirements as needed. When necessary, they will direct a client to other resources. The following sections include general information on sample containers, preservatives. and holding times. These are essential components in preserving the chemical and physical properties possessed by the sample at the time of collection.

6.1 Sampling Containers and Preservatives

The EPA outlines the requirements for sample container types, sample volume, and preservation. ACZ's inventory includes various sizes of plastic and glass containers that range from pre-sterilized to certified-clean by the supplier. Amber bottles are used when specified by the method. Glass containers are obtained from vendors that specialize in the sales of environmental sample containers, and all non-certified bottles are purchased from reputable lab/industry vendors. Refer to FRMAD045 and FRMAD046 for bottles types and preservation techniques for specific analyses. Refer to the pertinent test method SOP for specific information regarding EPA requirements for container types, chemical, and thermal preservation.

All sample containers shipped to our clients are new, contain the appropriate preservative(s), and are color-coded to identify preservation and storage. Out-going containers are packed in clean coolers with a copy of ACZ's Sample Acceptance Policy, general directions for sample collection, bottle labels, ice packs, sampling information, blank chain of custody, return shipping labels, and custody seals. Trip blanks and rinsette water are included when requested by the client or when mandated by a specific analytical method. After samples have been collected they are cooled to a temperature ≥ 0 °C and ≤ 6.0 °C. Samples that require thermal preservation must be maintained within this temperature range until all analyses have been completed.

6.2 Holding Times

The EPA has conducted lengthy studies of sample degradation versus time to establish a maximum holding time for each parameter, and the results of these studies are compiled into holding-time tables to provide guidelines for litigation purposes. Data for a sample prepared / analyzed outside of the established holding time may be rejected by regulators as unusable. Holding times will vary slightly from regulation to regulation, thus further emphasizing the need for a client to consult with their Project Manager prior to sample collection. The holding time typically begins at the time or date of collection in the field. Holding times observed by ACZ are specified in the laboratory's test method SOPs.

If ACZ Laboratories, Inc. receives samples past holding times or near the expiration of the holding time, sample analysis will proceed unless the client has indicated on the CCOC that an attempt to contact the client must first be made. Analyses performed outside of holding time will be appropriately qualified on the final report. Holding times ≤ 72 hours are calculated based on the hour of the sample date/time. Holding times > 72 hours are calculated based on the day of the sample date/time.

In general, and unless otherwise noted in the test SOP, sample preparation and analysis must be completed within the stated holding time. For analyses that extend beyond the intended scope of the method for an analyte or matrix, the hold time stated in the SOP must be met or the samples must be appropriately qualified.

7 SAMPLE CUSTODY & SAMPLE HANDLING

Sample custody begins with receipt of sample containers from the client and continues beyond preparation and analysis to the proper disposal of primary and secondary sub-samples. Complete and accurate documentation must be provided at all stages of custody. There are many key elements to sample custody including laboratory security, chain of custody records, sample storage, internal custody logs, sample tracking within the laboratory, control of subcontracted work, and sample disposal. Unless otherwise specified, ACZ is contractually committed to retain samples for a minimum of 30 days after the invoice of a project[2].

7.1 Sample Receipt and Log-in

Refer to SOPAD045, *Sample Receipt & Log-In Procedure / Maintenance of Sample Integrity,* for the details of ACZ's sample receipt and log-in procedures. Upon delivery of samples to ACZ, Log-In personnel evaluate the condition of the cooler and custody seals. The custody seals are then broken to retrieve the Chain of Custody (COC), which must be signed by the sample custodian to document transfer of sample possession to ACZ.

Sample conditions are evaluated and any problems, such as expired hold times, lack of preservative or improper cooler temperature, are noted. Clients are notified of problems as soon as possible so that a contingency plan can be initiated if necessary. Samples are logged-in and are delivered to the assigned storage areas. Samples (including subsamples, extracts, etc.) must be stored away from standards, reagents, food, and other potential contaminants. Following log-in, every project is reviewed by the assigned PM. Upon completion of the review, the client receives an electronic summary that details the project information. This summary allows the client an opportunity to make changes to the project before samples are analyzed. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

7.2 Internal Custody Logs

Some clients may specify additional custody tracking of the samples once they have been logged in. Internal custody may require that samples are stored in a manner that ensures limited access. The internal custody log (FRMQA015) shall accompany the samples from log-in through completed analysis. The person responsible for the work signs and dates each entry and/or page in the logbook. When all data from a sample set is compiled, copies of all logbook entries shall be included in the final report package. For projects requiring internal custody, ACZ will adhere to the procedure described in the SOP *Client Service Policies and Procedures* (SOPAD043).

7.3 Sample Tracking

Sample flow through the laboratory is facilitated by the use of an Oracle-based LIMS database (Laboratory Information Management System). Every product (requested analysis) logged into the LIMS for a sample has a specific, pre-determined department path. All products have default paths of at least Login Review and Reporting. Between these two departments, a product may go through, for example, Soil Prep and Metal Analysis or Soil Prep, Organic Prep and GC Analysis. At each department step in a product's path, the status can be updated and viewed at any time. Analytical product statuses are defined below. Additional information regarding sample tracking is available in the SOP *Client Service Policies and Procedures* (SOPAD043).

NEED	Prep or Analysis has not been started
WIP	Prep or Analysis has been started (Work In Progress)
PREP	Sample preparation is complete and sample is ready for analysis
UPLD	Analytical data has been uploaded into LIMS
AREV	Analyst has reviewed and accepted analytical data
SREV	Supervisor has reviewed and accepted analytical data
DONE	Analysis or task has been completed
REDO	Sample requires reanalysis
REDX	Sample requires re-digestion/extraction

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[2] Currently, samples scheduled for any radiochemistry parameters are held for a minimum of 90 days to facilitate radioactive material inventory monitoring. This policy is subject to change at any time in harmony with ACZ's Radiation Safety Plan.

CANT	Sample preparation or analysis cannot be performed
NREV	Project requires PM review before work can begin
HOLD	Prep or analysis postponed
SENT	A final report has been issued to the client

8 PROCUREMENT, INVENTORY AND TRACEABILITY OF SUPPLIES

8.1 Procurement / Inventory

All consumable supplies are purchased from reputable vendors that have been evaluated for service, quality, and price. To the extent possible, materials traceable to national or international standards of measurement are purchased for use in technical operations. Supplies are purchased using ACZ's purchase order (PO), remote inventory management system (RIMS), and the Aestiva ordering system. The Purchasing Agent is not permitted to make a substitution for any material specifically requested unless the Laboratory Department Supervisor approves the substitution. Upon receipt, reagents, chemicals, standards, and other laboratory consumables are stored in the Chemical & Supply Room, which has limited access, or are delivered to the laboratory. Refer to ACZ's SOP *Purchase, Receipt, and Storage of Consumable Materials for Technical Operations* (SOPAD037) for additional information.

8.2 Glassware

ACZ uses only laboratory grade glassware. Prior to use, glassware is cleaned to meet the sensitivity of the method. Refer to individual test SOPs for detailed cleaning procedures.

8.3 Other Supplies

Routine consumables (centrifuge tubes, autosampler tubes, pipette tips, etc.) are purchased through an automatic system managed by Fisher (RIMS). All other supplies are purchased on an as-needed basis through ACZ's Purchase Order and the Aestiva ordering system. Refer to SOPAD037 for additional information.

8.4 Traceability of Standards and Reagents

To provide complete traceability, each data package must reference every standard and reagent used for sample preparation or analysis, including but not limited to acids, bases, preservatives, color reagents, pH indicators, buffers, and instrument reagents. Each PCN and/or SCN must be documented either on the workgroup bench sheet, data review checklist, or a current standard/reagent form. The open date for all original containers is not tracked in LIMS; however, good laboratory practice dictates the open date be noted on the sample container.

8.4.1 Primary Control Number (PCN)

Upon receipt, all stock chemicals, standards, and reagents are assigned a unique PCN in LIMS for tracking and traceability purposes. A label with the PCN and the expiration date is affixed to the container and the Certificate of Analysis is scanned or downloaded and saved in the public drive (if applicable). The data for each PCN is entered using the certified value(s) supplied by the vendor, as indicated on the Certificate of Analysis. Because the certified value is entered, the final concentrations for prepared standards may vary slightly from the theoretical value indicated in the test SOP. Certified values shall be used for standards when available. If certified values are not available, informational values may be used. If the certified reference values for any PCN are changed after the PCN has been used in the laboratory, then complete documentation must be provided as a major corrective action (FRMQA001).

8.4.2 Secondary Control Number (SCN)

To ensure complete traceability, a unique SCN must be created when any intermediate or working standard is prepared from one or more stock solutions, stock chemicals, or intermediate solutions. A standardized format is used for creating the SCN: a two-letter code indicates the lab section and is followed by the prep date and then by a daily sequential number. For example, the SCN **II051128-2** denotes the second standard prepared on November 28, 2005 in the Inorganic Instrument lab. An acceptable alternative is to let LIMS assign a unique number when prompted.

An SCN for any working standard subjected to a LIMS calculation must be created electronically in LIMS. The initial volume and concentration of each constituent and the final volume of the prepared solution are entered in the SCN Wizard program to calculate the final concentration of each analyte using the formula $C_1V_1 = C_2V_2$. The preparation date, expiration date, and preparer's initials are included as part of this electronic record. A hard copy of the SCN report may be affixed to the standard/reagent logbook, depending on individual department practice; however, it is not required.

Prepared reagents do not require an SCN be created electronically in LIMS; however, preparation must be recorded in the department's designated logbook. At a minimum, the logbook entry must clearly identify what reagent was prepared, its subcomponents, the preparer's initials, the preparation date, and the expiration date. This information is sufficient for color reagents, buffer solutions, instrument reagents, etc. because details of the preparation are stated in the test SOP.

8.5 Preparation and Expiration of Standards and Reagents

8.5.1 Preparation of Standards and Reagents

Refer to individual test SOPs for detailed information regarding standard and reagent preparation. In general, either Class A pipettes or mechanical pipettes are used to measure and dispense aliquots of any solution used to prepare a standard or reagent. Accurate delivery of mechanical pipettes must first be verified as described in ACZ's SOP *Control, Calibration, and Maintenance of Measuring and Test Equipment* (SOPAD013).

All containers of prepared reagents and standards stored for more than one day must be properly labeled with the SCN (or other unique identifier), name/description, preparation date, and expiration date. Preparation of reagents and standards must be documented as described in §8.4.2.

8.5.2 Expiration of Purchased Standards and Chemicals (PCNs)

When provided, the manufacturer's expiration date will be assigned. If the manufacturer does not provide an expiration date, an expiration date of 5 years from receipt is assigned unless the laboratory has knowledge indicating a longer or shorter shelf life is appropriate.

An expired stock material may continue to be used if its reliability can be verified. For the purpose of ensuring transparency, the rationale for extending the expiration date must be documented on FRMQA051 and submitted to the QA department or pertinent technical director for approval. If the extension is granted, FRMQA051 is saved on a network drive. Unusable materials should be replaced and the standard or reagent remade as soon as possible. Remove the container from the lab or the supply room and dispose of properly. Contact ACZ's HWO for assistance.

8.5.3 Expiration of Prepared Standards

Storage conditions and shelf life for prepared standards are provided in the individual test SOPs. The following guidelines may be used to determine the shelf life for a prepared standard if the method does not prescribe a shelf life:

1) A standard that has been prepared in-house may continue to be used after its assigned expiration date for as long as its reliability can been verified. Whenever possible, reliability should be verified by comparison to another, unexpired standard containing the same constituents. For applicable procedures, instrument response may be considered when determining whether or not a solution is still reliable.

    - In cases where reliability has been verified, the expiration date of the SCN must be updated in LIMS and/or the standard/reagent logbook. The rationale for extending the expiration must be documented on FRMQA051 and submitted to the QA department for approval.
    - In the event the solution was used prior to updating the SCN then documentation must be provided as part of the workgroup to indicate the solution was used past the shelf life stated in the SOP (a minor corrective action or FRMQA051 may be used if more than one workgroup is affected). The expired standard must be remade as soon as its reliability becomes questionable – it is the responsibility of the analyst to use their best judgment.

2) The shelf life of any prepared standard with any analyte concentration < 10 mg/L is 90 days from the preparation date. This is a general guideline – if any constituent does not remain in solution for 90 days, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

3) The shelf life of a prepared standard with analyte concentration $\geq$ 10 mg/L is one year from the preparation date. This is a general guideline – if any constituent does not remain in solution for one year, then the standard must be prepared more often. If the manufacturer's expiration date for any stock standard is sooner, then the expiration date of the SCN is the manufacturer's expiration date for a single analyte solution or the earliest manufacturer's expiration date for a multiple analyte solution.

4) In general, prepared Radiochemistry standards expire one year from the preparation date. The solution may be re-evaluated using control charts, efficiency checks, or other criteria and the expiration date extended by year intervals if the solution is still deemed usable. Refer to the specific test SOP for details.

8.5.4 Expiration of Reagents

In general, a reagent is a solution, which does not contain the target analyte(s). Storage conditions and shelf life are stated in the individual test SOPs. The expiration date can be extended for a prepared reagent provided its reliability can be verified. LCS/LFB performance (QC criteria met) may be used to verify reagent stability if the control standard is a valid indication of the reagent's continued functionality/stability. Reagents used to treat samples for interference may not be verified this way. Reagents used to dissociate complexed target analytes may not be verified this way unless the LCS is an appropriate complex. FRMQA051 must be submitted to QA or the pertinent technical director for approval whenever an expiration extension is requested.

9 MAINTENANCE AND CALIBRATION OF INSTRUMENTATION & EQUIPMENT

9.1 Maintenance of Instruments and Support Equipment

The best protocol for producing quality work is to prevent errors and non-conformances rather than react to and correct problems after they occur. An essential part of this protocol is ensuring that all laboratory instrumentation and equipment used for the generation of data have been optimized and are functioning properly before commencing work on client samples. Performing routine maintenance and optimizing instrument-operating conditions prior to sample analysis minimizes instrument downtime, thereby improving productivity and ensuring quality of the data. It is the responsibility of the designated analyst(s) to perform and properly document daily and routine maintenance, instrument optimization, troubleshooting, instrument service or repair, and repair or replacement of parts.

All manufacturer-prescribed inspection and maintenance shall be performed according to the schedule indicated in the operator's manual (or similar) provided by the manufacturer and must be documented in the instrument logbook, a separate maintenance logbook, or on the instrument maintenance checklist (available in LabWeb). ACZ management recognizes that performing all maintenance procedures at the frequency indicated by the manufacturer may not be necessary to sustain instrument optimization. Therefore, at a minimum, instrument part(s) and optimization shall be inspected according to the schedule. The analyst must use their professional judgment to determine if maintenance or replacement is necessary at that time. Decisions to deviate from the manufacturer's schedule shall be documented.

All support equipment (any device that may not be the actual test instrument, but is necessary to support laboratory operations) must be monitored regularly to confirm proper functioning. The temperature of all drying ovens, refrigerators, freezers, and incubators must be checked each day the equipment is in use and each check recorded on the associated Temperature Logsheet. Refer to SOPAD013 for more detail.

Equipment that does not meet performance specifications must be taken out of service and FRMAD029 attached to indicate the instrument or equipment is waiting for repair and cannot be used. During this downtime the department supervisor, Production Manager, and Project Manager may collectively determine it is necessary to sub-contract samples until correct performance of the repaired instrument or equipment has been demonstrated by a successful calibration or other suitable test. Document all contact with the manufacturer, as well as all repairs and other services, in the instrument or maintenance logbook to be used as a reference for solving future instrument problems. Transport and storage of measuring equipment shall be done in accordance with manufacturer recommendations. Additionally, when instrumentation or equipment goes outside of the direct control of the laboratory, the functioning and calibration status must be checked and shown to be satisfactory before it is returned to service. Refer to SOPAD013 for additional information.

To minimize downtime and prevent analytical delays, each laboratory should maintain an adequate inventory of reagents, stock standards, glassware, etc. and should keep a sufficient supply of extra "critical" parts in-house. Instrument redundancy should be established for all analyses and Instrument Qualification (IQ) should be maintained on backup instruments.

9.2 Instrument Calibration

The accuracy of all instrument-generated data relies on proper calibration. In general, calibration or standardization involves defining the relationship between instrument response and the amount or concentration of analyte introduced into the instrument. The graphical depiction of this relationship is referred to as the calibration curve.

Calibration frequency must be performed in accordance with the manufacturer's guidelines, test method or other regulatory requirements, or client contract stipulations, whichever is most stringent. Every calibration or standardization must meet the acceptance criteria stated in the SOP and shall be subsequently verified by analyzing an initial calibration verification standard (ICV) or other control standard (if specified in the SOP) that contains all target analytes and has been prepared or obtained from a different source than the one used to prepare the calibration standards.[3] Calibration standards and the second-source verification standard should be prepared on different days. If they are prepared concurrently, then another qualified analyst should prepare the second-source verification standard. This minimizes the risk of both solutions being prepared consistently incorrectly.

A continuing calibration verification standard (CCV) containing all analytes of interest must be analyzed at the frequency stated in the test SOP to ensure the stability of the initial calibration curve has not varied over time due to any change in the analytical instrument and its detection system, such as instability of standards, instrument cleanliness, column performance, matrix effects, flow changes, and changes within the laboratory environment.

For applicable methods, all initial and continuing calibration steps must be clearly detailed in the test SOP. Additionally, each test SOP must specify the frequency and acceptance limits for the calibration and subsequent verification (ICV and CCV). In general, acceptance criteria are method-specific; however, the SOP may also include requirements of other regulatory agencies. Prior to resuming sample analysis, immediate corrective action must be taken if the calibration, ICV, or CCV is outside of the acceptance criteria. Technical corrective actions are described in the individual test SOPs. Refer also to §11.2 for additional information.

General calibration guidelines are listed below. Additional information is provided in the individual test SOP's and ACZ's SOP *Control of Measuring & Test Equipment* (SOPAD013).

- Understand the method requirements for calibration (minimum number of standards, etc.)
- Use the correct calibration model (linear, second-order, etc.)
- Include all target analytes in the calibration standards and second-source standard
- Analyze a calibration standard with a concentration less than or equal to the quantitation limit.
- Do not remove points from the middle of the calibration (only high or low standards may be dropped).
- Calibration is a single-event process. A retest of a calibration standard must be performed immediately.
- Documentation and resolution of calibration abnormalities is critical

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[3] If a second source standard is not available calibration shall be verified using a standard from a different lot. If a different lot is not available, an analyst who did not prepare the calibration standards may prepare the calibration verification standard. For some standards, it is important to consider whether manufacturers have obtained their material from the same lot.

10 CONTROL AND STORAGE OF RECORDS AND DOCUMENTS

A formal and systematic control of records and documents is necessary to accurately reconstruct the entire history of any sample and guarantee the quality and defensibility of the data. All information pertaining to instrumentation and equipment, analytical test methods, and related laboratory activities, such as sample receipt, sample preparation, data verification, audits, corrective actions, method validation, and data reporting must be documented, must identify all personnel involved, and must be readily understood. All records, including those pertaining to calibration and test equipment, certificates and reports, must be maintained, and the management system must facilitate the retrieval of all working files and archived records for inspection and validation purposes. Documents and records must be safely stored (protected against fire, theft, loss, environmental deterioration, and vermin) and must be held secure and in confidence to the client for a minimum of 10 years. The hard copy of all records and documents must be maintained in a designated storage area with limited access. To the extent possible, hard copies for the most recent two (2) years are stored on-site, and if necessary, may be moved to off-site storage after two years. Off-site storage conditions must meet the same criteria that apply to on-site storage.

10.1 Workgroups

10.1.1 Changes made to any workgroup record (hardcopy or electronic) must be documented.

1) If a workgroup is “dissolved” or its data deleted from LIMS, the analyst is prompted in LIMS to provide an explanation of why he/she is performing the task.

2) Changes to upload files must be documented on the hard copy of the workgroup.

10.1.2 Workgroup data that is re-uploaded *for any reason* must first be deleted. If any of the data changes, the Run Approval report shall be corrected. The workgroup shall be rescanned if necessary.

10.1.3 Document Control or other administrative personnel use a multi-page scanner with its own PDF scanning software to scan all hardcopy portions of workgroups.

1) Before the workgroup is scanned, the top page is reviewed to make sure it has both the AREV and SREV initials and dates.

2) The person scanning the workgroup must initial in the lower right hand corner of the front page of the workgroup. This provides an indication the document has been scanned.

3) The workgroup is scanned to the designated network directory and is then moved through an automated process to the appropriate read-only LabWeb directory. This directory is accessible to all employees. When a workgroup is rescanned, the previous file is maintained. A copy will be automatically created so as not to overwrite any files and will have a letter appended; starting with “A” the first time the workgroup is rescanned. The most current file will not have a letter appended.

10.1.4 The hard copy is filed by workgroup number in a file cabinet in the supply room by the front office. When capacity is reached, the workgroups are boxed and prepared for long-term storage. The front of the full storage box is labeled with the year and the workgroups contained in the box. The first box of each new calendar year is “1.” Full boxes are consecutively numbered, transferred to a designated location and stored in numerical order. The storage room is locked at all times and access is limited to authorized staff.

10.1.5

10.2 Electronic File Retention & Storage

All electronic records, stored either on instrument computers or on the network, are systematically backed up to both fixed and removable media. These records include Oracle data, instrument raw data, workgroups, client reports, instrument upload files, SOPs and other controlled documents, and department data.

10.2.1 Critical system data is protected by Microsoft's Data Protection Manager. The Data Protection Manager is configured to maintain data for a period of 10 years.

10.2.2 All archived data is moved to a secondary machine on a weekly basis. From there, it is backed up to removable media to provide additional data redundancy.

10.2.3 The removable media from the first week of the month is pulled from service and moved to ACZ's safe deposit box at a local bank. The most recent 6 months of tapes are kept in the bank safe deposit box. Months 7 through 12 are placed in a secure, data rated, 4-hour fireproof safe. Note that this removable media only contains data from December 1st of the previous year to the present date.

10.2.4 At the conclusion of the calendar year, a master copy is made that comprises all of the data from December 1st of the previous year through January 31st of the following (current) year. This 14-month span of data is then moved to ACZ's safe deposit box at a local bank. At that time, the removable media that has aged 10 years is removed from the safe deposit box and its contents are destroyed. All data on the secondary machine from prior to December 1st of the previous year is removed from the system so that it is no longer included on the weekly backup.

10.2.5 Data that has aged 5 years is deleted from the Oracle Database on a monthly basis.

10.3 Instrument Data Files

Instrument raw data files are backed up by ACZ's Instrument Data Backup Application (IDBA). IDBA is a program that accesses local directories from instrument computers. Each morning the program retrieves and backs up individual data files from the specified directory on each instrument computer. Refer to ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details.

10.4 Client Reports

10.4.1 Client reports are generated and signed electronically and are automatically stored as a PDF at a designated location on the network that has limited access. If a copy of any report exists on the network, and a new report is generated, then the existing copy will be renamed so that it is not overwritten. This way ACZ maintains a copy of all reports generated for a client.

10.4.2 Hardcopy documentation associated with a client project (CCOC, invoice, Login Review Form, etc) is filed by project number and stored in the document storage location.

10.4.3 Electronic Data Deliverables (EDD) are stored on the network at a designated location.

10.4.4 Once a project has been invoiced, the working directory is moved to the designated storage network location as a read-only PDF. If a project is un-invoiced, the project folder is copied back to the working directory where changes may take place. If an invoice is altered, a revised invoice is included with the project hardcopy.

10.4.5 In general, changes are not allowed to projects (including compilation) if the project has been invoiced. If a change needs to be made, the project must first be un-invoiced. At the time of un-invoicing, the user must provide a reason in LIMS to explain why the project was un-invoiced. This information is then stored in the Oracle database.

10.4.6 If a test report requires amendment after it has been issued to the client, the entire report shall be re-issued with the amendment. The amended report shall include a case narrative describing change(s) from the original report. Amended reports shall be uniquely identified and contain a reference to the original report. Typically, the laboratory number assigned to the project serves as the link to the original report. Amendments shall meet all the requirements of ACZ's quality system.

10.5 Documents

10.5.1 Standard Operating Procedures

10.5.1.1 Refer to §2.2 or SOPAD049 for additional information pertaining to SOPs.

10.5.1.2 The original master copy of each SOP is stored as a PDF in a secured public directory. The cover page indicates approval authorities. Approval is documented through emails. Whenever an SOP or SOP revision is approved, QA emails all staff whose job activities intersect the SOP or SOP revision with training instructions and a request for read receipt. The pertinent technical director or supervisor shall be included in the email distribution list. This email constitutes QA's signature of approval. Read receipts constitute training signatures and the technical director's or supervisor's signature of approval. Emails requesting read receipts for training documentation purposes shall contain a statement that by sending read receipt the sender attests they have read, understand, and agree to follow the identified policy. MS Outlook's read receipt is mimicked for this process. To send read receipt, trainees and approval authorities reply to the sender and replace "Re" with "Read" at the beginning of the subject field. Emails documenting training and/or approval shall be saved in a public outlook email folder or converted to PDF's and stored in the same directory as the SOP master copy or a subdirectory therein.

SOP master copies pre-dating the above paperless policy are located in the document control office.

10.5.1.3 A printed controlled copy of any SOP may be obtained from ACZ's LabWeb.

1) To ensure outdated information is not inadvertently used as a reference, Invalid or obsolete SOPs must be promptly removed from all points of use or clearly marked to indicate the purpose of retention

10.5.1.4 SOP Revisions: Any revision to a procedure must be approved by QA before changes may be implemented.

10.5.2 When documents are found to contain conflicting policies or procedures, the most recent document will be followed unless the conflict is prescribed as an exception to general protocol by a document more specific to the application.

10.5.3 Forms containing procedures or equations shall be controlled. Equations shall be validated and protected from inadvertent alteration.

10.5.4 All controlled forms must be printed from LabWeb and may not be stored on a separate network drive. If photocopies are used then any unused copies of the expired version must be disposed of as soon as a new version is uploaded to LabWeb. This ensures that the effective version of any controlled form is in use at all times. Exceptions may be granted by the QAO on a case by case basis.

10.5.5 The original certificate of analysis for any stock material, if provided, is stored in electronic format on ACZ's network.

10.5.6 Accreditation certificates are stored as PDF files to a designated network location. Original copies are maintained by QA. Certificates are also posted to ACZ's website.

10.5.7 Original calibration certificates and related documentation for support equipment (including but not limited to pipettes, thermometers, and glass micro liter syringes) are maintained by the QA Department.

10.5.8 LIMS and other problems pertaining to IT are documented and managed by the electronic system called Help Desk. If an employee encounters a problem that requires attention, that employee will submit a request through Help Desk. The request requires a priority be assigned. This system allows ACZ to track all changes made to computer systems.

10.6 Records

10.6.1 Records include, but are not limited to: all logbooks; phone logs; raw data, derived data, and calibration data; training documentation (training forms, MDL studies, DOCs, etc.); proficiency testing results; calibration and certification records; internal audit reports; external audit reports; corrective action reports; management reports; and regulatory correspondence.

10.6.2 Records related to sample log-in are maintained as described in SOPAD045.

10.6.3 Records related to support equipment calibration and calibration verification are maintained as described in SOPAD013.

10.6.4 Certificates of cleanliness and volumetric accuracy received with consumable supplies (e.g. sample containers, centrifuge tubes) shall be submitted to and maintained by QA. Any other type of certificate that does not have a defined storage location shall be submitted to QA.

10.6.5 Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, dictated observations, and recorded data from automated instruments.

10.6.6 Original copies of records, except those pertaining to analytical data, are maintained by the QA department or Document Control, and access is limited.

10.6.7 Relevant qualifications, training skills, and experience of technical personnel are maintained in the employee's training file.

10.6.8 Records such as transcripts, applications for employment, performance evaluations, etc. are maintained in the personnel files, which are stored in the secured office of the CFO.

10.6.9 The DOC certification statement (FRMAD023), initial method training form (FRMQA004), General Lab Practice Training Form (FRMQA047), and Method Calibration Training Form (FRMQA050) are filed with the workgroup if the DOC was logged-in; otherwise, the DOC package is filed in the method files. An analyst training spreadsheet referencing training dates and documentation locations is maintained on a public drive.

10.6.10 Each employee's legal name, legal signature, and initials are documented on the New Employee Checklist (FRMAD043). The form is maintained in the employee's personnel file, which is stored in the CFO's office. Additionally, employee names, signatures, and initials are documented in a logbook maintained by ACZ's CFO. In the event an employee legally changes their name, the CFO is responsible for garnering new signatures and initials in the logbook; FRMAD043 is not updated in this event.

10.6.11 Each Organic Instrument ICAL data package is scanned to the designated network directory as a PDF and the hard copy stored in labeled boxes. Alternatively, a PDF may be generated directly from the instrument files. ICAL information that needs to be attached to any subsequent workgroup(s) must be printed from the PDF.

10.6.12 Logbooks shall be maintained and controlled as described in SOPAD013.

10.6.13 Project Managers are responsible for maintaining all emails pertaining to a client and/or project. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043).

10.6.14 Changes to electronic records must be traceable to the individual who made the correction, and the reason for the change must be provided. Erroneous entries cannot be destroyed by methods such as overwritten files.

10.6.15 Record Storage and Retention

10.6.15.1 The minimum record retention period of 10 years may be increased dependent upon client request, regulatory requirement, or civil action order.

10.6.15.2 Records stored by a computer must have hard copy or software backup copies.

10.6.15.3 Records stored only on electronic media must be supported by the hardware and software necessary for their retrieval and utilization in the proper format.

10.6.15.4 Records stored on electronic media must be stored in a way to provide protection from electronic or magnetic sources.

10.6.15.5 If there is a change in ownership and/or a change in location, all records and documents will be made available to clients for 10 years. Under no circumstances shall any records or documents be destroyed – all records and analyses performed that pertain to TNI accreditation are subject to inspection by the TNI accrediting authorities for a 5 year period. (The 10 year record retention policy is client driven, TNI standards require records be retained for a minimum of 5 years.) A new owner of ACZ will assume possession of all records and documents.

10.6.15.6 If ACZ goes out of business, all records and documents will be stored and maintained according to protocol in a location to be determined at the time of closure.

10.6.16 Access to Archived Records

10.6.16.1 Access to archived information must be documented with an access log. A log is kept in each storage location, and any person entering a storage location must provide the required information in the log.

10.6.16.2 Hard copy records are stored in a locked environment with limited access. When a record is removed from its location, a "checkout card" must be filled out to indicate who removed the record, the date the record was taken, and a description of the record. The card marks the place in the storage box, and when the record is returned the card is pulled from the box.

10.6.16.3 Any changes to be made to archived electronic data will require assistance from IT to do so.

10.6.16.4 Electronic data that has been archived to removable media is stored in a bank safety deposit box. Access is limited to ACZ's EVPs, IT staff, and CFO and recorded in a logbook maintained by the IT Manager.

10.6.17 Record Disposal

10.6.17.1 Records are disposed of in a manner that ensures client confidentiality.

10.6.17.2 Stored records will be reviewed to determine which ones can be destroyed in compliance with ACZ's record retention policies.

10.7 Computer Data and Records

10.7.1 Network File Server

Computer files pertaining to all aspects of ACZ's business are stored on a series of file servers. To gain access, an employee logs on to the "LAB" domain. Each employee has a unique network user name so that security rules may be enforced. No "guest" logon is permitted. Every employee belongs to a specific "group" and directory security is enforced through privileges granted to these groups. An employee is granted access to files that pertain to their job functions. Other files will be granted read-only or no access as appropriate to the employee's position.

Data generated and reported by ACZ is extremely confidential and the company may be liable for the consequences of the release of this data to any unauthorized person. The implementation of password security is not arbitrary and ensures data is protected and cannot be disclosed to outside parties. Weak passwords that are not changed frequently make this scenario more likely.

In general, the network will prompt employees to change their password every 30 days. The password must be at least five (5) characters. Numeric characters are optional. Passwords may not be shared with other employees, unless necessary for work purposes. The use of another employee's password without permission from ACZ's EVPs, or IT Manager (with the exception of common passwords for shared computers) is grounds for disciplinary action.

10.7.2 LIMS Server

a. Information stored in LIMS consists of all sample and client information needed for day-to-day production activities. The information is stored in an Oracle database. Access is controlled through membership in "groups." Employees may update and change database records according to their job responsibilities. Otherwise, information is restricted to read-only access or no access.

b. No modifications to data can be made through applications not authorized by ACZ's IT department unless a CAR or Help Desk ticket is submitted or documentation is provided on the hardcopy of the workgroup. Unauthorized applications include any form of direct database manipulation.

c. Tracked changes will be audited on a regular basis by the QA department or its designee to ensure sufficient information is being supplied as to why changes occur. The explanations must be both professional and specific.

10.7.3 Docs Server

For general users, access to the docs server is read-only and is permitted through Internet Information Services (IIS) authentication and is logged in IIS log files. Direct access is limited to authorized users or groups who need to bypass the IIS to perform their job duties. The server is updated on a regular basis by automated scripts.

11 ELEMENTS OF QUALITY CONTROL

A critical focus of ACZ's quality control policies and protocols involves monitoring sample preparation and measurement processes to determine matrix effects and to evaluate laboratory performance. Quality control samples are typically analyzed with every batch of environmental samples. Each test SOP provides detailed information regarding quality control sample types, acceptance criteria, and corrective actions, if applicable to the procedure, and reflects the requirements of the method and/or other regulatory authorities.

Performance control samples demonstrate precision or accuracy and expose out-of-control events. Matrix-specific control samples indicate possible effects of the matrix on method performance and may also identify data as in-control or out-of-control. Data that is out-of-control dictates corrective action ranging from re-preparation and re-analysis to reporting data with qualifiers. The corrective action specified in the SOP shall be performed if any quality control sample does not meet the acceptance criteria.

To the extent possible, client samples are reported only if all quality control measures are acceptable. If any measure is outside of the acceptance criteria, and the data will be accepted and reported to the client, then the appropriate data qualifier(s) must be assigned to all associated samples. The list of current extended qualifiers is maintained in the LIMS database.

11.1 Method Performance

11.1.1 Negative Control – Prep Blank (Method Blank)

A prep blank or method blank shall be analyzed at a minimum of one per batch. The blank shall be processed along with and under the same conditions as the associated samples. Method blanks are not applicable for certain analyses, such as pH, Conductivity, Flash Point, and Temperature.

The prep blank is used to assess possible contamination introduced during sample processing steps. A prep blank is prepared using Type I water or other similar matrix that is free of the target analyte(s) and contains all reagents in the same volumes used to prepare the client samples. Unless specified in the test SOP, sample concentration may not be corrected for the prep blank value.

While the goal is to have no detectable contaminants, each prep blank must be carefully evaluated as to the nature of the interference and the effect on the analysis of each sample in the batch. Contamination in the prep blank results from four principle sources: the environment the analysis is performed in; the reagents used; the supplies and apparatus used; and the analyst performing the analysis. Contamination sources vary and the test SOP must be referenced to determine appropriate corrective action.

When method blanks fail acceptance criteria, potential sources shall be investigated and measures taken to correct, minimize or eliminate the problem, and associated client samples must be reprocessed and reanalyzed. Alternatively, data may be reported with the appropriate qualifier if reprocessing and reanalysis is not possible or if one of the following criteria is met:

1) The concentration of a target analyte in the blank is at or above the acceptance limit and the measured concentration of the analyte in an associated sample is greater than 10 times the measured concentration of analyte in the blank.
2) The concentration of the target analyte in the associated sample is less than the MDL.
3) Corrective actions could not be performed or are ineffective. Thoroughly document any corrective action taken and the outcome.

11.1.2 Positive Control (however named)

Laboratory Fortified Blank (LFB), Laboratory Fortified Blank Duplicate (LFBD), Laboratory Control Sample Water (LCSW), Laboratory Control Sample Water Duplicate (LCSWD), Laboratory Control Sample Solid (LCSS), Laboratory Control Sample Solid Duplicate (LCSSD).

1) The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps.
2) The LCS is a quality system matrix, known to be free of the analytes of interest, spiked with known concentrations of analytes. Alternatively, an appropriate Certified Reference Material (CRM) containing the analytes of interest may be used.
3) If no separate preparation method is used (e.g. dissolved metals), an ICV or CCV may double as the LCS. If different acceptance criteria are specified, the most stringent criteria shall be observed.
4) Each test SOP must define the positive control to be used for the procedure, the required frequency, acceptance criteria, and contingencies for corrective action.
5) Unless the reference method specifies a different frequency, the LCS shall be analyzed at a minimum of one per batch, not to exceed 20 environmental samples.
6) Any affected samples associated with a failing LCS shall be re-processed for analysis or the results reported with appropriate data qualification. A failing LCS may be re-tested once to confirm the failure. Additional re-tests must be accompanied by documented corrective action taken between tests. For example, the instrument did not sample from the correct tray position in the first two tests; alignment was corrected for the third test.

   Note: In general, qualification of data for LCS failures is only permitted if there is insufficient sample for re-analysis, the data is extremely time sensitive, or the LCS failed high but the analyte was not detected above the reporting limit in the sample.
7) The components to be included in the LCS shall be as specified by the method, regulation, or as requested by the client. **In the absence of such specifications, the following rules shall be observed (Radiochemistry excluded)** :
   a) For those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.
   b) For those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported. The following criteria shall be used for determining the minimum number of analytes to be spiked. **However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period**:
      i. For methods that include one (1) to ten (10) targets, spike all components.
      ii. For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.
      iii. For methods with more than twenty (20) targets, spike at least sixteen (16) components.
8) An LCSW duplicate may be prepared and analyzed with the batch, typically in lieu of a matrix duplicate or spike duplicate. Data is acceptable if the LCSW and/or LCSWD is within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if either of the following occurs:
   a) LCSW/D RPD fails the acceptance criteria specified in the SOP.
   b) % R of both the LCSW and LCSWD is outside the acceptance limits.
9) For a solid or semi-solid matrix, an LCSS and LCSSD are often prepared and analyzed.[4] The data is acceptable if the LCSS and/or LCSSD are within the acceptance limits and the RPD passes. Associated samples must be re-prepped and reanalyzed if any of the following occurs:
   a) LCSS/D RPD fails the acceptance criteria specified in the SOP.
   b) % R of both the LCSS and LCSSD is outside the acceptance limits.

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[4] Corrective action for Recommendation #5 cited in the 2002 ADHS audit report.

10) When the acceptance criteria for the LCS are exceeded [i.e. high bias] then any associated client sample with a measured concentration less than the reporting limit (MDL or PQL) may be accepted and reported with the appropriate qualifier.

11) Refer to §11.1.3.3 for additional information regarding data assessment for solid-matrix workgroups prepared with both LCSS/LCSSD and MS/MSD.

12) An LCS is not required for those analytes for which no spiking solution is available.

13) The following apply to radiochemistry only:

    a) The activity of the LCS shall be at least 10 times the Lower Limit of Detection (LLD) or Minimum Detectable Activity (MDA). Note: this requirement does not apply to DOCs.

    b) Whenever possible, the standards used to prepare the laboratory control sample shall be from a source independent of the standards used for instrument calibration.

    c) Where a radiochemical method, other than gamma-ray spectroscopy, has more than one reportable analyte isotope (e.g. plutonium, 238Pu and 239Pu, using alpha-particle spectrometry), only one of the analyte isotopes needs to be included in the laboratory control sample at the indicated activity level. However, where more than one analyte is detectable, each shall be assessed against the specified acceptance criteria.

    d) Where gamma-ray spectrometry is used to identify and quantify more than one analyte, the laboratory control sample shall contain gamma-emitting radionuclides that represent the low (e.g., Am^{241}), medium (e.g., Cs^{137}) and high (e.g., Co^{60}) energy range of the analyzed gamma-ray spectra. As indicated by these examples, the nuclides need not exactly bracket the calibrated energy range or the range over which nuclides are identified and quantified.

    e) The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.

11.1.3 Sample Specific Controls

The effect of different sample matrices on the performance of any method can be profound; therefore, matrix spikes, duplicates, and surrogate compounds are analyzed to evaluate matrix effects on data quality. Each SOP includes specific information regarding the usage and evaluation of matrix-specific QC samples and also states the required corrective action to take if any matrix QC fails.

ACZ provides analytical services to numerous and varied clients. Therefore, the possibility of routinely favoring one client or sample is highly unlikely, and over time the samples from all routine sources should be fortified. ACZ recommends that analysts, to the extent possible, select samples to spike or duplicate that are representative of the workgroup. Analysts are not to associate QC with a client sample known to be or believed to be any type of blank or Proficiency Testing sample. Several exceptions exist for selecting samples for spiking or duplicating:

1 A sample is not spiked or duplicated if the volume is inadequate and the client sample and QC sample(s) would require dilution; however, if no other option is available then the client sample and Duplicates should be prepared and analyzed on the same dilution whenever possible. Matrix spikes will not be accepted on different dilutions (minor d.f. variations in soils samples are acceptable) unless no other alternative exists. The data must be qualified in this event.

2 Use the same weights (as close as possible) to prepare duplicates of solid matrix samples.

3 A client may require that one or more of their samples be spiked or duplicated. A “RUN QC” comment is added when the sample is logged in to notify the analyst that QC must be performed for a specific sample or project. Alternatively, the Special Instructions function in ACZ’s LIMS may be used to communicate the request. If a client requests that their sample(s) be spiked or duplicated, ACZ will accommodate the client for a fee.

4 A reactive sample is unpredictable and is a poor choice for spiking or duplicating.

5 A PT sample is not a real-world sample and is a poor choice for spiking or duplicating, because the data does not provide any useful information about possible matrix effects. When selecting samples for batch QC such as spikes or duplicates, PT samples should be avoided. If insufficient volume exists to spike or duplicate any other samples in the batch, it is appropriate to select a PT sample. It is better to use the PT sample for a duplicate than a spike if this choice is presented. If a batch consists solely of a PT sample, QC designed to assess matrix effects is not required (e.g. spike, SDL); an assessment of precision is still required and may be accomplished by duplicating the PT sample, or preferably, running a duplicate of the positive control.

11.1.3.1 Surrogates

Surrogates are organic compounds that are similar to the target analyte(s) in chemical composition and behavior in the analytical process, but are not normally found in environmental samples. Surrogates are included in the scope of Organic methods and are used to evaluate accuracy, method performance and extraction efficiency and are added to environmental samples, controls, and blanks, in accordance with the method requirements.

When surrogate recoveries fail acceptance limits, corrective action stated in the test SOP shall be performed. If corrective action cannot be performed or is ineffective, reported data must be appropriately qualified.

11.1.3.2 Matrix Spike Samples

A matrix spike sample (however named) is used to determine the level of bias (accuracy) associated with a particular matrix. For the purposes of this document, “MS” designates a matrix spike, and “MSD” designates a matrix spike duplicate. Spikes are prepared by adding a known and appropriate quantity of each target analyte to a replicate aliquot of client sample.

The required analytical frequency is specified by the method or other regulating entity and is indicated in the test SOP. Each result is evaluated against the acceptance criteria, and matrix effects are determined and reported to the client. The following evaluation criteria apply to spikes that are subjected to processing steps and post-digestion spikes (analytical spikes).

- Percent Recovery (%R) is considered for all spikes.
- %R is evaluated only if the theoretical concentration in the spiked aliquot is greater than or equal to the PQL; otherwise, each associated client sample must be reported with the appropriate qualifier, regardless of %R, unless a representative number of analytes as described in §11.1.3.2.1 are evaluated for %R.
- If %R for the MS and/or the MSD is outside of the acceptance limits, the RPD passes, and all other pertinent prep and instrument QC passes, each associated client sample may be accepted and reported with appropriate qualification.

11.1.3.2.1 The components to be included in the MS & MSD shall be as specified by the method, regulation, or as requested by the client. **In the absence of such specifications, the following rules shall be observed (Radiochemistry excluded)**:

1) For those components that interfere with an accurate assessment, such as spiking simultaneously with technical chlordane, toxaphene and PCBs, the spike shall be chosen that represents the chemistries and elution patterns of the components to be reported.
2) For those methods that have extremely long lists of analytes, a representative number may be chosen. The analytes selected shall be representative of all analytes reported. The following criteria shall be used for determining the minimum number of analytes to be spiked. **However, the laboratory shall insure that all targeted components are included in the spike mixture over a two (2) year period**:

a) For methods that include one (1) to ten (10) targets, spike all components.
b) For methods that include eleven (11) to twenty (20) targets, spike at least ten (10) or 80%, whichever is greater.
c) For methods with more than twenty (20) targets, spike at least sixteen (16) components.

11.1.3.3 Matrix Duplicates and Matrix Spike Duplicates

The matrix-specific precision associated with an analysis is determined through the use of a matrix duplicate (DUP) or spike duplicate (MSD), which are performed at a frequency specified by the method or other regulating entity (refer to the specific test SOP). If the method does not prescribe a frequency, a duplicate shall be included in each workgroup, not to exceed 20 samples. The results are evaluated, and the matrix affect on precision are determined and reported to the client.

- Relative Percent Difference (RPD) is used to evaluate precision, unless the test SOP specifies a different technique (§12.4.6).

- RPD for a spike duplicate is evaluated only if the observed concentration is greater than or equal to the PQL; otherwise each associated client sample must be reported with the appropriate qualifier.

- RPD for a matrix duplicate is evaluated only if the observed concentration is greater than 10 times the MDL or 2 times the PQL if an MDL has not been established; otherwise each associated client sample must be reported with the appropriate qualifier, regardless of RPD.

- In the absence of other contributing factors, a DUP failure for a solid or semi-solid matrix is attributed to non-homogeneity of the sample, and each associated client sample may be reported with the appropriate qualifier.

- For an aqueous matrix, if the DUP fails then all associated samples must be retested. If permitted by the instrument software the sample and DUP can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- For an aqueous matrix, if the MS/MSD RPD fails then the associated samples must be reanalyzed. If permitted by the instrument software the sample and MS/MSD can be reanalyzed at the end of the analysis in lieu of retesting all associated samples.

- If applicable, evaluate the LCS/LCSD if the RPD fails for a matrix duplicate or spike duplicate. Each associated client sample may be reported with the appropriate qualifier if the LCS/LCSD meets the criteria stated in §11.1.3.2.

- For a solid or semi-solid matrix, if both the LCSS and LCSSD recoveries pass but the RPD fails, then acceptable precision may be demonstrated by a passing RPD for the MS/MSD, and each associated client sample may be reported with the appropriate qualifier.

- A sample and duplicate may only be re-analyzed once before additional corrective action is required. If more than one re-analysis is performed, the workgroup documentation must include justification.

11.2 Instrument Specific Controls

All data must be associated with a passing instrument calibration and initial calibration verification. To the extent possible, all data must be associated with passing continuing calibration verification. If the initial calibration verification results (ICV/ICB) are outside of the acceptance criteria, then the source of the failure must be identified, necessary corrective action performed, and the instrument recalibrated if necessary before proceeding with sample analysis.

If the continuing calibration verification results (CCV/CCB) do not meet the acceptance criteria, then the source of the failure must be identified and corrective action performed, including recalibration if necessary, before continuing with sample analysis. If reanalysis of any sample associated with failing calibration verification is not possible and results will be reported, the data shall be appropriately qualified.

For instruments that permit the analysis of subsequent workgroups using the most recent calibration, two (2) consecutive attempts of the opening CCV/CCB are allowed. If both attempts fail to produce acceptable results then the sources of failure must be identified and corrective action performed, including recalibration if necessary, before commencing sample analysis.

If a CCV or ICV *retest* fails and the instrument is not recalibrated, 2 consecutive passing CCVs or ICVs are required before continuing with analysis.

Unless stated otherwise by the test SOP, passing calibration verification must bracket all batch quality control samples, and results for additional instrument check standards, if applicable, must be within the acceptance criteria stated in the SOP. However, when the acceptance criteria for a CCV or CCB are exceeded (i.e. high bias) any associated client sample with a measured concentration less than the MDL may be accepted and reported with the appropriate qualification. This exception is not allowed if the workgroup contains a batch LCS (however named) which fails low.

11.3 Other Control Indicators

11.3.3 Internal Standards

Internal Standards (IS) are measured amounts of certain compounds added after preparation or extraction of a sample to be analyzed. The IS is an analyte not likely to be found in the environment and is used in a calibration method to correct sample results affected by column injection losses, purging losses or viscosity effects. The IS is added to client samples, controls and blanks in accordance with the method requirements. When the results are outside of the acceptance limits for applicable quality control samples, corrective actions shall be performed. Once system control has been reestablished, all samples analyzed while the system was malfunctioning shall be reanalyzed. If corrective actions could not be performed or are ineffective and associated sample results will be reported, the data must be appropriately qualified.

11.3.2 Trip Blank

The trip blank is a sample container filled in the laboratory with Type I water that is shipped to the collection site in the sample cooler, returned to the laboratory, logged-in, and analyzed in the same manner as the client samples. With the exception of Hg-1631, trip blanks are not opened in the field.

11.3.3 Instrument Blank

The instrument blank is an aliquot of Type I water processed only through the instrument steps of sample analysis and is used to determine presence of instrument contamination. For Organic instrument methods, neither surrogate nor IS standards are added.

11.3.4 Equipment Blank

An equipment blank is provided by the client and is used to assess the effectiveness of equipment decontamination procedures. Type I water is poured into (or over) or pumped through the sampling device, collected in a sample container and transported to the lab to be analyzed for all parameters requested for the environmental samples collected at the site.

11.3.5 Ambient Blank

The ambient blank consists of Type I water poured into a VOA vial at the sampling site (in the same vicinity as the associated samples). It is handled like an environmental sample and transported to the laboratory for analysis. Ambient blanks are prepared when samples are to be analyzed for VOA analytes and are used to assess the potential introduction of contaminants from ambient sources (e.g. active runways, engine test cells, gasoline motors in operation) to the samples during sample collection. The frequency of collection for ambient blanks is specified in the client's field-sampling plan. Ambient blanks are not required for all projects.

11.3.6 Radiological Tracers & Carriers

Radiological tracers and carriers are used for radiological analyses. The control reacts in the same manner as the target isotope and is used to assess analyte recovery. The tracer is added to client samples and QC in accordance with the requirements stipulated in the test SOP. Because the tracer recovery has a direct impact on the LLD, the recovery must be high enough to yield LLDs that are within the scope of the project or meet ACZ's acceptance criteria. Refer to the test SOP for evaluation criteria and corrective action(s) for out-of-control tracer recovery.

11.4 Titrants – Where applicable, test SOPs shall include procedures for verifying the concentration of titrants prepared by the laboratory. Verification is not required for purchased titrants with certified values. If a purchased titrant is diluted, verification is required.

12 EVALUATING QUALITY CONTROL SAMPLES

In general, acceptance criteria for quality control samples are method-specific; however, compliance with the requirements of clients and regulatory or other accrediting agencies must also be demonstrated. Immediate corrective action must be taken if any quality control is outside of the acceptance criteria. Appropriate corrective actions are described in the test SOP. To the extent possible, client samples are reported only if all quality control measurements are acceptable. If a quality control measure is outside of acceptance criteria, and the data will be reported, then all samples associated with the failed QC must be appropriately qualified. Clients will occasionally request limits different from those in a published method. Deviations from ACZ's policies pursuant to client request must be explicitly noted on client reports. ACZ will not be held liable in the event such deviations do not meet client regulatory needs.

Unless otherwise stated, for the purpose of determining conformance to specifications, ACZ employs the rounding method described in ASTM E29. When using this method, observed values are rounded to the same decimal place limits are expressed before assessing conformance. For example, if the calculated percent recovery for an LCS is 89.5% and the QC limits are 90 to 110%, the percent recovery would be rounded to 90% and evaluated as passing. (Note: double rounding is NOT permitted, e.g. 89.48 rounds to 89.5 rounds to 90.) Conversely, if limits were expressed as 90.0 to 110.0%, the same LCS would be evaluated as failing acceptance criteria. Analysts must consider whether the QC limits expressed in the test method cohere in a technically sound manner with the rounding method. If they do not, the SOP must express the limits to a technically sound numerical place value, or the absolute method must be employed. The absolute method takes a limit of 6˚C, 6.0˚C, and 6.000˚C all to mean the same thing, exactly 6 degrees Celsius.

For methods that permit the use of control charts or do not specify acceptance criteria for quality control measurement, limits may be generated by plotting historical data obtained from analytical processes considered in control. Whenever practical, a minimum of 20 data points is used. The process of rejecting data points relies heavily on the statistician's judgment and control chart activities are therefore restricted to supervisors and experienced analysts. All points must be associated with passing calibrations and calibration verification(s). Data points with known anomalies must be rejected. Data points should not be rejected solely because they fail acceptance criteria. Control chart documentation must clearly indicate rejected data points. ACZ's LIMS has a utility for querying and retrieving historical data for control chart applications. Control chart limits are typically set at ± 3σ. All control chart limits are reviewed and approved by the QA department prior to implementation. When possible, a comparison to previous limits is included in the review and may form the basis for rejecting new limits and requiring an investigation of the analytical system's condition. Previous limits are archived in a network folder. Default acceptance criteria established by the Arizona Department of Health Services (ADHS) may be used in lieu of generating a control chart to establish limits; however the SOP must specify which limits are in use.[5] **NOTE:** For all data evaluation, final results ending with 1 – 4 are rounded down and results ending with 5 – 9 are rounded up.

12.1 Accuracy

Accuracy is defined as "The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations". Control samples (LCS or LFB) and spiked samples are analyzed with every batch of samples or as stipulated by the specific test SOP to assess accuracy and matrix effects.

- Percent Recovery (%R) for a control sample is calculated as follows:

$$\%R = \frac{M}{S_p} \times 100$$

Where: M = Measured concentration of the control sample

S_p = True value of the control sample

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[5] Arizona Administrative Code (A.A.C.), Title 9, Ch. 14, Table 6.4 (September, 2016)

- Percent Recovery (%R) for a spike is calculated as follows:

$$\%R = \frac{M - S}{S_p} \times 100$$

Where: M = Measured concentration of the spiked sample
S = Measured concentration of the sample aliquot
S_p = True value of the spike concentration

12.2 Precision

Precision is defined as "The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms." Matrix duplicates and spike duplicates are analyzed with every batch of samples or as stipulated by the test SOP to determine the precision associated with the analysis. If any method does not specify acceptance criteria for the RPD, then default criteria of RPD $\leq$ 20 is used (a value that rounds to 20 is acceptable).[6] The Relative Percent Difference (RPD) as an absolute value is calculated as follows:

$$|RPD| = \frac{(S - D)}{[(S + D) / 2]} \times 100$$

Where: S = Sample Value
D = Duplicate Value

12.3 Other Calculations

- Solids Dilution Factor:

$$\text{Dilution Factor} = \frac{V}{(W)(\%\ \text{solid})}$$

Where: V = Final digestate volume, in mL
W = Sample weight used, in g
%solid = %solid of the sample as a fraction

- Sample Concentration for Solids:
  - ❑ wet weight [biota tissue, fruit or vegetable matter, etc.]: $\text{mg/Kg} = \frac{DF * C * V}{W}$
  - ❑ dry weight [plant matter, grasses, soil, sludge, etc.]: mg/Kg = SF * C * DF

Where: DF = instrument dilution factor
C = raw data value, in mg/L
V = Final volume of digestate, in L
W = sample (as received) weight used, in Kg
SF = soil dilution factor

- Percent Difference for Serial Dilution (SDL):

$$|\%D| = \frac{[I - (s * 5)]}{I} \times 100$$

Where: I = initial sample result
s = serial dilution result (raw data value)

For SDL calculations in LIMS, "s" is multiplied by 5 and the resulting "reg value" is compared to the "found value" to calculate %D.

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[6] ADHS Information Update #87 (July 7, 2005)

12.4 Radiochemistry Calculations: (**NOTE**: Specifications in the individual test SOPs supercede the information detailed below.)

12.4.3 Activity

The results of radioactivity are typically reported in terms of activity per unit volume or mass. Units are normally expressed in picocuries (pCi), which equal 2.22 disintegrations per minute (dpm). Specific formulas to determine activity are in the SOP for each method. The general formula is as follows:

$$C = \frac{R_{net}}{(e)(y)(i)(v)(u)}$$

Where: C = activity per unit volume (pCi/L)
R_{net} = net counts per minute
e = counting efficiency, cpm/dpm
y = chemical yield
i = ingrowth correction factor
v = volume or mass being counted (L)
u = units correction factor, 2.22 for cpm to pCi

12.4.4 Counting Error

Radiochemical data are considered incomplete without reporting associated random and systematic errors. For this reason all radiochemical results should be accompanied by a counting error at the 95% confidence level (1.96*standard deviation). The general counting error formula is as follows:

$$E = \frac{1.96(R_o/t_1 + B/t_2)^{1/2}}{(e)(y)(i)(v)(u)}$$

Where: E = counting error
R_o = gross sample, cpm
t_1 = sample count duration, min
B = background, cpm
t_2 = background count duration, min
e, y, i, v, and *u* are as previously defined.

12.4.5 Lower Limit of Detection (LLD)

LLD (also referred to as Minimum Detectable Activity or MDA) is considered the smallest quantity of sample radioactivity that will yield a net count for which there is a pre-determined level of confidence that radioactivity is present. At the 95% confidence level, the following equation calculates the LLD for any single nuclide. The calculation uses the standard deviation for the background counting rate, assuming the sample and background counting rates should be very similar at the LLD. A formula for determining LLD is as follows:

$$\mathrm{LLD}_{95} = \frac{4.66 S_b}{(e)(y)(i)(v)(u)}$$

Where : LLD_{95} = Lower limit of detection at the 95% confidence interval
S_b = Standard deviation of the instrument background counting rate, cpm
e, y, i, v, and *u* are as previously defined

12.4.6 Precision

The normalized absolute difference, or Replicate Error Ratio (RER), between the sample and the laboratory duplicate, given by the following equation shall be used to determine that results do not differ significantly when compared to their respective 2* sigma uncertainty.

$$RER = \frac{|Sx - Dup|}{\sqrt{(Sx_{error})^2 + (Dup_{error})^2}} \leq 2.0$$

Where: Sx = sample concentration in pCi/L
Sx_{error} = sample counting error (in pCi/L) at the 95% confidence level.
Dup = duplicate concentration in pCi/L
Dup_{error} = duplicate counting error (in pCi/L) at the 95% confidence level.

NOTE: For Radchem samples, both RPD and RER may be used to evaluate precision. RPD is the default assessment for Drinking Water samples; RER is the default assessment for non-Drinking Water samples. Data for both RER and RPD are uploaded to LIMS for all analyses. Use the following guidelines to correctly assess precision. Further details are provided in ACZ's Wiki and should be consulted to ensure data for each workgroup is correctly evaluated. Go to LabWeb \ Wiki \ Analytical Departments \ Radio Chemistry.

<u>Drinking Water:</u>

RPD ≤ 20, RER < 2.0 – Precision is judged to be in control
RPD ≤ 20, RER > 2.0 – Precision is judged to be in control;
RPD > 20, [sx] < 5x [LLD], RER < 2.0 – Precision is judged to be in control; qualify data.
RPD > 20, [sx] > 5x [LLD], RER> 2.0 – Precision of the prep batch is questionable.
RPD > 20, [sx] > 5x [LLD], RER < 2.0 – Precision of the prep batch is questionable.

<u>Non-Drinking Water</u>:

RER < 2.0, RPD ≤ 20 – Precision is judged to be in control.
RER < 2.0, RPD > 20 – Precision is judged to be in control;
RER > 2.0, RPD ≤ 20 – Precision of the sample prep batch is questionable.
RER > 2.0, RPD > 20 – Precision of the sample prep batch is questionable.
RER > 2.0, [sx] > 5x [LLD], RPD ≤ 20 – Precision is judged to be in control; qualify data.

13 VALIDATION AND REVIEW OF ANALYTICAL DATA

ACZ has a responsibility to provide the best data possible to ensure our clients can make sound and cost-effective decisions regarding public health and the environment. In order to generate and report reliable data, the analytical systems used need to be properly functioning, and the review process must be conducted in a manner that is logical and reasonable and would be defensible if subjected to legal scrutiny. Decisions regarding data quality must be backed by good science and sound professional judgments.

The entire validation and review process encompasses more than solely evaluating the final results for client and quality control samples. To this extent, the necessary steps must also be performed *prior* to sample preparation or analysis to ensure the quality of the data. Following sample analysis, data is uploaded to the LIMS database and then submitted to a variety of process chains such as calculations, rounding, application of qualifiers, etc. A multi-level data review process is utilized to verify the uploaded analytical data meets all documented ACZ requirements as well as any client-specific quality objectives. At a minimum, the validation process must include the following steps, as applicable:

- Monitor the expiration dates for all stock, intermediate, and working standards, reagents, and chemicals.

- Prior to analysis, determine that holding times have not been exceeded. Unless otherwise specified by the test SOP, sample preparation and analysis must be completed within the holding time.

- Prior to analyzing samples, verify the correct set-up and operation of the instrument or equipment. Perform calibration, maintenance, and optimization as necessary to ensure proper functioning.

- QC Association
  1) In general, for QC frequency of 1 per10 or less client samples, the first set of QC is associated with samples 1 – 10. If there are fewer than 20 samples in the workgroup, then the remaining client samples are associated with the second set of QC.
  2) If sample characteristics or amount dictate that 2 of the first 10 samples be spiked or dup'd, then the first spike or DUP is associated with samples 1 through 11 excluding the 2nd sample spiked or dup'd, and the 2nd spike or dup is associated with itself and samples 12-20. For example, if samples 3 & 5 are spiked in a 20 sample batch, sample 3 is associated with 1-4 & 6-11, and sample 5 is associated with 5 and 12-20. The same principle applies if both spiked or dup'd samples reside in the 2nd set of ten within the workgroup sequence.
  3) Variations to the QC association rules noted above are permitted but must be documented with the WG. The documentation must define the altered QC association and provide a compelling, technically sound reason for the deviation. QC association may **not** be changed after data has been acquired.
  4) QC association must be properly defined in LIMS.

- Before completing workgroup creation, verify the correct PCNs and/or SCNs have been entered. Percent recovery for control samples and spikes is calculated using the information in LIMS for each.

- Verify the proper sub-sample (green dot, yellow dot, etc.) is being used for preparation or analysis.

  - Notify the supervisor or Production Manager as soon as possible if a sample cannot be located.
  - Document on the bench sheet if a sub-sample other than the type indicated in the SOP is used.

- Clearly label tubes, beakers, autosampler cups, etc. to identify the sample (and dilution factor, if applicable).

- Manage sample volume to ensure all analyses from a bottle type can be completed.

- Document all dilution factors at the time the dilution is performed.

- Record complete and accurate observations when an analysis, sample preparation, or sample matrix is unusual or problematic.

- Ensure transcription errors do not occur. Verify all data manually entered into LIMS is correct before completing the upload process.

- The calibration workgroup must be associated with all subsequent workgroups. Record the calibration workgroup number (or calibration file name) on the data review checklist.

- Provide complete traceability for all standards and reagents used for sample preparation and analysis.

- Batch quality control samples must be treated in the same manner as client sample, including preparation.

- If it is necessary to perform a calculation manually, use the values in the raw data [do not truncate] and then round the final result to the appropriate numerical place value. If the final result passes the acceptance criteria then pass the QC in LIMS and note on the data review checklist that it passes.

- LIMS performs several additional QC calculations on the approved data including cation/anion balance (CAB) checks, calculated TDS versus actual TDS ratios, and Total versus Dissolved ratios. The Project Manager may update the status of pertinent samples to REDO if one of these calculations indicates a discrepancy with the associated data.

- If two attempts fail to produce acceptable data then notify the supervisor or Production Manager before taking further action. It may be necessary to first determine if a larger problem is interfering with the analysis. Investigate the problem before qualifying the associated data.

- If there is an indication the analytical system is out of control, the issue must be investigated. Notify the supervisor immediately. Conduct troubleshooting in a systematic, organized manner.

- All data must be reviewed initially in LIMS [AREV] by the analyst who performed the analysis or another individual authorized to perform or AREV the procedure. The department supervisor or another individual authorized for SREV performs the secondary review [SREV]. The following are data review guidelines:

    1 A data review checklist must be completed during the review process. Verify all items listed and note any errors, problems or non-compliances and the corrective action(s) taken.

    2 If applicable, review the raw data to verify the analytical system was in control and to ensure no anomalies exist. Check for notes on the bench sheet regarding the preparation or analysis.

    3 For client samples and quality control samples, ensure all results are within the measurement range and are bracketed by a passing calibration and passing calibration verification [ICV/ICB or CCV/CCB]. Sample values outside of the measurement range must be appropriately qualified if reanalysis is not possible.

    4 The corrective action specified in the SOP must be performed if any quality control sample does not meet the acceptance criteria.

    5 Data generated after the hold time has elapsed may not be usable for the client. If reprep or reanalysis will be conducted outside of the holding time, check first with the supervisor.

    6 Confirm all dilutions are appropriate. A reasonable explanation must be provided on the bench sheet if a sample was diluted and the value is less than the quantitation limit (refer also to §15).

    7 If a spike fails, determine if the sample concentration is disproportionate to the spike added. If the analyte concentration in the sample is more than **4 times** the spike concentration, note the failure on the checklist and appropriately qualify the associated samples.

8 If a spike recovery suggests the sample was not spiked, matrix interference must be confirmed prior to qualifying samples. If matrix interference cannot be confirmed, then re-prep and/or re-test all associated samples.

9 Each associated client sample must be appropriately qualified if the matrix spike, matrix duplicate, or spike duplicate data cannot be used for validation purposes.

10 Confirm failed QC by verifying the correct PCN or SCN was entered. Make corrections if necessary before proceeding with data review.

11 Verify all assigned qualifiers are appropriate. Does use of a particular qualifier make sense? Could data be defended using the qualifier assigned to the scenario or problem?

12 If a case narrative is necessary, the reason for accepting and reporting the data must be sound and logical. Provide sufficient and accurate verbiage to ensure the data is legally defensible.

13 If a sample was retested in the same workgroup, verify the correct data will be reported. All other data for the sample must be failed; LIMS cannot report multiple datum for the same sample-product-analyte combination.

14 Confirm all samples have the correct status (PASS, FAIL, REDO, REDX) before completing the review process. For multi-parameter workgroups, all analytes must have the correct status.

15 Refer also to §11 for data evaluation criteria.

14 DETECTION LEVELS

Current practice identifies several detection levels, each of which has a defined purpose: Instrument Detection Limit (IDL), Method Detection Limit (MDL), Reporting Limit (RL), and Practical Quantitation Limit (PQL). The MDL and PQL are stated in each test SOP and are adjusted accordingly in LIMS when data is uploaded to reflect the use of smaller sample volume (dilution) or larger sample volume (concentration).

14.1 Instrument Detection Limit (IDL)

The concentration equivalent to the analyte signal which is equal to three times the standard deviation of a series of 10
replicate measurements of the calibration blank signal at the selected analytical mass. (EPA Method 200.8 definition.)

14.2 Method Detection Limit (MDL)

The EPA defines the MDL as the "minimum concentration of substance that can be measured by a specific testing protocol and reported with 99% confidence that the analyte concentration is greater than zero…" This confidence interval means that any substance detected at a concentration equal to the MDL is 99% likely to be present, but it also means there is a 1% chance that the substance will be considered falsely present (false positive). The MDL procedure is designed so that the probabilities of both false positive and false negative errors are acceptably small; however, the procedure has limitations. Data users must understand the limitations when evaluating low level data and must proceed with caution when interpreting data reported between the MDL and PQL in order to minimize the risk of making poor environmental decisions.

MDLs are dependent on variables (temperature, instrument conditions, analysts, matrix, etc.) and are typically determined by processing, preferably over the course of several days, at least seven individual replicates of a fortified blank sample through the method's preparation and analytical schemes. MDLs determined for the same method / matrix / technology must be compared to ensure they are in agreement.

ACZ maintains a current MDL for each applicable method. A qualitative verification of the MDL must be performed annually for each applicable method, analyte, instrument, and matrix and before a new instrument or method is utilized for client samples. Refer to ACZ's SOP *Demonstration of Capability & Method Detection Limit Studies* (SOPAD001) for additional information.

14.3 Practical Quantitation Limit (PQL)

The PQL represents the lowest quantitative level that can be reported with a specified degree of confidence. Data reported at or above the PQL is considered reproducible, allowing for comparison of analytical results over a relatively long period of time, which is important to the monitoring of environmental data. ACZ *typically* defines the PQL as a value 2 – 10 times the MDL with an accuracy of 70 to 130% in a matrix free of interferents. The low calibration standard shall be at or below the PQL. Reported values less than the PQL are qualified as estimated. The region between the MDL and PQL is a continuum of uncertainty, lacking distinct cutoff points, and the error below the PQL is increased to the extent that the statistical validity of the result is questionable.

15 SAMPLE DILUTIONS

Sample dilution may be necessary for one or more of the following reasons: (1) sample concentration exceeds the established measurement range of the procedure/method; (2) sample volume or material is limited; (3) matrix interference is indicated or suspected; (4) sample matrix is reactive; (5) aqueous sample contains high sediment; (6) color, odor or other physical characteristics are present; (7) For ICP and ICPMS, TDS is greater than 2000 mg/L. In all cases, the analyst must use good professional judgment when determining the most appropriate dilution. Whenever possible, prepare and analyze client samples and any complimentary duplicates or spikes on the same dilution.

For samples that contain high concentration of analyte(s), the analyst will use their knowledge of the measurement range of the procedure to determine an optimal dilution that yields quantifiable data with minimal error propagation. In general, prepare the dilution so the final concentration is near the mid-point of the measurement range. A sample must be retested on a smaller dilution if analyte concentration is less than the reporting limit; exceptions must be explained on the bench sheet. For multi-parameter analyses, it may not be practical to report all analytes within the desired range, and the analyst must use their best judgment when determining a reasonable dilution factor.

The following requirements pertain to all dilutions:

- Document all dilution factors when the dilution is performed.
- Assign the appropriate “D” qualifier if data for the diluted sample is less than the quantitation limit
- Retest sample on smaller dilution if the result is less than the quantitation limit (or document justification for accepting the data on the bench sheet or data review checklist)
- Document the reason for any dilution on the bench sheet [not required for sample values that exceed the measurement range of the procedure]

16 ERROR CORRECTION PROTOCOL

When an error occurs in any type of record it must be crossed out with a **single line**. The error must not be erased, deleted, overwritten, obliterated, or made illegible. Alterations to make data legible are considered error corrections. The correct value must be entered alongside. All changes to hard copy records must be initialed and dated by the person making the correction. [7]Under no circumstances may White-Out® or any other substance be used to conceal data. Concealing or improperly altering data is fraudulent and may be grounds for termination from ACZ. Equivalent measures must be taken to avoid loss or change of original data in the case of records stored electronically. Refer to §10 for details of corrections made to electronic records. The following is an example of proper error correction:

fleece BWC 10-20-06
Mary had a little lamb, it's ~~feet~~ as white as snow. And everywhere that ~~Lary~~ went, the lamb was sure to go.
Mary BWC 10-20-06

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[7] There is one exception to this rule. Client identification may be obliterated from a record if it’s presence compromises client confidentiality (e.g. client ID is mistakenly entered in a logbook). In this event, the rationale for obliteration must be clearly stated and initialed and dated by the person making the correction.

17 COMPUTER / AUTOMATED PROCESSES

ACZ employs its proprietary LIMS (Laboratory Information Management System) to acquire, record, process, store, and archive data. LIMS is the primary application for all employees and encompasses the combination of hardware and software throughout the entire facility. Tasks performed with LIMS include but are not limited to creating workgroups, reviewing data, and generating client reports. ACZ implements the defined standards of Good Automated Laboratory Practices (GALP) to establish a uniform set of procedures to assure that all LIMS data used by our clients is reliable, credible, and legally defensible.

17.1 Software

The software used to achieve GALP goals is a combination of industry standard commercial off the shelf (COTS) software and internally developed applications. COTS software is purchased through professional and well-developed companies such as Oracle, Microsoft, and Lab Vantage Systems that complete sufficient testing and quality control to assure their products function properly. Internal applications undergo testing before being implemented and distributed throughout the laboratory.

Electronic records are protected, backed up, and archived to prevent unauthorized access or amendment. Refer to §10 of this document and ACZ's SOP *Backup and Archive of Instrument Data Files* (SOPAD044) for details.

17.2 Hardware

ACZ deploys many servers using industry standard architecture. All servers run standard enterprise operating systems such as Microsoft Windows Server and SuSE Linux. All data residing on network servers is routinely backed up.

To the extent possible, instrument PCs comply with at least the minimum recommendations of the instrument manufacturer and they are connected to ACZ's network. This allows transparent backup and access to computers by system administrators.

17.3 Security

GALP security is controlled through a set of passwords. A log-in name and password are required to access ACZ's network. User passwords must be at least five characters and must be changed when the user is prompted. Each user has a given set of network rights and is restricted to software necessary to complete their job functions as well as his/her own documents. Refer also to §10.7.1 for additional information.

A firewall protects the network from internet traffic. The only traffic permitted access to the internal network is protocols approved by ACZ such as IMAP, SMTP and HTTP. Incoming and outgoing E-mails are scanned for viruses and content. Email that fails this automated scan is quarantined for further review. Web traffic that is potentially harmful or inappropriate is automatically blocked by ACZ's proxy server.

17.4 Electronic Signatures

ACZ permits the use of electronic signatures to approve documentation produced by the laboratory and to enter contractual agreements. Electronic signatures meeting the following criteria are considered equivalent to a handwritten signature:

(1) Each electronic signature shall be unique to one individual and shall not be reused by, or reassigned to, anyone else.
(2) Signing shall be password protected.
(3) Signatures shall be embedded with a timestamp.
(4) Faxed handwritten signatures are considered equivalent to a wet signature unless proven unreliable.
(5) E-documents that contain contractual commitments must be signed by an officer of the company.

18 CLIENT SERVICES

18.1 Contracting Services

ACZ's sales representatives and project managers are responsible for reviewing requests, preparing quotes, and entering contractual commitments with clients. Prior to accepting new work, it must be verified that the laboratory has appropriate facilities and resources to meet client needs. To the extent possible and pragmatic, ACZ shall use the latest valid edition of a standard. This is dictated largely by what ACZ's accrediting authorities will issue certification for. Where an older standard is universally recognized by ACZ's accrediting authorities but the latest is not, ACZ will typically use the older standard. As necessary, sales representatives and project managers must collaborate with ACZ's Production Manager, QAO, and/or technical directors to evaluate laboratory capacity, capability, and resources. Refer to SOPAD043 for additional details.

18.2 Subcontracting

ACZ utilizes subcontract labs to perform analyses for various reasons. A subcontracted lab must meet the clients DQOs and laboratory certification requirements for the subcontracted analysis. When applicable, ACZ advises its clients in writing of its intentions to subcontract any portion of the testing to another party. Any non-accredited tests shall be clearly identified as such to the client. ACZ scans this report as an attachment to be included as part of ACZ's final report. A comment is added to ACZ's final report indicating which subcontracted laboratory performed the analyses, if the name is not indicated on the attachment. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

18.3 Data Reporting

Once all analyses and the entire review process have been completed, a client report is generated and submitted for final validation by the Project Manager. If necessary, a case narrative is written describing the details of the project and any non-conformances or other relevant issues. The PM electronically signs the report, and the Document Control department sends the report to the client in an electronic format. At a minimum, the following information appears on an ACZ analytical report:

Client Name
Client Address
Client Contact
Lab Sample ID
Client Sample ID
Client Project ID
ACZ Report ID
Date/Time Sampled
Date/Time Received
Date/Time Analyzed

Sample Matrix
Parameter/Analyte
Method Reference
Result
Units
LIMS Qualifier (U, B, J, H)
MDL or LLD
PQL
Analyst's Initials
Extended Qualifiers (as separate page)

A complete electronic data package contains the analytical reports, the external chain of custody records, sample shipping documentation, and any other relevant project information. Department Reference Sheets explaining acronyms, qualifiers, and method references are also included. All of these documents are an integral part of the final data package and must always be viewed as a whole. To prevent the separation of reports, each page identifies the project number, the sequential page number, and the total number of pages in the data package. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

If requested by a client, custom and standard Electronic data deliverables (EDDs) are generated by the Document Control department. These deliverables, containing data in client specified format, are sent by e-mail with the client report. EDDs and analytical reports access data from the same Oracle tables, thus eliminating the possibility of inconsistent results. Refer to ACZ's SOP *Client Service Policies and Procedures* (SOPAD043) for more detail.

Results may be reported in a simplified manner for internal customers or in accordance to a written agreement with a customer.

18.3.1 ACZ Report Packages

ACZ provides different levels of data packages based on client request. ACZ defines the different levels as follows:

Level 2: Standard analytical reports

Level 3: Standard analytical reports; Electronic Data Deliverable (EDD); Standard QC summary

Level 4A: Standard analytical reports, Extended QC Summary (standard QC plus calibration verification checks, interference checks and serial dilutions) EDD, raw data and run logs. This package can be provided either on a disk or in a full paginated data package with the raw data

Level 4B: “CLP like” data package: CLP like forms 1-12; Run Logs and raw data incorporated into the full paginated data package.

NOTE: Surcharges apply for non-standard reports.

18.4 Data Confidentiality

ACZ has an obligation to each client to maintain custody of samples, data, and reports and to keep all data or other information confidential. To uphold this responsibility, ACZ retains custody of the information at all times – data or other client information obtained by ACZ is not allowed to leave the premises. This includes but is not limited to Chains of Custody, raw data, workgroups, run logs, logbooks, reports, QC summaries, data packages and other media containing data. Client data cannot be released to anyone except the client (as directed on the Chain of Custody) or the client’s designated representative, and project data, including any client information, is not to be discussed with anyone other than ACZ employees and/or the client without first receiving written permission from the client. Additionally, client-specific information is not to be documented on raw data, workgroups, logbooks, or other records that may be provided to any client as part of an extended data package. All information must be referenced using only the ACZ log-In number. Refer to ACZ’s SOP *Data Integrity Principles and Policies* (SOPAD039) for additional details of policies pertaining to confidentiality.

External access to the ACZ network is limited to employees that may need to access information remotely. Employees requiring such access use ACZ's Virtual Private Network (VPN). The VPN client is setup on the employee's computer so that it adheres to ACZ security standards. These standards include (1) a unique user name (2) a password with at least 12 characters, and (3) 128 bit encryption of data to and from the client from the ACZ servers. After the VPN server has authenticated the employee, the employee must logon to the ACZ domain through normal domain security in order to access any ACZ network resources. Most employees initiate a "Remote Desktop" connection to their office PCs, thus ensuring that ACZ data is never accessible from the client PC hard drive.

18.5 Client Feedback

Handling client feedback is a joint effort between QA, Project Managers, Laboratory Department Supervisors, and Client Service representatives. If a client has a concern or complaint, either a Project Manager or Client Service Representative takes the call and initiates the feedback procedure by documenting the complaint or problem and requesting the assistance of the Laboratory Department Supervisor and/or QA Officer. If the issue cannot be easily resolved, then it must be documented using FRMAD024, which is routed from the initiator to other appropriate parties, including the QAO if necessary. All client feedback is submitted to management as part of the Management Review of the Quality System. Refer to ACZ’s SOP *Client Service Policies and Procedures* (SOPAD043) for additional information.

19 FACILITIES

ACZ Laboratories, Inc. inhabits a modern 31,000 square foot laboratory facility architecturally designed and specifically organized to ensure efficient operation and meet the needs of a large capacity analytical laboratory. Complete lists of instrumentation, balances, thermometers, & weight sets are maintained on a network drive. Incompatible activities are effectively separated. Refer to FRMQA066 for ACZ's floor plan.

19.1 Accommodation of Environmental Test Conditions

19.1.1 Temperature and room pressure are controlled by an HVAC system which maintains 19 independent zones. The clean room, metals lab, and organic instrument lab are kept under positive pressure to prevent contaminant infiltration. The radiochemistry and organic prep labs are kept under negative pressure to prevent the migration of fire, smoke, and chemical releases from the laboratory space. All other zones are maintained at a neutral pressure.

19.1.2 In humid environments, a sudden rise in temperature can result in condensation on microcircuitry leading to problems such as reduced life cycle, inaccurate readings, corrosion, etc. Due to the laboratory's location at 6730 feet above sea level, these concerns are irrelevant and humidity monitoring is only required for desiccators and the clean room.

19.1.3 Servers have a 20 minute backup power supply. If there is an interruption in power, the IT Manager receives a text. This provides sufficient time to ramp down the servers.

19.2 Security

A secure facility is essential to maintaining sample and data integrity and to providing safety to employees and visitors. ACZ has an electronic security system, which controls and limits access to only authorized personnel. The following steps have been taken to ensure this security:

- All entryways are secured. ACZ has three entries equipped with proximity readers which allow access to an employee only after he/she presents their access card. Access to the front visitor entry is controlled by an interior push button monitored by ACZ staff.
- All employees are required to use their access cards to enter and exit the building.
- If any employee does not have their access card, they must sign in at the front desk. This ensures a record is maintained of which personnel were in the building at any time. A temporary access card will then be activated and issued to the employee for the day. These access cards are identified by the word "Temporary" written on a scenic background.
- During normal business hours, public access into the building can be made at the front entrance and the west shipping entrance. Both doors are equipped with a buzzer.
- Visitors must enter and exit through the main entrance and must sign the register at the front desk upon arrival and before departure. A visitor pass is issued at sign in and collected at sign out. There are two types of visitor passes. A red pass identified by the word "Visitor", will not function as an access card and symbolizes the visitor requires an escort. The other visitor pass is identified by the word "Visitor Pass" written on a scenic background and will not function as an access card. This visitor does not require an escort. The determination of which pass the visitor gets is made first, by the visitor's trust level and, second, by the visitors access needs. Visitor passes must be collected when the visitor leaves for the day.
- Companies or individuals under contract to perform recurring or extensive work for ACZ are assigned an access card similar to employees. Contractor passes function as an access card for a defined period of time commensurate with the contract work.
- Emergency Exit doors are to be used only for emergency purposes. If a door is opened, an alarm will sound.
- Loaning or transferring access cards to anyone, including other ACZ employees, is prohibited.

20 RADIOCHEMISTRY

20.1 DATA TRANSFORMATION

ACZ's radiochemistry department utilizes excel spreadsheets to transform instrument response into final results. Spreadsheet equations are locked and password protected in order to reduce the likelihood of inadvertent modifications. Additionally, spreadsheet equations are validated by the radiochemistry supervisor or a sufficiently experienced analyst on an annual basis. Initial validation must be performed by hand calculating results. Annual validation may be performed by populating the current template with data that has been hand calculated in a previous validation and comparing the calculated results from the current template to the hand calculated results from the previous validation. Documented secondary review is required for all updates to spreadsheet templates (e.g. incorporating new mass attenuation coefficients).

20.2 INSTRUMENTATION

Radioanalytical instrumentation is located adjacent to the radiochemistry prep lab. In order to maintain appropriate temperature control in the instrument lab, separation must be maintained. The door between the two lab areas must be kept closed when not in use. Except as noted, instrument checks and other determinations must be performed and documented annually, or more often if necessary.

NOTE: To eliminate potential contamination, planchets must be stored in a covered container or in a drawer.

20.2.1 Gas-Flow Proportional Counter

20.2.1.1 Instrument Reliability Test (Voltage Plateau Determination) – The proper voltage plateau for alpha and beta is where the counting rate is consistent (should not exceed > 5% over a 150 volt change in anode voltage).

20.2.1.2 Cross Talk (Carryover) Check - Cross talk is defined as the percentage of alpha counts represented on the beta plateau. Once the amount of cross talk is determined, the cross talk settings are adjusted on the instrument to eliminate cross talk.

20.2.1.3 Detector Efficiency Curve (Self Absorption) - Efficiency curves are graphs plotting counts versus sample residue density and determine the efficiency of the alpha and beta counter as a function of sample residue density. This factor is part of the overall determination of sample activity.

20.2.1.4 Background Determination - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. The background is determined weekly by counting an empty planchet for 12 hours. On each day of use the instrument is checked for background drift by counting an empty planchet for 90 minutes. Background counts must fall within established control chart limits or corrective action must be taken before analyzing samples. Although most radiation measurement systems are noteworthy for their stability, sudden changes can occur due to instrument component failure, loss of gas pressure, vacuum, or contamination of a detector or sample chamber from a high activity sample. Subsequently, instrument drift in detector efficiency and background must be checked both before and after measuring samples used for drinking water compliance monitoring. Refer to individual test SOPs for additional details.

20.2.1.5 Instrument-Response Check (Performance Check) – This continuing calibration check verifies the instrument response and stability and is performed daily for each detector. For a performance check measurement, the same calibration sources must be used as for the calibration measurement in order to verify the current measuring results still match the results of the calibration measurement stored last. At the end of the check the count rates and the relative deviations from older calibration measurements are displayed. The system signals

"OK" if the deviations do not exceed the maximum deviation defined by the user. Samples used for drinking water compliance monitoring must be bracketed by passing performance checks. Refer to individual test SOPs for additional detail.

20.2.2 Liquid Scintillation Counter

20.2.2.1 *Optimal Window* - When determining radionuclides by liquid scintillation, it is necessary to select the optimal window by counting a standard for five minutes and generating a sample spectrum. For better clarity, a log scale for the channel number axis should be used. On the graph, the region of interest is determined by the energy of the peak one is trying to quantitate. The optimal window is formed by extending this region by 10% on each side of the alpha peaks.

20.2.2.2 *Efficiency Quench Curve* – The liquid scintillation instrument, a Beckman LS 6000TA, automatically corrects for quenching by the H - Method. Refer to SOPRC010 for details.

20.2.2.3 *Background Check* - Three background blanks are run with every batch. The first two are run immediately after calibration. The third, the CCB, is employed as a measurement of instrument drift and is run immediately before the final LCS. For both checks, the counting duration must be equivalent to the longest sample counting duration.

20.2.2.4 *Instrument-Response Check Source* - This continuing calibration check verifies instrument response and stability and must be performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a new efficiency curve, background checks, and/or instrument maintenance. If insufficient data exists for control charts, ±10% of the initial source value is considered acceptable. The source for this check is a Tritium standard.

20.2.3 Alpha Spectrometer

20.2.3.1 *Energy vs. Channel Calibration* - Each alpha spectrometer has a set number of channels associated with it. To associate these channels to a specific alpha particle, the channels must be calibrated. One known calibrated solid source is placed into the detector and analyzed for five minutes to determine its associated channel to its calibrated energy peak. Since the energy is linear across the channels, all of the channels now have an associated energy. This determination is performed on an annual basis, or whenever maintenance is performed that could potentially affect the calibration.

20.2.3.2 *Background Checks* - Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. Placing an empty sample tray in the counting chamber and counting it for as long as the longest sample-counting duration can determine the background rate (or a background check can be completed overnight). An overnight background determination must be completed at least quarterly.

20.2.3.3 *Instrument-Response Check Source* - This continuing calibration check verifies the instrument response and stability and is performed daily. If the source count is within two standard deviations (sigma) of the previously determined average count rate, instrument reliability and stability is established. If the source rate is outside the ±2 sigma-warning limit, then the variability should be further investigated. If the source check is outside the ±3 sigma out of control limits, then no further samples should be analyzed until the problem is resolved. Resolution might include a background check, and/or instrument maintenance. If insufficient data exists for control charts then ±10% of the true value is considered acceptable.

20.2.4 Gamma Spectrometer

20.2.4.1 *Background Checks* –Characteristic of most detectors is a background or instrument count rate attributed to cosmic radiation, radioactive contaminants in instrument parts, counting room construction material and/or the proximity of radioactive sources. A cave background must be measured monthly and the background gross activity recorded. The cave background is determined by counting the empty cave for a period of time at least as long as the longest sample-counting duration. When drinking water samples are present in the batch, and additional background check is measured at the end of the batch to monitor instrument drift.

20.2.4.2 *Instrument-Response Check (Performance Check)*- The total activity of a calibration or check source will check the efficiency calibration currently in use and the general operating parameters of the system, including source positioning, contamination, library values, and energy calibration. This activity calculation uses the general analysis program to ensure that the total system is checked. This check is performed for every workgroup. If the performance check is within the defined acceptance limits, instrument reliability and stability is established. If the performance check does not meet acceptance criteria, then no further samples should be analyzed until the problem is resolved. Samples used for drinking water compliance monitoring must be bracketed by acceptable performance checks. Resolution might include a background check, and/or instrument maintenance. Refer to SOPRC016 for additional information.

21 CERTIFICATIONS

ACZ has primary or secondary (reciprocal) certification with numerous states and EPA regions. Current certificates can be viewed at http://acz.com/certifications/. Each certificate contains a scope of accreditation listing each method the laboratory is accredited for by the issuing authority.

APPENDIX A REFERENCES UTILIZED BY ACZ

- “TNI Standards,” National Environmental Laboratory Accreditation Conference, (current version).
- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," USEPA, Federal Register Vol. 67, No. 205, October 23, 2002.
- "Manual for the Certification of Laboratories Analyzing Drinking Water," USEPA, (current version).
- "Methods for the Chemical Analysis of Water and Wastes," USEPA, EPA-600/4-79-020, March 1983.
- "Test Methods for Evaluating Solid Waste," USEPA, SW-846 Third Edition, Update IV, January 2008.
- “Guidelines in Establishing Test Procedures for the Analysis of Wastewater Pollutants,” Code of Federal Regulations 40, Parts 136, 141, 143.
- "Quality Assurance of Chemical Measurements,” Taylor, J., Lewis Publishers, Michigan, 1987
- "Annual Book of Standards, Water Analysis," ASTM, 1989.
- "Quality Control in Analytical Chemistry," Kateman, G., Vol. 60, 1985.
- "Principles of Environmental Analysis, Analytical Chemistry," Keith, L.H., et al., Vol. 55, 1983.
- "Handbook for Analytical Quality Control in Water and Wastewater Laboratories," USEPA, 1979.
- “Guidance for the Data Quality Assessment: Practical Methods for Data Analysis,” USEPA, EPA 600/R-96-084, July 2000.
- “Methods for the Determination of Metals in Environmental Samples,” USEPA, EPA 600/4-91-010, June 1991.
- “Methods for the Determination of Metals in Environmental Samples,” Supplement I [to EPA 600/4-91-010], USEPA, EPA 600/R-94-111, May 1994.
- “Methods for the Determination of Inorganic Substances in Environmental Samples,” USEPA, EPA 600/R-93-100, August 1993.
- "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," USEPA, EPA 821/B-96-005, December 1996.
- "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," USEPA, EPA 600/4-80-032. August 1980.
- “Determination of Lead-210, Thorium, Plutonium and Polonium-210 in Drinking Water: Methods 909, 910, 911, 912,” 01A0004860 (Region 1 Library), March 1982.
- “Good Automated Laboratory Practices - Principles and Guidance to Regulations for Ensuring Data Integrity in Automated Laboratory Operations” USEPA, 2185, 1995.
- “Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications”, ASTM E29-08

APPENDIX B DEFINITIONS OF TERMS

Acceptance Criteria: specified limits places on characteristics of an item, process, or service defined in requirement documents.

Accreditation: verification by a competent, disinterested, third party that a laboratory possesses the capability to produce accurate test data, and that it can be relied upon in its day-to-day operations to maintain high standards of performance.

Accrediting Body: The Territorial, State, or Federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation.

Accreditation body: Authoritative body that performs accreditation.

Accuracy: the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.

Aliquot: A discrete, measured, representative portion of a sample taken for analysis.

Analyte: The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family, and which are analyzed together. (EPA Risk Assessment Guide for Superfund; OSHA Glossary)

Analytical Spike (AS): an aliquot of client sample to which a known amount of target analyte is added and that demonstrates the absence or presence of interference in the matrix. The AS is prepared exactly the same way as the LFB, only spiking into sample instead of reagent blank, and is not prepped (digested) prior to analysis. The AS may also be referred to as a post-digestion spike.

Analytical Spike Duplicate (ASD): a second replicate analytical spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Analytical System: the combination of events, techniques, and procedures used to generate analytical results.

Analyst Review (AREV): See Primary Review.

Atomization: A process in which a sample is converted to free atoms.

Audit: a systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity.

Batch: environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same matrix, meeting the above criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of 20 or less prepared environmental samples (extracts, digestates or concentrates) that are analyzed together as a group. QC samples (e.g. LCS, MS, MSD) do not count towards the maximum of 20.

All required QC samples must be prepared and/or analyzed with each batch at the frequency required by the method, even if there are less than 20 client samples in the batch. If the workgroup has more than 20 samples, then sufficient batch QC must be analyzed for additional samples. Every batch of environmental samples is assigned a unique (i.e. traceable) six-digit numerical identifier called the LIMS Workgroup number.

Blank: a sample that has not been exposed to the analyzed sample stream utilized to monitor contamination during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. See also Equipment Blank, Field Blank, Instrument Blank, Method Blank, Reagent Blank. Refer to §11.3 for types of blanks.

Blind Sample: a sub-sample for analysis with a composition known to the submitter. The analyst or laboratory may know the identity of the sample but not its composition. It is used to test the analyst or laboratory's proficiency in the execution of the measurement process.

Calibration: to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument, or other device. The levels of applied calibration standard should bracket the range of planned or expected sample measurements.

Calibration Curve: the graphical relationship between the known values, such as concentrations, or a series of calibration standards and their instrument responses.

Calibration Range: The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.

Case Narrative: Additional documentation provided in the client report that describes any abnormalities and deviations that may affect the analytical results and summarizes any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data.

Certified Reference Material (CRM): A reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body.

Chain of Custody Form: a legal record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; the collector; time of collection; preservation; and requested analyses.

Client: Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations. (ANSI/ASQ E4-2004)

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to:

- Second column confirmation;
- Alternate wavelength;
- Derivatization;
- Mass spectral interpretation;
- Alternative detectors; or
- Additional cleanup procedures. (TNI)

Conformance: An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements. (ANSI/ ASQC E4-1994)

Congener: A member of a class of related chemical compounds (e.g., PCBs, PCDDs)

Continuing Calibration Blank (CCB): the same solution as the calibration blank, it detects baseline drift in the calibration of the instrument. When specified by the method, analyze a CCB immediately after each CCV, including the final CCV.

Continuing Calibration Verification (CCV): a solution of method analytes of known concentrations used to confirm the continued calibration of the instrument. The CCV is analyzed at the frequency indicated in the test SOP.

Corrective Action: the action taken to eliminate the causes of an existing nonconformity, defect, or other undesirable situation in order to prevent recurrence.

Data Audit: a qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e. the data meet specified acceptance criteria)

Data Reduction: the process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form.

Definitive Data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Suitable for final decision-making. (UFP-QAPP)

Demonstration of Capability (DOC): a procedure to establish the ability of the analyst to generate acceptable accuracy [and precision, if applicable].

Detection Limit: the lowest concentration or amount of target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value (see Method Detection Limit).

Digestion: A process in which a sample is treated (usually in conjunction with heat) to convert the sample to a more easily measured form.

Document Control: the act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly, and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Eluent: A solvent used to carry the components of a mixture though a stationary phase. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Elute: To extract; specifically, to remove (adsorbed material) from an adsorbent by means of a solvent. (Merriam-Webster's Collegiate Dictionary, 2000)

Elution: A process in which solutes are washed though a stationary phase by the movement of a mobile phase. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Equipment Blank: a sample of analyte-free media that has been used to rinse common sampling equipment to check the effectiveness of decontamination procedures.

False Positive (Type I or alpha error): concluding that a substance is present when it truly is not.

False Negative (Type II or beta error): concluding that a substance is not present when it truly is.

Field Blank: a blank prepared in the field by filling a clean container with Type I water and appropriate preservative, if any, for the specific sampling activity being undertaken.

Holding Time (Maximum Allowable Holding Time): the maximum time that samples may be held prior to analysis and still be considered valid or not compromised.

Homologue: One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, CH3OH (methanol), C2H5OH (ethanol), C3H7OH (propanol), C4H9OH (butanol), etc., form a homologous series. (*The Condensed Chemical Dictionary* G.G. Hawley, ed. 1981)

Initial Calibration Blank (ICB): a solution identical to the calibration blank and confirms the absence of background contamination in the calibration blank. When specified by the method, an ICB is analyzed immediately after the ICV.

Initial Calibration Verification (ICV): a solution of method analytes of known concentrations intended to determine the validity of the instrument calibration. The ICV must be analyzed immediately after each calibration and must be prepared from a source independent of the calibration standards, preferably purchased from a different manufacturer.

Instrument Blank: an aliquot of Type I water or solvent processed through the instrument steps of the measurement process; used to determine presence of instrument contamination.

Interference, spectral: Occurs when particulate matter from the atomization scatters the incident radiation from the source or when the absorption or emission of an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Interference, chemical: Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Internal Standard (IS): a known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Isomer: One of two or more compounds, radicals, or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane. (Websters)

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.

Laboratory Fortified Blank (LFB): a reagent blank spiked with a known concentration of analyte. The LFB is analyzed exactly like a sample and determines whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

Legal Chain of Custody Protocols: procedures employed to record the possession of samples from the time of sampling until analysis and are performed at the special request of the client. These protocols include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Linear Dynamic Range (LDR): concentration range over which the instrument response to analyte is linear.

Matrix Duplicate (DUP): a second aliquot of a client sample that is prepared and analyzed in the same manner as all other samples in the same workgroup. The DUP demonstrates the precision of the method.

Matrix Spike (spiked sample or fortified sample): a sample prepared by adding a known amount of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes (MS or LFM) are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate: a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

Maximum Contamination Limit (MCL): the numerical value expressing the maximum permissible level of contaminant in water that is delivered to any user of a public water system.

May: denotes permitted action, but not required action.

Measurement Quality Objectives (MQOs): The desired sensitivity, range, precision, and bias of a measurement.

Measurement System: A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s).

Method Blank: a sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as client samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for the sample analyses.

Method Detection Limit: the minimum concentration of an analyte, in a given fortified matrix, that can be measured and reported with 99% confidence that the concentration is greater than zero.

Method of Standard Additions: A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is often called spiking the sample.) (Modified Skoog, Holler, and Nieman. Principles of Instrumental Analysis. 1998)

Must: denotes a requirement.

Negative Control: Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.

Nonconformance: An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.

Outlier (Statistical): an observation or data point that deviates markedly from other members of the population.

Performance Audit: the routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.

Positive Control: Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.

Precision: the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample.

Primary Review (AREV): The first level of data review conducted after data has been generated and uploaded to LIMS. Primary review is typically conducted by the analyst who generated the data but may be performed by another authorized individual. Quality control and corrective actions are evaluated as part of this review. Where acceptance criteria fails, samples are scheduled for re-preparation and/or re-analysis or data is appropriately qualified.

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories. (TNI)

Proficiency Testing Study Provider: Any person, private party, or government entity that meets stringent criteria to produce and distribute TNI PT samples, evaluate study results against published performance criteria and report the results to the laboratories, primary accrediting authorities, PTOB/PTPA, and TNI.

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria. (QAMS)

Protocol: a detailed written procedure [SOP] for laboratory operation that must be strictly followed.

Quality Assurance: an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality.

Quality Control: the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality Manual [QAP]: a document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

Quality System: a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control.

Quantitation Limit [Limit of Quantitation, Practical Quantitation Limit]: level, concentration, or quantity of a target variable (i.e. target analyte) below which data is reported as estimated. The quantitation limit may or may not be statistically determined, or may be an estimate that is based upon analyst experience or judgment.

Quantity Sufficient (QS): Refers to the addition of appropriate diluent to the solution to achieve the final volume.

Raw Data: any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for reconstructing and evaluating the report of the activity or study.

Reagent Blank (method reagent blank): a sample consisting only of Type I water and reagent(s) without the target analyte(s) or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

Reference Method: a method of known and documented accuracy and precision issued by an organization recognized as competent to do so (EPA, etc.). The reference method is included on the client report.

Reporting Limit (RL): The lowest analyte level (concentration or mass) the laboratory will report as a detected result. ACZ's default reporting limit is the MDL; however the RL may be defined as the PQL or another level dependent on project needs.

Retention Time: The time between sample injection and the appearance of a solute peak at the detector. (Skoog, West, and Holler. *Fundamentals of Analytical Chemistry*. 1992)

Sample: Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis

Sample Tracking: procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include the use of a Chain of Custody form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

Secondary Review (SREV): The second level of data review conducted after primary review (AREV) has been completed. Secondary review is typically conducted by the pertinent department supervisor but may be performed by another authorized individual. Quality control and corrective actions are evaluated as part of this review. Data qualifiers and sample statuses assigned at AREV are evaluated and corrected if necessary.

Selectivity: (Analytical chemistry) The capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances. (EPA-QAD)

Sensitivity: the capability of a method or instrument to discriminate between measurement responses representing different levels (i.e. concentrations) of a variable of interest.

Shall: denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there is no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled.

Should: denotes a guideline of recommendation whenever noncompliance with the specification is permissible.

Signal to Noise Ratio (S/N): a dimensionless measure of the relative strength of an analytical signal (S) to the average strength of the background instrumental noise (N) for a particular sample.

Spike: a known amount of target analyte added to a blank sample or client sub-sample; used to determine the recovery efficiency or for other quality control purposes.

Standard Deviation: the measure of the degree of agreement (precision) among replicate analyses of a sample. The population standard deviation (n degrees of freedom) should only be used for more than 25 data points; otherwise, when referenced, standard deviation implies sample standard deviation (n-1 degrees of freedom).

Standard Operating Procedure (SOP): a written document which details the manner in which an operation, analysis, or action is performed. The techniques and procedures are thoroughly prescribed in the SOP and are the accepted process for performing certain routine or repetitive tasks.

Supervisor [however named]: the individual designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training, and experience to perform the required analyses.

Surrogate (SURR): a substance with properties that mimic the analyte of interest. It is unlikely to be found in environmental samples and is added to them for quality control purposes.

Test Method: adoptions of a scientific technique for a specific measurement problem, as documented in a laboratory SOP or published by a recognized authority.

The NELAC Institute (TNI): a voluntary organization of state and federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories.

Traceability: the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Validation: The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: Confirmation by examination and provision of evidence that specified requirements have been met.

APPENDIX C TECHNICAL DIRECTORS

Name	Department	Degree
Steve Pulford	Metals	BS, Chemical Engineering, Minor in Biochemistry
Gus Torde	Organics	BS, Chemistry
Alyssa Dybala	Wet Chemistry	BS, Pharmaceutical Marketing
Matt Sowards	Radiochemistry (reserve)	BA, Neuroscience
Brian Uhrig	Wet Chemistry	BS, Biological Sciences
Brett Dalke	Geochemistry	BA, Geology & English
Mark McNeal	Radiochemistry	BS, Biology
If a technical director is absent for a period exceeding fifteen calendar days, another qualified full time employee shall be assigned to temporarily fulfill the duties of technical director. Defined reserve technical directors shall assume these duties by default. Where reserves are not yet defined, management shall appoint a qualified individual as necessary. If a technical director is absent for more than 34 days, it is the QAO's (or delegee's) responsibility to notify accrediting bodies in writing.		

2017 Multi-Media Investigation Work Plan Mayflower Tailings Impoundments Area

APPENDIX B - Health and Safety Plan (HASP)

April 2017

Prepared for:

Sunnyside Gold Corporation
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Prepared by:

FORMATION
ENVIRONMENTAL

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LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATV	All-Terrain Vehicle
CPR	Cardiopulmonary Resuscitation
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
IDLH	Immediately Dangerous to life or Health
JSA	Job Safety Analysis
MSDS	Material Safety Data Sheet
NIOSH	National Institute of Occupational Safety and Health
OHV	Off-Highway Vehicle
OSHA	Occupational Health and Safety Association
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
SHSO	Site Health and Safety Officer
SOP	Standard Operating Procedures
SPF	Sun Protection Factor
STEL	Short-Term Exposure Limit
TLV	Threshold Limit Value
TWA	Time Weighted Average
UTV	Utility-Terrain Vehicles
UV	Ultraviolet

1.0 INTRODUCTION

This Health and Safety Plan (HASP) establishes policies and procedures to protect workers from the potential hazards posed by field activities associated with environmental sampling of various media in and around the Mayflower Tailings Impoundments and surrounding area (Site) including the Animas River. The project area is located near Silverton, Colorado (Figure 1).

The HASP assigns personnel responsibilities, prescribes mandatory operating procedures, establishes personal protective equipment (PPE) requirements, and describes actions to be taken during a site emergency. The HASP has been prepared to comply with the requirements of 29 CFR 1910.120 (b)(4) and the requirements of the Environmental Protection Agency (EPA) Occupational Health and Safety Manual. In addition, the EPA Interim Standard Operating Safety Guide will be followed during site activities.

The provisions of this plan are mandatory for all personnel assigned to the project, including all employees of Formation Environmental, and will serve as a guideline for subcontractors and visitors. A copy of this plan will be made available to all personnel, contractors, subcontractors, and authorized visitors that may enter work areas. This plan does not apply to the EPA or State of Colorado personnel or their on-site representatives.

Formation Environmental personnel working at the site must have received the Occupational Safety and Health Administration (OSHA) HAZWOPER training (29 CFR 1910.120(e)(3)) as applicable. HAZWOPER training certificates will be maintained on-site by the Site Health and Safety Officer (SHSO). Those personnel must be involved in the communication and understanding of potential chemical hazards through a Hazard Communication Program in accordance with the provisions of the OSHA Regulations 29 CFR 1910.1200.

This plan also provides for alternative procedures to address changing situations that may arise during field operations. This plan shall be present and readily available during all on-site activities. All personnel working on or visiting work areas shall be briefed on the HASP and adhere to all provisions of this plan. Any supplemental plans used by subcontractors shall conform to this HASP as a minimum.

All project-related personnel on-Site, including contractors, shall be informed of the Site emergency response procedures and any potential fire, explosion, health, or safety hazards of the operation. This HASP summarizes those hazards and defines protective measures.

This plan must be reviewed and an agreement to comply with the requirements must be signed by all personnel prior to performing field work at the Site.

During development of this plan, consideration was given to current safety standards as defined by the EPA, OSHA, and the National Institute of Occupational Safety and Health (NIOSH), health effects, and standard for known contaminants, and procedures designed to account for the potential for exposure to unknown substances. The following reference sources have been consulted:

- OSHA 29 CFR 1910.120 and EPA 40 CFR 311;
- OSHA/NIOSH/EPA/United States Coast Guard Occupational Health and Safety Guidelines;
- NIOSH Pocket Guide to Chemical Hazards; and
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values.

This plan has been developed using the historical information and the analytical data available. As additional information is collected, this HASP may be updated to reflect new hazard analysis and new health and safety program requirements.

Overall Hazard is: High: ________ Moderate: __________

Low: ___X_____ Unknown: _________

1.1 Site Description

As shown on Figure 2, the study area in the upper Animas River Valley extends along the river and the floodplain from just upstream of the confluence of the upper Animas River and Arrastra Creek downstream to the 14th Street bridge crossing in Silverton.

There are four Mayflower Tailings Impoundments and they are located approximately one mile to the northeast and upstream of Silverton on the right bank of the Animas River. Tailings Impoundment No. 1 is the most upstream, and subsequent impoundments are numbered in the downstream direction (Figure 2). Presently the impoundments are dry and support a sparse vegetative cover.

Extensive historic mining and milling activity occurred throughout the upper Animas River basin over the past 150 years, including areas upstream of the Mayflower Tailings Impoundments. Discharging mine adits and historic mine waste rock piles are present at numerous locations, and historic mills typically discharged tailings to the Animas and its tributaries. As a result of the historic mining and milling activities, concentrations of metals such as aluminum, cadmium, iron, manganese, and zinc have historically exceeded their respective Colorado water quality standards for reach of the Animas River that is within the study area. Elevated metals concentrations in the Animas River have been documented to occur in the vicinity of the Mayflower Tailings Impoundments.

1.2 Project Description

Formation is performing investigational sampling within the Study Area. Field activities associated with the sampling will include field measurements of stream flow, drilling and monitoring well construction, groundwater level measurements, and the collection of groundwater, surface water, pore water, sediment, and other solid phase media (e.g., soil, mine waste, mineralized rock) samples laboratory analysis.

1.3 Plan Revisions

The procedures presented herein are intended to serve as guidelines. They are not a substitute for the sound judgment of on-site personnel. Work conditions may change as the project progresses. As appropriate, the plan will be modified by the Project Manager and reissued. Prompt notification of changing work conditions requiring possible modification of this plan is the responsibility of the Project Manager. Additional field tasks with unique hazards or risks may also require changes to this plan. In addition, procedures and equipment specified in this plan will be reviewed and updated as new technologies and equipment are developed. In any event, no changes to this plan will be implemented without prior approval of the Project Manager.

HASP Attachment 1 will be reserved for HASP addenda. The addenda will be identified by letter and will refer to the latest current revision of the plan (e.g., the first addendum to this plan will be Addendum 1A). Each person with a copy of this plan will be provided with each addendum. A list of those persons who have a copy of this plan will be kept by the Field Supervisor.

2.0 KEY PERSONNEL

The names and contact information of key project personnel are shown in Table 1.

Table 1: Key Project Personnel

Key Personnel	Name	Affiliation	Work Phone	Other Phone
Project Manager	Brian Hansen	Formation Environmental	303-442-0267	720-635-6911
Field Supervisor	Patrick Lennberg/Nat Beal	Formation Environmental	303-442-0267	512-659-2990
Health and Safety Officer	Patrick Lennberg/Nat Beal	Formation Environmental	303-442-0267	512-659-2990

2.1 Project Manager

The Project Manager will coordinate all Site activities for the project. The Project Manager will have the responsibility to interface with any regulatory agency personnel and to ensure that appropriate reporting occurs.

The Project Manager’s responsibilities include the following:

- Overseeing project implementation;
- Primary point of contact with regulatory agency personnel;
- Decisions of changes to the HASP; and
- Coordinating with the Field Supervisor and Health and Safety Officer on project health and safety requirements.

2.2 Field Supervisor

The Field Supervisor will be designated as the person responsible for oversight of the project implementation, including all health and safety activities. The Field Supervisor will have the responsibility for implementation of the HASP during actual field operations. His responsibilities include the following:

- Conducting the pre-entry briefing with field personnel;
- Informing personnel involved in the field operations of the proper procedures during emergencies;
- Immediately reporting any unusual or unsafe conditions to the Project Manager;

- Verifying that all employees under his or her leadership work in a safe manner according to Simplot policies and this HASP;
- Providing a copy of the HASP to all contractors, and informing them or their representatives of any potential safety hazards that exist on-Site or that may be identified during normal operations;
- Observing work party members for symptoms of overexposure or stress;
- Conducting daily tailgate safety meetings;
- Performing Site audits to verify adherence to the requirements of the HASP; and
- Modifying health and safety equipment or procedures based on data gathered at the worksite.

2.3 Health and Safety Officer

The Health and Safety Officer will be supervising for all health and safety activities during the project implementation. The Health and Safety Officer will report directly to the Field Supervisor when sampling activities are occurring if these roles are not undertaken by the same person. Specific responsibilities include:

- Participating in the preparation of and implementation of this HASP;
- Conducting initial briefings for personnel beginning work at the Site. Personnel will supply copies of all training, medical surveillance, and fit testing documentation. Such documentation will be reviewed and maintained by the Health and Safety Officer;
- Available for daily tailgate safety meetings (meetings will be documented [attendees and safety issues discussed] and documentation maintained on-Site). The Daily Pre-Work/Job Site Assessment form is provided as HASP Attachment 2;
- Informing personnel involved in the field operations of the proper procedures during emergencies;
- Ensuring that personnel involved in this project are aware of the provisions of this HASP;
- Informing and reminding personnel of the potential hazards associated with this project;
- Ensuring that field personnel receive Site-specific training the first day on-Site;
- Selecting appropriate protective clothing and equipment;
- Monitoring on-Site intrusive operations and conditions;
- Immediately reporting any unusual or unsafe conditions to the Field Supervisor;

- Coordinating emergency procedures, evacuation routes, and calling the appropriate emergency contacts; and

- Approving this plan and making any updates or changes based on experience at the Site or new data gathered.

2.4 Project Staff Responsibilities

Specific responsibilities for all field personnel involved with the project include:

- Complying with the plan;

- Administering necessary precautions to minimize injury or chemical exposure to themselves or other personnel; and

- Notifying the Field Supervisor or Health and Safety Officer of unsafe or potentially unsafe conditions, as well as of any accidents or injuries.

2.5 Contractors

Contractors and third party contractors shall bear the ultimate responsibility for all matters dealing with safety in the performance of their work. This responsibility includes the safety of all persons and property and any and all employees of contractors that may perform work on their behalf. This requirement will apply continuously regardless of time or place, and will in no way be altered because Formation Environmental personnel provide general directions as to the location where work should be performed and/or samples taken. The contractor, their employees and any and all employees of subcontractors that may perform work on their behalf may be required to work with potentially hazardous substances. The Health and Safety Officer will, to the best of his or her ability, inform contractors or their representatives of any potential electrical, fire, explosion, health, or other safety hazards that have been identified during operations. A copy of this HASP shall be made available to all contractors performing project-related work at the Site.

3.0 HAZARD EVALUATION

The major goal of the procedures defined in this HASP is to protect the workers from physical and chemical hazards that may be encountered during implementation of the work. The sections below discuss the hazards that could potentially be encountered during the course of the project. A Job Safety Analysis (JSA) document is provided in HASP Attachment 3. While the attached JSA is specific to work performed in and around streams, ponds, and lakes, the hazards and safe job procedures apply to other environmental monitoring work as well.

3.1 Task Risk Analysis

The following describe specific hazards associated with planned site activities. The protective measures to be implemented during completion of those operations are also identified under Section 5, Personal Protective Equipment.

3.1.1 Surface Water, Pore Water and Sediment Sampling

Field activities on or near ponds, fast-moving streams, or other surface waters pose a potential drowning hazard. The hazard is addressed in 29 CFR 1926.106: “Employees working over or near water, where the danger of drowning exists, shall be provided with U.S. Coast Guard-approved life jackets or buoyant work vests.” Workers working over water in boats will be required to don a life vest. Workers working near water will not be required to wear life vests; however, life vests will be available within 50 feet of the work activity. Procedures specified in the JSA (see HASP Attachment 3) will be followed for work in and around water.

When collecting surface water samples utilizing the unmanned aerial system (drone) every effort should be made not to decant sample water while being directly under the drone. Additionally, proper protective headwear should be worn and the drone should be moved to side and lowered in altitude.

3.1.2 Drilling

All the safety provisions of normal site operations should be followed.

- Use all of the following means to locate underground utilities prior to any drilling: (1) Underground Service Alert (USA); (2) site maps and drawings (when available); (3) private utility locators (unless utility location services are provided by others); (4) site markings and conditions; (5) hand-probing or excavating to a depth of at least 4 feet; and (6) site personnel familiar with the history of site usage (when available). Be especially wary of electrical, natural gas, and product lines. NEVER rely solely on site drawings or site personnel to determine the exact location of buried utilities.

- Observe safe distances from overhead utilities of at least 10 feet. In accordance with OSHA requirements, greater distances are required for overhead lines carrying greater than 50,000 volts. Greater distance should also be maintained if there is a risk that stray or broken (snapped) cables could come into contact with electrical lines

- At sites where non-project personnel may be present, properly demarcate the area to be excavated with barricades, fencing, and/or flagging. When appropriate, post warning and "No Smoking" signs conspicuously, and enforce them.

- Fire extinguishers (at least one, 10-lb. ABC) must be on site and readily accessible at all times.

- All drilling locations should be verified and marked by an authorized person.

- Locate emergency shut-off valves and switches (kill switch), and (if present) confirm that the drilling crew knows where they are and how to use them.

- Drill rig must be properly grounded at all times.

- Observe proper lifting techniques when transporting core samples to be lithologically logged and samples collected.

- Drilling should stop if any of the following conditions are encountered: (1) levels of contamination that are significantly higher than those contemplated in the Site Health and Safety Plan; (2) unknown substances that are not contemplated in the Site Health and Safety Plan; (3) explosive atmospheres (exceeding 10% of the lower explosive limit); or (4) utility lines. In such instances, all operations will stop until the situation is evaluated with the Field Supervisor and the Project Manager has been notified. All drilling and sampling equipment should be left in the ground, equipment should be turned off, and cuttings and samples should be containerized, if necessary.

3.1.3 Monitoring Well Installation and Maintenance

- Wear appropriate personal protective equipment during installation or maintenance activities.

- Precautions should be taken to avoid trip, slip, and fall accidents when walking or climbing on irregular or slippery surfaces. When changing locations, the area will be visually surveyed for slippery surfaces and tripping hazards. If it becomes necessary to perform work on the drill mast, the mast will be lowered prior to performing work. If the mast cannot be lowered then personnel working on the mast will have an OSHA approved safety harness and use it to avoid any falls from height.

- Field personnel will avoid placing body parts at points of operation and/or pinch points. Legs should be used to lift heavy objects, avoiding awkward positions and twisting of the body. Assistance should be requested for awkward or heavy loads.

- Working with drill rigs can result in injuries from equipment dislodging and striking unsuspecting personnel, and from impacts due to flying objects or overturning vehicles. Therefore, follow these precautions:

  - Drill rig will be inspected visually before each use. Routine inspections of drill rig throughout shall include brakes, hydraulic lines, fire extinguishers, fluid levels, tires, treads, horns, and other safety devices. If inspection reveals unsafe conditions, rig will be removed from service and repaired.

  - Operator and other personnel in area during lifting of tools onto rig mast shall position themselves so that they are not under the load, between equipment, or in areas where lifted items could fall.

- Be careful when opening wells, pipes, or valves that may have become pressurized. Vent off the pressure if possible, or provide shielding to avoid splashing of materials. Keep face away from well heads. Be careful when opening well covers. Watch for spiders, wasps and other insects.

3.1.4 Groundwater Sampling and Aquifer Testing

- During groundwater sampling activities, wear the appropriate protective gear for the operation.

- Be careful when opening wells, pipes, or valves that may have become pressurized. Vent off the pressure if possible, or provide shielding to avoid splashing of materials. Keep face away from well heads. Be careful when opening well covers. Watch for spiders, wasps and other insects. Exercise caution when opening or handling sampling containers containing acid (hydrochloric, nitric, sulfuric) preservatives. Do not allow sampling containers containing acid to sit in the sun. Warmed acids may fume when the containers are opened causing irritation to the eyes, nose and throat.

3.1.5 Solid Phase Media Sampling

- During solid phase media sampling (e.g., soil, mine waste, and mineralized rock) activities wear the appropriate protective gear for the operation.

- Make sure others on site (especially equipment operators) know where you are and that you maintain line-of-sight contact. During collection of soil samples, minimize contact with soil with your clothing and body.

3.2 Physical Hazards

The following describes the various potential physical hazards in the Study Area that may be encountered during the planned field work. Injuries that may result from theses physical hazards can range from simple slip-trip-fall types of accidents to casualties, including fatalities due to moving heavy equipment or electrocution. Injuries resulting from physical hazards can be avoided through the adoption of safe work practices and employing caution when working with or near machinery. Never put your hands near moving equipment (e.g., cables, pulleys, or automated hammers).

Additional physical hazards associated with hard rock mine features are, but not limited to, the presence of steep slopes, high walls, and the operation of heavy equipment. Work should be avoided, to the extent possible, in areas where these hazards may exist. In addition, work will be conducted in the vicinity of cold, fast-moving streams. Project personnel should only enter such streams for the purposes of discharge measurements or sampling with the appropriate PPE and safety equipment. Project personnel may decline to enter such streams if they deem conditions to be unsafe.

At the start of each day, the Field Supervisor shall inform the Project Manager of the locations and nature of the planned work. All field personnel shall be conscious of their work environment and should notify the Field Supervisor or other appropriate supervisory personnel of any unsafe conditions. The Field Supervisor will be responsible for informing all workers of any physical hazards related to the Site. All field personnel should also familiarize themselves with other contractors' safety procedures. The protective measures to be implemented during completion of field activities are also identified under Section 5, Personal Protective Equipment (PPE).

3.2.1 Heavy Equipment

Operation of heavy equipment (drilling rigs, graders, compactors, trucks, and dozers) presents a potential physical hazard to personnel. All PPE must meet or exceed the relevant standards set by NIOSH (National Institute for Occupational Safety and Health), ASTM (American Society for Testing and Materials), or ANSI (American National Standards Institute) for safety hard-toed boots, safety glasses or safety sunglasses, and hard hats, all of which should be worn whenever such equipment is present. Personnel should at all times be aware of the location and operation of heavy equipment, and take precautions to avoid getting in the way of their operation. High visibility vests may be appropriate in open areas subject to heavy equipment traffic. When approaching the operator of any heavy equipment, be sure to make and maintain a clear line-of-sight contact.

3.2.2 Trenching/Excavation

Trenches and excavations may pose a physical hazard to Site personnel during the collection of samples for geotechnical and/or laboratory analysis or other field work activities. All trenching and excavation work shall comply with the requirements of 29 CFR 1926, Subpart P. No worker shall enter an excavation without ensuring that the excavation and procedures comply with 29 CFR 1926. The contractor shall train any personnel that may enter an excavation in safe practices. Some requirements for safe trenching are:

- Whenever possible workers will not go into trenches or excavations.

- Any excavations and/or trenches exceeding five (5) feet in depth and in which personnel may be entering must be sloped, shored, braced or otherwise supported. Sloping angles and/or shoring/bracing requirements shall be determined after an inspection of the soils and conditions by a competent individual. The water content of the soil, the soil type, the degree of compaction, superimposed loads and vibration can effect the stability of a trench excavation. Support systems shall be planned and designed by a qualified person.

- Excavations and trenches will be inspected by a competent person before workers enter them. Furthermore, daily inspections shall be made and trenches shall be reinspected after every rainstorm or other hazard-increasing event.
- Excavated materials (spoils) shall be stored at least two feet or more from the edge of the excavation, or otherwise retained, in order to prevent this material from falling into the excavation.
- In locations where oxygen deficiency or hazardous gaseous conditions are possible, air in the excavation or trench shall be tested. Controls shall be established to assure acceptable atmospheric conditions. When flammable gases are present, adequate ventilation shall be provided or sources of ignition shall be eliminated. Attended emergency rescue equipment, such as breathing apparatus, a safety harness and line, basket stretcher, etc., should be easily available where adverse atmospheric conditions may exist or develop in an excavation or trench. A log of all test results shall be maintained.
- When employees are required to be in trenches four feet deep or more, an adequate means of exit, such as a ladder or steps, will be provided and located no more than 25 feet from any work area.

3.2.3 Cold Stress

Personnel working outdoors in low temperatures, especially at or below 40° Fahrenheit (F), wet conditions, wind speed 5 miles per hour or higher, lack of water, previous cold injuries, use of tobacco, fatigue and low activity are subject to cold stress. Exposure to extreme cold for a short time causes severe injury to the surface of the body. Areas of the body which have high surface area-to-volume ratio such as fingers, toes, feet and ears are the most susceptible.

Two factors influence the development of a cold injury: ambient temperature and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. A wind chill chart is shown in HASP Attachment 4.

Frostbite

Local injury resulting from cold is included in the generic term frostbite. Frostbite of the extremities can be categorized as:

- "Frost nip or incipient frostbite" which is characterized by sudden whitening of skin;
- "Superficial frostbite" which is characterized by skin with a waxy or white appearance and is firm to the touch, but tissue beneath is resilient; and

- "Deep frostbite" which is characterized by tissues that are cold, pale, and solid.

Hypothermia

Hypothermia is most likely at very cold temperatures but it can occur even at cool temperatures if an individual becomes chilled from rain or sweat. Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages:

- Shivering, exhaustion;
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95° F;
- Unconsciousness, glassy stare, slow pulse, and respiratory rate;
- Freezing of the extremities; and
- Death.

Field activities shall be terminated by the Health and Safety Officer or Field Supervisor if initial signs of frostbite or hypothermia exist and activities may be terminated if equivalent wind chill temperature is below 0° F. All affected personnel shall be kept warm and receive immediate medical care.

Additional notes to remember:

- Do not rub the frostbitten part;
- Do not use ice, snow, gasoline or anything cold on the frostbitten area;
- Do not use heat lamps or hot water bottles to rewarm the part; and
- Give a warm drink - not coffee, tea, or alcohol.

3.2.4 Heat Stress

When personnel are working in hot environments, the Field Supervisor and all field personnel should be trained to recognize the symptoms of heat stress and provide initial first aid treatment if required until more qualified personnel take over. Heat stress occurs when the rate of heat gain is greater than the body's ability to remove it. It is important to understand the factors that cause overheating and mechanisms to control those factors. A heat stress education poster is included as HASP Attachment 5.

Heating of the body occurs from three sources:

- Radiant heating from heat sources or sunlight;
- Convective heating from contact with a warmer object or liquid; and
- Metabolic heating caused by activity.

Cooling occurs through three mechanisms:

- Respiration: Exhaled air is warm. As the body overheats, respiration becomes more rapid;
- Radiation: Heat is released at the surface of the skin. As the body overheats, the surficial blood vessels dilate and allow more heat to be lost; and
- Evaporation: Perspiration is released to the skin surface and evaporates. The skin is cooled by evaporative cooling.

Employee Education

Heat stress symptoms and treatment are described in Table 2

Table 2: Heat Stress Symptoms and Treatment

CONDITION	COMMON SYMPTOMS	TREATMENT
Slightly elevated body temperature	Body temperature between 99 and 101° F Headache	Drink cool fluids. Rest in cool place until temperature and pulse are below 99° F and 110 beats per minute respectively.
Heat rash	Rash mainly on back	Shower at the end of the shift. Observe for signs of heat exhaustion.
Heat cramps	Muscle cramps or twitching often starting in abdominal area. Pain in hands, feet and abdominal areas.	Remove from field work. Take off PPE. Encourage consumption of cool fluids designed to replenish electrolytes (e.g., Gatorade). Observe for signs of heat exhaustion.
Heat exhaustion	Body temperature between 99 and 102° F Headache, weakness Elevated pulse Profuse sweating Pale skin Cool wet/clammy skin Lethargic Nausea	Act immediately. Remove to a cool shaded area. Take off PPE. Drink cool fluids, about a cup every 15 minutes unless sick to the stomach. Spray with a cool mist of water or apply wet cloth to skin. Treat as a medical emergency if the person does not feel better in a few minutes. No field work for at least 48 hours.

	Dizziness	
Heat stroke **LIFE THREATENING**	Temperature greater than 102° F Hot, dry pale skin with no sweating Flushed skin Irritability, confusion, seizures, unconsciousness. Rapid pulse	Treat as a medical emergency. Remove from field work. Remove PPE. Spray with a cool water mist, or apply cool wet cloth to skin, not cold water. Place ice packs under armpits and groin area until emergency medical services arrive. Written release from doctor required to return to work.

Effects of PPE

Heat stress may occur with or without the use of PPE. PPE adds layers of clothing that insulate the wearer from cooling air. Chemical protective clothing generally has a vapor barrier to keep out chemical vapors. The vapor barrier also prevents evaporative cooling of perspiration. In short, PPE increases the heat stress on workers.

Practical Methods to Reduce Heat Stress

These methods will be discussed during safety meetings:

- Become acclimated to heat for several days whenever possible. Plan work in the cooler portions of the day. Early morning hours and evening hours are cooler.

- Perform Site preparations before the field team dresses out. Instrument calibrations, equipment preparation, and planning for the work day, etc., should be performed before dressing in PPE.

- Take frequent breaks and consume at least one pint of cool fluid every hour. Replenish electrolytes through the consumption of diluted drinks. The body loses more water than electrolytes. Concentrated salt, electrolyte, or juices can increase susceptibility to heat stress.

- Avoid beverages with caffeine, which make the body lose water and increase risk for heat illnesses.

Occupational Exposure Standards

The EPA and the ACGIH have published heat stress monitoring recommendations. The EPA recommends heat-stress monitoring at temperatures above 70° F when chemical PPE is used.

The tabulated information assumes that no chemical PPE is being worn. Since chemical PPE tends to increase heat stress, ACGIH has published correction factors in the same standard. OSHA enforces the ACGIH recommendation.

3.2.5 Ultraviolet (UV) Radiation (sun exposure)

Health effects regarding UV radiation are confined to the skin and eyes. Overexposure can result in many skin conditions, including erythema (redness or sunburn), photoallergy (skin rash), phototoxicity (extreme sunburn acquired during short exposures to UV radiation while on certain medications), premature skin aging, and numerous types of skin cancer.

Acute overexposure of UV radiation to the eyes may lead to photokeratitis (inflammation of the cornea), also known as snow blindness. Symptoms include redness of the eyes and a gritty feeling, which progresses to pain and an inability to tolerate any kind of light. This condition can also occur when working in or around water and other UV radiation reflectors. In addition, long-term exposure to sunlight is thought to cause cataracts or clouding of the lens of the eye.

Limit Exposure Time

- If possible, rotate staff to tasks with decreased sun exposure so the same personnel are not exposed all of the time.
- Try to limit exposure time when UV radiation is at peak levels (approximately 2 hours before and after the sun is at its highest point in the sky).
- Avoid exposure to the sun, or take extra precautions when the UV index rating is high.
- Provide Shade
- Try to take lunch and breaks in shaded areas.
- If possible create shade or shelter through the use of umbrellas, tents, and canopies.
- Use fabrics such as canvas, sailcloth, awning material and synthetic shade cloth that create good UV radiation protection.
- Check the UV protection of the materials before buying them. Seek protection levels of 95 percent or greater, and check the protection levels for different colors.

Clothing

- Reduce UV radiation damage by wearing proper clothing; for example, long sleeved shirts with collars, and long pants. The fabric should be closely woven and should not let light through.
- Head protection should be worn to protect the face, ears, and neck. Wide-brimmed hats with a neck flap or “Foreign Legion”-style caps offer added protection.
- Wear UV-protective sunglasses or safety glasses. These should fit closely to the face. Wrap-around style glasses provide the best protection.

Sunscreen

- Apply sunscreen generously to all exposed skin surfaces at least 20 minutes before exposure, allowing time for it to adhere to the skin.
- Re-apply sunscreen at least every 2 hours, and more frequently when sweating or performing activities where sunscreen may be wiped off.
- Choose a sunscreen with a high SPF. Most dermatologists advocate SPF 30 or higher when subjected to significant sun exposure.
- Select waterproof sunscreens for use in or near water, and by those who perspire sufficiently to wash off non-waterproof products.
- Check for expiration dates, because most sunscreens are only good for about 3 years.
- Store in a cool place out of the sun.
- Remember that no sunscreen provides 100% protection against UV radiation. Other precautions must be taken to avoid overexposure.

3.2.6 Weather

It is a Formation Environmental policy that field work be conducted under safe conditions. Rain, snow and/or high wind conditions may occur during the time period of a scheduled work activity.

Protective clothing for wet conditions will be utilized as necessary. Heavy rains, high winds or other weather conditions may result in the cessation of Site activities, at the discretion of the Project Manager or Field Supervisor.

Outdoor operations will be suspended when lightning is within a 15 second count of the Site (i.e., the time difference between seeing a lightning strike and hearing the sound). High profile equipment operation, such as drill rigs, shall be suspended when lightning is within 30 seconds of the Site. Equipment operators shall stop their equipment and park it safely before heading for shelter. No personnel will be left on the ground in an exposed location. Preferred shelter during thunderstorms is a permanent building. Personnel may also take shelter in trailers or low profile rubber tired equipment (e.g., pickups). Avoid driving pickups or any other equipment, except to help evacuate personnel.

Thunderstorms always have the potential for down bursts and hail. Weather forecasts should be monitored frequently for changing weather conditions. Work may resume after a 30 minute period without lightning occurring within the 15 or 30 second count specified.

The Field Supervisor will ensure that a dedicated watch is posted during periods of tornado watch or warning. Personnel will be evacuated to permanent structure when necessary. During tornado warnings, refuge should be sought in buildings under archways, tables or in closets below ground level or on the main floors. If the tornado is too close to evacuate to a permanent structure, refuge should be sought in low areas such as ditches.

Extra care must be taken by Site workers during snowy weather. Adequate protective clothing must be donned. Site workers must be allowed rest periods in warm shelters at regular intervals. Vehicle speeds on Site will be limited to below 10 mph during snowy conditions. All work shall be suspended under blizzard conditions and Site workers shall immediately seek warm, sturdy shelters, such as buildings.

3.2.7 Noise

Personnel working around large construction equipment and loud, congested areas can be exposed to excessive noise causing temporary or permanent damage to hearing. The effects of noise can include:

- workers being startled, annoyed, or distracted;
- physical damage to the ear; and
- impediment to communication that may increase potential hazards.

All personnel shall wear hearing-protective devices (i.e., either ear plugs or muffs) when noise levels interfere with normal speech. Hand signals will be established by on-Site personnel, as appropriate, to facilitate communications while involved in high-noise activities.

3.2.8 Dangerous Animals, Insects, and Plants

The Mayflower Tailings Impoundments are in a high-altitude, mountainous setting. In warm months, workers must be prepared for mosquitoes, ticks, chiggers, yellow jackets and other insects, and for snakes. At the end of the workday, workers should check their legs and scalp for ticks or other insects.

Animal bites and insect stings are usually nuisances (i.e., localized swelling, itching, and minor pain) that can be handled with first-aid treatments. The bites of certain snakes and spiders contain sufficient poison to warrant medical attention. There are diseases that can be transmitted by insect and animal bites. Examples are Lyme disease (tick), rabies (mainly dogs, skunks and foxes), malaria, and equine encephalitis (mosquito). The greatest hazard and most common cause of fatalities from animal bites, particularly from bees, wasps, and spiders, is a sensitivity reaction. Anaphylactic shock due to stings can lead to severe reactions in the circulatory, respiratory, and central nervous systems, which can also result in death.

The project Site is located in geographic area where Lyme disease and rabies are possible. Lyme disease is spread primarily by a very small tick – the deer tick. It can be found near wooded areas, tall grass and brush. Although the disease is rarely fatal, it can cause flu-like symptoms, arthritis, heart arrhythmias, facial palsy, severe headaches, and loss of sensation. Protection against the tick consists of wearing clothing that covers the whole body, tucking pant legs into boots or socks and tucking a long-sleeve shirt into pants. A white Tyvek is recommended for protection. Use of repellents containing DEET is also effective. It is also important to frequently check for the ticks, which are about the size of a period on this page. Some warning signs include a "bull's eye" rash that may appear days to weeks after the bite, flu-like symptoms, swelling and pain in joints and, less common, heart arrhythmia, weakness in legs, facial paralysis and numbness. If employees feel they may have contracted the disease, they must notify the Health and Safety Officer.

The most dangerous toxic effects from plants are due to ingestion of nuts, fruits, or leaves. Consequently, personnel are prohibited from eating any fruits, nuts, or other plant material, which may grow on the Site. Of more concern to response personnel are certain plants including poison ivy, poison oak, and poison sumac, which produce adverse effects from direct contact. The usual effect is dermatitis, an inflammation of the skin. The protective clothing and decontamination procedures used for chemicals reduce the exposure risk to the plant toxins. Cleaning the skin thoroughly with soap and warm water immediately after contact will reduce risk.

3.2.9 Manual Lifting

Activities may require personnel to move large, heavy objects by hand. The human body is subject to severe damage in the forms of back injury and hernia if caution is not observed when handling, lifting, or moving large heavy objects.

General Rules:

- Get a good footing;
- Place feet about one shoulder width apart;
- Bend at knees to grasp weight;
- Keep the back straight; and
- Get a good hold.

3.2.10 Slip, Trip, and Fall Hazards

Protection from slip, trip and fall hazards will be provided through standard safety procedures including good housekeeping. Removing equipment and debris, and taking general precautions during Site operations will be standard operating procedures. Workers will be apprised of any potential trip hazards through regularly scheduled health and safety meetings. Whenever possible, trip and fall hazards will be eliminated or clearly identified with yellow “caution” tape. Impalement hazards to workers will be neutralized as soon as they are identified.

3.2.11 Overhead Utilities

Before Site activities begin, all overhead utilities will be identified and field verified. As necessary, utilities will be deactivated, or operational procedures and project logistics will be established to avoid overhead lines. This will be the responsibility of the Field Supervisor. The contractor(s) will be responsible for operation of equipment in a safe manner and follow the relevant regulations of 29 CFR 1926.952. These regulations include, but are not limited to:

- All electrical equipment shall be de-energized;
- Assume that all overhead lines are energized unless de-energized by the person owning the line or the electrical utility authorities indicate that it is not an energized line and it has been visibly grounded.
- No hoisted loads shall be left unattended.

These regulations require all operating equipment maintain minimum safe operating distances from overhead power transmission lines as given in 29 CFR 1926.950 (Table 3).

Table 3: Minimum Safe Working Distances (Alternating Current)

Voltage Range (phase to phase)	Minimum Working and Clear Hot Stick Distance
(kilovolt)	***(Stick Distance)***
2.1 to 15	2 feet 0 inches
15.1 to 35	2 feet 4 inches
35.1 to 46	2 feet 6 inches
46.1 to 72.5	3 feet 0 inches
72.6 to 121	3 feet 4 inches
138 to 145	3 feet 6 inches
161 to 169	3 feet 8 inches
230 to 242	5 feet 0 inches
345 to 363	7 feet 0 inches[1]
500 to 552	11 feet 0 inches[1]
700 to 765	15 feet 0 inches[1]

The deactivation of utilities, when necessary, should be certified by the proper utility company personnel and the certification record retained.

3.2.12 Underground Utilities

Before excavation activities begin, all utilities (i.e., electricity, natural gas lines, water lines, sewer lines, etc.) should be identified and deactivated as needed. The location of field work should be adjusted to avoid active underground utilities, if possible. The deactivation of utilities, when necessary, should be certified by the proper utility company personnel and the certification record retained. Location of the utilities and any deactivation will be the responsibility of the Field Supervisor.

3.2.13 Fire Prevention

Fire extinguishers shall be provided in the field vehicle and shall be available on-Site. All extinguishers will be inspected, serviced, and maintained. Inspections shall be recorded on the inspection tag attached to each extinguisher.

3.2.14 Vehicle Operation

Vehicle traffic will maintain a safe speed while operating on the Site. Occupants of any vehicle shall wear seatbelts at all times. Cell phones use is prohibited while the vehicle is in motion. Vehicles and equipment will be equipped with the safety procedures outlined in 30 CFR Subparts H and M and, as applicable, 29 CFR 1926.601. Precautions will be made to warn foot traffic or other vehicles as necessary.

OHVs are vehicles that are not designed to travel streets or highways, including all-terrain vehicles (ATVs), utility-terrain vehicles (UTVs), snowmobiles, and off-road motorcycles. In addition to following field work procedures, OHV/UTV use requires a formal assessment, training, and appropriate personal protective equipment. Where required by state law, operators must have a special state endorsement to operate off-highway vehicles. See JSA in HASP Attachment 3 for further discussion on operating snowmobiles in remote locations.

The operator shall reference the vehicle owner’s manual. Before every ride, a pre-ride inspection must be performed. The following are examples of items that should be checked:

- Tires and wheels.
- Controls and cables.
- Lights and electrical.
- Oil, fuel, fluids, and air filter.
- Chassis, chain/driveshaft, suspension, external equipment.

When seat belts are available, all vehicle occupants must wear seat belts while the vehicle is in motion. Fire extinguishers and first aid kits must be readily available when using an OHV.

3.2.15 Driving When Fatigued

Operating a vehicle after a full day of work or when you are fatigued drastically decreases focus and response time, and increases the risk of being involved in a vehicle accident which could result in property damage, injury, or death. Avoid driving more than 8 hours in one workday. If the number of hours driving to/from a jobsite combined with the number of hours to be worked on the site will equal more than 14 total hours, alternate arrangements should be arranged. Be aware of your fatigue level while driving and stop to rest if you feel overly tired.

3.3 Chemical Hazards

Potential chemical hazards related to field sampling activities are relatively minor. The data collection activities will include sampling of both surface water and groundwater, soil, and possibly vegetation, and biota that may contain elevated concentrations of metals.

Results from previous sampling performed at the Site indicate that contaminant hazards may be encountered at the Site during field activities. In general, chemical substances in gaseous, liquid, or solid form can enter the unprotected worker by inhalation, skin absorption, ingestion, or through a puncture wound (injection). A contaminant can cause damage at the point of contact or can act systemically in different parts of the body.

In general, chemical exposure by inhalation is a concern since the lungs are extremely vulnerable to chemical agents. In addition, substances can pass through lung tissue into the bloodstream and onto other susceptible areas of the body. Since some toxic chemicals are not detectable by human senses, their toxic effects may not produce any immediate symptoms. Respiratory protection is therefore extremely important if there is a possibility that the worksite atmosphere may contain such hazardous substances.

The skin and eyes also represent important routes of exposure. Some chemicals directly affect the skin, while others may pass through the skin into the bloodstream where they can be transported to other vulnerable organs. Skin absorption is enhanced by abrasions, cuts, heat, and moisture. The eye is particularly vulnerable because airborne chemicals can dissolve on its moist surface and be carried to the rest of the body via capillaries located very close to the surface of the eye. Protection against skin and eye contact may be provided by:

- Wearing protective equipment (i.e., Tyvek coverall suits);

- Wearing protective safety glasses or goggles;
- Avoiding the use of contact lenses in contaminated atmospheres since they may trap chemicals against the eye surface;
- Keeping hands away from the face; and
- Minimizing contact with liquid and solid chemicals.

Inadvertent ingestion can occur as a result of personal habits such as chewing gum or tobacco, drinking, eating, smoking cigarettes, and applying cosmetics. These practices may provide a route of entry for chemicals and are restricted.

Zinc Exposure Limits and Health Effects

Permissible Exposure Limit (PEL) – 5 mg/m3 (8 hour workday)

> The PEL is the maximum average time weighted concentration of a substance that a worker can be exposed to over a workday.

Action Level – 2.5 mg/m^3 (8 hour workday)

> OSHA does not at this time have a specific action level for zinc. Thus the action level is half the PEL. The action level is a time weighted average that indicates the level at which medical surveillance or increased industrial hygiene monitoring is required for a given substance.

Threshold limit value (TLV) – 2 mg/m^3

> The TLV is a time-weighted average concentration for a normal 8-hour workday or 40-hour workweek to which nearly all workers may be repeatedly exposed.

Exposure to zinc in dust can result in headache, fever, weakness and sore throat. As described above, zinc is present in seep and river water and inhalation is not expected to be a significant pathway. Additional information on health effects from exposure to zinc is provided in HASP Attachment 6.

Threshold Limit Values-Time Weighted Average (TLV-TWA) values are the time-weighted average concentration for a normal 10-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) values are the concentrations to which workers can be exposed intermittently for short periods of time (15 minutes or less) without suffering from: 1) irritation; 2) chronic or irreversible tissue damage; or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. TLV-TWAs are established by the American Conference on Governmental Industrial Hygienists (ACGIH, 1995) and provide the basis for safety regulations of OSHA. The Immediately Dangerous to Life and Health (IDLH) limit (OSHA) is defined as an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

Other contaminants may be encountered during the course of the Site activities. If unusual odors or conditions are encountered, personnel should suspend work activities and contact the Field Supervisor for guidance before proceeding.

3.3.1 General Precautions

If signs of contamination different from those addressed in this HASP are encountered, such as visible soil stains or unusual odors, stop all work in the area, barricade or otherwise isolate the area, and immediately contact the Project Manager. Protection of worker health and safety shall be the first priority. Continuation of work in the area and the amount of additional personal protective equipment, if any, shall be determined by the Project Manager. Other precautions to be undertaken to provide a safe work place on this project where the potential for chemical exposure may exist include:

- No smoking, eating, or drinking in areas where contaminants may be present.

4.0 PERSONNEL TRAINING REQUIREMENTS

Prior to initiation of Site activities, all Formation Environmental field personnel shall have completed a 40 hour Hazardous Materials Health and Safety Course and 8-hour annual refresher course(s), as appropriate. All field personnel shall have a minimum of three days of actual field experience under the direct supervision of a trained, experienced supervisor.

Compliance with sample collection Standard Operating Procedures (SOPs), as provided in the Field Sampling Plan, is required for all personnel performing assigned tasks. In addition, as applicable, JSA (Job Safety Analysis) documents (see HASP Attachment 3) are a tool to help workers identify potential hazards and safe work practices to address those hazards, thereby, avoiding accidents.

The Field Supervisor shall have completed at least eight additional hours of specialized supervisor training as per 29 CFR 1910.120 (e)(4). All courses shall have been conducted by a qualified trainer as specified in 29 CFR 1910.120 (e)(5). These courses should cover chemical hazards, hazard recognition, hazard assessment and personal protective equipment. If necessary, the Site Health and Safety Officer will have been trained in standard first aid measures and cardiopulmonary resuscitation (rescue breathing) or CPR.

All personnel who may participate in the Site activities shall be required to have completed appropriate training as specified in 29 CFR 1910.120 (e)(3). The supervisor-training requirement may also apply to the contractor supervisors. If needed, the contractor shall provide copies of written certificates documenting said training. Copies of training certificates for on-site personnel will be kept at the Site in the possession of the Field Supervisor.

Prior to the initiation of each phase of field work, all personnel and contractors who will participate in the work shall attend a pre-entry briefing. The pre-entry briefing will review information contained in this HASP, including:

- Names of personnel responsible for Site safety and health;
- Safety and health concerns, including physical and chemical hazards present at the Site;
- Use of personal protective equipment;
- Work practices by which the employee can minimize risks from hazards;
- Engineering controls and safe use of equipment on Site;
- Medical surveillance requirements, including recognition of symptoms and signs which might indicate overexposure to hazards;
- Site control measures;

- Site decontamination procedures;
- Emergency response procedures; and
- Spill containment procedures.

In addition, all persons participating in field activities shall be required to read this HASP. Information discussed at the pre-entry briefing will be reinforced, in turn, during tailgate safety meetings (see below). Additional pre-entry briefings may be required for additional phases of work or if new personnel are assigned to the project.

Tailgate safety meetings will be conducted as necessary, or whenever new personnel arrive and/or when a unique work assignment warrants employee training. Tailgate safety meetings will be conducted by the Field Supervisor. These meetings will cover the projected work for the day or the specific task and will review and reinforce good safe work practices (e.g., proper protective clothing, effective deterrents of heat stress, etc.). Information discussed at the tailgate safety meetings may be revised and updated, based on any new data obtained pertaining to Site characterization and analyses. The Daily Pre-Work/Job Site Assessment form is provided as HASP Attachment 2.

5.0 PERSONAL PROTECTIVE EQUIPMENT

5.1 Personal Protective Equipment Levels

The following sections describe the anticipated levels of personal protection for field work at the Site. These levels are based upon the physical and chemical hazards at the Site, and previous experience at similar locations with similar chemicals of potential concern.

The following minimum PPE requirements will apply:

- Workers engaged in the active large-scale excavation or grading (drilling oversight personnel, grader operators, ground crew/spotters, and dozer operators) will wear Level D protection.
- Workers engaged in water, soil, and/or biota sampling activities will wear modified Level D protection.
- Support workers (supervisors, observers etc.) will wear Level D protection.

The level of personal protection worn by field personnel will be defined, controlled, and implemented by the Field Supervisor. Protection may be upgraded or downgraded by the Project Manager, as deemed necessary throughout the project. Required PPE items include the following: hardhats, hard-toed boots, safety glasses, and hearing protection. Additional safety items to be maintained in each vehicle include, but are not limited to: chock block, 2-way radio, lights/flags, cones, spill kit, fire extinguisher, and first aid kit. Other PPE and safety items may be required depending on conditions and safety procedures specified by the mine.

5.1.1 Level C Personal Protection

- Disposable Tyvek® coveralls (exchanged when heavily soiled or after breaks, at least once per work day);
- Work gloves (disposable nitrile or cotton, depending on task);
- Approved NIOSH safety hard-toe work boots (conforming to ANSI Standard Z 41.1);
- Hard hats (conforming to ANSI Standard Z 89.1);
- Safety goggles (conforming to ANSI Standard Z 87.1);
- Hearing protection (when excessive noise is present); and
- Full-face or half-face respirator with a high efficiency particulate air (HEPA) cartridge filter (conforming to ANSI Standard Z 88.2).

5.1.2 Modified Level D Personal Protection

Modified Level D personal protective equipment may include the following:

- Blue jeans or natural fiber pants, long sleeve natural fiber shirt;
- Work gloves (disposable nitrile or cotton, depending on task);
- Approved NIOSH safety hard-toe work boots (conforming to ANSI Standard Z 41.1);
- Hard hat (conforming to ANSI Standard Z 89.1);
- Safety glasses or sunglasses (conforming to ANSI Standard Z 87.1);
- Orange traffic safety vest;
- Hearing protection (when excessive noise greater than 85 dBa is present); and
- Disposable Tyvek coveralls (exchanged when heavily soiled or after breaks, at least once per work day).

5.1.3 Level D Personal Protection

Level D personal protective equipment is basic and includes the following:

- Blue jeans or natural fiber pants, long sleeve natural fiber shirt;
- Work gloves;
- Approved NIOSH safety hard-toe work boots (conforming to ANSI Standard Z 41.1); and
- Hard hat (conforming to ANSI Standard Z 89.1).
- Safety glasses or sunglasses (conforming to ANSI Standard Z 87.1.

5.2 PPE Deviation/Modification

Protection levels may be upgraded, downgraded, or modified as deemed necessary by the Project Manager based upon work task or Site-specific, safety-related factors such as:

- When excessive noise levels exceed 85 dBa;
- Change of season/weather;
- When temperature extremes or individual medical considerations (i.e., heat stress, medication, etc.) limit the effectiveness of PPE; or
- Contaminants other than those previously identified are encountered.

5.3 Limitations of PPE

PPE ensembles designated for use during work tasks have been selected to provide protection against contaminants at known or anticipated concentrations in soil or water matrices. However, no protective garment, glove, or boot is chemical-proof, nor will it afford protection against all types of chemicals. Permeation of a given chemical through PPE is a complex process governed by contaminant concentrations, environmental conditions, physical condition of the protective garment, and the resistance of a garment to a specific contaminant. Chemical permeation may continue even if a garment is resistant to a specific contaminant and may continue even after the source of contamination has been removed from the garment.

In order to obtain optimum usage from PPE, the following procedures are to be followed by all Site personnel using PPE:

- When using disposable Tyvek coveralls, don a clean, new garment after each rest break or at the beginning of each shift;
- Inspect all clothing, gloves, and boots both prior to and during use for:
  - Imperfect seams;
  - Nonuniform coatings;
  - Tears; and
  - Poorly functioning closure.
- Inspect reusable garments, boots, and gloves both prior to and during use for:
  - Visible signs of chemical permeation;
  - Swelling;
  - Discoloration;
  - Stiffness;
  - Brittleness;
  - Cracks;
  - Any sign of puncture; and
  - Any sign of abrasion.
- Reusable gloves, boots, or coveralls exhibiting any of the characteristics listed above will be discarded. PPE used in areas known or suspected to exhibit elevated concentrations of contaminants will not be reused and will be discarded.

5.4 Donning of PPE

A routine will be established and followed at the Site for donning PPE. The procedures will be discussed in detail during the Site safety meeting before starting the project and briefly during periodic Site safety meetings.

Before wearing any level of PPE, it will be checked that it is in proper condition for the purpose for which it is intended. Also, workers with any minor injuries and/or openings in the skin surface, such as cuts and scratches, will be attended to in order to protect such areas which may potentially enhance exposure effects. Workers with large cuts, rashes, or other such skin damage will not be allowed to don PPE.

5.5 Medical Surveillance Requirements

Contractors will be required to have medical surveillance programs that comply with 29 CFR 1910.120 (f). This program requires annual medical monitoring (including pulmonary function evaluation) for all field personnel. Records for this program are kept in compliance with the requirements of 29 CFR 1910.120. These records include:

- The name and social security number of the employee;
- Physician's written opinions, recommended limitations, and results of examinations and tests;
- Any employee medical complaints related to exposure to hazardous substances; and
- A copy of the information provided to the examining physician by the employee.

6.0 SITE CONTROL MEASURES

The Site control measures program is designed to minimize the exposure of personnel to potentially hazardous substances and/or situations. In this section, the term “site” refers to the immediate work area. This objective will be accomplished by the establishment of work zones, the proper decontamination of personnel and equipment, and proper maintenance of safety equipment.

Exclusion Zone: The area where contamination is either known or likely to be present, or because of activity, will provide a potential to cause harm to personnel. Entry into the exclusion zone requires the use of personal protective equipment. The exclusion zone for this work is the area in a 50-foot radius from any excavating, demolition, or trenching equipment and areas where lining activities are occurring.

Decontamination Zone: Personnel performing equipment decontamination will wear personal protective gear. Specific procedures for personnel decontamination are outlined under Section 4.8, Decontamination Plan. The contamination reduction zone will be set up adjacent to each exclusion zone.

Support Zone: The area situated in clean areas near the work areas.

The following general safe work practices will apply during site activities:

- All on-site personnel and any visitors to the site during work activities described in this HASP shall read and sign this safety plan prior to entering and/or working on the site. The master copy (with signature sheet) of this safety plan will be held by the Health and Safety Officer.
- No project personnel may be allowed on-site without the prior knowledge and consent of the designated Field Supervisor.
- Project personnel shall bring to the attention of the Field Supervisor or Health and Safety Officer any unsafe condition or practice associated with on-site project-related activities.
- Personnel will not eat, chew gum or tobacco, smoke, take medicine or perform any other practice that increases the likelihood of hand-to-mouth transfer of potentially hazardous substances from gloves, unwashed hands or equipment.
- No one is to carry "strike-anywhere" matches or cigar/cigarette lighters.
- Personnel will stand upwind of all intrusive activities involving disturbance of the ground surface (e.g., drilling).

- Dust control measures should be instituted if visible dust is created during excavation and other on-site activities by moving all personnel upwind or laterally from the dust source, and by misting the dust source with a water spray.

- Hands, face, and all other potentially contaminated areas shall be thoroughly cleaned prior to eating or leaving the site.

First aid supplies and drinking water will be located on-site.

6.1 Decontamination Plan

6.1.1 Personnel Decontamination

Decontamination and maintenance of personal protective equipment is required for proper functioning of the equipment. At a minimum, nitrile gloves and Tyvek coveralls shall be replaced daily or after breaks; if they become damaged, they shall be replaced immediately.

The decontamination areas will be established prior to initiation of field activities, and the exact decontamination procedures will be established at that time based on field conditions, space considerations, etc. In general, dry equipment doffing procedures will be used (i.e., protective equipment will be removed and containerized without water washing). Respiratory protection equipment will be removed only after all soiled coveralls and gloves have been removed and containerized. Respirators will then be removed and cleaned with soapy water, followed by washing of hands and faces with soapy water. The above decontamination procedures apply only to activities where Level C (if needed on the project) and Modified Level D PPE are required (e.g., intrusive activities). For other activities, such as walk arounds or Site visits, a less rigorous decontamination procedure may be practiced, such as a thorough dry scrubbing of boots, etc.

6.1.2 Equipment Decontamination

Equipment decontamination will not be required during the project, because contaminant levels are low and associated with spring and seep water.

6.2 Emergency Response/Contingency Plan

The required elements of an emergency response plan as specified in 29 CFR 1910.120(1) are listed below. As described in the regulation, many of these items primarily pertain to emergency responses at uncontrolled hazardous waste sites, and thus are not entirely applicable to the anticipated Site activities, which do not constitute an emergency response situation. Any on-Site contractors will be responsible for providing an emergency response plan for their activities. An explanation of how each plan element will be implemented at the Site is provided below:

1) Pre-emergency planning - This emergency response plan will be provided to all personnel, including contractor personnel, working on the Site during the pre-entry briefing. In addition, emergency response actions will be reviewed with all personnel during the pre-entry briefing and the tailgate safety meetings.

2) Personnel roles, lines of authority, and communication - The Field Supervisor will be responsible for emergency coordination at all times. Any accidents and/or injuries shall immediately be reported to him or her. The Field Supervisor will immediately report any accidents to the Project Manager.

3) Emergency recognition and prevention - Physical and chemical hazards at the Site will be reviewed at the pre-entry briefing and the tailgate safety meetings.

4) Safe distances and places of refuge - Should emergency conditions arise requiring Site evacuation, the Field Supervisor will notify all on-Site personnel immediately through the use of hand signals and verbal instructions.

5) Evacuation routes and procedures - The Field Supervisor will notify all on-Site personnel of the need for immediate evacuation. Site evacuation will be performed in an orderly fashion under the direction of the Field Supervisor.

7) Emergency decontamination procedures - In the event of a medical emergency, personnel decontamination prior to medical treatment may be omitted. Whenever possible, Formation personnel will accompany contaminated victims to the hospital to provide advice on matters involving decontamination. If on-Site first aid is rendered and the victim does not require transport to the hospital, clothing and equipment decontamination as described in Section 1.8 will be performed after first aid measures have been performed.

8) Emergency medical treatment and first aid - Based on the severity of the injury/exposure, additional medical treatment will be obtained as described in paragraph 9 below.

9) Emergency alerting and response procedures - The procedures listed below will be used in the event of any Site emergency:

   a) Remove any injured person(s) from immediate danger and administer first aid as needed.

   b) The Field Supervisor will carry a cell phone that provides communication to emergency personnel (911). Field workers will also carry cell phones at all times to allow contact with mine Field Supervisor or emergency personnel. Any medical incidents are to be reported to the Field Supervisor, and Project Manager immediately.

   c) The nearest medical facility is the Mercy Regional Medical Center in Durango, CO. Driving directions to the hospital are presented in Figure 3.

d) Notify Project Manager before resuming work.

10) Critique of response and follow-up - Any accidents or emergency incidents shall be reported to the relevant local, state and federal agencies by Simplot. The report will include a summary of the emergency, a description of the conditions that led to the emergency, a review of the response actions implemented following the emergency and a discussion of steps that might have been taken to prevent a recurrence of the emergency. In addition, all Simplot emergency reporting procedures will be followed. The Project Manager will coordinate with the Field Supervisor, the Health and Safety Officer and other appropriate Simplot personnel on follow-up reporting.

11) PPE and emergency equipment - All personnel will be required to have complete Level D, and Modified Level D PPE ensembles available for use when on Site. In addition, the Field Supervisor will have available a first aid kit, a fire extinguisher and possibly a portable eyewash kit.

6.3 Confined Space Entry Procedures

No confined space entry is anticipated during Site activities.

6.4 Spill Containment Program

Hazardous substance releases will be controlled and managed in accordance with Federal and State regulations. Water from decontamination efforts will be contained and allowed to evaporate. A spill kit will be included in each vehicle to facilitate early response actions to any substance releases.

6.5 Hazard Communication

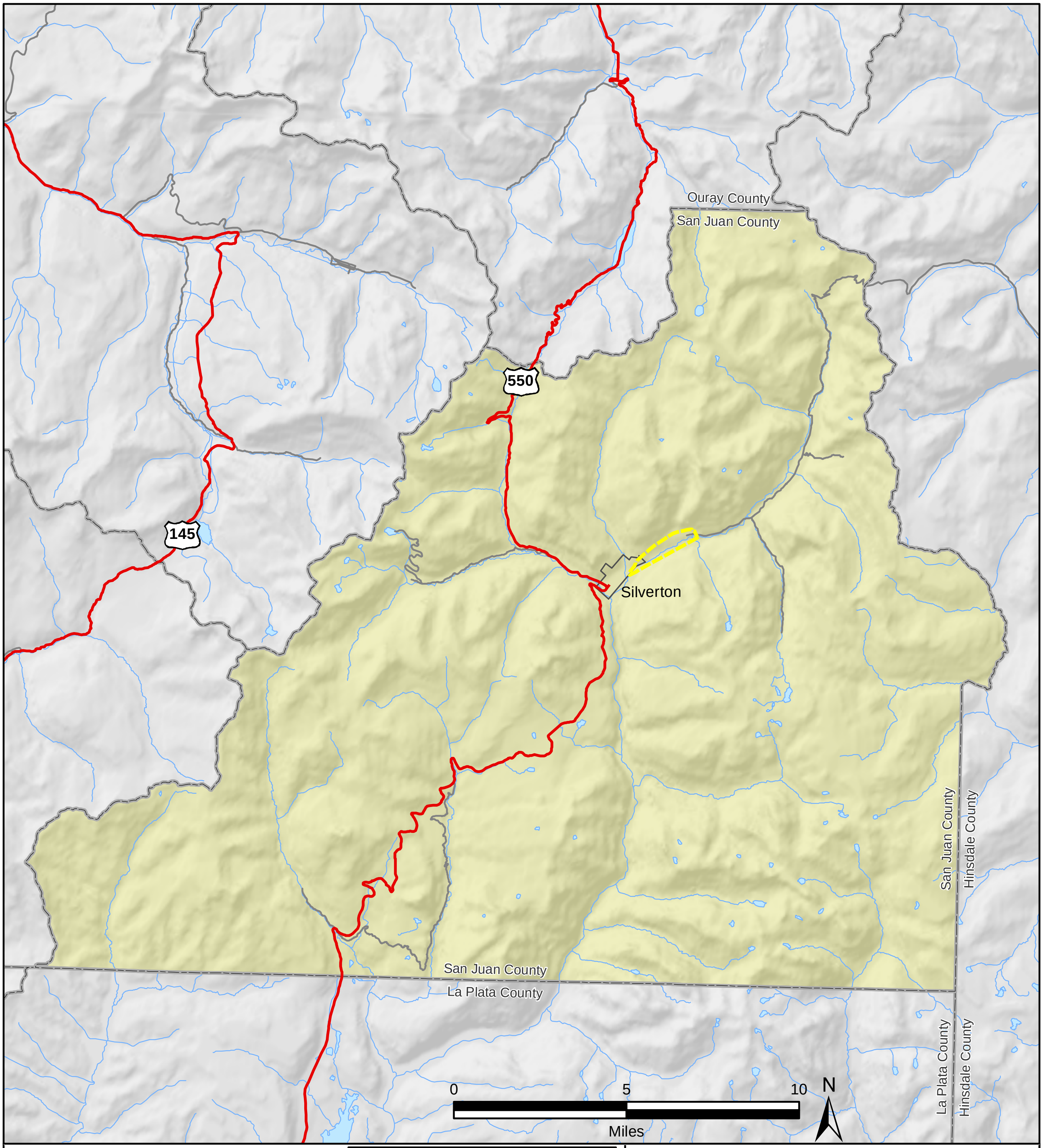
The Hazard Communication Act (29 CFR 1910.1200), commonly referred to as the “Worker Right to Know Act”, was instituted by OSHA to reduce illness and injury caused by chemical exposure in the workplace.

Formation will inform its employees of potential hazards associated with chemicals brought to the Site to perform various field activities. The information will be distributed in the form of Material Safety Data Sheets (MSDSs). Copies of the MSDS for each chemical brought to the Site will remain on Site during the period that the chemical is being utilized. Safe handling practices and emergency first aid for each chemical will be discussed during the pre-entry briefing, tailgate safety meetings, etc.

7.0 HEALTH AND SAFETY PLAN REFERENCES

American Conference on Governmental Industrial Hygienists (ACGIH), 1995. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 1995-1996: Cincinnati, OH.

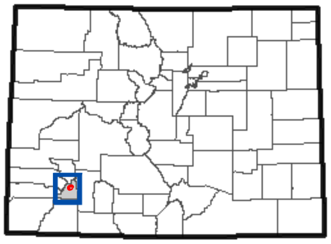
FIGURES



Legend

- ─ Roads
- ━ Highways
- ▭ Counties
- ▭ Silverton, CO
- ⬚ Study Area

Location of Study Area
In San Juan County



SUNNYSIDE GOLD

SILVERTON, CO

FIGURE 1

STUDY AREA

LOCATION MAP

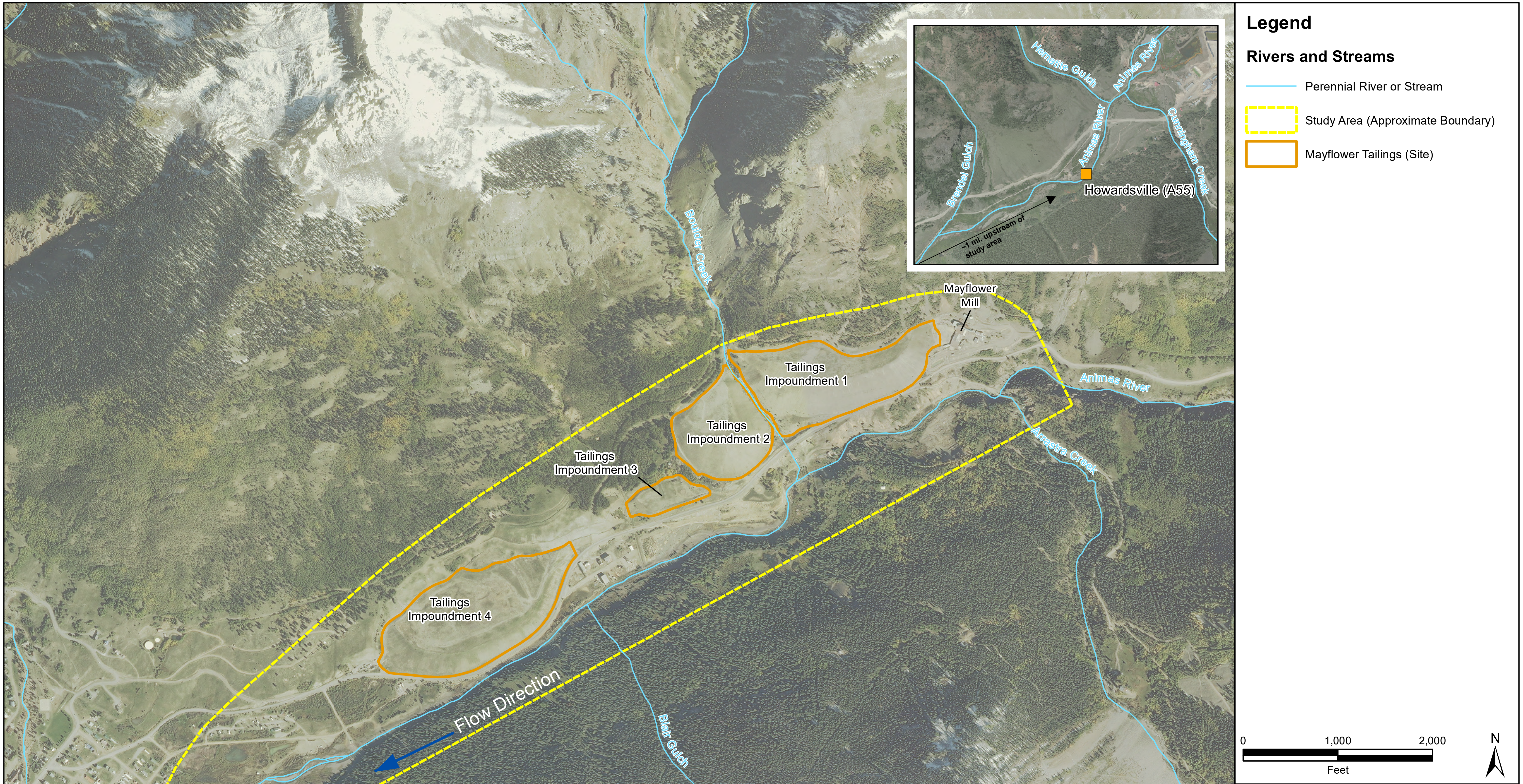
DATE: APR 13, 2017

BY: DKG

FOR: NBB

FORMATION
ENVIRONMENTAL

S:\GIS\a5\065-001-Sunnyside-UpperAnimas\plt\WorkPlan_2017\Fig_1-01_SiteLocation.mxd



SUNNYSIDE GOLD

SILVERTON, CO

FIGURE 2

SITE PLAN AND STUDY AREA

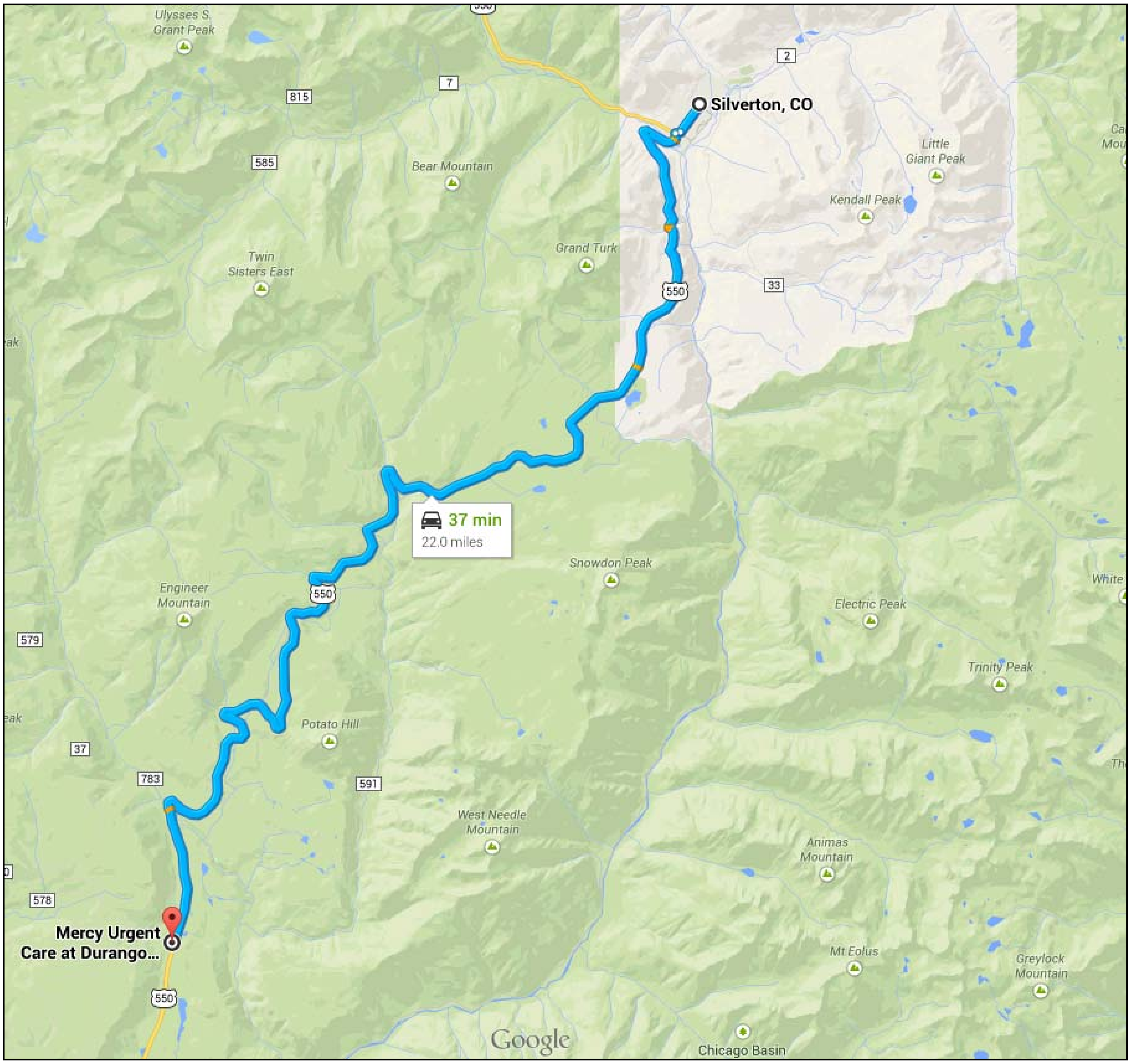
DATE: APR 17, 2017

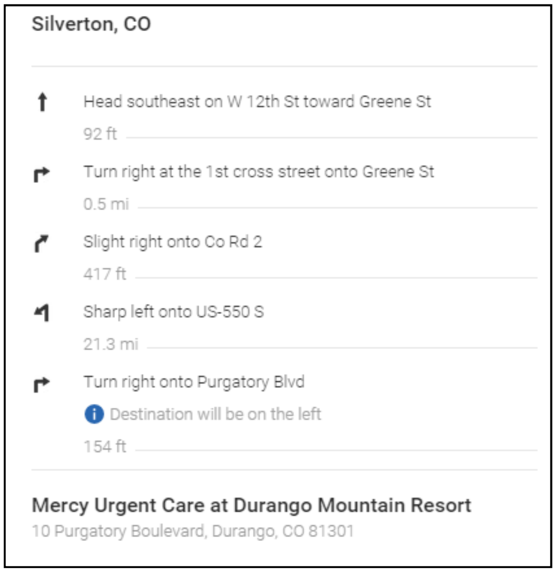
BY: DKG

FOR: NBB

FORMATION ENVIRONMENTAL

S:\GIS\a5\065-001-Sunnyside-UpperAnimas\plt\WorkPlan_2017\Fig_1-02_SitePlanStudyArea.mxd




Silverton, CO

↑ Head southeast on W 12th St toward Greene St
92 ft

↱ Turn right at the 1st cross street onto Greene St
0.5 mi

↗ Slight right onto Co Rd 2
417 ft

↰ Sharp left onto US-550 S
21.3 mi

↱ Turn right onto Purgatory Blvd
ⓘ Destination will be on the left
154 ft

Mercy Urgent Care at Durango Mountain Resort
10 Purgatory Boulevard, Durango, CO 81301

SCALE

2 MILES

N

SUNNYSIDE GOLD

Silverton, CO

FIGURE 3

ROUTE TO NEAREST EMERGENCY FACILITY

DATE APR 01, 2015

BY: NBB

FOR: BGH

FORMATION ENVIRONMENTAL

ATTACHMENT 1
PLAN ADDENDA

ATTACHMENT 2
DAILY PRE-WORK/JOB SITE ASSESSMENT FORM

Daily Pre-Work/Job Site Assessment
Environmental Sampling

Date:__________ Performed by:________________________ Title:___________________

Brief Description of Assigned Task (s):

Work Area Inspection:	Acceptable		Describe actions taken to correct any deficiency:
	Yes	No	
1. Slope safe compared to where workers are located. 2. Work performed adjacent to mining activities. 3. Ground conditions safe to begin work. 4. Safe access provided to all work areas. 5. Hazardous materials stored properly. 6. Project materials stored safely. 7. Barricades & warning signs adequate. 8. Workers wearing appropriate PPE. 9. First aid, fire extinguishers, radios and special PPE readily available. 10. Power/hand tools, machinery and equipment meet safety standards. *Parts of the inspection can be done by designees.			

Hazard Assessment of Assigned Task(s): [Note Hazard & Control Method]

Time of “pre-job” briefing: ___________

Attendees:

Additional Comments:

ATTACHMENT 3
JSA – JOB SAFETY ANALYSIS

Job Safety Analysis (JSA) April 2017

Field Monitoring – In and around streams, ponds, lakes

Sequence of Basic Job Steps	Potential Accidents or Hazards*	Recommended Safe Job Procedures
Prepare for site visit, identify PPE needs, ensure field crew has appropriate safety training	N/A	Familiarize self with site prior to visit, including terrain and potentially hazardous water flows and temperatures. Prepare Health and Safety Plan (HASP), ensure field crew has reviewed HASP and are aware of potential hazards. Ensure at least one or more member of each field crew is First Aid-trained. Inspect all PPE and equipment and ensure that it is working properly.
Assess weather conditions to be encountered during site visit	Heat exposure Sun exposure Cold exposure (dry and wet)	Familiarize self with signs of heat related illnesses: cramps, heat rash, dehydration, heat exhaustion, and heat stroke. Keep body protected; wear sunscreen, sunglasses or safety glasses, wide-brimmed hat or hardhat (depending upon PPE requirements), proper clothing. Ensure adequate fluid intake. During cold weather - layer clothing and wear wind impervious outerwear; during warm months – wear a long sleeve cotton/breathable fabric shirt and pant. In water work – wear appropriate waders and boots, gloves and outer wear to reduce cold and wet exposure.
Carry and load sample coolers and equipment	Slip/Trip/Fall Muscle strains	Employ proper ergonomics when lifting; Get help from a coworker to carry and load coolers and other equipment.
Travel to and from site	Moving vehicles on road or in parking areas Traffic hazards Slip/Trip/Fall Vehicle contact with fixed or movable objects	Be attentive to outside conditions when entering or exiting vehicle. Secure equipment load to avoid shifting. Follow defensive driving practices. Reduce speed on surfaces suspected of being slippery due to ice, rain or other conditions.
Conduct visual inspection of site conditions	Animals, stinging insects, ticks, sharp objects (wire, fence,	Identify areas where biological hazards may be present; wear insect repellant

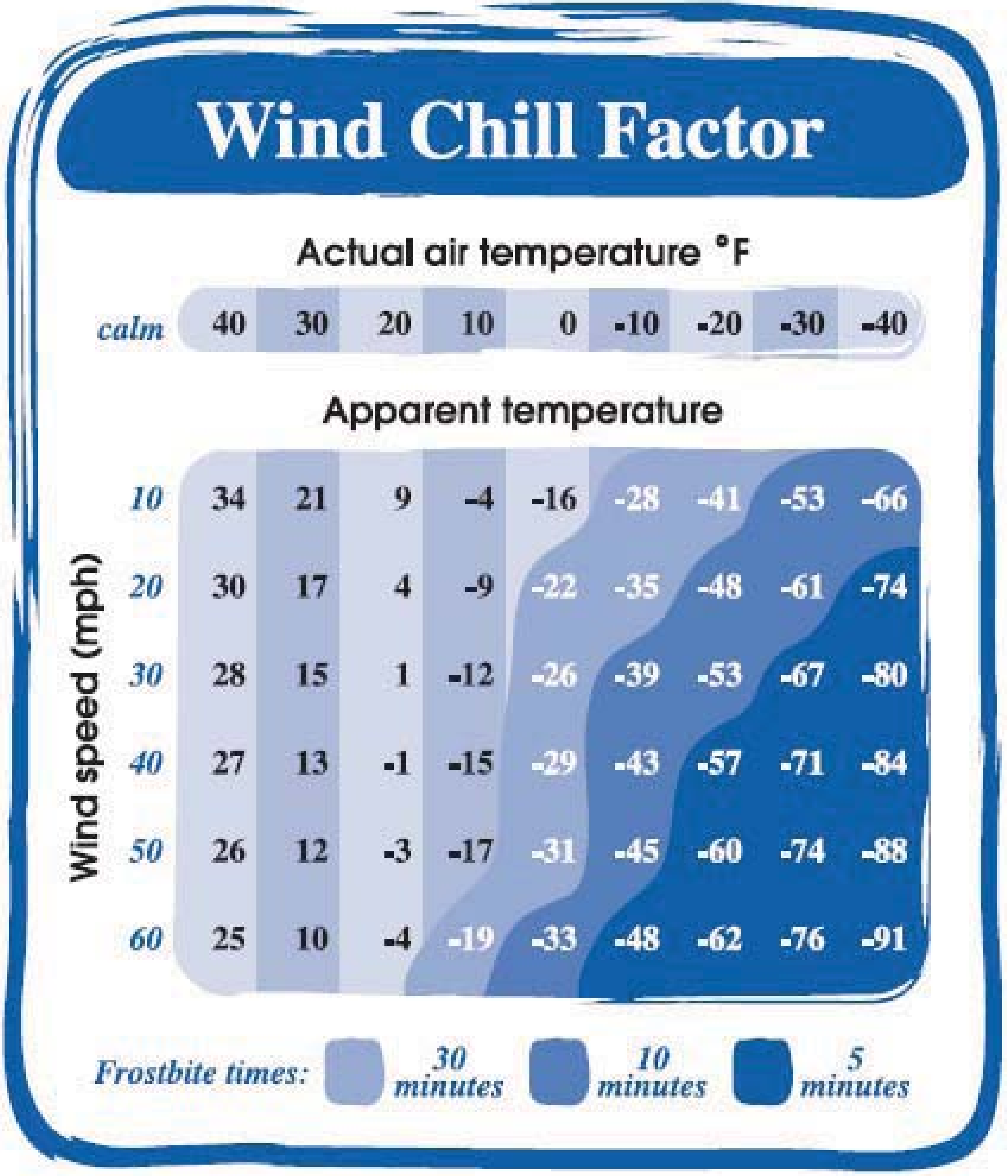
	protruding branches or sharp rocks); Slip/Trip/Fall Haul Trucks and other heavy equipment	on exposed skin surfaces; wear long sleeve shirt and full length pants; avoid high grass areas if possible; tuck pants leg into boot; do not put hand/arm into/under an area that you cannot see into/under clearly. Avoid fences if possible, or use help to move through fenced areas to avoid scrapes, cuts abrasions. Wear gloves when opening/closing gates to protect against splinters and barbs. Be sure of footing (wet/muddy conditions may exist, loose rock may be present, sage brush or other woody materials may be present with protruding branches). Where site is on or near mine property, be aware heavy equipment that may be operated nearby. Follow appropriate site-specific safety precautions when parking (use chocks), travelling (wear seatbelts), or working near or on the mine site.
Lifting heavy objects (generators, sampling equipment, coolers, 5-gallon buckets, totes, etc.)	Muscle strain	Use proper ergonomics when lifting heavy objects; use two people to lift gear and equipment as needed based on weight to be lifted.
Donning and doffing waders	Slip/Trip/Fall	Donning and doffing waders to be done on stable ground or a sitting position to avoid losing balance.
Sampling including retrieval of surface water and sediment samples, and flow measurement	Contaminated media Eye/skin contact with biological agents and chemicals Inhalation of chemical vapors (preservatives) Dangerous animals and vegetation Heat exhaustion and sun exposure Hypothermia/cold water exposure Stinging insects Slip/Trip/Falls Muscle and soft tissue injury Drowning	Wear site/activity-appropriate PPE; Review and understand MSDS for all chemicals being handled. Be careful when handling acids and caustic substances. Wear adequate PPE and wash hands after completion of task. Position body in order to minimize downwind exposure. Be aware of surroundings. Learn to identify, and avoid, toxic plants such as poison ivy. Watch for dangerous animals, such as aggressive dogs on private property, badgers, and harmful insects. Be aware of animal burrows, uneven, and/or loose terrain. Avoid dehydration, excessive sun and heat exposure, wear hats, sunglasses and sunscreen. Wear appropriate PPE for site conditions.

		Wear waders and non-skid wading boots. Where water depths exceed on average waist-deep for an individual, wear a personal flotation device (PFD). Wear wading belt, securing fastener at waist, to minimize filling waders in case of submersion. If a worker does not feel comfortable about the velocity of the river water, do not enter. Fast-moving water could result in a fall and subsequent risk of drowning. Avoid muddy and/or steep banks when entering or existing the water. If necessary, use a buddy system to aid entrance and existing water.
Icing (reicing) sample coolers, transporting coolers and other equipment back to laboratory	Slip hazard Muscle and back Injury	Use due care when draining water from coolers, use proper ergonomics when lifting and moving coolers and other equipment.
Operating snowmobile	Injury to operator	Helmets must be worn whenever the snowmobile is under its own power, even when loading and unloading
Traveling on snowmobile	Becoming stranded	Ensure adequate supplies, such as water, food, clothing, and other survival kit equipment. Never travel alone Check the most current weather forecast prior to leaving for the field to ensure conditions conducive for safe snowmobile travel . Always follow your planned route of travel or inform PM of changes in your travel plans. If unsure if something's a good idea, error on the side of caution. If you become stranded, stay with your machine, inform PM of your situation, if possible, and prepare to wait to be rescued (build a warming fire and make yourself as comfortable as possible). To avoid the next person becoming stranded, report all mechanical problems to maintenance coordinator or your PM
Traveling on snowmobile	Collisions	Always wear an approved helmet

	- collisions with other riders, stationary objects, other trail users) - other hazards including fence, cattle guards, cables	(meets SNELL M95 or M2000 standards) with goggles or face shield. Avoid or minimize fogging of goggles or face shield to maximize your ability to see hazards. Maintain safe speed to coincide with existing, and anticipated terrain, snow, trail, and visibility conditions. Maintain adequate distance between machines, a minimum of 100 feet or "4 second rule"; travel at safe speeds with a safety margin for unseen hazards. Check headlights, taillights, and brake lights prior to using machine; travel only when all lights are operating properly. When traveling on groomed trails, keep to the right hand side of the trail to allow room for oncoming traffic. Pull to the far right hand side, or off the trail if possible, when it is necessary to stop. When traveling off groomed trails, be constantly alert for fences. Only the top wire may be visible, or just the posts, but the wire or post may catch your skis or track. When riding near/on roads, be cautious of cattle guards and suspended cables.
Traveling on snowmobile	Loss of control of machine. Steep terrain Excessive speed Skill limitations	Know your own limitations and abilities as well as the limitations of the machine that you are riding, and ride within your own limitations and abilities. Don't follow more experienced operators into situations that make you uncomfortable. When traveling as part of a group, travel at the speed of the slowest member of the group. Off road/trail use is limited to ground that is generally less than 35% slopes.
Traveling on snowmobile	Avalanches	Avoid those known areas that are characteristic of avalanche zones. Know and be aware of snow conditions that may result in avalanche conditions

		(i.e. periods of heavy precipitation, warming periods, loose snow, or recent snow). Always carry a collapsible probe, collapsible shovel, and a transceiver pair and take additional avalanche training.
Traveling on snowmobile	Hypothermia, frostbite, fatigue	When riding in conditions that require a great deal of effort (off groomed trails, in deep powder, or soft snow conditions), rest as often as is needed to maintain your strength and concentration. Always be alert for the symptoms of hypothermia, and frostbite. Avoid becoming wet or overheated. Dress in layers that can be adjusted to match conditions
Becoming unstuck, snowmobile	Back injury	If you become stuck and elect to deal with it on your own, use proper lifting techniques, and deal within your limitations. If you are seriously stuck, call your working partner, assess the situation and work together, or make a joint decision to call for help
Snowmobile crossing frozen streams	Becoming stuck, drowning, get ting wet	Plan ahead and when possible, avoid crossing frozen streams and small bodies of water, except at culverts or bridges. If stream must be crossed, check stream bank for best location to cross, check ice thickness and determine if crossing is safe before proceeding
Snowmobile crossing open roads and operating in parking lots	Loss of control on pavement, Collisions	Plan to allow more room and more time for operating on paved surfaces. Approach road to be crossed cautiously; stop; listen and look for traffic; look both ways and proceed directly across road (at right angle if possible).
Site exit	Contaminated vehicle	Wash hands promptly. Used disposable PPE should be disposed on-site. If excess mud or debris is present on truck, wash before leaving mine site.
Drive home or to next site	Traffic hazards	FOLLOW "TRAVEL TO SITE" PROCEDURES

ATTACHMENT 4
WIND CHILL CHART



Wind Chill Factor

Actual air temperature °F

calm	40	30	20	10	0	-10	-20	-30	-40

Apparent temperature

Wind speed (mph)

10	34	21	9	-4	-16	-28	-41	-53	-66
20	30	17	4	-9	-22	-35	-48	-61	-74
30	28	15	1	-12	-26	-39	-53	-67	-80
40	27	13	-1	-15	-29	-43	-57	-71	-84
50	26	12	-3	-17	-31	-45	-60	-74	-88
60	25	10	-4	-19	-33	-48	-62	-76	-91

Frostbite times: *30 minutes* *10 minutes* *5 minutes*

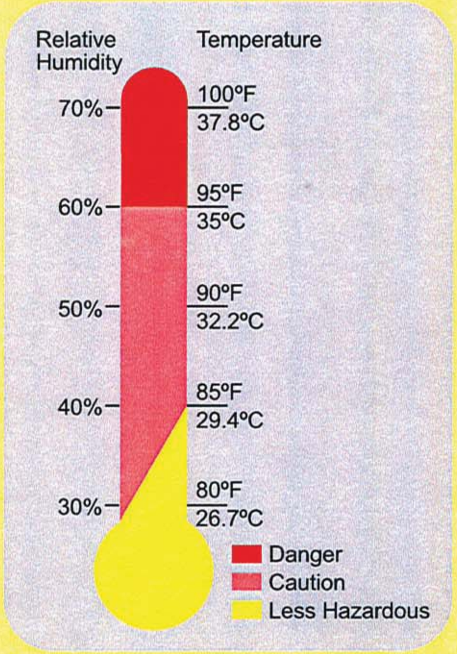
National Weather Service (NWS) Wind Chill Chart adapted May 2004 from http://www.nws.noaa.gov/om/windchill/

ATTACHMENT 5
HEAT STRESS EDUCATION POSTER

The Heat Equation

HIGH TEMPERATURE + HIGH HUMIDITY + PHYSICAL WORK = HEAT ILLNESS

When the body is unable to cool itself through sweating, **serious** heat illnesses may occur. The most severe heat-induced illnesses are heat exhaustion and heat stroke. If left untreated, **heat exhaustion** could progress to **heat stroke** and possible **death**.



U.S. Department of Labor
Occupational Safety and Health Administration
OSHA 3154
2002

Heat Exhaustion

What are the symptoms?

HEADACHES; DIZZINESS OR LIGHTHEADEDNESS; WEAKNESS; MOOD CHANGES SUCH AS IRRITABILITY, CONFUSION, OR THE INABILITY TO THINK STRAIGHT; UPSET STOMACH; VOMITING; DECREASED OR DARK-COLORED URINE; FAINTING OR PASSING OUT; AND PALE, CLAMMY SKIN

What should you do?

- Act immediately. If not treated, heat exhaustion may advance to heat stroke or death.
- Move the victim to a cool, shaded area to rest. Don't leave the person alone. If symptoms include dizziness or lightheadedness, lay the victim on his or her back and raise the legs 6 to 8 inches. If symptoms include nausea or upset stomach, lay the victim on his or her side.
- Loosen and remove any heavy clothing.
- Have the person drink cool water (about a cup every 15 minutes) unless sick to the stomach.
- Cool the person's body by fanning and spraying with a cool mist of water or applying a wet cloth to the person's skin.
- Call 911 for emergency help if the person does not feel better in a few minutes.

Heat Stroke–A Medical Emergency

What are the symptoms?

DRY, PALE SKIN WITH NO SWEATING; HOT, RED SKIN THAT LOOKS SUNBURNED; MOOD CHANGES SUCH AS IRRITABILITY, CONFUSION, OR THE INABILITY TO THINK STRAIGHT; SEIZURES OR FITS; AND UNCONCIOUSNESS WITH NO RESPONSE

What should you do?

- Call 911 for emergency help immediately.
- Move the victim to a cool, shaded area. Don't leave the person alone. Lay the victim on his or her back. Move any nearby objects away from the person if symptoms include seizures or fits. If symptoms include nausea or upset stomach, lay the victim on his or her side.
- Loosen and remove any heavy clothing.
- Have the person drink cool water (about a cup every 15 minutes) if alert enough to drink something, unless sick to the stomach.
- Cool the person's body by fanning and spraying with a cool mist of water or wiping the victim with a wet cloth or covering him or her with a wet sheet.
- Place ice packs under the armpits and groin area.

How can you protect yourself and your coworkers?

- Learn the signs and symptoms of heat-induced illnesses and how to respond.
- Train your workforce about heat-induced illnesses.
- Perform the heaviest work during the coolest part of the day.
- Build up tolerance to the heat and the work activity slowly. This usually takes about 2 weeks.
- Use the buddy system, with people working in pairs.
- Drink plenty of cool water, about a cup every 15 to 20 minutes.
- Wear light, loose-fitting, breathable clothing, such as cotton.
- Take frequent, short breaks in cool, shaded areas to allow the body to cool down.
- Avoid eating large meals before working in hot environments.
- Avoid alcohol or beverages with caffeine. These make the body lose water and increase the risk for heat illnesses.

What factors put you at increased risk?

- Taking certain medications. Check with your health-care provider or pharmacist to see if any medicines you are taking affect you when working in hot environments.
- Having a previous heat-induced illness.
- Wearing personal protective equipment such as a respirator or protective suit.

ATTACHMENT 6
MSDS Zinc Oxide

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.™

Search the NIOSH Pocket Guide

SEARCH

Enter search terms separated by spaces.

Zinc oxide

Synonyms & Trade Names Zinc peroxide

CAS No. 1314-13-2

RTECS No. ZH4810000 (/niosh-rtecs/ZH496510.html)

DOT ID & Guide 1516 143 (http://wwwapps.tc.gc.ca/saf-sec-sur/3/erg-gmu/erg/guidepage.aspx/guide143/) (http://www.cdc.gov/Other/disclaimer.html)

Formula ZnO

Conversion

IDLH 500 mg/m^3
See: 1314132 (/niosh/idlh/1314132.html)

Exposure Limits **NIOSH REL** : Dust: TWA 5 mg/m^3 C 15 mg/m^3
Fume: TWA 5 mg/m^3 ST 10 mg/m^3
OSHA PEL † (nengapdxg.html) : TWA 5 mg/m^3 (fume) TWA 15 mg/m^3 (total dust) TWA 5 mg/m^3 (resp dust)

Measurement Methods
NIOSH 7303 (/niosh/docs/2003-154/pdfs/7303.pdf) , 7502 (/niosh/docs/2003-154/pdfs/7502.pdf) ;
OSHA ID121 (http://www.osha.gov/dts/sltc/methods/inorganic/id121/id121.html) (http://www.cdc.gov/Other/disclaimer.html) , ID143 (http://www.osha.gov/dts/sltc/methods/inorganic/id143/id143.html) (http://www.cdc.gov/Other/disclaimer.html)
See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html) (http://www.cdc.gov/Other/disclaimer.html)

Physical Description White, odorless solid.

MW: 81.4	**BP:** ?	MLT: 3587°F	Sol(64°F): 0.0004%	**VP:** 0 mmHg (approx)	**IP:** NA
Sp.Gr: 5.61	**Fl.P:** NA	**UEL:** NA	**LEL:** NA		

Noncombustible Solid

Incompatibilities & Reactivities Chlorinated rubber (at 419°F), water [Note: Slowly decomposed by water.]

Exposure Routes inhalation

Symptoms Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; malaise (vague feeling of discomfort); chest tightness; dyspnea (breathing difficulty), rales, decreased pulmonary function

Target Organs respiratory system

Personal Protection/Sanitation (See protection codes (protect.html))
Skin: No recommendation
Eyes: No recommendation
Wash skin: No recommendation
Remove: No recommendation
Change: No recommendation

First Aid (See procedures (firstaid.html))

Breathing: Respiratory support

Respirator Recommendations
NIOSH/OSHA

Up to 50 mg/m^3:
(APF = 10) Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100, P100.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
(APF = 10) Any supplied-air respirator

Up to 125 mg/m^3:
(APF = 25) Any supplied-air respirator operated in a continuous-flow mode
(APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter.

Up to 250 mg/m^3:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
(APF = 50) Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode
(APF = 50) Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter
(APF = 50) Any self-contained breathing apparatus with a full facepiece
(APF = 50) Any supplied-air respirator with a full facepiece

Up to 500 mg/m^3:
(APF = 1000) Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode
(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.
Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.
Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: INTRODUCTION (/niosh/npg/pgintrod.html) See ICSC CARD: 0208 (/niosh/ipcsneng/neng0208.html) See MEDICAL TESTS: 0246 (/niosh/docs/2005-110/nmed0246.html)

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