Field Sampling Plan

Outfall 001 at Great Salt Lake
Southwest Groundwater Treatment Plant

Prepared for

Jordan Valley Water Conservancy District
Kennecott Utah Copper LLC

Prepared by

CH2MHILL®

215 S. State Street, Suite 1000
Salt Lake City, Utah 84111

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Contents

Tables

Figure

Acronyms and Abbreviations

°C	degrees Celsius
COC	chain-of-custody
DQO	Data Quality Objective
DWQ	Utah Division of Water Quality
EPA	United States Environmental Protection Agency
FSP	Field Sampling Plan
GPS	global positioning system
GSL	Great Salt Lake
HSP	Health and Safety Plan
I	Interstate
JVWCD	Jordan Valley Water Conservancy District
KUC	Kennecott Utah Copper LLC
LCS	laboratory control sample
MB	method blank
MDL	method detection limit
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MGD	million gallons per day
MS	matrix spike
MSD	matrix spike duplicate
ng/g	nanogram(s) per gram
ng/L	nanogram(s) per liter
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RO	reverse osmosis

RPD	relative percentage difference
RS	reference sample
SOP	standard operating procedure
SWGWTP	Southwest Groundwater Treatment Plant
UPDES	Utah Pollution Discharge Elimination System

1.0 Introduction

This Field Sampling Plan (FSP) was prepared on behalf of Jordan Valley Water Conservancy District (JVWCD) to meet requirements as set forth by Utah Pollution Discharge Elimination System (UPDES) permit number UT0025836 and Kennecott Utah Copper LLC (KUC). This FSP provides for the routine survey of birds, collection of environmental samples and reporting of concentrations of selenium and mercury in the water, sediment, macro-invertebrates, and bird eggs during the nesting season in the discharge channel and delta of JVWCD's Outfall 001 and KUC's Outfall 012. Both outfalls are located along the south shore of Great Salt Lake (GSL) in Gilbert Bay (see Figure 1).

1.1 Background

JVWCD will operate the Southwest Groundwater Treatment Plant (SWGWTP) to remediate contaminated groundwater from historic mining activities in southwest Salt Lake County and other groundwater impacted by non-mining conditions. A reverse osmosis (RO) treatment process will be used at the treatment plant to treat contaminated groundwater and supply drinking-quality water to its member agencies to meet increasing drinking water demands. The RO byproduct water will be routed via a 21-mile pipeline to be discharged to Gilbert Bay of GSL at JVWCD Outfall 001 under UPDES Permit No. UT0025836. Initially the byproduct discharge from JVWCD will be 1.5 million gallons per day (MGD); the ultimate build-out flow rate is 3 MGD. The flow rate from KUC's Outfall 012 varies from zero to 50 MGD.

KUC is currently operating a copper mine and tailings impoundment with a periodic discharge to Gilbert Bay. This discharge is permitted under Permit No. UT0000051 at Outfall 012. KUC's UPDES permit does not contain the same monitoring requirements as JVWCD's at this time; however, KUC is cooperating with JVWCD in this data collection. JVWCD's Outfall 001 is located approximately 20 feet east of the existing KUC Outfall 012.

1.2 Objectives

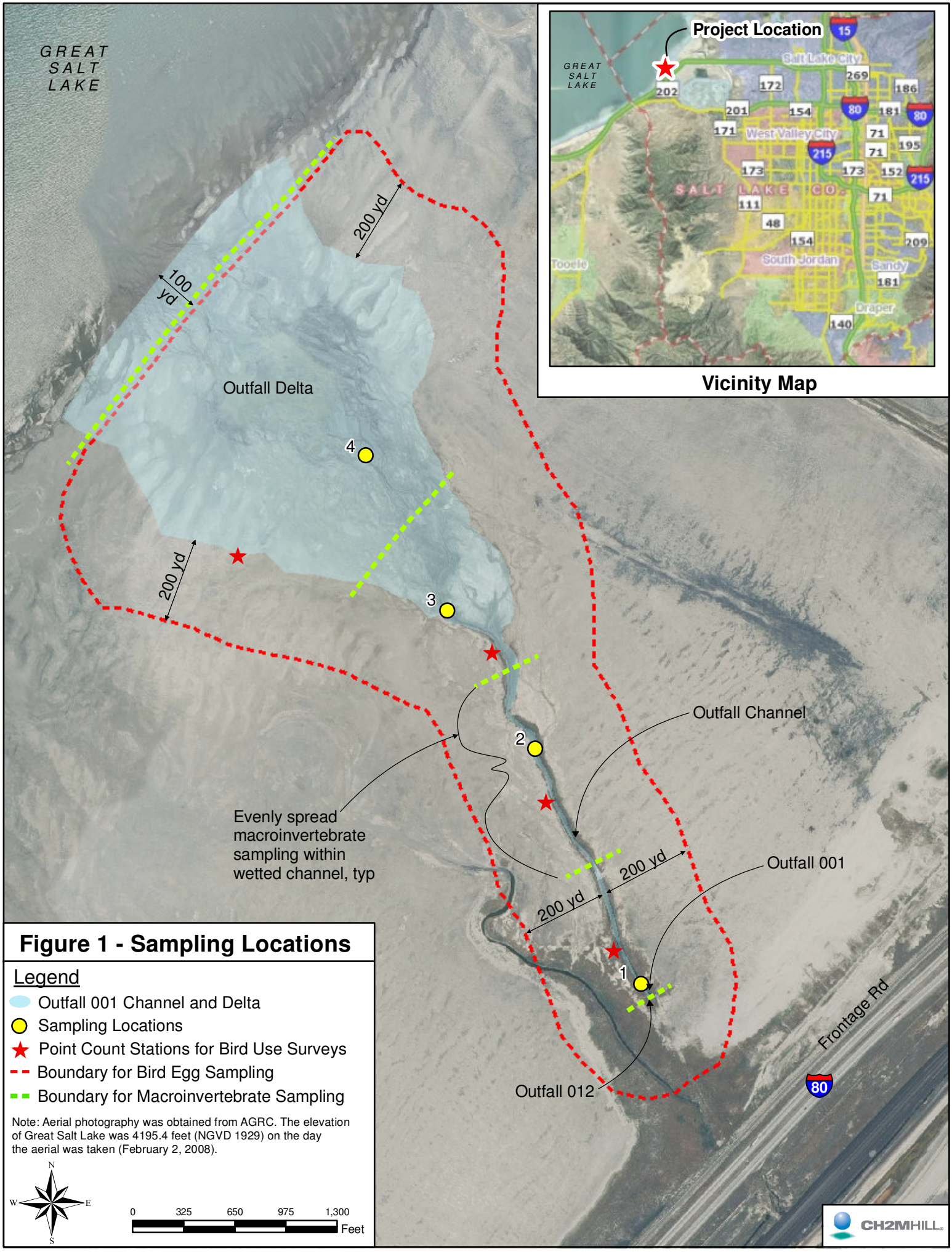
The objective of this FSP is to collect and report the required information defined in JVWCD's UPDES permit to the Utah Department of Environmental Quality, Division of Water Quality (DWQ). This FSP defines the sampling quality objectives, survey and sampling procedures, analytical procedures, safety considerations, and documentation and reporting requirements to be implemented by JVWCD.

1.3 Site Description

Outfall 001 is located on the south shore of Gilbert Bay, generally 1,000 feet northwest of Interstate (I) 80 near Mile Marker 105 (Latitude 40°45'37.59"N; Longitude 112°10'13.32'W) (see Figure 1). The outfall is most-readily accessed from a frontage road on the north side of

I-80 via Exit 102 on I-80 (i.e., Saltair exit). Parking is limited due to a very narrow and soft shoulder along the frontage road.

JVWCD's discharge is from an 18-inch-diameter pipeline into an existing, incised channel that ranges from 10 to 15 feet wide. This channel also conveys an existing permitted discharge from KUC's 54-inch-diameter pipeline. The channel flows approximately 2,500 feet generally to the northwest where it disperses into a wide delta region before reaching the waters of Gilbert Bay. The delta consists of numerous braided, very shallow channels. The location of the confluence of flows from the outfalls and Gilbert Bay varies depending upon lake levels.


GREAT SALT LAKE
Project Location
Vicinity Map
Outfall Delta
200 yd
100 yd
200 yd
200 yd
200 yd
200 yd
4
3
2
1
Outfall Channel
Outfall 001
Outfall 012
Evenly spread macroinvertebrate sampling within wetted channel, typ
Frontage Rd
80
Figure 1 - Sampling Locations
Legend
Outfall 001 Channel and Delta
Sampling Locations
Point Count Stations for Bird Use Surveys
Boundary for Bird Egg Sampling
Boundary for Macroinvertebrate Sampling
Note: Aerial photography was obtained from AGRC. The elevation of Great Salt Lake was 4195.4 feet (NGVD 1929) on the day the aerial was taken (February 2, 2008).
N
W
E
S
0
325
650
975
1,300
Feet
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2.0 Data Quality Objectives

The United States Environmental Protection Agency's (EPA's) seven-step Data Quality Objective (DQO) process (EPA, 2006) was used to guide the requirements and design rationale for the GSL sampling and analysis plan. The DQO's define the type, quantity, and quality of data and establish performance and acceptance criteria to ensure that data collected support the goals of the study.

Table 1 details the DQOs for this study.

TABLE 1
DQOs for GSL Monitoring Program for JVWCD's Outfall 001 at Gilbert Bay

Step	DQO for JVWCD
1. Problem Statement	**Problem:** DWQ has identified a concern for selenium and mercury in JVWCD's RO byproduct water to potentially adversely affect aquatic organisms and aquatic-dependent wildlife in both the water column and the transitional waters (mudflat wetlands) of GSL. DWQ is requiring JVWCD to conduct bird surveys and monitor the concentration of selenium and mercury in water, sediment, macro-invertebrates, and bird eggs during the annual bird nesting season. **Project Team Members**: JVWCD will coordinate with KUC and other parties conducting sampling efforts in any given season to complete the sampling, analysis, and reporting required by the UPDES permit. **Available Resources:** JVWCD will supplement its staff with consultants as required to complete the required sampling, analysis, and reporting. **Relevant Deadlines:** JVWCD is required to submit laboratory results to DWQ by March 1 following the end of the calendar year for which the results were obtained as a part of the Annual Project Operating Report.
2. Goal of the Study/Decision Statements	**Key Questions:** 1. What are the concentrations of total selenium and mercury in co-located samples of water, sediment, macro-invertebrates, and bird eggs collected along the outfall channel and delta at Gilbert Bay during the nesting season? 2. What are the abundance, diversity, and nesting and feeding habitats of birds at the outfall during the nesting season? **Possible Outcomes:** 1. Ability to collect samples from all required sampling locations. 2. Due to an elevated GSL water level, samples cannot be collected from the required sampling locations. 3. Eight or less bird eggs are available to assess compliance with the selenium limit defined in JVWCD's UPDES permit. 4. Bird eggs are not available to assess compliance with the selenium limit in JVWCD's UPDES permit. JVWCD will notify DWQ and summarize sampling searches and all other data in the Annual Project Operating Report. 5. Significant changes in the GSL level may affect sampling locations and/or procedures defined in this FSP and will require an evaluation of and modification to the FSP.

TABLE 1
DQOs for GSL Monitoring Program for JVWCD's Outfall 001 at Gilbert Bay

Step	DQO for JVWCD
3. Inputs to the Decision	**Informational Inputs:** The following information will be collected at the required sampling locations along the outfall channel and delta, as shown in Figure 1: 1. Annually, sample eight bird eggs (1 egg per nest), if available, or less if eight are not available, but not to exceed 20 percent of observed available eggs, during the nesting season (May 1 through June 30). Eggs will be collected from bird nests in the joint JVWCD Outfall 001 and KUC Outfall 012 area (within 200 yards of the water, as shown in Figure 1). Whole eggs shall be analyzed for total selenium and total mercury on dry-weight basis; moisture content of the samples also will be measured and reported. Black-necked stilts and American avocet are the species first targeted for egg sampling. If eggs from these species are not available, other shore birds will be targeted. 2. Annually, sample co-located water, sediment, and macro-invertebrates from the outfall channel and delta and analyze for total selenium and total mercury; moisture content of sediment and macro-invertebrate samples will be measured and reported. Sediment and macro-invertebrate results will be reported on dry-weight basis. Water samples will be analyzed for methyl-mercury concentration. 3. Conduct annual bird surveys about every 2 weeks between May 1 and June 30 (four times per nesting season) to document bird species, abundance, diversity, and use of the joint JVWCD Outfall 001 and KUC Outfall 012 area, particularly for evidence of feeding and nesting. **Variables/characteristics to be measured:** Total selenium concentrations in the following: • Bird eggs • Co-located water, sediment, and macro-invertebrates Total mercury concentrations in the following: • Bird eggs • Co-located water, sediment, and macro-invertebrates Methyl-mercury concentrations in the following: • Water Moisture content of sediment and biological samples; report dry-weight concentrations and moisture percentage of biota samples Bird species, abundance, diversity and use, particularly feeding and nesting within joint JVWCD Outfall 001 and KUC Outfall 012 area
4. Study Boundaries	Open channel and delta formed by flow from Outfall 001, extending from the discharge point to the confluence with open waters of Gilbert Bay; for bird eggs, the sampling area extends to within 200 yards of the edge of water in the channel and delta. The discharge point of JVWCD Outfall 001 is located at Latitude 40°45'37.59"N; Longitude 112°10'13.32"W. The discharge location for KUC Outfall 012 is Latitude 40°45'37.63"N; Longitude 112°10'13.95"W. **Temporal:** The period of data collection will be during the nesting season, May 1 through June 30. **Practical Constraints on Data Collection:** • Occurrence of breeding birds feeding and nesting along Outfall 001 is a constraint as it will dictate the presence of appropriate bird eggs for sampling. • Predators/people are a constraint as they may limit breeding along and near Outfall 001 and result in loss of an inability to find eggs. • GSL lake level may be a constraint and affect sampling locations. • The presence and depth of water and lack of presence of macro-invertebrates in the

TABLE 1
DQOs for GSL Monitoring Program for JVWCD's Outfall 001 at Gilbert Bay

Step	DQO for JVWCD
	Outfall 001 channel and delta may be a constraint; all sites may not equally yield co-located samples.
5. Decision Rules	1. If samples collected and data analyzed are adequate to meet the requirements of the UPDES permit, JVWCD will complete reporting as required. 2. If samples collected and data analyzed are not adequate to quantify selenium and mercury in bird eggs then JVWCD will notify DWQ in a timely manner and complete reporting as required. 3. If samples collected and data analyzed are not adequate to quantify selenium and/or mercury in water, sediment, and/or macro-invertebrates then JVWCD will notify DWQ in a timely manner and complete reporting as required.
6. Tolerable Limits on Decision Rules	Tolerance limits for laboratory analysis data quality are specified under Table 5, in terms of acceptability criteria. In general, acceptability criteria for analysis of selenium and mercury in tissues are ±10 percent and that for water and sediments are ±25 percent. The quality control (QC) procedures specify all quality assurance (QA)/QC objectives for sample measurement based on each matrix.
7. Optimization of the Sampling Design	The sampling plan is summarized as follows: • The area of and adjacent to the outfall channel and delta will be surveyed a total of four times during the annual nesting season (every two weeks, May 1 through June 30). Observers will document bird abundance, diversity, and patterns of use for feeding and nesting. • Co-located samples of water, sediment, and macro-invertebrates will be collected annually from four sampling locations located along the outfall channel and delta. Samples will be analyzed and results reported for total selenium and total mercury, plus moisture content of invertebrates. • Up to eight bird eggs (1 egg per nest), but no more than 20 percent of observed eggs, from the area adjacent to the outfall channel and delta (within 200 yards of the water, as shown in Figure 1) will be collected and analyzed for total selenium and total mercury on a dry-weight basis. Moisture content of the samples will also be measured and reported. Black-necked stilts and American avocet are the species targeted for egg sampling; if these are unavailable, eggs of other species will be collected. Sampling locations are fixed to facilitate comparison of year-to-year data. Locations may be adjusted to account for significant changes in lake level (±2 feet). New locations, if needed, will be coordinated with DWQ prior to sample collection and included in annual report.

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3.0 Sample Locations

Figure 1 illustrates the required locations for bird surveys and the collection of water, sediment, macro-invertebrate, and bird egg samples. The sampling locations are at fixed locations and are consistent with existing sampling locations used by KUC. Usage of these sampling locations will facilitate future analysis of year-to-year changes at these locations. Sample points and their exact coordinates are summarized in Table 2. Samples will be collected in coordination with KUC, who currently discharges to the same outfall channel and delta and monitors their discharges for selenium concentration.

GSL water levels are expected to vary over time. If lake levels rise and inundate any or all of the sampling locations, JVWCD will notify DWQ a minimum of 30 days prior to starting the annual bird surveys and environmental sampling of the site. Any changes to sampling locations agreed to with DWQ will be documented in the Annual Project Operating Report. Changes to sampling locations will not necessitate a revision to this FSP.

TABLE 2
Sample Points and Coordinates

Sample Points	Coordinates
1	40°45'37.87"N 112°10'14.03"W
2	40°45'52.71"N 112°10'23.51"W
3	40°46'1.72"N 112°10'31.02"W
4	40°46'11.20"N 112°10'37.77"W

Broad areas will be surveyed for bird species, abundance and diversity, as well as for feeding and nesting activity along the discharge channel. The approximate location of stations for bird use surveys are shown in Figure 1. Broad areas will also be searched to obtain the required diversity and abundance of biota tissue samples. Birds feeding from the discharge channel and the delta are expected to nest along the edge of water in the outfall channel and delta. For this reason, an area of about 200 yards (600 feet) on the either side of the discharge channel will be considered appropriate for bird egg sampling. Based on previous experience (Skorupa and Ohlendorf, 1991), this area is an average area expected for the foraging of these bird species around their nests. Eggs collected from this area will be a better indicator of bird species feeding directly from the channel and delta. The area is shown in red dashed lines on Figure 1. Similarly, sufficient mass of macro-invertebrates should be collected to be able to enable analysis of concentrations of selenium and mercury and a relatively large area may be needed to collect adequate biomass. Thus, the area for macro-invertebrates sampling will be evenly spread with the four sampling points as central locations and are indicated in green dashed lines in Figure 1.

The objective of this FSP is to characterize conditions in the channel and delta of JVWCD's Outfall 001 and KUC's Outfall 012, thus samples should be collected in areas a minimum of 100 yards from the water edge of Great Salt Lake. It is left to the judgment of field staff to identify the lake edge as the lake level is dynamic.

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4.0 Sampling Procedures/Methodology

Before going out for field sampling, a checklist of all routine material and equipment needed during sampling will be prepared. A separate list will be created for specialized sampling equipment, if required. Specialized sampling may include materials and equipments for clean sampling methods. In addition, safety gear, such as life jackets and safety vests, as well as appropriate clothing and shoes, will be worn as required during sampling.

4.1 Health and Safety

A site hazard analysis and Health and Safety Plan (HSP) should be prepared prior to completing sampling activities as required by JVWCD. While possible hazards include accessing the outfall and working in and around moving water, the field sampling team should assess all hazards and address them in the HSP prior to going to the field. All staff involved with field sampling activities will follow the HSP. Possible hazards include, but are not limited to:

- Outfall 001 is located approximately 1,000 feet northwest of the frontage road. The shoulder in this area is very narrow, thus presenting safety concerns for both parking and walking to sampling sites.
- Sampling will be performed in and around moving water. Sampling personnel should work in groups of two, at a minimum, when obtaining samples. During and after sample collection, personnel should keep their hands away from their eye and mouth areas, and always wash their hands with soap and water after sampling. Staff should be watchful for sharp objects, such as broken glass, and should not pick up suspicious objects.

4.2 Bird Use Surveys

Bird use survey will be conducted along the discharge watercourse from the discharge point to the water edge where Outfall 001 enters the standing waters of the GSL. Four surveys between May 1 and June 30 will be conducted at intervals of about 2 weeks. The objective of bird surveys along the channel and delta will be to characterize the relative abundance, and diversity of birds along with their feeding and nesting activity.

4.2.1 Pre-sampling Checklist

The pre-sampling checklist of materials will include the followings:

- A global positioning system (GPS) unit
- A map showing sampling sites with coordinates
- Digital camera
- Field measuring tape (300 yards)

- Bird survey form
- Clipboard
- Bound field log book
- Binoculars
- Pens and pencils
- Cell phones in case of emergency
- First-aid kit

4.2.2 Field Method

The basic method for the bird survey will be a modification of the Point Count method (Ralph et al., 1993, 1995). This method uses a series of point counts at fixed stations at a minimum distance of 300 yards apart within the site with the observer recording all birds seen and heard within a 10-minute time period and avoiding counting birds that were recorded at a previous sampling station. In addition, observers will record observations of birds seen between the identified fixed stations separately. All surveyors will be familiar and experienced with using the Point Count method.

The approximate location of the four Point Count stations for this FSP is shown in Figure 1. Actual GPS coordinates of stations to be recorded by surveyors. All surveys will be conducted from one side of the channel. Before surveying, surveyors will delineate the observing area into three zones based on distance from the channel boundary as follows:

- Zone 1 – Less than 100 yards
- Zone 2 – Between 100 and 200 yards
- Zone 3 – More than 200 yards

The observers will be familiar with most, if not all, of the bird species that are likely to be encountered. Bird activity, time of day, and weather conditions will be recorded on a standard form by species along with the counts. Standard bird survey forms are shown in Table 3. In addition, nesting activity and the presence of nests will be noted and counted as a measure of habitat quality and bird use. Any observations and evidence of birds and bird nest predation will be clearly documented. Field notes of all field activity will be recorded in a bound field logbook. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

TABLE 3
Bird Survey Forms

Location:	**Date:**
Observer:	**Start Time:**
Wind (mph):	**End Time:**
Cloud (%):	**Temperature:**

Species	Numbers	Activity	Remarks/Behavior/Predation
Less than 100 yards from Point Count Station			
100 to 200 yards from Point Count Station			
More than 200 yards from Point Count Station			

4.3 Bird Egg Sampling

Sampling of bird eggs for selenium and mercury analysis will provide a direct measure of the bioaccumulation of these constituents in resident nesting birds that are likely to be feeding (at least in part) in Outfall 001 during the nesting season. The results may be used to relate water, sediment, and invertebrate concentrations to those observed in the bird eggs. This will aid in the estimation of exposure and risk to the birds from selenium and mercury. It should be noted that **appropriate regulatory agencies should be contacted to ensure that permits and/or documentation are obtained prior to sampling bird eggs**.

4.3.1 Pre-sampling Checklist

The pre-sampling checklist of materials needed during egg sampling will include the followings:

- Permits (eggs should be collected under Utah Scientific and Federal collecting permits)
- A GPS unit
- A map showing sampling sites with coordinates
- Bound field log book
- Binoculars
- Field distance measuring instruments
- Digital camera
- Padded egg collection boxes (hard-sided container [e.g., egg cartons, Tupperware or tackle box, with foam padding])

- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit

4.3.2 Field Methods

Eggs from American avocet or black necked stilt nests will be collected from the area around the channel as shown in Figure 1 during the nesting season from May 1 through June 30. If these species are observed to be unavailable during the bird use survey, eggs from nests of other shorebirds with similar feeding habits will be collected. The nesting period varies from year to year and among species. Therefore, it is anticipated that three to four sampling events will be required between May 1 and June 30 to collect eight eggs (one per nest), if available, as required by the UPDES permit. However, the number of eggs collected will not exceed 20 percent of available eggs in the bird eggs sampling area shown in Figure 1. Every attempt will be made to collect equal number of eggs from the two species (four eggs from each species), but if there is a shortage for one species the total number will be collected by taking more eggs of the other species. If the required number of eggs and equal number of eggs from each species cannot be obtained during a nesting season, and one species is represented more than the other is, this will be noted while reporting and interpreting the data.

Some nests will be located during bird surveys by watching for the adults leaving the nest, displaying, or "sneaking" away from the nest. Other bird nests will be located by looking for birds displaying behaviors associated with nesting activities, searching for adults on nests with binoculars, and opportunistically finding nests while conducting surveys and other activities. Locations identified during bird surveys will be searched for nests with eggs.

Eggs will usually be collected as soon as a nest is discovered to avoid losing samples to predation and to maximize the number of nests sampled for selenium and mercury. After a nest is located, one egg will be removed if the nest contains two or more eggs. At collection, each egg will be marked with a unique nest code and the date it was removed using a marker pen. Collected eggs should be whole and not cracked, since cracking increases variation in percent moisture and may lead to leakage or contamination of contents.

A preformatted field data sheet will be filled out that will include a unique nest/egg identification code, bird species, location (using GPS coordinates for the nest), date, and number of eggs in the clutch. The egg will be placed in a container to avoid damage and the container will be placed in a cooler with wet ice. Collected eggs should be whole and not cracked. Eggs removed from nests will be transported to laboratory in hard container with sufficient padding. Eggs will be refrigerated at 4 degrees Celsius (°C) within 1 to 2 hours of collection and until opened, ideally no longer than seven days.

Field notes of all field activity will be recorded in a bound field logbook. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

4.3.3 Egg Breakout

Store eggs in a refrigerator as required above if they cannot be processed immediately after collection. Do not freeze whole eggs because this will crack the shell. Ideally, eggs should be processed as soon as possible after collection, and within seven days of collection. However, because refrigeration arrests development, the vascularization and bright red color of the blood in an egg collected with a living embryo is preserved for a longer period of time. The following describes the process of harvesting avian eggs in the laboratory. The goal of this description is to collect a standardized set of data on whole eggs, embryos, and shells while minimizing the possibility of laboratory contamination of samples.

All methods and results will be recorded in a bound laboratory logbook. Laboratory notes will include date and time, names of personnel processing the eggs, the work performed, any problems identified as well as corrective actions taken, and other appropriate results and general comments and observations.

Required Supplies

The supplies needed for the procedures include:

1. **Whole Egg Measurements:** distilled-deionized water, volumeter (immersion chamber or graduated cylinder), egg candler, Kimwipes, laboratory balance (to 0.05 g increments), vernier caliper (graduated to 0.0l mm).
2. **Egg Harvest:** glass jars of appropriate size (chemically-cleaned and with TFE cap-liners) or Nalgene jars (depending on contaminant), weigh boats, stainless steel surgical scissors, forceps, blunt probe, lead pencil or waterproof marker.
3. **Shell Thickness:** Micrometer modified for measuring eggshell thickness such as Federal 35 comparator with rounded contacts (graduated measurement to 0.01 mm –estimatable to nearest 0.001 mm) or modified Starrett micrometer (graduated measurement to 0.01 mm – estimatable to nearest 0.001 mm).

Egg Measurement Procedure

1. If possible, eggs will be candled to determine if cracks are present in the shell. Any cracked egg should not be rinsed or immersed in water as this may contaminate the sample.
2. If an egg is not cracked and is dirty (soil, feces) it should be cleaned with a Kimwipe and distilled-deionized water that is at or near the temperature of the egg.
3. Write the sample ID number on both ends of the eggshell with a dull pencil or waterproof marker (both IDs must be legible).
4. Record any remarkable characteristics of the egg (e.g., cracked, dented, discolorations, small in size, etc.).
5. Record the mass (g) of the whole egg, then measure the length (mm) and breadth (mm) of the egg at their greatest dimensions with calipers. (To obtain an accurate measurement of length, one must ensure that the caliper jaws are parallel to the

longitudinal axis of the egg. For the breadth measurement, the jaws must be held perpendicular to the longitudinal axis of the egg.)

6. Determine and record the egg volume (cm^3), the method of choice will depend on whether the shell is intact or cracked and what contaminants are being investigated. If determining the fresh weight of the egg is important (e.g., investigating organochlorine contaminants) the "Intact Shell" method is recommended, for investigating contaminants such as selenium the volume can be calculated from measurements (i.e., "Cracked Shell" method).

7. **Intact Shell:** For eggs with intact shells, determine the egg volume using the water displacement technique outlined below.

    a. If using an immersion chamber, place it next to and above the pan of a laboratory balance. Set a collection vessel on the balance's pan under the side arm of the volumeter. Next, place a wire loop in the volumeter. Fill the volumeter with distilled-deionized water that is slightly warmer than the egg temperature until it flows freely from the volumeter side arm (remember, the temperature of the water should be as close to the temperature of the egg as possible as this will minimize water movement across the eggshell pores). When the water stops flowing, empty the receptacle and return it to the balance pan. Tare the water receptacle. Gently raise the wire loop and place the egg on it. Gently lower the egg until it is completely submersed (lower the egg as quickly as possible without overflowing the volumeter, or breaking the egg). The weight of the displaced water equals the volume (cm^3) of the egg. Repeat this procedure three times for each egg and report the average value.

    b. If using a graduated cylinder, fill it with distilled-deionized water and note the starting volume. Using a wire loop, immerse the egg into the graduated cylinder until top of the egg is just below the water surface. Note the final volume and subtract starting volume to determine egg volume. Repeat this procedure three times for each egg and report the average value.

8. **Cracked Shell** (or if an immersion chamber or graduated cylinder is not available): For eggs that are cracked or dented, egg volume is estimated using the length and breadth measurements and an equation from the published literature (e.g., Westerskov, 1950; Stickel et al., 1973; Hoyt, 1979).

Egg Harvest

(Note: All tools used in egg harvest and embryo exam must be cleaned between egg exams. Investigators should wear surgical gloves and change gloves between eggs.)

1. **Vent egg if necessary.** For eggs with a strong odor (indicating advanced decomposition of the contents), it is advisable to vent the egg before attempting to open it (explosions are possible). With safety glasses in place, gently insert a chemically-clean needle into the blunt end of the egg. Use gentle but steady pressure to pierce the shell.

2. **Open window at blunt end of the egg**. Tare a chemically- clean jar and loosen the lid and tare the jar. Work over a c lean glass Petri dish or weigh boat. Method 1- using surgical scissors, apply gentle pressure while rotating the scissors so a small hole is made in the shell at the blunt end of the egg just above the air cell. Continue cutting

from the hole and cut around the entire egg above the air cell. Method 2—Rest the egg lengthwise on an appropriate surface (compatible with the analyses requested). Using a clean sharp scalpel, gently score the egg about the blunt end of the egg. Apply gentle, steady pressure and make several rotations. If candling of the egg revealed an advanced state of incubation with air cell development, try to remove shell from just above the air cell. Membrane may need to be peeled back to allow further inspection of the embryo.

3. **Inspect embryo position in the egg.** Visually inspect the egg contents through the window and note the size of the air cell. This window is used to assess whether the position of the embryo in the egg is normal. Note embryo position and whether the embryo has pipped into the air cell. Determination of embryo position is not accurate until the embryo is ready to pip the air cell (i.e., the last 4–5 days of incubation). Shedding the nare caps is a good landmark for avocets and stilts. Normal position of the embryo during the final stages before pipping is with the head in the blunt end of the egg, with the head under the right wing and with the beak pointed toward the air cell. If incubation stage is very late (i.e., just prior to pipping from the shell), the embryo beak is in the air cell to allow pulmonary respiration to begin. There are six malpositions of the avian embryo, as follows:

    a. head between thighs
    b. head in small end of egg
    c. head under left wing
    d. embryo rotated so that the beak is not directed toward air cell
    e. feet over head
    f. beak over right wing

4. Malpositioned embryos usually do not hatch, and positions I, III, and V are usually lethal.

5. Usually the egg contents can be poured out into the container from the window opened for embryo inspection. If necessary, use surgical scissors and make transverse cuts from the blunt end to the narrow end of the egg to facilitate egg opening.

6. **Open egg.** Inspect embryo position and note age of the embryo. To estimate age of the embryo use stages of incubation from literature. The model reference for aging embryos is Lillie's development of the chick (Hamilton, 1952) Chapter 3. Good day-by-day embryo stage data with pictures exist for chickens, mallards (Caldwell and Snart, 1974), kestrels (Pisenti et al., 2001), and cockatiels (Abbott et al., 1991). If no embryo can be found, examine the yolk for the presence of a blastodisc. If fertile and the yolk is intact, this will appear as a white donut shape floating on top of the yolk. If infertile, no distinct donut will be apparent. Note presence (and whether they are of normal size for the stage of development) or absence of eyes and of limbs or limb buds; note presence and number of digits on the feet; measure length of tarsus and upper mandible. Look for evidence of internal hemorrhage, edema, brain swelling, or failure of the body wall to completely close. Minimize handling of the embryo to the degree possible and conduct as much as possible of the above exam in the half shell. Use clean forceps, and beware of cross contamination. Pour the contents into the opened jar. If necessary, use a clean spatula to scrape any remaining contents into the jar (be careful not to tear the shell

membrane when using spatula). Record presence or absence of an embryo, estimated age of embryo, other measurements taken, and abnormalities (if any).

7. **4 Egg contents mass (g):** Measure and record the weight in grams of the tared jar.
8. Label jar with SAMPLE ID and SAMPLE MASS (place one label on the lid and the other on the jar itself), and immediately store the sample in the freezer. Sample shall be kept frozen during transportation to laboratory for analysis.
9. Rinse the interior of the shell halves with tap water being careful not to tear the membrane, or erase the sample IDs. After the shells dry, use a waterproof marker to remark the shells with their sample ID. Store the shells in a cool dry place for at least 30 days, or until they have attained a constant mass. Recycled egg cartons serve as excellent storage containers for egg shells. One tip to ensure that shells do not migrate from their respective compartments, is to place a folded sheet of paper over the shells before closing the carton.

Shell Thickness Measurement

1. Determine the eggshell mass (to nearest 0.001 g) of dried shells.
2. Allow eggshells to air dry for at least 30 days and measure eggshell thickness using an appropriate micrometer. Take thickness measurements of each shell along the equator at five places. Minimize influence of shell shape and curvature on the measurement taken. Report the average of all five measurements as the final thickness measurement. If the membrane has separated from the shell, take measurements without the membrane but be sure to make note of this on the data sheet. If possible then obtain measurement of membrane fragments.
3. Calculate the Ratcliffe Index (Ratcliffe, 1967) with the following formula:
4. THICKNESS INDEX = EGGSHELL MASS (mg)/ EGG LENGTH (mm) x EGG WIDTH (mm)

4.4 Macro-invertebrate Sampling

Macro-invertebrate samples will be collected to measure total selenium and total mercury in the discharge channel and delta. Macro-invertebrates are the primary food for the bird species targeted for egg collection and are good indicators of water quality. If present in the discharge channel, they may bioaccumulate selenium and mercury and pass it on to the higher trophic level of the food chain. The results obtained from sampling macro-invertebrates may be used to relate concentrations in water and sediment to those observed in the bird eggs.

4.4.1 Pre-sampling Checklist

The pre-sampling checklist of materials needed during macro-invertebrate sampling will include the following:

- A GPS unit
- A map showing sampling sites with coordinates

- Bound field log book
- Field distance measuring instruments
- Digital camera
- Waders and boots
- Aquarium nets or larger kicknets
- Whirlpak or Ziploc bags with labels
- Gloves
- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit
- Distilled water
- White plastic sorting tray
- Forceps

4.4.2 Field Methods

The four sampling areas for macro-invertebrates are shown in Figure 1. Samples will be collected once every nesting season, as close in time as practical to the bird egg collection from the delineated areas and as close as practical to each of the fixed sampling locations. Sampling of water, sediment, and macro-invertebrates should be completed in conjunction with each other. The objective of providing delineated areas for macro-invertebrate sampling, instead of specific sampling points, is to allow samplers to identify regions within each area where the birds are foraging, and to be able to collect sufficient macro-invertebrate biomass for analysis. A 5-minute feeding observation before sampling within each foraging area may provide guidance on where macro-invertebrates will be collected from the water column. Preference should be given to collecting macro-invertebrates at the same location as water and sediment samples are collected.

Aquatic invertebrate food items will be collected opportunistically in the general sampling area. Although abundant along the lake edge, sampling of adult brine flies should be avoided. Invertebrates collected at each station should be of sufficient biomass for analysis (target 5 grams) and additional biomass when that is feasible, using aquarium nets or larger nets (kicknets) by sweep netting. Each sample will be stored in a Whirl-pak or Ziploc bag and labeled with its location or sample number and collection date. Samplers will make a visual estimation of relative abundance (by mass) of families of macroinvertebrate within each sample and record this information in their field notes. Samples will be stored in a cooler until transported to laboratory. In the laboratory, they will be frozen until analyzed.

Lack of sufficient organisms for testing requirements at any location will be noted in the field log book. Field notes of all field activity will be recorded in a bound field logbook. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

4.5 Water Sampling

Water samples will be collected to measure total selenium and total and methyl-mercury in the discharge channel and delta.

4.5.1 Pre-sampling Checklist

The pre-sampling checklist of materials needed during water sampling will include the followings:

- A GPS unit
- A map showing sampling sites with coordinates
- Bound field log book
- Waders
- Wading boots, if required
- 1-liter glass bottles with fluoropolymer or fluoropolymer-lined cap with labels
- Digital camera
- Disposable gloves/elbow gloves
- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit
- Distilled water

4.5.2 Field Methods

The four water sampling locations are shown in Figure 1, and their coordinates are provided in Table 1. Water samples will be collected 6 to 12 inches below the water surface directly as grab samples into 1-liter glass sample bottles, where possible. At the delta stations where water is less than 6 inches deep, a one foot deep hole will be dug and the water will be allowed to flow through and collect in the hole. Any suspended sediments will be allowed to settle down, after which the water sample will be collected as explained above. Sampling locations with less than 6 inches of water depth will be recorded and a description of the manner used for sampling will be documented.

The field team will follow EPA Method 1669 (EPA, 1996) for clean hands/dirty hands techniques to collect water samples to be analyzed for total and methyl-mercury.

Each bottle will be labeled with sample number and date and time of collection (in most cases, containers will be pre-labeled).

4.6 Sediment Sampling

Sediment samples will be collected to measure total selenium and total mercury in the discharge channel and delta.

4.6.1 Pre-sampling Checklist

The pre-sampling checklist of materials needed during sediment sampling will include the followings:

- A GPS unit
- A map showing sampling sites with coordinates
- Bound field log book
- Pre-cleaned polyethylene scoops
- Waders and boots
- Digital camera
- Whirl-pak or Ziploc bags or glass jars with labels
- Disposable gloves/elbow gloves
- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit
- Distilled water

4.6.2 Field Methods

Sediment samples are collected after any water samples are collected where water and sediment are taken in the same reach. Care will be taken not to sample sediments that have been walked on or disturbed in any manner by field personnel collecting water samples. The top 2 centimeters of the sediment will be collected using a pre-cleaned polyethylene scoop. Five, small equal volume samples will be collected randomly from a small area at the site (over approximately 10 square feet) and will be placed into the single sampling container for that site. Sediment samples will be homogenized prior to analysis. This may be done in the field or at the laboratory. Homogenization techniques will vary depending on sample texture and moisture content. Drying may be necessary to facilitate thorough homogenization. If drying is necessary, temperatures will be low enough to prevent loss of analytes of concerns. Homogenization will be accomplished by shaking or stirring the sample either in the sample container or if necessary, by transferring to a stainless steel bowl.

Each composite sample will be stored in a Whirl-pak or Ziploc bag or pre-cleaned glass jars and labeled with its location or sample number and collection date. Samples will be stored in a cooler until transported to laboratory. In the laboratory, they will be frozen until analyzed.

Field notes of all field activity will be recorded in a bound field logbook. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

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5.0 Field Documentation

The field team leader will record daily field notes in a bound field logbook. Field notes will include the work performed, problems identified as well as corrective actions taken, conversations of significance, and other appropriate, general comments or observations.

5.1 Field Logbook

Field activities will be documented through journal entries in a bound field logbook, which is dedicated to this project. The field logbook will be water-resistant, the pages will be sequentially numbered, and all entries will be made in indelible ink. Each page of the field logbook will be dated and signed by the person making the entry. The field logbook will contain all pertinent information about sampling activities, site conditions, field methods used, general observations, and other pertinent technical information. Examples of typical field logbook entries include the following:

- Date and time of sample collection
- Name of personnel present
- Referenced sampling location description (in relation to a stationary landmark), GPS coordinates, and maps
- Daily temperature and other climatic conditions
- Field measurements, activities, and observations (e.g., depth of water, condition of water, other relevant conditions)
- Media sampled
- Sample collection methods and equipment
- Types of sample containers used
- Sample identification and cross-referencing
- Types of analyses to be performed
- Site sketches
- Visitors to the site

As required by JVWCD's project manager, additional information will be recorded in the field notebook.

5.2 Photographs

Color photographs taken during sampling activities will be numbered to correspond to photo log entries. The name of the photographer, date, time, site location, and photograph description will be entered sequentially in the photo log as photographs are taken.

6.0 Laboratory Analyses Methods

All water, sediment, macro-invertebrates, and bird egg (egg contents only) samples will be analyzed for total selenium and total mercury concentrations. Entire contents of eggs, macro-invertebrates, and sediment samples will be stored frozen at -20°C until analyzed. Water samples will be stored at 4°C. Care should be taken to avoid cracking or breaking of sample glass bottles when stored in -20°C. The laboratory will homogenize each sample prior to analysis so that the results represent the average concentrations.

Analysis techniques for selenium and mercury are shown in Table 4.

TABLE 4
Total Selenium, total mercury and methyl-mercury analysis methods

Analyte	Matrix	Method	Reference
Total Selenium	Biota	Hydride Generation AA	GSL Water Quality Study Quality Assurance Project Plan (QAPP), 2006
	Sediment	Hydride Generation AA	GSL Water Quality Study QAPP, 2006
	Water	Hydride Generation AA	GSL Water Quality Study QAPP, 2006
Total Mercury	Biota	Appendix to Method 1631	EPA, Office of Water, 2001
	Sediment	Appendix to Method 1631	EPA, Office of Water, 2001
	Water	EPA Method 1631	EPA, Office of Water, 2001
Methyl-mercury	Water	EPA Method 1630	EPA, Office of Water, 2001

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7.0 Quality Control Procedures

7.1 Sample Labeling and Containers

Environmental samples of water, sediment, macro-invertebrates, and bird egg contents will be collected directly into pre-cleaned containers provided by the laboratory when appropriate. Containers will generally be provided by the laboratory that will be completing the analytical testing, but will also be purchased in some cases by the sampling team.

Self-adhesive sample labels will be provided and affixed to each sample container. The sample label will be completed using indelible ink and will include the following information:

- Project name
- Sample identification number
- Date and time of sample collection (added in field)
- Matrix (coded as to sediment, water, or biota type)
- Sampler's initials (added in field)
- Analyses requested

Sample labels will be affixed to the sample containers and covered with clear tape.

7.2 Chain-of-Custody Procedures

Chain-of-custody (COC) records document sample collection and shipment to the laboratory. A COC form will be completed for each sampling event. The original copy will be provided to the laboratory with the sample shipping cooler and a copy will be retained in the field documentation files. The COC form will identify the contents of each shipment and maintain the custodial integrity of the samples. All COC forms will be signed and dated by the responsible sampling team personnel. The "relinquished by" box will be signed by the responsible sampling team personnel, and the date, time, and air bill number will be noted on the COC form. The laboratory will return the executed copy of the COC with the hardcopy report.

At a minimum, the COC form must contain the following:

- Site name
- Project manager's name, telephone number, and fax number
- Unique sample identification
- Date and time of sample collection
- Source of sample (including name, location, sample type, and matrix)
- Number of containers

- Analyses required
- Name of sampler
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratories
- Bill of lading or transporter tracking number (if applicable)
- Lab name, address, and contact information
- Any special instructions

Erroneous entries on COC records will be corrected by drawing a line through the error and entering the corrected information. The person performing the correction will date and initial each change made on the COC form.

7.3 Sample Packaging and Transport

The following sections contain guidelines for sample packaging and transport.

Sample Container Preparation

- The labels will be secured to each container with clear tape, if not previously done.
- Container lids will be checked for tightness, and if the container is not full, the outside of the container will be marked with indelible ink at the sample volume level.
- Sample bottles will be double-bagged in heavy-duty plastic. Glass containers will be covered with bubble wrap to prevent breakage.

Shipping Cooler Preparation

- All previous labels used on the sample-shipping cooler will be removed.
- The drain plugs will be sealed to prevent melting ice from leaking.
- A cushioning layer of packing material such as bubble wrap will be placed at the bottom of the cooler (approximately 1 inch thick) to prevent breakage during shipment.
- All ice will be double-bagged in a Ziploc plastic bag. If samples are shipped frozen with dry ice, the proper paperwork from the shipping carrier will be followed.

Placing Samples in the Cooler

- The COC form will be placed in a Ziploc bag.
- Samples will be placed in an upright position in the cooler.
- Ice will be placed on top of samples and between samples. Ideally, ice will be placed in resealable plastic bags in duplicate to minimize leakage of ice melt into the cooler.
- Void space between samples will be filled with packing material.

Closing the Cooler

- The cooler lid will be taped with strapping tape, encircling the cooler several times.
- Custody seals may also be affixed to the cooler lid to further ensure the integrity of the samples.

Transport

- Sample coolers will be transported to the laboratory (an overnight courier may be used) as soon after sample collection as possible.
- The laboratory will be notified that samples are being shipped.

Sample Receipt

The laboratory will designate a sample custodian who will log in samples using a standardized Sample Receipt Form. The custody seal will be inspected to verify that it is intact, and the sample custodian will then check the condition of samples and verify custody records. Any breakage, leakage, or other damage will be noted and recorded. The sample custodian will record all tracking information and pass it to the data librarian and the laboratory project manager. All of this information will appear on the Sample Receipt Form. If discrepancies are noted between the COC report and the actual contents of the container, these will immediately be reported to the JVWCD project manager. Along with sample receipt documentation, the following information will be documented on the Sample Receipt Form by the sample custodian:

- Date samples received
- Contractor sample identification number
- Laboratory sample identification number
- Analytical tests requested for each sample batch
- Sample matrix
- Number of samples in the batch
- Container description and location in the laboratory

After being logged in, the samples will be refrigerated or frozen as appropriate.

7.4 Quality Control Samples

The purpose of QC is to follow routine procedures to control the reliability and defensibility of data. QC samples collected in the field will be used to assess the overall quality of the project data. Field QC samples will include field duplicates. Laboratory QC will include method blank (MB), laboratory control sample (LCS) or reference sample (RS), matrix spike/matrix spike duplicate (MS/MSD), and sample duplicate. The analytical laboratory is responsible to ensure appropriate QC measures are implemented, verified, and recorded.

Field Duplicate Samples

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process. Duplicate

samples will be collected simultaneously or in immediate succession, using identical techniques, and treated in an identical manner during storage, transportation, and analysis. One field duplicate sample will be collected and analyzed each for surface water, sediment, and macro-invertebrates (where they are appropriately abundant). Eggs are already duplicated as they are all considered replicates, within species. The field sampling team will determine which materials will be used for QC samples.

Method Blank

MBs are used to monitor each preparation or analytical batch for interference and/or contamination from glassware, reagents, and other potential sources within the laboratory. An MB is an analyte-free matrix to which all reagents are added in the same amount or proportions as are added to the samples. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. There will be at least one MB per preparation or analytical batch. If a target analyte is found at a concentration that exceeds the acceptance criteria as indicated in Table 5, corrective action must be performed to identify and eliminate the contamination source. All associated samples must be re-prepared and re-analyzed after the contamination source has been eliminated. No analytical data may be corrected for the concentration found in the blank.

Laboratory Control Sample/Reference Sample

The LCS or RS will consist of an analyte-free matrix spiked with a known quantity of the target analyte from a traceable source. Total selenium and total mercury will be spiked into the LCS/RS. Ideally, the spike levels will be less than or equal to the midpoint of the calibration range. If LCS/RS results are outside the specified acceptable limits as provided in Table 5, corrective action must be taken, including sample re-preparation and re-analysis, if appropriate. If more than one LCS is analyzed in a preparation or analytical batch, the results of all LCS/RSs must be reported.

Matrix Spike/Matrix Spike Duplicate

A sample matrix fortified with known quantities of specific compounds is called a MS. It is subjected to the same preparation and analytical procedures as the native sample. Total selenium and total mercury will be spiked into the sample. MS recoveries are used to evaluate the effect of the sample matrix on the recovery of the analytes of interest. An MSD is a second fortified sample matrix. At least one MS/MSD will be analyzed for this project for each matrix, i.e., tissues, water, and sediment, for each sampling event. The relative percent difference between the results of the MSDs should be acceptable based on limits provided in Table 5. Results outside acceptable criteria will be subjected to corrective measures.

Laboratory Sample Duplicate

A sample duplicate selected by the laboratory is called a laboratory sample duplicate. Both samples are subjected to the same preparation and analytical procedures. The data collected may also yield information regarding whether the sample is heterogeneous. The acceptable relative percent difference between the results is provided in Table 5. Results outside acceptable criteria will be subjected to corrective measures.

Table 5 summarizes the QC requirement for this field sampling and laboratory analysis for this study, including method detection limits, field and laboratory QC samples, and acceptability criteria of the relative percentage difference (RPD) between results obtained from the QC samples.

TABLE 5
Analytical Method Detection Limits, QC Analyses to be Performed, and the QC Criteria for Acceptability

Matrix	Method Detection Limit for Selenium	Method Detection Limit for Total Mercury	Method Detection Limit for Methyl Mercury	QC Sample	Acceptability Criteria
Tissue	0.5 milligrams per kilogram (mg/kg) (dry weight)	1 nanogram per gram (ng/g) (dry weight)	Not Required	MB LCS/RS MS/MSD Sample Duplicate	±10%
Water	0.002 milligram per liter (mg/L)	0.5 nanogram per liter (ng/L)	0.06 nanogram per liter (ng/L)	MB LCS/RS MS/MSD Sample Duplicate	±25%
Sediment	0.1 mg/kg (wet weight)	1 ng/g (dry weight)	Not Required	MB LCS/RS MS/MSD Sample Duplicate	±25%

7.5 Laboratory Procedures

7.5.1 Laboratory Deliverables

The laboratory that will perform analyses must have established procedures to conduct data reduction, review, and reporting. Laboratory-specific procedures will be evaluated to ensure that the process steps discussed in this section are properly performed.

The primary analyst(s) will be responsible for review of their work as their work is being performed and for applying the measurement qualifiers (i.e., laboratory qualifier flags). During this process, a case narrative or QC exception report will be generated documenting nonconformance issues and resolutions. A designated peer reviewer, defined as a qualified staff member who is not the primary analyst, will perform an independent review to determine that project specifications have been met. The laboratory manager or designee will be responsible for final approval of the laboratory analytical report prior to sending the report to project staff.

Most laboratories use a Laboratory Information Management System to store, transfer, and report analytical data. These files must also undergo a QC check to verify that results are complete and correct. The laboratory is responsible for generating hard copies (i.e., final analytical report) and electronic files of the analytical results in standard formats needed by

the project staff. The specific information and electronic file formats are established and tested before analysis of any samples to ensure that the formats will be compatible with the project database, and that all required information is reported.

The hard copy and electronic laboratory reports for all samples and analyses will contain the information necessary to perform data evaluation. The following information is a comparable list that may be included for each preparation batch (when applicable) and each analytical batch, however, the typical e-delivery tables from the laboratory will be reviewed for completeness. The final list of deliverables may not include all of these parameters:

- Field identification number
- Date received
- Date prepared
- Date analyzed
- Method
- Results for each analyte
- Sample-specific reporting limit
- Units
- Laboratory qualifier flags, also called measurement qualifiers, for all data that do not meet project QC specifications
- Narrative
- MS and laboratory control spike concentrations
- MS and laboratory control spike results
- MS and laboratory control spike recoveries and RPDs
- Method blank results
- Initial and continuing calibration verification results (hard copy only)
- Initial and continuing calibration verification recoveries (hard copy only)
- Analytical batch number
- Preparation batch number
- Analytical sequence or laboratory run log that contains sufficient information to correlate samples reported in the summary results to the associated method QC information, such as initial and continuing calibration analyses
- Confirmation results
- Method of standard addition results (if applicable; required in hard-copy format only)
- Any other method-specific QC sample results

Complete documentation of sample preparation and analysis and associated QC information will be maintained by the laboratory for all project samples in a manner that allows easy retrieval in the event that additional validation or more information is required.

Data flow from the laboratory and field to the project staff and data users follows established procedures to ensure that data are properly tracked, reviewed, and validated for use. Analytical data from the laboratory will be matched to field data to ensure accurate reporting and adherence to project specifications. Results will be reviewed for correct sample identification, dates, sample-specific detection limits, flags, and agreement.

7.5.2 Laboratory Quality Control and Reporting

Quality Assurance and Quality Control

Laboratory QA/QC is designed to detect, reduce, and correct deficiencies in a laboratory's internal analytical process prior to the release of results and improve the quality of the results reported by the laboratory. Table 5 shows the QA/QC procedures proposed for this sampling and analysis.

Data Reporting

The laboratory will perform an internal data check in accordance with their QA/QC protocols. The following will be reviewed: instrument performance, initial and continuing calibration verification, error determination (bias and precision), blanks results, compound identification, compound quantitation and reporting limits, performance evaluation sample results, and overall assessment of data. Any data that was manually entered into an electronic format will be verified by the responsible analyst. Data that does not meet QA/QC criteria will be flagged.

Laboratory Data Review

The analyst performing the laboratory tests will review all of the definitive data. Upon their completion, a senior analyst will perform an independent review of all data using the same criteria and methods. At a minimum, the following elements for review and verification must include:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate standard operating procedures (SOPs) and analytical methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including integrations
- Appropriate application of QC samples and compliance with established control limits
- Verification of data transfers
- Documentation completeness

Data Qualifiers

During data reporting and review, qualifiers are applied to ensure that the laboratory has provided data of known quality. During data validation, qualifiers will be applied to alert the data end user to quality problems that may impact the usability of the data. Table 6

identifies the codes that will be used when reporting data values either meet the specified description outlined in the table or do not meet the QC criteria of the laboratory.

TABLE 6
Laboratory Data Qualifiers

Qualifier	Description
Q	One or more QC criteria failed. Data must be carefully assessed by the project team with respect to the project-specific requirements and evaluated for usability. Subsequent assessment by the project team may result in rejection of the data.
M	Matrix effect: The concentration is estimated due to matrix effect.
J	Estimated: The analyte was positively identified, the quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria.
F	Found: The analyte was positively identified but the associated concentration is an estimation above the method detection limit (MDL) and below the reporting limit (RL) (or lowest calibration standard).
B	Blank contamination: The analyte was found in an associated blank above 1/2 the RL, as well as in the sample.
U	Undetected: The analyte was analyzed for, but not detected.
UJ	The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet the QC criteria. Data is unusable for project purposes.

All data will be presented in a standardized format, with QA/QC results, and provided electronically. When appropriate, a summary of the data will be provided in addition to the complete data set. A case narrative will be provided to explain any problems encountered in the analysis of the samples, and identify conflicting results or unusable data. The data will then be reviewed by the project QA/QC manager to determine completeness, identify flagged data, and summarize any limitations of the data.

Each laboratory will maintain records for a period of 2 years. These records will include sample data, sample management, test methods, and QA/QC reports. These records allow for verification of the COC, analytical methods with anomalies noted, sample preparation and analysis, instrument calibration, test specific criteria, detection limits, and various QC checks.

8.0 Reporting to DWQ

Sampling is to begin during the 2011 bird nesting season (May through June) and be repeated on an annual basis per conditions defined in JVWCD's UPDES permit. The detailed field and laboratory data, analysis, and summary of results will be submitted to DWQ in an Annual Project Operating Report. This report is due by March 1 following the end of the calendar year summarized in the report.

JVWCD will keep project files including electronic copies of analytical data, field notes, data sheets and journals, photographs, analyses, and reports for a period of at least 5 years after the year of data collection.

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