Great Salt Lake Basin
Reference Standard Sites (2014):
Targeted Survey of Wetland Condition

Sampling and Analysis Plan

Revision 1

Effective 27 June, 2014

Prepared by the Utah Division of Water Quality
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This Document builds on two previously developed Sampling and Analysis Plans (SAPs), the 2012 Impounded Wetland Probabilistic Survey and the 2013 Fringe Wetland Targeted Survey.

DISTRIBUTION LIST

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ACKRONYMS AND ABBREVIATIONS

ac	Acre
asl	Above sea level
CWA	Clean Water Act
DEQ	Department of Environmental Quality
DQI	Data Quality Indicator
DQO	Data Quality Objectives
DWQ (or Division)	Division of Water Quality
GSL	Great Salt Lake
ha	Hectare
IR	Integrated Report
MSM	Monitoring Section Manager
ppm	Parts Per Million
QA/QC	Quality Assurance/Quality Control
QAC	Quality Assurance Council
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
UAC	Utah Administrative Code
UPHL (or State Lab)	Utah Public Health Laboratories
USEPA (or EPA)	United States Environmental Protection Agency
USGS	United States Geological Survey

1.0 Introduction and Background Information

This Sampling and Analysis Plan (SAP) was prepared by the Utah Division of Water Quality (DWQ) to satisfy elements of DWQ's Quality Assurance Program Plan (QAPP) for Monitoring Programs[1], and to support a Wetland Program Development Grant (WPDG) awarded to DWQ by the United States Environmental Protection Agency (EPA) in 2011 (CD968122-01, *revised*). This SAP documents the quality assurance and quality control (QA/QC) requirements and project planning details for an exploratory survey of potential Reference Standard wetlands within Utah's West Desert region. These potential Reference Standard sites are targeted to include both Impounded Wetland (IWs) and Fringe Wetland (FRNG) classes. Specific sampling details for each wetland type are included fully in each corresponding SAP; for impounded wetlands, see the 2012 Impounded Wetlands SAP (IW-SAP, hereafter); and for fringe wetlands, see the 2013 Fringe Wetlands SAP (FRNG-SAP, hereafter). This SAP is meant to be a practical, usable document and is therefore subject to change; the Designated Project Manager (DPM) will ensure that all persons listed on the **Distribution List** (page 2) receive the most current version.

1.1 Project Background/Problem Definition

Biological assessments of aquatic resources, including wetlands, rely on three key components. First, integrated measures of biological integrity must be developed for each ecosystem type. These measures are commonly based on the taxonomic composition of aquatic assemblages, such as algae, amphibians, macroinvertebrates or plants. The second component involves the identification and characterization of a collection of *Reference Standard Sites* (i.e. unaltered or least/minimally disturbed areas) that can be used as a baseline for all site comparisons within a given ecosystem type. The third component consists of an appropriate, probabilistic survey design that allows for generalization of wetland health at the watershed scale (Stevens and Jensen, 2007).

Recent work by DWQ's *Wetlands Program* has developed and validated an integrated assessment framework for impounded wetlands (IWs) based on three biological responses (cover of SAV, occurrence of surface algal mats, and composition of benthic aquatic macro-invertebrate communities) (DWQ, 2009). This work was based on a 50-site probabilistic survey (DWQ, 2012 [IW-SAP]; and CH2MHill, 2014) and incorporated into Utah's 2014 305(b) *Integrated Report* (DWQ, 2014).

Given that all IWs associated with Great Salt Lake are man-made and that most of these ponds are actively managed for waterfowl production, we lack a clear, *a priori* set of *Reference Standard Sites* to use as a basis for comparing the relative health among wetlands. For the 2014 *Integrated Report* we benchmarked our sites against the Best Attainable Condition (BAC)

[1] See: http://www.deq.utah.gov/Compliance/monitoring/water/docs/2014/05May/DWQ_QAPP_5.1.14_Rev0.pdf

ecological reference standard described by Stoddard et al. (2006), where BAC represents the expected ecological condition of sites receiving best management practices and having the least amount of impact from adjacent land use. This reference standard was determined empirically, based on the upper 75th percentile of biological response metrics.

This SAP describes an effort to obtain baseline information on IW and FRNG wetland condition (i.e. health) from targeted sites in more remote areas of the GSL basin. An explicit assumption here is that sites farther from urban development will have higher levels of ecological integrity.

1.2 Project Objective

The objective of this project is to collect environmental data from a selection of IW and/or FRNG wetlands that may serve as *Reference Standard Sites* for continuing surveys of wetland health. Our goal is to use the data from these new sites to describe the key characteristics of wetlands having the lowest amounts of disturbance and exhibiting the highest ecological integrity. These data will be incorporated into the current assessment frameworks for both IW and FRNG wetlands. The IW assessment framework includes a Multi-Metric Index (MMI; Karr and Chu, 1999) consisting of four main indicators: water chemistry, submerged aquatic vegetation, surface mats and macroinvertebrates (DWQ, 2009). A similar MMI is currently being developed for FRNG sites, however additional data collection is required before a preliminary MMI model can be developed.

At the end of this study, DWQ will compare previous data to these new Reference Standard Site data and evaluate whether the Reference Standard Sites represent the expected conditions of wetlands having the highest ecological integrity. This work will also support efforts to:

- Validate and refine the MMI for impounded type wetland classes, and evaluate:
    - Extent and relative risk of stressors to IWs
    - Effect of natural covariates on chemical and biological properties of wetlands
- Identify sites or areas with potentially degraded conditions for follow-up intensive monitoring and assessments (CWA §303(d))

1.3 Study Area

More detailed descriptions of Great Salt Lake basin study areas can be found in both the IW-SAP and the FRNG-SAP documents. For this project, the study area is considered to be wetlands within the Great Salt Lake desert.

This project will target both IW and FRNG wetlands surrounding Great Salt Lake, Utah, where property access is acquired and site reconnaissance reveals no substantial impacts to the wetland or wetland buffer area.

The project area includes portions of Juab and Millard counties.

GSL wetlands are most commonly dominated by two wetland classes: impounded wetlands (IWs) and fringe (FRNG) wetlands. Impounded wetlands represent areas where dikes, berms, ditches and culverts have been constructed to control the inflow and outflow of water through wetlands. These wetlands are entirely human-made and occur as large, shallow ponds that range in size from 20 to over 500 acres (Miller and Hoven, 2007).

Fringe wetlands are often (but not always) associated with impounded wetlands, and occur where freshwater flows over very gently sloping portions of the exposed lakebed. Fringe wetlands are often found below the outlets from impounded wetlands, from wastewater treatment facilities, and from other low-gradient surface channels or small streams. Depending on the quantity of water flow, wetland geomorphic features and lake elevation, fringe wetlands can span from the border of impounded wetlands to the margin of Great Salt Lake itself. As such, these wetlands commonly contain wide gradients in water salinity.

1.4 Summary of Project Tasks and Schedule

Sites were identified via GIS-based reconnaissance and discussions with scientists and resource managers knowledgeable about the area. Environmental data collections will take place during the summer and early-autumn of 2014, approximately July to October, and will include 2 visits to each sampling location. Once all of the field and laboratory results are validated through DWQ’s QA process, DWQ will generate a QA/QC report to accompany the dataset.

The dataset be analyzed following the approaches described in the IW-MMI Validation report, and the wetlands chapter for the 2014 IR. DWQ will use the data to compare against results from the IW (2012) and FRNG (2013) surveys, as appropriate. The findings will be incorporated into DWQs baseline dataset for assessment of GSL wetland health, and as part of the long-term monitoring plan for GSL wetlands.

2.0 Objectives and Design of the Investigation

2.1 Specific Objectives of this Study

The project-level data quality objective for this study is to collect data of the appropriate type, quality, and quantity to allow DWQ to perform wetland condition assessments of GSL wetlands, make decisions about the use and applicability of wetland assessment tools and methods, and set long-term goals for monitoring the health GSL wetlands. Data quality objectives (DQOs) are qualitative and quantitative statements derived from systematic planning that clarify the study objective, determine the most appropriate type of data to collect, determine the most appropriate conditions from which to collect the data, and specify the level of uncertainty allowed in the collected monitoring data while still meeting the project objectives. This information is summarized in Table 1 (below).

The specific objective of this project is to collect data on sites that, because of the remoteness, are expected to exhibit a high degree of ecological integrity and a low magnitude of stress. Data from these sites, termed *Reference Standard Sites*, will be used to describe the upper baseline for indicators and metrics of wetland health.

Figure 1 (a). Potential Reference Standard Wetlands at Fish Springs National Wildlife Refuge

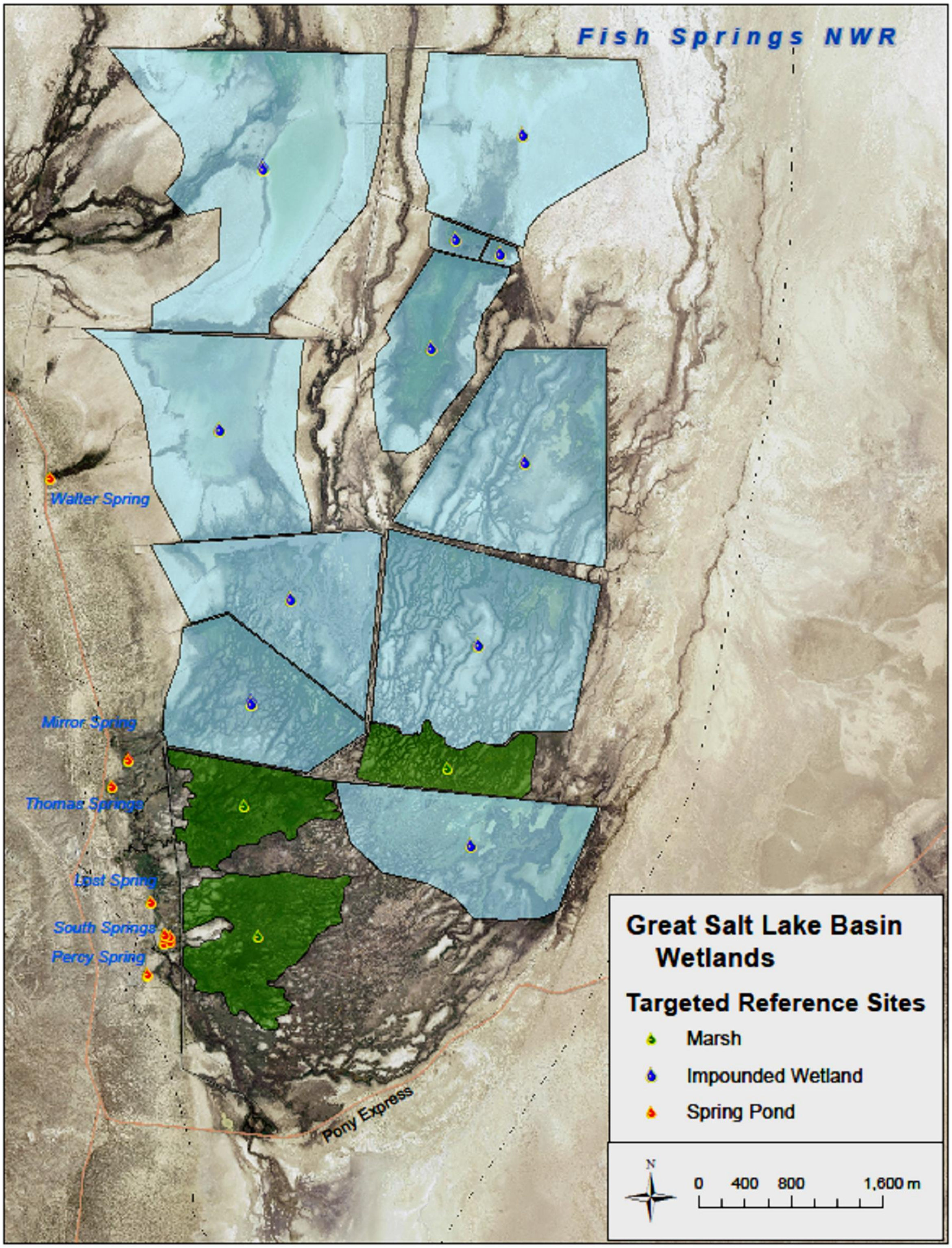
Fish Springs NWR
Walter Spring
Mirror Spring
Thomas Springs
Lost Spring
South Springs
Percy Spring
Pony Express
Great Salt Lake Basin
Wetlands
Targeted Reference Sites
Marsh
Impounded Wetland
Spring Pond
N
0 400 800 1,600 m

Figure 1 (b). Potential Reference Standard Wetlands in Snake Valley, Utah (Bishop Springs)

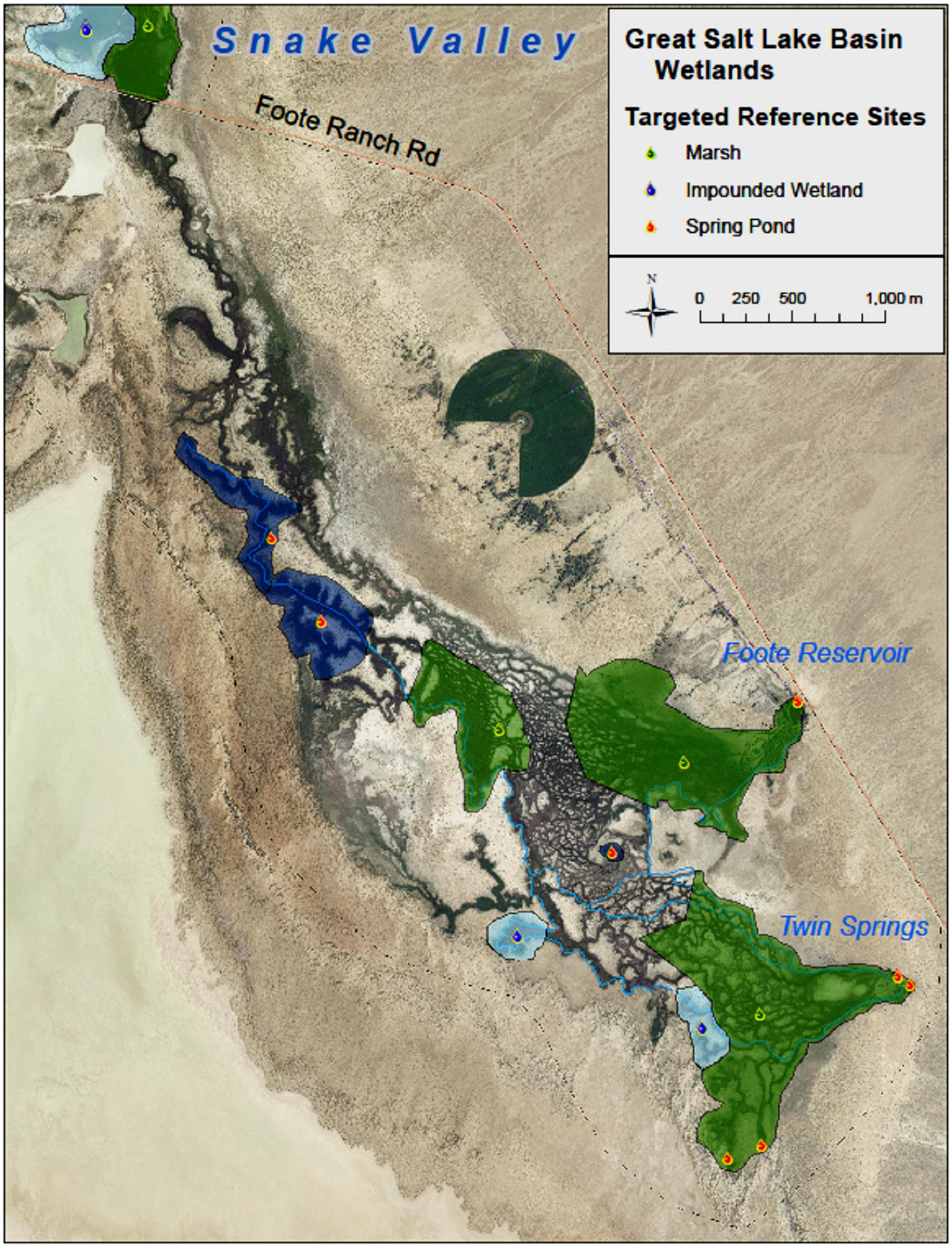

Figure 1 (c). Potential Reference Standard Wetlands at Clear Lake Waterfowl Management Area (near Delta, UT)

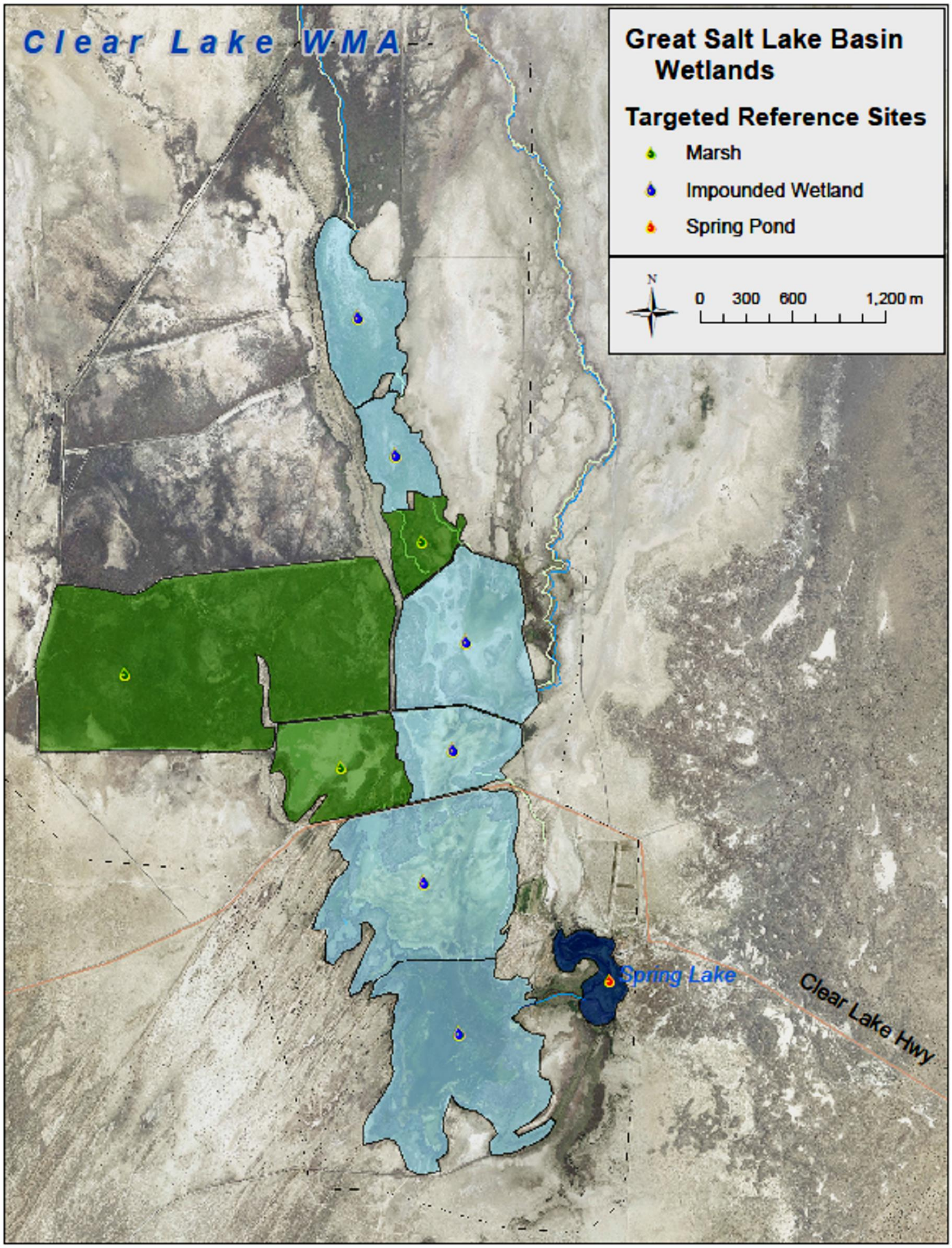

Table 1 Data Quality Objectives

Step	DQOs for 2012 Great Salt Lake Basin Reference Standard Sites Survey
1. Problem Statement	DWQ's *Wetlands Program* is developing tools to assess, monitor, and report on the water quality of Utah's wetlands. These efforts are based on a multiple lines of evidence approach using multimetric indices (MMIs). Current work involves refinement of a MMI for impounded wetlands and development of a MMI fringe wetlands associated with Great Salt Lake. An important aspect of DWQ's wetlands assessment work is the reporting of wetland condition (i.e. relative health) within and among watersheds, for example Utah's CWA 305(b) *Integrated Report*. Analysis of ecological condition metrics from a 50-site probabilistic survey of GSL IWs revealed that the preliminary MMI approach was sound; however, attempts to compare site-level assessment results against a defensible benchmark for integrated, ecologically-based water quality standards revealed the importance of developing a well-characterized network of *Reference Standard Sites*. As such, the goal of this project is to collect samples and analyze data from potential *Reference Standard Sites* representing IW and FRNG wetlands to support an effort to characterize the range of natural variability of biological and chemical parameters under conditions of low / minimal human disturbance. This data will be incorporated into respective IW and FRNG datasets, and evaluated with regard to whether these new sites represent the ecological condition of minimally disturbed IW and FRNG sites. Given the remoteness of the potential *Reference Standard* study areas and the lack of human-induced point-source pollutant loads (e.g. from POTWs or industrial / residential development) this assumption appears reasonable. This project will provide an initial description of biologic and chemical parameters from sites with low levels of human disturbance.
2. Goal of Study / Decision Statements	**Key Question[s]** Q_0: How do wetland biological response metrics and MMI scores from sites far from human disturbance compare with scores from sites associated with GSL? Q_1: What is the range of natural variation in biological and chemical parameters (indicators), relative to data from more highly disturbed GSL wetlands? **Potential Outcomes** 1: Information is adequate to calculate MMI scores for: i) water chemistry, ii) benthic macroinvertebrates, iii) SAV, and iv) surface mats; DWQ will compare data with cumulative data from GSL IW and FRNG wetlands 2: Information is inadequate to calculate MMIs. DWQ will identify potential confounding factors, develop appropriate sampling and analytical methods, revise the sampling plan, and complete reporting as above

Step	DQOs for 2012 Great Salt Lake Basin Reference Standard Sites Survey
3. Inputs to Decision	**The following information will be collected:** • Field sampling, including collection of water chemistry and biota samples, will be conducted two times during the 2012 growing season (mid-summer and early-autumn) for IW wetlands, and once in mid-summer for FRNG wetlands, at targeted sites within the GSL basin Specific water chemistry parameters and biological metrics for IW and FRNG wetlands are provided in **Table 1** of the respective sampling and analysis plans (IW-SAP and FRNG-SAP), attached to this document. This information is described in Section 2.4.
4. Study Boundaries	The project area is shown in **FIGURE 1**. This area includes impounded and fringe wetlands within the Great Salt Lake basin. Sampling sites will be field-checked to ensure that: • Represent the sample target - IW / FRNG wetlands managed for wetland-associated wildlife • Are Accessible - DWQ has received permission to visit IWs on private property • Represent wetlands that are highly likely to have sufficient water for sampling Specific geographic, hydrologic, and temporal boundaries for IW and FRNG wetlands are available from the respective SAPs. • Availability of boats and other field equipment, as well as equipment functionality, may limit the scheduling of field activities • Staff and equipment availability will be monitored throughout the project period • Weather is a major constraint for all sampling and monitoring activities because storms can limit access to field sites and the ability to safely conduct sampling and measurement activities at the study area • Great Salt Lake levels and private property access may be a constraint and affect sampling locations. Ownership information and permission will be obtained as early in the study as possible
5. Decision Rules	• If information is adequate to address the key questions, then these sites will be used as an initial set of *Reference Standard Sites*. These sites will then be sampled over multiple years to develop an understanding of the range of natural, interannual variation of biological response and stressor metrics. • If information is inadequate to address the key questions, DWQ will identify potential confounding factors, develop appropriate sampling and analytical methods, revise the sampling plan, and complete reporting as above

Step	DQOs for 2012 Great Salt Lake Basin Reference Standard Sites Survey
6. Acceptance Criteria	• PARCC elements for data ○ Precision - Field replicates will be collected at 10% of sites for water chemistry, macroinvertebrate, and soil samples as well as field measurements (plant cover, multi-parameter probe measures, etc.) ○ Accuracy - Special efforts will be made to minimize contamination of water chemistry samples through proper collection of field samples, monitoring of sampling-bottle blanks, and the use of appropriate laboratories for analysis. Field surveys will be performed by a wetland monitoring crew trained in each method. Species richness of emergent and submerged-aquatic plant communities is commonly low, and plants are easily identified, however, questionable specimens will be collected and returned to the office for further identification by local experts. Taxonomic identification of macroinvertebrates and zooplankton will be performed by Dr. Larry Gray. ○ Representativeness - The sampling locations have been well-defined. Field sampling will occur following standardized sample collection procedures as described in Standard Operating Procedures (SOPs) for each method. Inventory methods were designed to collect data at a scale most descriptive of GSL wetlands (~20 hectares). Site photos and field notes will be collected at each site and can be used to describe any unusual conditions that may occur. ○ Completeness - To ensure the sampling goal of 100% completeness at the end of the season, we will use field reconnaissance and in-depth discussions with wetland managers to verify that sites have the proper hydrologic conditions to support the wetland class. ○ Comparability - All field sampling and analytical procedures will be completed following the previously-tested SOPs for each metric, and will be performed by the same field crew throughout the sampling season • Measurement quality objectives for chemical measurements are specified in **Table 7**. • DWQ QAPP specifies the minimum QA/QC objectives for sample measurement
7. Sampling Plan and Design	The baseline sampling program includes: • Collection and analysis of water, benthic macroinvertebrates, zooplankton, and surface sediment nutrients and metals • Field observations of emergent vegetation and ground cover, including SAV and algal mat cover This data will be used to estimate the baseline condition of targeted IW and FRNG wetlands within the southern Great Salt Lake basin. Data will be used to construct MMIs for key indicators based on wetland type. These indicators have been previously linked to the beneficial uses of these wetlands through their relationships to wetland physical, chemical, and biological condition. Successful completion of this project will support development of appropriate assessment frameworks for IW and FRNG wetland classes and provide information on how stressors related to human activity may affect biological responses within the wetlands.

2.2 Sampling Design

The sampling design is based on targeted identification of known wetland complexes, including impoundments managed for waterfowl use, located far from urban areas within the Great Salt Lake basin. Industrial ponds (i.e. evaporation ponds) and ponds managed for non-waterfowl/waterbird wildlife (e.g. fish, stock ponds) are excluded from the target population. The minimum size of IWs is five acres (approximately 2.0 ha). The NWI dataset was used when available, and supplemented by other data as necessary.

Polygons of potential sample sites were digitized by hand using ArcGIS 10.2 and available imagery for the project area (e.g. statewide NAIP 2006, 2009, 2011), and stored in a geodatabase.

Criteria to evaluate potential sampling sites include:

1) Target / Non-target: Does the site represent an an appropriate wetland type (> 5 acres) that is managed for waterfowl or other wetland-associated wildlife? (Fishing ponds or water sources solely used for livestock are excluded).
2) Permission / Access: Has explicit permission to access the site been obtained from the landowner?
3) Sampleable: Can the site be sampled during the appropriate sampling index period(s)? (This is described in greater detail below).

The project goal is to sample up to 10 IW and 10 FRNG sites within the project area in 2014.

2.3 Study Boundaries

Impounded and fringe wetlands represent important components of discharge zones within Utah's semiarid valleys. While the physical boundaries of impounded wetlands are entirely created by human efforts, high-quality impounded wetlands are prized for their ability to support large and diverse populations of waterfowl and other waterbirds. Similarly, the physical boundaries of fringe wetlands are largely constrained by the availability of freshwater inflows, such that these wetlands are prized for their ability to retain sediments and immobilize nutrients and support diverse populations of resident and migratory water birds.

In order to properly assess the baseline condition of these wetlands, the following sections describe where they occur in the landscape, and provide guidance to help identify comparable sampling areas for data collection.

2.3.1 Geographic Boundaries

As shown in **Figure 1**, the project area includes wetlands along the southern portion of the Great Salt Lake basin. In general, these wetlands are derived from isolated groundwater discharge zones within the semiarid valleys.

2.3.2 Hydrologic Boundaries

Impounded wetlands are essentially shallow, steep-sided ponds and their principal source of water is from surface water delivered via extensive networks of canals, ditches and head gates.

The relative importance of terrestrial vs. aquatic features within these wetlands can change markedly from year to year and across the growing season. The water source for fringe wetlands is similar to that for IWs, since FRNG wetlands commonly occur below the outfall of IWs. However, for wetlands in the southern GSL basin, much of the surface water is derived from groundwater discharge of regional basin-fill aquifers (Kirby and Hurlow, 2005).

More specific information on IW and FRNG wetland hydrologic boundaries is available in the IW-SAP and FRNG-SAP documents.

2.3.3 Temporal Boundaries (Index Period)

Building on the IW and FRNG assessment work (see SAPs), the IW sites will be sampled during two separate index periods, IP-1 (July), and IP-2 (late-August to mid-September). FRNG sites will be sampled in mid-summer, from late-July to early September.

2.4 Parameters to be measured

Data will be collected from samples of surface water, surface soils (0-10 cm), benthic macroinvertebrates, and emergent and submerged vegetation (as appropriate), following the wetland-specific SAPs. Measurements will follow the appropriate methods, as outlined in the wetland SOPs. Supplemental indicators, such as plant and soil $\delta^{15}N$ and $\delta^{13}C$ isotope ratios and C, N, and P concentrations may be determined as resources allow.

Table 2. Parameters to be measured

Description	Field Method *	Details
Emergent Vegetation (FRNG)	Visual Observation	1 m x 100 m belt transects aligned orthogonal to waterflow at 100 m, 300 m, and 500 m from inflow of water to the wetland.
	Leaf Harvest	Five leaves from the dominant plant species at end and mid-point of each 100-m transect; sample mature leaf. ** One gallon zip bag per sampling location (9 per site) ** *Sent to USU Isotope Laboratory and UU ICP-MS Lab*
Aquatic Vegetation (IW)	Visual Observation	Five 1 m^2 quadrats along 100-m transect; Plant cover
	Leaf Harvest	At least 5 samples of 2-5 plants along the transect. ** One gallon zip bag per site ** *Sent to USU Isotope Laboratory and UU ICP-MS Lab*
Benthic Macroinvertebrates (IW & FRNG)	Sample Collection using D-net	Five x 1-m sweeps with 500 µm D-net along 100-m transect One wide-mouth polyethylene quart jar *Sent to Gray Lab*
Zooplankton (IW)	Sample Collection using Wisconsin Net	Five x 5-m tows (radial) with Wisconsin Net One 50-mL centrifuge tube *Sent to Gray Lab*

<table>
<tr><th colspan="2">Description</th><th>Field Method *</th><th>Details</th></tr>
<tr><td rowspan="8">Water Chemistry</td><td>Field Parameters (IW & FRNG)</td><td>Multi-Parameter Probe</td><td>Temperature, Specific Conductance, pH, Dissolved Oxygen</td></tr>
<tr><td>Total (unfiltered) Nutrients (IW & FRNG)</td><td>Grab Sample Collection</td><td>NH_4^+, NO_3^-/NO_2^-, Total Kjeldahl Nitrogen (TKN), Total P
One 500 mL bottle with H_2SO_4 preservative
Sent to State Water Lab</td></tr>
<tr><td>Dissolved (filtered) Nutrients (IW)</td><td>Grab Sample Collection and Field Filtering</td><td>NH_4^+, NO_3^-/NO_2^-, Total N (dissolved), Dissolved P, DOC
One 500 mL bottle with H_2SO_4 preservative
Sent to State Water Lab</td></tr>
<tr><td>Dissolved (filtered) Metals (IW)</td><td>Grab Sample Collection and Field Filtering</td><td>Aluminum, Arsenic, Barium, Cadmium, Cobalt, Copper, Iron, Mercury, Manganese, Nickel, Lead, Selenium, Zinc
One 250 mL bottle, preserved with HNO_3
Sent to State Water Lab</td></tr>
<tr><td>General Chemistry (IW & FRNG)</td><td>Grab Sample Collection</td><td>Alkalinity, Total Suspended Solids, Total Volatile Solids, Total Dissolved Solids, Sulfate ($SO_4^=$), major cations and anions
One 1000 mL bottle
Sent to State Water Lab</td></tr>
<tr><td>Sulfide (IW & FRNG)</td><td>Grab Sample Collection</td><td>Hydrogen sulfide as Total sulfide
One 120 mL bottle with ZnoAc and NaOH preservative
Sent to State Water Lab</td></tr>
<tr><td>Chlorophyll-a (IW & FRNG)</td><td>Grab Sample and Field Filtering</td><td>0.7 µm filter residue
Sent to State Water Lab</td></tr>
<tr><td>Oxygen Demand (IW)</td><td>Grab Sample Collection</td><td>5-day Biochemical Oxygen Demand (BOD_5)
One 2000 mL bottle
Sent to State Water Lab</td></tr>
<tr><td colspan="2">Sediment Available Nutrients (IW & FRNG)</td><td>Sample Collection using a Corer</td><td>Five 0-10 cm cores (composited); Stored in 1-quart zip bag (Nutrient Extracts: NH4, NO3/NO2, PO4); Total N, Total and Organic C
Sent to USU Analytical Lab</td></tr>
<tr><td colspan="2">Sediment Total Metals (IW & FRNG)</td><td>Sample Collection using a Corer</td><td>Five 0-10 cm cores (composite); Stored in 1-gallon zip bag
Aluminum, Arsenic, Barium, Cadmium, Cobalt, Copper, Iron, Mercury, Lithium, Manganese, Nickel, Lead, Selenium, and Zinc
Sent to UU ICP-MS Lab</td></tr>
</table>

* See Section 3.0 and DWQ's Standard Operating Procedures for additional details
Note: All parameters will be measured during both Index Periods unless stated otherwise above

2.5 Decision Rules and Tolerable Limits

1.) If information is comparable to previously collected data, then DWQ will summarize and submit these results with the next CWA §305(b) Integrated Report.

2.) If information is not comparable, DWQ will re-evaluate sample collection and analysis procedures. This information will then be summarized prior to further sampling.

Tolerance limits exist primarily for laboratory analyses, where data quality indicators are defined in DWQ's Quality Assurance Project Plan (QAPP) in terms of acceptability criteria. This information is summarized in Table 4 in the wetland-specific SAPs. The DWQ QAPP defines procedures that specify minimum quality assurance (QA) and quality control (QC) objectives for sample measurements based on the sample matrix.

3.0 Field Sampling Methods

This section summarizes the work-flow and methodology for environmental sample collection from the IW sites and incorporates the Data Quality Objectives outlined in previous sections.

3.1 Safety precautions and plan

Field personnel should take appropriate precautions when operating watercraft and working on, in, or around water, as well as possibly steep or unconsolidated banks, or edges of ponds. All field crews should follow appropriate safety procedures and be equipped with safety equipment such as proper wading gear, gloves, first aid kits, cellular phone, etc. All boats should be equipped with safety equipment such as personal floatation devices, oars, air horn, etc. Utah's Boating Laws and Rules shall be followed by all field personnel.

Field personnel should be aware that hazardous conditions potentially exist at every water body. If unfavorable conditions are present at the time of sampling, the sample visit is recommended to be rescheduled. If hazardous weather conditions arise during sampling, such as lightning or high winds, personnel should cease sampling and move to a safe location.

Most often, sample bottles are prepared by the State Lab and already contain preservative. During packing and handling of bottles, be sure that caps are tightly sealed. Be careful to avoid contact with preservative (acid). If minor skin contact occurs, rinse with copious amounts of water. If major skin or internal contact occurs, seek medical attention.

Wear gloves or be sure to wash hands after sampling, especially when sampling potentially contaminated areas.

3.2 Field protocols by parameter group

The sample-specific collection activities are described in the wetland specific SAPs as well as the accompanying SOPs for each method.

3.2.1 Water Chemistry Sampling

Sampling of water chemistry parameters involves two separate activities, as shown in Table 3. *Field parameters* are measured using a multi-parameter probe (Hydrolab or similar). This project will use the temperature, specific conductance, pH, and DO probes. Multi-parameter probe data will be recorded on field sheets once the results have been verified as acceptable by the field crew, and stored on the instrument; field sheets will also include any notes about site conditions observed during the measurement.

Table 3. Data quality indicators

Data Quality Indicator	QC Check / QC Sample	Evaluation Criteria	Goal
Precision - *measure of agreement among repeated measurements of the same property under identical or substantially similar conditions*	Field replicate pairs	Relative percent difference (RPD)	Water samples: ± 20%; Sediments : ± 40%; *For results above lab reporting limits*
	Laboratory duplicates	RPD	RPD from laboratory duplicates [1]
	Matrix spike duplicates	RPD	RPD from laboratory data [1]
Bias - *the systematic or persistent distortion of a measurement process that causes errors in one direction* and Accuracy - *measure of the overall agreement of a measurement to a known value, such as a reference or standard; includes both random error (precision) and systematic error (bias) components of sampling and analytical operations*	Randomized site selection (GRTS), with stratification by hydrologic units (HUC8) and accounting for three IW size classes (<20 acres, 20-100 acres, and >100 acres)	Procedures for GRTS are properly implemented	100% compliance
	Calibration of field water quality instruments	Documentation of successful instrument calibration	100% compliance
	SOPs for environmental data collection	Qualitative determination of adherence to SOPs, and field audits	All data collected following SOPs or specific procedures described in this SAP
	Field / Equipment blanks	Detection Limit	< Detection Limit
	Method blanks	Detection Limit	< Detection Limit
	Lab control / Matrix spikes	% Recovery of spikes (and RPD)	% Recovery and RPD from laboratory [2]
Representativeness - *degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or environmental condition*	SOPs	Qualitative determination of adherence to SOPs, and field audits	All data collected following SOPs
	SAP requirements	Adherence to sampling location, time, and conditions	100% compliance unless approved by Project Manager & noted in field notes
	Field photos / notes	Document any variation from SAP/ SOP	100% compliance
	Holding times	Holding times	100% compliance

Data Quality Indicator	QC Check / QC Sample	Evaluation Criteria	Goal
	Field replicates Field/trip/equipment blanks	RPD Detection Limit	Water samples: ± 20%; Sediments : ± 40%; *For results above lab reporting limits* < Detection Limit
Comparability - *qualitative term expressing the measure of confidence that one dataset can be compared to another and can be combined in order to answer a question or make a decision*	SOPs (sample collection and handling) Holding times Analytical methods Similar frequency and types of QC samples (field dups, blanks, lab QA)	Qualitative determination of SOP adherence and field audits Holding times DWQ or EPA-approved methods Verify	All data collected following SOPs or specific procedures described in this SAP 100% compliance 100% use of approved methods Evaluate for comparability
Completeness - *measure of the amount of valid data obtained from a measurement system compared to the amount of valid data expected to be obtained*	Complete sampling	% Valid data	100% completeness
Sensitivity - *capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest; primarily a lab parameter*	Laboratory detection limit	Must be below action level required by SAP	100% compliance

[1] ± 10 to 20%, based on a compilation of laboratory reporting for commonly analyzed constituents

[2] ± 10 to 20%, based on a compilation of laboratory reporting for commonly analyzed constituents

RPD - Relative Percent Difference (RPD (%) = $\{(X_1 - X_2)/(X_1+X_2)\}/2 \times 100$, where X_1 = result from first sample and X_2 = result from second sample

Field collection of water samples for chemical analysis is the second sampling component. This is also typically one of the first activities performed during a site visit. Specific procedures for collection of water grab samples are described in the SOP.

3.2.2 Zooplankton Sampling

Zooplankton sampling is performed using a tow net to collect large plankton within the upper portion of surface waters. The contents are rinsed into a sample container (typically a 50 mL centrifuge type).

3.2.3 SAV and Emergent Vegetation Sampling

Aquatic vegetation is sampled by visual estimation of aerial cover along 100-m transects. Emergent vegetation and ground cover is sampled by visual estimation of aerial cover within a 1 m band along each 100 m transect.

3.2.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates are collected from an undisturbed area using a D-net along a 100-m transect. At each sampling location, the D-net is tapped along the sediment/soil surface while performing a figure-eight type motion along a 1-m length.

3.2.5 Sediment Chemistry Sampling

For IWs, sediment available nutrients and total metals are sampled from 5 sediment cores along a 100-m transect. For FRNG, sediments are sampled from an undisturbed area within the open water flow path and at the end of each vegetation transect for all three sample locations. Briefly, the goal is to collect the top 10 cm of the loose sediment (or mucky soil).

3.3 General Decontamination Procedures

All equipment used in the field, or temporary sample containers, must be cleaned and disinfected according to the procedures described in each SOP.

3.4 Field sampling workflow

The flow of activities at the sampling site are more fully described in the wetland-specific SAPs.

3.5 Special training

Field crews are required to read this SAP and *all applicable* SOP's prior to conducting the field work described in this SAP, and acknowledge they have done so via a signature page that will be kept on file at DWQ along with the official hardcopy of this SAP.

Personnel performing water sampling must be familiar with sampling techniques, safety procedures, proper handling, and record keeping. Field crews should have the supplies and training to provide first aid in the event of an injury or illness.

3.6 Field Complications and Corrective Actions

All sites to be sampled for this project will be evaluated prior to the beginning of the sampling period, to determine whether i) the site meets the project target wetland class, ii) DWQ has received explicit permission to access sites located on private property, and iii) the site contains the physical environment necessary to meet project goals, as described in Section 2.3 of this document. However, it is possible that hydrologic conditions or management actions of a site could change between the time of field reconnaissance and sampling.

Other abnormal field conditions may arise during the course of sampling. Field crews are required to adhere to all proper safety precautions and plans during this project. For example, high winds may represent dangerous and unpredictable conditions within large impounded wetlands, and may also deleteriously degrade water quality by temporarily mixing sediment into the water column. In this case, it is recommended that sampling that site be postponed for that day (or moving to another site that is not affected by high winds). Wind-induced turbidity may subside within a day or two for most impounded wetlands with a large windward fetch.

4.0 Laboratory Sample Handling Procedures

All sample collections will be obtained following the protocols outlined in Section 3.2 above and described in the method-specific SOP (see **Appendices B-I**). The table below (**Table 5**) lists the required container type, sample volume, preservatives (if any) and the allowable holding time for all sample collections in this project.

Table 4. Sample container requirements

Sample Type / Analyte	Container Type	Volume	Preservative	Holding Time	Receiving Lab
Vegetation					
Composite samples	Plastic bag	1 gallon	ice chest / lab freezer	n/a	USU Isotope Lab & UU ICP-MS Lab
Benthic Macroinvertebrates					
5-Sample Composite	Plastic jar	1 Qt, wide-mouth	95% Ethanol	n/a	Gray Lab, UVU
Zooplankton					
5-Sample Composite	Plastic tube	50 mL centrifuge tube	95% Ethanol	n/a	Gray Lab, UVU
Water Chemistry					
Total (unfiltered) Nutrients	Plastic bottle	500 mL	H_2SO_4 *	28 d	State Lab
Dissolved (filtered) Nutrients	Plastic bottle	250 mL	H_2SO_4 *	28 d	State Lab
Dissolved (filtered) Metals	Plastic bottle	250 mL	HNO_3 *	28 d - 6 mo	State Lab
General Chemistry (unfiltered)	Plastic bottle	1.8 L	ice chest & fridge at the shop	7 d	State Lab
Sulfide	Plastic bottle	120 mL	ice chest & fridge at the shop	7 d	State Lab
Chlorophyll-α	Filter membrane wrapped in Aluminum foil	100 to 500 mL	Dry ice & freezer at the shop	3 weeks	State Lab
Oxygen Demand	Plastic bottle	2 L	ice chest & fridge at the shop	48 hr	State Lab
Sediment Nutrients					
5-Separate Samples	Plastic bag	1 gallon	ice chest / lab freezer	n/a	USU Stable Isotope Lab
Sediment Metals					
5-sample Composite	Plastic bag	1 gallon	ice chest / lab freezer	n/a	UU ICP-MS Lab

* State Lab will supply preservative in the sample container

** Lab for Sediment analyses is currently being negotiated (8 June, 2012)

4.1 Receiving Laboratory Contact Information

Contact information for laboratories receiving project samples.

State Lab

State of Utah's Public Health Laboratories, Chemical and Environmental Services Bureau
Contact: Dr. Sanwat Chaudhuri
4431 South 2700 West
Taylorsville, UT 84119
(801) 965-2470

Gray Lab

Department of Biology, Utah Valley University
Contact: Dr. Larry Gray
800 West University Parkway
Orem, UT 84058
(801) 863-8558; email: grayla@uvu.edu; Web: research.uvu.edu/GRAY/

Utah State University Stable Isotope Analysis Laboratory

Contact: Dr. John Stark or Ms. Tasha Prettyman
Logan, UT
(435) 797-0060; email: john.stark@usu.edu; tasha.cosgrove@usu.edu

University of Utah ICP-MS Laboratory

Contact: Dr. William P. Johnson
Salt Lake City, UT
(801) 664-8289; email: william.johnson@utah.edu

5.0 Project Quality Control Requirements

Baseline Quality Control requirements for this project will follow those described in DWQ's Division QAPP (available from the project QA Officer), and are outlined in Table 4 (above).

5.1 Field QC Activities

Field QC checks and samples will be performed or collected, respectively, as often as appropriate and practical during field sampling. The most detailed QC checks are focused on the collection and analysis of water chemistry samples, however, the entire project design has been constructed with the data quality indicators outlined in Table 4 in mind. Adherence to SOPs for all measurements will minimize bias, improve accuracy and precision, and support data representativeness and comparability associated with this project.

Two types of QC samples will be collected in the field.

Field Replicates: Replicate samples will be obtained for 10 percent of all field collections listed in **Table 2-3** (two sites). This includes water chemistry samples, benthic macroinvertebrates, and sediment chemistry.

<u>Performance goal</u>: <20 percent difference between replicates for water (<40 percent for sediment) chemistry. *Performance goals for biological measures are not yet defined; this dataset will be used to inform those goals for future monitoring activities*.

<u>Field Blanks</u>: One set of "Field Blanks" will be collected per week. Reagent-free deionized water will be added to *General Chemistry* (1,000-milliliter), *Total Nutrients* (500-milliliter), and *Total Metals* (250-milliliter) bottles in the field, and then capped and handled in the same manner as other samples.

<u>Performance goal</u>: Blank values are below detection limits.

A third QC sample may be collected as appropriate (IW sites only):

<u>Equipment Blanks</u>: Collected at the end of each *full* week of sampling, for samples that require in-field filtration. Reagent-free DI water will be run through each piece of sampling equipment and collected in appropriate sample bottles / containers. This will be performed for the Chlorophyll-a samples using a 0.2 µm filter (filter is retains following SOP, Appendix D), and for *Dissolved Metals* and *Dissolved Nutrients* using the same apparatus as used for field samples (Appendix C).

<u>Performance goal</u>: Blank values are below detection limits.

This information is summarized in Table 6 below.

Table 5. Quality Control Sample Collections

		Submerged Aquatic Vegetation	Water Chem: General Chemistry	Water Chem: Dissolved Nutrients	Water Chem: Dissolved Metals	Water Chem: Sulfide	Water Chem: Chlorophyll-a	Benthic Macroinvertebrates	Zooplankton	Sediment Diatoms	Sediment Nutrients	Sediment Metals
QC Type	***Frequency***											
(1) Field Replicate	One per 10 sites	X	X	X	X	X	X	X	X	X	X	X
(2) Field Blanks	1 set per week		X	X	X	X						
(3) Equipment Blanks	1 sets per week			X	X		X					

5.2 Analytical QC limits

Analytical QC limits are described in each laboratory's quality assurance manual and conform to the requirements laid out in DWQ's QAPP. Contracts initiated with laboratories will contain agreements that outline how QC test results will be reported to DWQ. DWQ and its analyzing laboratories will cooperate to ensure laboratories receive ample sample to perform requested analyses, and to run tests such as lab duplicates and matrix spikes. The following table (Table 7) describes QC limits, reporting range and accuracy requirements for laboratory analyses.

QC limits for field measurement of water chemistry parameters using a multi-parameter probe (Hydrolab, etc.) can be found in the instrument manuals, and described in the SOPs and the DWQ QAPP.

Field monitoring crews are responsible for performing immediate corrective actions in the field if a QC issue is found during field QC checks. Typically this corrective action will involve instrument maintenance or recalibration; monitors will document this type of corrective action in the field notes.

Special effort will be made by the DPM to validate all incoming project data against data quality indicators and QC limits as they are received by DWQ, and to ensure the timely receipt of results for all submitted samples. This will be performed in conjunction with the QA Officer and Monitoring Section Manager, through the use of a database to track the status of all samples collected and submitted to outside laboratories. Initial validation of the dataset by the DPM will focus on the identification of field and equipment blanks and whether these samples meet DQI requirements (i.e. non-detectable element concentrations). Ancillary field observations, or other available data, will be used to ascertain the causes of blank samples that fail the DQIs; corrective measures will be discussed with the QAO and the field crew and implemented.

Table 6. Analytical QC limits and reporting ranges

Sample Type	Parameter	Method #	MRL *	Units	Calibration Range	Precision	Accuracy	Recovery	Current Numeric Criteria **		
									2A/2B	3B/3C/3D	4
Water Chemistry (nutrients)	NH_4-N	350.1	0.05	mg/L	0.05 - 10.0	± 15%	± 15% †	± 15%		pH dependent	
	NO_2/NO_3-N	351.4	0.10	mg/L	0.10 - 10.0	± 15%	± 15%	± 15%	4	4 / 4 / na,	na
	TKN ††	353.2	0.10	mg/L	0.10 - 5.0	± 15%	± 15%	± 15%			
	TP	365.1	0.02	mg/L	0.01 - 1.0	± 15%	± 15%	± 15%	0.05	0.05 / na / na	na
	DOC	5310B	0.5 *est*	mg/L	0.5 - 20.0	± 15%	± 15%	± 15%			
Water Chemistry (metals)	Al	200.8	10	µg/L	10 - 100	± 15%	± 15%	± 15%		87 / 750	
	As	200.8	1	µg/L	10 - 100	± 15%	± 15%	± 15%			
	Ba	200.8	100	µg/L	10 - 100	± 15%	± 15%	± 15%			
	~~Cd~~[tdh1]	~~200.8~~	~~10~~	~~µg/L~~	~~10 - 100~~	~~± 15%~~	~~± 15%~~	~~± 15%~~			
	Co	200.8	?	µg/L	n.d	± 15%	± 15%	± 15%			
	Cu	200.8	1	µg/L	1 - 100	± 15%	± 15%	± 15%		9 / 13	200
	Fe	200.7	20	µg/L	4 - 4000	± 15%	± 15%	± 15%		1000 max	
	Hg	245.1	0.2	µg/L	0.2 - 10	± 15%	± 15%	± 15%		0.012 /	
	Mn	200.8	5	µg/L	5 - 100	± 15%	± 15%	± 15%			
	Ni	200.8	5	µg/L	5 - 100	± 15%	± 15%	± 15%		52 / 468	
	Pb	200.8	0.1	µg/L	0.1 - 100	± 15%	± 15%	± 15%		2.5 / 65	100
	Se	3114 C	1	µg/L	1 - 10	± 15%	± 15%	± 15%		4.6 / 18.4	50
	Zn	200.8	10	µg/L	10 - 100	± 15%	± 15%	± 15%		120 / 120	
	Hardness	200.7			--- calculated from D-Ca and D-Mg ---						
Sulfide	H_2S	376.2	0.1	mg/L	0.1 - 20	± 10% *est*	± 10%	± 15%			
Water Chemistry (general)	Alkalinity	2320 B	4	mg/L	4 - 1230	± 15%	± 10%	± 10%			
	TDS	2540 C	10	mg/L	10 +	± 15%	± 10%	± 10%			
	TSS	160.2	4	mg/L	4 +	± 15%	± 10%	± 10%			
	TVS	160.4	5	mg/L	5 +	± 15%	± 10%	± 10%			
	$SO_4^{=}$	375.2	20	mg/L	20 - 300	± 15%	± 10%	± 10%			
Water Chemistry (other)	Chl-a	10200 H	0.1	µg/L	0.1 - 20	± 15%	± 10%	± 10%			
	BOD_5	405.1	3	mg/L	24 - 240	± 10%	± 10%		5	5 / 5 / 5	5
Benthic Macro-invertebrates				Taxa	> 50 indiv	Genus or better	Reference collections				
Zooplankton				Taxa	> 200 indiv						

* Method Reporting Limit; ** Numeric Criteria for Beneficial Uses of State-managed wetlands (R317-2 Standards of Quality for Water). *Note that nutrients presented as Pollution Indicators; values for dissolved metals refer to chronic / acute values*. [na = not applicable]. † Matrix control samples are within ±20% (nutrients) & ±30% (metals), per State Lab QA Manual. †† Total N used to calculate organic N (filtered), for Total N: MRL = 0.2 mg/L, Range = 0.2-10; other QC values same as TKN.

6.0 Data Analysis, Record Keeping, and Reporting Requirements

All field data sheets will be scanned by the field crew (as pdf files) as part of routine operations in between field sampling trips. These files will be stored on the DWQ network drive on a bi-weekly basis. Site photos will also be uploaded to the DWQ network drive for this project.

Once all data have been received and results from all field-collected blanks have been validated, the dataset will be formatted as requested by the contractor (CH2MHill) who will perform the data analysis for this project. Their report on the validation of the IW-MMI and condition assessment of GSL IWs is anticipated in May, 2013. The DPM will work with the contractor during the data analysis period to evaluate and assess project progress, make suggestions during MMI evaluation and testing, and update other project team members on a routine basis. The results of data analysis will be presented to DWQ via a 305(b)-style assessment on GSL IW condition for inclusion in the 2014 Integrated Report, and will include a proposal for long-term monitoring of Great Salt Lake impounded wetlands. Once the project report has been reviewed and finalized, this work will be integrated into a report to EPA as a contract deliverable.

7.0 Schedule

Table 7. Project schedule

Task	2012							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Compile Sampling and Analysis Plan		X						
Site Reconnaissance			X					
Sampling - Index Period #1			X					
Sampling - Index Period #2					X			
Sample Analysis						X	X	
Data Validation							X	
Data Analysis							X	
Report Writing							X	X

This project is funded by a WPDG grant to DWQ (*contract # CD-96712201*).

Anticipated Equipment -- Equipment needs for each sampling type is listed in method-specific SOPs (see Appendices B through I). Equipment needs for this project have already been addressed and necessary equipment has been purchased. The Monitoring Team Leader will monitor the inventory of consumable supplies and place orders when needed.

8.0 Project Team and Responsibilities

Table 9 lists key project personnel, identifying responsibilities among project personnel.

Table 8. Project Team contact information

Title	Name	Organizational Affiliation	Key Tasks or Responsibilities	Telephone number/ email
Project Manager	Toby Hooker	UDWQ	Oversees direction of project, data analysis, reporting	(801) 536-4289 tobyhooker@utah.gov
UDWQ QA Officer	Jim Harris	UDWQ	Oversees QA for Division, responds to QA issues, supervises monitoring team	(801) 536-4360 jamesharris@utah.gov
Monitoring Team Leader	Alex Anderson	UDWQ	Directs day-to-day work of project, performs field data collection	(801) 536-4361 aranderson@utah.gov
Monitoring Team	Brent Shaw, Summer Interns	UDWQ	Performs field data collection	Contact Alex Anderson
Laboratory Contact	Sanwat Chaudhuri	State Laboratory	Water analyses	(801) 965-2470
Laboratory Contact	Lawrence Gray	Utah Valley University	Macroinvertebrate analyses	(801) 863-8558 grayla@uvu.edu

UDWQ Project Management Staff

The lead project sponsor will be the Utah Department of Environmental Quality (DEQ), UDWQ whose mission is to "Protect, maintain and enhance the quality of Utah's surface and underground waters for appropriate beneficial uses." The UDWQ Director is Walt Baker and the Assistant Director of the Engineering and Water Quality Branch is Leah Ann Lamb.

The UDWQ Project Manager for this study will be Toby Hooker, the DWQ staff Wetlands Scientist. He will be responsible for project management, tracking, review of technical reports, and dissemination of project results.

James Harris serves the Division Quality Assurance Officer (QAO). He is the point of contact for all data quality assurance matters with the Division, is a DWQ representative to the DEQ's Quality Assurance Council (QAC), and assures that only the current versions of the Division QAPP and associated SOPs are in use. James provides approval for all project SAPs. He is also the Monitoring Section Manager and oversees the monitoring staff and field activities for the Division.

Alex Anderson is the Monitoring Team Leader for this project. Alex coordinates the summer field crew and equipment needs for this project, ensures that all sampling procedures are understood and adhered to during the sampling campaign, and arranges for collected samples to be delivered to the appropriate labs for analysis. Alex also coordinates the scanning and uploaded of field data and photos to the project folder on the DWQ network drive. Alex provides the DPM frequent updates regarding the status of field sampling progress and initiates discussion of any problem situations encountered.

8.1 Field Activities

Day-to-day field operations will be overseen by Alex Anderson, an experienced member of the UDWQ Monitoring Section. He has previous experience monitoring the GSL IW. The monitoring team will consist of one other UDWQ Monitor and two project interns.

8.2 Laboratory Activities

A variety of sample types will be collected during this study, requiring multiple analyzing laboratories.

Water chemistry samples will be analyzed by the Chemical and Environmental Services Bureau of the State of Utah's Public Health Laboratories (hereafter referred to as the State Lab). The laboratory is overseen by Dr. Sanwat Chaudhuri. The State Lab maintains an in-house QAPP, available from the QAP (James Harris). Macroinvertebrate and Zooplankton samples will be analyzed by Utah Valley University (Dr. Larry Gray, Department of Biology). Sediment-Nutrient samples will be analyzed by the Utah State University Stable Isotope Analysis Laboratory. Sediment-Metal samples will be analyzed by University of Utah ICP-MS laboratory.

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