Great Salt Lake Impounded Wetlands: 2012 Probabilistic Survey of Wetland Condition

Sampling and Analysis Plan

Revision 1

Effective 8 June, 2012

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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 requirements outlined in DWQ's Quality Assurance Program Plan (QAPP) for Monitoring Programs and DWQ's Wetland Program Development Grant (WPDG), awarded to DWQ by the United States Environmental Protection Agency (EPA) in 2010. This SAP documents the quality assurance and quality control (QA/QC) requirements and project planning details for a Probabilistic Survey of Great Salt Lake (GSL) Impounded Wetlands (IW), scheduled for 2012. 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

The objective of this project is to collect environmental data from 50 randomly-selected impounded wetlands during the summer/fall of 2012 in order to assess the average condition and identify key stressors for all GSL IW. This project is funded by a WPDG awarded to DWQ. The overarching goal of the WPDG is to develop methods to quantify the condition of GSL wetlands.

DWQ's efforts investigating impounded wetlands began in response to stakeholder concerns that nutrient loads from water treatment facilities adjacent to Great Salt Lake may have deleterious impacts on these productive and highly valued ecosystems. Initial work focused on IW's adjacent to Farmington Bay, where wetland managers and conservation groups observed the occasional dominance of Cyanobacterial mats, a common indicator of phosphorus-induced eutrophication. The concern was that these mats could negatively impact the health and vigor of extensive swards of submerged aquatic vegetation (SAV) (e.g. sego pondweed, *Stuckenia* sp.) and alter the species composition of macroinvertebrate communities. Both SAV and benthic macroinvertebrates are key food sources for migrant waterfowl species (Miller and Hoven, 2007) and important ecological components of shallow ponds (Keddy, 2010).

A large proportion of impounded wetlands adjacent to GSL are managed for waterfowl and other wetland-associated avian species by the Division of Wildlife Resources as Waterfowl Management Areas (WMAs), and the US Fish and Wildlife Service's Bear River Migratory Bird Refuge (BRMBR). Wetlands within these management areas have specifically-designated water quality protections (Utah Administrative Code, R317-2-13.9) based on their support for "waterfowl, shore birds and other water-oriented wildlife…including necessary aquatic organisms in their food chain" (UAC, R317-2-6). However, similar wetland types that occur outside the boundaries of these management areas are not currently afforded specific water quality protections; rather they hold narrative standards based on their location within the lake. Presently, it is not clear whether there are practical differences in the level of water quality protection among these wetland areas, or whether current levels of water quality protection are sufficient to protect and maintain the wetlands' beneficial uses.

There are no established numeric water quality criteria for nutrients, such as N and P, that apply to the designated aquatic wildlife uses associated with GSL wetlands. This is largely due to the complex response of wetlands to nutrient loading, which is controlled by site-specific abiotic and biotic factors that are not yet well understood for GSL impounded wetlands. While there are established numeric criteria for indicators known to affect aquatic wildlife (Beneficial Uses: 3A-D and 5), such as dissolved oxygen (DO), pH, and soluble metals (see: UAC, R317-2, Table 2.14.2), the implementation of these criteria to wetlands has proven to be problematic for two reasons (DWQ, 2009). First, the standards as applied to wetlands are based solely on their geographic location, such that they apply only to areas that are currently designated by specific beneficial uses (state and federal wetland management areas). Wetlands within these management areas account for approximately 80% of the impounded wetlands, but less than 15% of other important wetland types, such as fringe (or sheetflow) wetlands. As such, water quality standards may apply to one wetland area within a WMA, but not to a similar area adjacent to it. Moreover, these water quality standards do not account for the wide diversity of wetland types (or classes) that occur within a management area; GSL wetland classes range from marginal saltgrass or sedge-dominated meadows to permanently flooded ponds (Ducks Unlimited, 2008; Emerson and Hooker, 2012), and each wetland class may represent distinct biological communities and ecosystem processes (Smith et al., 1995; Mitsch and Gosselink, 2007; Keddy, 2010).

The second problem is that the current water quality standards are based on criteria that may have little relevance to protecting the designated uses of wetlands. For example, both DO and pH criteria are commonly exceeded in impounded wetlands, and yet available data suggest that these wetlands continue to support their designated uses (DWQ, 2009). Moreover, exceedances for DO and pH have been observed in nutrient-rich wetlands as well as more oligotrophic, non-impacted ‘reference’ sites. While these parameters may be important in maintaining high-quality aquatic wildlife conditions in lakes and streams, where they were developed, they do not appear to be robust or sensitive indicators of wetland health.

Current efforts are being directed toward developing appropriate water quality standards for wetlands by several states (ASWM, 2012). Utah’s efforts are included as part of an adaptive wetland monitoring and assessment program for Great Salt Lake wetlands (see: www.deq.utah.gov/Issues/gslwetlands/). Initial fieldwork and analysis was completed through collaboration among DWQ and stakeholder groups, culminating in an initial assessment method that compiled multiple lines of evidence that relate to the physical, chemical, and biological condition of GSL wetlands (DWQ, 2009). Data were collected over a period of several years and used to develop a Multi-Metric Index (MMI; Karr and Chu, 1999) assessment framework consisting of four main indicators: water chemistry, submerged aquatic vegetation, surface mats and macroinvertebrates (DWQ, 2009). For this preliminary assessment framework to be properly implemented, the MMI tool must be validated against an independent dataset. This SAP describes the methods and procedures for collecting the environmental data that will be used to validate the impounded wetland MMI (IW-MMI).

At the end of this study, DWQ expects to be able to complete and standardize monitoring, data analysis, and assessment protocols for the GSL impounded wetland class, and expand DWQ’s routine monitoring and assessment programs to include these types of wetlands, utilizing the validated MMI. Specifically, data generated from this study will be used 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
- Capitalize on the statistical strengths of this project's sample design (see Section 2.2) to quantify the range of chemical and biological conditions that occur among all GSL IWs
- Report on the current condition of GSL IW in Utah's *Integrated Report*, as required by the Clean Water Act (CWA §305(b))
- Identify sites or areas with potentially degraded conditions for follow-up intensive monitoring and assessments (CWA §303(d))

Refer to DWQ's 2009 report, *Development of an assessment framework for impounded wetlands of Great Salt Lake* for more information regarding the historical regulatory framework for GSL wetlands, previous data collections, and development of the MMI for IW.

1.2 Study Area

The updated *National Wetlands Inventory* (NWI, 2008) estimated approximately 427,000 acres of wetlands along Great Salt Lake. These wetlands serve as vital habitat for millions of migratory shorebirds, waterfowl and other wildlife. In addition, these wetlands provide essential ecosystem services, including: moderation of surface water and ground-water flows, and removal of nutrients and other pollutants. There continues to be an essential need to maintain the health and extent of these ecologically critical wetlands, especially in the face of severe and persistent threats from population growth (the majority of Utah's citizens reside within the GSL watershed), industrial and urban development, excessive surface-water and ground-water withdrawal, invasive species and high rates of nutrient loading (Millennium Ecosystem Assessment, 2005; Dahl, 2006). Protecting and sustaining the health of these waters first requires scientifically-defensible and quantitative measures of their condition.

This project will take place in the impounded wetlands surrounding the Great Salt Lake, Utah, HUC Sub-region 1602. The project area includes portions of Salt Lake, Box Elder, Weber, Davis and Tooele counties. GSL wetlands are dominated by two main wetland classes: impounded wetlands and fringe 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. Future studies will focus on fringe type wetlands, but the current project focuses on impounded wetlands. Impounded wetlands surrounding the GSL encompass approximately 100,000 acres and are actively managed by State and Federal agencies for waterfowl habitat. Figure 1 shows the study area within its larger geographic region.

1.3 Summary of Project Tasks and Schedule

Region 8 EPA provided DWQ with 50 random sampling locations along with oversample (alternative) locations in April, 2011 for this project. Sampling locations will be ground-truthed and finalized in spring of 2012. Next, a sampling schedule will be planned and attached to this SAP. Environmental data collections will take place during the summer and fall of 2012, 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 and QA/QC report will be presented to a contracted party (CH2MHill) for analysis. The contracted party will use the data to validate the MMI and assess the overall condition of GSL IW. Their findings will be presented to DWQ on or before May 31, 2013 via 1) a 305(b)-style assessment on GSL IW condition inclusion in the 2014 Integrated Report, and 2) a proposed long-term monitoring plan for GSL IW.

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 IWs, make decisions about the use and applicability of the previously developed MMI, and set long-term goals for monitoring the health GSL IW.

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 develop a valid monitoring tool for wetland water quality assessments. Building on previous work, this project will:

i) validate the MMI approach based on biotic and water quality parameters, and
ii) verify that the IW-MMI can describe the range of wetland conditions encountered along the margins of GSL, through a random sample of 50 impounded wetlands.

Figure 1. Great Salt Lake Study Area and Potential Sampling Points

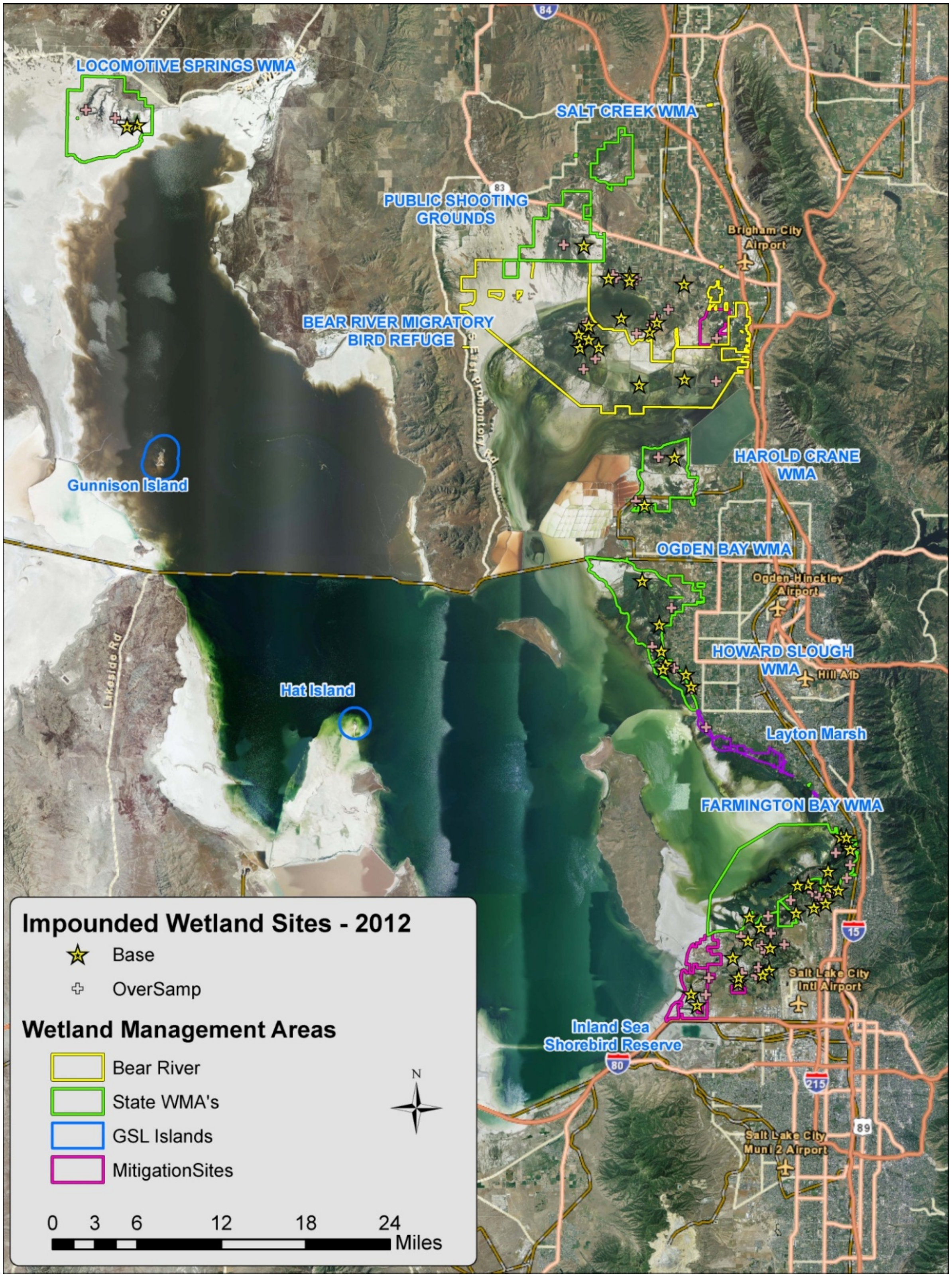


Table 1 Data Quality Objectives

Step	DQOs for 2012 Great Salt Lake Impounded Wetland Random Survey
1. Problem Statement	Wetland resource managers and stakeholders observed the occurrence of algal mats within some impounded wetlands (IWs) associated with high N and P loading from wastewater treatment facilities, and are concerned about the potential impact these mats could have on the food sources of waterfowl in preparation for their seasonal migration schedule. It was suspected that IWs with high nutrient loads may not be supporting their beneficial use of waterfowl habitat, including the necessary food chain. In response, a limited survey of IWs was performed and it was reported that many of these wetlands exceeded DO and pH water quality parameters. However, complementary results indicated that these parameters were not associated with differences in benthic macroinvertebrate community composition or SAV cover, two important elements of the food chain for waterfowl. As such, the relevance of DO and pH water quality parameters for wetlands were called into question, and an Assessment Framework for Wetland Water Quality Standards was designed. Previously collected data were compiled using a multiple lines of evidence approach to construct a Multimetric Index (MMI). This assessment tool, the MMI for impounded wetlands (IW-MMI) needs to be validated against an independent set of sites and evaluated and/or refined.
2. Goal of Study / Decision Statements	**Key Question[s]** Q_0: What is the overall condition of GSL's impounded wetlands? Q_1: Is the IW-MMI capable of describing the full range of conditions of IWs as it is currently structured? Q_2: For IWs that have been characterized as degraded by the IW-MMI, can site-specific stressors be identified and evaluated in terms of their extent and relative risk to IWs? **Potential Outcomes** 1: Information is adequate to calculate unbiased MMI's for i) water chemistry, ii) benthic macroinvertebrates, iii) SAV, and iv) surface mats, and DWQ will estimate the overall condition of GSL impounded wetlands and submit results for the IR 2: The IW-MMI is not well correlated with the previously developed MMI. The structure of the overall MMI scores will be re-evaluated to better understand the effects of multi-year variability on the metrics, including the evaluation of potential stressors. The revised IW-MMI will be used to estimate wetland condition for GSL IWs, and results will be submitted for the IR as above 3: Information is inadequate to calculate unbiased MMI's. DWQ will identify potential confounding factors, develop appropriate sampling and analytical methods, revise the sampling plan, and complete reporting as above
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) at 50 randomly selected IW sites adjacent to GSL

Step	DQOs for 2012 Great Salt Lake Impounded Wetland Random Survey
	• Water chemistry parameters: Total nutrients, dissolved nutrients, dissolved metals, BOD_5, and field measures (DO, temp, pH, salinity) using appropriate and documented methods • Benthic and water column biota: Species composition of benthic macroinvertebrate, diatoms, and zooplankton communities using appropriate and documented methods • Field measures of submerged aquatic vegetation (SAV) and surface mat (algae and floating aquatic plants) cover will be collected using appropriate and documented methods • Sediment metals and nutrient availability: Total (digested) metals and exchangeable concentrations of NH_4, NO_3, and PO_4 using appropriate and documented methods This information is described in Section 2.4 and Tables 3 and 5.
4. Study Boundaries	The study area for this project is shown in (FIGURE 1). This area includes impounded wetlands within: Farmington Bay, Ogden Bay, Bear River Bay, Gunnison Bay, and Gilbert Bay portions of Great Salt Lake. Spatial data identifying impounded wetlands is derived from National Wetland Inventory maps. Sampling sites will be field-checked to ensure that: • Represent the sample target - Impounded 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 during *both* sample windows o Representative water depth is 0.5 to 1.0 m in June *and* 0.25 to 0.50 m in September Field visits include two separate sampling windows: mid-summer, approximately June through July; and early-autumn; approximately mid-August through September. All sites will be sampled during *both* sampling windows • 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 calculate unbiased MMI's for i) water chemistry, ii) benthic macroinvertebrates, iii) SAV, and iv) surface mats; then DWQ will estimate the overall condition of GSL impounded wetlands and submit results for the IR
	    o If the IW-MMI is well correlated with the previously developed MMI, results will be reported in the IR
	    o If the IW-MMI is not well correlated with the previously developed MMI, then the structure of the overall MMI scores will be evaluated to better understand the effects of multi-year variability on the metrics
	• If information is inadequate to calculate unbiased MMI's; 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 Impounded Wetland Random Survey
6. Acceptance Criteria	• PARCC elements for data o Precision - Field replicates will be collected at 10% of sites (5 sites) for water chemistry variables. Due to the disruptive nature of transect (SAV/algal mats) and macroinvertebrate samples, field replicates will be separated by > 5m. o 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 of SAV and algal mats will be performed by a wetland monitoring crew trained in each method. Few species of SAV occur within the project area and are easily identified, but questionable specimens will be collected and returned to the office for further identification. Taxonomic identification of macroinvertebrates and zooplankton will be performed by Dr. Larry Gray. o 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. Site photos and field notes will be collected at each site and can be used to describe any unusual conditions that may occur. o Completeness - To ensure the sampling goal of 100% completeness at the end of the season, we will use field reconnaissance to verify that sites have the proper hydrologic conditions to maintain sufficient inundation through both index periods, and collect data from 10% more sites than needed. o 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 diatoms and nutrients • Field observations of SAV and algal mat cover This data will be used to estimate the baseline condition of impounded wetlands associated with Great Salt Lake. Data will be used to construct MMIs for four key indicators: Water Chemistry, Benthic Macroinvertebrates, Submerged Aquatic Vegetation, and Algal Mats. 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 provide for a validation of the MMI approach for impounded wetlands using an independent, randomly selected dataset, and will allow for an unbiased estimate of the condition (i.e. the relative health) of GSL's impounded wetlands.

2.2 Sampling Design

The sampling design is based on a target population of impounded wetlands associated with Bear River, Farmington, and Gilbert Bays of Great Salt Lake, as mapped by the National Wetlands Inventory in the 1980s and 1990s. Industrial ponds (i.e. evaporation ponds) and ponds managed for non-waterfowl/waterbird wildlife are excluded from the target population. The minimum size of IWs is five acres (approximately 2.0 ha). The NWI dataset was supplemented by inclusion of wetland polygon data for two extensive wetland compensatory mitigation areas (Inland Sea Shorebird Reserve and Legacy Nature Preserve), where impounded wetlands were either rehabilitated or restored.

The sample frame consists of GIS polygons representing individual impounded wetlands, where:

1) Elevation < 4218 feet asl
2) NWI System = Lacustrine (L) or Palustrine (P)
3) NWI Class = Aquatic Bed (AB), Unconsolidated Shore (US), or Unconsolidated Bed (UB)
4) NWI Water Regime = Permanently Flooded (H), Intermittently Exposed (G), or Semipermanently Flooded (F)
5) NWI Special = Diked or Impounded
6) Water-related Landuse ≠ Evaporation Pond
7) Area > 5.0 ac (2.0 ha)

Sampling locations were identified using a Generalized Random Tessellation Stratified (GRTS) survey design, through assistance by Tony Olsen and USEPA. The GRTS design is a compromise between simple random sampling and systematic sampling. The GRTS design allows for the probability of site occurrence to be inversely proportional to the population density, and generates site locations that are randomized among multiple hierarchical levels. Because IWs vary widely in size (2 to over 1000 ha), the sample frame was separated into three size classes: *Small*, < 20 acres; *Medium*, 20-100 acres; and *Large*, > 100 acres. In addition, the survey area was stratified into four sub-watershed hydrologic units based on HUC8 codes: Curlew Valley, Jordan River, Lower Bear-Malad, and Lower Weber. The latter three subwatersheds were given equal weighting, while Curlew Valley had a lower weight since only a few IWs occur there. Based on survey area characteristics described above, the expected sample size is shown below.

Table 2. Distribution of sampling sites based on a Total Sample Size of 50 sites

	Impoundment Size Class			
Region	Large	Medium	Small	Sum
Curlew Valley	1	1	0	2
Jordan River	4	6	6	16
Lower Bear-Malad	7	6	3	16
Lower Weber	5	5	6	16
Total	17	18	15	50

A MS-Excel file was provided to DWQ by EPA containing the coordinates, size classes, strata, ownership information and size of each sampling site. The table includes a 100% oversample to ensure that a sufficient number of sites can be sampled during the project index period. The initial sample draw is shown as 'Base' and the extra sites as 'OverSamp' in the column 'panel'.

When working with the sampling site table, sites (identified by their unique 'siteID' code) *must be sorted within each stratum*. During office or via field reconnaissance, the 'Base' sites will be evaluated first. If a base site is not sampleable, then the next 'OverSamp' site *in order* (i.e. within the same subwatershed) can be added to the list to be evaluated.

Criteria to evaluate potential sampling sites include:

1) Target / Non-target: Does the site represent an impounded wetland (> 5 acres) that is managed for waterfowl or other wetland-associated wildlife? (Note that wetland-associated wildlife does not include fishing ponds or water sources solely used for livestock).
2) Permission / Access: Has explicit permission to access the site been obtained from the landowner?
3) Sampleable: Can the site be sampled during *both* windows of the sampling index period? (This is described in greater detail below. Site must have sufficient water depth to *potentially* include SAV and allow collection of water chemistry samples during both July-August and September-October index periods).

If any of these criteria cannot be met during the initial site evaluation, the site must be rejected, the reason for the rejection should be recorded in the sample site database. If a site is rejected, then the next site on the oversample list is evaluated *in order* of occurrence on the list.

The project goal is to obtain 100% of the data required (50 sites sampled during both summer and autumn index periods; see Data Quality Indicators below). Since water levels of GSL IWs can vary greatly from year to year, *we will collect data on an additional 10% of sites* (<u>55 instead of 50 sites</u>) to ensure that data for all metrics are collected during both index periods.

2.3 Study Boundaries

Impounded wetlands represent an important and unique component of the Great Salt Lake ecosystem. 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. As such, IWs located within WMA's and the BRMBR have specific water quality standards explicitly recognized by the state. In addition, many IWs are hydrologically connected to one another through an extensive series of dikes, ditches and canals, and these systems are highly sensitive the *quantity* of water they receive during the growing season. In order to properly assess the baseline condition of IWs associated with GSL with respect to water *quality*, it is necessary to clearly describe where IWs occur in the landscape, and to identify comparable portions of IWs to be sampled during data collection.

2.3.1 Geographic Boundaries

As shown in Figure 1, the project area includes wetlands along the eastern and southeastern shores of Great Salt Lake and an isolated area of wetlands in the northwestern portion of Gunnison Bay. Additional, finer-scale maps for the four major subwatersheds are included in the Appendix A. All impounded wetlands are located above the elevation of GSL and below 4218 feet above sea level.

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.

In order to provide for maximum waterfowl habitat, wetland managers utilize a variety of tools to maintain water depths at the desired levels throughout the year. Current WMA goals for waterfowl production are to provide IWs with approximately 46 cm water depth for maximum growth of submerged aquatic vegetation (Hoven and Miller, 2009); however, this goal may not always be attained by WMA's when water supplies are limited.

Two important measurement parameters of the IW assessment are water chemistry and the cover of submerged aquatic vegetation (SAV) (see below). Water depth exerts a strong influence of these parameters, above and beyond any potential effects of water quality, per se. Previous work suggests that optimal water depths for healthy SAV growth within IWs ranges from approximately 25 to 100 cm; the former water level is also roughly the minimum water depth desirable for collection of water chemistry samples. As such, specific efforts will be made during sampling site reconnaissance to identify areas within each IW where these depth conditions can be met. Sampling locations within a given site will be at least 50 m from an adjacent dike or shoreline and roughly 100 m from the IW outflow path. These sampling restrictions will allow the field crew to collect data from deeper portions of the wetland, where water chemistry is expected to be most consistent and where samples integrate processes throughout the wetland.

An example of sample location setup for an IW site is shown in Figure 2. The guidance on sampling locations, given above, should be used to identify and sample the most appropriate area within the IW that best represents the conditions of the aquatic features of that wetland site.

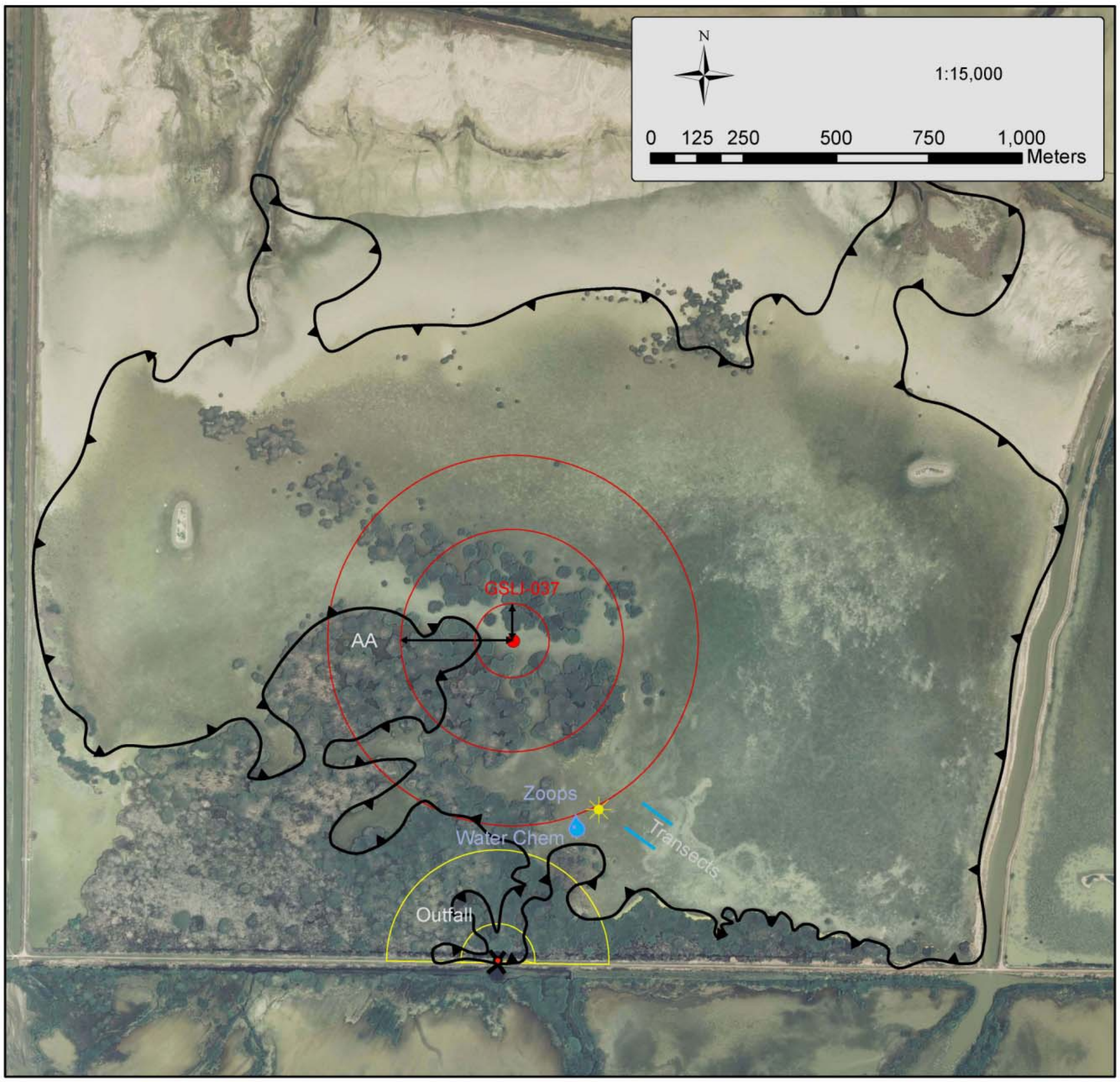
2.3.3 Temporal Boundaries (Index Period)

Previous work evaluating the ecological characteristics of impounded wetlands and their biological response to nutrient loading has identified seasonal changes in SAV cover as a potentially powerful measure of wetland condition (Hoven and Miller, 2009; DWQ, 2009). Early senescence of SAV was observed in some nutrient-enriched ponds in late summer, while SAV persisted through autumn in more oligotrophic ponds (DWQ, 2009). While this pattern was observed for only a limited number of sites, early SAV senescence could negatively impact migratory waterfowl who rely on SAV tubers as an autumnal food source.

The seasonal change in SAV cover between summer and autumn was a useful element of the preliminary IW-MMI (DWQ, 2009). This measurement will be obtained from 50 randomly selected sites in this project (plus 10% oversample, as described above), by collecting data during both summer and autumn index periods. Index periods are commonly used in biological assessments because they help minimize temporal variation in biological parameters and optimize the information gained from measures of community composition.

The index periods for this project are June through July (summer), and September through October (autumn).

Figure 2. Example Locations for Impounded Wetland Field Measurement and Collections



Locations for field activities at an impounded wetland site. Solid red filled circle represents the Site location from the sample database. Additional red circles represent 100, 300, and 500 m (radius) polygons; when applied to data collection points, they represent the assessment area.

Yellow half-circles represent 100 and 300 m (radii) areas to guide the selection of the water chemistry sampling location. The outflow of this IW (represented by a smaller red dot and a black "X") is being encroached by the invasive weed *Phragmites australis*. The weedy encroachment at the outflow requires the sampling location to be moved further into the wetland, as shown by the "Water Chem" and "Zoops" markers. Also shown are two hypothetical lines representing 100-m transects for SAV and benthic macroinvertebrates.

2.4 Parameters to be measured

The previously developed IW-MMI utilized four distinct indices (DWQ, 2009):

1) Benthic macroinvertebrate community
2) Submerged aquatic vegetation cover
3) Surface mat cover
4) Water chemistry

In order to validate this assessment method, the same measurements will be repeated on 50 random sites during summer and autumn index periods in 2012. Subsequent work has proposed additional or alternative indices that may be useful, including:

* Zooplankton communities
* Surface sediment diatoms
* Sediment nutrient availability and total metals

These parameters will be measured at all sites. Zooplankton and surface sediment diatom communities, and sediment nutrient availability will be examined during both index periods, while sediment metals will be determined only during the second, autumn index period. A brief description of each measured parameter is included in Table 3 below.

Table 3. Parameters to be measured

Description		**Field Method** *	**Details**
Aquatic Vegetation		Visual Observation	Five 1 m^2 quadrats along 100-m transect % Submerged Aquatic Vegetation (SAV), % Filamentous Algae, and % Floating Aquatic Vegetation
Benthic Macroinvertebrates		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		Sample Collection using Wisconsin Net	Five x 5-m tows (radial) with Wisconsin Net One 50-mL centrifuge tube *Sent to Gray Lab*
Water Chemistry	Field Parameters	Multi-Parameter Probe	Temperature, Specific Conductance, pH, Dissolved Oxygen
	Total (unfiltered) Nutrients	Grab Sample Collection	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*
	Dissolved	Grab Sample	NH_4^+, NO_3^-/NO_2^-, Total N (dissolved), Dissolved P, DOC

Description		Field Method *	Details
	(filtered) Nutrients	Collection and Field Filtering	One 500 mL bottle with H_2SO_4 preservative *Sent to State Water Lab*
	Dissolved (filtered) Metals	Grab Sample Collection and Field Filtering	Aluminum, Arsenic, Barium, Cadmium, Cobalt, Copper, Iron, Mercury, ~~Lithium~~, Manganese, Nickel, Lead, Selenium, Zinc, and *Hardness* One 250 mL bottle, preserved with HNO_3 *Sent to State Water Lab*
	General Chemistry	Grab Sample Collection	Alkalinity, Total Suspended Solids, Total Volatile Solids, Total Dissolved Solids, Sulfate ($SO_4^{=}$) One 1000 mL bottle *Sent to State Water Lab*
	Sulfide	Grab Sample Collection	Hydrogen sulfide as Total sulfide One 120 mL bottle with ZnoAc and NaOH preservative *Sent to State Water Lab*
	Chlorophyll-*a*	Grab Sample Collection and Field Filtering	0.7 µm filter residue *Sent to State Water Lab*
	Oxygen Demand	Grab Sample Collection	5-day Biochemical Oxygen Demand (BOD_5) One 2000 mL bottle *Sent to State Water Lab*
Sediment Diatoms		Sample Collection using a Corer *Index Period #1 ONLY*	Composite of five x 1-cm sediment cores along 100-m transect One 250 mL bottle *Sent to Rushforth Lab to be plated on slides for future analysis*
Sediment Available Nutrients		Sample Collection using a Corer *Index Period #1 ONLY*	Separate five x 9-cm cores (1-9 cm, below sediment diatom sample) along 100- transect Stored in separate 1-quart zip bags (Nutrient Extracts: NH4, NO3/NO2, PO4); Total N, Total and Organic C *Sent to USU Analytical Lab*
Sediment Total Metals		Sample Collection using a Corer *Index Period #1 ONLY*	Composite of five x 9-cm cores (collect half of each sediment-nutrient core and composite) Stored in 1-gallon zip bag Aluminum, Arsenic, Barium, Cadmium, Cobalt, Copper, Iron, Mercury, Lithium, Manganese, Nickel, Lead, Selenium, and Zinc *Receiving Lab being negotiated (6/8/2012)*

* 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 adequate to verify the previously developed IW-MMI and to estimate the baseline condition of impounded wetlands associated with Great Salt Lake, then

DWQ will summarize and submit these results with the next CWA §305(b) Integrated Report.

2.) If information is not adequate to verify the previously developed IW-MMI, DWQ will incorporate the supplemental parameters into a new MMI based on the current project sites. This information will then be summarized and submitted with the next Integrated Report.

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 below. The DWQ QAPP defines procedures that specify minimum quality assurance (QA) and quality control (QC) objectives for sample measurements based on the sample matrix.

Table 4. 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

Data Quality Indicator	QC Check / QC Sample	Evaluation Criteria	Goal
	Holding times Field replicates Field/trip/equipment blanks	Holding times RPD Detection Limit	100% compliance 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

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

This section provides a brief overview of the field sampling activities to be performed at each site. Specific instructions, including required equipment and procedures are located in the SOPs attached to this document. The general workflow of activities is described in the next section.

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 is typically one of the first activities performed during a site visit. Procedures for (daily) calibration and use of the multi-parameter probe are provided in the SOP (**Appendix B**). 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.

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 (**Appendix C**). Several volumes of surface water will be collected for seven different types of analysis. Four bottles will be filled for *Total Nutrients*, *General Chemistry*, *Sulfide*, and BOD_5. One or more 'transfer bottles' will also be filled and then filtered for *Dissolved Nutrients* and *Dissolved Metals*. Additional water will be filtered separately and the residue collected for *Chlorophyll-α* analysis (**Appendix D**).

3.2.2 Zooplankton Sampling

Zooplankton sampling is performed using a tow net to collect large plankton within the upper portion of surface waters. Procedures are described in the SOP (**Appendix F**). Briefly, an undisturbed area is selected and the tow net is cast and recovered for a total of five 5-meter tows. The contents are rinsed into a sample container (typically a 50 mL centrifuge type). Care will be taken to avoid to sediment/soil materials and surface mats in the sample container. In addition, best results are obtained when the top of the tow net is oriented horizontally, just below the water surface, while the net is being recovered; this maximizes the collection of plankton per tow.

3.2.3 SAV and Surface Mat Cover

Aquatic vegetation is sampled by visual estimation of aerial cover along 100-m transects. Procedures are described in the SOP (**Appendix G**). Briefly, five values from a random numbers table (range of 0 to 100) provide the distance along a transect where the cover of SAV and/or surface mats within a 0.5 x 2.0 m quadrat are recorded. This data, along with other pertinent observations are recorded on a field sheet. No collections are made.

3.2.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates are collected from an undisturbed area using a D-net along a 100-m transect. Procedures are described in the SOP (**Appendix H**). Briefly, five random numbers (ranging from 0 to 100) are used to identify sampling points along a transect. This transect should be at least 5 m 'upstream' (towards the interior of the IW) from the SAV transect described above. 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. Three figure eights over the same area constitute a 'sweep', and one 'sweep' is performed at each sampling location along the transect.

3.2.5 Sediment Diatom Sampling

Sediment diatoms are collected as a composite of 5 sediment core samples, using a modified KB coring device, along a 100-m transect. This transect should be at least 5 m away from any other sampling transect (or other disturbed area), and at least 50 m from the IW boundary. Procedures are described in the SOP (**Appendix I**). Briefly, a core will be collected at each of five random locations along the transect, and using the coring device, only the top 1 cm will be retained from each sample core. These five 1-cm samples are composited. The remaining material will be retained for sediment chemistry (see below).

3.2.6 Sediment Chemistry Sampling

Sediment available nutrients and total metals are sampled from 5 sediment cores along a 100-m transect. The transect should be at least 5 m away from another transect or other disturbed area. This procedure is slightly modified from that described in the SOP (**Appendix I**).

Briefly, the goal is to sample the top 10 cm of the loose sediment (or mucky soil) at five random locations along the transect. For this project, sediment for chemistry sampling will be obtained from the same cores used to collect surface (0-1 cm) sediment diatoms, where the 1 to 10 cm depth is kept for chemical analysis.

The 1 to 10 cm core will be split in the field, using a soil spatula, and each half of the sediment core placed in separate sample bags: one-half of the core will be placed in a labeled plastic 1-quart zip bag, the other half of the core will be placed in a labeled 1-gallon zip bag. This process will be repeated for all five samples collected per site. For *Sediment Available Nutrients*, the samples will be stored in *separate* plastic 1-quart zip bags. For *Sediment Total Metals*, the samples will be composited in one gallon-size zip bag.

After all processing is complete there will be seven (7) sediment samples: 1 jar for sediment diatoms (see Section 3.2.5), five 1-quart bags for sediment nutrients, and one 1-gallon bag for sediment metals (see Table 5). All samples will be collected during Index Period #1 *only*.

3.2.7 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.

3.3 Field sampling workflow

The flow of activities at the sampling site will generally occur in the following order:

1. Determine if IW is sampleable, check coordinates, determine appropriate location for transects
2. Water chemistry and field parameters at/near outflow
3. Gather equipment for transect work in sleds/float tubes
4. Move out into the pond, towards the GPS point, until a sufficient point is reached. The SAP provides detail as to this location, but in sum:
    a. At least 50 m from impoundment dikes
    b. At least 100 m from the outflow
    c. An area where the transects will move through water 25 to 100 cm deep.
5. Record the new pond point location and take any pertinent pictures
6. The zooplankton tow will be made at the start of the 100 m transect location, 5 tows
7. The SAV field sheet will have 3 sets of 5 random numbers, used for the SAV cover measurements, macroinvertebrate sample sites, and sediment sample sites
8. Once transect collections and observations are made, return to the vehicle and process the samples
9. Label all samples according to the SAP and use proper preservative until samples are delivered to appropriate lab

3.4 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 (see **Appendices B-I**) 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.

3.5 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.

If a previously evaluated site no longer represents the sample target for this study during the first index period (June through July), then the field crew should contact the *Designated Project Manager* (DPM) and continue on to the next site to be sampled that day. The non-target site will be labeled as 'non-sampleable' in the site database and a new site will be selected from the survey list following the procedure described in Section 2.2. If the non-target site was successfully sampled during the first index period, but conditions have drastically changed, so that there is no sampleable location within the impounded wetland, then the site must be dropped. If a site is dropped, this information will be added to the site database, including a description of why the site was dropped.

In an effort to ensure that DWQ acquired high-quality data from 50 randomly selected sites (i.e. 100% completeness, see Table 4), we will begin sampling with an initial 55 sites (10% oversample) to account for the variable hydrologic nature of these wetlands.

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 5. Sample container requirements

Sample Type / Analyte	Container Type	Volume	Preservative	Holding Time	Receiving Lab
Aquatic Vegetation					
	No Collection				
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 Diatoms					
5-Sample Composite	Plastic jar	250 mL	ice chest / lab freezer	n/a	Rushforth Lab
Sediment Nutrients					
5-Separate Samples	Plastic bag	1 quart	ice chest / lab freezer	n/a	USUAL lab
Sediment Metals					
5-sample Composite	Plastic bag	1 gallon	ice chest / lab freezer	n/a	Private Lab** (or 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/

Rushforth Lab

Rushforth Phycology, LLC
Contact: Dr. Sam Rushforth
Orem, UT
(801) 225-5736; email: sam@rushforthphycology.com;
Web: rushforthphycology.com/201.html

Utah State University Analytical Lab

Contact: Pam Hole
Logan, UT
(435) 797-2217; email: usual@usu.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. For example, the GRTS site selection procedure was designed to minimize bias when sampling large areas of complex sample units (impounded wetlands stratified by subwatershed). Adherence to SOPs for all measurements will minimize bias, improve accuracy and precision, and support data representativeness and comparability associated with this project. Finally, the project design includes a 10% oversample to ensure that MMI data are 100% complete over both sampling index periods.

Three types of QC samples will be collected in the field. First, replicate samples will be obtained for 10% of all field collections listed in Table 3 (5 sites per index period). This includes water chemistry samples, SAV, zooplankton, benthic macroinvertebrates, sediment diatoms and sediment chemistry.

<u>Performance goal</u>: < 20% difference between replicates for water (< 40% 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*.

Second, one set of "Field Blanks" will be collected per week. Reagent-free deionized (DI) water will be added to *General Chemistry* (1000 mL), *Dissolved Nutrients* (500 mL), and *Dissolved Metals* (250 mL) 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.

Third, three sets of "Equipment Blanks" will be collected per *full* week of sampling (i.e. at least four days of sampling); at the beginning, middle, and end of that week's list of sites. For partial-week sampling, Equipment Blanks will be collected at the beginning and end of the week's sites. 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 6. Quality Control Sample Collections

QC Type	***Frequency***	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
(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	3 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 7. 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	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 8. Project schedule

Task	2012								2013						
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Compile Sampling and Analysis Plan	X														
Site Reconnaissance	X														
Sampling - Index Period #1		X	X												
Sampling - Index Period #2					X	X									
Sample Analysis			X	X		X	X								
Data Validation							X	X							
Data Analysis									X	X	X	X			
Report Writing												X	X	X	
Final Review															X

This project is funded by a WPDG grant to DWQ (*contract # CD-96711401*).

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 9. 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
Technical Manager	Jeff Ostermiller	UDWQ	Oversees technical aspects of project, budget, data analysis and reporting	(801) 536-4370 jostermiller@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
Project QA Manager	Trisha Johnson	UDWQ	Oversees QA Activities for Field, Lab, Data Review, Database Management	(801) 536-4193 tbjojhnson@utah.gov
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
Laboratory Contact	Pam Hole	Utah State University	Sediment analyses	(435) 797-2217 usual@usu.edu
Laboratory Contact	Sam Rushforth	Rushforth Laboratory	Sediment/water analyses	(801) 863-8980 sam.rushforth@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.

Jeff Ostermiller is the Water Quality Management Section Manager and has extensive experience with the management and implementation of monitoring and assessment programs. In particular, he has created biological assessment tools for numerous state and federal agencies, including oversight and analytical work for Utah's newly developed wetland MMI. He will serve as technical advisor and will be a primary user of the dataset.

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.

Trisha Johnson manages the QA/QC support activities for this project, handling day-to-day QA activities. She is also a representative to the QAC. Trisha reviews, revises, and maintains the QA/QC documentation for the Division, including the QAPP, SOPs and SAPs. She also interacts with laboratories and assists the DPM with data review and validation. The QA/QC support staff are generally independent from data generation activities, in that they only rarely perform environmental data collection.

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) or the QA/QC staff (Trisha Johnson).

Macroinvertebrate and Zooplankton samples will be analyzed by Utah Valley University (Dr. Larry Gray, Department of Biology).

Sediment-Diatom samples will be prepared for analysis Rushforth Laboratory (Dr. Sam Rushforth). As additional funds become available, these samples will be analyzed.

Sediment-Nutrient samples will be analyzed by the Utah State University Analytical Lab (USUAL) (Pamela Hole, see Section 4.1 or Table 9).

Sediment-Metal samples will be analyzed by a laboratory currently being negotiated by DWQ.

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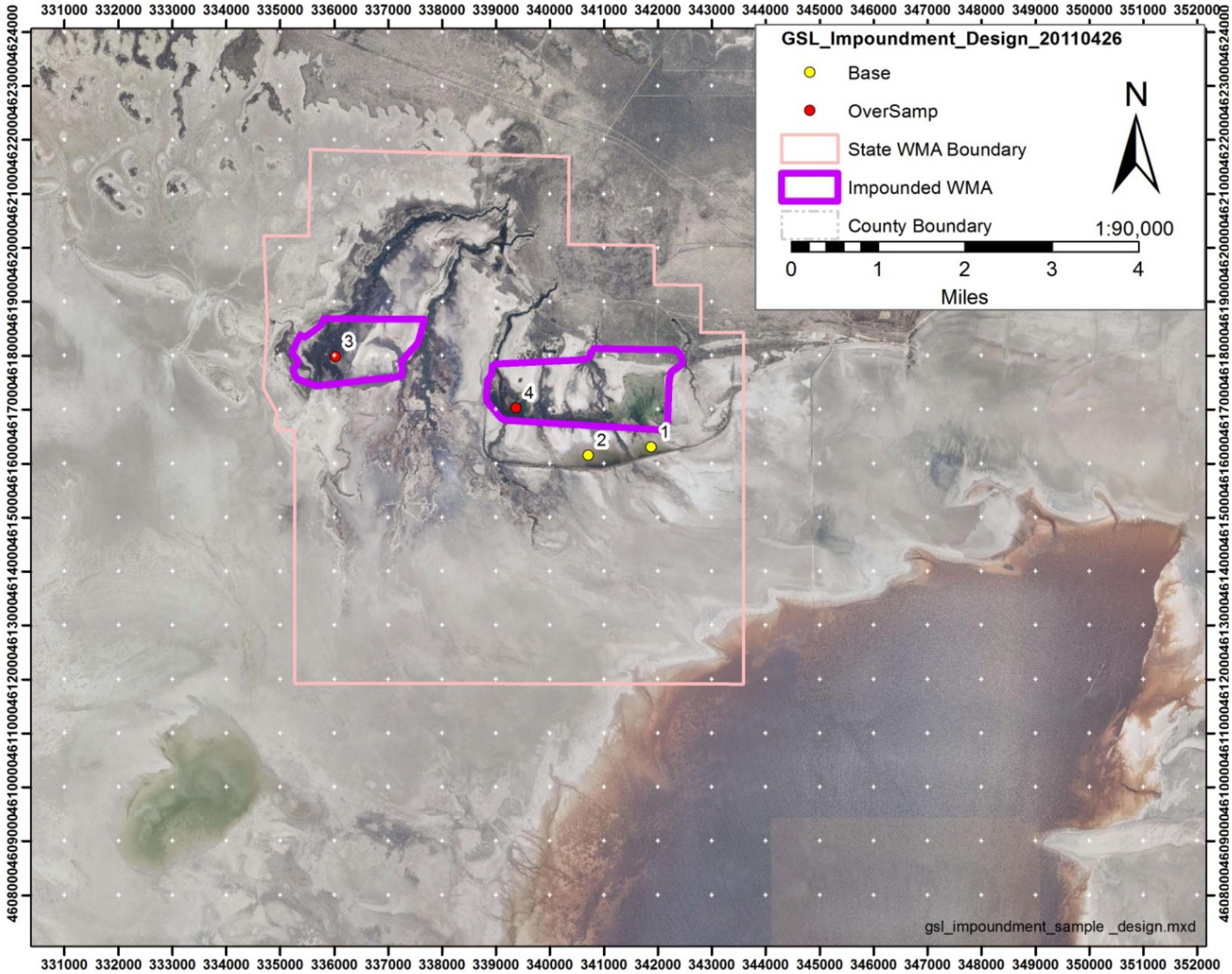
Appendices

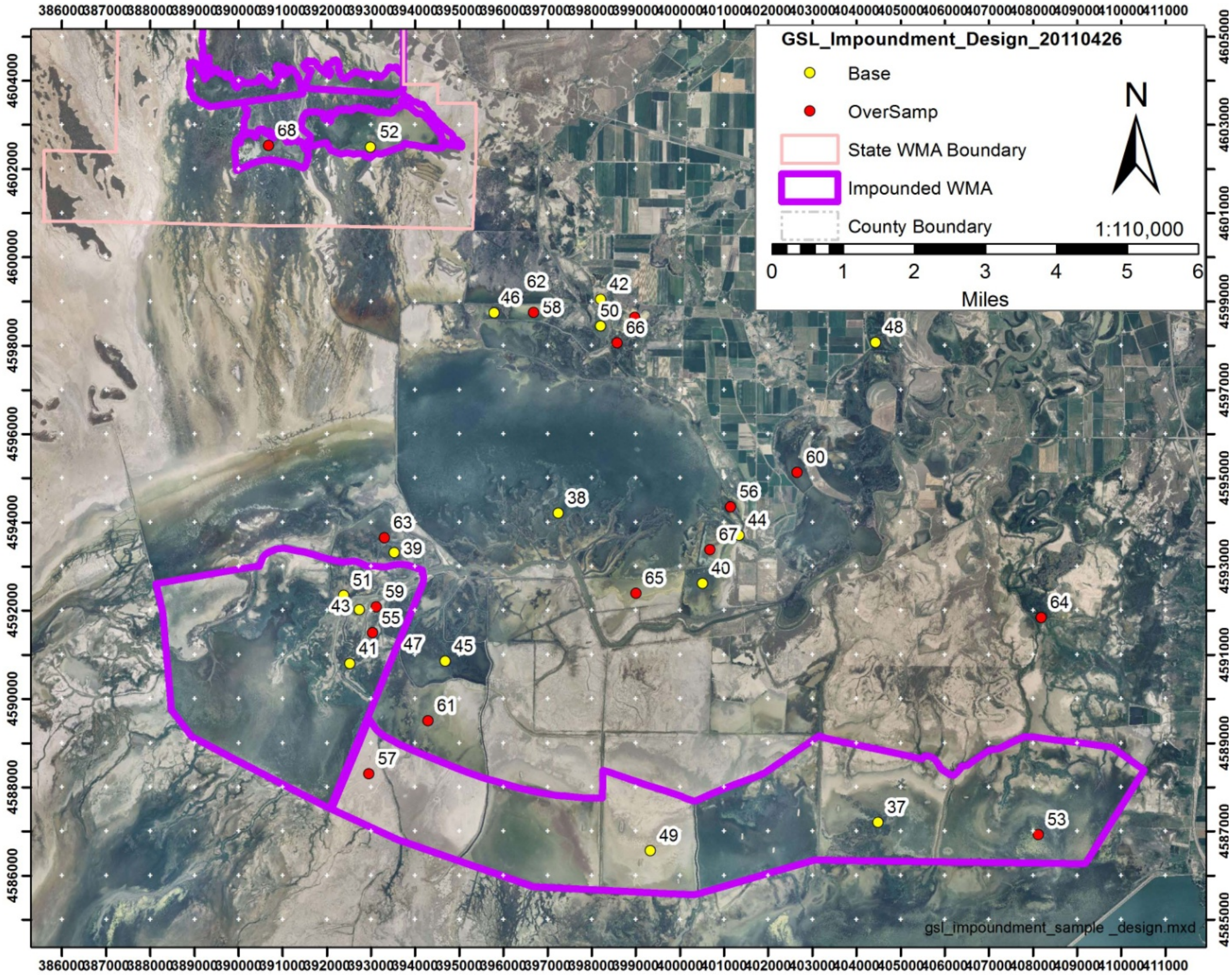
Appendix A Maps of IW sites by GSL locale

a. Map 1. Locomotive Springs
b. Map 2. Bear River Bay
c. Map 3. Ogden Bay
d. Map 4. Farmington Bay

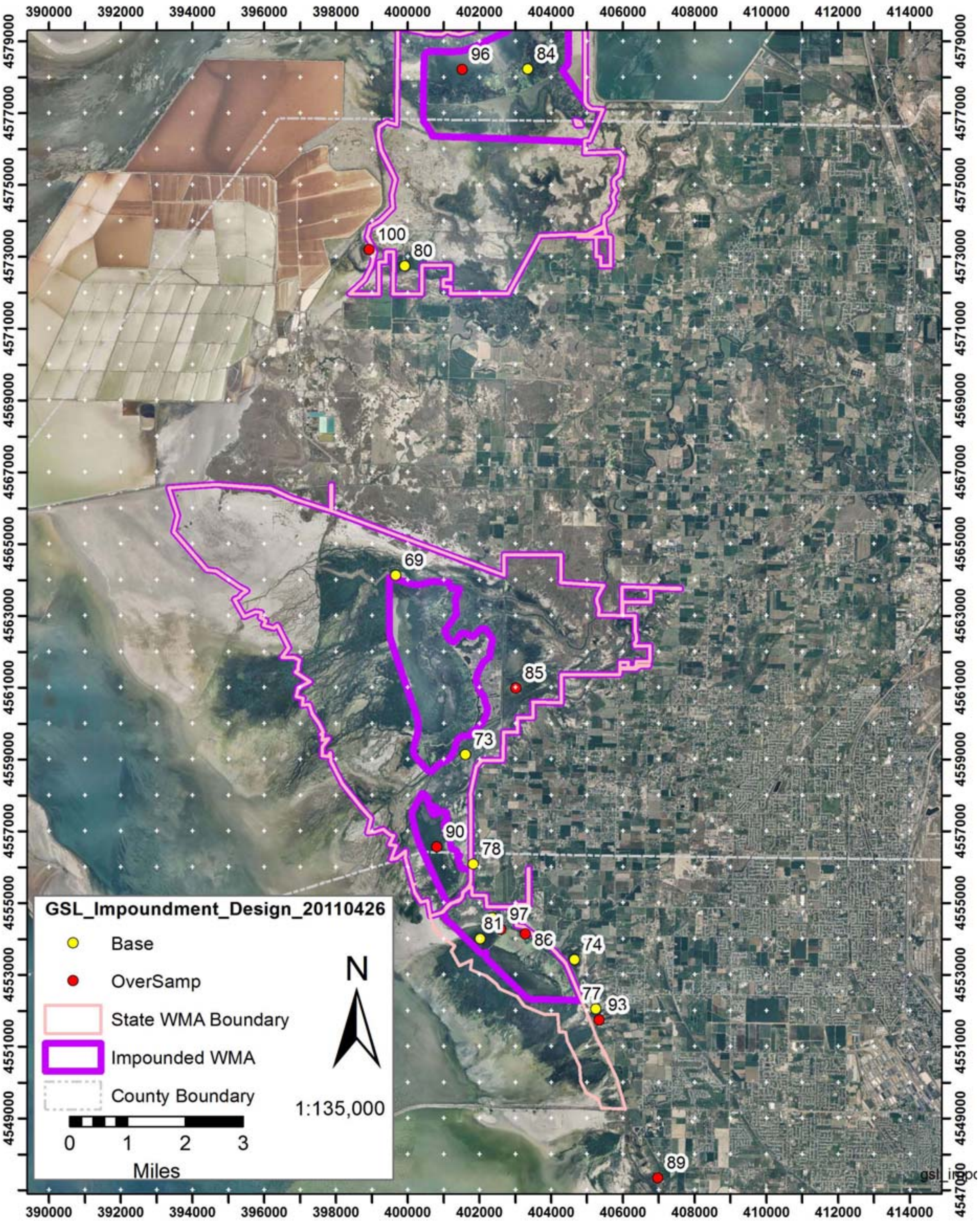
Map 1. Locomotive Springs



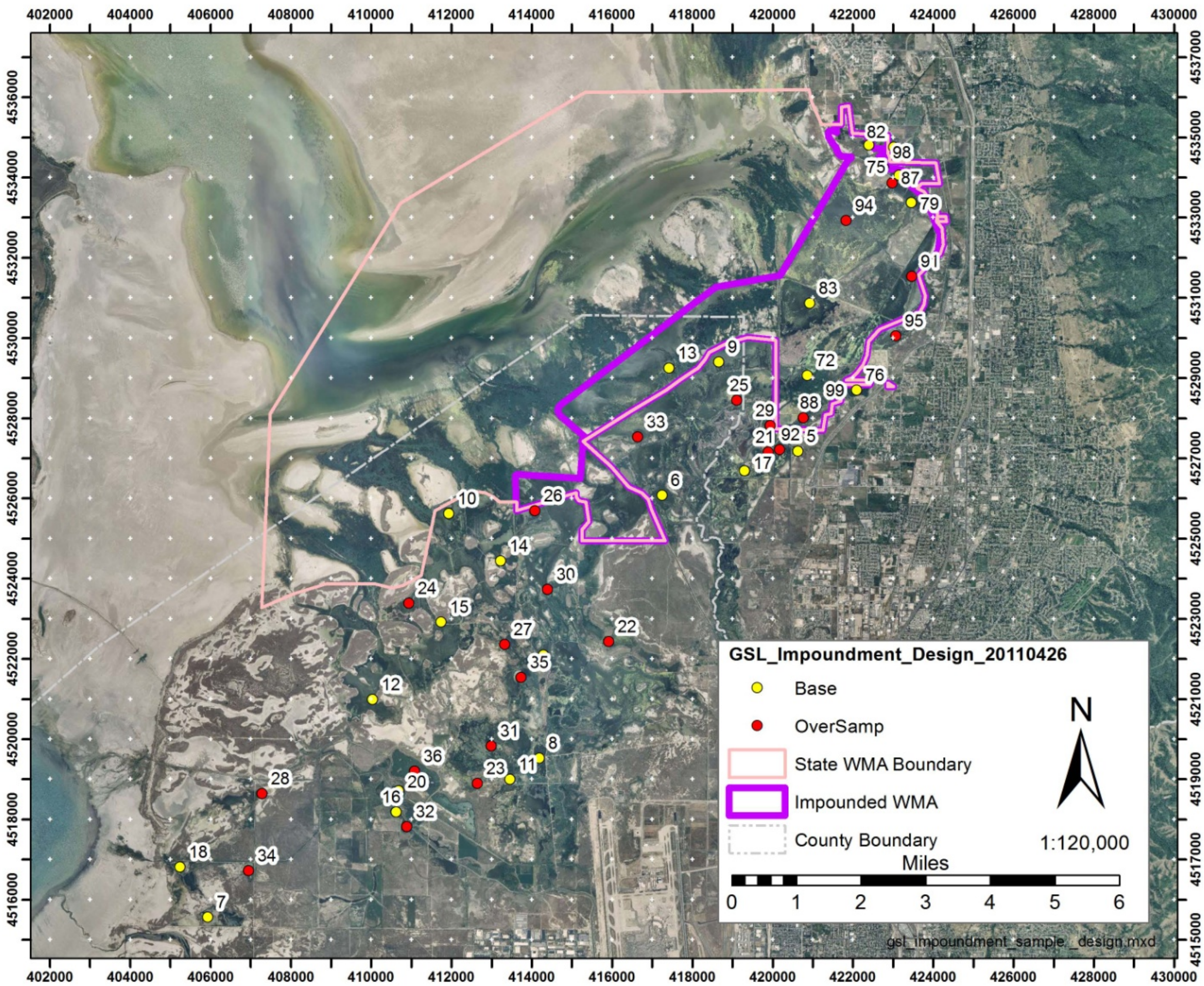
Map 2. Bear River Bay



Map 3. Ogden Bay



Map 4. Farmington Bay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OverSamp
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Impounded WMA
County Boundary
N
1:120,000
Miles
0 1 2 3 4 5 6
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