Final

2011 Sampling Plan

Development of Water Quality Standards for Willard Spur

April 2011

Prepared by

CH2MHILL

Acknowledgements

This sampling plan was developed in conjunction with staff from the Utah Department of Environmental Quality, Division of Water Quality.

The sampling plan would not have been possible without the vision, insight, direction, and contributions from members of the Willard Spur Steering Committee and stakeholders.

The following individuals contributed important insight and review comments that significantly improved the final document:

- Theron Miller, Ph.D., Wetlands Ecologist, Jordan River and Farmington Bay Water Quality Coalition
- John Isanhart, Ph.D., U.S. Fish & Wildlife Service
- Sharook Madon, Ph.D., Wetlands Ecologist, CH2M HILL

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Acronyms and Abbreviations

BRMBR	Bear River Migratory Bird Refuge
DQO	Data Quality Objective
DWQ	Utah Department of Environmental Quality, Division of Water Quality
DWR	Utah Department of Natural Resources, Division of Wildlife Resources
EPA	United States Environmental Protection Agency
GSL	Great Salt Lake
QA	Quality Assurance
QAPP	Quality Analysis Project Plan
QC	Quality Control
SAV	Submerged Aquatic Vegetation
UPDES	Utah Pollution Discharge Elimination System
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area

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1.0 Introduction

This Sampling Plan (Plan) was prepared by the Utah Department of Environmental Quality, Division of Water Quality (DWQ) at the request of the Willard Spur Steering Committee. This Plan provides for the collection of environmental samples for the purpose of establishing a 2011 baseline for the condition of Willard Spur (see Figure 1-1). This background information will be used by a proposed science panel to define research to be completed from 2012 to 2014.

1.1 Background

Construction of the Perry/Willard Regional Wastewater Treatment Plant (Plant) was completed in 2010. The DWQ received numerous comments as part of the public notice process for the Plant's Utah Pollution Discharge Elimination System (UPDES) discharge permit to Willard Spur. Many of these comments expressed concern over the potential impact the effluent could have on the water body and petitioned the DWQ to prohibit all wastewater discharges to Willard Spur or to alternatively reclassify Willard Spur to protect the wetlands and current uses of the water.

Although the Utah Water Quality Board denied the petition made, the Water Quality Board directed the DWQ to develop a study design to establish defensible protections (i.e., site-specific numeric criteria, antidegradation protection clauses, beneficial use changes, etc.) for the water body. The Water Quality Board also directed the DWQ to pay for phosphorus reductions at the Plant while the study is conducted. This path forward, developed in conjunction with stakeholders, allows the Plant to operate while the studies are underway, with reasonable assurances that the effluent will not harm the ecosystem.

1.2 Objectives

The objective of this Plan is to collect environmental data that accomplish the following:

1. Provide at least one data point describing the present characteristics of the effluent from the City of Willard's lagoon system, its outfall channel, and mixing zone in Willard Spur before the new Plant begins operation
2. Provide background information describing the overall condition and function of Willard Spur that can serve as the basis for a proposed science panel to make recommendations for the studies requested by the Water Quality Board

This Plan defines the data quality objectives, sampling and analytical procedures, safety considerations, and documentation and reporting requirements to be implemented by the DWQ for the collection of environmental samples (e.g., water, sediment, macroinvertebrates, etc.) in 2011 in Willard Spur. Further, this Plan identifies supplemental studies to be completed in 2011 to address the stated objective.

1.3 Site Description

Willard Spur is a unique and dynamic ecosystem located in the eastern part of the Bear River Bay of Great Salt Lake (GSL) (see Figure 1-1). Willard Spur encompasses over 11,780 hectares (ha) (equivalent to approximately 29,100 acres or almost 45.5 square miles) of wetlands with almost 20 percent of that area contained within the Bear River Migratory Bird Refuge (BRMBR). Its waters are generally bounded on the north by the southern dike of the BRMBR (also known as the D-line dike), on the east by the natural rise of topography, and on the south by the northern dikes of Willard Bay Reservoir, the Harold S. Crane Wildlife Management Area (WMA), and Great Salt Lake Minerals. The waters and mudflats of Bear River Bay stretch to the west of Willard Spur. The open waters of GSL are located south of Bear River Bay. This study will initially focus only on the open waters of Willard Spur as shown in Figure 1-1.

The unique habitat of Willard Spur varies dynamically throughout any given year and is directly linked to the hydrologic cycle of GSL's watershed. Willard Spur is where GSL's saline waters and freshwater entering from the Bear River and Weber River basins begin to mix when lake levels exceed 4200 feet (per bathymetry developed by Hansen and Associates in 2010). Freshwater entering Willard Spur from the Bear River and Weber River basins makes up over 40 percent of the annual inflow to GSL (Arnow and Stephens, 1987). When lake levels fall below an elevation of approximately 4200 feet, Willard Spur no longer mingles with GSL's saline waters, and its habitat is then controlled largely by the freshwater inflows. Great Salt Lake was last at an elevation of 4200 feet in August 2001; Willard Spur has since been transitioning into freshwater dominated wetlands (U.S. Geological Survey, National Water Information System. Accessed March 29, 2011, http://waterdata.usgs.gov/nwis). As inflows dissipate and water levels in Willard Spur drop, a natural rise in the lake bottom on the western boundary of Willard Spur (locally known as the "sandbar") disconnects the waters of Willard Spur from Bear River Bay and the waterbody becomes a natural impoundment. This can happen on an annual basis depending on available inflows.

While it is unknown whether a detailed classification of the wetlands habitat of Willard Spur has been completed, the United States Fish and Wildlife Service (USFWS) include five management categories for the Willard Spur wetlands within the boundaries of the BRMBR (USFWS, 2004). The areal extent of each of these categories is largely dependent on the hydrology in a given growing season:

- Deep submergent wetlands (18 to 24 inches of water dominated by sago pondweed [*Stuckenia pectinata*] with very little emergent vegetation).
- Shallow submergent wetlands (4 to 18 inches of water dominated by sago pondweed with sparse emergent vegetation).
- Middepth emergent wetlands (8 to 12 inches of water and 50 percent emergent vegetation with alkali bulrush [*Schoenoplectus maritimus*] largely in shallower areas and hardstem bulrush [*Schoenoplectus acutus*] in deeper areas, large stands of cattails [*Typha latifolia and T. angustifolia*] and phragmites [*Phragmites australis*] possible).

- Shallow emergent wetlands (2 to 8 inches of water predominantly alkali bulrush, some stands of cattails, and phragmites).

- Vegetated mudflats (0 to 2 inches of surface water during high-inflow periods or large precipitation events, highly saline soils, often unvegetated, can support shallow-rooted vegetation such as pickleweed [*Salicornia rubra* and *S. utahensis*], saltgrass [*Distichlis spicata*], and seepweed [*Suaeda calceoliformis* and *S. moquinii*]).

The varied habitat that Willard Spur provides is a haven for birds and fish; the immense populations of birds being perhaps what Willard Spur is most well known for. USFWS has documented over 210 bird species that regularly use the adjacent BRMBR, at least 67 of which nest in the area. The vegetation, macroinvertebrates, and fish the wetlands of BRMBR and Willard Spur provide are ideally suited for these migrating populations of waterfowl, shorebirds, and other waterbirds from the Pacific Flyway and Central Flyway. These waters, in conjunction with other waters of GSL, were recognized for their importance to shorebirds as a Western Hemisphere Shorebird Reserve Network Site in 1992 (USFWS, 2004).

The waters of Willard Spur have been protected for their beneficial uses through the use of numeric and narrative criteria (R317-2-7). The beneficial uses of Willard Spur vary depending upon location. Areas within the BRMBR are classified as 2B, 3B, and 3D while areas outside of BRMBR are classified as 5C and 5E. Table 1-1 provides a summary of the beneficial uses associated with these classes (R317-2-6).

Understanding the dynamics and complexity of the Willard Spur food web, how it interweaves with the varying and unique habitat and hydrology, and the role water quality serves as a critical linkage is a challenge that this study will begin to address.

TABLE 1-1
Water Classification and Beneficial Uses of Willard Spur

Classification	Beneficial Uses
2B—Recreation and Aesthetics	Infrequent primary contact recreation, secondary contact recreation
3B—Aquatic Wildlife	Warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain
3D—Aquatic Wildlife	Waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
5C—Bear River Bay	Infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain
5E—GSL Transitional Waters < 4,208 ft elevation	Infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain

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MAP SOURCE: GOOGLE EARTH PRO, JUNE 18, 2010.

\\snowbird\proj\NorthDavisCountySewe\341055\WillardSpur\Hydrology\WillardSpur Study Area_v2.ai APR-11 ckm

FIGURE 1-1
Map of Study Area and Vicinity

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2.0 Data Quality Objectives

The United States Environmental Protection Agency's (EPA's) seven-step data quality objective (DQO) process (EPA, 2006) is being used to guide the requirements and design rationale for Willard Spur sampling in 2011. The DQOs define the type, quantity, and quality of data and establish performance and acceptance criteria so that data collected support the goals of the study.

2.1 Problem Statement

2.1.1 Problem

There is very little existing environmental data that describe the hydrology, water quality, and environmental condition of Willard Spur. The only known samples of water and macroinvertebrates from Willard Spur were collected by the DWQ in August 2010. This created a critical need to collect data that could help describe the condition of Willard Spur before the proposed discharge began. This information will help inform future discussions regarding the presence and significance of impacts to Willard Spur from the proposed discharge. Further, the proposed approach for the Willard Spur research program entails collecting and providing a proposed and yet-to-be-formed science panel with background data from Willard Spur. This information will help the science panel define final research objectives and work plans and prioritize efforts. This dataset will ideally define conditions through the 2011 hydrologic cycle and will serve as the foundation for data to be collected by the research program in future years.

2.1.2 Project Team

Implementation of the Plan will require an interdisciplinary effort. The team consists of various members from the following:

- The DWQ (collection of water, sediment, diatom, and macro-invertebrate samples, flow, and vegetation monitoring)
- United States Geological Survey (USGS) (flow, water level, and meteorological monitoring)
- CH2M HILL (coordination)

2.1.3 Available Resources

The DWQ will use existing staff and resources to attempt to begin to collect samples in February 2011 and continue at a monthly interval. The DWQ will contract with the USGS to complete flow, water level, and meteorological monitoring for a period of at least 1 year. CH2M HILL will assist with sampling and flow monitoring design and coordinate the requisite agreements with various parties. Costs for 2011 will be covered under monies provided by the Water Quality Board.

2.1.4 Relevant Deadlines

It was critical that at least one sampling event be completed before the Plant began to discharge to characterize historical flows from the Willard City's wastewater lagoons and conditions in the outfall and its mixing zone in Willard Spur. After numerous attempts by DWQ to collect samples were impeded by ice and the lack of a boat, the Plant agreed to delay its discharge until March 7, 2011. DWQ was able to complete one sampling event on March 2, 2011. The Plant began its discharge on March 7, 2011. It should be noted that this sampling event was completed, before completion of this Plan.

This Plan, comprising the DWQ's strategy (i.e., methods, frequency, locations, etc.) for subsequent sampling events and monitoring, will be reviewed by independent experts (Theron Miller, PhD/Jordan River and Farmington Bay Water Quality Council, John Isanhart, PhD/USFWS, and Sharook Madon, PhD/CH2M HILL) before being reviewed for approval at the April 28, 2011, Steering Committee meeting.

Spring runoff typically begins in force in April. It is critical that flow monitoring equipment be installed to collect as much information as possible about spring runoff.

The proposed approach includes a mid-year report of analytical results to the science panel in August 2011 and an end-of-year report in February 2012.

2.2 Goal of the Study/Decision Statements

2.2.1 Objectives

The objective of this Plan is to collect environmental data that accomplish the following:

1. Provide at least one data point describing the present characteristics of the effluent from the City of Willard's lagoon system, its outfall channel, and mixing zone in Willard Spur before the new Plant begins operation

2. Provide background information describing the overall condition and function of Willard Spur that can serve as the basis for a proposed science panel to make recommendations for the studies requested by the Water Quality Board

2.2.2 Key Questions

The overall objective of the proposed Willard Spur research program is to answer the question posed by the Water Quality Board:

> *What water quality standards are appropriately protective of beneficial uses of Willard Spur waters as they relate to the proposed POTW discharge?*

There are many questions that will need to be answered to answer this question; most of which will be answered in during the research studies to be completed in the years 2012 through 2014. Flow monitoring and sampling efforts in 2011 will work toward gaining an understanding of and answering the following question:

> *What is the current condition of Willard Spur?*

Toward that end, this Plan identifies investigations that will begin to answer the following research questions:

1. What are the hydraulic/hydrologic characteristics of Willard Spur?
   1.1. Where are the inputs/outputs of flow and what is their timing?
   1.2. What is the annual hydrograph (mass balance) for water entering/leaving Willard Spur?
   1.3. How does the water surface elevation change in relation to inputs/outputs?
   1.4. How does the volume and residence time of water change in relation to inputs/outputs?
   1.5. Are wind seiche events a predominant feature in Willard Spur?
2. What are the sources of waterborne contaminants entering Willard Spur, and what is the relative significance of the various sources?
   2.1. What potential contaminants are of concern for Willard Spur (i.e., nutrients, selenium, mercury, etc.)?
   2.2. What are the contaminant concentrations and loads in water entering Willard Spur? In water leaving Willard Spur to Bear River Bay?
   2.3. What is the mass balance for contaminants in Willard Spur?
3. What are the relative concentrations of potential contaminants in water, sediment, and macroinvertebrates in Willard Spur?
   3.1. Do contaminant concentrations in Willard Spur change after the Plant begins operation in March 2011?
   3.2. How do concentrations vary spatially in comparison to sources of water?
   3.2.1. Where in Willard Spur are sediments deposited?
   3.3. How do concentrations vary throughout the year for different seasons/hydroperiods?
   3.4. What is the relative contribution of nutrients to the water column (i.e., between nonpoint sources, point sources and sediment fluxes)? Does the sediment surface currently reach anaerobic conditions?
   3.5. How do concentrations vary per other collocated variables sampled?
4. What are the current vegetation, macroinvertebrate, phytoplankton compositions in Willard Spur?
   4.1. How predominant are invasive species (i.e., phragmites) in Willard Spur? Where are they located and to what extent? What drives the distribution of phragmites? (i.e. water or sediment salinity, duration of sediment inundation/saturation, concentrations of water or sediment nutrient concentrations, etc.)
   4.2. How do water column and sediment nutrient concentrations affect algal mat, submerged aquatic vegetation (SAV), and macroinvertebrate population characteristics (i.e., densities, distribution, etc.)?

5. What are the current bird and fish compositions in Willard Spur?
    5.1. What species of birds and fish currently rely upon Willard Spur? What are their population numbers?
    5.2. What habitat do these birds and fish rely upon? What is the timing of their use?

It is assumed that results will only be reflective of conditions in 2011. It is presumed that 2011 will represent an extremely wet hydrologic cycle where Willard Spur will experience high flow rates and be directly connected to Bear River Bay much of the year.

2.2.3 Possible Outcomes

1. Successfully collect all required samples, monitor flow at all locations, and measure water level and meteorological changes at least at one location.
2. Initial reconnaissance and sampling results result in modification to the sampling/monitoring plan.
3. Weather conditions (i.e., ice and electrical storms) or property access limitations preclude or limit the ability to collect samples.
4. Resources (i.e., boats, equipment, staff, contracts, and funding) are not available or in place to complete required sampling, monitoring, and analysis.
5. Information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur. The science panel will evaluate results and provide recommendations for the Willard Spur Research Program.
6. Information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have no measurable adverse effect on beneficial uses of Willard Spur. The science panel will evaluate results and provide a recommendation as to whether the Willard Spur Research Program should continue and if so, how?
7. Information is not adequate to quantify the condition of Willard Spur or to determine whether current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur. The science panel will evaluate results and provide recommendations for the Willard Spur Research Program.

2.3 Inputs to the Decision

2.3.1 Informational Inputs

Pre-discharge Condition

Water and sediment samples will be collected from up to 10 locations near the existing Willard City wastewater lagoon discharge point before the new Plant begins its proposed discharge.

Seasonal Conditions

1. Flow rates will be monitored on a continuous basis (34 sites), and water samples will be collected on a minimum monthly basis from inflow points to Willard Spur (45 sites). Water samples will be collected biweekly during spring runoff at high-priority inflow sites (7 sites).
2. Water samples will be collected on a monthly basis along and near the existing Plant outfall channel and mixing zone (6 sites). Macroinvertebrates will be sampled once at these sites.
3. Water samples will be collected on a monthly basis along a transect extending the length of Willard Spur (12 sites). Macroinvertebrates will be sampled once at 12 of these sites plus an additional open water site near the Plant outfall. Additional water samples will be collected to either side of this transect during a one-time sampling event (22 additional sites).
4. Samples of phytoplankton and zooplankton will be collected monthly along the outfall and the transect extending the length of Willard Spur (14 sites).
5. Sediment samples will be collected in summer and fall near the Plant outfall and mixing zone and along a transect extending the length of Willard Spur (14 [fall], 16 [summer]). These samples will be analyzed for diatoms and chemistry, respectively. Diatoms will be evaluated as they are common measures of the biological integrity of a wetlands ecosystem.
6. Vegetation (SAV and emergent vegetation) will be characterized on a monthly basis along a transect extending the length of Willard Spur (14 sites).
7. Fish abundance will be characterized and samples will be collected during a one-time event along a transect extending the length of Willard Spur (6 sites). This sampling event will be coordinated with the sampling of water and macroinvertebrates at the same time so that water, fish, and macroinvertebrates may be analyzed for selenium and mercury. Both selenium and mercury have been identified as contaminants of concern elsewhere in GSL, thus this information will help establish a baseline for Willard Spur.
8. General observations of bird use will be made while collecting all samples.
9. Standard suites of field measurements and analytical suites will be completed to characterize the chemistry of mediums sampled.

Hydrology/Hydraulic Characteristics

Five continuous flow gauges will be installed and operated by the USGS for a period of at least 1 year. These sites are considered the most critical in representing the hydrology of Willard Spur. The DWQ will install up to 11 additional flow gauges at secondary locations to augment primary sites. The water surface elevation and local meteorological conditions will be monitored by the USGS at one site in Willard Spur. The DWQ will additionally attempt to monitor the water surface elevation at two additional sites on Willard Spur to characterize seiche events. The DWQ will measure the outflow from Willard Spur on three occasions. Two measurements of the residence time of water in Willard Spur will be completed by the DWQ.

2.3.2 Variables/Characteristics to Be Measured

1. Flow rates (cubic feet per second) at inflow and outflow points
2. Water surface elevation (feet) of Willard Spur pool
3. Meteorological conditions at Willard Spur (short- and long-wave radiation, temperature, humidity, wind, precipitation, and barometric pressure)
4. Residence time (hours) of flow in Willard Spur
5. Water chemistry
6. Chemistry and diatom characterization of sediments
7. Diversity, numbers, and contaminant concentrations of macroinvertebrates
8. Diversity and numbers of phytoplankton and zooplankton
9. Numbers and contaminant concentrations of fish
10. Percent cover of SAV and emergent vegetation
11. General bird use

2.4 Study Boundaries

The study area, shown in Figure 1-1, includes the wetlands, open waters, and drainage of Willard Spur as bounded by dikes/berms of the BRMBR, Harold S. Crane WMA, Willard Bay Reservoir, and GSLM, the natural "weir" (a.k.a., sand bar) separating Willard Spur from Bear River Bay on the west and Interstate 15 on the east.

2.4.1 Temporal

Hydrology will be monitored for a minimum of 1 year. Environmental samples will be collected, and supplemental studies will be completed throughout 2011. A report summarizing early results from 2011 should be prepared by August 2011 and a final report including all data finalized before the end of February 2012.

2.4.2 Practical Constraints on Data Collection

1. Property access agreements will need to be negotiated and confirmed.
2. Availability of boats and other field equipment, as well as equipment functionality, may limit some activities.
3. Staff and funding availability will need to be confirmed.
4. Weather is a major constraint for all sampling and monitoring activities, because storms can limit the ability to safely conduct sampling and measurement activities at the study area.
5. The presence of ice and/or lack of water could limit the ability to collect samples.

2.5 Decision Rules

1. If information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur, then the science panel will provide recommendations for the Willard Spur Research Program.
2. If information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have no measurable adverse effect on beneficial uses of Willard Spur, then the science panel will evaluate results and provide a recommendation as to whether the Willard Spur Research Program should continue and, if so, how?
3. If information is not adequate to quantify the condition of Willard Spur or to determine whether current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur, then the science panel will evaluate results and provide recommendations for the Willard Spur Research Program.

2.6 Tolerable Limits on Decision Rules

Tolerance limits for laboratory analysis data quality are defined in the Quality Analysis Project Plan (QAPP) (See Appendix B), in terms of acceptability criteria. The QAPP defines procedures that specify all quality assurance (QA)/quality control (QC) objectives for sample measurement based on each matrix.

The science panel, to be formed in late 2011, will provide the Steering Committee and the DWQ with its recommendation regarding the suitability and adequacy of the available information with regard to the decision rules. The Water Quality Board will make the final decision of whether and how the Willard Spur Research Program should continue.

2.7 Optimization of the Sampling Design

After detailed consideration of reasonable alternatives and given current scheduling constraints, the following design is the most resource effective:

1. Use available and trained DWQ personnel to collect environmental samples and complete the special and supplemental studies.
2. Use established, existing, and local sampling infrastructure (sampling equipment, sampling protocol, vehicles, and laboratories) to execute the sampling plan.
3. Use USFWS boats and personnel to access sampling locations at open water sites, with the DWQ to purchase an airboat to facilitate long-term collection of samples at Great Salt Lake wetlands.
4. Collaborate with USFWS and Utah Department of Natural Resources, Division of Wildlife Resources (DWR) researchers where possible.
5. Use trained USGS stream gauging technicians that are locally available for gauge installation and gauge servicing.

6. Use established USGS methods, discharge equipment, and software for gauge operation, data transmission, and data archiving.
7. Use existing technical, database, and publication resources for data QA/QC, data archiving, and publication and distribution of results to interested parties.

It is assumed that these DQOs and all sampling, gauging, analytical, and QA/QC methods will be reviewed on an ongoing basis, discussed with representatives of the Steering Committee, revised as required, and eventually accepted by the science panel before the data are used for decision rules or publication.

3.0 Sampling Work Plan

A draft copy of the DQOs presented in Section 2.0 was circulated among stakeholders and the Willard Spur Steering Committee at the February 28, 2011, Steering Committee meeting. Input on the DQOs was received, discussed, and further developed into concepts with stakeholders. This section summarizes a sampling work plan that incorporates these concepts to achieve the objectives of the DQOs for this study. Work to be completed as part of this study in 2011 can be characterized into three categories:

1. Environmental sample collection: These activities will work toward understanding the temporal and spatial condition of Willard Spur.
2. Special studies: These are studies that will be completed to address specific questions that are critical to meeting the objectives of this Plan.
3. Supplemental studies (i.e., studies that should be completed to meet objectives if resources are available)

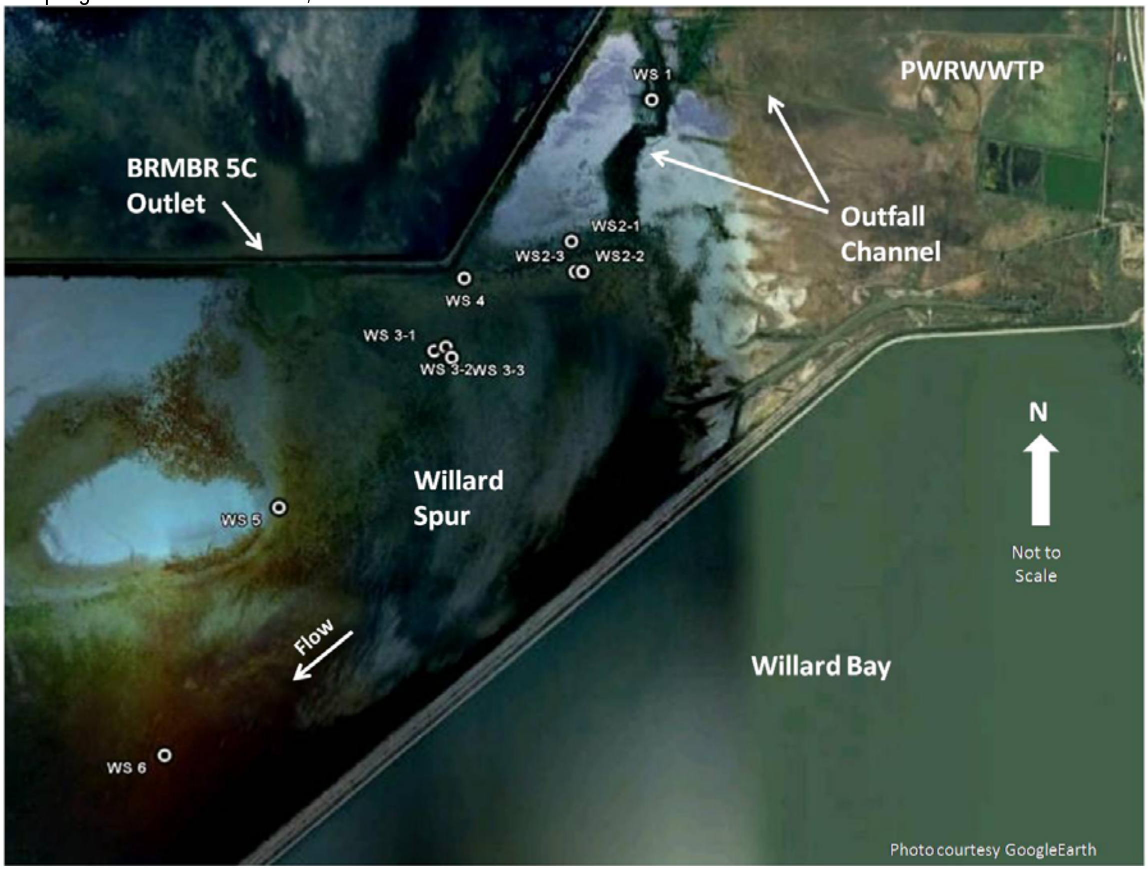
3.1 Environmental Sample Collection

The majority of the DWQ's resources for this effort will be dedicated to collecting environmental samples that describe conditions at inflow and outflow points of Willard Spur as well as within the open waters of Willard Spur. This data will be critical in benchmarking the present condition and understanding what studies may be required to meet the Water Quality Board's objectives for Willard Spur. This section provides a summary of the approach the DWQ will use for sampling in 2011.

3.1.1 Pre-discharge Condition at Existing Outfall

The DWQ completed a sampling event on March 2, 2011, to characterize the condition of the Plant outfall channel, mixing zone, and open waters of Willard Spur before the new facilities begin operation. The new Plant began discharging on March 7, 2011. Water and sediment samples were collected at 10 locations, as shown in Figure 3-1. Further collections along the length of Willard Spur to the west were not possible due to ice. Macroinvertebrates were not observed during the sampling event likely due to winter conditions. Analytical results from this sampling event will be summarized when available and reported to the Steering Committee in a brief technical memorandum.

FIGURE 3-1
Sampling Locations on March 2, 2011



3.1.2 Sampling of Inflows

An initial review of historical aerial photography identified almost 50 possible locations where water flows into Willard Spur from three different areas. These included points from the BRMBR, the east side drainage area, and the WMA area (see Figure 3-2). Discussions with people familiar with drainage in these areas and field visits to these areas narrowed the number of inflow sources to 32 sites (see Section 3.2.1 for further discussion of inflow points). Table 3-1 summarizes the chemical parameters that all water samples will be analyzed for. Table 3-2 provides a summary of site locations and activities to be completed at those locations. Figure 3-3 illustrates these locations throughout Willard Spur. Figure 3-4 provides a larger scale illustration of sampling locations in the East Drainage Area. Appendix A provides a summary of discussions with the DWR to identify a proposed plan for monitoring flows and collecting water samples from the WMA drainage area. Appendix A also includes a figure illustrating sampling locations at the WMA. Sampling procedures, analytical methods, and quality assurance requirements are found in the QAPP in Appendix B.

FIGURE 3-2
Drainage Areas of Willard Spur

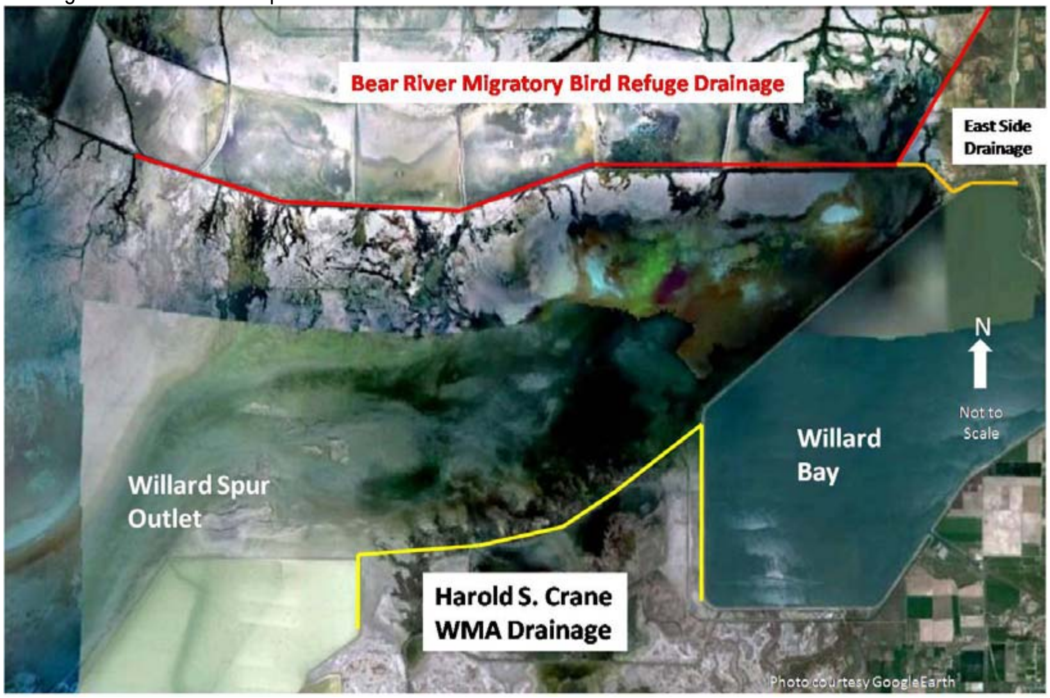


TABLE 3-1
Water Chemistry Parameters

Description	Parameters
Field Parameters	Temperature, specific conductance, pH, dissolved oxygen, turbidity, secchi depth
Biochemical Oxygen Demand (BOD)	Carbonaceous BOD
Total (Nonfiltered) Nutrients	Ammonia, Nitrate/Nitrite, Total Phosphorus, TKN
Dissolved (Filtered) Nutrients	Nitrate/Nitrite, Total Phosphorus, TKN or ON
General Chemistry	Carbonate, bicarbonate, carbon dioxide, hydroxide, chloride, sulfate, alkalinity, turbidity, specific conductance, total suspended solids, carbonate solids
Total (Nonfiltered) Metals	Total Selenium, Total Mercury
Dissolved (filtered) Metals	Aluminum, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, and potassium
Other	Total Suspended Solids, chlorophyll-a, ash-free dry mass, volatile organic compounds

NOTES:
ON = organic nitrogen
TKN = total Kjeldahl nitrogen

FIGURE 3-3
Proposed Sampling and Monitoring Sites

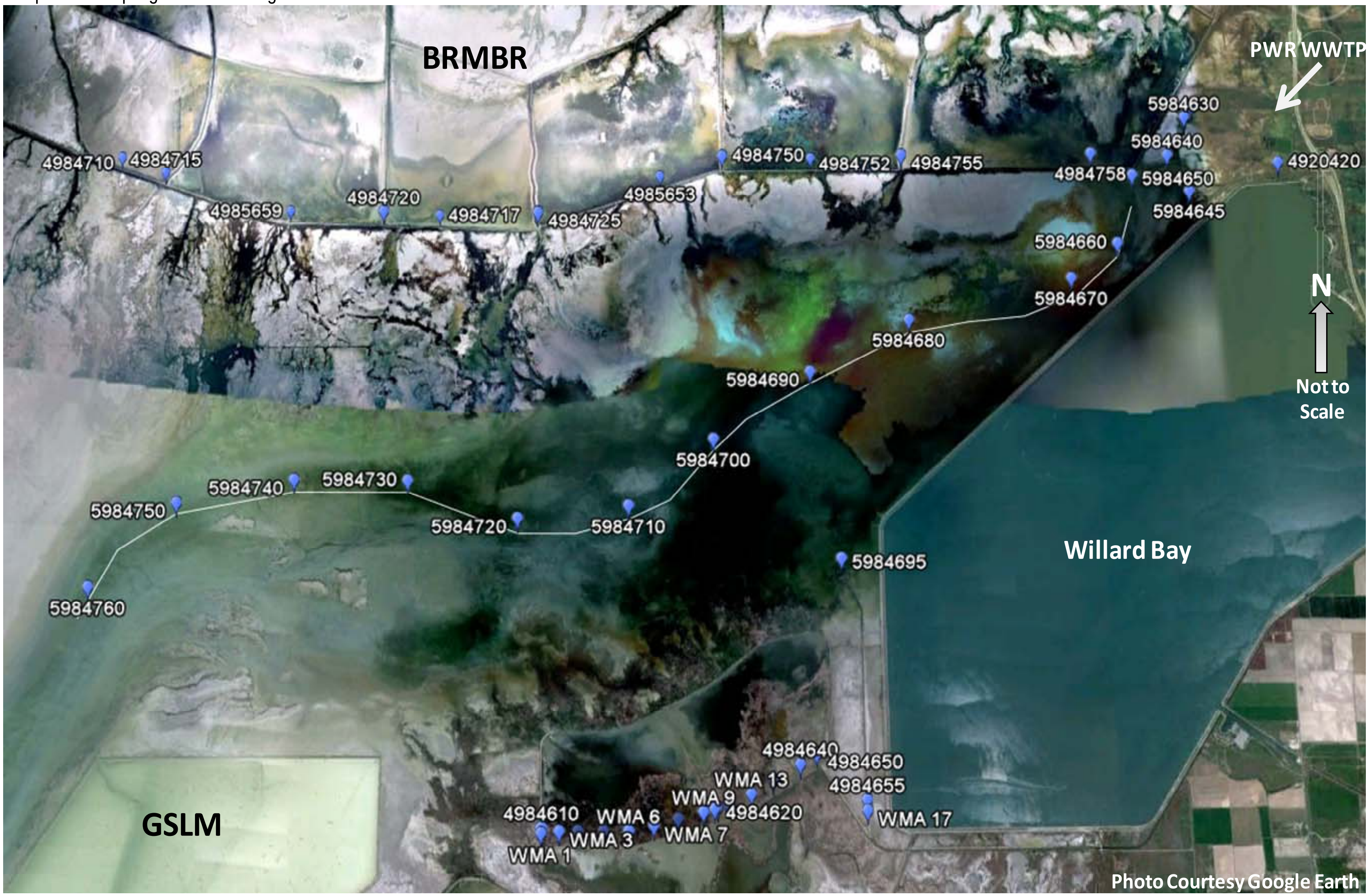


FIGURE 3-4
Proposed Sampling and Monitoring Sites in East Drainage Area

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TABLE 3-2
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling		Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No.	ID	Inflow Site or Open Water (OW) Site	Description	Latitude	Longitude	Continuous	Three events	Biweekly in April, May, June	Monthly	Two Composite Sampling Events	One-time grab sample[1]	One-time Event (summer – diatoms, chemistry)[1]	One-time Event (August - chemistry)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	One-time Event[1]
Bear River Migratory Bird Refuge																				
1	4984710	Inflow	Bear River Bird Refuge BRR 1	41°25'25.17"N	112°15'51.60"W	X			X											
2	4984715	Inflow	Bear River Bird Refuge BRR 2	41°25'18.07"N	112°15'23.70"W	X			X											
3	4985659	Inflow	Bear River Bird Refuge BRR 3	41°24'59.69"N	112°14'3.98"W	X			X											
4	4984720	Inflow	Bear River Bird Refuge BRR 4	41°24'58.10"N	112°13'5.50"W	X		X	X											
5	4984717	Inflow	Bear River Bird Refuge BRR 5	41°24'57.22"N	112°12'30.16"W	X			X											
6	4984725	Inflow	Bear River Bird Refuge BRR 6	41°24'56.90"N	112°11'28.60"W	X		X	X											
7	4985653	Inflow	Bear River Bird Refuge BRR 7	41°25'14.46"N	112°10'11.75"W	X			X											
8	4984750	Inflow	Bear River Bird Refuge BRR 8	41°25'22.49"N	112° 9'32.59"W	X		X	X											
9	4984752	Inflow	Bear River Bird Refuge BRR 9	41°25'22.30"N	112° 8'36.70"W	X			X											
10	4984755	Inflow	Bear River Bird Refuge BRR 10	41°25'22.30"N	112° 7'39.50"W	X		X	X											
11	4984758	Inflow	Bear River Bird Refuge BRR 11	41°25'22.41"N	112° 5'39.50"W	X		X	X											
East Side Drainage																				
12	4984760	Inflow	Irrigation Return Flow 1	41°25'45.1"N	112°04'34.8"W	X		X	X					X						
13	4984762	Inflow	Willard Perry Outfall	41°25'43.7"N	112° 4'34.1"W	X		X	X	X				X						
14	DWQWS1	Inflow	Outfall/NPS Channel	41°25'39.12"N	112° 4'39.03"W				X			X		X						
15	4920420	Inflow	Willard Bay Res N Outlet	41°25'17.40"N	112° 3'41.52"W				X			X		X						
16	ES7	OW	Outfall Confluence	41 25 21.36 N	112 4 51.12 W				X			X		X		X		X		X
Harold C. Crane Wildlife Management Area																				
17	WMA 1	Inflow	Weir	41°20' 25.8"N	112°11' 23.9"W	X			X											
18	4984610	Inflow	WMA 2 Weir	41°20'26.2"N	112°11'23.8"W	X			X											
19	WMA 3	Inflow	Weir	41°20' 26.2"N	112°11'13.3"W	X			X											
20	WMA 4	Inflow	Weir	41°20' 26.2"N	112°11'02.2"W	X			X											

TABLE 3-2
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling		Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No.	ID	Inflow Site or Open Water (OW) Site	Description	Latitude	Longitude	Continuous	Three events	Biweekly in April, May, June	Monthly	Two Composite Sampling Events	One-time grab sample[1]	One-time Event (summer – diatoms, chemistry)[1]	One-time Event (August - chemistry)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	One-time Event[1]
21	WMA 5	Inflow	Weir	41°20'26.2"N	112° 10'47.1"W	X			X											
22	WMA6	Inflow	Weir	41°20' 26.2"N	112°10'32.2"W	X			X											
23	WMA7	Inflow	Weir	**41°20'28.3"N**	**112°10'17.3"W**	**X**			**X**											
24	WMA8	Inflow	Weir	**41°20'31.1"N**	**112°10'03.0"W**	**X**			**X**											
25	WMA9	Inflow	Weir	**41°20'33.8"N**	**112°09'47.9"W**	**X**			**X**											
26	4984620	Inflow	WMA 10 Weir	**41°20'35.1"N**	**112°09'41.3"W**	**X**			**X**											
27	4984630	Inflow	WMA 11 Weir	**41°20'35.5"N**	**112°09'39.5"W**	**X**			**X**											
28	WMA12	Inflow	Weir	**41°20' 36.6" N**	**112°09' 33.4"W**	**X**			**X**											
29	WMA13	Inflow	Weir	**41°20' 41.0" N**	**112°09' 19.4"W**	**X**			**X**											
30	WMA14	Inflow	Weir	**41°20' 46.5" N**	**112°09' 06.5"W**	**X**			**X**											
31	4984640	Inflow	WMA 15 Weir	**41°20'53.3"N**	**112°08'50.2"W**	**X**			**X**											
32	4984650	Inflow	WMA 16 Weir	**41°20'57.79"N**	**112°08'40.37"W**	**X**			**X**											
35	4984655	Inflow	WMA Bypass	**41°20'38.2"N**	**112° 8'11.1"W**	**X**			**X**	**X**										
36	WMA18	Inflow	Water level in pond			**X**														
Willard Spur																				
33	WSLVL1		Lake stage (USGS)			**X**														
34	WSLVL2		Lake stage/MET (USGS)			**X**														
35	WSLVL3		Lake stage			**X**														
36	5984645	OW	Outside Willard Bay Tailrace	**41°25'04.52"N**	**112° 4'38.48"W**				**X**			**X**		**X**		**X**		**X**		
37	5984650	OW	WS1 Mile 1	**41°25'12.06"N**	**112° 5'13.98"W**				**X**			**X**		**X**		**X**		**X**		**X**
38	WS1a	OW									**X**		**X**		**X**		**X**		**X**	
39	WS1b	OW									**X**		**X**		**X**		**X**		**X**	
40	5984660	OW	WS2 Mile 2	**41°24'40.57"N**	**112° 5'25.45"W**				**X**			**X**		**X**		**X**		**X**		

TABLE 3-2
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling		Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No.	ID	Inflow Site or Open Water (OW) Site	Description	Latitude	Longitude	Continuous	Three events	Biweekly in April, May, June	Monthly	Two Composite Sampling Events	One-time grab sample[1]	One-time Event (summer – diatoms, chemistry)[1]	One-time Event (August - chemistry)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	One-time Event[1]
41	WS2a	OW									**X**		**X**							
42	WS2b	OW									**X**		**X**							
43	5984670	OW	WS3 Mile 3	41°24'24.66"N	112° 5'55.44"W				X			X		X		X		X		X
44	WS3a	OW									X		X		X		X		X	
45	WS3b	OW									X		X		X		X		X	
46	5984680	OW	WS4 Mile 4	41°24'06.15"N	112° 7'37.72"W				X			X		X		X		X		
47	WS4a	OW									X								X	
48	WS4b	OW									X								X	
49	5984695	OW	Outside Harold Crane WMA Drainage Ditch	41°22'20.51"N	112° 8'22.92"W				X			X		X		X		X		
50	5984690	OW	WS5 Mile 5	41°23'43.01"N	112° 8'39.71"W				X			X		X		X		X		X
51	WS5a	OW									X		X		X		X		X	
52	WS5b	OW									X		X		X		X		X	
53	5984700	OW	WS6 Mile 6	41°23'13.38"N	112° 9'39.80"W				X			X		X		X		X		
54	WS6a	OW									X								X	
55	WS6b	OW									X								X	
56	5984710	OW	WS7 Mile 7	41°22'44.31"N	112°10'31.98"W				X			X		X		X		X		X
57	WS7a	OW									X		X		X		X		X	
58	WS7b	OW									X		X		X		X		X	
59	5984720	OW	WS8 Mile 8	41°22'39.17"N	112°11'39.58"W				X			X		X		X		X		
60	WS8a	OW									X								X	
61	WS8b	OW									X								X	
62	5984730	OW	WS9 Mile 9	41°22'56.02"N	112°12'46.86"W				X			X		X		X		X		X
63	WS9a	OW									X		X		X		X		X	

TABLE 3-2
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling		Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No.	ID	Inflow Site or Open Water (OW) Site	Description	Latitude	Longitude	Continuous	Three events	Biweekly in April, May, June	Monthly	Two Composite Sampling Events	One-time grab sample[1]	One-time Event (summer – diatoms, chemistry)[1]	One-time Event (August - chemistry)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	Monthly	One-time Event (August)[1]	One-time Event[1]
64	WS9b	OW									X		X		X		X		X	
65	5984740	OW	WS10 Mile 10	41°22’56.78"N	112°13’56.36”W				X			X		X		X		X		
66	WS10a	OW									X								X	
67	WS10b	OW									X								X	
68	5984750	OW	WS11 Mile 11 (Outlet)	41°22’47.10"N	112°15’07.71”W		X		X			X		X		X		X		
69	WS11a	OW									X		X		X		X		X	
70	WS11b	OW									X		X		X		X		X	
71	5984760	OW	WS12 Mile 12	41°22’10.66"N	112°15’59.07”W															

NOTES:
[1]Samples collected at same time as routine monthly samples.

Water samples will be collected at a minimum monthly interval at all inflow locations identified in Table 3-2 (34 sites). Biweekly water samples will be collected at the five primary discharge sites from the BRMBR and three locations in the Plant outfall area to improve estimates of loading during the spring runoff. The DWQ will mobilize a composite sampler at the new Plant outfall on two occasions to characterize how water quality varies at this location.

Sediment and macroinvertebrates will be collected in the east drainage area at the locations and intervals summarized in Table 3-2.

Inflow from the WMA is largely dominated by local spring runoff and stormwater runoff and can be very dynamic. Further, challenges in accessing the WMA's north dike make it extremely difficult to routinely monitor flows and sample water where water directly enters Willard Spur from the WMA through the north dike. The DWQ will instead monitor flows and collect water samples at the south dike of the Main Unit of the WMA where access and collaboration with DWR is more feasible (see Figure 3-3 and Appendix A for locations). The DWQ will also collect water samples at the north dike (23 sites) on two occasions that coincide with the routine collection of water samples at the south dike. This will allow for a comparison of the quality of water entering the WMA's Main Unit through the south dike and leaving the Main Unit through the north dike before entering Willard Spur. The DWQ will also mobilize composite samplers at the WMA on two occasions to characterize how water quality varies with episodic storm events.

3.1.3 Sampling of Conditions within Open Waters of Willard Spur

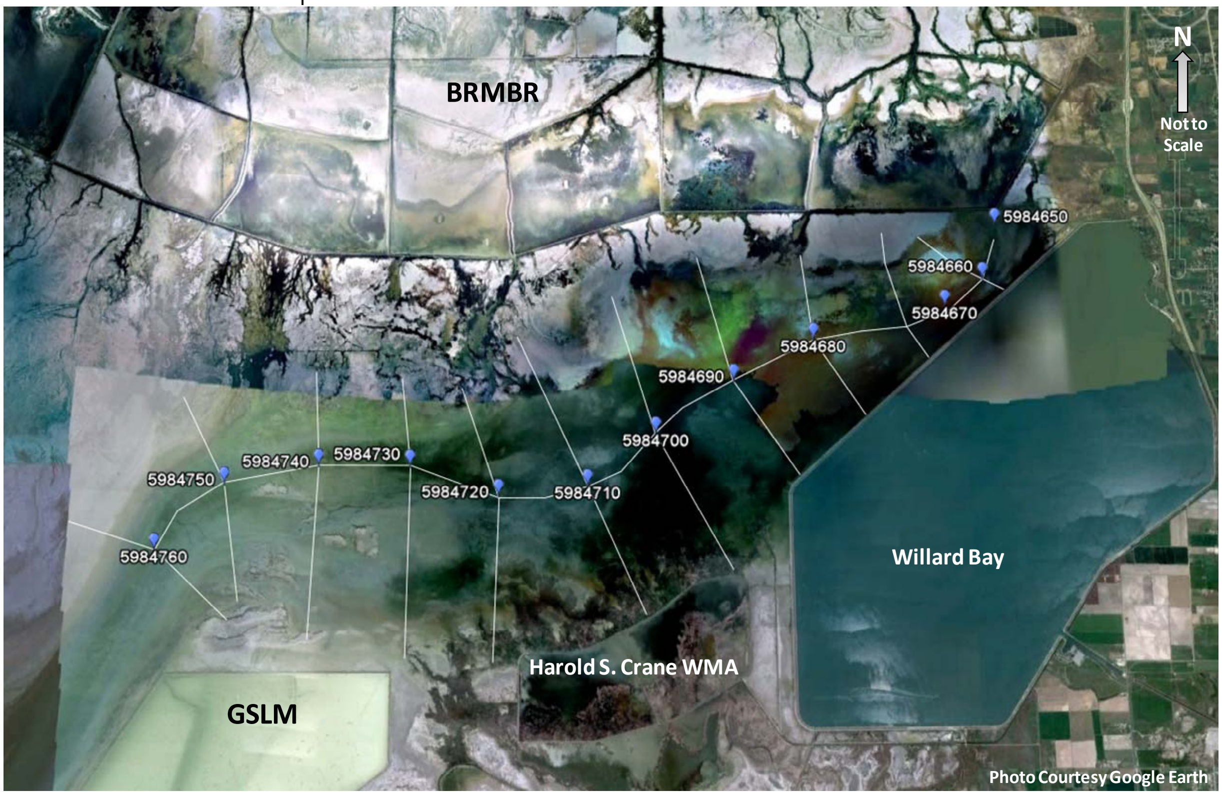
Sampling sites within Willard Spur will be located at 1-mile intervals along a longitudinal transect that extends the length of Willard Spur. This transect was defined by a review of available historical aerial photography to identify the likely primary flow path through Willard Spur for a wide range of flow conditions (see Figure 3-5). One additional open water site is located approximately 200 feet away from the confluence of the Plant's outfall and the open water of Willard Spur.

Sampling and characterization of water, sediment, macroinvertebrates, phytoplankton, zooplankton, vegetation and fish will be completed at the open water locations and intervals indicated in Table 3-2. The DWQ will also document observations of water depth and discernable flow direction, presence of birds at sampling site, light penetration (turbidity and secchi depth), and presence of algal mats whenever samples are collected in the open water. Sampling procedures, analytical methods, and quality assurance requirements are found in the QAPP in Appendix B.

Water samples will be collected in a one-time sampling event from an additional 22 sites throughout the open waters of Willard Spur. These sites will be located to either side of the longitudinal transect along the length of Willard Spur. Additional transects were defined that are perpendicular to and cross the longitudinal transect at the 11 sampling sites (see Figure 3-5). Water samples will be collected at points halfway between the longitudinal transects and edge of water along these secondary transects.

The DWQ will deploy sondes at least once along the longitudinal transect (11 sites) to record diurnal variations in temperature, pH, specific conductance, and dissolved oxygen in the open waters of Willard Spur.

FIGURE 3-5
Transect Locations in Willard Spur



3.2 Special Studies

The DQOs include a number of questions that build on and extend beyond the understanding that environmental samples can provide. This section summarizes studies that will be completed in 2011 to augment the environmental sample collection efforts described in the previous section and meet the objectives described in the DQOs.

3.2.1 Hydrology Study

The objective of the hydrologic study is to better understand the sources and timing of how water is conveyed into and through the water body. This study will identify where the sources of inflow are located, estimate the timing and volume of inflow and outflow of Willard Spur, and evaluate how the volume (i.e., water level and areal extent of water surface) and residence time of water in Willard Spur respond to these characteristics. It is likely that much of this data will be used as the basis of a future hydrodynamic model of Willard Spur that could be used to better understand the assimilation of possible contaminants in the water body.

Early indications of snow accumulated in the watershed during the 2010–2011 winter as well as underlying hydrologic conditions point toward 2011 being a year with significant flows entering Willard Spur. It is recognized that these flows may or may not be representative of a "typical" hydrologic cycle for this watershed. A working hypothesis is that high runoff year will dilute and flush contaminants in the water column out of Willard

Spur (better case scenario) versus a low runoff year will cause possible contaminants to concentrate and stay within Willard Spur (worst case scenario). The objective for this year is to understand the condition in 2011 so as to better inform studies to be completed in subsequent years.

The hydrologic study will focus on collecting data in three areas:

- Measurement of flows
- Water level measurement
- Meteorological monitoring

Measurement of Flows

The project team completed initial reconnaissance of the study area in late February to identify potential points of inflow to Willard Spur. Reconnaissance activities included an evaluation of available historical aerial photography, field visits, and meetings with agency personnel responsible for managing the surrounding wildlife management areas.

While continuous measurement of every inflow point is not feasible, a significant effort will be undertaken to characterize the timing and volume of the vast majority of the surface water inflows. There are three basins contributing surface water to Willard Spur: the Bear River basin to the north (i.e., BRMBR drainage), the east side drainage, and the Weber River basin to the south (WMA drainage) (see Figure 3-2). This study does not address groundwater inflows or outflows. Groundwater hydrology may be addressed by the science panel at a later time.

Bear River Basin. There are 11 possible inflow points contributing surface water from the Bear River into Willard Spur through the BRMBR. The USGS met with the USFWS to identify the 5 points contributing the most significant quantities of inflow (see Table 3-2). The USGS will install a gauging station at each of these 5 points. Each of these stations will include telemetry that will allow remote monitoring of data and equipment performance to minimize the risk of loss of flow data at these critical points. The DWQ will install a gauging station at each of the remaining six points. These six gage stations will not include telemetry and will be visited on a monthly basis to confirm operation and download data. Standard operating procedures for these gauging stations will follow the methods as described in Cartern and Davidian (1968) and Buchanan and Somers (1968, 1969). Assuming these gauge stations operate as intended, they will provide near-continuous monitoring of surface water inflows to Willard Spur.

East Drainage Area. The drainage area contributing surface water to Willard Spur from the east is largely dominated by local runoff and irrigation return flows and includes flows from the Perry/Willard Regional Wastewater Treatment Plant (see Figure 3-2). The DWQ will install three gauging stations to measure inflows from the three primary ditches contributing flows to Willard Spur. Potential inflows from Willard Bay via the tailrace will be estimated from Weber Basin Water Conservancy District’s records.

Weber River Basin. The majority of surface water entering Willard Spur from the Weber River basin enters through the Harold S. Crane Wildlife Management Area, an area located between Willard Bay and Great Salt Lake Minerals (see Figure 3-2). Much of this flow represents urban runoff and irrigation return flows. There are a number of challenges to measuring and sampling these inflows, including access and dynamic flow conditions. These challenges are discussed in detail in Appendix A.

The proposed plan is to install a water level sensor in the large wetland pool south of the WMA's Main Unit's south dike. By developing a rating curve for each of the 16 weirs in the south dike that describes their flow characteristics and coupling that with near-continuous water level measurements, the DWQ will be able to characterize the dynamics of water flowing into the WMA. These flows will be assumed to be representative of flows entering Willard Spur. The DWQ will likewise install a gauging station on the Bypass Drain east of the WMA to measure flow through this ditch to Willard Spur. It is acknowledged that groundwater inflow, precipitation, and evaporation will have some effect on the actual flow from the WMA to Willard Spur, but it is assumed that this will be negligible.

Outflow. Surface water flowing out of Willard Spur into Bear River Bay flows over a wide expanse locally known as the "sand bar." Continuous measurement of outflow through this area is not considered feasible at this time. The DWQ will measure flow depth and velocity at discrete locations along the width of the outflow and integrate these values to estimate the flow rate two to three times during 2011.

Water Level Measurement

The dynamics of how Willard Spur responds to inflows is important to understanding the areal extent of the water body and its habitat. Three lake stage sensors will be installed in Willard Spur to understand how the water body responds to inflows and wind events. The USGS will install one lake stage sensor that will be equipped with telemetry to allow for remote monitoring of data and equipment performance. The DWQ will install two lake stage sensors, one on each end of Willard Spur, to better understand how wind events affect the movement of water within the water body and how that affects the areal extent of water within Willard Spur.

Meteorological Monitoring. Understanding local weather conditions is essential to understanding evaporative losses, precipitation inflows, effects of wind on water movement, and how weather may impact water quality conditions. The USGS will install a meteorological station on its lake stage platform to measure short and long-wave radiation, temperature, humidity, wind, precipitation, and barometric pressure.

3.2.2 Sediment Accretion Study

Understanding the chemical composition of sediment, where it is deposited, and at what rate will help us understand nutrient assimilation within Willard Spur. This is a long term study that involves minimal effort in 2011. The objective is to determine sediment accretion rates for various areas of Willard Spur.

The DWQ will establish a marker horizon (using white clay such as feldspar) at a minimum of 10 sites throughout Willard Spur using the method described at http://www.pwrc.usgs.gov/set/installation/markers.html. The DWQ will then return to these sites at the interval the science panel recommends to determine the depth and nutrient load within sediment deposited over the prescribed study time period. Sediment cores at these sites will not be retrieved as part of the 2011 sampling effort and will be done only after the science panel determines objectives and methods. These sites may also be used in conjunction with the collection of deeper sediment cores to look at long-term loading rates.

3.2.3 Coordination with Satellite Imagery

The DWQ will coordinate with the required authorities to determine when overhead satellites will be capturing imagery of the Willard Spur study area. Field sampling studies will be coordinated to coincide with these images to provide a link between datasets. At a minimum, the satellite imagery will capture valuable information regarding the areal extent of water and vegetation that may be linked to water quality data. Remote sensing techniques will also be explored to determine if the images can be leveraged to evaluate other characteristics of Willard Spur (i.e., chlorophyll-a) over a wider area at a lesser cost. These methods could then possibly be extrapolated to historical satellite imagery to explore how the water quality of Willard Spur has changed over time.

3.3 Supplemental Studies

Additional studies were identified that may be completed by the DWQ or others if resources are available or may be postponed until additional funds are available and input is received from the proposed science panel. These supplemental studies are identified in this document not as requirements for 2011 but to foster cooperation with other agencies and provide guidance if funds become available. These studies include the following:

- Residence time experiment in Willard Spur
- Mapping the existing distribution of phragmites in Willard Spur
- Bird surveys
- Detailed evaluation of mixing patterns in the Plant's mixing zone
- Collection, dating, and evaluation of sediment cores

3.3.1 Residence Time of Water in Willard Spur

A key factor in how Willard Spur assimilates contaminants is the time that water resides within the water body. To that end, the DWQ will attempt to complete dye studies on two separate occasions to better understand the residence time of water in the Plant outfall's mixing zone and the overall Willard Spur during different flow regimes: June (spring runoff) and August (dry season).

3.3.2 Mapping of Existing Distribution of Phragmites

The USFWS has completed extensive investigations of invasive species such as phragmites within the BRMBR (USFWS, 2007; Kettenring and Mock, 2009; Zaman and McKee, 2010). Mapping the presence and extent of phragmites within Willard Spur would serve as a benchmark that defines the extent of the current problem but also a means to begin to evaluate whether water quality standards may improve the present condition. The DWQ will work with the USFWS to determine if there are opportunities to collaborate on this effort.

3.3.3 Bird Surveys

The Utah Division of Wildlife Resources (DWR) completed extensive surveys of GSL bird populations from 1997 to 2001 that served as a basis for designating the Bear River Bay, including Willard Spur, as a Globally Important Bird Area and a part of the Western Hemisphere Shorebird Reserve Network. Surveys of Willard Spur identified a rich diversity of bird species and vast numbers. The area, however, is immense, and the study notes that due to the aerial methods used and the highly variable habitat, the survey accuracy in this area is likely understated (Paul and Manning, 2002). The DWR still completes routine bird surveys of Bear River Bay (Anderson, 2010). The USFWS and DWR routinely complete bird surveys at their wildlife management areas on the periphery of Willard Spur (per communication with John Isanhart and Val Bachman). It is unknown at the time of publication whether any agency is indeed currently completing bird surveys of Willard Spur itself.

While birds adapt their feeding habits to the available condition and thus make it difficult to assess whether this beneficial use is impaired, bird surveys would still provide a benefit in addressing the objectives of this study. Understanding the diversity and populations of birds using Willard Spur will help determine how this water body resource is being used and what needs to be protected. Understanding bird use could, at a minimum, provide anecdotal data that could be linked to other collocated environmental data collected as part of this study and that, in turn, could provide beneficial information that could help guide further research into how GSL wetlands water quality affects this beneficial use.

This study, if completed in 2011, would provide an updated survey of water birds utilizing Willard Spur. The study will identify the bird species utilizing Willard Spur and estimate their populations. Surveys will be timed to coincide with sampling efforts in a way that survey results could be linked to environmental data collected in 2011. Surveys will be coordinated with USFWS and DWR to utilize their avian biologists. Alternatively, DWQ's field teams could stop at a good vantage point for each sampling site, observe for 10 minutes, and document bird use at the sampling site. Protocol could be simplified by grouping birds into guilds, such as waterfowl, waders, shorebirds, or other waterbirds so that even inexperienced birders can capture this important information. At a minimum, the DWQ will provide anecdotal observations regarding bird use at sites where environmental samples are collected.

3.3.4 Evaluation of Plant's Mixing Zone

The existing mixing zone for the Plant's outfall is located in a back-eddy area on the east side of Willard Spur. Little is currently known about how the Plant's effluent actually mixes with the open waters of Willard Spur (i.e., where the effluent mixes). Other unknowns include the extent of the dilution effect of flow from BRMBR's 5C Outlet and the residence time of the effluent in the vicinity of the outfall. Some of these unknowns will be addressed by water quality samples to be collected by the DWQ (see Section 3.1) and by the proposed residence time experiment (see Section 3.2.1).

The objective of this study, if resources are available, is to collect water quality samples in a radial pattern from the outfall site to specifically quantify the dilution of effluent and determine how nutrient concentrations are dissipated in the mixing zone. This should be completed at a minimum for two hydrologic regimes, a high-flow scenario (spring runoff) and low-flow scenario (August through September).

3.3.5 Sediment Cores

Sediment cores have been used extensively to evaluate the historical deposition of various contaminants in GSL (Waddell and Giddings, 2004; Johnson et al., 2008; Naftz et al., 2009). The objective of this study is to collect sediment cores from strategic locations within Willard Spur to determine the historical deposition of nutrients and other possible contaminants (e.g., selenium and mercury). This information may then be used by the science panel to help assess whether current water quality standards have been effective in protecting the water quality of Willard Spur.

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APPENDIX A

Monitoring and Sampling Strategy at Harold S. Crane WMA

Reconnaissance of Harold S. Crane Wildlife Management Area

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FROM: Jeff DenBleyker

DATE: February 24, 2011

The objective of our visit to the Harold Crane Wildlife Management Area (WMA) was to better understand some of the challenges that will need to be overcome and identify a means to measure the quantity and quality of water discharged from the WMA to Willard Spur. The following summarizes key challenges toward meeting this objective and a proposed path forward:

Challenges

- Many of the roads at the WMA are often impassable due to mud and unstable dikes. This includes the road extending to the north along the eastern boundary of the WMA and most of the roads that are on top of the dikes within the WMA. Most notably, the road on top of the north dike where the WMA discharges to Willard Spur is impassable except to foot traffic. This makes monitoring and sampling flow out of the WMA very problematic.
- Flow rates are very dynamic. Spring runoff is the most dominant flow period but the WMA often gets peak flows during local rain events as well. Flows can peak at up to 300 cfs over a short period. Monthly sampling would likely miss these dynamics (and resulting flow volumes).
- Water flowing into the WMA from the south and east is spread across numerous submerged and partially exposed culverts (see Figure 1). Measuring flow and collecting water samples at the inflow points to the WMA would be extremely difficult logistically and likely quite expensive. None of the points are currently gauged and there is little to no historical record.
- There is one ditch located between the WMA and Willard Bay Reservoir (east of the WMA) that conveys flow directly to Willard Spur from the South Drain.
- There is a large area between the WMA and Great Salt Lake Minerals (west of the WMA) that conveys flow directly to Willard Spur. Much of this is overflow that bypasses the WMA during flooding conditions. This may be controlled now as part of a recent flood bypass that was constructed on the east side of the WMA.
- Vandalism can be a problem. Any fixed equipment will need to be discrete.

- Scheduling access around planned bird surveys, hunting season, research, planned burns, and other management activities will be required.

FIGURE 1
Harold S. Crane Wildlife Management Area and Drainage Area

Proposed Plan

The proposed sampling plan at the WMA includes a combination of continuous and monthly flow monitoring and sampling along the most accessible dike at the WMA. This southern dike is also where flows and DWR operations are most concentrated (see Figure 2).

Almost all flow entering the WMA flows through the south dike of the WMA. The only exceptions are flows that go west of the WMA during extreme flow events and flows in the ditch on the eastern boundary of the WMA at the foot of the Willard Bay embankment. While there are sixteen (16) weir structures on the south dike, most of the flow through the south dike is concentrated at six (6) different weir structures as shown in Figure 2. Flow would pass through the other weir structures only during flooding conditions.

Figure 1 and 2 illustrate the proposed monitoring and sampling sites. The plan will include the following elements:

1. DWQ will establish one continuous flow measurement station on the ditch on the eastern boundary of the WMA (labeled "WMA Ditch"). This may consist of installing a pressure transducer to monitor water level (and thus flow) changes. Water samples will be collected at this location on a monthly basis. Water in this ditch is from the South Drain.

FIGURE 2
Proposed Monitoring and Sampling Locations

2. DWQ will establish one continuous water level measurement station in the pool south of the southern dike (labeled "water level"). Figure 3 illustrates a possible concept for this station. This pool is fed by all of the various drains, ditches, and creeks supplying water to the WMA and controls flow over the weirs in the south dike of the WMA.

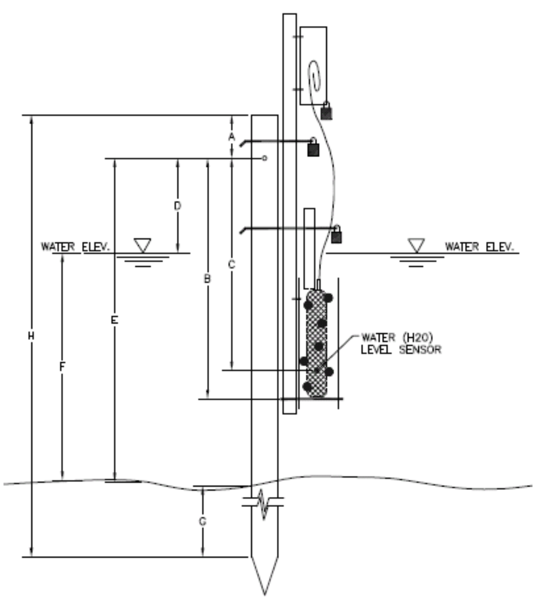

FIGURE 3
Possible Water Level Monitoring Station Configuration with Wood Post

3. A rating curve will be established for each of the 16 weirs/culverts on the southern dike. Flow rates over the weirs will be calculated using the known water level in the pool upstream of the weirs. This assumes the following:

    - The entire pool south of the dike is hydraulically connected, thus at the same elevation throughout.
    - DWR can identify their preferred weir configuration for the 10 weirs that typically pass no water and leave them as is (no flow condition for non-flood events). Labeled with pink icon (Nos. 3-9 and 12-14). *This may require confirming that the flashboards are in place.*
    - DWR can identify their preferred configuration for the 6 weirs that are typically used and record if and when they make changes to those weirs. Labeled with blue icon (Nos. 1, 2, 10, 11, 15, and 16). DWQ will work with DWR to identify the simplest means to record these changes. Changes in flow over the weirs can be estimated from the recorded weir modifications and pool water surface elevation.
    - DWR will continue to maintain the current structures as they do now. They can verify and record the flow condition of each weir (flowing vs not flowing) when they travel the south dike (perhaps monthly or bi-weekly).
    - We cannot guarantee that beavers will not alter flow conditions at the weirs.

4. DWQ will check each weir on a monthly basis, verify flow rates, and collect samples at flowing weirs. The fact that only 6 weirs typically experience flow minimizes the number of samples and simplifies flow rate verification.

5. DWQ will sample the north dike culverts one or two times during 2011. This will require traveling the dike by foot and/or when DWR can assist with travel by ATV. The intent is to collect these water samples in conjunction with samples collected along the south dike to evaluate how water quality is changed before discharging to Willard Spur (i.e., is water quality at the south dike similar to what is found at the north dike?).

6. DWQ may look at installing an event-based composite water sampling system on a temporary basis to capture how water quality may change during storm events and/or other flow “pulses”. Its location will be determined at a later time.

7. Need to verify flow patterns west of the WMA. CH2M HILL to discuss this area further with DWR and with Great Salt Lake Minerals.

APPENDIX B

Quality Assurance Project Plan

The QAPP and Standard Operating Procedures are still in development and will be submitted for review under separate cover.