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A GREAT SALT LAKE WATER QUALITY STRATEGY

Photo courtesy of Charles Uibel—greatsaltlakephotos.com

April 2012

Utah Division of Water Quality

A water quality strategy to ensure Great Salt Lake continues to provide its important recreational, ecological, and economic benefits for current and future generations.

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This Great Salt Lake Water Quality Strategy is available on the Internet at:
http://www.waterquality.utah.gov/greatsaltlake

CONTENTS

ACRONYMS AND ABBREVIATIONS

CWA	Clean Water Act
FFSL	Utah Division of Forestry, Fire, and State Lands
POTW	Publicly Owned Treatment Works
UAC	Utah Administrative Code
UDWQ	Utah Division of Water Quality
UPDES	Utah Pollution Discharge Elimination System

A GREAT SALT LAKE WATER QUALITY STRATEGY

UTAH DIVISION OF WATER QUALITY

EXECUTIVE SUMMARY

Great Salt Lake is of vital economic importance, contributing over $1billion to Utah's economy each year (Bioeconomics, Inc., 2012). The lake is also of critical ecological importance to the millions of birds who depend on the lake's resources. The Utah Division of Water Quality (UDWQ) has worked to ensure that water quality remains sufficient to maintain the lake's many important benefits. However, these efforts have been undertaken without an overarching plan and vision appropriate for this unique resource. Water quality rules applied elsewhere cannot be directly translated to Great Salt Lake. As a result, permits are difficult to develop and are often appealed. More importantly, it is challenging to determine scientifically what is needed to ensure the protection of the lake's biological and recreational uses. It has become increasingly apparent—to both UDWQ and our stakeholders—that filling this knowledge gap is of vital importance. This effort will require a significant commitment of resources, along with careful planning to ensure efficient and effective use of these resources. As a result, UDWQ has prepared a Water Quality Strategy that defines a comprehensive water quality approach for protecting the water quality of Great Salt Lake and its surrounding wetlands. Details for these planning efforts are modular, with several components that provide details of UDWQ's approach for stakeholder input. This document provides important background materials that explain why a water quality approach specifically aimed at Great Salt Lake is both needed and appropriate. Next the document introduces several important components of the strategy and discusses how each component relates to ongoing management efforts for Great Salt Lake.

I. UDWQ'S VISION AND NEED FOR A GREAT SALT LAKE WATER QUALITY STRATEGY

Great Salt Lake is of hemispheric importance as both a refueling stop for millions of migratory birds and a nesting area for others. Eighty percent of Utah's wetlands surround the lake. Over $1 billion per year (Bioeconomics, Inc., 2012) are contributed to Utah's economy from the mineral extraction industry, duck hunting clubs, and the brine shrimp industry, which are all dependent on the vitality of the lake. Nature enthusiasts flock to the lake because of its ecological importance. Utahans draw a significant amount of their heritage and identity from the lake. As pressures increase regarding appropriate uses and protections for the lake, so does the need to manage this resource proactively and wisely.

Utah citizens continue to express a desire to be responsible stewards of this wonderful treasure—Great Salt Lake. Entrusted with the responsibility of protecting water quality of the lake, UDWQ intends to fulfill its responsibilities in the lake's management. Together with our state and federal partners, UDWQ is committed to ensuring that the lake continues to benefit those who use and enjoy Great Salt Lake and its many resources. In so doing, UDWQ will be guided by the following vision: Great Salt Lake provides its important recreational, ecological, and economic benefits for current and future generations.

> ***UDWQ's Vision for Great Salt Lake:***
>
> ***Great Salt Lake provides its important recreational, ecological, and economic benefits for current and future generations.***

UDWQ recognizes Great Salt Lake's significance and indeed is required by law to protect the lake's "beneficial uses"—recreational activities such as swimming and duck hunting and protection for waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain (Utah Administrative Code [UAC] R317-2-6). *Protecting these beneficial uses—by ensuring the protection of the lake's chemical, physical, and biological integrity— is UDWQ's primary water quality objective*. Yet the extent that the lake is resilient to or threatened by pressures such as population growth and pollutant inputs—and how these pressures are affecting the lake's beneficial uses—is difficult to assess. Great Salt Lake is so unique that data gathered from other aquatic environments may or may not apply. However, decisions regarding lake water quality continue to be made, and the many stewards of the lake rightfully expect that these decisions be based on the best available science and a thorough understanding of the lake's unique characteristics, which is not always possible due to an incomplete understanding of this unique ecosystem.

Great Salt Lake (GSL) Facts:

4th largest terminal lake (no outlet) in the world

Remnant of Lake Bonneville—a prehistoric lake that was 10 times larger than the GSL

Average 75 miles long, 35 miles wide, and 14 feet deep

Primary sources of water are from precipitation and the Bear, Jordan, Ogden, and Weber Rivers

Salinity ("saltiness") varies throughout the lake and ranges from freshwater to 7 times saltier than the ocean

Mostly fish free, the keystone species are brine shrimp and brine flies

Causeways divide the lake into four distinct bays (Gunnison, Gilbert, Bear River, and Farmington)

80% (360,000 acres) of Utah's wetlands are adjacent to the lake

7 to 12 million birds, 250 species, visit the lake every year

$1.3 billion in total economic output to the State of Utah is generated by GSL industry, aquaculture and recreation.

Currently, there are few clearly defined water quality benchmarks (i.e., numeric criteria) for Great Salt Lake that can be used to interpret the potential impacts of existing or proposed pollutant inputs to the lake. This lack of clearly defined water quality protections for Great Salt Lake potentially leads to regulatory decisions that are either over- or underprotective of the lake's important uses. Overprotective water quality regulations are needlessly costly for industry and municipalities. Underprotective regulations are potentially illegal and would be detrimental to the lake's ecosystem, which supports millions of birds, not to mention a multimillion-dollar brine shrimp industry. Clearly, a strategy is needed to fill key knowledge gaps to generate appropriate water quality protections for Great Salt Lake in the most efficient and scientifically defensible way possible.

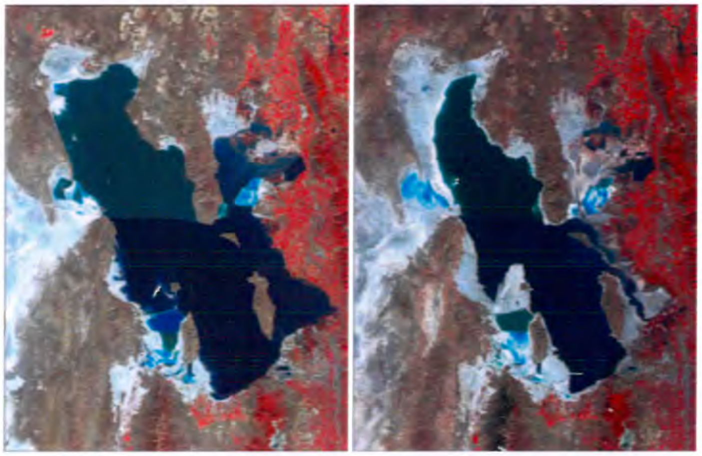
UDWQ continues to make environmental decisions based on the best available data and information, yet the uncertainty surrounding appropriate requirements for the lake continually leads to numerous challenges to many of these decisions. A new water quality strategy, based on acquiring information about the lake's unique characteristics and needs, and translating this information into appropriate and transparent policy, is required. UDWQ has designed this water quality strategy to fill critical knowledge gaps, improve the precision and clarity of UDWQ's water quality management decisions, reduce regulatory uncertainty for regulated entities, and improve all partners' capacity to be stewards of lake water quality.

II. A UNIQUE LAKE WITH UNIQUE NEEDS

Great Salt Lake's unique characteristics, particularly salt concentrations that range from freshwater conditions to conditions seven times greater than the ocean, require an approach to water quality that is specific to the lake. Appropriate water quality policies must protect the unique species that depend on the lake, yet more information is needed to know how these unique species respond to pollutants or even to the lake's natural cycles. The lake's salty conditions also affect how a pollutant behaves (i.e., transport, cycling, and storage), and these processes are highly complex and dynamic. This section summarizes the importance of understanding these Great Salt Lake–specific characteristics to meet water quality goals.

Lake Level Fluctuations, Salinity, and Ecology

Great Salt Lake is a dynamic terminal lake located adjacent to a rapidly growing metropolitan area in Northern Utah (see Figure 1). It is the sixth largest lake in the United States and the world's fourth largest terminal lake. As is characteristic of terminal lakes, Great Salt Lake has no outlet. Water that flows in can only evaporate or percolate through the substrate, leaving minerals and salts behind that continually accumulate. Because the lake is terminal, it is greatly influenced by variations in precipitation and the volume of stream inflows, which in turn dramatically affect lake area and salt concentrations (salinity). Since Great Salt Lake is large (an average 75 miles long and 35 miles wide), shallow (average depth of 14 feet), and gently sloping, small changes in the water surface elevation result in dramatic changes in surface area and create a highly variable shoreline. At the historic low elevation of 4,191 feet in 1963, the lake covered 950 square miles. During the 1980s flood, the lake reached an elevation of 4,212 feet and had a surface area of about 3,300 square miles (United States Geological Survey, 2009).



Difference in Great Salt Lake elevation and area between years 1999 and 2009

The seasonal and annual change in lake level affects the salinity that dictates the variation in the lake's aquatic habitats and the aquatic organisms supported. In addition, the gradation in saline environments from the rivers through the wetlands and into the lake creates many different types of habitats—uplands, mudflats, river deltas, ephemeral ponds, brackish and freshwater marshes, and open water with varying salinity—a complexity that attracts millions of birds who contribute to the lake's unique ecology. For this reason, the Great Salt Lake ecosystem is internationally significant to migrating and breeding birds and has been designated a regional and hemispheric important site as part of the Western Hemispheric Shorebird Reserve Network.

Union Pacific Railroad Causeway

Lake levels determine not only salinity but also the connectivity/fragmentation between the lake's major bays. Distinct salinity conditions have developed in the four major bays (Gunnison, Gilbert, Bear River, and Farmington) due to the rock-filled causeways that separate them. In 1959, the Northern Pacific Railroad causeway (renamed as the Union Pacific Railroad Causeway) was constructed that bisected the lake into two halves, Gunnison Bay (North Arm) and Gilbert Bay (South Arm). Bear River Bay, which receives the majority of freshwater inputs to the lake, is also isolated from Gilbert Bay due to this causeway. Two additional automobile causeways almost completely isolate Farmington Bay from Gilbert Bay. With limited exchange flow between the bays, each of these bays is now a unique—albeit interrelated—ecosystem with different physical and chemical environments. Different organisms depend on each of the bays due to the salinity, which means that water quality protections needed to protect lake organisms vary from place to place within the lake. As a result, Utah's water quality regulations differentiate each bay as well as the lake's surrounding wetlands (see section on UDWQ's regulatory role).

Typical Salinities of Great Salt Lake's Bays (at high and low lake levels) compared with other water bodies:

Great Salt Lake's Bays:

- *Gunnison Bay: 16 to 27%*
- *Gilbert Bay: 7 to 15%*
- *Bear River Bay: 1 to 6%*
- *Farmington Bay: 2 to 6%*

***Ocean:** 3.5%*
***Utah Lake:** 1.1%*
***Jordan River:** 0.05%*

Gunnison Bay

With limited inflows, Gunnison Bay has become extremely saline (hypersaline) when compared with the other bays, with an average salinity of 27 percent (UDWQ, 2010). At this level, relatively few species can survive, and it supports mainly halophilic ("salt-loving") bacteria that give the bay its red hue. The highly concentrated salts in this bay support one of the lake's mineral extraction facilities that supplies sulfate of potash, a necessary fertilizer for fruits and vegetables. These high salt concentrations are also ecologically important because they are transported south to Gilbert Bay, which helps maintain healthy salt concentrations for brine shrimp. The salt balance between Gunnison Bay and Gilbert Bay is also crucial to the mineral extraction facilities in Gilbert Bay that contribute to the world's need for magnesium, titanium, and salts. It is not currently known to what extent other chemicals, particularly toxic metals like mercury, are also concentrated within this bay and transported elsewhere within the lake.

Gilbert Bay

Gilbert Bay is also considered hypersaline with historical salinity levels ranging from 7 to 15 percent (UDWQ, 2010). Primary productivity is higher in this bay due to lower salinities, supporting an assemblage of algae and bacteria that are the food source for brine shrimp and brine flies. Brine shrimp and brine flies are the keystone species of the Great Salt Lake ecosystem and are a primary source of food for millions of migrating waterbirds and shorebirds. Brine shrimp are also valuable for the hard-walled eggs they produce (cysts), which are commercially harvested and used worldwide in the aquaculture industry. Brine shrimp thrive in hypersaline conditions with salinity ranges from 11 to 17 percent (SWCA Environmental Consultants, 2012). Under these conditions predators and competitors are few and algal production is high, providing brine shrimp with an abundant source of food. Brine shrimp are a critical component of the lake's food web, but they do not survive in all places or at all times in the lake. For instance, conditions in most areas of Gunnison Bay are too saline to support brine shrimp, whereas the water in many areas in Bear River and Farmington Bays are too fresh. Although when lake levels are high and the salinity in the bays change, the brine shrimp will move to places where the conditions suit their productivity. Brine flies play an essential role in converting organic material (algae, bacteria, and organic refuse) entering the lake into food for wildlife living along the lake's shoreline and migrating waterbirds. Brine flies rear on calcified biostromes, which are reef-like structures that cover the lake bed and develop as a result of the precipitation of carbonates by algae (Utah Division of Forestry, Fire, and State Lands [FFSL], 2011).

Brine Shrimp

Biostromes

Bear River and Farmington Bays

Both Bear River Bay and Farmington Bay are less saline (salinities range from 1 to 5 percent [UDWQ, 2010]) and support more aquatic organisms than Gilbert Bay and Gunnison Bay. These include aquatic bugs such as Water Boatman (Corixids), Gnats (Midges), and occasionally fish. The salinity levels in both these bays are similar to ocean or marine conditions. Salinity levels also vary within these two bays, from most fresh at the outlets of the major rivers to more saline at the causeway openings between the bays. During the spring runoff period, fish are carried out into these bays from the freshwater wetlands and rivers. In these areas, near freshwater inflows, the bays have salinities closer to freshwater conditions than marine.

Great Salt Lake Fringe and Impounded Wetlands

The wetlands surrounding the lake are unique because they cover a large expanse of inland, alkaline, and saline wetlands that attract and support millions of migrating and breeding birds. They also provide necessary functions such as flood control and water quality improvements by filtering pollutants. Approximately 360,000 acres of wetlands exist adjacent to the Great Salt Lake (FFSL, 2011), which represent almost 80 percent of all wetlands in Utah. The wetland areas are generally located along the eastern shore of Great Salt Lake including (from north to south) Bear River Bay, Willard Spur, Ogden Bay, and Farmington Bay. The wetland habitats (emergent wetland, hemi-marsh, mudflats, and playas) occur as fringe wetlands along the lake shore and as impounded wetlands within embankments adjacent to the lake. These aquatic habitats are highly variable in hydrology, species composition, and vegetation in response to lake level fluctuations, elevation, and salinity. The impounded wetlands are both privately and publicly managed to produce high-quality seasonal habitats for millions of migrating and breeding shorebirds and waterfowl (FFSL, 2011).


Photo courtesy of Charles Uibel—greatsaltlakephotos.com

Great Salt Lake Wetlands

Water Quality Protections

Lake level fluctuations and salinity and their effects on the ecology of the lake require water quality protections that are specific to this dynamic ecosystem. Increased knowledge of lake water quality under changing hydrologic and saline conditions and for the various beneficial uses requires an adaptive and focused approach.

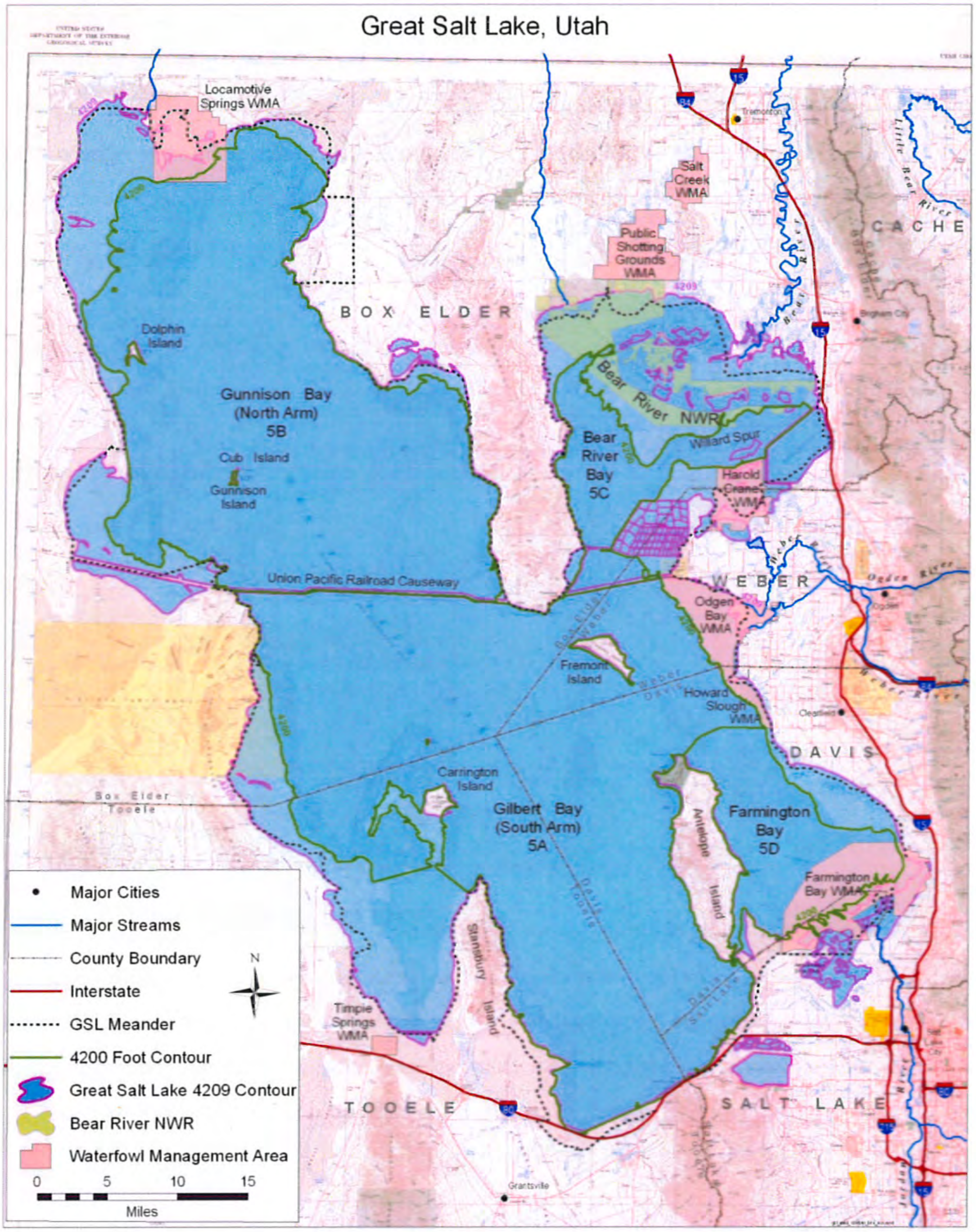


FIGURE 1. GREAT SALT LAKE, UTAH

Great Salt Lake is a saline terminal lake located in Northern Utah. The primary sources of water to the lake are from precipitation and the Bear, Ogden, Weber, and Jordan Rivers. The lake spans across five county boundaries (Box Elder, Weber, Davis, Tooele, and Salt Lake). The Great Salt Lake meander line represents the boundary of sovereign lands managed by the FFSL. The historic (1847–1986) average elevation of the lake is 4,200 feet (United States Geological Survey, 2009). Utah Water Quality Act beneficial uses for Great Salt Lake (Classes 5A through 5E) extend to an elevation of 4,208 feet. Since this contour is not available spatially, the 4,209-foot contour is shown.

The Potential Threat of Pollutants to the Lake's Beneficial Uses

Great Salt Lake is the lowest point in a 33,000-square-mile drainage basin that encompasses most of Northern Utah, parts of Southern Idaho, western Wyoming, and eastern Nevada. The surrounding drainages contribute approximately 3.5 million acre-feet of freshwater annually to the lake from four large drainage systems—Jordan, Ogden, Weber, and Bear Rivers—and numerous smaller drainages. Approximately 77 percent of Utah's population, or 1.4 million people, live within the watersheds draining to Great Salt Lake (United States Census Bureau, 2012). Agricultural, industrial, and urban development within these watersheds greatly contributes to Utah's vibrant economy, yet this growth has also resulted in significant agricultural, stormwater, and wastewater discharges to Great Salt Lake. As a result, the list of possible contaminants that have flowed into the lake is large and diverse. Possible contaminants of concern include toxic metals, petroleum hydrocarbons, pesticide products, and excessive nutrients, among others (Wadell and Giddings, 2004).

Several federal, local, and state agencies have conducted research to evaluate environmental contaminants within the lake and its surrounding wetlands. For instance, UDWQ and collaborators have conducted extensive evaluations of mercury and selenium throughout the past decade. Other pollutants of concern such as nutrients, arsenic, copper, and lead are present at potentially detrimental concentrations when compared with other aquatic ecosystems, but these concentrations may be normal for a terminal lake or may not threaten species that are adapted to the lake's unique environment. Currently, UDWQ does not have the necessary information to evaluate precisely whether these pollutants are affecting the lake's ecosystem in subtle but important ways, like reducing the hatching success of the ducks and shorebirds. Additional information is needed to further understand what happens when pollutants enter the lake and what levels of pollutants are acceptable in the context of ensuring the long-term support of the lake's beneficial uses. Consistent and reliable monitoring is also needed to identify water quality trends to identify pollutants that are accumulating to potentially unsafe future concentrations.

> ***Approximately 77% of Utah's population or 1.4 million people live within the watersheds draining to Great Salt Lake.***

Without comparative pollutant thresholds, UDWQ cannot always determine with acceptable certainty if the beneficial uses are currently being protected. Similarly, it is also difficult to estimate potential water quality effects of proposed developments—such as the proposed expansions of Kennecott Utah Copper and Great Salt Lake Minerals—to the lake's uses. This uncertainty can potentially result in insufficient water quality protection or may unintentionally require excessive levels of protection, which could be costly for industry and Utah taxpayers.

UDWQ's Regulatory Role

Under both state law (UAC R317) and federal Clean Water Act (CWA) authority, UDWQ is entrusted with the responsibility to maintain the chemical, physical, and biological integrity of Utah's surface waters, including Great Salt Lake. Three minimum water quality goals are specified in Section 101(a) of the CWA: (1) water quality that supports propagation of fish, shellfish, and wildlife; (2) water quality that supports recreation in and on the water; and (3) no discharges of toxics in toxic amounts. In order to meet these goals, UDWQ must begin by designating beneficial uses followed by establishing and enforcing water quality criteria. Following is a description of these requirements and the nuances we encounter when making programmatic decisions for Great Salt Lake. This strategy is designed to aid and direct better decision making in the future.

Great Salt Lake Beneficial Uses

Beneficial uses are descriptions of how the water will be used by humans and other organisms, or, in other words, what the water quality is intended to support. The current beneficial uses assigned to the Great Salt Lake (UAC R317-2-6.5) include primary and secondary contact recreation (e.g., water quality sufficient to swim at Antelope Island and/or wade while duck hunting at one of the Wildlife Management Areas) and wildlife protection (a quality sufficient for waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain). In 2008, the State of Utah (UAC R317-2-6) reclassified the beneficial uses of Great Salt Lake (Class 5) into five subclasses (Classes 5A, 5B, 5C, 5D, and 5E) to more accurately reflect different salinity and hydrologic regimes and the unique ecosystems associated with each of the four major bays and adjacent wetlands (see Figure 2 and Table 1). Classification of Great Salt Lake in this manner allowed UDWQ to develop methods to assess beneficial use support for each of these unique ecosystems. However, changes to this classification system may be needed to address the influence of lake level fluctuations on salinity and how salinity varies from place to place and over time within a bay. Since salinity is the driving force behind what aquatic organisms survive and reproduce, UDWQ is proposing an approach for water quality

> ***What Are Beneficial Uses?***
>
> *Beneficial uses are descriptions of how the water will be used by humans and other organisms and are classified in UAC R317-2-6 as:*
>
> 1. *Drinking Water*
> 2. *Recreation*
> 3. *Aquatic Wildlife*
> 4. *Agricultural Uses*
> 5. *Great Salt Lake*

protections that relies on levels of salinity, from freshwater to hypersaline, rather than a fixed geographical boundary.

TABLE 1. BENEFICIAL USES DESIGNATED TO THE GREAT SALT LAKE

Class	Geographical Boundary	Beneficial Uses
Class 5A: Gilbert Bay	All open waters at or below approximately 4,208-foot elevation south of the Southern Railroad Causeway, excluding all of the Farmington Bay south of the Antelope Island Causeway and salt evaporation ponds.	Protected for frequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.
Class 5B: Gunnison Bay	All open waters at or below approximately 4,208-foot elevation north of the Southern Railroad Causeway and west of the Promontory Mountains, excluding salt evaporation ponds.	Protected for infrequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.
Class 5C: Bear River Bay	All open waters at or below approximately 4,208-foot elevation north of the Southern Railroad Causeway and east of the Promontory Mountains, excluding salt evaporation ponds.	Protected for infrequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.
Class 5D: Farmington Bay	All open waters at or below approximately 4,208-foot elevation east of Antelope Island and south of the Antelope Island Causeway, excluding salt evaporation ponds.	Protected for infrequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.
Class 5E: Transitional waters along the shoreline of Great Salt Lake	All waters below approximately 4,208-foot elevation to the current lake level of the open water of Great Salt Lake receiving their source water from naturally occurring springs and streams, impounded wetlands, or facilities requiring a Utah Pollution Discharge Elimination System permit. The geographical areas of these transitional waters change according to the fluctuation of open water elevation.	Protected for infrequent primary and secondary contact recreation, waterfowl, shorebirds, and other water-oriented wildlife including their necessary food chain.

Note: (see Figure 1 for location)

Narrative Standard

Narrative and numeric water quality criteria (toxicity thresholds) define specific water quality objectives that must be met to ensure that each beneficial use is maintained. Great Salt Lake currently lacks numeric standards for all pollutants except selenium; however, this absence of numeric standards does not mean the lake remains unprotected. In the absence of numeric standards, the beneficial uses of Great Salt Lake have instead been protected by the Narrative Standards (UAC R317-2-7):

> *7.2 Narrative Standards*
>
> *It shall be unlawful, and a violation of these regulations, for any person to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color,*

odor or taste; or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures.

Narrative standards are inherently subjective but are an important water quality tool because they prohibit undesirable conditions that are sometimes difficult to detect with routine water quality data. For instance, most would agree that it should be unlawful for an individual to dump tires into a lake or stream, but the deleterious effects of this action would be difficult to capture with routine water quality samples. However, the narrative standards are much more difficult to interpret when applied to a water body such as Great Salt Lake that is constantly changing and the potential effects of pollutants in a highly saline system are poorly understood. These uncertainties have resulted in conflicting interpretations regarding whether the lake water quality complies with the Narrative Standard or continues to comply following proposed municipal or industrial developments. These conflicting interpretations, combined with an additional potential for subjectivity due to scientific uncertainty about the lake's ecological processes, makes it more difficult for the regulated community to understand, plan for, and ultimately comply with the Clean Water Act regulations. Similarly existing regulations are more difficult for UDWQ to fairly enforce.

What is the difference between a numeric standard and a narrative standard?

Numeric Standard:
A precise measurable level of a particular chemical or conditions allowable in a water body

Narrative Standard:
Narrative statement (i.e., free from scum) that establishes water quality goals

The approach as proposed in the documents of this strategy is intended to reduce these uncertainties by collecting critical data on the ecosystems and toxicological effects of pollutants on the lake biota. This information will lead to better decision making, which is vital for UDWQ programs such as the Utah Pollution Discharge Elimination System (UPDES) discussed in the next section.

The Permitting Process: Utah Pollution Discharge Elimination System

UDWQ requires and issues UPDES permits to all entities that discharge pollutants from a point source to waters of the state, including discharges of domestic and industrial wastewater, and more diffuse sources like stormwater. In the case of domestic and industrial dischargers, these permits establish allowable concentrations of pollutants and/or mass loadings in the permittee's discharge (and includes monitoring requirements) to ensure that the resulting water quality in the discharge is sufficient to protect the applicable beneficial uses and that the discharge is consistent with the antidegradation policy (UAC-R317-2-3). In the case of stormwater discharges, permits establish best management practices to insure beneficial uses are protected. The development of allowable concentrations/ loadings (i.e., permit limits) for Great Salt Lake discharges has been complicated by the lack of numeric criteria for the pollutants of concern. Permit limits are based on the most stringent of (1) technology-based effluent limits (which includes, but is not limited to, secondary treatment standards for municipal wastewater treatment plants and/or categorical effluent limits prescribed for a given industry), (2) numeric criteria, and (3) application of the Narrative Standard. Currently, permitted discharges, whether directly to Great Salt Lake or indirectly through the main rivers, fall into four major classifications: (1) municipal wastewater treatment facilities or publicly owned treatment works (POTWs), (2) stormwater discharges, (3) mineral extraction facility discharges, and (4) other industrial facility discharges (see Figure 2). POTWs that discharge directly to the lake have permit limits that are currently derived from secondary treatment standards, which are technology-based limits that establish the minimum national standards for municipal

Mineral Extraction Facilities

> ***What is a UPDES Permit?***
>
> *A Utah Pollution Discharge Elimination System (UPDES) Permit is required by all entities that discharge pollutants from a point source to waters of the state.*

wastewater treatment facilities. Industrial activities such as mining and other common types of industrial dischargers (e.g., chemical manufacturing, refineries, landfills, etc.) have permit limits that are derived from the most stringent among technology-based effluent limits, water-quality-based effluent limits, or best professional judgment. Insufficient information currently exists to ascertain whether these technology-based effluent limits (e.g., secondary treatment standards for municipal wastewater treatment facilities or POTWs) are sufficiently protective of the lake's uses.

Publicly Owned Treatment Works Facility

Over the past decade, both new permits to the lake and permit renewals have been repeatedly appealed. For instance, in 2007 the permit renewal for Kennecott Utah Copper's discharge was appealed and the facility continues to operate under their existing permit. Other industrial and mining UDPES permits for ATI Titanium and Great Salt Lake Minerals have also been challenged. The plaintiffs making these appeals disagree with UDWQ's conclusions that technology-based effluent limits (e.g., the Ore Mining and Dressing Effluent Limitation Guideline for ore mining) alone are sufficient to comply with the Narrative Standards. Numeric criteria would eliminate much of the controversy regarding effluent limits, or at least would streamline the appeals process. In addition, numeric criteria would avoid the potential for permit limits being under- or overprotective when they are based on technology-based standards that may or may not be appropriate for Great Salt Lake.

FIGURE 2. UTAH POLLUTION DISCHARGE ELIMINATION SYSTEM (UPDES) INDUSTRIAL AND MUNICIPAL PERMITS

III. STRATEGY COMPONENTS

UDWQ's Great Salt Lake Water Quality Strategy is designed to develop numeric water quality criteria for the lake, improve water quality monitoring and prioritize research, implement a plan to assess and protect Great Salt Lake wetland water quality, better coordinate and communicate with key partners and stakeholders, and secure the necessary resources and funding partners to do so. UDWQ will use the enhanced knowledge to develop appropriate water quality protections to help ensure that Great Salt Lake continues to benefit Utah citizens now and in the future.

Specifically, UDWQ will employ a five core component strategy (described in greater detail below):

1. **Numeric Water Quality Criteria Development**
2. **Strategic Monitoring and Research**
3. **Wetland Program Plan**
4. **Public Outreach Plan**

5. Resource Plan

Details for each component are further described separately in stand-alone documents that contain the rationale, approach, and a proposed implementation schedule. While each component will be described in stand-alone documents, the components are interrelated and not sequential. Much of the work will occur concurrently at a pace defined by resources that can be obtained to meet both short- and long-term project objectives. The wetland program plan will be developed with wetland stakeholders to devise an assessment and implementation framework for wetland specific water quality protections. The public outreach and resource plans will be developed in collaboration with key Great Salt Lake partners and stakeholders to develop a process that facilitates incorporation of feedback throughout implementation of all components of this strategy.

1. Numeric Water Quality Criteria Development

A key component of this strategy is to develop a process that will ultimately allow UDWQ to implement numeric water quality criteria for Great Salt Lake. UDWQ anticipates that in many cases different criteria will be needed for different salinity levels due to changes in the species that require protection. In Core Component 1, the proposed approach is an adaptive process that allows UDWQ to continually improve the numeric water quality goals as our knowledge of the effects of pollutants on the lake's beneficial uses continues to improve. This approach allows UDWQ to capitalize on, to the greatest extent possible, previously conducted scientific investigations while ensuring that results from outside investigations account for the lake's unique chemical and biological environments before they are incorporated into a regulatory framework for the lake . The process also provides UDWQ with tools to improve the scientific underpinnings of regulatory decisions over the short and long term through clearly defined prioritization processes. A draft of UDWQ's proposed approach for developing numeric criteria was released in concert with this overview document.

2. Strategic Monitoring and Research

Conducting strategic, targeted, and sufficiently comprehensive monitoring is critical for understanding current lake conditions and to document deleterious water quality trends. Water quality monitoring has been conducted at Great Salt Lake for decades, but a comprehensive baseline sampling plan has never been implemented. As a result, water quality information is often sporadic and sometimes redundant with several agencies collecting similar data. In addition, robust tests have never been conducted to evaluate whether laboratory methods yield accurate and reliable data, which may not be the case due to complications associated with analyzing hypersaline waters. Clearly, successful implementation of a water quality strategy begins with establishing consistent and reliable data.

In Core Component 2, UDWQ presents its strategic monitoring and research plan for Great Salt Lake. The objectives of the plan are to collect environmental samples to assess the current condition of the lake and track spatial and temporal trends of contaminants of concern that may affect the lake's beneficial uses. The plan addresses the accuracy, reliability, and quality of sampling and analyzing various parameters under highly saline conditions. In addition, the plan recommends studies to inform, build on, and advance the monitoring plan aimed at understanding the lake's complex biogeochemistry, hydrology, and ecosystems.

Implementation of this monitoring plan will lead to a new level of knowledge about lake conditions and needs, as well as identification of any remaining data gaps critical to developing numeric criteria. The monitoring plan is intended to be adaptive and will be revised as the knowledge and understanding of Great Salt Lake processes improves. Research needed to implement both components will be prioritized according to need and resources. A draft of UDWQ's monitoring approach and associated research objectives was released in conjunction with this water quality strategy.

3. Wetland Program Plan

Approximately 360,000 acres of wetlands exist adjacent to the Great Salt Lake, which are of critical importance for recreation and biological uses (FFSL, 2011). A comprehensive water quality strategy would be incomplete without explicit consideration of wetland water quality. For several reasons, UDWQ believes that the wetland strategy should be a related yet independent component of the water quality strategy for Great Salt Lake. First, like the open waters of Great Salt Lake, its wetlands are ecologically unique from other wetlands throughout the Intermountain West because of their connectivity to the lake. In addition, the types of criteria to assess and protect the beneficial uses may need to be wetland specific according to wetland type. For example, impounded wetlands that are managed for waterfowl have been hydrologically altered and are different ecologically than the fringe wetlands that surround the lake. Great Salt Lake's numerous wetlands have been subjected to varying degrees of human-caused disturbance so assessment tools to evaluate condition (from poor to good) will be developed.

Over the past several years, UDWQ, in collaboration with numerous water quality partners, has been working on improving existing numeric criteria and alternative assessment methods for Great Salt Lake wetlands. To date, UDWQ has primarily focused on the development of tools that will allow UDWQ and our partners to map the extent of these waters and to develop rigorous and comprehensive assessment tools. Despite progress in these areas, a more comprehensive water quality strategy is needed. In particular, UDWQ needs to define how assessment results will be used to refine existing numeric criteria to make them wetland-specific and to broaden their scope to all Great Salt Lake wetlands, not just those found within State Wildlife Management Areas. In addition, this plan should explicitly state how assessment results will be used to identify and subsequently improve waters with degraded water quality conditions.

UDWQ intends to develop this strategy in collaboration with stakeholders with varying interests in the protection of Great Salt Lake wetlands. To accomplish this task, UDWQ will hold several stakeholder discussions and open houses to develop a wetland assessment and implementation program plan.

4. Public Outreach Plan—Collaborating with Stakeholders and Key Partners

Great Salt Lake has a diverse set of critically interested stakeholders and partners, and collaboration and coordination with them is crucial for this strategy to be credible, effective, and successfully implemented. UDWQ will engage in a robust dialogue with the different public agencies that have responsibilities for and interests in the lake (Utah Department of Natural Resources, United States Environmental Protection Agency, United States Geological Survey, etc.) and with key stakeholders such as industry, municipal governments, hunting and birding associations, and environmental organizations as well as interested citizens. This coordination will focus on both fostering stakeholder review of, input into, and support for the strategy's components and designing the coordination mechanisms between responsible authorities needed to efficiently leverage all parties' efforts for improving the water quality protections for Great Salt Lake. UDWQ is committed to working collaboratively with key partners and stakeholders to devise and implement a process of input, coordination, and participation of the strategy components. To meet this commitment, UDWQ has developed a short-term outreach strategy that discusses plans for unveiling this strategy and the first two core components. Over the next year, UDWQ will work with stakeholders to develop a broader and longer-term communication and outreach strategy that takes outreach efforts through the development and implementation of water quality programs that are aimed specifically at the needs of Great Salt Lake.

5. Resource Plan

UDWQ has or will soon begin many of the foundational planning activities of the strategy, which will be refined with stakeholder input over the coming year. Planning is important, but it is only the first step. Addressing problems with the status quo requires consistent progress toward filling data gaps and developing new lake-specific water quality criteria. UDWQ anticipates that full implementation of this strategy, including enactment of new water quality criteria or other alternative protection measures, will take much of the next decade. Many of these activities are reliant on gaining support for the strategy and acquiring the resources needed to continue its robust implementation. After the objectives for each component are better defined with stakeholder input, the needs, prioritization, and resources necessary to implement the components will be identified. These details will be provided in the related core component documents, but efficient use of limited resources can only be realized with a comprehensive review of research and data collection needs. An important aspect of this component is continued collaboration with other state and federal agencies to help identify efficiencies that can be achieved through cooperative monitoring and research activities. UDWQ looks forward to engaging with its many partners and stakeholders who share a profound interest in protecting the water quality of Great Salt Lake and its important beneficial uses. Over the next year, UDWQ will create a document that summarizes short- and long-term resources that are needed to ensure continued progress in meeting strategy objectives.

VI. IMPLEMENTATION

Over the next year, UDWQ will finalize the initial planning documents for all strategy components. At a minimum, these strategic planning documents will be revisited every 3 years to ensure that they remain relevant water quality planning documents.

Many efforts are already underway that can directly feed into the organizational structure of this framework (see Section V and Appendix 1 for more details). Other activities specifically related to meeting core objectives are also underway. For instance, in 2011, UDWQ and our partners completed the first year of routine sampling identified in the strategic monitoring plan (see Core Component 2). Data obtained from these efforts are being evaluated to decide whether revisions to proposed field or laboratory procedures are warranted. Similarly, UDWQ is conducting preliminary reviews of existing studies that could potentially serve as catalysts for numeric criteria development (see Core Component 1).

Ongoing progress is important to ensure that momentum toward strategy implementation is maintained. However, real progress toward meeting long-term goals requires development of concrete goals that are specific to each core component. Specifically, UDWQ has proposed 3-, 5-, and 10-year implementation goals for each core component. These goals may need to be adapted to accommodate resources that can be applied to these efforts. However, goals will always be written with enough specificity to ensure accountability for whatever resources can be brought to bear toward meeting these water quality objectives.

VII. LEVERAGING RELATED GREAT SALT LAKE WATER QUALITY EFFORTS AND SUPPORTING OTHERS' EFFORTS

UDWQ is engaged in efforts in several areas that already exemplify how the strategy will be developed and implemented and/or will be informed or improved by the implementation of this strategy. Some of these efforts are specific UDWQ activities related to ongoing lake water quality concerns. For instance, UDWQ continues to collaborate on numerous studies aimed at understanding the effects of selenium and mercury pollution on lake health. Outside of the Division's direct actions, many other Great Salt Lake efforts require UDWQ's support and offer opportunities for coordination. For example, water quality is a key element of the FFSL Great Salt Lake Comprehensive Management Plan, and UDWQ has actively participated in their recent efforts to revise the plan to include lake level management strategies and increased coordination amongst state agencies. This strategy will inform the water quality aspects of their management decisions such as changes in water quality that can occur due to new or existing mineral leases. UDWQ also continues to participate with the legislative Great Salt Lake Advisory Council, who will undoubtedly play a pivotal role in the successful implementation of this strategy. These efforts and others are described in more detail in Appendix 1 to this document because together they convey some of the challenges posed with the status quo and the benefits that could potentially be realized through strategy implementation.

> *UDWQ is committed to fulfilling its duty to protect the water quality of Great Salt Lake based on sound scientific principles and current and accurate information.*

In order for this strategy to be successful, it will be critical to continually link these related efforts and future indirect efforts back to the strategy's organizational framework. Similarly, efforts should be made to apply information obtained from strategy-specific efforts to other management objectives whenever possible. Such coordination will only be realized if UDWQ directly engages with all stakeholders—from other government agencies, to elected representatives, to Utah citizens—in the development and implementation of the strategy.

VIII. CONCLUSION

UDWQ is committed to fulfilling its duty to protect the water quality of Great Salt Lake based on sound scientific principles and current and accurate information. UDWQ has developed this water quality strategy to improve its capacity to do so and believes that implementing this strategy will result in improved water quality protection of the lake's beneficial uses, greater certainty for regulated industries and cities, and more effective use of scarce resources by all concerned.

UDWQ looks forward to engaging key stakeholders and partners in the strategy's successful conceptualization, development, and implementation. Over time, this strategy will improve UDWQ's ability to provide clarity and certainty for those who use the lake and its resources in a manner consistent with UDWQ's mandate to protect the lake's beneficial uses for today and future generations.

IX. REFERENCES

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APPENDIX 1: ONGOING ACTIVITIES RELATED TO STRATEGIC PLANNING EFFORTS

Leveraging Related Water Quality Efforts

Willard Spur Site-specific Water Quality Standard

Construction of the Perry/Willard Regional Wastewater Treatment Plant (PWRWTP) was completed in 2010. The Utah Division of Water Quality (UDWQ) received numerous comments as part of the public notice process for the PWRWTP's Utah Pollution Discharge Elimination System (UPDES) discharge permit to Willard Spur. Many of these comments expressed concern over the potential impact that the effluent could have on the water body and petitioned UDWQ 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, the Water Quality Board directed UDWQ to develop a study designed 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 UDWQ to pay for phosphorus reductions at the PWRWTP while the study is conducted. This path forward, developed in conjunction with stakeholders, allows the PWRWTP to operate while the studies are underway, with reasonable assurances that the effluent will not harm the ecosystem. Critical to the success of this approach is the involvement of the Steering Committee and Science Panel to provide input, guide research, and provide recommendations to UDWQ. UDWQ is facilitating this process, and final recommendations of the appropriate water quality protections for Willard Spur will be made to the Utah Water Quality Board. For more information please visit http://www.willardspur.utah.gov/.

Great Salt Lake Wetlands Assessment

Historically, UDWQ applied numeric water quality standards to protect recreation and warm water aquatic life beneficial uses for the state Wildlife Management Areas and the Bear River Migratory Bird Refuge. However, UDWQ found that applying existing water quality standards to these wetlands was problematic for two reasons. First, the standards applied were based on the geographical location of the wetland rather than their ecological characteristics and represented only a subset of the wetlands around Great Salt Lake. Second, the standards applied were based on rivers or "flowing" systems and were not applicable to wetland biota.

To address these issues and in response to stakeholder concerns of excessive algae in the Great Salt Lake impounded wetlands, UDWQ and its partners have expended considerable time and resources to build an ecological understanding of wetlands around Great Salt Lake and how they support designated recreation and aquatic wildlife uses. To date, UDWQ has developed a preliminary Multimetric Index (MMI) for the Great Salt Lake Impounded Wetlands that includes quantitative indicators of water chemistry, submerged aquatic vegetation, surface mats, and benthic macroinvertebrates. These indicators provide multiple lines of evidence that together quantify the relative condition of Great Salt Lake's impounded wetlands. Ultimately, this MMI will allow UDWQ to assess support of aquatic life beneficial uses for these waters. Ongoing data collection and research will focus on improving and validating the assessment framework. The MMI for impounded wetlands represents the first step toward UDWQ's management program for assessing all of Great Salt Lake Wetlands. Program tasks to be completed in an iterative manner include the following: (1) develop monitoring and assessment methods for wetland ecosystems starting with impounded and fringe wetlands (representing the majority of Great Salt Lake wetland classes), (2) adopt an assessment (decision) framework, and (3) revise existing water quality standards as appropriate and necessary to protect beneficial uses. For more information please visit http://www.deq.utah.gov/Issues/gslwetlands/index.htm.

Implementation of the Great Salt Lake Selenium Criterion

The Utah Water Quality Board promulgated a selenium criterion for Gilbert Bay in November 2008. The selenium criterion, Great Salt Lake's first numeric criterion, is 12.5 milligrams per kilogram (mg/kg) dry weight in bird eggs (Utah Administrative Code R317-2-14). This criterion is intended to be protective for all birds and aquatic life in Gilbert Bay. In addition to the criterion, lower selenium concentrations were adopted as triggers for additional action. UDWQ periodically collects and analyzes bird eggs from Gilbert Bay for selenium to assess if selenium is impairing the beneficial uses (see Component 2). Selenium is a good example of the benefits of using an iterative and adaptive process. The initial goal of determining a numeric criterion for selenium was met. However, the lack of data regarding the relationship between selenium concentrations in water and eggs has hampered the full implementation of the selenium criterion. For instance, the water concentration that would result in eggs exceeding 12.5 mg/kg is unknown, and the significance of this data gap was not fully understood until implementation of the criterion for the UDPES program. Until this relationship is better characterized, the triggers are intended to ensure that action can be taken before the criterion is exceeded. The egg tissue criterion has technical challenges in implementation such as representative sampling, sampling limited to the nesting season only, and negatively impacting the very resource it was intended to protect (destroying bird eggs to analyze for selenium). UDWQ continues to explore methods for filling this data gap. For more information, please visit http://www.deq.utah.gov/workgroups/gsl_wqsc/selenium.htm.

Great Salt Lake Mercury Assessment

In 2003, water column measurements conducted by the United States Geological Survey reported elevated methyl mercury concentrations, some of the highest recorded levels in the United States (Naftz et al., 2008). Waterfowl breast muscle tissue was then analyzed for total mercury because of the potential for mercury to accumulate in the Great Salt food chain, from algae, plants, and bugs to waterfowl and local hunters. Testing from 3 of the 10 waterfowl species in 2005 and 2006 showed mean mercury concentrations in the waterfowl breast muscle tissue above the screening value of 0.3 part per million (Naftz et al., 2008). In response, the Utah Department of Health issued the first United States waterfowl consumption advisory for the 3 species of waterfowl (Cinnamon Teal, Northern Shoveler, and Common Goldeneye). These elevated mercury concentrations were the impetus for additional investigations into possible toxic exposures to the biota of Great Salt Lake and to people who hunt waterfowl. UDWQ devoted considerable resources in 2007 and 2008 to assess the extent to which mercury poses a risk to Great Salt Lake aquatic birds and organisms in their food chain. Researchers from the United States Fish and Wildlife Service, Utah Division of Wildlife Resources, United States Geological Survey, Utah State University, and UDWQ collected data in the water, sediment, and aquatic birds and their food chain for mercury concentrations from key focus areas funded by a United States Environmental Protection Agency (EPA) grant and state funds. The data from this study and others were compiled and compared with literature benchmarks assembled by the EPA. While these efforts have greatly improved UDWQ's understanding of mercury in Great Salt Lake, significant questions currently remain. For instance, selection of the most appropriate benchmarks to use for quantifying biological responses to mercury has not been finalized. In addition, the link between avian tissue concentrations and exposure to Great Salt Lake as opposed to other waters visited by birds remains unknown. These data gaps will be investigated and incorporated into an ecological risk assessment framework and the development of numeric criteria to help UDWQ determine if the lake's beneficial uses are protected or not due to mercury pollution. For more information, please visit the Statewide Mercury Workgroup website at http://www.deq.utah.gov/Issues/Mercury/workgroup.htm.

Jordan River Total Maximum Daily Load

The Jordan River is one of three major tributaries to Great Salt Lake. Water quality in the Jordan River does not meet water quality standards and UDWQ is thus required to conduct a total maximum daily load analysis (TMDL). The TMDL process identifies causes and sources of pollutants, allocates pollutant loads sufficient to meet water quality standards to the various sources, and helps inform all parties about what actions are necessary for Jordan River water quality to meet the water quality standards. Implementation of the Jordan River TMDL could result in improvements in the water quality delivered to the wetlands and ultimately to the lake. For more information please visit http://www.waterquality.utah.gov/TMDL/JORDAN/index.htm.

The Utah Water Quality Board

The Utah Water Quality Board guides the development of water quality policy and regulations in the state. The Board's makeup, defined by statute in the Utah Code, Section 19-5-103, is designed to represent various interest groups of the water quality community. As a result, the Board is ideally suited to help UDWQ ensure that the strategy ultimately produces water quality goals that adequately protect the Great Salt Lake ecosystem without placing unnecessary or inefficient regulatory burdens on industry or Utah taxpayers. The Board is appointed by the governor, with the consent of the Utah State Senate. UDWQ is the administrative arm of the Board. The Board will interface with the water quality strategy in significant ways such as endorsing its purpose and direction, authorizing resources to UDWQ (if requested of the Board) needed to enact this strategy, and reviewing and approving any future water quality standards that might be proposed as part of the strategy. For more information please visit http://www.waterquality.utah.gov/WQBoard/index.htm.

Supporting and Supplementing Other Great Salt Lake Efforts

The 2010 Update of the Great Salt Lake Comprehensive Management Plan

The Utah Division of Forestry, Fire, and State Lands (FFSL) is charged by law to manage Great Salt Lake for multiple use and sustained yield. The 2000 Great Salt Lake Comprehensive Management Plan (CMP) and the 1996 Great Salt Lake Mineral Leasing Plan are considered the current governing documents for the management of the sovereign lands and resources of the lake. In 2010, FFSL coordinated with multiple agencies to revise the CMP to address current issues and concerns regarding the resources of the lake and to ensure that management decisions made by FFSL in the future continue to reflect FFSL's updated understanding of its public trust responsibilities (FFSL, 2010). As a member of the planning team, UDWQ has been actively engaged in this process and substantively contributed to the discussions on the CMP's water quality component. The priorities and components of UDWQ's water quality strategy, as well as new information obtained as part of this strategy, will help inform UDWQ's input into the CMP, FFSL decisions based on lake level, and the future coordination board. Collaboration will improve efficiency and help to ensure that any future water quality regulations best balance the many ecological and economic uses provided by Great Salt Lake. For more information, please visit http://www.ffsl.utah.gov/sovlands/gsl.php.

The Great Salt Lake Advisory Council

Through adoption of House Bill 343 during the 2010 general session of the Utah Legislature, the Great Salt Lake Advisory Council—consisting of elected officials from communities surrounding the Lake and primary stakeholders— was created to advise/assist the governor, Utah Department of Natural Resources, and Utah Department of Environmental Quality on the sustainable use, protection, and development of Great Salt Lake in terms of balancing: (1) sustainable use, (2) environmental health, and (3) reasonable access for existing and future development. In 2011, the Great Salt Lake Advisory Council commissioned two studies to define the ecological health of the Great Salt Lake ecosystem and report on the economic significance of Great Salt Lake to the state of Utah. Together the information generated by these reports highlight the importance of the Great Salt Lake ecosystem as a natural and economic resource to the region and state of Utah and warrants a high level of protection from the state. Specifically, the ecological health study showed that most ecological targets surrounding Great Salt Lake were considered to be in good health; however, some targets, such as the open water of bays and unimpounded marsh complexes, were found to have a high level of uncertainty due to the lack of data and scientific understanding. The level of water-borne pollutants that could impair the ecological health of the birds, brine shrimp, and brine flies was listed by the scientific panel as the highest priority for future research. Several habitats were found to be in poor or fair health, including the impounded wetlands around Farmington Bay and the open water of Gunnison Bay (SWCA Environmental Consultants, 2012). Economically, Great Salt Lake contributes a staggering $1.32 billion dollars in total economic output to the state of Utah based on mineral extraction, aquaculture, and recreational uses and accounts for $373 million dollars in total labor income and 7,700 full- and part-time jobs (Bioeconomics, Inc., 2012). The industries that generate this economic output are those that are required to have UPDES permits to discharge to the lake and are dependent on accurate information for design and operation. The information generated by these reports will inform the UDWQ's water quality strategy; and in turn the water quality strategy, through the development of numeric water quality criteria and more efficient monitoring and research, will help direct the Council's deliberations on the science of the lake's sustainable use and environmental health. Engaging the Advisory Council throughout the development and implementation of this water quality management strategy will help to ensure that water quality is sufficient to maintain the lake's uses for future generations, without unnecessarily impeding the economic development of surrounding communities. For more information, please visit http://www.gslcouncil.utah.gov/index.htm.

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