POSITION PAPER ON WATER QUALITY STANDARDS FOR GREAT SALT LAKE

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Introduction

The purpose of this paper is to provide a well-reasoned, scientifically supported statement by Friends of Great Salt Lake (FoGSL) regarding the current lack of and need for numeric water quality standards governing the Great Salt Lake. At present, there are only narrative standards applied to the Great Salt Lake. This issue is particularly pertinent as recently considerable public attention has been focused on the potential effects of selenium, among other contaminants, on the Great Salt Lake ecosystem. As the population of Utah continues to grow and disposal requirements of the Salt Lake City area grow even greater, the need for quantitative standards becomes imperative.

Position Statement

The mission of Friends of Great Salt Lake is to preserve and protect the Great Salt Lake (GSL) ecosystem and to increase public awareness and appreciation of the Lake through education, research and advocacy. Protection of this ecosystem requires that we have suitable understanding of the current chemistry of the lake and how natural variation and changes in the chemistry of the lake affects the biota. Protection also requires that we have sufficient water quality standards in place to protect the integrity of GSL as required by the Clean Water Act. Consequently, on the basis of the great social and biological value possessed by the Lake, and the potential impact of water pollution on those values, FoGSL is IN FAVOR of numeric water quality standards for the GSL. Background and reasoning behind this position are summarized below.

Water Quality Standards and Beneficial Uses

The goal of the Clean Water Act, passed in 1972, is to protect the chemical, physical and biological integrity of the nation's waters. This legislation allows states to develop water quality standards to protect water bodies. A standard is a provision of law that consists of a designated use for a water body and the criteria for supporting the use. A designated use is a description of what the water will be used for by humans and other organisms. Utah currently recognizes 9 categories of designated uses (agriculture, domestic water, GSL, cold water aquatic life, warm water aquatic life, non-game fish and other aquatic life, primary recreation, secondary recreation and wildlife habitat). A criterion is a concentration or level (numeric or narrative) of some aspect of water that supports a particular use. In many cases this is a "do not exceed" quantity (e.g. concentrations of nitrate cannot exceed 10 mg/L in potable water) but in some cases these are a minimum quantity that must be maintained (e.g. oxygen concentrations cannot be lower than a 30 day average of 6.5 mg/L in a cold water fishery). These criteria are established and supported by scientific research, including evaluations of impacts on human health (e.g. cancer potency) or aquatic organisms (e.g. mortality, bioaccumulation). This approach is valuable because not all bodies of water require the same level of protection. For example, a reservoir that supplies drinking water may require stricter criteria than one used for irrigation. By assigning designated uses to a water body, we can then more easily assign appropriate water quality standards.

The current designated use for the GSL is narrative and protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction (Class 5). The standards assigned to this designated use are different than those applied to other water bodies in Utah because they are not numeric. That is, rather than being associated with a number or concentration that a certain pollutant cannot exceed, there is a statement of requirements. Narrative standards state that "It shall be unlawful...for any person to discharge or place any waste or other substance in such a way as will be or may become offensive...; 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" (Utah Division of Water Quality).

The GSL possesses unique chemistry and hydrology compared to other water bodies in Utah. It is a terminal lake basin, i.e., having no outflow. This means that chemicals and pollutants that are introduced to the lake have no way to exit the lake, and are instead concentrated as water is removed from the lake by evaporation. This makes GSL more sensitive than flow-through systems to pollution. Since GSL is also a hypersaline system, special consideration needs to be taken to determine how salinity may interact with pollutants to affect the biota of the lake and makes it impossible to assume that effects observed in freshwater systems are applicable to GSL. GSL is unique among hypersaline lakes because it is located close to a major population center; Salt Lake City and surrounding counties currently hold greater than 1 million residents, and projections indicate this will grow to 5 million by year 2050 (Utah Governor's Office of Planning and Budget). These factors together mandate that appropriate water quality standards are assigned to the lake to protect it in the future.

Narrative standards for Great Salt Lake are an inadequate approach for several reasons. Narrative standards imply that concentrations of pollutants in the GSL currently are not negatively impacting aquatic organisms. This has never specifically been examined, and we also have little knowledge of conditions in the lake prior to human disturbance. Narrative standards do not include an implicit compliance gauge and so the assessment of impact to water quality is open to interpretation. Pollution may not have an immediate effect as assumed in the narrative standard, and undesirable tastes, smells, physiological responses and human health effects may accumulate over time leading to severely degraded conditions. Infrequent and spatially limited monitoring make it impossible to determine what chemistry conditions are present in much of the lake, and how these conditions may vary through time. Finally, since the most important water pollution control programs in Utah are based on numeric standards (National Point Discharge Permits and the Total Maximum Daily Load process); not having numeric standards for the GSL largely excludes the lake from these processes and leaves the lake unprotected.

Potential Standards for Great Salt Lake

As explained above, water quality standards are designed to maintain certain levels of different chemicals in waters. Standards have many purposes and include a wide range of chemical substances and compounds. Some general classes of chemicals that should be included in numeric standards for GSL are: oxygen, metals, inorganic nutrients, and pesticides and other organic compounds.

Inorganic Nutrients: The two most commonly managed inorganic nutrients in aquatic ecosystems are nitrogen and phosphorus. This is because in most systems one of these two nutrients is limiting to algal growth. When nitrogen or phosphorus are added to aquatic systems, high algal production can occur that has many undesirable side effects, including decreased water clarity and growth of toxic forms of algae. Additionally, when algae die they are decomposed by bacteria that consume oxygen in the water, leading to anoxic conditions. There is evidence that excess nutrients in Farmington Bay may be leading to high levels of algal production in Farmington Bay, with potential implications for the health of this ecosystem.

Oxygen: In aquatic systems, anoxia generally occurs when respiration levels are very high. As explained above, bacteria cause anoxia when they use oxygen to decompose organic matter that is produced by algal production or delivered by inflowing rivers and streams. Anoxia commonly occurs in the bottom part of the water column in Farmington and Gilbert Bays in areas that are underlain by deep brine layers (relatively stable layers of high salinity water that infrequently mix with the overlying water). Oxygen dynamics are further complicated in hypersaline water, because the high salt content of the water reduces the amount of oxygen that can be held in the water, leading to low levels of oxygen saturation (typically 3-6 mg/L in GSL, vs. 8 mg/L in freshwater at this elevation).

Oxygen standards are generally used to ensure sufficient oxygen levels to allow organisms such as fish to respire. Although the GSL does not contain any fish, it still contains many important organisms, including brine shrimp and brine flies. Brine shrimp are an important part of the GSL ecosystem; the brine shrimp cyst harvest on the Lake contributes $80 million to the Utah economy annually has about 60 percent world market share. Brine shrimp are also an important food source for many of the up to five million water birds that migrate through the Lake each year. It is unclear how oxygen levels may affect brine shrimp survival, but it is possible that brine shrimp would not be able to tolerate low or no oxygen conditions. Anoxia is an additional concern in aquatic systems, because when oxygen is absent different chemical reactions occur. In one reaction that occurs under anoxic conditions, sulfates, which are naturally abundant in the hypersaline water of GSL, are reduced to hydrogen sulfide. Hydrogen sulfide is commonly known as the "rotten-egg" gas; hydrogen sulfide production in various areas of GSL may contribute to odor events that frequently plague Salt Lake City and the surrounding areas.

Metals: Because the GSL is a terminal system, the levels of metals in the lake are generally higher than observed in lakes and streams because they have been concentrated. For example, GSL is naturally high in arsenic, with concentrations of approximately 100 µg/L, which is 10 times higher than the current EPA drinking water standard of 10 µg/L. Organisms living in GSL may have evolved greater tolerances to some metals than would be seen in other aquatic systems. The examination of metals in GSL is further confounded by interactions with salinity and oxygen. For example, toxicity of a metal may be different in Gunnison Bay, where salinity is near 32%, compared to Gilbert Bay where salinity is currently near 16%. Additionally, metals may be bound or released depending on oxygen concentrations, which could result in variations in toxicity between anoxic deep brine layers and overlying oxygenated water. These spatial variations in toxicity should be considered when implementing water quality standards for the Lake.

Great danger is posed by metals that bioaccumulate (stored in the bodies of animals with increasing concentrations and adverse effects observed higher in the food chain), including selenium. Aquatic ecosystems that are shallow and slow moving, such as GSL, are most likely to accumulate selenium and experience toxic impacts in fish and wildlife. Selenium consumed by adult birds is passed to their offspring in eggs, where the young absorb the selenium as they grow, resulting in deformities, reproductive failure, and death. As little as 10-15 ug/L dissolved selenium can cause reduced weight gain in adult water birds, reduced egg viability and reduced hatchling survival. Selenium and other metals that bioaccumulate should be of great concern in GSL because of (1) the large bird migration that occurs each year through the GSL and surrounding wetlands, making the Lake part of the Western Hemispheric Shorebird Reserve network (WHSRN) and (2) the removal of brine shrimp cysts for use in aquiculture, with humans as the ultimate consumer of shellfish fed with brine shrimp cysts. More monitoring and laboratory examinations need to be completed to determine the current levels and impacts of selenium and other metals in GSL.

Pesticides and other organic pollutants: Current water quality trends in metropolitan areas have shown that human-created chemicals are causing some of the greatest pollutant threats to aquatic ecosystems. Commonly used pharmaceuticals such as estrogen are reaching detectible levels in water bodies that are highly impacted by human development. Pesticides are widely used along the Wasatch Front for agriculture and for general pest management, and the effects of these pollutants may be particularly difficult to detect since they are frequently delivered to surface water systems in short time periods immediately following application or storm events. Additionally, these organic compounds are present in very low concentrations that are difficult to measure, but may have lasting effects on organisms. Some of these chemicals may also bioaccumulate. With the growing population along the Wasatch Front, the effects of organic chemicals on the GSL ecosystem should be considered important current and future threats.

Determining Appropriate Water Quality Standards for Great Salt Lake

A significant amount of research needs to be conducted to ensure that appropriate water quality standards are applied to the Great Salt Lake. Because the Great Salt Lake is not a drinking water reservoir, less strict standards may need to be applied than would be inappropriate for other Utah lakes. However, the lake is still an important source of food for migratory shorebirds and for aquaculture, and those uses must be reflected in appropriate standards. Also, it will be difficult to apply standards to Great Salt Lake that have been developed in freshwater systems, because it is unclear how salinity may interact with pollutants to alter organism tolerances and toxicity levels. However, numeric water quality standards have been developed for other hypersaline systems, such as Mono Lake in California, and we should rely on science developed in these systems as a starting place for GSL standards.

A major cost associated with developing numeric standards will be developing chemical and biological analytical techniques that are accurate and precise in hypersaline water. Extensive literature review, laboratory quality control, and development of novel techniques using state-of-the-art analysis equipment will be essential to meet this goal. This will be a difficult hurdle to overcome, as all of the current water quality analysis in Utah is based on Standard Methods for the Examination of Water and Wastewater, a book of analytical techniques published by the American Public Health Association based on freshwater systems. However, technique development is not impossible, and some individual labs are already working on high salinity methods used in their research. Without a concerted effort to develop techniques, it will be impossible to implement standards for the Great Salt Lake.

The use of bioindicators may also aid in the development of GSL water quality standards. Bioindicators can be a species or group of species of fish, insects, algae or plants that show a quick, dramatic response to a disturbance. For example, if Chemical A is introduced to the Great Salt Lake, it may quickly kill all the individuals of one algae species in the lake, but may have a delayed and less detectable effect on brine shrimp and brine flies. The algae species may be used as a single-species bioindicator for Chemical A, because of its rapid response to Chemical A compared to other organisms in the Great Salt Lake. Initial work could focus on determining the species in GSL that are most sensitive to different types of pollutants, followed by determining the levels of pollutant that cause decline of that species using traditional toxicity techniques. This could reduce the number of tests ultimately needed to create useful water quality standards for GSL.

Afterword

FOGSL recognizes that developing water quality standards for GSL is an expensive and extremely complex undertaking. The success of this undertaking will hinge on a commitment by its stakeholders to work collaboratively to achieve this goal. Because so little is currently known about the spatial and temporal variations in chemical concentrations in the lake, we first must establish the current state of pollutants and other chemicals in GSL. This is further complicated by little knowledge of historical trends in water quality on the lake. However, this lack of knowledge is not sufficient reason to avoid the development of numeric standards for the lake as urban growth continues to impact this ecosystem. We must consider the effects of different pollutants on the GSL ecosystem and on the services that we, as neighbors, derive from the lake. We must ensure that our own uses of the lake are sustainable and not endangered by water pollution. We believe that with timely development of water quality standards for the lake, we can continue to maintain the integrity of the GSL ecosystem along with the growth of our population.

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