Farmington Bay Open Water
Outstanding Issues

General Statement of Findings:

Farmington Bay is a hypereutrophic portion of the Great Salt Lake. It receives runoff and treated effluent from the Salt Lake and Davis County areas, as well as stream flows from the Jordan River and local canyons. The Bay has variable saline concentration, usually in the range of about 1% to 8%. Significant cyanobacteria growths occur in the Bay at lower salinity. Also at lower salinity, the Bay may have little or no measurable dissolved oxygen and, at times, high pH (pH > 9). The wetlands surrounding the Bay are very productive and significant waterfowl and shore birds nest in these areas. The Bay is protected for "primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary aquatic organisms in their food chain, and mineral extraction." Brine shrimp are not always present in the Bay. Low saline concentrations are not conducive to brine shrimp growth and reproduction. If Farmington Bay were a fresh water or sea water habitat, ambient conditions would impact potential beneficial uses. As a hypersaline lake, current research has not demonstrated that the protected uses are impaired. However, significant questions remain to be answered to insure that impairment does not exist or to identify the specific impairment mechanism if an impairment is occurring. The following is a partial list of research questions that require further analysis.

1. Brine shrimp survival in Farmington Bay: A number of issues relating to brine shrimp in Farmington Bay require further research. These are

    A. At low salinity, high concentrations of cyanobacteria are present in the Bay. The cyanobacteria produces possible toxins. Can possible toxins be an inhibitor for the brine shrimp population?
    B. At moderate salinity (about 5%) brine shrimp and cyanobacteria may co-exist in the Bay. Can brine shrimp use cyanobacteria as a viable food source?
    C. Some research suggests that the brine shrimp population does not have sufficiently high birth rate at low salinity to maintain itself especially when higher predator populations are present at the lower salinity. Either

new research, or a compilation of existing research needs to be completed to validate that birth rates vary significantly with salinity changes. The survivability of brine shrimp across a salinity gradient from 0.5 to 8% needs to be developed. Also, can increased predator populations alone deplete the brine shrimp population in the Bay at low salinity?

2. Are cyanobacteria producing toxins that are harmful for humans, bird populations or aquatic organisms in the food chain at significant concentrations?

3. Brine fly populations appear to be significantly less in the Bay than the open water of the Lake especially at low salinity. Is this a result of salinity, predation, or environmental conditions (pH, toxins, etc.)?

4. H_2S is sometimes present at high concentrations in the Bay especially in the deep brine layer. Additional work is needed to understand the impacts of these high concentrations on the Bay. Are H_2S concentrations sufficient to cause prolonged anoxia? A mass balance of this possibility is needed. Are sediments producing and releasing H_2S to the water column, and if so, can this production be controlled? At times in the same location the deep brine layer concentration of H_2S varies significantly. What are the causes of these significant variations? Are H_2S releases to the atmosphere sufficient to be the primary cause of lake stink? Does release occur at significantly higher rates during wind events?

5. The pH in the Bay has been shown to be greater than 9 at times. Does this high a pH affect any organisms that would normally be present in the food chain? If so, what are these impacts?

6. Legionellla has been identified in the Bay. Is this of any significance? What are possible sources? If present, can any of these sources be controlled?

7. Farmington Bay is normally a very shallow water body with average depths of 1m. Given the shallow nature of the Bay, wind events can stir up significant sediment into the water column. Research has shown that such mixing of the sediment can add significant concentration of H_2S and phosphorus to the water

column. What impacts do these mixing events have on the beneficial uses? If the sediment is a sink for phosphorus, can phosphorus reductions to the Bay have any impact on the water quality or algal (including blue green) production?

8. Previous studies by USGS - Dave Naftz suggests that at times possible cyanobacteria fixed nitrogen is a significant part of the brine shrimp diet. Based on higher salinity in the open water, cyanobacteria probably does not survive well there. This would possibly mean that cyanobacteria from Farmington Bay is a significant source of food for brine shrimp in the open water. Is Farmington Bay the “bread basket” for the remainder of the lake? If it is, what impact does reduction of nutrients and subsequent reduction of cyanobacterial growth in the Bay have on the overall brine shrimp population?

Summary of Issues Prepared by Leland Myers and Theron Miller.

Farmington Bay Wetlands
Study Issues

Great Salt Lake is a very shallow, hypersaline terminal lake. The lake is too saline to support aquatic/wetland vegetation. However, all tributary inflows provide the fresh water necessary for supporting wetland vegetation and the gentle slopes of the shoreline allow for the development of approximately 450,000 acres of wetlands associated with river deltas, springs and point source discharges. Intensive management and control of tributary inflows has converted approximately 250,000 acres to impounded wetlands (both public and private lands) that are managed for waterfowl. We have classified much of the remainder as sheetflow and this consists of the tailwater from the impoundments, springs and the dispersed flow of POTW discharges. Although this emergent vegetation is at the "mercy" of rising and falling lake levels (the salt water will destroy all macrophytic vegetation), we have found it to be highly used shorebird nesting, rearing, foraging and resting habitat.

The value of this "mid-flyway" resting and refueling habitat is huge. Approximately 2.5 million waterfowl and shorebirds use Great Salt Lake and particularly the wetlands for nesting and migratory staging each year. The vast majority of the North American population of some species (i.e. Wilson's phalarope and eared grebe) *requires* Great Salt Lake and its wetlands in order to "refuel" before continuing their intercontinental migration. Thousands of American avocets, blacknecked stilts, snowy plovers and various duck species choose to nest in GSL wetlands. As such, the GSL has been recognized as a critical component of the Western Hemispheric Shorebird Reserve System.

Findings Thus Far

Our wetland classes under study are impounded and sheetflow wetlands. We have identified reference (control) wetlands for both of these classes at the Public Shooting Grounds. At PSG, both the impounded and the sheetflow sites have very low nutrient concentrations (total P = 0.02-0.08) mg L^{-1} and NO_3-$N0_2$ concentrations are nearly always below detection limits (0.05 mg L^{-1}).

Targeted (nutrient enriched) wetlands were identified at the impounded wetlands at the mouth of Jordan River and the sheetflow sites leading from the discharge points of Central Davis and North Davis Sewer Districts. Inflow water contained 2-4 mg L^{-1} total P and from non-detectable to 2 mg L^{-1} nitrate-nitrite. These sites were selected based on the ability to track nutrient concentrations through a series of three to four connected ponds or at regular distances encompassing 1.5 to 3 kilometers downgradient from the POTW discharges. In this manner, we expected to see attenuation of nutrient concentrations as the inflow water passes from pond to pond or at regular distances downgradient for the POTW discharges. This actually occurred at only one study system, Ambassador Duck Club. We believe that, because the other impounded systems (Newstate Duck Club and Farmington Bay Wildlife Management Area) have much higher flow-through rates, there was insufficient time to assimilate similar amount of nutrients.

In addition to the variable of residence times, all inflow waters from the Jordan River or from the POTWs are extremely nitrogen limited. This uniformly has favored aquatic vegetation that can fix nitrogen, particularly in the first pond or two of each study system. This is exhibited by the presence of duckweed (*Lemna minor)* and/or Cyanobacteria (mostly *Lyngbia sp*.). The duckweed by itself does not fix nitrogen. Rather, epiphytic (attached) heterotrophic nitrogen-fixing bacteria and Cyanobacteria colonize the "roots" and underside of the leaves. Although duckweed is utilized by some waterfowl, the preferred species by managers is the submergent sago pondweed (*Stuckenia sp*.). Cyanobacteria, on the other hand, are generally considered not palatable by various aquatic organisms, waterfowl and wildlife. Indeed, some species produce very toxic compounds known as cyanotoxins that have been known to kill waterfowl, fish and livestock. *Lyngbia* is a nitrogen-fixing filamentous Cyanobacterium that can also nearly completely cover pond surfaces and can even anchor itself to leaves and stems of sago pondweed. We believe the duckweed and *Lyngbia* are outcompeting the preferred sago pondweed because of the their ability to fix nitrogen *and* shade significant portions of the water column. The lower (downstream) ponds in the series have greater bottom coverage and biomass than the upstream inflow ponds.

Another developing issue is the frequent spraying of nearly all GSL wetlands for mosquito control. As one example, we established four transects that track the discharge of the Central Davis Sewer District for approximately 2.5 kilometers. Nutrients have remained high (i.e. total P = circa 2 mg L^{-1}) along the entire distance while dissolved oxygen has remained relatively low (generally < 2 mg L^{-1}). Samples from the first transect (located approximately 100 m from the discharge point), were typical of secondarily treated effluent and included many individuals of midges, odonates (dragon fly and damsel nymphs), amphipods, snails, flatworms and roundworms. The second transect was nearly devoid of macroinvertebrates during all sampling periods. There were only amphipods and roundworms. The third transect was similarly lacking in macroinvertebrates during the June sampling but showed substantial recovery in the August samples. The macroinvertebrate community at the fourth transect was quite diverse during all sampling events and included the sensitive ephemeropterans (mayflies) as well as odonates, corixids, midges, gastropods, coleopterans, roundworms and flatworms. Again, it should be noted that there was no significant change in nutrients, pH or DO among sites. Rather, spray records indicate that the first, second and third transects were sprayed approximately weekly with Trumpet EC (an adulticide and broad spectrum insecticide) and weekly with BTI (a larvacide that kills mosquito and midge larvae but does not typically affect other invertebrates). The BTI was sprayed three to four days later than the Trumpet EC so that the wetlands were actually sprayed every three to four days throughout the summer and fall. The August 4 samples at the fourth transect were particularly rich in both mosquito and midge larvae (many hundreds of individuals of each as well as the other common wetland species mentioned above) – suggesting that spraying had not occurred for some time at this location. Yet, after being informed that Davis County had sprayed this area on August 8 we resampled at all of the transects. In this second sample we found only 1 midge and 1 mosquito. These kinds of data would totally distort our data analysis and lead to erroneous conclusions if we tried to attribute these findings to nutrient loading. Similar treatments and biological responses occurred at the reference sheet flow area at Kays Creek and even the impoundments at Public

Shooting grounds. Overall spraying intensity and declining invertebrate populations was much greater in 2006 than during 2005.

Critical Research Needs

1. **Nutrient limitation, cyanobacterial toxicity and shading**

   More focused monitoring and experimentation needs to be conducted in impoundments to ascertain linkages between nutrient flow, nitrogen limitation, nitrogen fixation rates and the presence and toxicity of cyanotoxins. This investigation will be facilitated by performing N isotopic studies to identify anthropogenic vs natural (nitrogen fixation) sources of nitrogen. This question is similar to bullet #2 for the Farmington Bay open water research needs.

2. **Mosquito abatement spraying vs ambient water quality**
   We must ascertain the linkage between mosquito abatement spraying and macroinvertebrate community response. This will require accurate timing of ambient sampling with spraying events and confirmation bioassay tests (to determine does responses using controlled/constructed wetlands).

   There is also concern that chlorine may adversely affect the macroinvertebrate community below the discharge of Central Davis and North Davis Sewer District Discharges. This could also be examined using constructed wetlands.

   The result of these observations is that it is extremely difficult to discern the effects of nutrient loading from that of pesticide spraying. The only manner in which this can be discerned is to perform controlled bioassays.

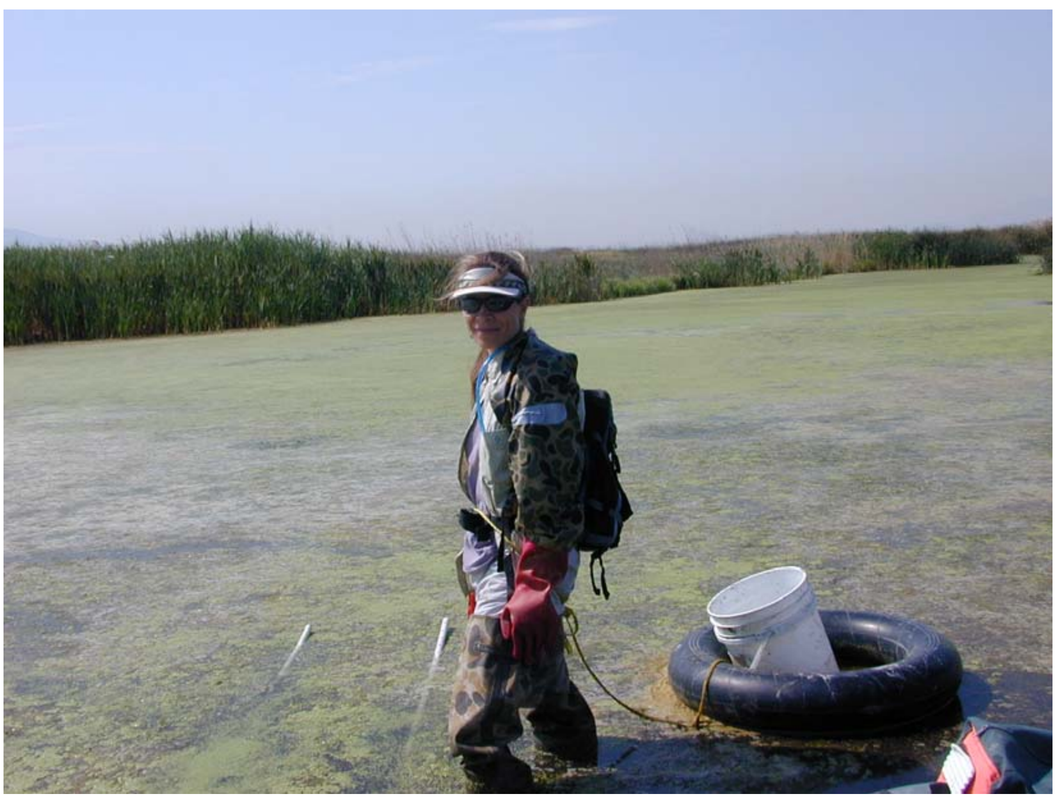
3. **Linkage between macroinvertebrate community and waterfowl and shorebird support**
   As our rules state, Farmington Bay and its wetlands are protected for waterfowl, shorebirds and other water-oriented wildlife including the necessary aquatic life in their foodchain. Toward this objective we began a nesting and rearing success study in 2005 to determine food availability and preference of nesting adults and foraging juvenile American avocet and blacknecked stilts. As supported by the literature, we found that the most important food items are corixids and midge larvae. In addition, overall nesting success has been among the highest reported in the country. However, because of the more intensive spraying, we need to quantify the density of these species in foraging habitats and particularly in reference to spray frequency. Also, nesting avocets and stilts are very selective in nesting site selection. We need to characterize the vegetation type, height, density and proximity to water in relation to actual nesting success. Note that this study item directly links water and biological quality to our defined designated beneficial use.
4. **Develop appropriate metrics to determine threshold concentrations or characteristics that can define beneficial use support status**
   Current contractors have been able to statistically associate some trends in dominant invertebrate and plant community species with trends in important

water quality parameters including nutrients, pH, dissolved oxygen and salinity. Additional testing and analysis is necessary to assess the strength of these relationships. The next necessary step is to identify thresholds of water quality parameters that are responsible for unacceptable changes in the invertebrate or plant community (e.g. unacceptable reduction in a valuable food chain organism or habitat characteristic). The use of biological metrics (biocriteria) for beneficial use assessment does not rely on just one metric. Rather, we will explore several dozen metrics suggested in the literature that may be applied to wetland ecosystems. The accumulative or average scores over a multitude of metrics will then be used to rank the site as fully supporting or possibly impaired.

Finally, it should be pointed out that no other state or federal organization is as advanced as Utah DEQ in the development of assessment methods for nutrients in wetland ecosystems. All of the work we are doing is ground-breaking research and monitoring.

New State Duck Club
Transect 1
July 21, 2005

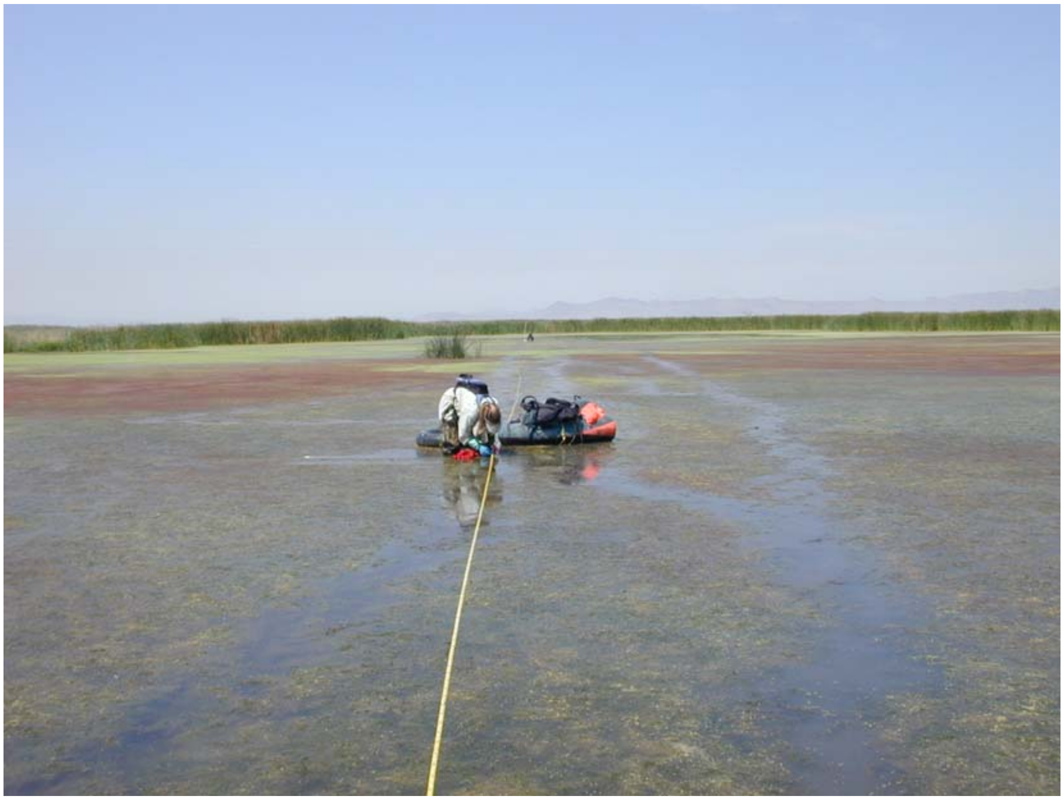
NEWSTATE T1- Pond algal cover.



NEWSTATE T1- Water clarity, duckweed/ Mexican mosquitofern (red).
Heidi Hoven, Ph.D. Wetlands Ecologist

SP05 NEW T1- Start of transect.

NEWSTATE T1- Data collection/ water clarity. Duckweed cover.


NEWSTATE T1- End of transect.