Ecological and Beneficial Use Assessment of Farmington Bay Wetlands:

Assessment and Site-Specific Nutrient Criteria Methods Development

Phase I

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and
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Submitted by

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Executive Summary

Background and Purpose of Study

There has been a growing concern by waterfowl managers, scientists and citizen groups that the nutrient load from wastewater discharges along the Wasatch front may be exceeding the assimilatory capacity of the wetland and Farmington Bay ecosystems. Concurrent with this growing concern, EPA has been encouraging states to develop methods for assessing wetland condition. Utah DWQ applied for and received three Wetlands Protection Grants starting with the 2004 field season. The primary objective of this study is to develop assessment methods that will be used to perform §305(b)/303(d) assessments. This process will include establishing site-specific criteria for phosphorus. Total nitrogen never exceeded Utah's narrative standard of 5 mg L^{-1} and it was indeed often below instrument detection limits of 0.05 mg L^{-1}. Therefore, although the wetlands and Farmington Bay were nearly always nitrogen limited, it is unlikely that treatment options would reduce ambient nitrogen concentrations and therefore change ecological conditions of the Bay or wetlands. Additional evidence for this conclusion is the frequent dominance of nitrogen-fixing Cyanobacteria throughout the Bay and wetlands, which would negate any nitrogen removal in wastewater treatment systems.

This effort represents one of the first attempts by any of the states to establish water quality standards and methods for wetlands 303(d) assessment. This is primarily because wetlands assessment methods development is in its infancy and there is a dearth of data describing the relationship between nutrient gradients and biological responses in wetlands, particularly Great Salt Lake wetlands. Therefore, our goals are twofold: 1) test existing parameters outlined in EPA's various assessment modules and other potentially useful parameters for their utility in assessing Great Salt Lake wetlands; and 2) Develop metrics and ultimately an Index of Biological Integrity (IBI) that will identify thresholds of significant change (impairment) that can be attributed to nutrients. These thresholds will then be used to set a site-specific water quality standard for phosphorus and simultaneously used to determine beneficial use support status.

The initial wetlands study design focused on measuring nutrient attenuation along a longitudinal gradient established by water passing through successive impoundments or at increasing distances across the mudflats from POTW discharges. We identified reference (least impacted) as well as target (nutrient enriched) sampling sites. Particular biotic parameters that we focused on include: macrophytes (percent cover, stem height, species composition, tissue nutrient concentrations and ratios, above ground biomass) phytoplankton and periphyton community structure; macroinvertebrate community composition and shorebird nesting success and forage preference studies. Abiotic factors in the water include total phosphorus (P), nitrate-nitrite (N), ammonia, metal concentrations, pH, electrical conductance (EC), dissolved oxygen (DO) and temperature. Sediment nutrient concentrations, organic carbon, pH and EC were also measured.

Several reports were prepared by individual contractors (see Appendices). This report summarizes and assimilates the wetland reports and data and includes additional analyses pertaining to wetland function and nutrient dynamics. Potential metrics are reviewed and additional data gaps are identified that will increase the accuracy of the wetland assessment.

Similar reports that assimilate the existing data and analyses for the open water and for selenium speciation and partitioning in the wetlands will be released in the coming few months.

Plant Community Responses to Water Quality at Impounded and Sheetflow Sites

The two wetland types that we studied are impounded and sheetflow wetlands. Among our impounded wetland sites, pH rarely exceeded 9 and some of these measurements were made in Public Shooting Grounds (reference) ponds that had less than 0.05 mg L^{-1} total P. Yet, DO in the Public Shooting Grounds was often 120% to 200% saturation. In this case, the source of high dissolved oxygen was the dense meadows of the rooted and submerged vascular plant *Stuckenia* sp. (sego or fineleaf pondweed), and a calcareous green macroalga, *Chara* sp. Low nutrient and high dissolved oxygen concentrations with dense vegetative cover was a common condition among the impounded wetlands at our reference site.

Plant communities in the targeted impounded sites experienced important differences when compared to the reference ponds. Specifically, submerged aquatic vegetation (SAV), primarily *Stuckenia,* demonstrated a premature senescence during August. This amounted to more than 50% loss in aerial cover. Notably, this was before the arrival of waterfowl migrants. Extensive surface mats of filamentous algae or duckweed often developed on these ponds and heavy coatings of biofilms (composed of epiphytic algae, sediment, and possibly bacteria and fungi) were observed on the living leaves. This surface and epiphytic shading may reduce light penetration to below optimal or even threshold requirements. Further, this would expectedly be exacerbated by shorter photoperiod and lower sun angle as fall progressed. If photosynthesis rates are sub-optimal (i.e. $P<R$), there may not be adequate oxygen production to diffuse down to the roots and maintain an oxygen-rich root zone. There was also a concomitant reduction in macroinvertebrate species (primarily odonates and amphipods) that typically inhabit these underwater meadows. In turn, this could represent a decline in additional food availability during a time when waterfowl are attempting to nourish and regain energy stores. These observations warrant further investigation, particularly as to the seasonal timing and whether correlations between nutrient (water column and SAV tissues), light attenuation, and biomass (as Chlorophyll a (Chl a) of phytoplankton and epiphytes, and g dry weight SAV per unit area) exist. If such correlations are documented, they need to be quantified and considered for inclusion into an IBI. In addition, recent literature indicates that Photosystem II fluorescence is a useful indicator of stress (shading, etc.), and exhibits potential as an SAV community metrics of wetland condition. Ultimately, our concern is that large underwater meadows of *Stuckenia* (a preferred food by waterfowl) and associated macroinvertebrates may be largely disappearing prior to the arrival of migrating of waterfowl.

The sheetflow target sites (Publicly Owned treatment Works (POTW) discharges) are very different from the impoundments in their structure and characteristics. These sites contained relatively low pH values (circa 7.4-7.7), while total P ranged from 2 and 4 mg L^{-1} along the transects. Such high nutrient loads would be expected to cause very high levels of primary production that would also be associated with large diel swings in DO and pH, and noxious plant or algal blooms. Although DO at these sites fell to near 2 mg L^{-1} during evening hours, daytime values never exceeded saturation. In addition, although luxuriant stands of Phragmites and cattails occurred at the sheet flow target sites, there was very little attenuation of phosphorus along the range of sampling sites. This apparent lack of uptake from the water column in the midst of luxuriant emergent vegetation supports the paradigm that sediment is the primary source of nutrients for emergent macrophytes and secondly, that either sediment or plant binding/uptake sites are saturated and only a small amount of assimilation by the system is occurring. Both Phragmites and cattail (the dominant species at target sites) are well documented for removing nutrient burdens from water as a form of treatment and are acceptable in performing such functions. However, current P loading rates (~ 8-12 g m^{-2}) exceed recommended values (2 -4 g m^{-2}). This brings into question the actual efficacy of Phragmites and cattail to remove nutrients in this situation. Further assessment of biomass relative to nutrient loading and assimilative capacity of nutrients by emergent species would provide a metric for determining whether sheetflow sites outside of POTW and State Wildlife Management Areas (WMAs) are capable of treating nutrient enriched water.

In addition, one of the major metrics suggested in EPA's "*Methods for Evaluating Wetland Condition*" modules is changes in species composition to invasive/exotic species and a reduction in species richness. Although Phragmites/Typha communities occur adjacent to the POTW discharges they are not the dominant vegetation type at "downstream" sites. Rather, the succession we have observed since lake levels have subsided (2002-2006) is colonization by the salt-tolerant Salicornia and alkali bulrush (two native non-invasive species). Hence, the question remains: Will we eventually see dominance of these sheetflow sites by the more aggressive Phragmites and Typha as sediment salts continue to be flushed by fresh water? This important question cannot be answered in the short time-frame of this study and hence, this important metric is unavailable for inclusion in our IBI.

Finally, although Cyanobacteria were common among sampling sites, there were also diverse populations of diatoms, an algal group typically identified with mesotrophic or oligotrophic streams and lakes. Diatoms are well known indicators of water quality but identifying key species or assemblages of species takes seasonal sampling for several years. Additional literature and field research will be performed to determine whether the species found in Farmington Bay wetlands respond to the different nutrient concentrations in a predictive manner. This information will enhance our interpretation of ecological processes and provide more accurate assessments of water quality and beneficial use support for these wetland habitats.

Macroinvertebrate Response to Water Quality

Tolerance values for individual taxa and statistical analysis revealed important information. For example, mayflies (Ephemeroptera; the most sensitive taxa among all of the samples), were quite tolerant of Electrical conductance (EC) values up to10,000 umhos cm^{-2} and pH values to about 9.5. Yet, mayfly numbers were depressed or absent from enriched (high total P and low DO) sites. Mayfly relative abundance provides one of the most sensitive metrics of this study. Dragonflies and damselflies (Odonata) were sensitive to high salinity but, as a group, were tolerant of a broader range of other physical/chemical variables than mayflies. As expected, midges (Chironomidae) and water boatman (Corixidae) were the most ubiquitous and numerous taxa among all of the study sites. Their known wide tolerance range to various physical and chemical parameters would explain this occurrence. The only locations where midges were noticeably absent were the impoundments of the FB WMA and in the first three sites leading from the Central Davis Sewer District (CDSD). Water boatmen were similarly absent from the CDSD sites but were abundant at all other sites. When these sample data were aligned with Davis County mosquito spray records, we noted frequent spray events of both the larvacide BTI, as well as broad-spectrum adulticides at these locations. Careful co-located sampling of the pesticides and macroinvertebrates following spray events will be performed during 2007 to assess the importance of spraying. Despite large variances among samples, macroinvertebrate community responses appear to be useful metrics in developing an Index of Biological Integrity. These include: Relative abundance of Ephemeroptera (mayflies), and Odonata, relative abundance of the collector-gatherer feeding, and predator feeding groups, percent clingers and others. This will be enhanced by additional environmental tolerance information that is expected to be released shortly by EPA.

Shorebird Nesting Success and Prey Selection

A very intensive study of nesting and hatching success and prey availability and selection for black-necked stilts and American Avocet was performed. Approximately 3500 nests were marked and monitored. More that 95% of the nests located in Farmington Bay successfully produced offspring. Similarly, 96% of the eggs that survived until time-of-hatching, successfully hatched. These values were similar to those found in Bear River National Migratory Bird Refuge and which are the highest success rates ever recorded in the nation. These high success rates, however, are partly attributed to the aggressive depredation program operated by the US Fish and Wildlife Service and Utah Division of Wildlife Resources. Comparison of stomach analysis with ambient macroinvertebrate sampling indicated that corixids and midges were the most common prey item. As mentioned above, these were the two most common taxa throughout all of our study sites.

Nutrient Dynamics and Sediment Phosphorus Studies

There were two major observations concerning nutrient measurements: 1) Except for stations very near the POTW discharges, all sampling sites exhibited severe nitrogen limitation. (i.e. P was in great abundance for plant growth relative to N and C). Indeed, in many of the impoundments, N was undetectable (<0.05 mg L^{-1}); and 2) Contrary to our hypothesis, a substantial gradient only occurred in the four successive ponds at the Ambassador Duck Club complex and to a lesser extent, in the Newstate Duck Club complex. Attenuation in these ponds is attributed to relatively much longer retention times than the other impoundment systems. Throughout the other locations, there was only a slight decrease in water column P. Among the sheetflow sites, there was also rapid attenuation in N and again, only a slight reduction in P. Phosphorus concentrations remained within about 20% of those found in the upstream locations. This lack of nutrient attenuation is attributed to the exceedence of nutrient uptake potential by wetland vegetation and to saturation of binding sites in the sediments. Sediment samples contained 300 to 1200 mg kg^{-1} total P. Further, biologically available (soluble) P ranged from 10 to 80 mg kg^{-1} in the sediments- indicating that there is continual exchange with the water column.

Preliminary Conclusions

Results of the sheetflow plant and macroinvertebrate studies, the shorebird forage preference studies and the notable nesting and hatching success, suggest that the Farmington Bay sheetflow wetlands are supporting the beneficial use of support for waterfowl and shorebirds and the aquatic life in their foodchain. In addition, the large flocks of numerous species of shorebirds that congregate and aggressively feed during migratory staging adds further support for this conclusion. One additional set of information that would complete this study of the life history stages of shorebirds in Farmington Bay wetlands would be a detailed characterization of juvenile habitat and forage preference. This important period of time has received little attention in Great Salt Lake wetlands or other shorebird nesting colonies elsewhere in the US. Secondly, additional water/sediment/plant nutrient studies need to be performed to better understand nutrient movement throughout the sheetflow sites. This study will include an assessment of the potential for continued conversion from alkali bulrush/Salicornia community to a Phragmites/cattail community.

Results of the impounded wetland studies remain inconclusive. The extensive epiphyte cover on SAV leaves, surface mats of duckweed and filamentous algae, and the premature SAV senescence in the upstream ponds appear to be related to the high nutrient concentrations experienced at the target sites. This relationship needs to be verified and careful observations need to be made ascertaining the timing of senescence with arrival and residence time of migrating waterfowl.

Potential metrics for wetlands assessment

Based upon the data analysis thus far, candidate parameters for a multimetric index of biological integrity, as well as provide the essential data set for establishing an appropriate site-specific water quality standard for phosphorus include:

1. Macroinvertebrate species composition and density (during nesting season and fall migration season).
2. Percent of Ephemeroptera
3. Percent of Chironomidae
4. Percent Odonates or clingers
5. Percent exotic and/or invasive plants
6. Submerged aquatic vegetation above ground biomass
7. SAV percent coverage
8. C:N:P ratios in phytoplankton and macrophytes
9. Chlorophyll a / macrophyte fluorescence
10. turbidity/ light penetration
11. Presence/composition of floating vegetation
12. Summer mean diel DO
13. Diel minimum DO
14. Water column and sediment H_2S measurements

These parameters include most of those recommended by EPA (2002) and several that appear to be uniquely responsive in GSL wetlands. These will be measured during the 2007 field season.

In addition, data assemblages from 2004, 2005, 2006 and 2007 will be tested separately and in total to evaluate the reproducibility and representativeness of the data set.

Finally, Reports by Rushforth (Appendix D) and Wurtzbaugh (Appendix E) are also appended to this report to display the additional research that has been performed on Farmington Bay wetlands and open-water environments. However, detailed analysis and interpretation, such as presented here, are not included in this report. Rather, additional sample collection, data analysis and reporting will be provided by the end of 2007.

1.0 Introduction

The Great Salt Lake and its associated wetlands serve as breeding habitat and migratory-staging area for millions of waterbirds traveling the Pacific and intermountain flyways. As such, Great Salt Lake and its wetlands have been recognized as an essential component of the Western Hemispheric Shorebird Reserve Network. Yet, this valued resource is at potential risk of degradation and conversion due to rapid urbanization and point and nonpoint sources of nutrients and toxics. Farmington Bay wetlands, are receiving the great majority of secondarily treated sewage from a populace of more than one million people along the Wasatch front.

The Great Salt Lake is the fourth largest terminal lake in the world. On average, the lake is 3 to 5 times the salinity of the ocean. The lake is extremely shallow (maximum depth = 37 feet or 11 m). On average, the lake rises 1.5 feet each spring and looses that amount throughout the rest of the year through evaporation. At the average surface elevation of 4200 feet, the lake covers about 1,700 square miles (Figure 1.1). At the historic low surface elevation of 4191.5, measured in 1963, the lake covered only 950 square miles. The drop of 8.5 feet in elevation resulted in a loss of 44 percent in surface area. During 1986 and again in 1987, the lake reached an elevation of 4,211.6 feet and had a surface area of about 3,300 square miles. Hence, depending upon lake elevation, the lake may contain hundreds of square miles of saline mudflats. In other words, for every foot the lake rises or declines, 45,000 acres of mudflats are inundated or exposed. On average, these lacustrine mudflats include about 450,000 acres that have varying degrees of salinity and plant community development, depending upon lake elevation and the time that they are exposed to the flushing effects of rain and tributary flows of fresh water.

About 150,000 acres of wetlands occur in Farmington Bay, occupying the transition zone between the freshwater sources of the Jordan River, other small tributaries and POTW discharges and the hypersaline pelagic waters of Farmington Bay. These fringe wetlands receive and assimilate nutrient inputs from the most densely populated region of the lake’s watershed. Since the drought that began in 1999 (resulting in the surface elevation of 4193 by 2004), we discovered that about three years of leaching is required before plants begin to germinate successfully and wetland communities expand. As the region recovers from the drought (average lake surface elevation approximately 4196 ft. in 2006), tens of thousands of acres of emergent plant communities develop each year. Ultimately, the persistence and fate of these temporary plant communities and the concomitant invertebrate and bird communities that utilize and depend on them are subject to annual and long-term average precipitation in the watershed. The majority of the fringing wetlands of Farmington Bay fall into two classes: 1) impounded, defined by human-made levees that were constructed to create large, shallow ponds ranging from about

Figure 1.1. Great Salt Lake images during high water of 1988 (Left) and low water (2002). Note surface area of Farmington Bay (lower right corner of the lake).

20 to greater than 500 acres. These impoundments, constructed to attract and support waterfowl, are located in the delta of the Jordan River (like those of the Bear and Weber rivers); and 2) sheet flow which are created by water releases onto the mudflats from the final (downstream) impoundments, from POTW effluents that discharge directly to the lake (primarily into Farmington Bay) and from several small uncontrolled tributaries such as Kays Creek, Farmington Creek and Davis Creek. Farmington Bay receives POTW discharges from seven major plants either directly or from four plants that discharge to the Jordan River. This causes the Jordan River to be an effluent-dominated stream that contains between 1.5 and 3 mg P L^{-1}. The Jordan River is currently on Utah's 303(d) list for low dissolved oxygen and elevated phosphorus. As the Jordan River approaches Farmington Bay it is carefully controlled and distributed among and through large shallow impoundments (impounded wetlands) that are owned and managed by Utah Division of Wildlife Resources or several private duck clubs. These large ponds have residence times of several days to weeks and salinity increases as waters move through successive impoundments and approach the lake. Outlet water from these ponds and the POTW discharges flow across mudflats (sheetflow wetlands) until it reaches the standing water of Farmington Bay.

Resource managers and conservation groups are concerned about elevated nutrients in these impoundments, sheetflow wetlands and in the open water of Farmington Bay. In response to these concerns, the Division of Water Quality applied for Wetlands Protect Grants from EPA and, beginning in 2004, the Division received three successive grants with the primary objective of developing assessment methods that can be used to establish site-specific water quality criteria for nutrients. These criteria will then be used to determine whether Farmington Bay wetlands are supporting their beneficial use of support for waterfowl and shorebirds and the aquatic life in their food chain. In addition to the EPA grants (totaling $370,000), Central Davis Sewer District contributed $640,000 and the Division contributed $85,000 in matching funds toward this goal. Specifically, our studies described here are directed at understanding basic ecological functions, sensitive processes or species that occur in these wetland systems and how they respond to nutrient and salinity gradients.

As with biological monitoring and assessment goals in streams and lakes, these studies have been designed to 1) identify thresholds of adverse biological or ecological changes to gradients in nutrients and other parameters, such as extreme swings in pH and DO, that are typically associated with hypereutrophy, and 2) identify sensitive and ecologically important responses to nutrient enrichment in Farmington Bay and its wetlands. An array of these metrics would then be incorporated into an index of biological integrity (IBI) that quantifies (scores) various ecological functions against a gradient in nutrients. Ultimately, thresholds along this scoring range will be used to establish beneficial use support status. This effort represents one of the first attempts by any state to establish methods for wetlands 305(b)/303(d) assessment.

Several contractors were hired from academia and consulting companies to perform sample and data collection, laboratory analysis and statistical analysis. Individual reports were prepared by: CH2MHill; Dr. Larry Gray of Utah Valley State College; Dr. John Cavitt of Weber State University, Dr. Sam Rushforth of Utah Valley State College, Dr. Wayne Wurtsbaugh of Utah State University and Mr. Leland Meyers of the Central Davis Sewer District (Appendixes A.1, A.2, B, C, D.1, D.2, D.3,D.4, D.5, E and F respectively). The objectives of this report are to synthesize and summarize data from the various contract reports and provide additional analysis and interpretation.

This report focuses on our investigations of impounded and sheetflow wetlands. A forthcoming report will focus on the open water of Farmington Bay and limnological characteristics and ecological relationships associated with the nutrients and salinity of the open water.

Additional reports addressing the aquatic chemistry and toxicity of selenium in the wetlands will be completed at the end of 2007.

2.0 Methods and Study Design

The initial wetlands study design focused on measuring nutrient attenuation along a longitudinal gradient landward out to Farmington Bay or Great Salt Lake as water passes through successive impoundments or at increasing distances across the mudflats from POTW discharges (Figs. 2.1.1 and 2.1.2). Three or four sampling sites were established along each of these longitudinal gradients. In this manner we expected to describe a co-located biological response along the expected nutrient gradient. Our assumption was that we would observe a systematic attenuation in water column nutrient concentrations (a gradient) at sampling sites located at increasing distance from source waters. Concurrently, we assumed there would be an apposing gradient such that salinity would increase with increasing distance from source waters. In reality however, we discovered that a defined nutrient gradient only occurred at the Ambassador Duck Club. Retention times in the Ambassador ponds were much greater than the other impoundments in this study.

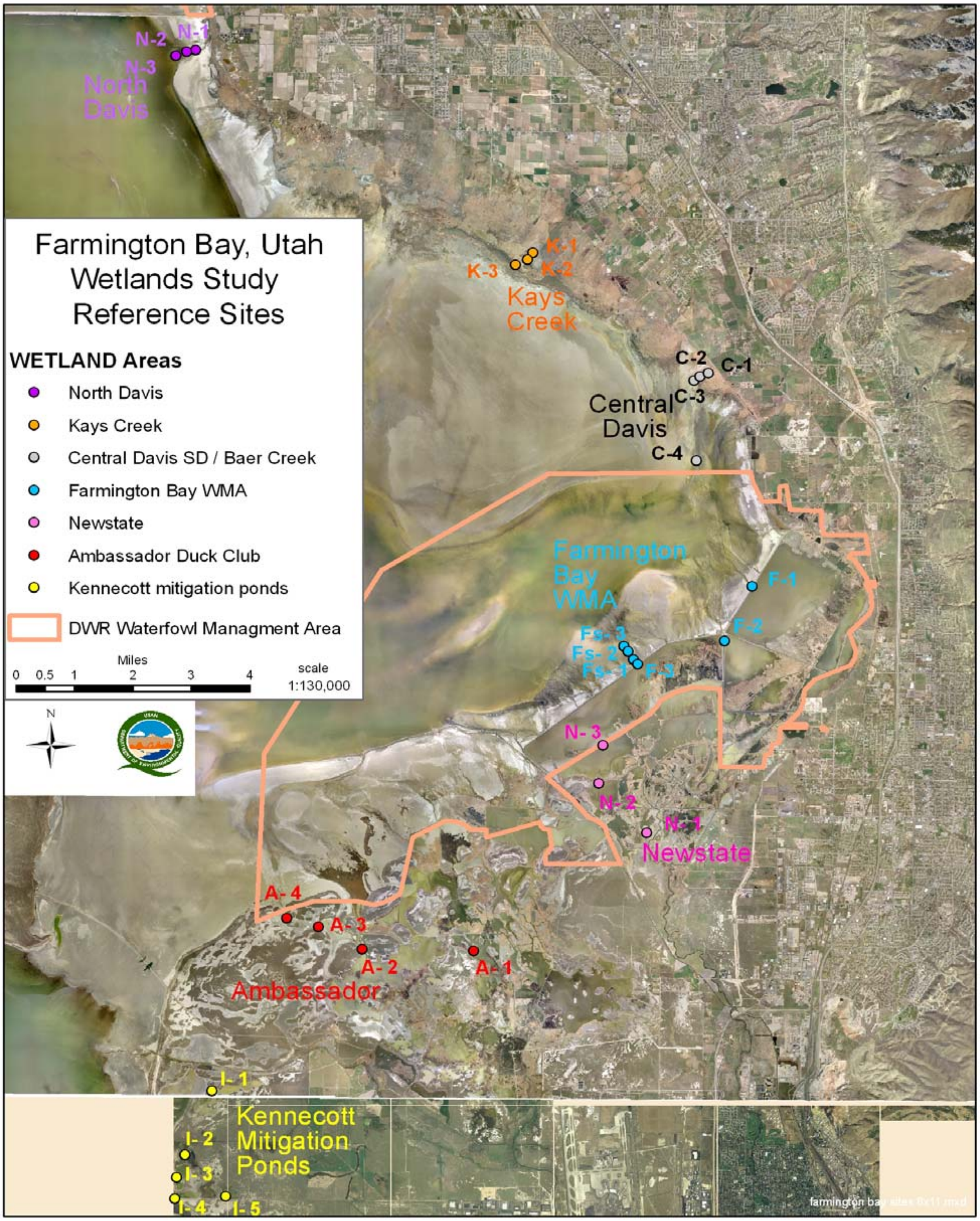


Figure 2.1.1. Sampling sites in Farmington Bay wetlands.

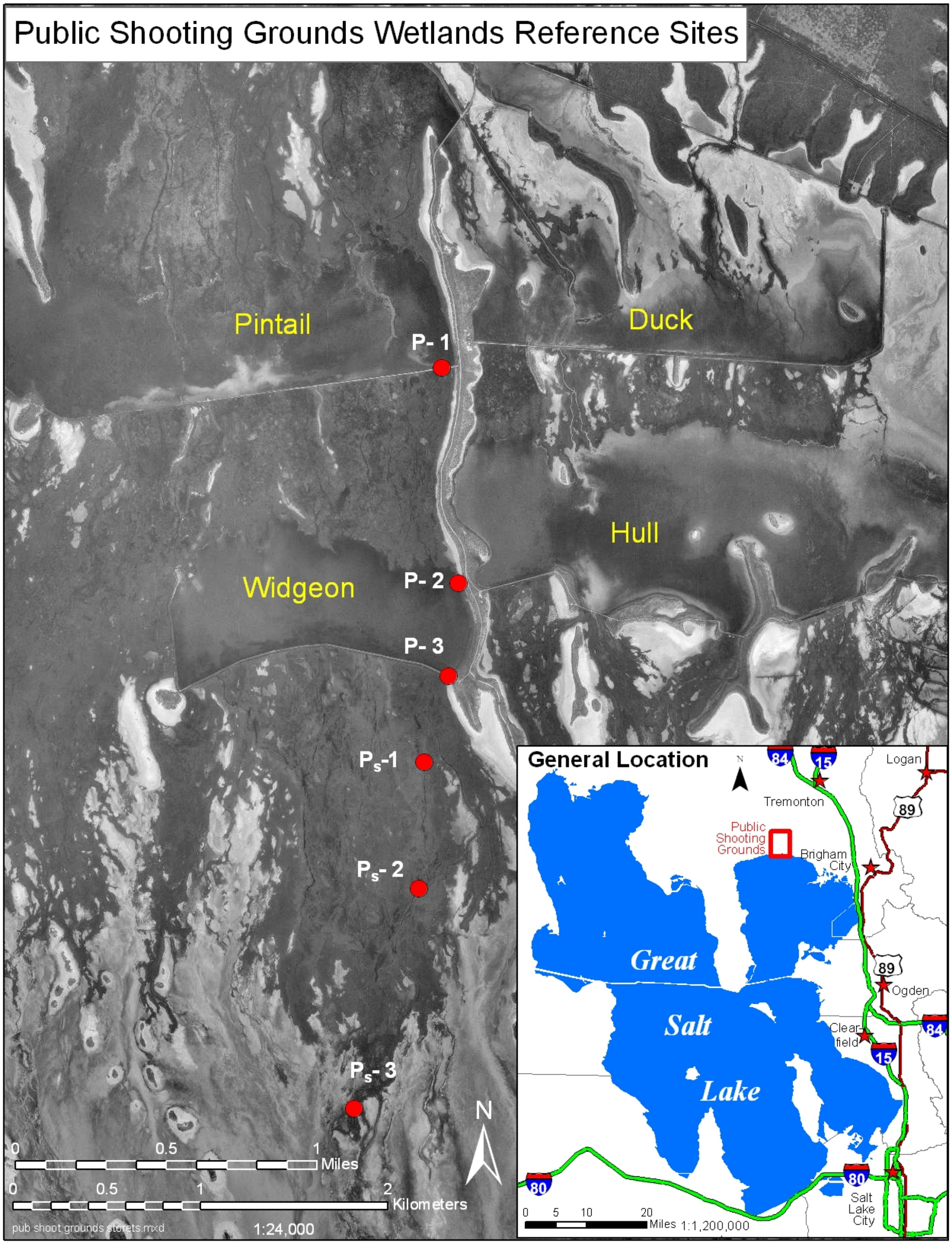


Figure 2.1.2. Wetland reference sites located in the Public Shooting Grounds Waterfowl Management Area in Bear River Bay.

Indeed there were long periods of time when no releases from these ponds occurred and this greater residence time likely resulted in greater assimilation of nutrients. Throughout the remainder of the locations, there was only a slight decrease in water column phosphorus concentrations as the water flowed toward the lake.

Biotic parameters included various macrophyte measures, such as percent aerial cover, stem height, species composition, tissue nutrient concentrations and ratios, and above ground biomass; phytoplankton and periphyton community structure; macroinvertebrate community composition; and phytoplankton and periphyton community composition. Abiotic factors in the water include total P, nitrate-nitrite, ammonia, metal concentrations, pH, EC, dissolved oxygen and temperature. Soil nutrient concentrations, pH and EC were also measured.

The lack of attenuation along our longitudinal transects prompted us to expand our statistical analysis to include factor analysis, which was valuable in identifying general relationships between water quality parameters and various biological response variables. Hence, we used univariate and multivariate analyses, including factor analysis and distance weighted least squares (DWLS). DWLS is a smoothing technique which allows the line to flex locally. Unlike linear or polynomial regressions, which force a line fit to a specific type of equation, the DWLS provides a true representation of the data. Factor analysis using invertebrate assemblages, biological measurements and physical/chemical factors was performed by Drs. Gray, Madon, and Hoven.

In addition, nesting and hatching success of more than one thousand pairs of black-necked stilts and American Avocets were monitored in order to perform a direct measure of beneficial use support. This study included forage availability and stomach analysis to identify food preference and availability. Some nesting habitat characteristics were also noted.

3.0 Results and Discussion

Targeted (nutrient-enriched) sites were identified in the delta area of Jordan River and included Farmington Bay WMA, the Newstate and Ambassador Duck Clubs and the Inland Sea Shorebird Reserve (ISSR). Reference conditions for impounded wetlands were identified at Public Shooting Grounds WMA (PSG) and reference conditions for sheetflow wetlands were identified at sites leading from the discharge point of the final impoundment of Public Shooting Grounds (Widgeon Lake) and at the mouth of Kays Creek. Kays Creek provides water to sheetflow wetlands from a natural (uncontrolled) tributary to Farmington Bay. Although we were careful to find the "cleanest and healthiest" reference sites possible, this proved to be difficult. For example, the Kays Creek reference site experiences considerable urban and agricultural runoff. Phosphorus concentrations routinely ranged from 0.1-0.3 mg L^{-1} total P. Therefore, phosphorus concentrations in the Kays Creek system fell somewhat mid-range between those measured at Public Shooting Grounds (0.02 to 0.05 mg L^{-1} total P) and those measured at the Central Davis Sewer District or North Davis Sewer District outfall (2.6 to 4.2 mg L^{-1} total P.

3.1 Vegetative Community Response

3.1.1 Impounded sites

Submerged aquatic vegetation (SAV) has been shown to be a sensitive indicator of water quality (Kemp et al., 1983; Orthe and Moore, 1983; Stumpf et al., 1999; Tomasko et al., 1996) and sentinel accumulators (Brix and Lyngby, 1983; Burrel and Schubel, 1977; Hoven, 1999; Ward, TJ, 1987; Wolfe et al., 1976) of anthropogenic stressors in shallow estuarine embayments worldwide. SAV provide myriad ecological functions to a watershed. They provide a protective environment and nursery function to invertebrates, fish, and shellfish; stabilize sediments; cycle nutrients and elements; attenuate nutrients and other pollutants; and filter suspended sediments. SAV requires relatively high levels of light and is susceptible to shading by algae (epiphytes, macroalgal mats, and / or phytoplankton), duckweed, suspended sediments, and water color. Increases in algal populations (blooms) are stimulated by increased nutrient loads and often associated with inputs from high human density and / or industrial areas or areas of agricultural runoff (Madden and Kemp, 1996; Staver et al, 1996) and have been shown to correlate with decline in aerial cover of seagrasses (Short and Burdick 1996, Valiela et al. 1997).

It should be pointed out that all of the impoundments along the Jordan River delta are managed for waterfowl support for nesting and fall migration. Because *Stuckenia sp.* is the preferred forage taxa by omnivorous waterfowl, the ponds are managed to optimize SAV growth and, indeed, the submergent plant *Stuckenia filiformis* (fine-leaf pondweed) dominated the impounded sites. *Ruppia cirrhosa* (spiral ditchgrass), another SAV, was present in the late-season samples of the more-saline ISSR ponds and the last pond of the Ambassador Duck Club. *Ceratophyllum demersum* (coon's tail) was also occasionally present in small proportions. There was also a varying amount of floating mats of filamentous green algae (primarily *Spirogyra sp.*), the Cyanobacterium *Oscillatoria* sp. (among others) and duckweed (*Lemna minor*), and epiphytic algae on the SAV at the targeted sites. Although duckweed is somewhat utilized by waterfowl, it is much less preferable than *Stuckenia*, and *Spirogyra* has no known value to waterfowl.

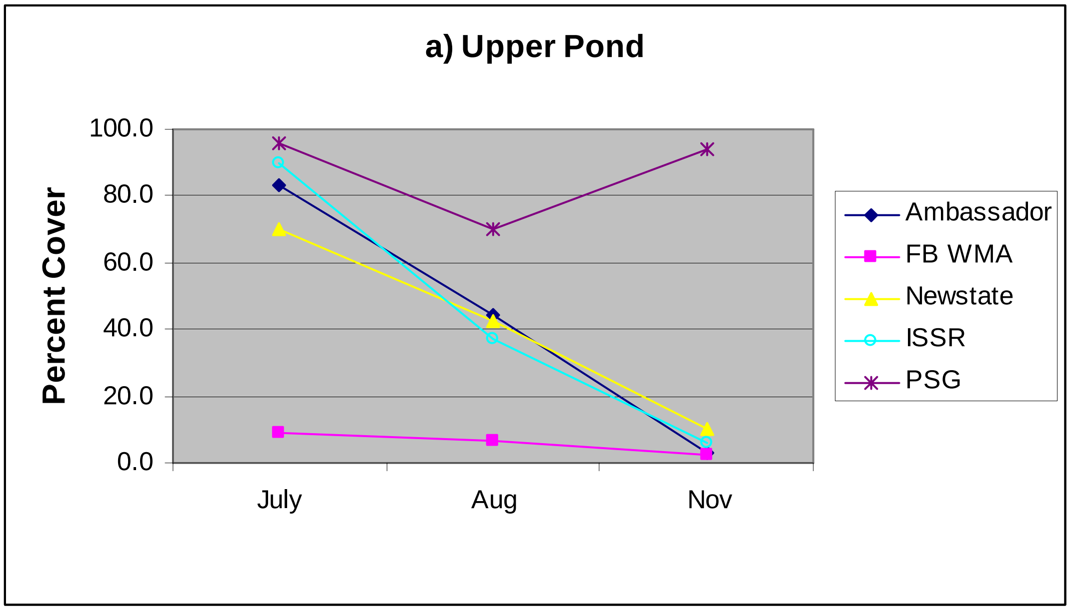
Seasonal biological and water quality sampling revealed substantial differences in plant community responses. The highest percent cover in the upper ponds at the targeted sites occurred in June and July and declined substantially from August through November (Figure 3.1.1a). Percent cover also varied dramatically between seasons at Newstate, Ambassador, and ISSR. Although the ISSR is specifically managed for shorebirds, its "upper pond" (South Pond B) is deep enough to grow *Stukenia* and attract waterfowl.

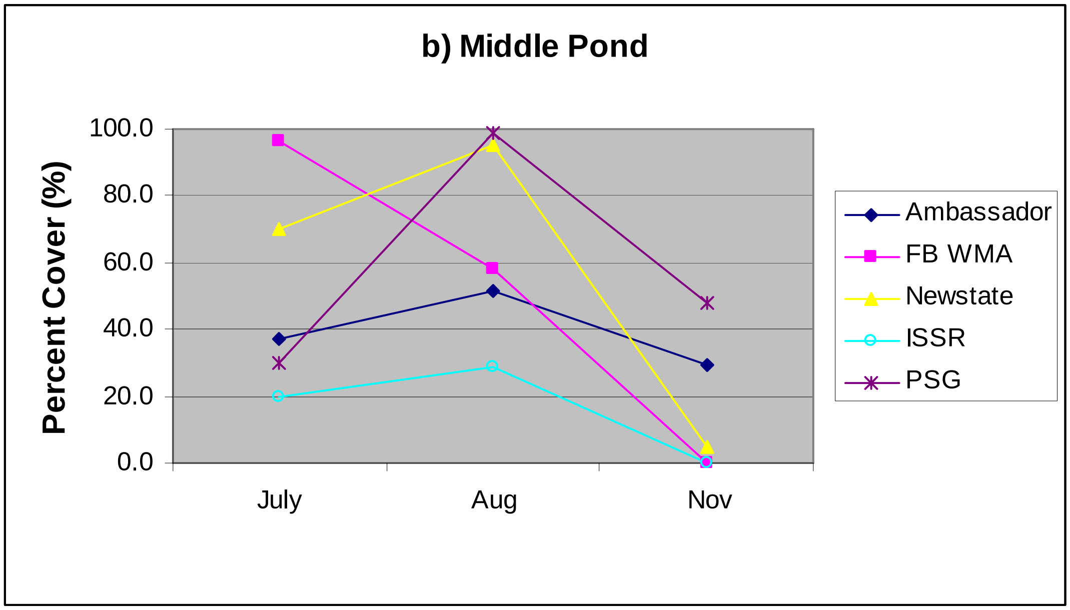
The middle ponds exhibited a hysteretic response in productivity (Figure 3.1.1b). With the exception of FB WMA, percent cover was 70 % or lower during July and increased during August. Percent cover in all ponds declined by November. The calcareous green alga, *Chara* sp., out-competed *Stukenia* for space at PSG middle pond and was the initial cause for low *Stukenia* cover during July. As the summer progressed, *Chara* was not observed and *Stukenia* became strongly established. As with all the impounded areas (except at the ISSR), carp removed a lot of vegetative material in search of macroinvertebrates. At PSG, carp grazing activity in conjunction with grazing pressure from waterfowl was likely the primary cause of reduced SAV cover. Yet, percent cover at

PSG was 2 to 4 times greater than that at the target site middle ponds during November, indicating that additional stress(s) other than grazing may be present at the target sites.

Percent cover SAV showed high percent cover at target site lower ponds at all but Ambassador during July and August (Figure 3.1.1c). The lower pond at PSG had 70 -80 % cover of *Chara* during these months so SAV cover was low in that pond. SAV in FB WMA, Newstate, and ISSR lower ponds declined in cover by November, while that in Ambassador rebounded somewhat. SAV in PSG, on the other hand, increased by November to comparable levels of the middle pond and had almost 3 times as much percent cover as the target sites.

It is possible that this seasonal decline in cover at target sites is a result of heavy grazing by waterfowl as they begin to congregate during mid- to late August. This would be particularly true for Unit 1 of the FB WMA whereby it is managed as a waterfowl resting pond and hence no hunting is allowed. Various waterfowl species readily learn this and congregate in great numbers in Unit 1. Thus, it might be expected that foraging activity would be reflected by the SAV percent cover data as vegetation is intensively uprooted and consumed. However, the Public Shooting Grounds are also managed for waterfowl where SAV did not decline in cover at all (upper pond) or as much (middle and lower ponds) as that at target sites and declines in percent cover of target site SAV was observed before large populations of birds arrived (SAV decline in the upper ponds was observed well before early to mid- September when waterfowl densities are greatest). Summer and fall water quality factors were determined following the factor analysis methods outlined in Madon, 2004 and 2005 (Appendixes A.1, A.2). Of the eight parameters used, TSS, conductivity, and temperature explained the least amount of variability when ordinated in the second and third factors and hence, were excluded to reduce the data to one factor. All water quality data were transformed by Log10, (Log10 (x + 1) for zeros). All % cover data were transformed by arcsine√x, arcsine(square root((0+3/8)/(15+3/4)), for zeros after Anscombe (1948). When % cover of SAV is compared with a water quality factor by season (summer vs. late fall) using regression analysis (analysis of variance), most of the impounded sites of this study showed moderate to abundant % cover SAV in the early through late summer and there was no significant difference among sites ($p = 0.364$). By the fall, most sites showed a decline in % cover with increasing nutrients and DO, with the exception of Public Shooting Grounds reference ponds, which had significantly higher % cover SAV than the other ponds (Figure 3.1.2, $p = 0.144$). This occurred even though water column P in PSG remained very low (circa 0.02 mg L^{-1}; and water column concentrations in the target impoundments remained > 0.2 mg L^{-1}).


a) Upper Pond
Percent Cover
100.0
80.0
60.0
40.0
20.0
0.0
July
Aug
Nov
Ambassador
FB WMA
Newstate
ISSR
PSG


b) Middle Pond
Percent Cover (%)
100.0
80.0
60.0
40.0
20.0
0.0
July
Aug
Nov
Ambassador
FB WMA
Newstate
ISSR
PSG

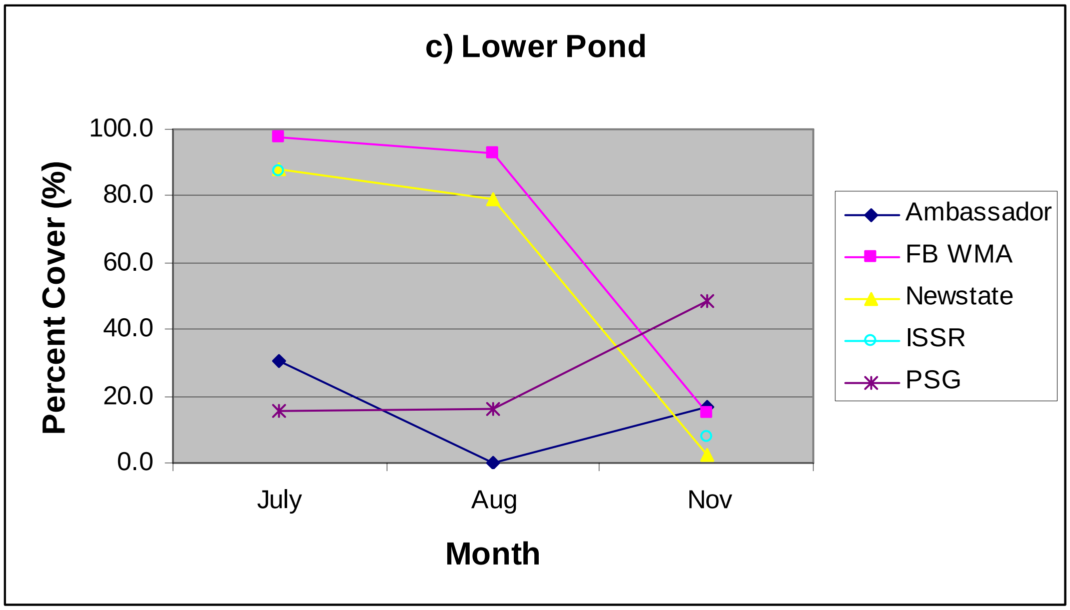


Figure 3.1.1. Seasonal changes in percent cover of SAV for the (a) upper, (b) middle, and (c) lower ponds of our reference system (Public Shooting Ground) and three target systems.

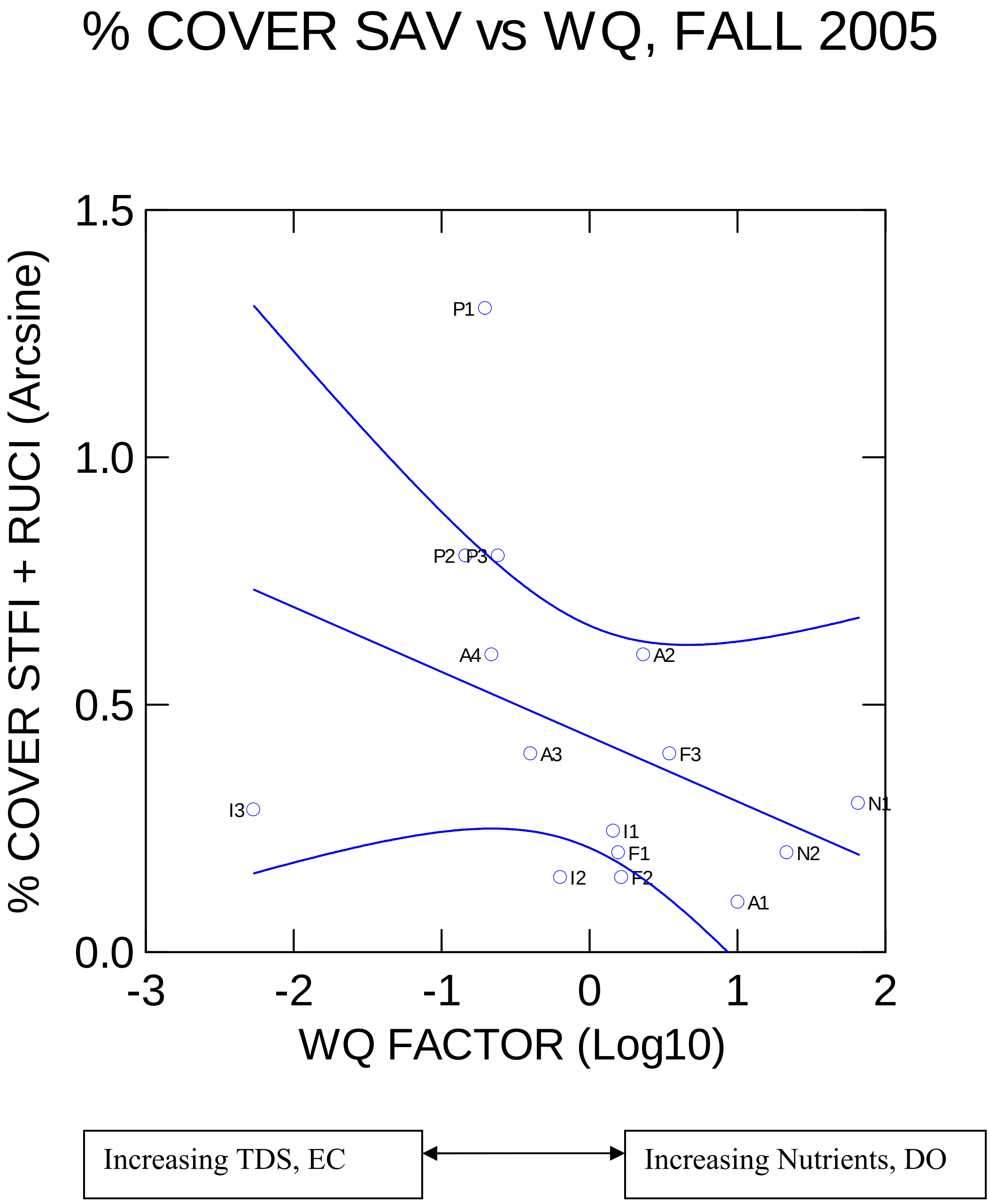


Figure 3.1.2 Percent cover of dominant SAV (*Stukenia filiformis* and *Ruppia cirrhosa*) versus water quality factor at target and reference ponds during the fall of 2005, $p = 0.144 \pm 95\%$ confidence interval.

This might appear to contradict the paradigm that lower nutrient concentrations should result in less biomass and more nutrients should support greater biomass. However, there are two important factors that support this apparent contradiction:

1) Both emergent and submergent vegetation can derive all of their N and P requirements from sediments (Thiebaut and Muller 2003, Carr and Chambers 1998, Madsen and Adams 1988, Carignan and Kalff 1980). Indeed, Canfield and Hoyer 1988 and Peltier and Welch (1969) found no relationship between macrophyte growth and water-column P and N concentrations. Carignan and Kalff (1980) reported that nine common species of aquatic macrophytes, including *Stuckenia pectinatus*, took all of their phosphorus from the sediments when grown in situ in both a mesotrophic and a mildly eutrophic bay. Even under hypereutrophic conditions, the sediments contributed an average of 72 percent of all the phosphorus taken up during growth. Therefore, submerged macrophytes in PSG obtain adequate nutrients from their associated sediments regardless of nutrient levels in the water column.

2) There is considerable evidence that the early senescence and loss of % cover in the target impounded sites and particularly in comparison to the reference ponds at the Public Shooting Grounds are the result of degraded water quality and related effects rather than normal seasonal changes. Total water column P in the target impounded sites was consistently more than an order of magnitude greater than in the PSG ponds and may be the driving factor that is overwhelming those systems. Often heavy epiphytic biofilms (including sediment) were observed on the leaves of the SAV, and floating and entangled mats of macroalgae (Chlorophyta and Cyanophyta) and duckweed were frequently present at the target sites where nutrients were elevated. The “premature”- senescence of SAV was likely induced by shade-related stress to the SAV by the epiphytic and macro-algal communities, and duckweed in some cases. Additionally, as percent cover of the SAV declines, suspended sediment from the wind events remains in the water column for longer periods since there is no physical structure (i.e. plants) to slow water currents and facilitate settling and water clarity (Short and Short, 1984; Ward et al. 1984). This turbidity causes additional stress on the remaining SAV due to reduced light.

Although somewhat lower, sediment P concentrations in PSG are in the same range as those in the targeted impoundments (see Section 3.4) yet SAV did not show a premature senescence as in the target sites. A simulation of eutrophication responses in submersed estuarine plant communities showed several important responses under nutrient-enriched conditions that may have implications for the Farmington Bay target sites (Madden and Kemp 1996). Epiphytic algal biomass was stimulated by an order of magnitude, while SAV biomass declined severely under both N + P enrichment. Phosphorous enrichment alone has not been shown to trigger community shifts in estuarine production but when N + P enrichments are introduced to mesocosm experiments and model simulations, epiphyte production can be exponential, while attenuating light to deleterious levels to SAV (Madden and Kemp, 1996; Taylor et al., 1995 and 1999). While N levels in most of the target ponds are low to negligible, it may be possible that the observed high occurrence of cyanobacteria provide enough fixed nitrogen locally to support heavy epiphytic growth (Powell et al. 1989). Additionally, N_2-fixing heterotrophs and cyanobacteria associated with duckweed mats have been found to fix as much as 15-20 % of the nitrogen requirement for duckweed (Zuberer, 1982), a substantial amount that could also contribute to the localized water column pool for SAV. The increased density and coverage in duckweed, and filamentous and epiphytic algae in response to increased nutrients has been well documented (Vaithiyanathan and Richardson 1999, Portielje and Roijackers 1995, and others). Accordingly, where nitrogen is limited, rich populations of epiphytic, nitrogen-fixing Cyanobacteria most often accompanies duckweed populations (Duong and Tiedje 1985, Zuberer 1982, Fink and Seeley 1978). This ability to manipulate nutrient availability provides a symbiotic relationship that favors a floating duckweed community. In turn, increased shading and concomitant increased tendency toward anoxia deeper in the water column may severely restrict health and survival of submerged vegetation (Morris et al. 2004). Further, Madden and Kemp (1996) found epiphytic growth on SAV in nutrient enriched scenarios became more dense as leaf tissue area decreased due to leaf mortality and sloughing and was an important factor in the decline of SAV due to increased shading - more so than turbidity related to phytoplankton blooms.

Another important conclusion from Madden and Kemp (1996) was that long-term shading stress to SAV in enriched environments inhibits carbon storage in root and rhizome tissues. SAV roots and rhizomes can provide a root buffering effect such that carbon stored from production periods is reserved for reproduction the following spring. When Madden and Kemp (1996) ran their model for successive years under sustained nutrient enrichment, detrimental epiphyte loads lead to negative P:R (production to respiration ratio) and resulted in reduced SAV biomass, reduced carbon stored in the roots and rhizomes, and ultimately a decreased reproductive potential. They concluded that a “root buffering effect” is essential for long-term survival of SAV beds and to restore plants to historic levels would likely require improvements to water quality that persist for several years to allow root rhizome systems to become re-established.

In Farmington Bay target ponds, it is likely that epiphytic growth on the SAV leaves and presence of algal mats and duckweed attenuated light below critical levels required by *Stukenia* and lead to a premature senescence of SAV. This condition was likely exacerbated as fall progressed and photoperiod and sun angle diminished. During fall collections at target ponds, SAV roots and rhizomes of remaining shoots were often rotting or not well developed (the only exceptions were ISSR T2 (West Pond A) and T3 (Southwest Pond South) and Ambassador T3 (W2) and T4 (W5) where *Ruppia cirrhosa* dominated; Hoven, personal observation). With reduced photosynthetic capacity and resultant reduction in oxygen transport to the roots, below ground tissue may have been susceptible to sulfide toxicity and / or infection by pathogens such as slime mold. Also, germinating seeds were frequently found in the sediment of target sites during the late summer through the fall. On the other hand, plants at the PSG reference ponds grew densely and were difficult to pull (i.e. their roots and rhizomes were well developed and strong) as late as December. Although the plants are perennial, it is likely that roots and rhizomes of SAV at target sites lack carbon stores to regenerate each spring and rely heavily on seedlings each year to maintain the beds.

When C:N:P ratios of similarly aged SAV leaves are compared between target and reference sites during July, all but one target site (Ambassador T2, pond 100) show carbon limitation and all sites (both target and reference) show nitrogen limiting ratios according to Redfield C:N:P ratios of organic matter, 106:16:1 (Table 3.1.1; Redfield, 1934). By late fall, most target sites lacked enough plants to provide enough leaf sample for analysis or were lacking plants altogether. Those that had plants, showed even lower carbon ratios (with the exception of a gain in both carbon and nitrogen above limiting levels at FB WMA T1, Unit 1). Presumably, the improved tissue nutrient ratios at FB WMA Unit 1 during the fall reflect inputs from the pond's use as a rest area for waterfowl; and new SAV growth in grazed areas at that unit may have had less of an epiphyte burden at that time of year and better photosynthetic capacity to fix carbon than during the summer months. However, there was limited SAV cover at that time of year (Figure 3.1.1.a). During the summer, plants at target sites are either competing for carbon with algal and duckweed communities (but not likely since SAV tissue carbon levels are consistent across all sites – see discussion below) or they are not photosynthesizing at optimum capacity due to low light levels a the leaf surface. Although slightly nitrogen limited, reference site plants are better poised to translocate fixed carbon to their roots and rhizomes as they have surplus carbon in their above ground tissue during the summer and fall. Nitrogen is non-limiting at the reference site, PSG T2, and nearly so at PSG T1 during the fall. When the nutrient concentrations of SAV leaf tissue is compared among sites and season, certain patterns come to light. Tissue carbon remains fairly constant at both reference and target sites during the summer and fall (Figures 3.1.3 and 3.1.4). SAV leaf N and P concentrations, however, reflect differences in available N and P levels in the water and sediment. In particular, SAV assimilated high levels of P at the target sites where P is elevated in the water and sediment, and maintained low levels of P at the reference sites both during the summer and fall. When tissue P levels are high, carbon levels remain generally constant, and N levels are low to only moderate, the plants are not functioning at optimum nutrient ratios.

Table 3.1.1 C:N:P of summer and fall SAV above ground tissue for reference and target sites, 2005; n = 3 for all sites. PSG = reference ponds.

SITE	July	November
AMBAS_T1	61:6:1	-
AMBAS_T2	111:10:1	97:9:1
AMBAS_T3	89:8:1	-
AMBAS_T4*	87:8:1	67:7:1
FBWMA_T1	75:5:1	176:19:1
FBWMA_T2	55:4:1	-
FBWMA_T3	79:5:1	58:6:1
ISSR_T1	86:7:1	-
ISSR_T2*	100:8:1	-
ISSR_T3*	73:8:1	-
NEW_T1	72:8:1	-
NEW_T2	90:9:1	-
NEW_T3	76:8:1	-
PSG_T1	166:11:1	188:14:1
PSG_T2	202:14:1	220:16:1^
PSG_T3	205:14:1	161:12:1

**Ruppia cirrhosa*, all other samples were *Stuckenia filiformis*; ^ = collected first week of December; - not enough plant material could be collected for nutrient analysis.

The analysis of the Phase I Farmington Bay SAV % cover data shows a reduction in SAV productivity (expressed as a decline in % cover) in nutrient enriched (target) sites compared to low nutrient (reference) sites. Shading caused by the observed (but not measured) overgrowth of epiphytic and macroalgal communities likely contributed to this low production. In turn, this epiphytic growth may be linked to the elevated P in the water column. A more thorough analysis that would include parameters such as light attenuation across nutrient regimes, biomass assessments of both SAV (as g dry weight · 0.25 m $^{-2}$) and epiphytes (as chl a), chl a from the water column, and chl a and fluorescence from SAV tissue could better define nutrient and light thresholds below which SAV in the impounded sites can maximize their productivity. Thus, percent cover of SAV may be an important metric for assessing wetland condition and, with refinement, a suite of metrics in SAV communities could be useful in assessing overall wetland condition.

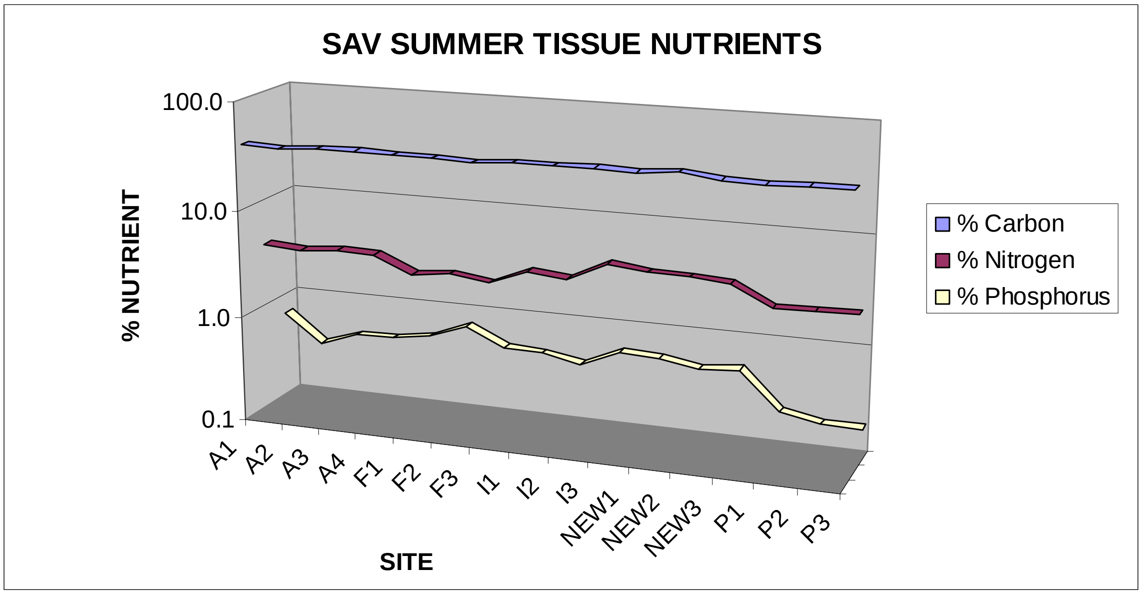


Figure 3.1.3 Percent carbon, nitrogen and phosphorus in SAV summer tissues, 2005. P = Public Shooting Grounds reference ponds.

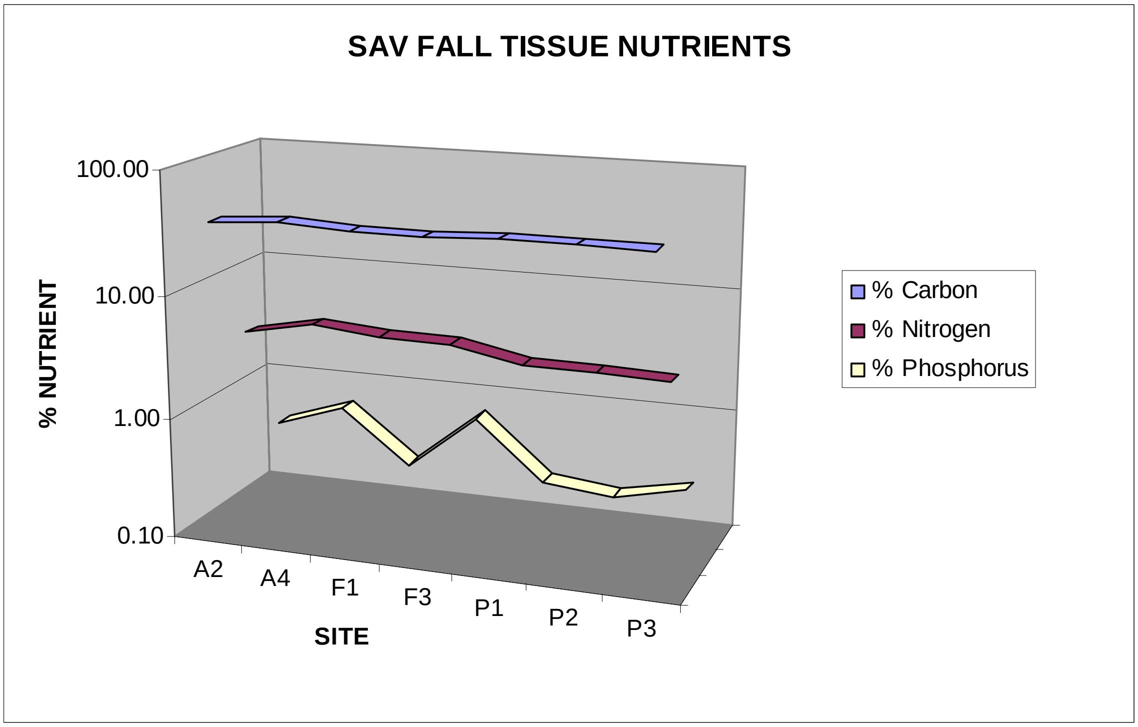


Figure 3.1.4 Percent carbon, nitrogen and phosphorus in SAV fall tissues, 2005. P = Public Shooting Grounds Reference ponds.

3.1.2 Vegetative Community Response at Sheetflow Sites

Statistical analyses of the Farmington Bay data (Appendix A.1 and A.2) assesses trends between a water quality (WQ) factor and percent cover of dominant species (Madon 2004) and community response as presence of native, introduced and invasive species (Madon 2004 and 2005). There are several parameters that were sampled during both years, yet, have not been completely assessed due to time constraints and intuitive focus on key parameters. This summary reviews the results of the statistical analysis and presents a cursory overview of additional relationships and interpretations of the data.

Dr. Madon conducted three tiers of statistical analyses on water and sediment quality parameters versus various plant community measurements from the sheetflow sites and univariate analysis on water quality parameters versus biotic variables (Appendix A.1 and A.2). Many measurements of the plant community were inversely related to water and soil pH. These included *Typha* and *Phragmites* % cover, and *Scirpus americanus* and *Distichilis spicata* stem height. A list of general conclusions summarizes these preliminary results (Appendix A.2; page 26 and 27.) The 2005 spring and summer data were initially combined for analyses (Appendix A.2). This seasonal data will be re-analyzed separately because understanding system function often depends upon temporal trends.

Water quality and water quantity are central to understanding community responses within emergent wetlands of Farmington Bay. Nitrogen (NO_3 and NO_2) rapidly attenuates with distance from the source (except at NDSD where, because of the large volume and short distance to the open water, N remains high along all three sampling sites, Section 3.4). Phosphorus, on the other hand, is often maintained at the same (or in some cases, higher) levels with distance from the source waters. Salinity increases with distance from the POTWs and WMAs.

At the first two transects of CDSD (C1 and C2), there is consistent, high flow rate and high nutrients (low WQ) and low number of native yet invasive species of plants (*Phragmites australis* and *Typha latifolia*). As the effluent moves through these areas, nutrient uptake by plants and its resultant nitrogen attenuation in the water column should be reflected in the primary productivity of the plants (as above ground biomass (AGB)) until increasing salinity begins to limit growth of non- salt tolerant species. Unfortunately, however, there was a quality control issue with the 2005 AGB samples at a subcontracted laboratory and the data from all sites was lost. When the flow rate dissipates by the third transect (C3), the number of native species increased but many of the species have invasive tendencies. The fourth transect (C4) is much further from the POTW (approximately 2 kilometers), and salinity is elevated. There is a decrease in the number of native species at this point and none of them are invasive. There was a moderate reduction in nutrients at C4. Similar community responses of vegetation along flow and salinity gradients occurred at NDSD.

Total number of native species from each site was plotted against the water quality factor (Fig. 3.1.5). Transects C1 and C2 fall at the negative end of the water quality factor with low species diversity including native invasive species and low water quality (high nutrients) yet the span of wetlands that the transect data reflects provides for N attenuation in the effluent. Phosphorus, on the other hand, does not attenuate as the effluent passes through these and subsequent transects – suggesting that P absorption by plants in this system is maximized. Yet, the threshold of maximum P assimilation by wetland plants in this region is not well understood, however, further discussion on this issue is presented in Section 3.5 below.

NDSD transects 1 (N1) and 2 (N2), C3, Kays Creek transects 2 (K2) and 3 (K3) fall in the mid-range of the water quality factor and may be showing a threshold response. Under certain conditions: eg. moderate flow, encompassing a sediment deposition zone, moderate to moderately high nutrients, and in some cases, other disturbance (eg. cattle, four wheeler activity), the number of native species increased, but the proportion of invasive species is also high. The increased proportion of invasive species is indicative of an imbalance in the system where elevated nutrients and other disturbances such as erosion and sediment deposition allow for their proliferation. It is not clear at what level nutrients and other disturbances trigger proliferation of invasive species. Thus, this mid-range of the water quality factor may be showing a tipping point leading to disturbance-based community responses (a fulcrum), or an apex of maximum disturbance. At the positive end of the water quality factor, FB WMA transects 1 (Fs1) and 2 (Fs2) and Public Shooting Grounds (PSG) transects 1 (Ps1), 2 (Ps2) and 3 (Ps3) showed reduced number of native species, reduced number of invasive species and moderately high to high water quality.

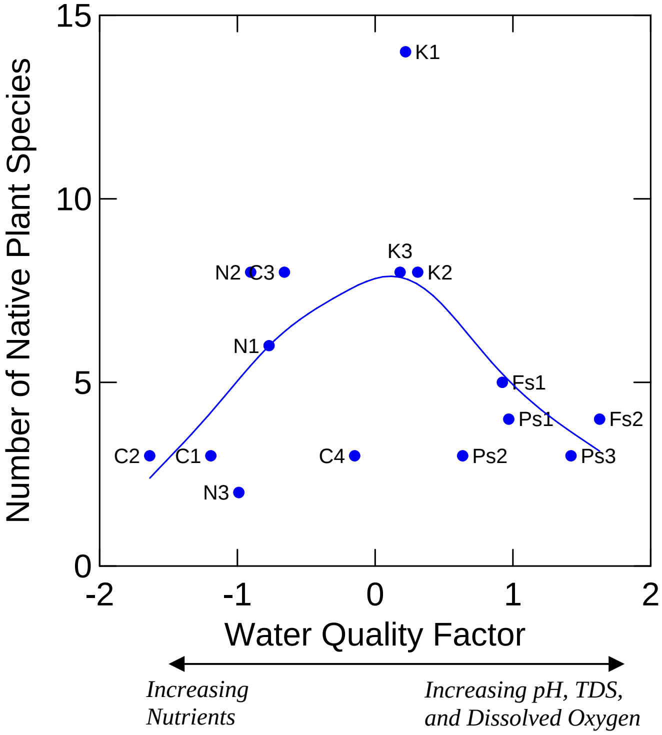


Figure 3.1.5. Total number of native species versus water quality factor at sheetflow sites, 2005. (From Maden, 2005; Appendix A.2)

FB WMA sheetflow sites have moderate levels of salinity (measured as electrical conductivity, EC, and total dissolved solids, TDS) and PSG sheetflow sites are more saline compared to other sites, so it is not clear whether salinity alone is responsible for limiting the occurrence of some invasive species found elsewhere.

There were no sites with nutrient levels between those of Kays Creek and Fs1, Ps1 and Ps2 and that had low EC or TDS so we are unable to exclude salinity as the only factor that kept invasive species in check. There may be conditions where natural competition from native, non-invasive species is not compromised, but those conditions do not appear to be described by the current data.

Unlike the impounded sites, plant tissue analysis in sheetflow sites indicated that nitrogen is limiting at only a handful of sites (FB WMA and KC T1 and T3 during the early summer, and CDSD T1 and T2, KC T1 and NDSD T1 during the late summer, Table 3.1.2). Because N:P ratios vary more among sites than among species, it is possible to compare sites for limiting nutrients using various species (Güsewell and Koerselman, 2002). It is clear that plants at CDSD, NDSD, and PSG are not N limited with any distance from the source water during the early summer (gray shaded ratios). At PSG, there are many springs within the sheetflow area that supplement the outflow from the impounded outlets and may prove to be sources of nitrogen for the plants. By the late summer, plants at CDSD T2 and T3, and NDSD T1 became N limited, while all sites at FB WMA were not N limited.

Nutrient concentrations of the same-aged leaves of the dominant species at each site are shown in Figure 3.1.6 (early summer) and Figure 3.1.7 (late summer). Variations within sites that have a shift in dominant species with distance from source waters (and increase in salinity) may reflect different assimilation capacities between species (Güsewell and Koerselman, 2002). However, plants at sites with either high N or high P generally reflected high water nutrient concentrations in their tissues (see Section 3.4).

Some anecdotal descriptions of the study sites are worth noting. Flow rates differed among sites and could contribute to the various vegetative community responses. For example, NDSD has a much higher volume of effluent than CDSD and although braided channels form, the velocity remains high enough to limit macrophyte growth within the channels. However, considerable deposition occurs between these channels as well as downstream. These areas of higher elevation provide a different environment for wetland plants than within the channels (soils may be saturated but are not inundated all the time), allowing increased species diversity. Yet, the scouring from erosional forces of water and sedimentation would limit species composition to plants that can tolerate that kind of disturbance. CDSD effluent volume is about 1/3 that of NDSD and, rather than form channels, flow rates are slow enough to allow emergent vegetation to develop in the immediate vicinity of the discharge point. Consequently, substantial spreading of the water occurs to form a true sheetflow condition with very few areas of deposition.

Springs were present throughout the PSG sheetflow site and may cause variability in WQ and plant community composition. The hydrology at Kays Creek varies from year to year such that water flowed from the bank in a southward direction during 2004 and continued through the transect areas. During 2005, debris in the main channel diverted flows to the north side of the bank, leaving the original K1 location dry. Therefore, all three sampling stations were re-established on the north side of the main channel in order to capture consistent flows. During 2004, Kays Creek management sprayed the wetlands by air for Phragmites control. The following year showed very little growth of all plant species (even by the early summer) and the longitudinal transect was discontinued.

In addition to factors affecting hydrology and WQ at several sites, we noted two additional sources of disturbance at Kays Creek. Cattle use the area for grazing and likely increase nutrient levels in surface flows and contribute to the observed increase in invasive species (through trampling existing vegetation and the soil, and seed transport via hoofs / hide and manure). There was also a considerable network of four-wheeler trails for mosquito control applications at Kays Creek and somewhat at CDSD for spraying and sampling purposes.

Table 3.1.2 N:P ratios of emergent vegetation at sheetflow sites during early summer (June) and late summer (August / September) of 2005; n = 3 at all sites.

Site	**Species**	**Early Summer**	**Late Summer**
CDSD_T1	TYLA	20:1	18:1
CDSD_T2	TYLA	20:1	13:1
CDSD_T3	SCMA	21:1	12:1
CDSD_T4	SCMA	21:1	17:1
FBWMAs_T1	PHAU	14:1	23:1
FBWMAs_T2	TYLA	11:1	17:1
FBWMAs_T3	TYLA	13:1	22:1
KC_T1	TYLA	13:1	11:1
KC_T2	SCMA	16:1	-
KC_T3	SCMA	15:1	-
NDSD_T1	PHAU	26:1	15:1
NDSD_T2	SCMA	19:1	23:1
NDSD_T3	SCMA	18:1	19:1
PSGs_T1	SCMA	18:1	25:1
PSGs_T2	SCMA	20:1	30:1
PSGs_T3	SCMA	19:1	28:1

Species codes are as follows: TYLA = *Typha latifolia* (cattail), SCMA = *Schoenoplectus maritimus* (alkali bulrush), PHAU = *Phragmites australis* (Phragmites). Gray = N limiting; - sites not sampled. Note species vary within some sites and among sites.

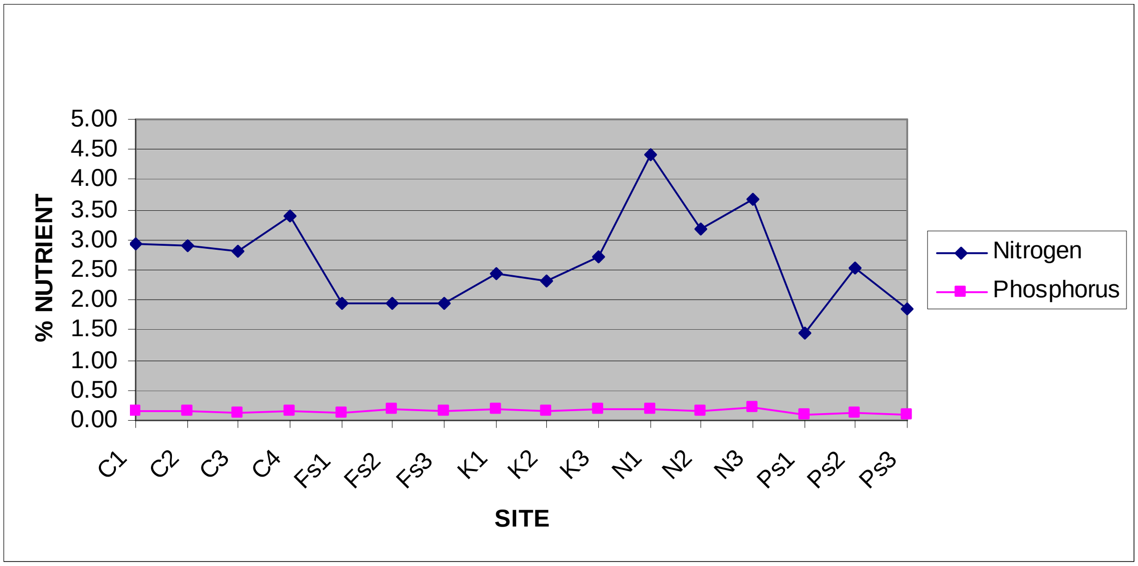


Figure 3.1.6 Percent tissue nutrients (nitrogen and phosphorus) in emergent leaves, early summer 2005; n = 3 at all sites.

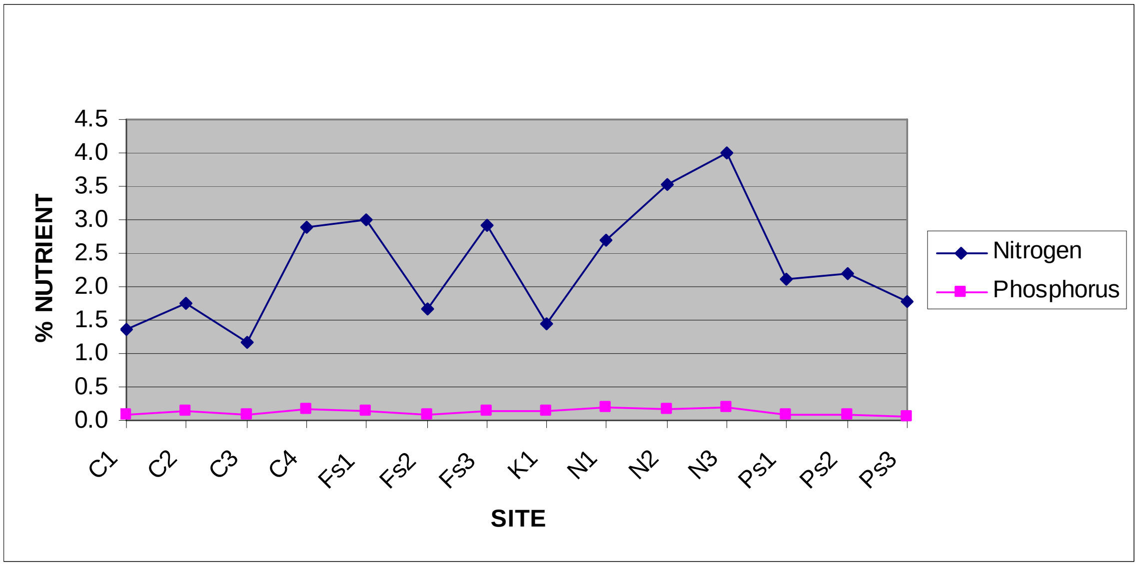


Figure 3.1.7 Percent tissue nutrients (nitrogen and phosphorus) in emergent leaves, late summer 2005; n = 3 at all sites.

3.1.3 Summary of Data Gaps

Additional understanding of the ecosystem and refinement of metrics can be achieved if some of the gaps identified in the data are addressed. Results of our initial efforts at impounded sites indicate that SAV can be useful indicators of stressors in their sub-watersheds and development of metrics based on parameters describing the SAV community shows good potential. Additionally, detailed measurements of nutrient loading, DO, light attenuation and turbidity and other known stressors (e.g. metals) in relation to SAV biomass and % cover may isolate and identify nutrient and turbidity thresholds of SAV impacts, including poor production, premature senescence and loss of below ground carbon stores for future re-growth.

At sheetflow sites, further assessment of biomass relative to nutrient loading and assimilative capacity of nutrients by emergent species will help define the condition of the wetland and its sub-watershed. Additional research needs to focus on identifying potential stressors at low to moderate energy sites i.e. anoxia, sulfide toxicity, nutrient loading, other biological and chemical disturbances versus a high energy system with higher flow rates (a system that is dominated by physical stresses that may either correlate with or confound nutrient related stresses). Although we observed higher above ground vegetative biomass at CDSD (C1, C2, C3), NDSD (N1, N2), and FB WMA (Fs1, Fs2) than reference PSG sheetflow sites, the target sites were composed primarily of Phragmites and cattail versus saltgrass, which also has invasive tendencies but is a much smaller plant. Both Phragmites and cattail are well documented for removing nutrient burdens from water as a form of treatment and are acceptable in performing such functions, However, current loading rates (~ 8-12 g m^{-2}) exceed recommended values (2 -4 g m^{-2}). This brings into question the actual efficacy of Phragmites and cattail to remove nutrients in this situation. Further assessment of biomass relative to nutrient loading and assimilative capacity of nutrients by emergent species would provide a metric for determining whether sheetflow sites outside of POTW and WMAs are capable of treating nutrient enriched water.

The following identifies additional studies that would improve our understanding of these wetlands and provide for additional and potentially important metrics that will contribute to a more complete and accurate assessment of beneficial use support.

3.1.3.1 Impounded

- Effects of light attenuation by epiphytes (with a control for duckweed and macroalgae) on submergent plant community
- Biomass comparisons of SAV communities among sites (as chl a of phytoplankton and epiphytes, and g dry weight SAV/ unit area)
- Turbidity as TSS in the water column (vacuum pumped and filtered portion of the water column)
- SAV as indicators of watershed stressors by assessing Photosystem II fluorescense
- Fall carbon stores in SAV roots and rhizomes in nutrient enriched sites vs low nutrient (reference) sites
- Sulfide toxicity as acid volatile sulfides (AVS)
- Statistical interaction between grazing activities from carp and % cover of SAV in nutrient enriched versus low nutrient (reference) sites
- Differences in grazing pressures from waterfowl by site and by season

3.1.3.2 Sheetflow

- Flow data and influence of velocity and channel depth on vegetative community structure
- Sedimentation rates and identification of deposition zones
- Are sulfates / sulfides overwhelming the oxidizing capacity of roots / root zones (AVS analysis)
- Relationship of AGB (and plant height and % cover) to soil and water nutrients
- Continued literature research on tolerance to various stressors (nutrients, velocity, suspended sediments, salinity, heavy metals, etc.) by species
- Nutrient assimilation capacity of wetland plants (empirical and literature research)
- Freshwater, low nutrient response of wetland plant community (all metrics)
- Is there a reasonable distance / wetland acreage for various flow rates through wetlands that renders acceptable nutrient attenuation during low lake-level years under current loading conditions?
- Are there management alternatives at POTW and WMA outfalls that might improve the biological integrity of their sheetflow sites?
- Finally, will any wetland or POTW design alternatives or combination thereof sufficiently reduce nutrients to a level that will improve the eutrophic conditions of the open water of Farmington Bay? (i.e. reduce cyanobacterial blooms, elevate DO and increase aquatic life diversity.)

3.2 Macroinvertebrate Communities

Invertebrate sampling was performed during late fall in 2004 and during summer and early fall in 2005 at the sheet flow sites and during summer, early fall and late fall in the impounded sites.

Univariate and multivariate statistics were used. Univariate analyses that were particularly useful include the responses of various taxa to water or soil pH. These include mayflies (Fig. 3.2.1a), corixids (Fig. 3.2.1b) and midges (Fig. 3.2.1c). Notably, abundance of these taxa began to decline at pH values between 9 and 9.5.

In addition to their sensitivity to pH, mayflies exhibited sensitivity to DO (Fig 3.2.2). However, the accuracy of this observation may be suspect. For example, diel DO measurements made among all of the study sites demonstrated that DO dropped to near or below 1 mg L^{-1} in most of these ponds during evening hours. Yet, mayflies were found in all of the Ambassador ponds during all three sampling periods and were occasionally found in the Newstate ponds. Hence, it is possible that this mayfly (*Calibaetis* sp) is more sensitive to pH or perhaps some other habitat parameter that has not been evaluated yet. For example, samples collected in the emergent vegetation along the pond fringes vs the submergent habitat will be performed during 2007.

Factor analysis was also performed on these data sets. When comparing water chemistry with macroinvertebrates, the primary chemical factor included the alignment of increasing pH, conductivity, total P and decreasing dissolved oxygen on the X axis being associated with increasing numbers of chironomids and leeches on the Y axis (Fig.3.2.3). Conversely, decreasing pH, EC, Total P and increasing DO was associated with increasing numbers of mayflies, odonates and hemipterans.

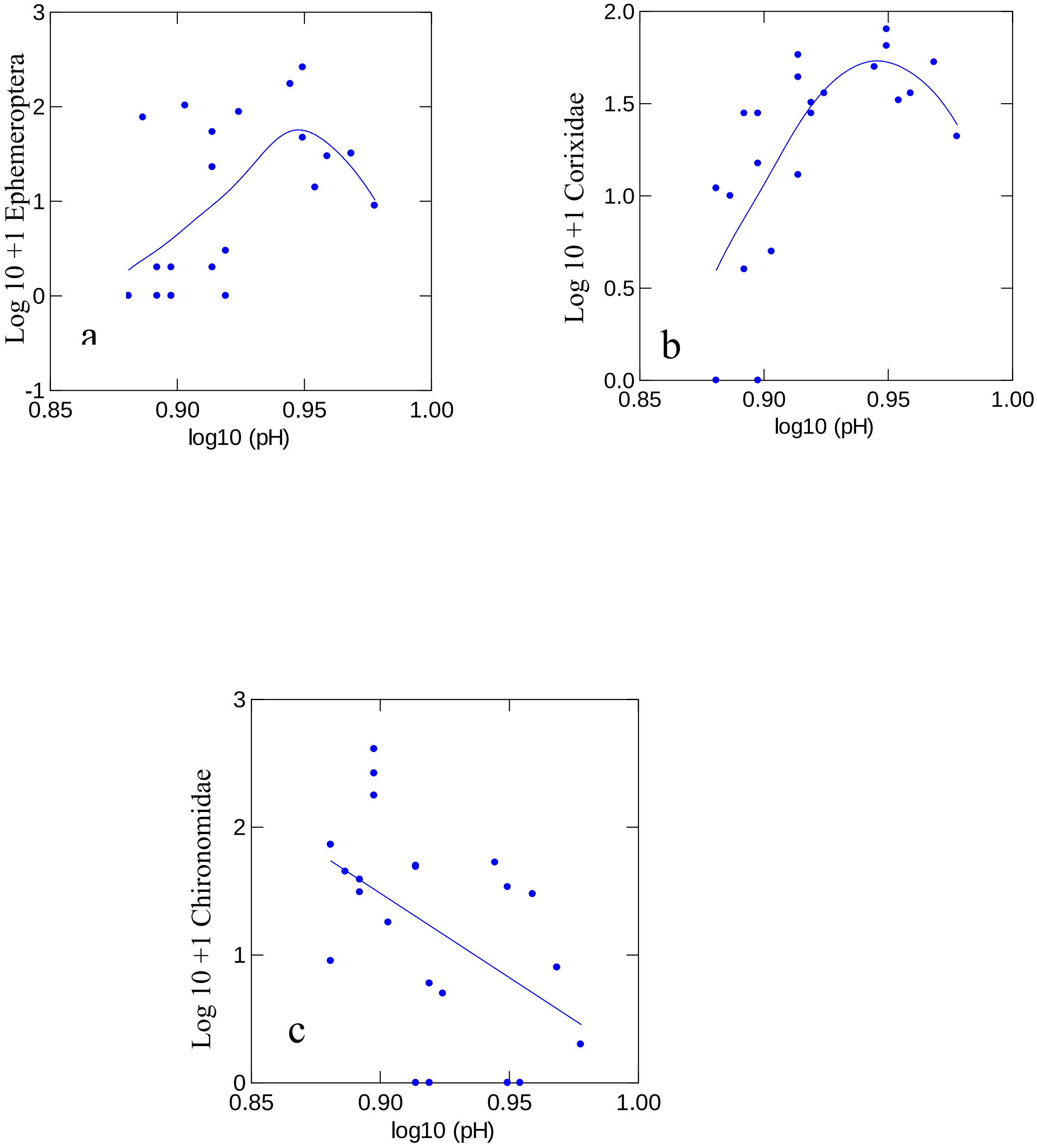


Figure 3.2.1. Responses of mayflies (a) Corixids (b) and midges (c) to differences in pH. For reference, the antilog of 0.96 equals pH 9.1.

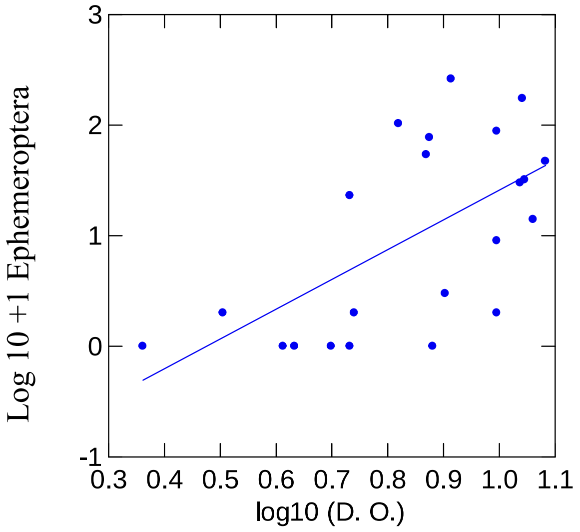


Figure. 3.2.2. Occurrence of mayflies (*Calibaetis* sp) in relation to dissolved oxygen.

The relationship between invertebrate and vegetation factors was also evaluated. Invertebrate communities dominated by mayflies, damselflies, water boatman, scuds (*Hyallela azteca*) and snails occurred at sites dominated by Stuckenia (generally impounded sites) (Fig. 3.2.4a). Conversely, sites dominated by midges, flatworms and leeches occurred where Phragmites, cattails and both Scirpus species were the dominant plant species (generally sheet-flow sites). This was also reflected in the multivariate factor analysis on the invertebrate, vegetation and water quality factors (Fig. 3.2.4b; see Appendix B). Similarly, sites dominated by mayflies, damselflies, water boatman, backswimmers, Hyallela, snails and Stuckenia were relatively more saline and less nutrient enriched. Conversely, the more eutrophic, but fresher sites, were dominated by Phragmites, cattails and both *Scirpus* species and an invertebrate assemblage composed mainly of chironomids, flatworms and leeches.

Also notable, numbers of climbing and clinging (on vegetation) macroinvertebrates declined after the June samples and remained at very low numbers among the targeted impoundments and particularly in FB WMA Unit. It is likely that this reduction in numbers was associated with the decline in SAV that provides habitat. We feel that refinement of sampling strategies, including additional diel measurements of DO and specific local habitat parameters during the 2007 season will reduce sample variability and more accurately assess the importance of local habitat.

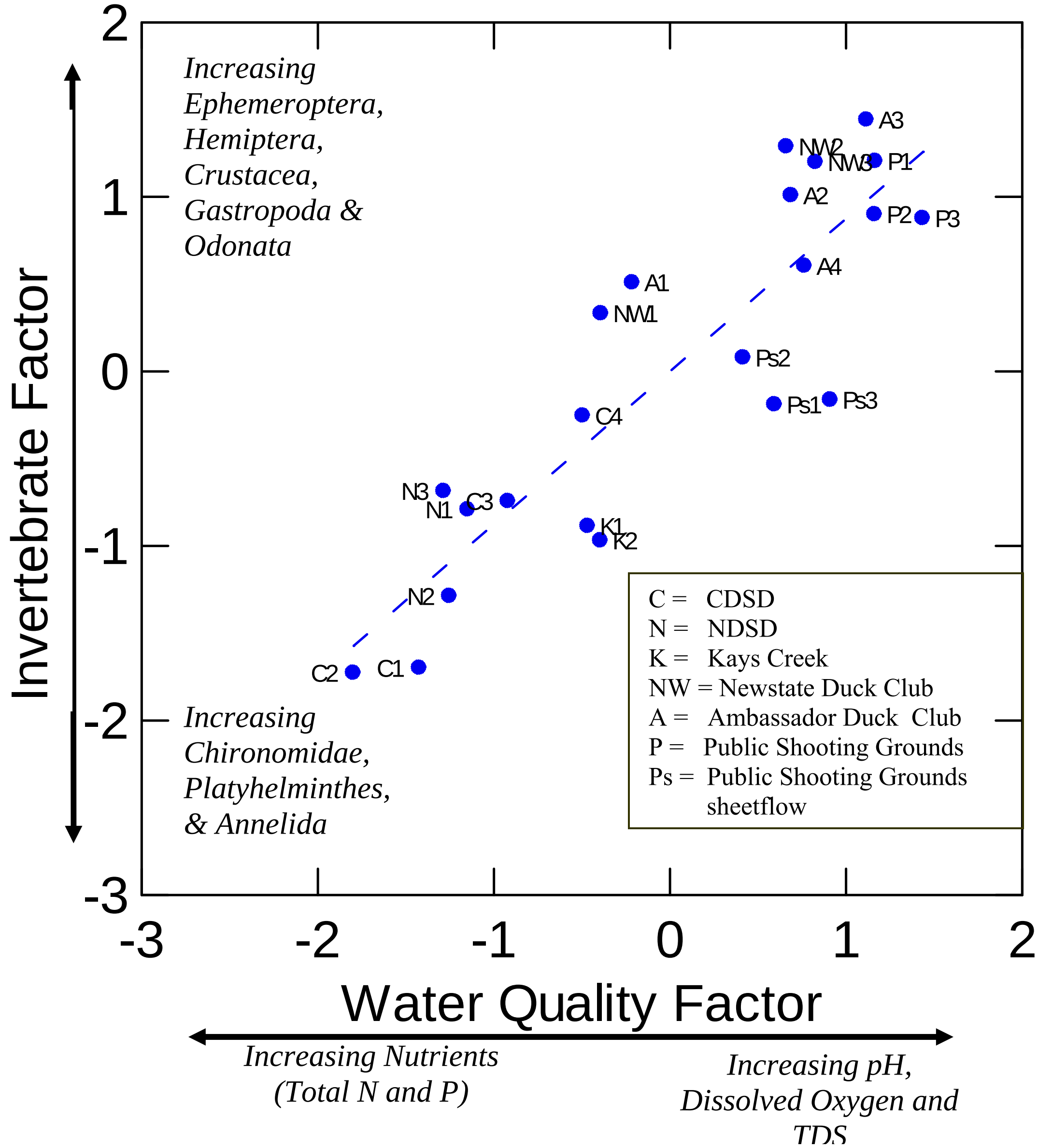


Figure.3.2.3. Results of factor analysis for the primary water quality factor and the primary invertebrate factor. Note general trend toward tolerant species with increasing nutrients.

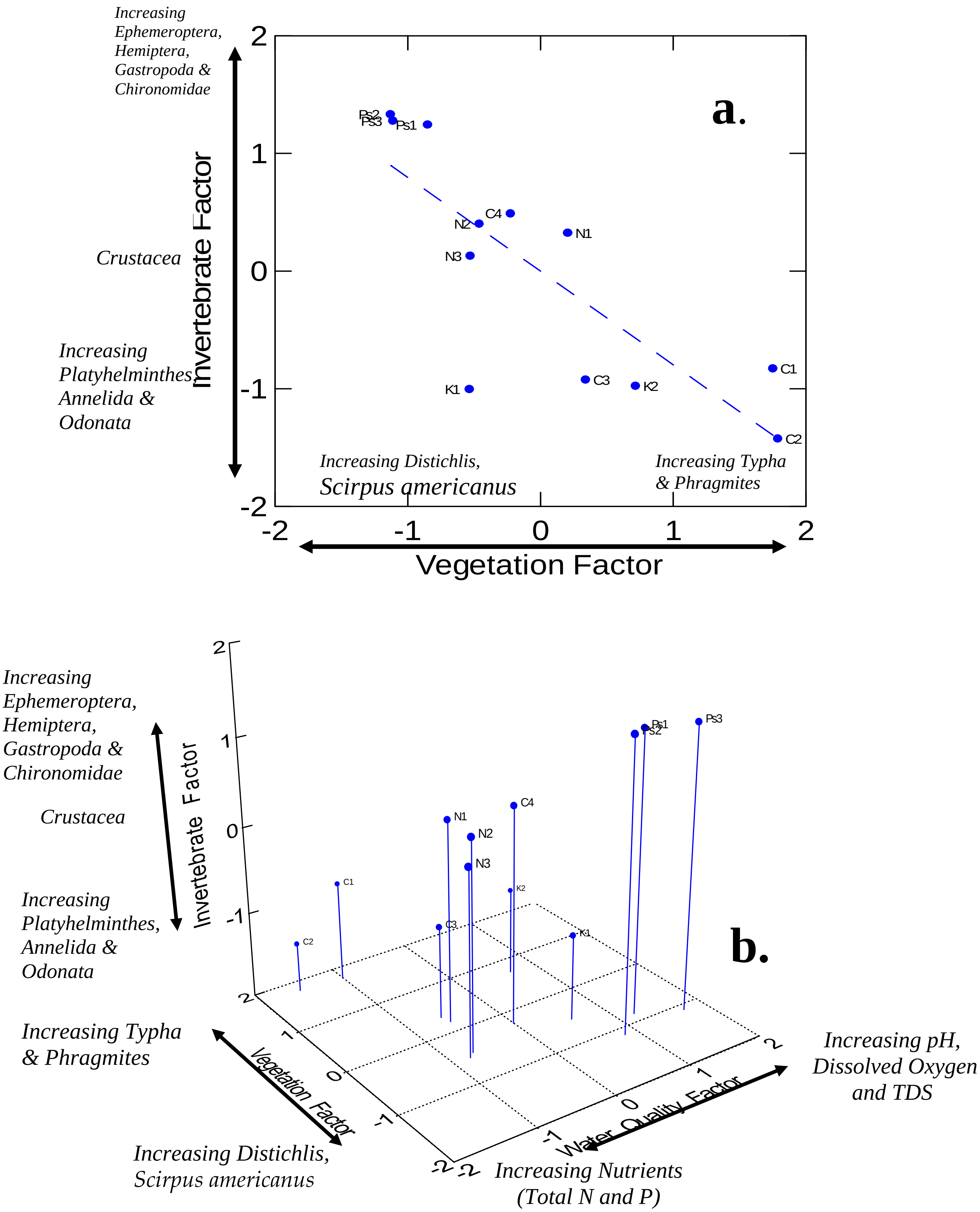


Figure 3.2.4. Results of factor analysis comparing the primary invertebrate factor with the primary vegetation factor (a) and combining the invertebrate, vegetation and water quality factor (b).

Another important caveat to note is that Davis, Weber and Box Elder counties conduct an aggressive mosquito abatement program in an effort to control the spread of West Nile virus. Active spraying from aircraft as well as ATVs was often observed by our field personnel. It is known that both BTI and malathion, a general pesticide used here as an adulticide, are used, depending upon the presence of larval vs adult mosquitoes. It is also known that midges are equally sensitive to BTI as are mosquito larvae and all the taxa present are sensitive to malathion. Location, frequency and pesticides used were actively noted during the 2006 field season and are now being determined for the 2005 field season in order to determine if spraying could have influenced 2005 invertebrate sampling results. Logging the spraying schedule for mosquito abatement will add substantially to the tolerance database and account for the overall influence of pesticide spraying. In addition, during 2007 we will sample macroinvertebrates and water for pesticide analysis to determine whether pesticides are reaching toxic concentrations in the water column and the concomitant invertebrate community structure.

3.3 Shorebird Studies

Shorebird studies were performed to provide a direct assessment of the designated beneficial use for Great Salt Lake (Cavitt 2006; Appendix C). This use has been defined as: "support for waterfowl and shorebirds and the aquatic life in their food chain." Data were collected during 2005 and 2006. These studies were able to incorporate a larger database of nesting colonies that has been supported by a National Science Foundation research grant. This study focused on American avocets and black-necked stilts that were nesting and feeding in the sheetflow environments. Study sites included locations in PSG, Bear River Migratory Bird Refuge, Great Salt Lake Shorelands Preserve (near the mouth of Kays Creek), FBWMA (near our WMA sheetflow water quality study sites and near the Salt Lake sewer canal) and in the ISSR. Farmington Bay WMA and Bear River Migratory Bird Refuge have an active predator control program and this undoubtedly contributed to nesting success and juvenile survival.

Study objectives included a description of nesting habitat and measurement of nesting success, hatching success and prey item selection. Prey selection was determined by collecting individuals immediately after they were observed feeding for at least five minutes and then dissecting out the digestive tract.

Nest site preference included areas with little or no vegetation that provide an unobstructed view by the attending adult. These included areas of early-stage communities of pickle weed (*Salicornia sp.*), or alkali bulrush (*Schoenplectus maritimus)* that were in close proximity (generally < 30 m) to surface water. Close proximity to water is essential in that the young are not fed in the nest. Rather, within 24 hours of hatching, the parents lead the young to surface waters where they begin foraging for themselves. Although these foraging areas include taller vegetation, providing essential cover, the adults attend to the young until flight is achieved.

A summary of nesting and hatching success for both species and for both years are summarized in Table 3.3.1. Hatchability and number of young leaving per nest were consistently between 93% and 96%. These are similar values to those measured in Bear River National Bird Refuge, both of which are equal to or greater than any other success rates reported in the literature.

Birds and macroinvertebrate samples were collected from each of the study sites in order to determine forage availability and forage preference (Appendix C). These data are summarized in Table 3.3.2 and illustrated in Figures 3.3.1 through 3.3.3. The most important invertebrate taxa consumed by the avocets and stilts were Corixidae (water boatmen) and Chironomidae (midges). In fact, 63% of the avocet diet was comprised of just three taxa (Corixidae, Chironomidae and Ephydridae (brine flies)). The black-necked stilt diet was slightly more diverse with 65% of the food material consisting of Corixidae, Chironomidae, Hydrophilidae (water scavenger beetles) and miscellaneous coleopteran (beetle) parts.

With regard to prey selection, the proportion of chironomids consumed by avocets did not differ from the proportion available as identified in the sweep samples. Likewise, there were no differences in the proportion of Corixidae consumed relative to the proportion available. However, the black-necked stilt diet exhibited a slight preference for corixids. They had a smaller proportion of chironomids than were in the sweep nets and a greater proportion of corixids than that in the sweep nets. Cavitt (2006) suggests that this preference is associated with their primary foraging behavior whereby stilts generally peck items from near the water surface and hence are likely attracted by movement. This would favor corixids as they are continuously active (periodically ascending to the surface for air) as compared to the more sedentary and benthic midges.

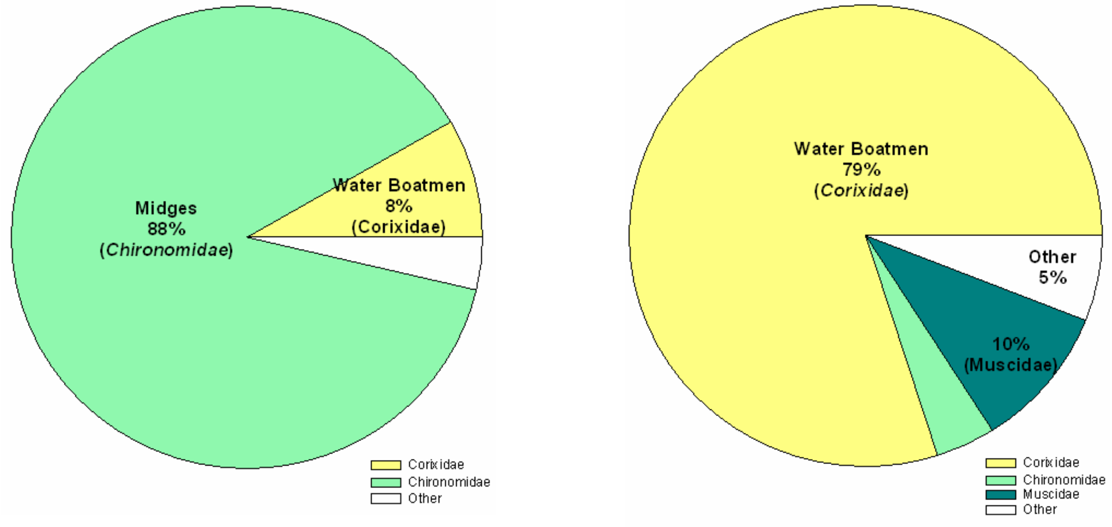
Overall, corixids and chironomids made up the majority of the diet for both species. In view of the known diverse diet and opportunistic feeding behavior of both avocets and black-necked stilts, the preponderance of corixids and chironomids in the diet is likely due to the cosmopolitan occurrence and density of these two taxa among Great Salt Lake wetlands.

Table 3.3.1. Measured values of productivity for each site according to year and species. Mean clutch size, hatchability and number of young produced to nest leaving (± standard error) for successful nests.

Site	Year	Species	Total Eggs Laid (total nests)	Clutch Size (n)	Hatchability (n)	Total Young Produced (average # eggs hatched / nest)	# Young Leaving/Nest (n)
BEAR	2005	AMAV	715 (311)	3.92 ± 0.67 (143)	0.96 ± 0.10 (143)	536 (1.7)	3.75 ± 0.72 (143)
		BNST	94 (29)	3.9 ± 0.57 (10)	0.98 ± 0.06 (10)	38 (1.3)	3.8 ± 0.42 (10)
	2006	AMAV	924 (302)	3.92 ± 0.52 (171)	0.94 ± 0.15 (151)	596 (1.97)	3.68 ± (162)
		BNST	84 (23)	4 ± 0 (18)	0.91 ± 0.15 (18)	65 (2.8)	3.61 ± (18)
FARM	2005	AMAV	1681 (481)	3.86 ± 0.51 (247)	0.96 ± 0.13 (247)	914 (1.9)	3.75 ± 0.57 (247)
		BNST	769 (411)	3.87 ± 0.48 (201)	0.97 ± 0.11 (201)	737 (1.79)	3.76 ± 0.62 (201)
	2006	AMAV	2146 (641)	3.93 ± 0.30 (413)	0.93 ± 0.15 (369)	1538 (2.4)	3.55 ± (435)
		BNST	1123 (313)	3.97 ± 0.21 (232)	0.96 ± 0.12 (221)	916 (2.9)	3.77 ± (243)
ISSR	2006	AMAV	507 (158)	3.9 ± .037 (42)	0.98 ± 0.08 (29)	122 (0.77)	3.59 ± (34)
		BNST	22 (8)	4 ± 0 (3)	-	4 (0.5)	4 ± 0 (1)
SHORE	2005	AMAV	18 (6)	4.0 ± 0.0 (3)	-		-
		BNST	-	-	-		-
	2006	AMAV	295 (106)	3.88 ± 0.33 (25)	0.89 ± 0.16 (14)	60 (0.57)	3.53 ± (17)
		BNST	20 (7)	4 ± 0 (4)	0.94 ± 0.13 (4)	15 (2.14)	3.75 ± (4)
SL CANAL	2005	AMAV	36 (11)	3.6 ± 0.70 (10)	1 ± 0.0 (5)	16 (1.45)	3.2 ± 0.84 (5)
		BNST	61 (16)	3.81 ± 0.54 (16)	0.98 ± 0.07 (13)	47 (2.9)	3.62 ± 0.65 (13)
	2006	AMAV	61 (19)	3.71 ± 0.76 (7)	1 ± 0 (8)	31 (1.63)	3.88 ± (8)
		BNST	-	-	-	-	-

Table 3.3.2. Mean aggregate % volume of food items recovered from the digestive tracts of American Avocets and Black-necked Stilts. See Appendix C for more details.

Taxa	AMAV N = 31	BNST N = 41
	Mean Aggregate % Volume	Mean Aggregate % Volume
Gastropoda	0.4	1.6
Odonata	0.2	5
Hemiptera		
Corixidae	23.2	30
Coleoptera		
Carabidae	3	0.6
Dytiscidae	0	2
Hydrophilidae	4.7	7.5
Coleoptera Parts	3	10.5
Trichoptera		
Limnephilidae	0.1	0
Diptera		
Culicidae	0.8	0.5
Ceratopogonidae	0	0.2
Chironomidae	33.7	17.2
Stratiomyidae	0	0.01
Syrphidae	0	3.6
Ephydridae	6.1	5.6
Muscidae	1.4	3.3
Misc. Diptera	0	2.6
Hymenoptera		
Braconidae	0.9	0.01
Seeds	15.2	4.2
Unidentifiable Parts	7	5.2



AMAV BNST

Figure 3.3.1. Volumetric proportion of food items recovered from the digestive tracts of American avocets and Black-necked stilts collected from Bear River Migratory Bird Refuge.

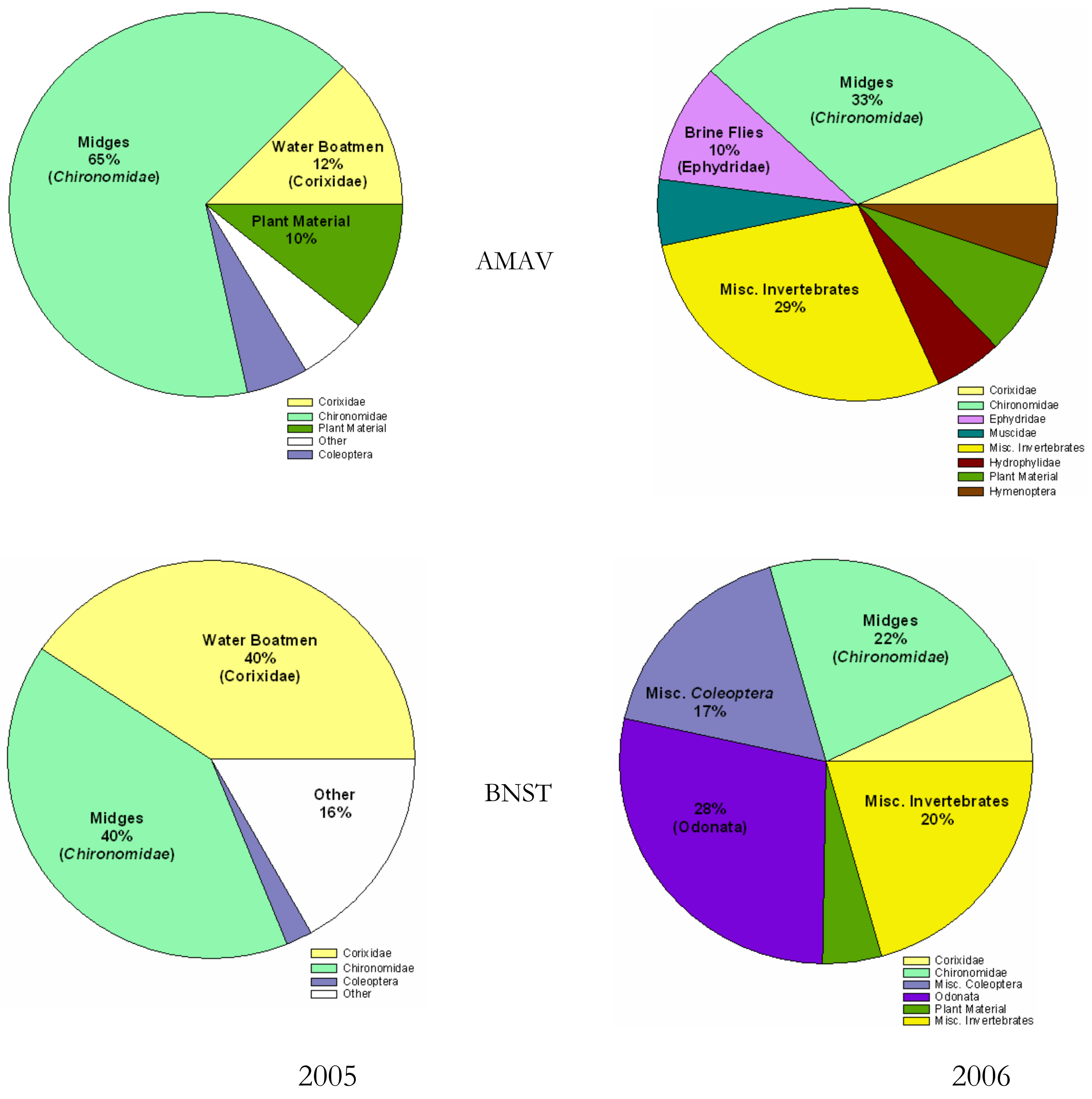
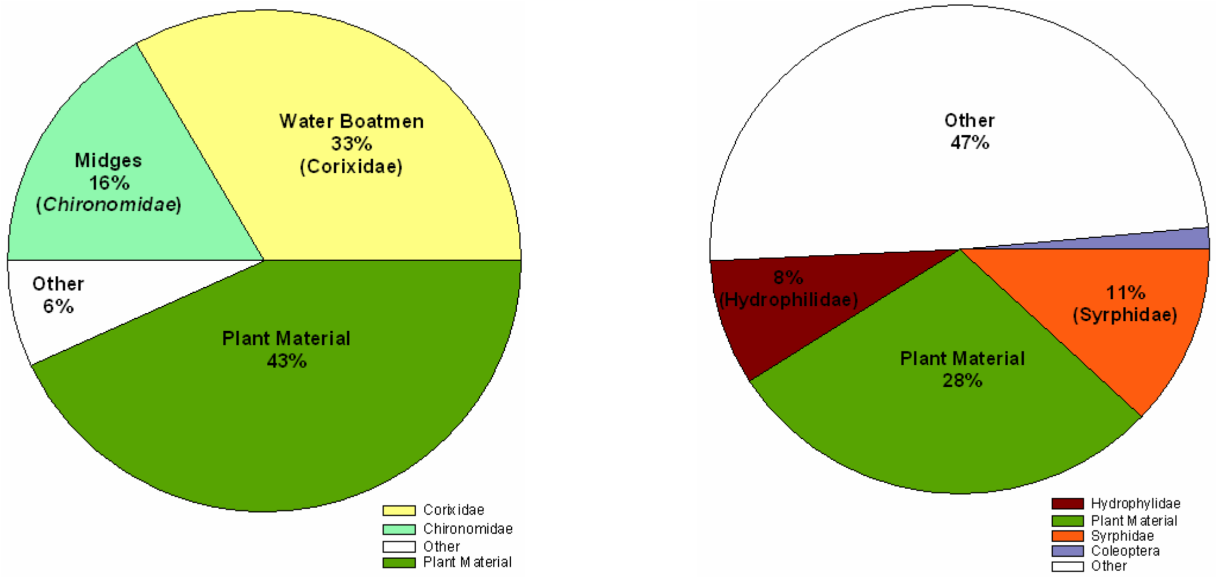


Figure 3.3.2. Volumetric proportion of food items recovered from the digestive tracts of American avocets and Black-necked stilts collected from Farmington Bay Waterfowl Management Area near the Turpin Dike.



AMAV

BNST

Figure 3.3.3. Volumetric proportion of food items recovered from the digestive tracts of American avocets and Black-necked stilts near the Central Davis Sewer Discharge.

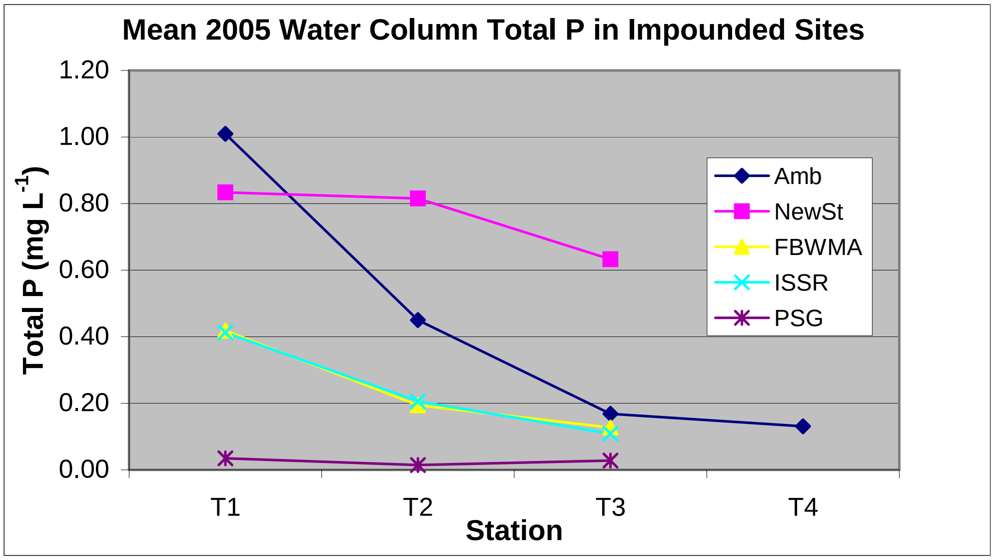
3.4 Water Column and Sediment Phosphorus Dynamics

One of the common paradigms of wetland function is the processing and reduction of nutrients from the water column (see Kadlec and Knight 1996). Indeed, one of the central tenets of our study design was to track the expected reductions in nutrients as water flows across the mudflats as sheetflow or through the successive impoundments built by the duck clubs and wildlife management areas. In reality, however, our observations did not support this hypothesis. With regard to N, except for the Newstate Duck Club ponds and the first pond of Ambassador Duck Club, water column nitrate-nitrite was nearly always below the detection limit (0.05 mg L^{-1}) at the impounded sites.

With regard to water column P, there was only slight reduction in concentrations throughout the successive ponds at the impounded sites (Figure 3.4.1). The only exception occurred among the four study ponds in the Ambassador Duck Club. In these ponds total water column P fell from a mean of greater than 1 mg L^{-1} at T-1 to about 0.1 mg L^{-1} at T-4. The primary reason for this substantial P reduction at Ambassador versus other target sites is a long water retention time in the Ambassador lower ponds. Consequently, estimated P loading rates in Ambassador ranged from about 10 g m^{-2} at T-1 to about 0.5 g m^{-2} at T-4 (Rino Decataldo, unpublished data). As a result, water and sediment concentrations of the Ambassador ponds declined substantially with each successive pond, as there was more time for assimilation. Notably, water and sediment P concentrations in Ambassador T-4 were the lowest of any sample site in Farmington Bay (Figures 3.4.2) and the sediment P concentrations in Ambassador T-4 was actually slightly less than those in the reference ponds of PSG. In contrast, estimated loading rates for Newstate Duck Club and FB WMA remained between 6 and 10 g m^{-2} at all ponds. Consequently, considerable P remained in the water column and passed from pond to pond in these other target systems.

In addition to a much shorter water retention time, the apparent lack of nutrient attenuation in the water column at most targeted sites is also attributed to saturation of binding sites in the sediments. Sediments collected from our sampling stations contained from 280 to 585 mg kg^{-1} total P. Most notably, biologically available (soluble) P ranged from 10 to 80 mg kg^{-1} in the sediments (data not shown). This readily available supply of P indicates that P concentrations between water and sediments are at equilibrium and explains why water column concentrations remained elevated (0.4 to 4 mg L^{-1}) throughout the targeted impoundments. These characteristic high P concentrations are likely responsible for the impacts described in Section 3.2 above.

At sheetflow sites, water column P in the target (POTW effluent) sites did not experience reductions in P concentrations as it progressed across the mudflats (except for a moderate reduction in the wetlands below the CDSD, Figure 3.4.1). Again, it is likely that sediment-binding sites for phosphorus and the assimilative capacity of wetland vegetation are saturated and further nutrient reduction is minimal. The high values for biologically available P and the high release rates of sediment samples suffused by various water sources (Appendix F; See Section 3.5 below) demonstrate that there is free exchange of P between sediment and the overlying water.



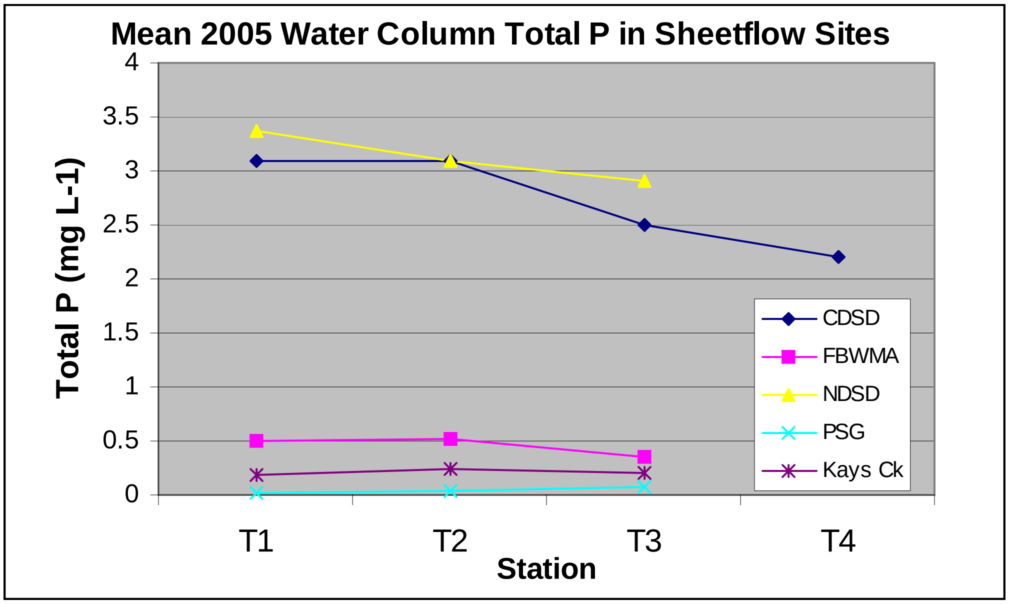
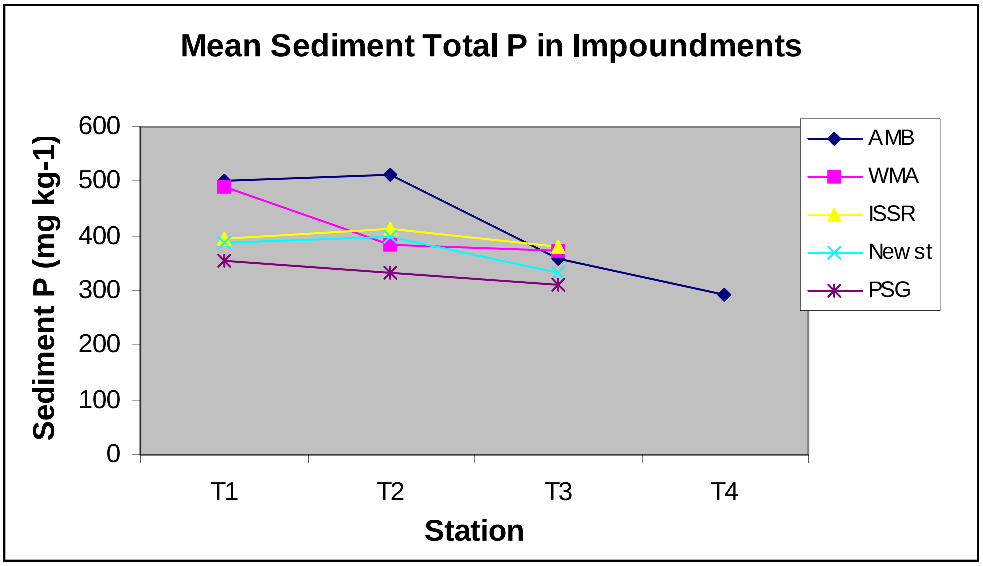


Figure 3.4.1. Phosphorus concentrations in water samples collected along impounded (upper) and sheetflow (lower) transects. (Amb – Ambassador Duck Club, Newst = Newstate Duck Club, CDSD =Central Davis Sewer District, NDSD =North Davis Sewer District, FBWMA – Farmington Bay Wildlife Management Area near Turpin Dike, PSG = Public Shooting Grounds Wildlife Management Area). Reference sites were located at Kays Creek and Public Shooting Grounds.



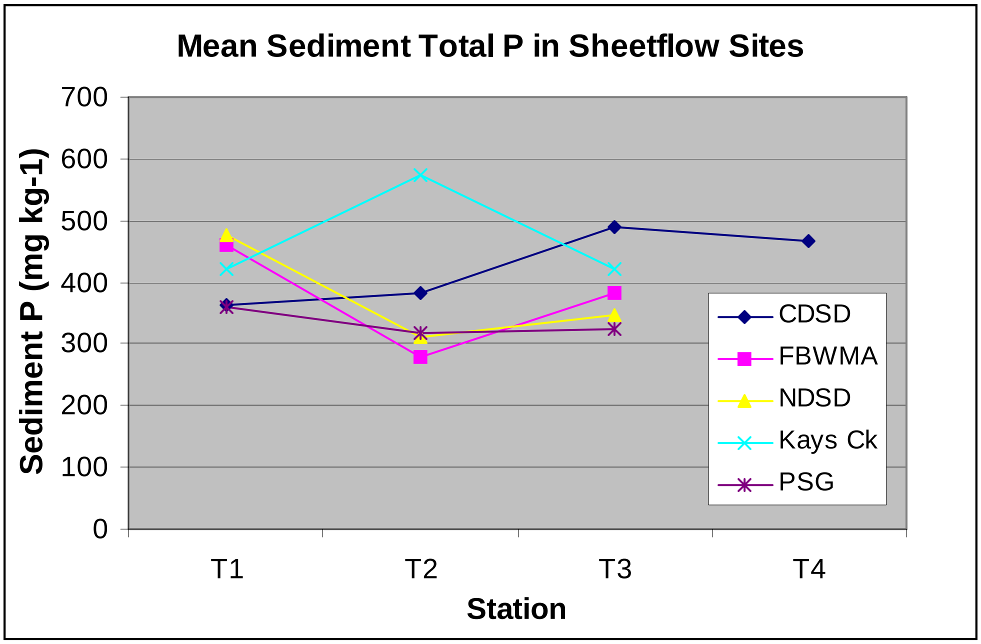


Figure 3.4.2. Sediment P concentrations at our impounded (upper) and sheetflow (lower) study sites. Reference sites were located at Kays Creek and Public Shooting Grounds Wildlife Management Area.

Perhaps the greatest insight into water/sediment nutrient relationships and wetland nutrient assimilation has been gained through the investigation of treatment wetlands. These results and subsequent treatment wetland design have been reviewed by Kadlec and Knight (1996), Faulkner and Richardson (1989), Richardson and Marshal (1986), Nichols (1983) and others. Suggested design of treatment wetlands includes loading rates of 0.5 to 3 mg P kg^{-1} yr^{-1}. Successful retention of P is dynamic and is primarily related to the amount of sediment Fe and Al and secondarily to Ca. Depending upon the sediment concentrations of these metals and loading rate, retention capacity is usually reached within the first 5 to 8 years. In other words, with a loading rate of 2 to 4 g P m^{-2} y^{-1} 90 to 95 % retention can be accomplished for the first few years. After that time retention is negligible and is primarily related to burial of organic debris (Kadlec and Hammer 1983). As expected, however, this burial can be enhanced with elevated concentrations of Fe, Al and Ca in the water as these metals are known to form organo-metal-P complexes (e.g. R(COO) $_3$Al H_2PO_4 where R represents any carboxylated compound, although humic and fulvic acids are the most commonly mentioned (Bloom 1981).

These processes, however, may be quite variable depending upon vegetation type and nutrient concentrations in the water. In emergent wetland systems (such as our sheetflow sites), the primary source of nutrients is sediments (see discussion in Section 3.2). Klopatek (1978) determined a nutrient budget for the emergent *Scheonplectus fluviatilis* and found 3.8 g m^{-2} yr^{-1} were translocated from the wetland soil to the plant shoots. At the end of the growing season about 12% of this P was transferred to the roots and stored over winter. Fifty eight percent of the P was leached into the water column during senescence and the rest remained associated with the dead plant material. Prentki (1978) found similar results in a Wisconsin cattail marsh. This process actually promotes a net annual movement of nutrients out of the sediment and into the water column. Wetlands dominated by SAV may behave similarly. For example, the above ground biomass is nearly completely decomposed within the water column and thereby releases similarly large amounts of nutrients back into the water column (Nichols and Keeney, 1973, Barko and Smart 1980, Brenner et al. 2006).

Notably, samples from the last pond of the Ambassador Duck Club complex (T-4) had the lowest water and sediment P, including those collected from the pelagic zone of Farmington Bay (Figures 3.4.1, 3.4.2 and Appendix F). The reduction of water column P is attributed to the much greater water retention time in the Ambassador ponds, allowing more efficient sorption and sedimentation of P. However, this doesn't explain why sediment concentrations are so low. Rather, annual macrophyte production, including obtaining the majority of P from sediments, followed by winter senescence and leaching to the water column and subsequent pond flushing at the end of the hunting season, would provide an annual net loss of sediment P. This would explain the successively lower sediment P that was measured in Ambassador T-3 and T-4.

In contrast, sediment samples from the CDSD transects had the highest P and N concentrations – suggesting that removal of P by macrophyte growth and senescence is readily replaced (or surpassed) by sorption and sedimentation of P from the effluent itself. Indeed, there is elevated sediment P along the eastern fringe of Farmington Bay that is either associated with POTW discharges and/or gradual burial of detritus. Stable isotope analysis such as described by Brenner (2006) may elucidate the whether the source of nutrients is from (internal) wetland sources, POTWs or from other tributary sources.

3.5 Water-Sediment Interactions

A series of experiments were conducted to assess the ability of Farmington Bay sediments to release P back into the water column. This ability has serious implications for present or future nutrient management decisions regarding Farmington Bay and its wetlands. Toward this goal CDSD, in conjunction with USGS, collected several dozen core samples from throughout Farmington Bay (Houston et al. 2006.; Appendix F). Sampling sites were selected in both littoral/wetland environments and pelagic sites.

Cesium dating of sediment cores indicates that approximately 0.4 cm of sediment is added annually to Farmington Bay. Further, P analysis in sediment cores indicates that high loading to Farmington Bay has occurred since before modern settlement (>150 years). Throughout the many core samples, P concentrations ranged from 400 to 1200 mg kg^{-1} sediment (data not shown). Highest concentrations occurred along the wetland fringe of the eastern shoreline and decreased with distance toward the west. Similarly, samples collected near the wetlands contained elevated P in the top 3-5 cm. Otherwise, phosphorus concentrations were quite uniform throughout the core sample.

Several tests were conducted to determine P transfer between sediment and water using aerobic and anaerobic sediments and four sources of fresh water: deionized, Kays Creek, CDSD effluent, and NDSD effluent. This was performed by placing a small amount of sediment (approximately 1 g wet weight), into 5 ml centrifuge tubes. Approximately 4 ml of water was then placed in the tubes followed by shaking for 1 min. The samples were then centrifuged for 30 sec and analyzed using a HACH DR-4000 spectrophotometer (Handbook, Method 8048). Enough replicates were prepared to provide P measurements at several time intervals, ranging from 5 min to 24 hr.

In one set of experiments, an aerobic sediment sample collected from the area between the CDSD discharge and the Farmington Bay WMA Unit one discharge and was suffused with either deionized water or with 100% Central Davis Sewer District effluent (Figure 3.5.2). This sediment sample sequestered a significant amount of phosphorus from the effluent water – until the final water concentration reached about 2 mg L^{-1}. However, when suffused with deionized water, this sediment gave up significant amounts of phosphorus – until the final water concentration reached about 1 mg L^{-1}. Interestingly, the average surface water P concentration at our sampling stations along the horizontal transect that follows the Central Davis effluent remained at about 2 mg L^{-1}.

In another experiment, an aerobic sediment sample collected adjacent to Antelope Island was suffused with either Kays Creek water or North Davis Sewer District effluent (Fig.) 3.5.3). Sediment P at this site was relatively very low (circa 300 mg kg^{-1}). Total P in Kays Creek water (background P concentrations ranging from 0.1 to 0.4 mg L^{-1}) remained stable at about 0.2 mg L^{-1} while the P concentration in NDSD water fell by 1.7 mg L^{-1} (from approximately 3.7 mg L^{-1} to 2 mg L^{-1}) to the aerobic sediments.

Anaerobic sediments reacted differently. Both Kays Creek and effluent water gained phosphorus from anaerobic sediments (Fig. 3.5.4). After six hours, both water sources contained between 5 and 6 mg L^{-1}.

Although these data are preliminary, they suggest that internal loading from anaerobic sediments may be substantial (although the assimilative capacity of vegetation growing in anaerobic sediments would counteract the internal loading somewhat). It should be noted that equilibrium is reached experimentally within a relatively short time. These studies support the explanation of why there was very little attenuation along the various longitudinal transects in our sheetflow study sites, i.e. saturation of sediment binding sites has been reached or surpassed – allowing re-entry of pore water or loosely-bound P into the water column.

Observations of P being released from either anaerobic or aerobic sediments strongly suggests that there is substantial amounts of pore-water P and/or P is loosely adsorbed to clay or silt particles or to organic material in the sediment rather than the more commonly described dissolution of Fe(OOH)≈P with reducing condition (Mortimer 1941, 1942, Van Lier, et al. 1983).

Some of this P release or sequestering in organic-enriched lakes and wetlands can be mediated by the microbial communities that utilize various forms of organic carbon (by either mineralization or bacterial growth). (e.g. Kelton et al. 2004). Organic carbon at our sampling sites was variable but quite high (1 to 5%). Therefore, it is likely that part of the sediment/water equilibrium is microbially mediated. However, there is little information as to the permanency of this relationship and particularly on a long-term basis.

Because Farmington Bay wetland and pelagic sediments have similarly high P and organic carbon, microbial processes and the more-labile organo-metal-P complexing may reflect the dynamic movement of P into or out of Farmington Bay sediments and play a major role in the equilibrium process.

Finally, the work of Brenner et al. 2006 may provide further insight into the complex sediment/water equilibrium processes. They reported that recent nutrient enrichment in shallow mesotrophic (mean TSI = 47) Lake Panasoffkee, Florida resulted in an increased presence of SAV. In view of the previous discussion, this would suggest that sedimentation of P might decline and perhaps even cause a net removal of P from sediments after the growth and senescence cycle. Yet, sediment P concentrations actually increased. Further, they linked recent carbon sedimentation to an increase in algal decomposition and sedimentation. This presents an apparent contradiction to the paradigm that most macrophyte dominated shallow lakes and wetlands support a low phytoplankton biomass. However, they proposed an interesting hypothesis that explains this contradiction by suggesting that the source of algae is the substantial epiphytic populations associated with the SAV. In turn, considerable photosynthesis of the epiphytic community resulted in localized elevation in pH and precipitation of nucleated calcite crystals or Ca-organic P complexes. They hypothesized that the primary sedimentation process occurs when encrusted carbonate sloughs off the leaves of higher plants, thereby delivering epiphytes along with organic- and carbonate-bound P to the sediments. Evidence supporting this process was obtained from C:N ratio data and the $\delta^{15}N$ isotopic signature which indicated that the organic C and N in the sediment were derived from algal sources rather than macrophytic tissue. In support of this hypothesis, in a

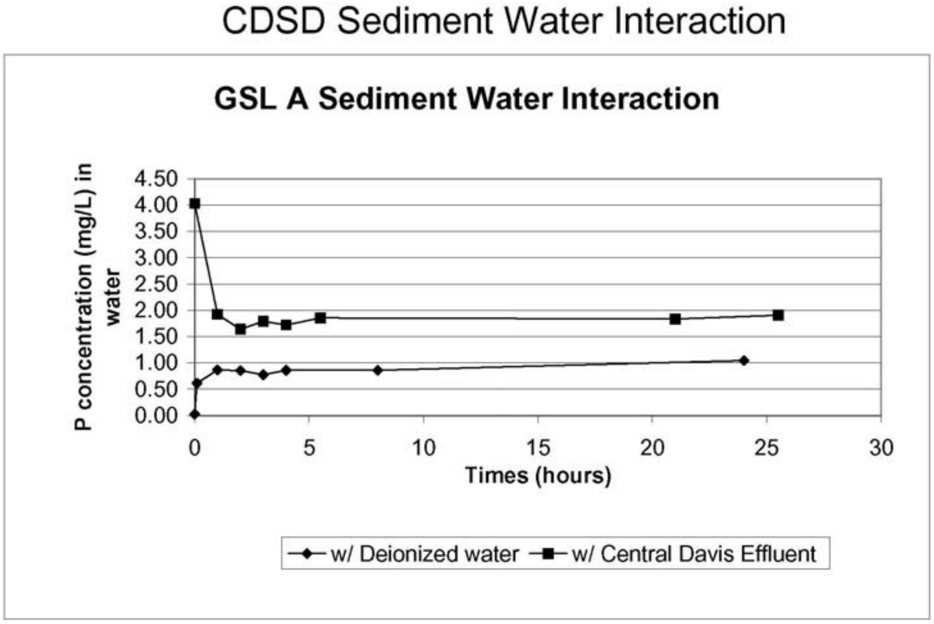


Figure 3.5.2. Accumulation of water column P concentrations after suffusing an aerobic Farmington Bay sediment sample with deionized water or Central Davis Sewer District effluent. The sediment sample was collected in the emergent wetland area approximately 2.5 km south of the Central Davis Sewer outfall. P concentrations and Time 0 = the initial concentrations before the water was applied.

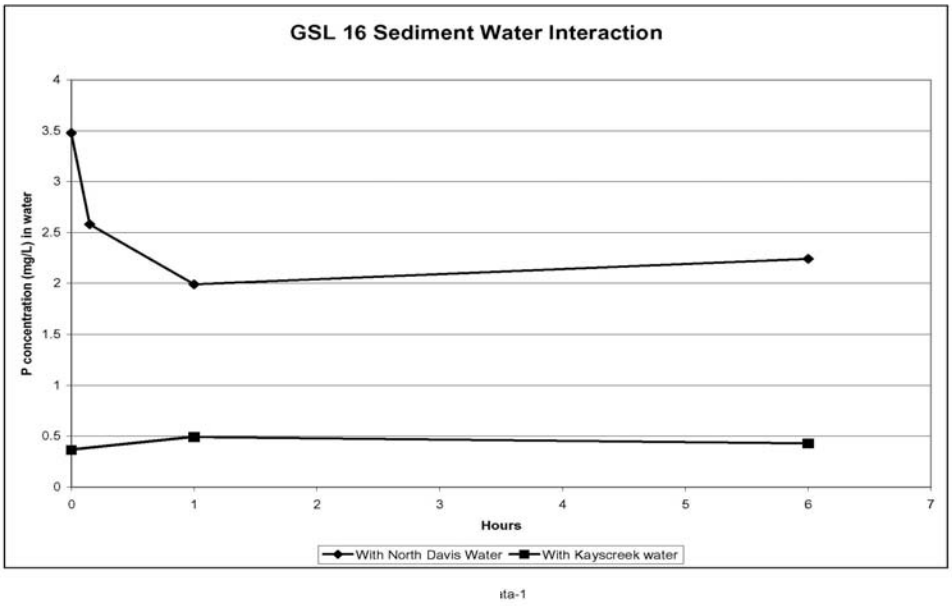


Figure 3.5.3. Accumulation of water column P concentrations after suffusing an aerobic sediment sample with either Kays Creek water or North Davis Sewer District effluent. The sediment sample was collected from a site near Antelope Island. P concentrations at Time 0 = the initial concentrations before the water was applied.

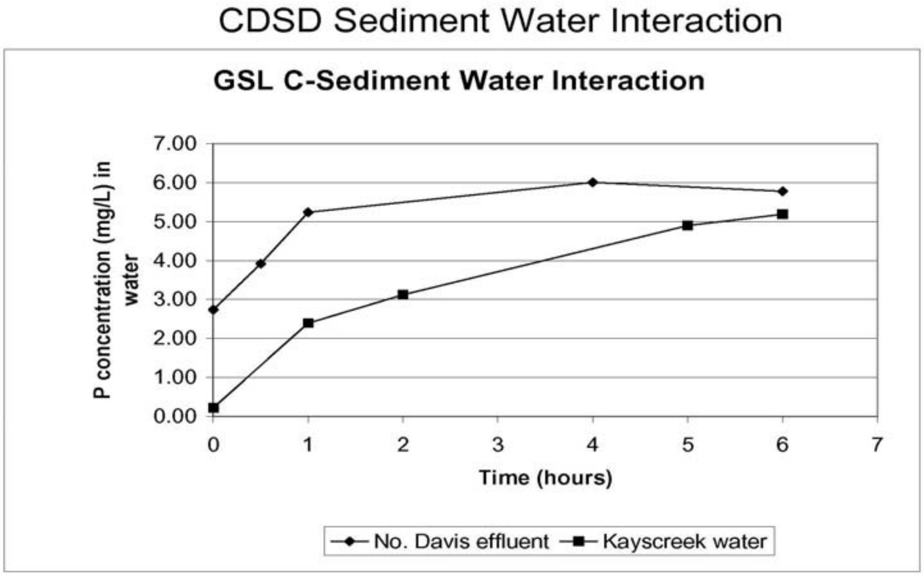


Figure 3.5.4. Accumulation of water column P concentration after suffusing an anaerobic sediment sample with either Kays Creek or North Davis effluent water. The sediment sample was collected from near the North Davis Sewer District discharge. P concentrations at Time 0 = the initial concentrations before the water was applied.

sample of 12 cores from five Florida lakes where similar C:N measurements and isotopic analysis was performed, total P was 2.6-fold greater in sediments derived from phytoplankton compared with sediments formed by macrophytes (Kenney et al. 2002). Because of the high calcium concentration in Farmington Bay tributary water, this may be an attractive hypothesis for nutrient management of the impounded target sites of Farmington Bay. For example, in Lake Panasoffkee, Florida, P concentrations generally averaged 0.1-2 mg L^{-1} (CM2MHill 1995). Our impounded sites encompass these values (i.e. total P in PSG impounded sites ~0.03 mg L^{-1} and target sites in Ambassador ranged from 1 mg L^{-1} down to 0.15 mg L^{-1}). Therefore careful sampling of water and sediment quality, including C:N:P ratios and stable isotopes of epiphytic algal communities could provide support for this hypothesis.

3.6 Conclusions

One of the major metrics suggested in EPA's "*Methods for Evaluating Wetland Condition*" modules is changes in species composition to invasive/exotic species and a reduction in species richness. Indeed, for the sheetflow sites, many measurements of the plant community were inversely related to water and soil pH. These included cattails and Phragmites % cover, and *Scirpus americanus* and *Distichilis spicata* stem height. However, diversity was actually higher in the fresher, more nutrient-rich sites. Moreover, this diversity was a result of non-native or aggressive invasive species. Those sites that were more proximal to the discharge points were dominated by native but aggressive cattails and Phragmites. The more-distal sites were dominated by native non-aggressive alkali bulrush (*Scirpus americanus)* and secondarily by pickleweed (*Salicornia* spp.). These two taxa were dispersed by seeds and, along with their relatively high tolerance to salinity, explains why these taxa were the first to colonize and rapidly expand across the mudflats as the lake receded and salts were successively leached from the sediments. On the other hand, stands of cattails and Phragmites expand primarily by rhizomes and are known to eventually shade out the shorter bulrush species. Phragmites and cattails are expanding across the mudflats and almost exclusively follow the freshwater flows. These taxa will likely continue to expand their dominance as sediment salts continue to be flushed by fresh water. These contrasting results are uniquely dependent upon the duration and intensity of freshwater leaching and ultimately leads to the possibility that, if the lake were to remain at relatively low levels, the mudflats will eventually become dominated by these two invasive and generally less desirable species.

Macroinvertebrate taxa that are tolerant of organic and nutrient enrichment were predictably dominant in the targeted sites. These include chironomids and corixids. Other taxa exhibited sensitivity to the nutrient gradient, including mayflies and odonates. These taxa are candidates for inclusion in the list metrics that will be developed for the assessment and the standard-setting process.

Although chironomids and corixids were generally dominant among the targeted sites, they were also the most common food items eaten by shorebirds. In addition to the observed high nesting and hatching success, the predominance of these taxa as food items suggests that shorebird populations are in a healthy condition.

For the impounded sites, the submergent Stuckenia (sego pond week) was the predominant taxa among both the targeted and reference sites. These ponds are intensively managed for this species because it is the most desirable forage species for waterfowl. Therefore, the early senescence of Stuckenia is of particular interest and concern because it provides a direct link to beneficial use support for waterfowl. This may be one of the most important measures for standard setting as well as an easily obtainable metric for biological monitoring. Therefore, it is imperative that plant density and persistence and associated measurements of surface mats and epiphytes be performed in order to confirm this observation and elucidate these complex relationships.

The considerable exchange between sediment and water in wetland and pelagic environments has huge implications for the potential management alternatives and decisions that will be made in regard to point and nonpoint source limits. Further, because of the potentially enormous financial requirements that would be necessary to reduce P inputs into Farmington Bay, the recycling of sediment P in the wetlands, both in aerobic and anaerobic sediments, warrants considerably more study to ensure that reduction of external loading is cost-effective and will improve water quality. For example, such decisions were faced by managers of a hypereutrophic shallow lake system in the UK, with similarly high sediment P (circa 1000 mg kg^{-1}, Phillips et al. 1994). Several million dollars were spent in reducing P inputs from point sources. Yet, in 1992, twelve years since achieving a 90% reduction in external phosphorus load, there was little reduction in water column P or primary production. They determined that peak internal phosphorus sources in this shallow lake system was still as high as 130 mg P m^{-2} d^{-1}, compared with an external load of only 12 mg P m^{-2} d^{-1}. They attributed the internal P source to organically-bound P, which formed at least 50% of the total sediment P, and likely involves the organo-metal-P complexes discussed above.

Several measures described in this report have demonstrated sensitivity to nutrient or turbidity gradients and are candidates for inclusion into a multimetric index of biological integrity for wetlands assessment. Moreover, we have made particular effort to select parameters that have a direct relationship to the beneficial uses identified for the wetlands. In addition to the data gap recommendations identified in Section 3.1.3, these measures will contribute to data set that is essential for establishing appropriate site specific nutrient criteria for these wetlands. A summary of these measures include:

1. Macroinvertebrate species composition and density (during nesting season and fall migration season).
2. Percent of Ephemeroptera
3. Percent of Chironomidae
4. Percent Odonates or clingers
5. Percent exotic and/or invasive plants
6. Submerged aquatic vegetation above ground biomass
7. SAV percent coverage
8. C:N:P ratios in phytoplankton and macrophytes
9. SAV leaf Chlorophyll a / macrophyte fluorescence
10. turbidity/ light penetration
11. Presence/composition of floating vegetation
12. Presence/composition of SAV epiphytes
13. Summer mean diel DO
14. Diel minimum DO
15. Water column and sediment H_2S measurements

Finally, Reports by Rushforth (Appendix D) and Wurtzbaugh (Appendix E) are also appended to this report to display the additional research that has been performed as part of this grant and program. However, detailed analysis and interpretation, such as presented here, is not included in this report. Rather, additional data collection, analysis and reporting will be provided by the end of 2007. As a result, some algal measures may be added to the list of potential metrics.

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APENDIX A.1

STATISTICAL ANALYSIS OF 2004 DATA ON WETLAND PLANTS AND INVERTEBRATES IN FARMINGTON BAY, GREAT SALT LAKE, UTAH

Sharook Madon, Ph.D.
CH2M - Hill

Statistical Analyses of 2004 Data on Wetland Plants and Invertebrates in Farmington Bay, Great Salt Lake, Utah

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DATE:	September 13, 2005
PROJECT NUMBER:	322512

Introduction

In 2004, The Utah Division of Water Quality (UDWQ) began a program to characterize the wetland and open water ecosystems of Farmington Bay in the Great Salt Lake. This characterization will serve as the basis for developing a successful and implementable plan for defining, evaluating, and protecting Farmington Bay's beneficial uses and resources. The ongoing program includes intensive sampling of multiple wetlands sites that represent a cross-section of the different wetland ecosystems along Farmington Bay. These wetland sites will be re-sampled in 2005 and 2006 in addition to the open water sites to provide a comprehensive characterization of the Farmington Bay ecosystem and its beneficial uses.

The first year of intensive sampling of wetland sites along Farmington Bay was recently completed and included sites receiving sheet-flow hydrology and impounded wetlands. Sampling was conducted during 2004 to characterize water quality, wetland soils, plants, and macroinvertebrates at each wetland site. Sample processing and analyses were recently completed. This technical memorandum describes the analyses and results of part of the wetland plant and macroinvertebrate data collected from Farmington Bay in 2004.

Data Analyses

This technical memo focuses on the analyses of relationships between plant, invertebrate, water, and soil chemistry variables measured at various sites in the Farmington Bay wetlands.

Wetland Sites

Data from the following wetland sites (Exhibit 1) exhibiting both impounded and sheetflow hydrology are incorporated into the analysis:

Impounded Sites (13 sites**)**
- Ambassador Transects 1-4 (AMBAS T1-T4 in Exhibit 1; A1-4 in Figures 89-97)
- Farmington Bay Water Management Area Transects 1-3 (FBWMA T1-T3 in Exhibit 1; F1-3 in Figures 89-97)
- Newstate Transects 1-3 (NEW T1-T3 in Exhibit 1; NW1-3 in Figures 89-97)
- Public Shooting Grounds Transects 1-3 (PSG T1-T3 in Exhibit 1; P1-3 in Figures 89-97)

Sheetflow Sites (16 sites)
- Central Davis Sewer District Transects 1-4 (CDSD T1-T4 in Exhibit 1; C1-4 in Figures 89-97)
- Farmington Bay Water Management Area Sheetflow Transects 1-3 (FBWMAs T1-T3 in Exhibit 1; Fs1-3 in Figures 89-97)
- Kays Creek Transects 1-3 (KC T1-T3 in Exhibit 1; K1-3 in Figures 89-97)
- North Davis Sewer District Transects 1-3 (NDSD T1-T3 in Exhibit 1; N1-3 in Figures 89-97)
- Public Shooting Grounds SheetflowTransects 1-3 (PSGs T1-T3 in Exhibit 1; Ps1-3 in Figures 89-97)

Variables Used in Data Analyses

Wetland Plant Variables

Percent cover and height data for six species of wetland plants most frequently observed at the sites are included in the analyses:

- *Distichlis spicata*, Desert saltgrass
- *Phragmites australis*, Common reed
- *Typha latifolia*, Broadleaf cattail
- *Scirpus americanus*, Olney's bulrush
- *Scirpus maritimus*, Cosmopolitan bulrush
- *Stukenia* (Potomageton) species, consisting primarily of *Stukenia filiformis*, Fineleaf pondweed, and *Stukenia pectinatus*, Sego pondweed

Other plant species were rarely encountered in the transects established at the sites to provide sufficient data, and are thus excluded from analyses.

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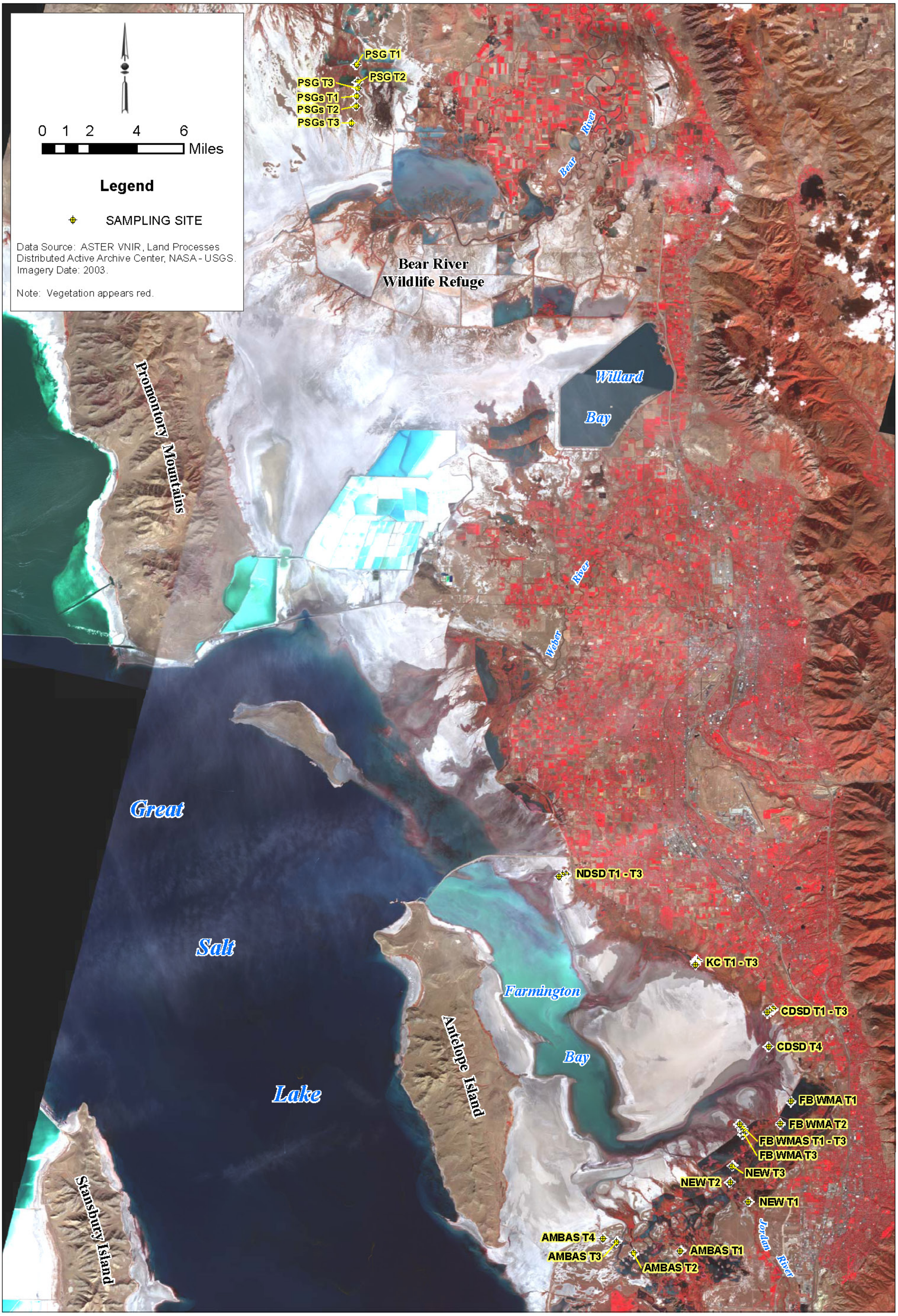


EXHIBIT 1
WETLANDS SAMPLING SITES
STATISTICAL ANALYSES OF 2004 DATA ON WETLAND PLANTS
AND INVERTEBRATES IN FARMINTON BAY, GREAT SALT LAKE, UTAH

CH2MHILL

Wetland Invertebrate Variables

The number of individuals per sample for the following macroinvertebrate taxa are included in the analyses. More detailed information on the various taxa can be found in Gray (2005):

- **Ephemeropterans:** Order Ephemeroptera, primarily mayflies of the genus, *Callibaetis*
- **Odonates:** Order Odonata, includes damselflies and dragonflies, of which the damselfly belonging to the genus, *Ischnura*, was most abundant
- **Hemipterans:** Order Hemiptera, represented primarily by corixids (water boatman) and notonectids (backswimmers)
- **Chironomids:** Order Diptera, primarily represented by the genus *Chironomus* (Family Chironomidae), commonly known as midges
- **Gastropods:** Primarily snails (Class Gastropoda) represented by the genera *Physella, Stagnicola* and *Gyraulus*
- **Crustaceans:** Primarily amphipod (commonly known as scuds) species *Hyallela azteca*
- **Platyhelminthes:** Primarily planarian flatworms of the genera *Phagocata* and *Dugesia*
- **Annelids:** Phylum Annelida, represented by leeches, primarily species *Helobdella stagnalis, Glossophonia complanata* and *Erpobdella parva* complex.

Other invertebrates such as various dipterans, isopods, and aquatic beetles were also present in the samples, but were too rare, and are included in the category titled "other" in the analyses.

Water Quality Variables

Physical/chemical data on water samples were collected to assess the responses of plant and invertebrate variables to a range of environmental conditions across wetland sites. These water quality parameters included:

- pH
- Total dissolved solids (TDS), mg/L
- Dissolved oxygen, mg/L
- Phosphorus as P, mg/L
- Nitrogen as N (nitrite and nitrate), mg/L
- Maximum water temperature (°C)

All water quality data is $\log_{10}$-transformed for the analyses, except in a few cases, as noted.

Soil Chemistry Variables

Physical/chemical data on soils were collected to assess the responses of plant and invertebrate variables to a range of environmental conditions across wetland sites.

- Soil pH
- Soil Conductivity (dS/m)
- Soil Organic Matter (% loss on ignition)

Data Analyses Approach

Univariate and multivariate statistical tests are used to explore relationships between physical, chemical, and biological variables measured at various wetland sites in Farmington Bay. A three-tiered statistical approach defines the analyses of Farmington Bay data and involves:

- **Tier 1:** Univariate regressions of plant and invertebrate variables on soil and water quality variables to explore individual relationships between these variables. Example: Simple regression of *Distichlis spicata* percent cover on soil pH.
- **Tier 2:** Variables from statistically significant univariate regressions are selected to include into multiple regression models. Example: Univariate regressions of *Typha latifolia* percent cover on total dissolved solids, water temperature and soil pH are statistically significant at the $p \leq 0.05$ level. These three environmental variables are chosen to construct a multiple regression model of *Typha latifolia* percent cover on total dissolved solids, water temperature, and soil pH. This type of analysis allows an assessment, for example, of the amount of variation in *Typha latifolia* percent cover that can be explained by total dissolved solids, water temperature, and soil pH.
- **Tier 3:** A multivariate test such as factor analysis is used to assess patterns between biological factors (plants and invertebrates) and physical/chemical factors (soil chemistry and water quality parameters) across wetland sites in the Farmington Bay. Multivariate tests are useful for exploring relationships in complex data sets involving multiple environmental and biological variables measured at multiple sites. Factor analysis, for example, parsimoniously treats multivariate biological community and environmental data, such that a few resulting factors (e.g., invertebrate factor, vegetation factor, water quality factor) can be used to interpret patterns and relationships across sites.

All statistical analyses are conducted on log-transformed data on biological and environmental variables. Logarithmic transformations ensure that the assumptions of statistical tests including normal distributions of data and homogenous distributions of variances are not violated. Plant percent cover and invertebrate numbers data (X) are $\log_{10}(X+1)$ transformed to account for data values that included 0. All plant height, soil chemistry, and water quality data are $\log_{10}$-transformed.

In the tier 1 analysis, visual examination of scatterplots of certain biological variables on environmental variables indicated non-linear relationships between these variables. In such cases, a distance-weighted least squares (DWLS) curve fitting method (Systat ver. 11) is used to define non-linear relationships. DWLS is a powerful and versatile method that fits a line to a set of points in a scatterplot by least squares methodology, where the line is allowed to flex locally to fit the data. The DWLS method produces a true, locally-weighted curve running through a set of points and does not assume the shape of the curve, as in the case of linear least squares and polynomial regressions.

Data Analyses Methods

Least squares univariate and multiple regressions and multivariate analyses are used to analyze the data, based on the three-tiered approach:

Tier 1: Simple Univariate Regressions

The following univariate regressions were conducted to explore potential relationships between:

Plants and soil chemistry

- Plant species percent cover and soil pH
- Plant species percent cover and soil conductivity
- Plant species percent cover and soil organic matter content
- Plant species height and soil pH
- Plant species height and soil conductivity
- Plant species height and soil organic matter

Plants and water quality

- Plant species percent cover and pH
- Plant species percent cover and total dissolved solids
- Plant species percent cover and dissolved oxygen
- Plant species percent cover and total phosphorus
- Plant species percent cover and total nitrogen
- Plant species percent cover and maximum water temperature
- Plant species height and pH
- Plant species height and total dissolved solids
- Plant species height and dissolved oxygen
- Plant species height and total phosphorus
- Plant species height and total nitrogen
- Plant species height and maximum water temperature

Invertebrates and soil chemistry

- Invertebrate taxa (numbers per sample) and soil pH
- Invertebrate taxa (numbers per sample) and soil conductivity
- Invertebrate taxa (numbers per sample) and soil organic matter content

Invertebrates and water quality

- Invertebrate taxa (numbers per sample) and pH
- Invertebrate taxa (numbers per sample) and total dissolved solids
- Invertebrate taxa (numbers per sample) and dissolved oxygen
- Invertebrate taxa (numbers per sample) and total phosphorus
- Invertebrate taxa (numbers per sample) and total nitrogen
- Invertebrate taxa (numbers per sample) and maximum water temperature

Invertebrates and plants

- Invertebrate taxa (numbers per sample) and *Typha latifolia* percent cover
- Invertebrate taxa (numbers per sample) and *Phragmites australis* percent cover
- Invertebrate taxa (numbers per sample) and *Distichlis spicata* percent cover
- Invertebrate taxa (numbers per sample) and *Scirpus americanus* percent cover
- Invertebrate taxa (numbers per sample) and *Stukenia* species percent cover

Relationships between various invertebrate taxa and *Scirpus maritimus* are not explored due to lack of sufficient data.

Tier 2: Multiple Regression Models

Based on the tier 1 analyses, plant, invertebrate, soil, and water chemistry variables are chosen to include into three categories of multiple regression models:

- Plant species percent cover vs. soil chemistry and water quality parameters
- Plant species height vs. soil chemistry and water quality parameters
- Invertebrate taxa (numbers per sample) vs. soil chemistry, water quality, and plant percent cover

Tier 3: Multivariate Factor Analysis of Biological Community and Environmental Data

Factor analysis is used to explore relationships between biological factors (plants and invertebrates) and physical/chemical factors across wetland sites in the Farmington Bay. The factor model explains variation within and relations among observed variables as partly common variation among factors and partly specific variation among random errors (Systat ver. 11). Factor analysis allows exploration of multivariate biological community and environmental data and has many advantages:

- Correlations of large number of variables can be studied by grouping the variables in factors (i.e., water quality factor, invertebrate factor, vegetation factor), so that variables within each factor are more tightly correlated with other variables in that factor than with variables in other factors.
- Many variables can be parsimoniously summarized by a few factors. For example, pH, DO, TDS, and nutrients, can potentially be summarized into a single water quality factor.
- Each factor can be interpreted according to the meaning of the variables. For example, a water quality factor may scale increasing pH, DO, and TDS on positive factor loadings and increasing nutrients on negative factor loadings.

Factor analysis on the 2004 Farmington Bay dataset is conducted using the following steps:

- A correlation matrix is computed for each biological community and environmental dataset.
    - Variables used to compute the plant percent cover correlation matrix included percent covers of *Distichlis spicata*, *Phragmites australis,Typha latifolia, Scirpus americanus, Scirpus maritimus,* and *Stukenia* (formerly known as *Potomageton*) species across various impounded and sheetflow sites in Farmington Bay (Figure 1).
    - The correlation matrix for water quality included pH, TDS, DO, total N, and total P across various sites.

  - Variables included in the invertebrates correlation matrix included numbers per sample of Ephemeroptera, Odonata, Hemiptera, Chironomidae, Gastropoda, Crustacea, Platyhelminthes, and Annelida across all sites.

- The factor loadings are estimated and the factors are then extracted for the biological community and environmental datasets. A single factor is extracted for each dataset.
  - Vegetation Factor: includes information on percent covers of the *Distichlis spicata*, *Phragmites australis,Typha latifolia, Scirpus americanus, Scirpus maritimus,* and *Stukenia* species
  - Water Quality Factor: includes information on pH, TDS, DO, total N, and total P
  - Invertebrate Factor: includes information on number of individuals per sample of Ephemeroptera, Odonata, Hemiptera, Chironomidae, Gastropoda, Crustacea, Platyhelminthes, and Annelida
- The factors are then rotated by an orthogonal rotation method known as Varimax rotation that minimizes the number of variables that have high loadings on each factor to make the loadings more interpretable
- The factor scores are computed and stored for correlation analysis. The relationships between factors are explored across the wetland sites:
  - Vegetation and water quality factors
  - Invertebrate and water quality factors
  - Invertebrate and vegetation factors
  - Invertebrate, vegetation and water quality factors

Soil chemistry factors are not included in the factor analysis as they do not correlate significantly with many biological variables in the tier 1 analysis.

Results

The section presents the results of the analyses conducted on 2004 Farmington Bay wetlands data. Presentation of the results follows the three-tiered analytical approach described in the methods section.

Tier 1: Results of Simple Univariate Regressions

Simple regressions of biological and environmental parameters are presented in Table 1. These regressions are of the form $Y = \alpha + \beta X$, and Table 1 contain the following regression coefficients and parameters:

- α = Y-intercept
- β = slope, where the sign (negative or positive) indicates whether the relationship between the dependent (Y) and independent (X) variables is negative or positive
- N = number of data pairs in the regression

- R^2 = proportion of variation in the dependent variable (Y) that can be accounted for by the independent variable (X)
- *F-ratio* is as the ratio between the mean square of the regression (MSR) and the mean square of the error (MSE) and is used to test whether the regression is significant. A large *F*-ratio indicates that the regression is significant
- *p-values* indicate the probabilistic level of significance

Plants and Soil Chemistry

Soil parameters such as soil pH, soil conductivity, and soil organic matter content, generally do not explain the variations observed in plant percent cover, except in the case of *Typha latifolia* percent cover which is significantly correlated with soil pH (Table 1, Figure 1).

TABLE 1. REGRESSIONS ESTIMATES OF WETLAND PLANT % COVER BY SPECIES ON SOIL PARAMETERS
Regressions are of the form: Plant % Cover (Y) = α + β*Soil Parameter (X), where α is the Y intercept and β is the slope.
Regression analyses is conducted on (log_{10} + 1) transformed values of plant %Cover and log_{10} transformed values of soil parameters. Stukenia species mainly consists of Stukenia filiformis and S. pectinatus.

PLANT % COVER (by species)	**α**	**β**	**N**	**R^2**	**F**	**p**
Independent Variable (X):						
SOIL pH vs:						
Distichlis spicata	2.79	-2.82	29	0.006	0.16	0.695
Phragmites australis	5.57	-5.93	29	0.033	0.92	0.346
Scirpus americanus	-1.35	2.17	29	0.003	0.08	0.779
Scirpus maritimus	8.54	-9.31	29	0.068	1.98	0.171
Stukenia species	1.08	-0.40	29	0.001	0.002	0.966
Typha latifolia	14.76	-16.35	29	0.225	7.84	0.009 ** (1)
Independent Variable (X):						
SOIL CONDUCTIVITY vs:						
Distichlis spicata	0.22	0.09	29	0.002	0.04	0.841
Phragmites australis	0.18	0.18	29	0.007	0.20	0.662
Scirpus americanus	0.92	-0.40	29	0.025	0.70	0.410
Scirpus maritimus	0.07	0.29	29	0.016	0.45	0.508
Stukenia species	0.89	-0.19	29	0.004	0.11	0.748
Typha latifolia	0.78	-0.52	29	0.056	1.61	0.215
Independent Variable (X):						
SOIL ORGANIC MATTER vs:						
Distichlis spicata	0.04	0.40	29	0.015	0.41	0.529
Phragmites australis	0.04	0.43	29	0.022	0.62	0.439

TABLE 1. REGRESSIONS ESTIMATES OF WETLAND PLANT % COVER BY SPECIES ON SOIL PARAMETERS

Regressions are of the form: Plant % Cover (Y) = $\alpha + \beta$*Soil Parameter (X), where α is the Y intercept and β is the slope.

Regression analyses is conducted on ($\log_{10}$ + 1) transformed values of plant %Cover and $\log_{10}$ transformed values of soil parameters. Stukenia species mainly consists of Stukenia filiformis and S. pectinatus.

PLANT % COVER (by species)	α	β	N	R^2	F	p
Scirpus americanus	0.69	-0.17	29	0.002	0.06	0.810
Scirpus maritimus	-0.19	0.76	29	0.058	1.67	0.207
Stukenia species	1.36	-0.95	29	0.048	1.38	0.251
Typha latifolia	-0.26	0.88	29	0.084	2.46	0.128

NOTES: p values > 0.05 indicate that the relationship between variables is not significant . ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships.

In contrast, heights of various plant species are significantly related to soil parameters (Table 2).

TABLE 2. REGRESSIONS ESTIMATES OF WETLAND PLANT HEIGHTS (CM) BY SPECIES ON SOIL PARAMETERS

Regressions are of the form: Plant Height (Y) = $\alpha + \beta$*Soil Parameter (X), where α is the Y intercept and β is the slope.

Plant height and soil parameters were Log_{10} transformed and regressions analyses conducted on log-transformed values. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT HEIGHT (by species)	α	β	N	R^2	F	p
Independent Variable (X):						
SOIL pH vs:						
Distichlis spicata	10.67	-10.38	6	0.379	2.44	0.193 † (2)
Phragmites australis	2.94	-0.85	8	0.008	0.05	0.835
Scirpus americanus	7.56	-6.48	12	0.455	8.35	0.016 ** (3)
Scirpus maritimus	8.34	-7.13	6	0.284	1.59	0.276
Stukenia species	5.89	-5.81	14	0.129	1.78	0.207
Typha latifolia	9.76	-8.59	8	0.389	3.82	0.099
Independent Variable (X):						
SOIL CONDUCTIVITY vs:						
Distichlis spicata	1.07	0.59	6	0.346	2.12	0.219 † (4)
Phragmites australis	2.17	0.04	8	0.009	0.05	0.826 † (5)
Scirpus americanus	2.07	-0.31	12	0.251	3.36	0.097
Scirpus maritimus	2.34	-0.29	6	0.386	2.52	0.188
Stukenia species	1.89	-0.49	14	0.134	1.85	0.199
Typha latifolia	2.56	-0.35	8	0.530	6.76	0.041 ** (6)

TABLE 2. REGRESSIONS ESTIMATES OF WETLAND PLANT HEIGHTS (CM) BY SPECIES ON SOIL PARAMETERS
Regressions are of the form: Plant Height (Y) = $\alpha + \beta$*Soil Parameter (X), where α is the Y intercept and β is the slope.
Plant height and soil parameters were Log$_{10}$ transformed and regressions analyses conducted on log-transformed values. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT HEIGHT (by species)	α	β	N	R^2	F	p
Independent Variable (X):						
SOIL ORGANIC MATTER vs:						
Distichlis spicata	0.80	0.99	6	0.524	4.40	0.104 † (7)
Phragmites australis	2.05	0.20	8	0.158	1.13	0.329
Scirpus americanus	2.10	-0.40	12	0.219	2.81	0.125
Scirpus maritimus	1.89	0.26	6	0.168	0.81	0.419
Stukenia species	0.93	-0.27	14	0.010	0.13	0.729
Typha latifolia	2.13	0.20	8	0.081	0.53	0.494

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. † indicates that a significant non-linear relationship exist between the variables. ** denotes a significant linear relationship between the log$_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships.

Patterns in heights of *Distichlis spicata* are significantly explained by soil pH, conductivity, and organic matter content (Table 2, Figures 2, 4, and 7, respectively). Variations in heights of *Scirpus americanus, Phragmites australis,* and *Typha latifolia* are also significantly explained by soil parameters (Table 2, Figures 3, 5, and 6).

Plants and Water Quality

Each water quality parameter correlates significantly with percent cover of at least two or more plant species, except total N, which fails to explain patterns in plant percent cover (Table 3, Figures 8–25).

TABLE 3. REGRESSIONS ESTIMATES OF WETLAND PLANT PERCENT COVER BY SPECIES ON WATER QUALITY PARAMETERS
Regressions are of the form: Plant Percent Cover (Y) = $\alpha + \beta$*Water Quality Parameter (X), where α is the Y intercept and β is the slope.
Plant percent cover values were (log$_{10}$ + 1) transformed and water quality parameters were log$_{10}$ transformed. Regression analyses were conducted on log-transformed values. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT % COVER (by species)	α	β	N	R^2	F	p
Independent Variable (X):						
pH vs:						
Distichlis spicata	7.12	-7.34	28	0.115	3.38	0.077
Phragmites australis	7.82	-8.14	28	0.202	6.60	0.016 ** (8)
Scirpus americanus	11.22	-11.57	28	0.257	9.01	0.006 ** (9)
Scirpus maritimus	6.79	-7.00	28	0.110	3.21	0.085
Stukenia species	-20.24	22.72	28	0.632	4.60	<0.001 ** (10)
Typha latifolia	7.32	-7.55	28	0.137	4.14	0.052

TABLE 3. REGRESSIONS ESTIMATES OF WETLAND PLANT PERCENT COVER BY SPECIES ON WATER QUALITY PARAMETERS
Regressions are of the form: Plant Percent Cover (Y) = $\alpha + \beta$*Water Quality Parameter (X), where α is the Y intercept and β is the slope.
Plant percent cover values were ($\log_{10} + 1$) transformed and water quality parameters were $\log_{10}$ transformed. Regression analyses were conducted on log-transformed values. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT % COVER (by species)	α	β	N	R^2	F	p
Independent Variable (X):						
TOTAL DISSOLVED SOLIDS (TDS) vs:						
Distichlis spicata	-0.54	0.27	28	0.011	0.28	0.601
Phragmites australis	3.63	-1.08	28	0.253	8.79	0.006 ** (11)
Scirpus americanus	3.74	-1.03	28	0.147	4.47	0.044 ** (12)
Scirpus maritimus	3.48	-1.02	28	0.166	5.17	0.032 ** (13)
Stukenia species	-2.88	1.17	28	0.120	3.53	0.072
Typha latifolia	4.98	-1.49	28	0.384	16.21	<0 .001 ** † (14 & 15)
Independent Variable (X):						
DISSOLVED OXYGEN (DO) vs:						
Distichlis spicata	0.66	-0.43	28	0.017	0.44	0.511
Phragmites australis	1.31	-1.18	28	0.183	5.81	0.023 ** (16)
Scirpus americanus	1.30	-0.89	28	0.066	1.83	0.188
Scirpus maritimus	1.00	-0.78	28	0.059	1.62	0.214
Stukenia species	-1.21	2.26	28	0.271	9.65	0.005 ** (17)
Typha latifolia	1.12	-0.89	28	0.083	2.36	0.137
Independent Variable (X):						
TOTAL PHOSPHORUS (P) vs:						
Distichlis spicata	0.12	-0.37	28	0.179	5.68	0.025 ** (18)
Phragmites australis	0.07	0.24	28	0.219	7.29	0.012 ** ! (19)
Scirpus americanus	0.52	-0.04	28	0.002	0.04	0.837
Scirpus maritimus	0.42	0.21	28	0.059	1.62	0.214
Stukenia species	1.04	-0.32	28	0.148	4.53	0.043 ** ! (20)
Typha latifolia	0.40	0.12	28	0.021	0.56	0.463

TABLE 3. REGRESSIONS ESTIMATES OF WETLAND PLANT PERCENT COVER BY SPECIES ON WATER QUALITY PARAMETERS
Regressions are of the form: Plant Percent Cover (Y) = $\alpha + \beta$*Water Quality Parameter (X), where α is the Y intercept and β is the slope.
Plant percent cover values were ($\log_{10}$ + 1) transformed and water quality parameters were $\log_{10}$ transformed. Regression analyses were conducted on log-transformed values. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT % COVER (by species)	**α**	**β**	**N**	**R^2**	**F**	**p**
Independent Variable (X):						
TOTAL NITROGEN (N) vs:						
Distichlis spicata	0.18	-0.21	28	0.071	1.98	0.172
Phragmites australis	0.37	0.16	28	0.061	1.70	0.203
Scirpus americanus	0.56	0.06	28	0.006	0.15	0.702
Scirpus maritimus	0.37	0.08	28	0.010	0.26	0.615
Stukenia species	0.68	-0.16	28	0.023	0.62	0.437
Typha latifolia	0.44	0.19	28	0.067	1.87	0.183
Independent Variable (X):						
MAX. WATER TEMPERATURE vs:						
Distichlis spicata	5.41	-3.69	16	0.219	3.93	0.068
Phragmites australis	8.57	-5.83	16	0.341	7.24	0.018 ** (21)
Scirpus americanus	8.80	-5.97	16	0.302	6.04	0.028 ** (22)
Scirpus maritimus	7.97	-5.39	16	0.257	4.85	0.045 ** (23)
Stukenia species	-10.47	8.05	16	0.267	5.09	0.041 ** (24)
Typha latifolia	9.61	-6.47	16	0.287	5.64	0.032 ** (25)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. † indicates that a significant non-linear relationship exist between the variables. ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships. ! indicates that the regression was conducted with untransformed water quality parameter.

The pH of water explains variations in percent cover of *Phragmites australi*s, *Scirpus americanus,* and *Stukenia* species (Table 3, Figures 8–10). Significant relationships also exist between total dissolved solids and *Phragmites australi*s, *Scirpus americanus, Scirpus maritimus,* and *Typha latifolia* (Table 3, Figures 11–15). Percent covers of *Phragmites australi*s and *Stukenia* species are significantly correlated to dissolved oxygen (Table 3, Figures 16–17), whereas total P concentration explains variations in percent covers of *Distichlis spicata, Phragmites australi*s, and *Stukenia* species (Table 3, Figures 18–20). Maximum water temperature is significantly correlated with percent covers of all plant species tested, except *Distichlis spicata* (Table 3, Figures 21–25).

Relatively fewer correlations exist between plant species heights and water quality variables (Table 4). Dissolved oxygen and total P concentrations do not correlate with heights of any of the plant species tested (Table 4).

TABLE 4. REGRESSIONS ESTIMATES OF WETLAND PLANT HEIGHT BY SPECIES ON WATER QUALITY PARAMETERS
Regressions are of the form: Plant Height (Y) = $\alpha + \beta$*Water Quality Parameter (X), where α is the Y intercept and β is the slope.
Regression analyses were conducted on $\log_{10}$ *transformed values of plant height and water quality parameters. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.*

PLANT HEIGHT (by species)	α	β	N	R^2	F	P
Independent Variable (X):						
pH vs:						
Distichlis spicata	0.36	1.28	6	0.003	0.01	0.919
Phragmites australis	6.10	-4.31	8	0.493	5.83	0.050 ** (26)
Scirpus americanus	-2.16	4.41	12	0.128	1.47	0.253
Scirpus maritimus	7.46	-5.94	6	0.455	3.34	0.142
Stukenia species	7.34	-6.95	14	0.304	5.25	0.041 ** (27)
Typha latifolia	5.87	-3.96	8	0.228	1.78	0.231
Independent Variable (X):						
TOTAL DISSOLVED SOLIDS (TDS) vs:						
Distichlis spicata	1.02	0.16	6	0.022	0.09	0.779
Phragmites australis	2.44	-0.08	8	0.012	0.07	0.795
Scirpus americanus	3.07	-0.41	12	0.300	4.29	0.065
Scirpus maritimus	3.73	-0.57	6	0.416	2.85	0.167
Stukenia species	2.02	-0.39	14	0.117	1.59	0.232
Typha latifolia	4.22	-0.68	8	0.525	6.62	0.042 ** (28)
Independent Variable (X):						
DISSOLVED OXYGEN (DO) vs:						
Distichlis spicata	1.26	0.04	6	0.079	0.34	0.591
Phragmites australis	2.43	-0.30	8	0.338	3.06	0.131
Scirpus americanus	1.59	0.30	12	0.075	0.81	0.389
Scirpus maritimus	2.30	-0.29	6	0.155	0.73	0.440
Stukenia species	1.91	-1.18	14	0.199	2.98	0.110
Typha latifolia	2.47	-0.24	8	0.121	0.83	0.398
Independent Variable (X):						
TOTAL PHOSPHORUS (P) vs:						
Distichlis spicata	1.43	-0.11	6	0.132	0.61	0.480
Phragmites australis	2.21	0.09	8	0.189	1.40	0.282

TABLE 4. REGRESSIONS ESTIMATES OF WETLAND PLANT HEIGHT BY SPECIES ON WATER QUALITY PARAMETERS
Regressions are of the form: Plant Height (Y) = α + β*Water Quality Parameter (X), where α is the Y intercept and β is the slope.
Regression analyses were conducted on $\log_{10}$ transformed values of plant height and water quality parameters. Stukenia species mainly consist of Stukenia filiformis and S. pectinatus.

PLANT HEIGHT (by species)	**α**	**β**	**N**	**R^2**	**F**	**P**
Scirpus americanus	1.81	-0.04	12	0.028	0.29	0.603
Scirpus maritimus	2.10	0.02	6	0.004	0.02	0.902
Stukenia species	0.70	-0.13	14	0.075	0.97	0.344
Typha latifolia	2.26	-0.04	8	0.019	0.12	0.743
Independent Variable (X):						
TOTAL NITROGEN (N) vs:						
Distichlis spicata	1.36	-0.23	6	0.542	4.73	0.095
Phragmites australis	2.21	0.04	8	0.099	0.66	0.449
Scirpus americanus	1.86	0.06	12	0.103	1.14	0.310
Scirpus maritimus	2.13	0.13	6	0.497	3.96	0.118
Stukenia species	0.84	0.14	14	0.125	1.72	0.215
Typha latifolia	2.32	0.18	8	0.769	20.0	0.004 ** (29)
Independent Variable (X):						
MAX. WATER TEMPERATURE vs:						
Distichlis spicata	*na*	*na*	*na*	*na*	*na*	*na*
Phragmites australis	6.05	-2.77	4	0.617	3.22	0.214
Scirpus americanus	-2.25	2.96	4	0.239	0.63	0.511
Scirpus maritimus	2.72	-0.41	4	0.091	0.20	0.699
Stukenia species	3.51	-1.91	10	0.067	0.58	0.469
Typha latifolia	-1.51	2.81	5	0.724	7.86	0.068 † (30)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. † indicates that a significant non-linear relationship exist between the variables. ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships. ! indicates regression on non-transformed water quality parameter. *na* = not applicable; insufficient data to perform regression analyses.

Heights of *Phragmites australis* and *Stukenia* species are significantly correlated with pH (Table 4, Figures 26–27), whereas the height of *Typha latifolia* is significantly correlated with TDS, total N concentration, and maximum water temperature (Table 4, Figures 28–30)

Invertebrates and Soil Chemistry

Variations in numbers of invertebrates belonging to a few taxa can be explained by soil chemistry parameters (Table 5). Linear relationships exist between flatworms and soil pH, ephemeropterans and soil conductivity, and annelids and soil organic matter (Table 5, Figures 32, 33, and 36). A few responses of invertebrates to soil parameters are non-linear, including gastropods and soil pH, gastropods and soil conductivity, and crustaceans and soil conductivity (Table 5, Figures 31, 34, and 35).

TABLE 5. REGRESSIONS ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON SOIL CHEMISTRY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Soil Chemistry Parameter (X), where α is the Y intercept and β is the slope. Regression analyses were conducted on ($\log_{10}$+1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of soil chemistry parameters.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Independent Variable (X):						
SOIL pH vs:						
Ephemeropterans (Mayflies)	6.02	-5.71	22	0.013	0.26	0.613
Odonates (Damselflies)	3.59	-2.81	22	0.007	0.15	0.710
Hemipterans (Water boatman, backswimmers)	9.09	-8.88	22	0.082	1.78	0.197
Chironomids (Midges)	-15.07	18.50	22	0.157	3.73	0.068
Gastropods (Snails)	1.95	-0.93	22	0.001	0.03	0.875 † (31)
Crustaceans (Scuds)	9.24	-9.53	22	0.033	0.68	0.420
Platyhelminthes (Flatworms)	16.59	-18.40	22	0.220	5.66	0.027 ** (32)
Annelids (Leeches)	6.48	-7.09	22	0.072	1.55	0.227
Other	1.19	-0.86	22	0.001	0.03	0.874
Independent Variable (X):						
SOIL CONDUCTIVITY vs:						
Ephemeropterans (Mayflies)	-0.47	1.80	22	0.252	6.73	0.017 ** (33)
Odonates (Damselflies)	1.84	-0.90	22	0.144	3.36	0.082
Hemipterans (Water boatman, backswimmers)	1.19	0.11	22	0.002	0.05	0.833
Chironomids (Midges)	1.06	0.21	22	0.004	0.08	0.786
Gastropods (Snails)	0.54	0.73	22	0.148	3.49	0.077 † (34)
Crustaceans (Scuds)	0.40	0.56	22	0.022	0.45	0.510 † (35)
Platyhelminthes (Flatworms)	1.25	-1.07	22	0.145	3.39	0.081
Annelids (Leeches)	0.44	-0.25	22	0.018	0.36	0.557
Other	0.10	0.42	22	0.067	1.28	0.271

TABLE 5. REGRESSIONS ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON SOIL CHEMISTRY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Soil Chemistry Parameter (X), where α is the Y intercept and β is the slope. Regression analyses were conducted on ($\log_{10}$+1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of soil chemistry parameters.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Independent Variable (X):						
SOIL ORGANIC MATTER vs:						
Ephemeropterans (Mayflies)	1.79	-1.14	22	0.067	1.43	0.245
Odonates (Damselflies)	1.26	-0.21	22	0.005	0.10	0.753
Hemipterans (Water boatman, backswimmers)	1.72	-0.64	22	0.055	1.16	0.294
Chironomids (Midges)	0.77	0.65	22	0.025	0.51	0.482
Gastropods (Snails)	0.79	0.48	22	0.042	0.89	0.358
Crustaceans (Scuds)	1.22	-0.52	22	0.013	0.26	0.616
Platyhelminthes (Flatworms)	-0.26	0.93	22	0.072	1.55	0.227
Annelids (Leeches)	-0.79	1.45	22	0.392	12.87	0.002 ** (36)
Other	0.40	0.06	22	0.001	0.02	0.903

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. † indicates that a significant non-linear relationship also exists between the variables. ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships.

Invertebrates and Water Quality

Responses of invertebrates to various water quality parameters are varied. Variations in pH, to various degrees, explain variations in invertebrate numbers (Table 5), including ephemeropterans (Figures 37–38), hemipterans (Figures 39–40), chironomids, gastropods, crustaceans (Figures 41–43, respectively), and annelids (Figures 44–45). In many cases, non-linear responses provide better fits to the invertebrate data.

TABLE 6. REGRESSION ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WATER QUALITY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Water Quality parameter (X), where α is the Y intercept and β is the slope of the relationship. Regression analyses were conducted on ($\log_{10}$ + 1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of water quality parameters.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Independent Variable (X):						
pH vs:						
Ephemeropterans (Mayflies)	-13.00	15.21	22	0.272	7.48	0.013 ** † (37 & 38)
Odonates (Damselflies)	-5.37	7.05	22	0.135	3.12	0.093
Hemipterans (Water boatman, backswimmers)	-8.93	11.1	22	0.377	12.10	0.002 ** † (39 & 40)
Chironomids (Midges)	13.35	-13.19	22	0.236	6.17	0.022 ** (41)
Gastropods (Snails)	-7.72	9.62	22	0.394	13.01	0.002 ** (42)

TABLE 6. REGRESSION ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WATER QUALITY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = α + β*Water Quality parameter (X), where α is the Y intercept and β is the slope of the relationship. Regression analyses were conducted on ($\log_{10}$ + 1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of water quality parameters.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Crustaceans (Scuds)	-20.37	23.08	22	0.568	26.32	< 0.001 ** (43)
Platyhelminthes (Flatworms)	7.03	-7.22	22	0.100	2.23	0.151
Annelids (Leeches)	6.37	-6.67	22	0.188	4.63	0.044 ** † (44 & 45)
Other	4.72	-4.66	22	0.112	2.52	0.128
Independent variable (X):						
TOTAL DISSOLVED SOLIDS (TDS) vs:						
Ephemeropterans (Mayflies)	-7.51	2.73	22	0.667	40.07	< 0.001 ** † (46 & 47)
Odonates (Damselflies)	4.15	-0.97	22	0.196	4.88	0.039 ** (48)
Hemipterans (Water boatman, backswimmers)	-0.50	0.57	22	0.075	1.63	0.217
Chironomids (Midges)	0.56	0.213	22	0.005	0.094	0.762
Gastropods (Snails)	-0.96	0.67	22	0.145	3.39	0.081
Crustaceans (Scuds)	-2.42	1.05	22	0.090	1.97	0.175
Platyhelminthes (Flatworms)	6.04	-1.81	22	0.482	18.63	< 0.001 ** † (49 & 50)
Annelids (Leeches)	2.67	-0.78	22	0.197	4.91	0.038 ** † (51 & 52)
Other	0.35	0.03	22	< 0.001	0.01	0.936
Independent variable (X):						
DISSOLVED OXYGEN (DO) vs:						
Ephemeropterans (Mayflies)	-1.28	2.69	22	0.373	11.89	0.003 ** (53)
Odonates (Damselflies)	1.22	-0.12	22	0.002	0.036	0.852
Hemipterans (Water boatman, backswimmers)	-0.46	2.06	22	0.568	26.25	< 0.001 ** (54)
Chironomids (Midges)	2.98	-2.089	22	0.259	6.87	0.016 ** (55)
Gastropods (Snails)	0.45	0.80	22	0.118	2.69	0.117
Crustaceans (Scuds)	-1.34	2.60	22	0.315	9.19	0.007 ** (56)
Platyhelminthes (Flatworms)	1.63	-1.47	22	0.181	4.43	0.048 ** (57)
Annelids (Leeches)	1.37	-1.35	22	0.339	10.25	0.004 ** (58)
Other	1.34	-1.04	22	0.245	6.48	0.019 **

TABLE 6. REGRESSION ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WATER QUALITY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Water Quality parameter (X), where α is the Y intercept and β is the slope of the relationship. Regression analyses were conducted on ($\log_{10}$ + 1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of water quality parameters.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Independent variable (X):						
TOTAL PHOSPHORUS (P) vs:						
Ephemeropterans (Mayflies)	0.60	-0.83	22	0.575	27.02	< 0.001 ** (59)
Odonates (Damselflies)	1.24	0.26	22	0.132	3.03	0.097
Hemipterans (Water boatman, backswimmers)	1.54	-0.27	22	0.314	9.15	0.007 ** ! (60)
Chironomids (Midges)	0.88	0.34	22	0.221	5.69	0.027 ** ! (61)
Gastropods (Snails)	1.08	-0.09	22	0.027	0.55	0.466
Crustaceans (Scuds)	0.82	-0.07	22	0.004	0.08	0.786 † (62)
Platyhelminthes (Flatworms)	0.47	0.17	22	0.041	0.84	0.369
Annelids (Leeches)	0.35	0.25	22	0.194	4.80	0.040 ** † (63 & 64)
Other	0.46	0.05	22	0.010	0.20	0.662
Independent variable (X):						
TOTAL NITROGEN (N) vs:						
Ephemeropterans (Mayflies)	0.63	-0.81	22	0.627	33.64	< 0.001 ** (65)
Odonates (Damselflies)	1.19	0.16	22	0.059	1.26	0.276
Hemipterans (Water boatman, backswimmers)	1.20	-0.17	22	0.073	1.59	0.223
Chironomids (Midges)	1.24	0.05	22	0.002	0.05	0.826
Gastropods (Snails)	0.98	-0.32	22	0.363	11.37	0.003 ** (66)
Crustaceans (Scuds)	1.18	-0.21	22	0.272	7.47	0.013 ** ! (67)
Platyhelminthes (Flatworms)	0.54	0.33	22	0.172	4.16	0.055
Annelids (Leeches)	0.29	0.14	22	0.064	1.37	0.256
Other	0.44	-0.004	22	< 0.001	0.001	0.970
Independent variable (X):						
MAX. WATER TEMPERATURE vs:						
Ephemeropterans (Mayflies)	-15.56	11.65	16	0.569	18.45	0.001 ** † (68 & 69)
Odonates (Damselflies)	1.15	0.13	16	<0.001	0.004	0.948
Hemipterans (Water boatman, backswimmers)	-7.68	6.39	16	0.485	13.18	0.003 ** † (70 & 71)

TABLE 6. REGRESSION ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WATER QUALITY PARAMETERS
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Water Quality parameter (X), where α is the Y intercept and β is the slope of the relationship. Regression analyses were conducted on ($\log_{10}$ + 1) transformed values of invertebrate numbers and $\log_{10}$ transformed values of water quality parameters.

INVERTEBRATE NUMBERS (by taxa)	α	β	N	R^2	F	P
Chironomids (Midges)	7.92	-4.87	16	0.110	1.73	0.210
Gastropods (Snails)	-2.90	2.92	16	0.132	2.13	0.167
Crustaceans (Scuds)	-9.80	7.71	16	0.228	4.14	0.061
Platyhelminthes (Flatworms)	11.44	-7.67	16	0.304	6.13	0.027 ** (72)
Annelids (Leeches)	7.71	-5.19	16	0.298	5.94	0.029 ** (73)
Other	4.24	-2.67	16	0.107	1.69	0.215

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. † indicates that a significant non-linear relationship also exists between the variables. ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships. ! indicates that regression was conducted on non-transformed water quality parameter.

Numbers of ephemeropterans, odonates, crustaceans, and annelids are also related to TDS (Table 6, Figures 46–52). Total dissolved oxygen explains variations in each of the invertebrate taxa included in the analysis, except odonates, gastropods, and the "other" category (Table 6, Figures 53–58). Invertebrates show responses to both total N and total P concentrations. Numbers of ephemeropterans, hemipterans, chironomids, crustaceans and annelids are significantly related to total P (Table 6, Figures 59–64), whereas total N concentrations help explain various degrees of variation in ephemeropterans, gastropods and crustaceans (Table 6, Figures 65–67). Maximum water temperature helps explain variations in numbers of ephemeropterans, hemipterans, flatworms, and annelids (Table 6, Figures 68–73).

Invertebrates and Plants

Statistically significant relationships are found between percent covers of various wetland plants and invertebrate taxa (Table 7). Significant relationships are found between percent cover of:

- *Typha latifolia* and ephemeropterans, flatworms, and annelids (Table 7, Figures 74–76)
- *Phragmites australis* and ephemeropterans, hemipterans, flatworms and annelids (Table 7, Figures 77–80)
- *Distichlis spicata* and odonates (Table 7, Figure 81)
- *Scirpus americanus* and gastropods, crustaceans (Table 7, Figures 82–83)
- *Stukenia* species and ephemeropterans, hemipterans, chironomids, gastropods, and crustaceans (Table 7, Figures 84–88)

TABLE 7. REGRESSIONS ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WETLAND PLANT PERCENT COVER
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Plant Percent Cover (X), where α is the Y intercept and β is the slope. Regression analyses were conducted on ($\log_{10}$+1) transformed values of invertebrate numbers and plant percent cover.
Stukenia species consists mainly of Stukenia filiformis and S. pectinatus.

INVERTEBRATE NUMBERS (by taxa)	α	β	N	R^2	F	P
Independent Variable (X): ***Typha latifolia* % COVER** vs:						
Ephemeropterans (Mayflies)	1.22	-0.79	22	0.279	7.73	0.012 ** (74)
Odonates (Damselflies)	1.03	0.31	22	0.100	2.23	0.151
Hemipterans (Water boatman, backswimmers)	1.35	-0.25	22	0.073	1.59	0.222
Chironomids (Midges)	1.28	-0.18	22	0.016	0.33	0.574
Gastropods (Snails)	1.19	-0.23	22	0.087	1.91	0.182
Crustaceans (Scuds)	1.02	-0.56	22	0.127	2.90	0.104
Platyhelminthes (Flatworms)	0.07	1.06	22	0.818	89.96	< 0.001 ** (75)
Annelids (Leeches)	0.06	0.59	22	0.561	25.60	< 0.001 ** (76)
Other	0.40	0.12	22	0.029	0.60	0.446
Independent Variable (X): ***Phragmites australis* % COVER** vs:						
Ephemeropterans (Mayflies)	1.23	-0.99	22	0.310	9.00	0.007 ** (77)
Odonates (Damselflies)	1.04	0.32	22	0.074	1.59	0.221
Hemipterans (Water boatman, backswimmers)	1.42	-0.61	22	0.310	9.00	0.007 ** (78)
Chironomids (Midges)	1.16	0.27	22	0.027	0.55	0.468
Gastropods (Snails)	1.15	-0.09	22	0.010	0.20	0.660
Crustaceans (Scuds)	0.98	-0.54	22	0.083	1.82	0.193
Platyhelminthes (Flatworms)	0.19	0.83	22	0.355	11.01	0.003 ** (79)
Annelids (Leeches)	0.04	0.80	22	0.721	51.70	< 0.001 ** (80)
Other	0.40	0.18	22	0.042	0.88	0.359
Independent Variable (X): ***Distichlis spicata* % COVER** vs:						
Ephemeropterans (Mayflies)	0.87	0.33	22	0.067	1.44	0.245
Odonates (Damselflies)	1.31	-0.52	22	0.401	13.41	0.002 ** (81)
Hemipterans (Water boatman, backswimmers)	1.36	-0.24	22	0.092	2.03	0.169
Chironomids (Midges)	1.20	0.05	22	0.002	0.04	0.851
Gastropods (Snails)	1.19	-0.17	22	0.065	1.38	0.254

TABLE 7. REGRESSIONS ESTIMATES OF INVERTEBRATE NUMBERS BY TAXA ON WETLAND PLANT PERCENT COVER
Regressions are of the form: Invertebrate Numbers (Y) = $\alpha + \beta$*Plant Percent Cover (X), where α is the Y intercept and β is the slope. Regression analyses were conducted on ($\log_{10}$+1) transformed values of invertebrate numbers and plant percent cover.
Stukenia species consists mainly of Stukenia filiformis and S. pectinatus.

INVERTEBRATE NUMBERS (by taxa)	**α**	**β**	**N**	**R^2**	**F**	**P**
Crustaceans (Scuds)	1.05	-0.54	22	0.170	4.08	0.057
Platyhelminthes (Flatworms)	0.36	0.09	22	0.008	0.16	0.693
Annelids (Leeches)	0.26	-0.08	22	0.014	0.29	0.594
Other	0.40	0.10	22	0.027	0.56	0.463
Independent Variable (X): ***Scirpus americanus*** **% COVER** vs:						
Ephemeropterans (Mayflies)	1.25	-0.48	22	0.125	2.85	0.107
Odonates (Damselflies)	1.28	-0.30	22	0.110	2.48	0.131
Hemipterans (Water boatman, backswimmers)	1.45	-0.32	22	0.147	3.45	0.078
Chironomids Midges)	0.99	0.43	22	0.114	2.58	0.124
Gastropods (Snails)	1.35	-0.41	22	0.330	9.87	0.005 ** (82)
Crustaceans (Scuds)	1.36	-0.91	22	0.412	14.02	0.001 ** (83)
Platyhelminthes (Flatworms)	0.29	0.18	22	0.028	0.57	0.459
Annelids (Leeches)	0.26	-0.05	22	0.005	0.11	0.746
Other	0.38	0.11	22	0.028	0.58	0.456
Independent Variable (X): ***Stukenia*** **species % COVER** vs:						
Ephemeropterans (Mayflies)	0.61	0.50	22	0.228	5.90	0.025 ** (84)
Odonates (Damselflies)	0.91	0.28	22	0.168	4.03	0.058
Hemipterans (Water boatman, backswimmers)	0.98	0.39	22	0.352	10.88	0.004 ** (85)
Chironomids (Midges)	1.58	-0.47	22	0.234	6.12	0.022 ** (86)
Gastropods (Snails)	0.94	0.25	22	0.201	5.02	0.037 ** (87)
Crustaceans (Scuds)	0.34	0.68	22	0.383	12.42	0.002 ** (88)
Platyhelminthes (Flatworms)	0.47	-0.13	22	0.025	0.51	0.481
Annelids (Leeches)	0.40	-0.22	22	0.162	3.86	0.064
Other	0.50	-0.08	22	0.026	0.53	0.477

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. ** denotes a significant linear relationship between the $\log_{10}$-transformed variables. Figure numbers (in parentheses) are referenced for significant relationships.

Tier 2: Results of Multiple Regression Models

Based on simple regression analyses, biological, physical, and chemical variables that are significantly correlated in the Tier 1 analyses are included into multiple regression models. These models offer useful insights into potential biological metrics that may eventually be useful in evaluating wetland function due to their strong responses to specific environmental variables.

Multiple regressions of percent covers of *Phragmites australis, Stukenia* species, and *Typha latifolia* on environmental variables (soil chemistry and water quality variables) are highly significant (Table 8). Conversely, multiple regression models of both *Scirpus* species are not statistically significant.

TABLE 8. MULTIPLE REGRESSIONS OF PLANT PERCENT COVER, PLANT HEIGHT, AND INVERTEBRATE NUMBERS ON ENVIRONMENTAL PARAMETERS MEASURED IN THE FARMINGTON BAY WETLANDS

Environmental parameters are independent variables in the multiple regressions and include water quality and soil chemistry parameters for regressions on plant percent cover and plant height. Multiple regressions on invertebrate numbers include water quality, soil chemistry and plant species percent covers as independent environmental parameters.

DEPENDENT VARIABLE	REGRESSION	N	ADJUSTED R^2	F	p
VEGETATION PERCENT COVER					
Phragmites australis	$\log_{10}$ (PHASpc +1) = -4.927 + 2.242($\log_{10}$ pH) – 0.558($\log_{10}$ TDS) – 1.599($\log_{10}$ DO) + 0.284(P) + 4.208($\log_{10}$ MaxT)	16	0.701	8.027	0.003 **
Stukenia species	$\log_{10}$ (STspc +1) = -13.731 + 19.939($\log_{10}$ pH) + 0.438($\log_{10}$ DO) - 0.144(P) – 2.828($\log_{10}$ MaxT)	16	0.659	8.259	0.002 **
Typha latifolia	$\log_{10}$ (TYLApc +1) = 13.767 – 1.265($\log_{10}$ TDS) – 2.246($\log_{10}$ MaxT) – 7.116($\log_{10}$ SpH)	16	0.464	5.336	0.014 **
Scirpus americanus	$\log_{10}$ (SCAMpc +1) = 7.592 – 0.114($\log_{10}$ pH) – 0.870($\log_{10}$ TDS) – 3.141($\log_{10}$ MaxT)	16	0.268	2.832	0.083
Scirpus maritimus	$\log_{10}$ (SCMApc +1) = 7.144 – 0.573*($\log_{10}$ TDS) – 3.557*($\log_{10}$ MaxT)	16	0.202	2.895	0.091
VEGETATION HEIGHT					
Typha latifolia	$\log_{10}$ (TYLAht) = 2.334 – 0.039($\log_{10}$ TDS) + 0.139($\log_{10}$ N) – 0.164($\log_{10}$ SEC)	8	0.701	6.464	0.050 **
INVERTEBRATE NUMBERS					
Ephemeropterans (Mayflies)	$\log_{10}$ (CALLI +1) = -5.753 – 0.843($\log_{10}$ pH) + 2.043($\log_{10}$ TDS) – 2.106($\log_{10}$ DO) - 0.280($\log_{10}$ P) – 0.158($\log_{10}$ N) + 2.670($\log_{10}$ MaxT) – 1.376($\log_{10}$ SEC) – 0.307($\log_{10}$TYLApc) -0.185($\log_{10}$ PHASpc) + 0.348($\log_{10}$ STspc)	16	0.913	16.812	0.003 **

TABLE 8. MULTIPLE REGRESSIONS OF PLANT PERCENT COVER, PLANT HEIGHT, AND INVERTEBRATE NUMBERS ON ENVIRONMENTAL PARAMETERS MEASURED IN THE FARMINGTON BAY WETLANDS

Environmental parameters are independent variables in the multiple regressions and include water quality and soil chemistry parameters for regressions on plant percent cover and plant height. Multiple regressions on invertebrate numbers include water quality, soil chemistry and plant species percent covers as independent environmental parameters.

DEPENDENT VARIABLE	**REGRESSION**	**N**	**ADJUSTED R^2**	**F**	**p**
Hemipterans (water boatman, backswimmers)	$\log_{10}$ (HEMIP +1) = 1.027 – 2.921($\log_{10}$ pH) + 0.608($\log_{10}$ DO) - 0.030(P) + 2.002($\log_{10}$ MaxT) – 0.657($\log_{10}$ PHASpc) - 0.074($\log_{10}$ STspc)	16	0.821	12.476	0.001 **
Platyhelminthes (flatworms)	$\log_{10}$ (PLATY +1) = 1.459 – 0.454($\log_{10}$ TDS) – 1.868($\log_{10}$ DO) + 2.069($\log_{10}$ MaxT) – 1.209($\log_{10}$ SpH) + 0.976($\log_{10}$TYLApc) – 0.593($\log_{10}$ PHASpc)	16	0.796	10.734	0.001 **
Annelids (leeches)	$\log_{10}$ (ANNE +1) = -2.767 – 0.744($\log_{10}$ pH) – 0.053($\log_{10}$ TDS) – 0.06($\log_{10}$ DO) + 0.182($\log_{10}$ P) + 2.550($\log_{10}$ MaxT) + 0.269($\log_{10}$ SOM) – 0.193($\log_{10}$TYLApc) + 0.592($\log_{10}$ PHASpc)	16	0.736	6.218	0.013 **
Gastropods (snails)	$\log_{10}$ (GASTR +1) = -5.751 – 7.654($\log_{10}$ pH) – 0.238($\log_{10}$ N) – 0.278($\log_{10}$SCAMpc) – 0.156($\log_{10}$ STspc)	22	0.602	8.949	< 0.001 **
Crustaceans (scuds)	$\log_{10}$ (HYALL +1) = -15.489 + 18.781($\log_{10}$ pH) – 0.569($\log_{10}$ DO) – 0.085(N) - 0.481($\log_{10}$SCAMpc) - 0.072($\log_{10}$ STspc)	22	0.582	6.848	0.001 **
Odonates (Damselflies)	$\log_{10}$ (ODON +1) = 3.993 – 0.864($\log_{10}$ TDS) – 0.497($\log_{10}$ DISPpc)	22	0.508	11.838	< 0.001 **
Chironomids (midges)	$\log_{10}$ (CHIRO +1) = 1.943 – 0.254($\log_{10}$ pH) – 0.538($\log_{10}$ DO) + 0.164(P) - 0.264($\log_{10}$ STspc)	22	0.145	1.889	0.159

** Indicates a significant relationship between the variables in the regression and the $p \leq 0.05$ level.

Abbreviations:

Water Quality Parameters: TDS = Total dissolved solids; DO = Dissolved oxygen; P = Total phosphorus; N = Total nitrogen; MaxT = Maximum water temperature

Soil Chemistry Parameters: SpH = Soil pH; SEC = Soil Electrical Conductivity; SOM = Soil organic matter

Plant Species Parameters: PHASpc = *Phragmites australis* % cover; TYLApc = *Typha latifolia* % cover; SCAMpc = *Scirpus americanus* % cover; SCMApc = *Scirpus maritimus* % cover; STspc = *Stukenia species* percent cover; DISPpc = *Distichlis spicata* % cover; TYLAht = *Typha latifolia* height

Invertebrate Parameters: CALLI = Ephemeropterans (Mayflies); ODON = Odonates (Damselflies); HEMIP = Hemipterans (Water boatman, backswimmers); CHIRO = Chironomids (Midges); GASTR = Gastropods (snails); HYALL = Crustaceans (scuds); PLATY = Platyhelminthes (flatworms); ANNE = Annelids (leeches)

Plant percent cover in relation to environmental variables:

- pH, total dissolved solids, dissolved oxygen, total P, and maximum water temperature helps explain 70.1 percent of the variation observed in percent cover of *Phragmites australis* (Table 8)
- pH, dissolved oxygen, total P, and maximum water temperature helps explain 65.9 percent of the variation observed in percent cover of *Stukenia* species (Table 8)
- total dissolved solids and maximum water temperature explains 46.4 percent of the variation observed in percent cover of *Typha latifolia* (Table 8)

Plant height in relation to environmental variables:

- total dissolved solids, total N, and soil electrical conductivity helps explain 70.1 percent of the variation observed in percent cover of Typha latifolia (Table 8)

All invertebrate taxa included in the multiple regression analyses, except chironomids, show statistically significant relationships with environmental variables (Table 8).

- 91.3 percent of the variation observed in numbers of Ephemeroptera (Mayflies) is explained by pH, total dissolved solids, dissolved oxygen, total P, total N, maximum water temperature, soil electrical conductivity and percent covers of Typha latifolia, Phragmites australis and Stukenia species (Table 8)
- 82.1 percent of the variation observed in numbers of Hemiptera (water boatman, backswimmers) is explained by pH, dissolved oxygen, total P, maximum water temperature, and percent covers of Phragmites australis and Stukenia species (Table 8)
- 79.6 percent of the variation observed in numbers of Platyhelminthes (flatworms) is explained by total dissolved solids, dissolved oxygen, maximum water temperature, soil pH and percent covers of Typha latifolia and Phragmites australis (Table 8)
- 73.6 percent of the variation observed in numbers of Annelida (leeches) is explained by pH, total dissolved solids, dissolved oxygen, total P, maximum water temperature, soil organic matter and percent covers of Typha latifolia and Phragmites australis (Table 8)
- 60.2 percent of the variation observed in numbers of Gastropoda (snails) is explained by pH, total N, and percent covers of Scirpus americanus and Stukenia species (Table 8)
- 58.2 percent of the variation observed in numbers of Crustacea (scuds) is explained by pH, dissolved oxygen, total N, and percent covers of Scirpus americanus and Stukenia species (Table 8)
- 50.8 percent of the variation in numbers of Odonata (Damselflies) is explained by just two variables, total dissolved solids and percent cover of Distichlis spicata (Table 8)

Tier 3: Results of Multivariate Factor Analyses

Factor analysis provides useful insights into patterns observed between the biological communities and environmental variables across the wetland sites in Farmington Bay. Factor analysis is also used to explore patterns in biological and environmental components separately in sites with sheetflow hydrology and impounded sites.

Vegetation and Water Quality Across All Sites

The vegetation factor included percent covers of *Phragmites australis, Typha latifolia, Scirpus americanus, Scirpus maritimus, Distichlis spicata,* and *Stukenia* species. The water quality factor included pH, dissolved oxygen, total dissolved solids, total N and total P concentrations. A plot of wetland sampling sites based on the vegetation and water quality factor scores for each site is shown in Figure 89. Low values on the water quality factor axis reflect freshwater habitats (low TDS, low pH, low dissolved oxygen) with high nutrient (N+P) loads. High values represent more saline habitats relatively low in nutrients. Sites in-between represent a more moderate water chemistry. On the vegetation factor axis, low values represent a plant community dominated by *Stukenia* species, whereas high values represent communities dominated by *Phragmites australis, Typha latifolia,* and both *Scirpus* species. Sites in-between tend to have *Distichlis spicata*. Overall, the plot indicates a trend from more freshwater, eutrophic sites dominated by *Phragmites australis, Typha latifolia,* and both *Scirpus* species to more oligotrophic and saline sites dominated by *Stukenia* species. Sites with moderate water chemistry had *Distichlis spicata*.

Invertebrates and Water Quality Across All Sites

The invertebrate factor included information on numbers per sample of all invertebrate taxa, except the “other” category of invertebrates. Low values on the invertebrate factor axis (Figure 90) represent sites dominated chironomids, flatworms and leeches, whereas high values reflect sites dominated by mayflies (Ephemeroptera), damselflies (Odonates), water boatman and backswimmers (Hemiptera), Hyallela (Crustacea), and snails (Gastropoda). Overall, the graph (Figure 90) indicates the general trend of more eutrophic, freshwater sites dominated by chironomids, flatworms and leeches to more saline, oligotrophic site dominated by mayflies, damselflies, water boatman, backswimmers, Hyallela, and snails.

Invertebrates and Plants Across All Sites

Figure 91 indicates the relationship between the invertebrate and vegetation factors. A general trend reflects invertebrate communities dominated by mayflies, damselflies, water boatman, backswimmers, Hyallela, and snails at sites where *Stukenia* is the dominant plant species. Conversely, sites dominated by *Phragmites australis, Typha latifolia,* and both *Scirpus* species contain an invertebrate community consisting mainly of chironomids, flatworms and leeches.

Invertebrates, Plants, and Water Quality Across All Sites

A three-way representation of the relationship between the invertebrate, plant and water quality factors is shown in Figure 92. This graph reveals an overall trend of more freshwater, eutrophic sites dominated by *Phragmites australis, Typha latifolia,* and both *Scirpus* species and an invertebrate assemblage composed mainly of chironomids, flatworms and leeches. Conversely, relatively saline, oligotrophic sites consist of a plant assemblage represented by *Stukenia* species with an invertebrate community composed of mayflies, damselflies, water boatman, backswimmers, Hyallela, and snails.

Vegetation and Water Quality: Comparing Sheet-Flow and Impounded Sites

A plot of wetland sites with sheetflow hydrology based on the vegetation and water quality factor scores for each site is shown in Figure 93. Low values on the water quality factor axis reflect freshwater habitats (low TDS, low pH, low dissolved oxygen) with high nutrient (N+P) loads. High values represent more saline habitats relatively low in nutrients. On the vegetation factor axis, low values represent a plant community dominated by *Distichlis spicata* and *Scirpus americanus*, whereas high values represent communities dominated by *Phragmites australis, Typha latifolia,* and *Scirpus maritimus*. Overall, the plot indicates a trend from more freshwater, eutrophic sites dominated by *Phragmites australis, Typha latifolia,* and *Scirpus maritimus* to more oligotrophic and saline sites dominated by *Distichlis spicata* and *Scirpus americanus*.

In impounded sites, the vegetation is dominated with *Stukenia* species, and other species observed in sheetflow sites are notably absent. Because of the dominance of a single plant species, factor analysis, which is designed for analysis of multivariate datasets, could not be conducted.

Invertebrates and Water Quality: Comparing Sheet-Flow and Impounded Sites

For sheetflow sites, low values on the invertebrate factor axis (Figure 94) represent sites dominated flatworms (Platyhelminthes), leeches (Annelida) and damselflies (Odonata), whereas high values reflect sites dominated by mayflies (Ephemeroptera), water boatman and backswimmers (Hemiptera), snails (Gastropoda) and chironomids. *Hyallela* (Crustacea) are represented by values inbetween. Overall, the graph (Figure 94) reveals a general trend where more eutrophic, freshwater sheetflow sites are dominated by flatworms, leeches, and damselflies, in contrast to more saline, oligotrophic sites which tend to be dominated by mayflies, water boatman, backswimmers, snails, and chironomids.

Impounded sites reveal a general trend with more saline, oligotrophic sites being dominated by mayflies, water boatman, backswimmers and chironomids, and more freshwater eutrophic sites represented by damselflies, snails, and *Hyallela* (Figure 95).

Invertebrates and Plants: Comparing Sheet-Flow and Impounded Sites

Figure 96 shows the relationship between the invertebrate and vegetation factors at sheetflow sites. The invertebrate community is dominated by mayflies, water boatman, backswimmers, snails, and chironomids at sites where *Distichlis spicata* and *Scirpus americanus* are the dominant plant species. Conversely, sites dominated by *Phragmites australis* and *Typha latifolia* contain an invertebrate community consisting mainly of flatworms, leeches, and damselflies.

The only dominant plant species in impounded sites is *Stukenia*; therefore multivariate analysis on the plant component could not be conducted and the relationship between invertebrates and plants for impounded sites is not explored.

Invertebrates, Plants and Water Quality: Comparing Sheet-Flow and Impounded Sites

The relationships between invertebrates, plants and water quality is shown for sheetflow sites in Figure 97. This graph shows an overall trend of more freshwater, eutrophic sites being dominated by *Phragmites australis* and *Typha latifolia,* and an invertebrate assemblage composed mainly of flatworms, leeches and damselflies. Conversely, relatively saline, oligotrophic sites consist of a plant assemblage represented by *Distichlis spicata* and *Scirpus americanus* and an invertebrate community composed of mayflies, water boatman, backswimmers, snails, and chironomids. Sites with moderate water quality are represented occasionally by *Hyallela* (Crustacea).

The only dominant plant species in impounded sites is *Stukenia*; therefore a three-way multivariate relationship between water quality, plants, and invertebrates could not be explored.

Conclusions

The data presented in this technical memorandum represents the first year of an ongoing effort to characterize the wetland systems of Farmington Bay. The purpose of this analysis is to provide a preliminary evaluation of some biological and environmental components of the Farmington Bay wetlands that, as part of an ongoing effort, serves as a first step towards characterizing the wetlands and defining its beneficial uses. This analysis also offers some insights into potential biological and environmental metrics that may be useful in evaluating wetland function. As such, results from this analysis could be used not only as part of a larger data set being collected in ongoing studies, but also to guide future sampling efforts and analysis on subsequent data sets (i.e., choice of data analysis methods, choice of biological and environmental metrics that show strong functional responses, focus sampling efforts on collecting data on metrics that work).

Some key conclusions based on the analysis conducted in this study are presented:

- Although the soil parameters (soil pH, soil conductivity, and soil organic matter) correlated with biological metrics on only a few occasions, it is suggested that sampling of these parameters continue in subsequent efforts. Certain metrics such as plant height and a few invertebrate taxa showed significant linear and non-linear responses to these soil parameters. Subsequent sampling should also focus on adding soil nutrients and soil texture to the suite of measurements.

- Continue with the sampling of all water quality parameters included in this analysis. The biological metrics (plants and invertebrates) measured in this study exhibit strong responses to the water quality parameters.

- The choice of sites that include sites with impounded and sheetflow hydrology over a large geographical area around Farmington Bay appears to be well-suited for this study. These sites reflect a wide range of environmental conditions based on soil and water chemistry parameters and exhibit a range of responses in the biological metrics that were measured.

- Plant percent cover and plant height were both useful metrics of wetland function as both showed significant responses to soil chemistry and water quality in certain plant species.

- Six species of plants were included in this analysis. Multiple regression models indicate that of these, three species, *Phragmites australis, Stukenia* species and *Typha latifolia* appear to show significant responses in percent cover to a range of soil chemistry and water quality parameters. Approximately 70 percent and 66 percent of the variation in percent cover of *Phragmites australis* and *Stukenia* species, respectively, could be explained by a few water quality parameters. To a lesser extent, approximately 46 percent of the variation in percent cover of *Typha latifolia* was explained by select soil chemistry and water quality parameters. *Typha latifolia* also shows responses in height and approximately 70 percent of the variation in height of this species was explained by a few soil and water parameters. Based on this analysis, *Phragmites australis, Stukenia* species, and *Typha latifolia* are potential candidate species for establishing key biological metrics to assess wetlands function in Farmington Bay. These species also represent both types of hydrology at the sites, with *Phragmites australis* and *Typha latifolia* dominant at sheetflow sites and *Stukenia* species at impounded sites. Future sampling efforts should however focus on sampling all plant species within each transect, as temporal shifts in species responses are likely.

- Invertebrate taxa in this analysis served as sensitive indicators of environmental condition and displayed a range of responses to soil chemistry and particularly to water quality. Numbers of individuals per sample appeared to be an appropriate metric for invertebrates in this analysis.

- Eight invertebrate taxa and a category, “other,” that included those taxa rarely found in the samples were included in this analysis. Multiple regression models indicate that of these, four taxa, Ephemeroptera (Mayflies), Hemiptera (water boatman, backswimmers), Platyhelminthes (flatworms) and Annelids (leeches) appeared to show the strongest responses to a range of soil chemistry, water quality, and plant parameters. From 74 percent to 91 percent of the variation in invertebrate numbers belonging to these four taxa was explained by soil, water and plant parameters. To a lesser extent, approximately 51 percent to 60 percent of the variation in numbers of Gastropoda (snails), Crustacea (scuds, mainly *Hyallela*) and Odonata (damselflies) was explained by soil, water and plant parameters. These invertebrate taxa could supplement the plant taxa noted as valuable biological metrics in assessing wetland function. It is recommended that future sampling efforts particularly focus on collecting invertebrates as part of the sampling at all sites.

- While univariate and multiple regression analyses offer useful insights into the potential relationships between biological and environmental variables, multivariate analysis helps to provide an overall assessment of the general trends and patterns of biological and environmental variable across sites. Multivariate analysis across all sites (sheetflow and impounded) shows that in general, freshwater sites that are more eutrophic tend to be dominated by a plant assemblage consisting of *Phragmites australis, Typha latifolia,* and both *Scirpus* species, and an invertebrate community composed of chironomids flatworms and leeches. Relatively saline, oligotrophic sites are dominated by *Stukenia* species and invertebrates such as mayflies, damselflies, water boatman, backswimmers, *Hyallela*, and snails.

- Multivariate analysis in sheetflow sites shows that more freshwater, eutrophic sites are dominated by *Phragmites australis* and *Typha latifolia,* and an invertebrate assemblage composed mainly of flatworms, leeches and damselflies. Conversely, relatively saline, oligotrophic sheetflow sites consist of a plant assemblage represented by *Distichlis spicata* and *Scirpus americanus* and an invertebrate community composed of mayflies, water boatman, backswimmers, snails, and chironomids. Sites with moderate water quality are represented occasionally by *Hyallela* (Crustacea). Data from the first year data (2004) should be compared to data from subsequent analyses (2005 and 2006) to detect any potential temporal and spatial changes in these patterns.

References

Gray, L. J. 2005. Composition of macroinvertebrate communities of the Great Salt Lake wetlands and relationships to water chemistry. Report prepared for the Utah Department of Environmental Quality, Water Quality Management Section. March 2005.

Systat. Version 11. 2004. Statistical Analysis Software. WWW.SYSTAT.COM

Figures

Figure 1. T. latifolia % Cover and Soil pH

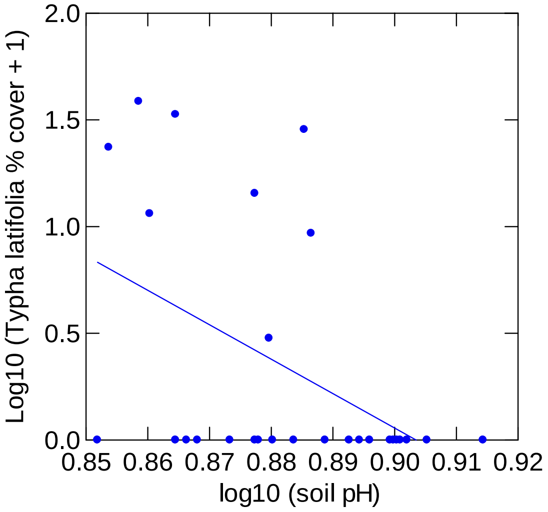


Figure 2. D. spicata height and Soil pH

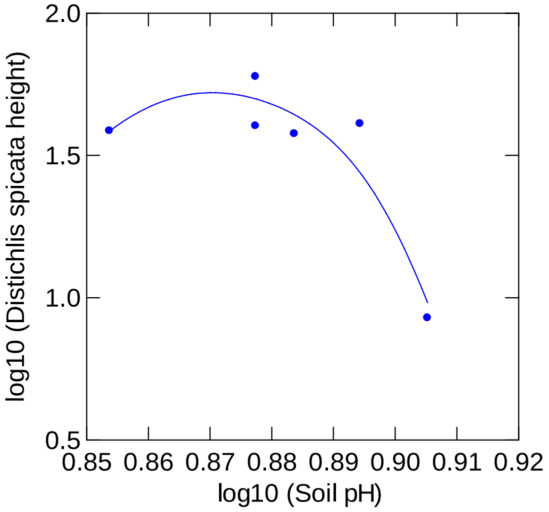


Figure 3. S. americanus height and Soil pH

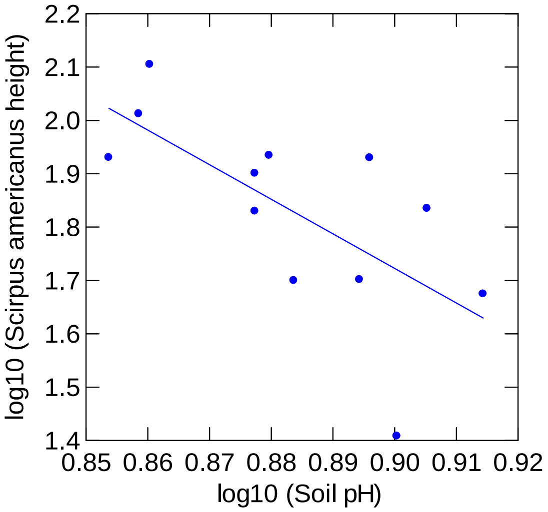


Figure 4. D. spicata height and Soil Conductivity - DWLS

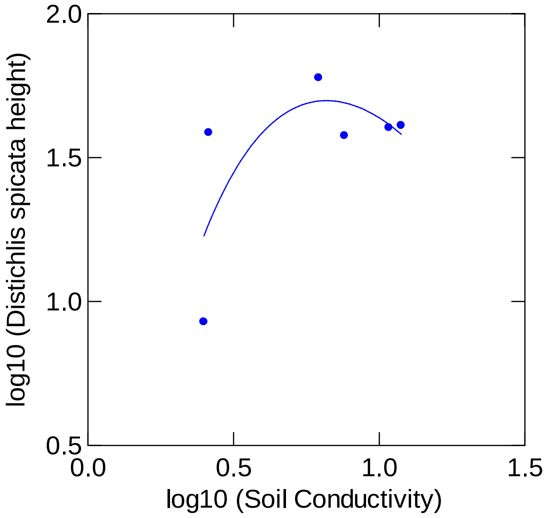


Figure 5. P. australis height and Soil Conductivity – DWLS

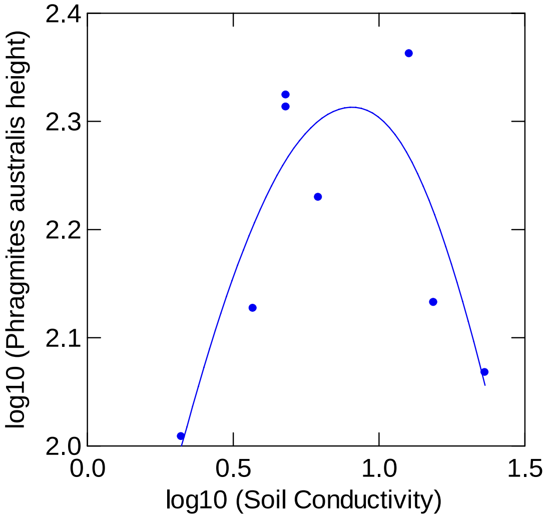


Figure 6. T. latifolia height and Soil Conductivity

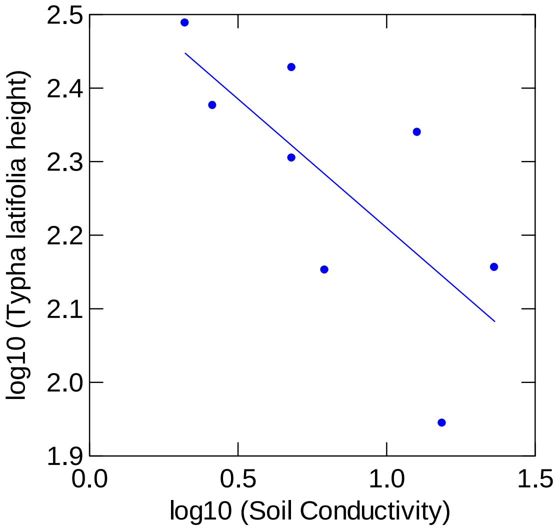


Figure 7. D. spicata Height and Soil Organic Matter

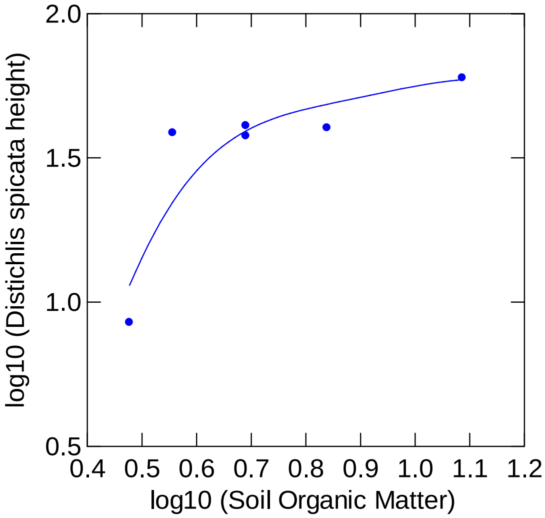


Figure 8. P. australis % Cover and pH

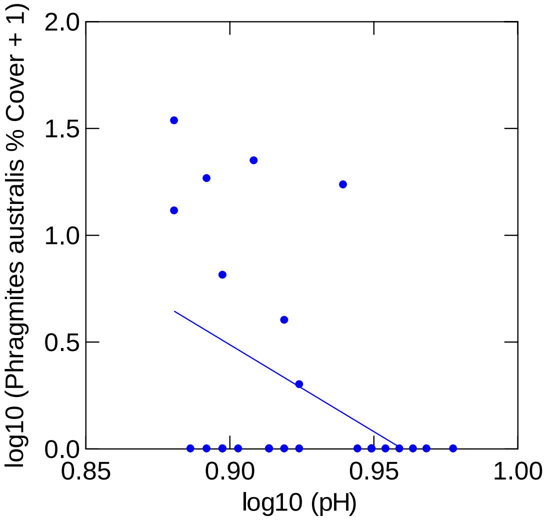


Figure 9. S. americanus % Cover and pH

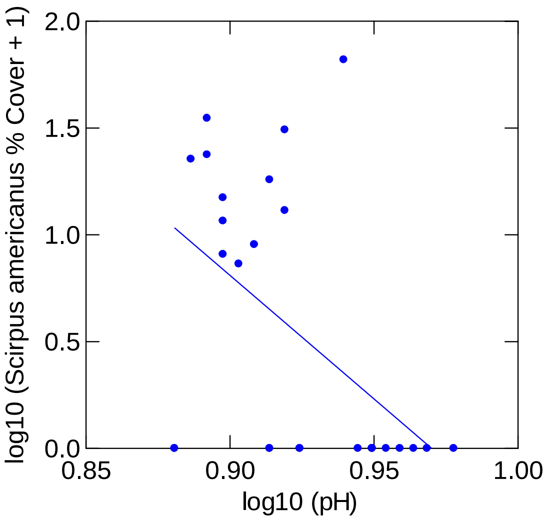


Figure 10. Stukenia spp. % Cover and pH

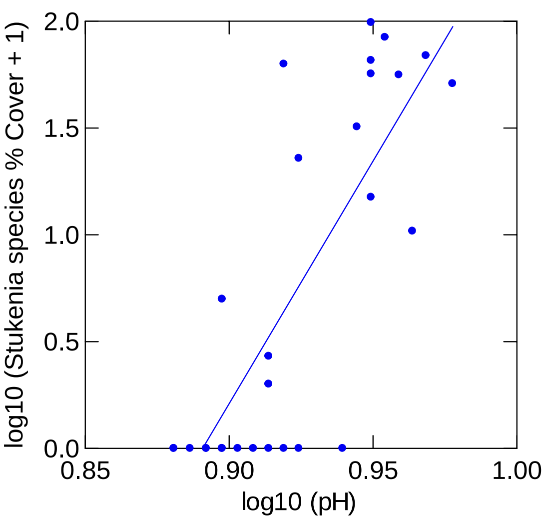


Figure 11. P. australis % Cover and TDS

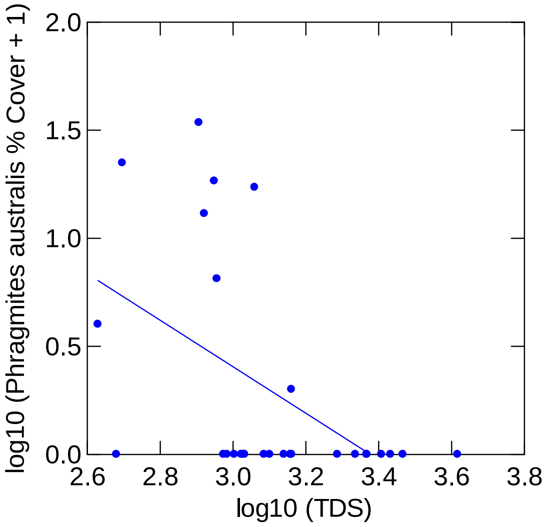


Figure 12. S. americanus % Cover and TDS

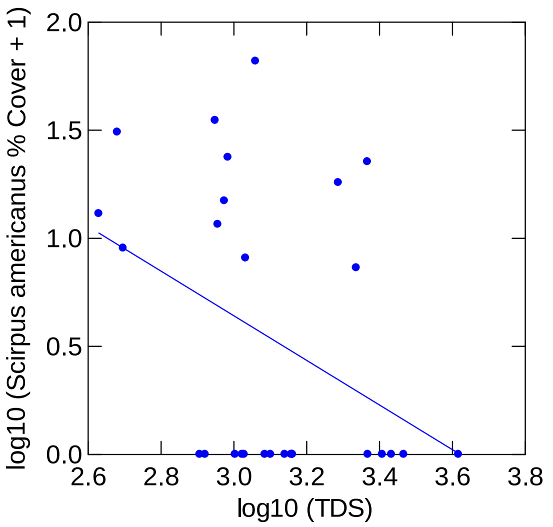


Figure 13. S. maritimus % Cover and TDS

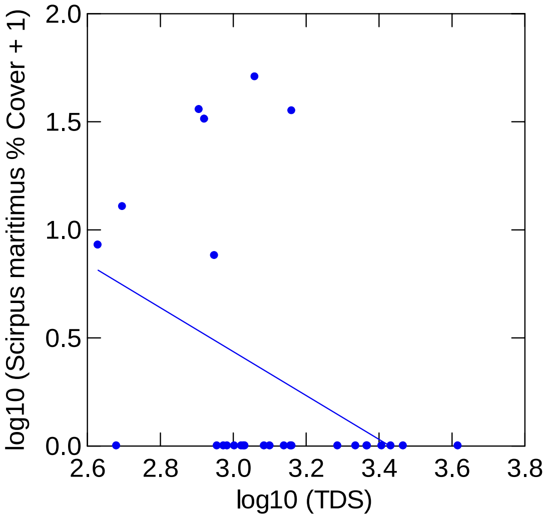


Figure 14. T. latifolia % Cover and TDS

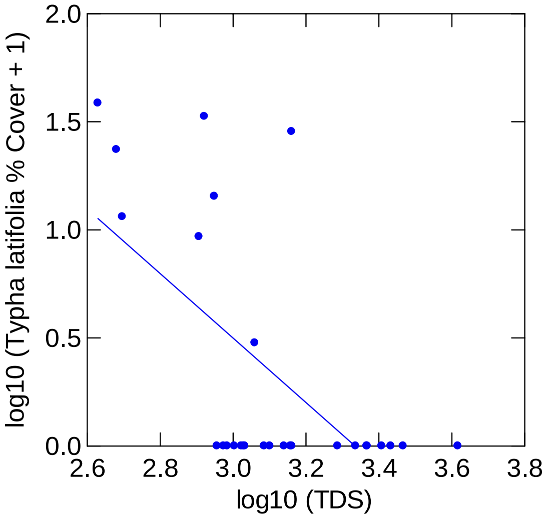


Figure 15. T. latifolia % Cover and TDS

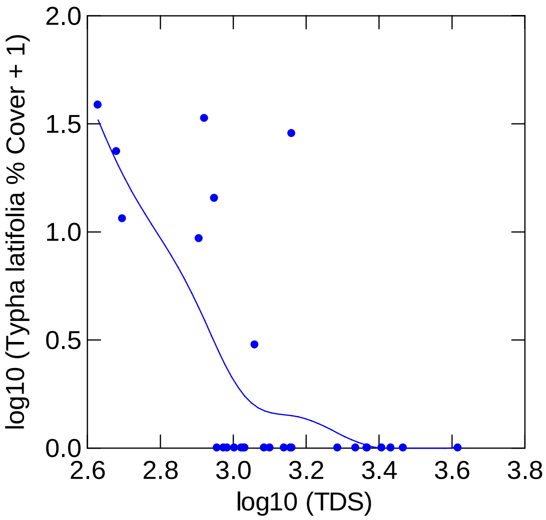


Figure 16. P. australis % Cover and D.O.

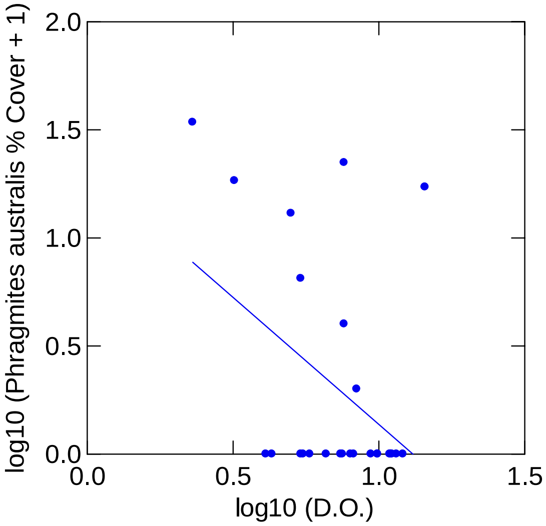


Figure 17. Stukenia spp. % Cover and D.O.

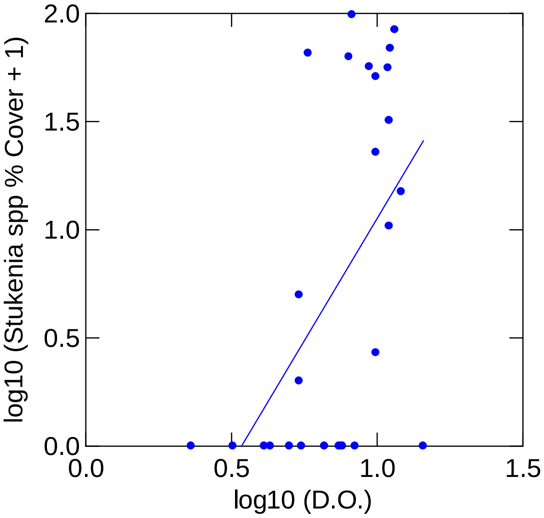


Figure 18. D. spicata % Cover and Total P

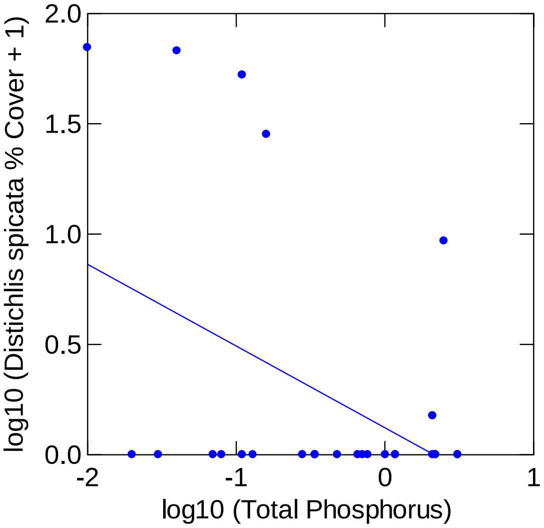


Figure 19. P. australis % Cover and Total P

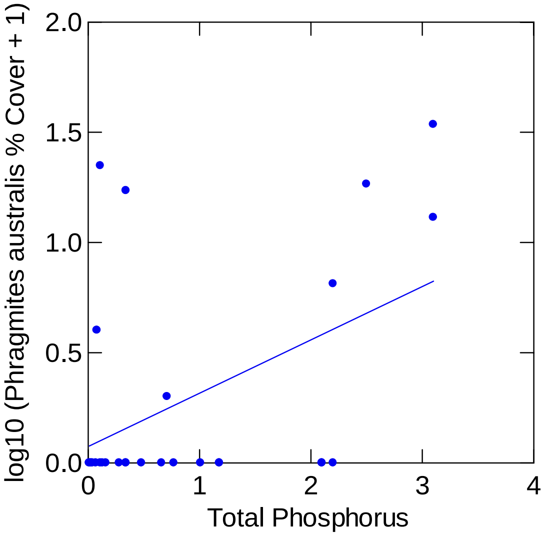


Figure 20. Stukenia spp. % Cover and Total P

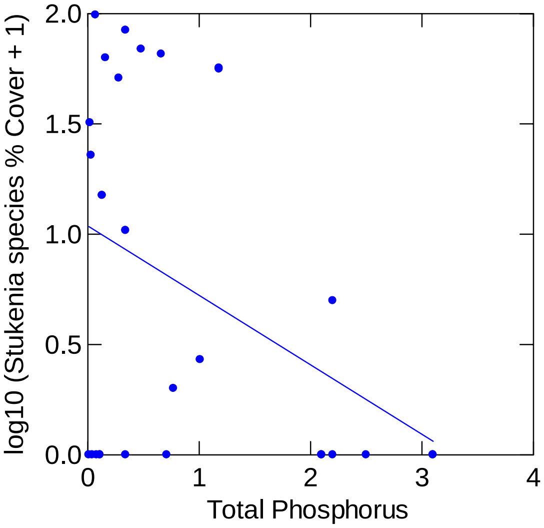


Figure 21. P. australis % Cover and Max. Water Temp.

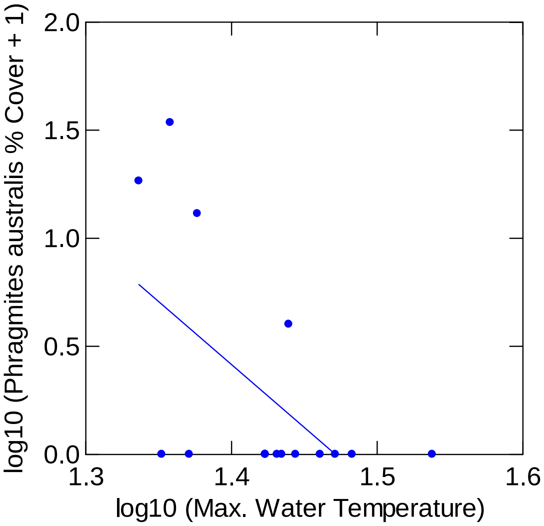


Figure 22. S. americanus % Cover and Max. Water Temp.

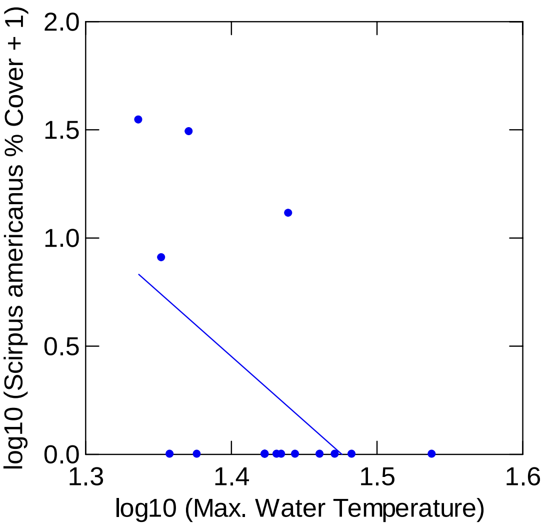


Figure 23. S. maritimus % Cover and Max. Water Temp.

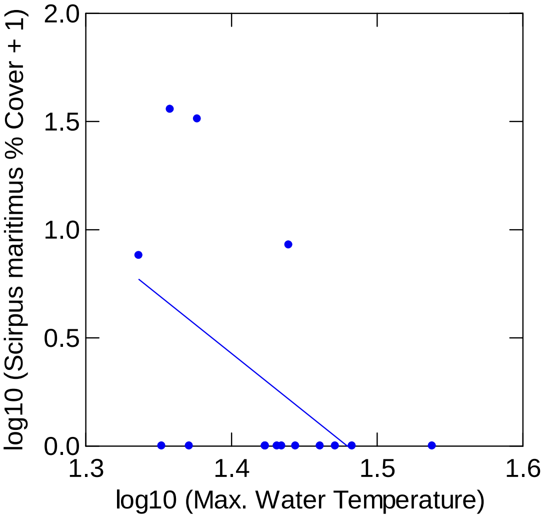


Figure 24. Stukenia spp. % Cover and Max. Water Temp.

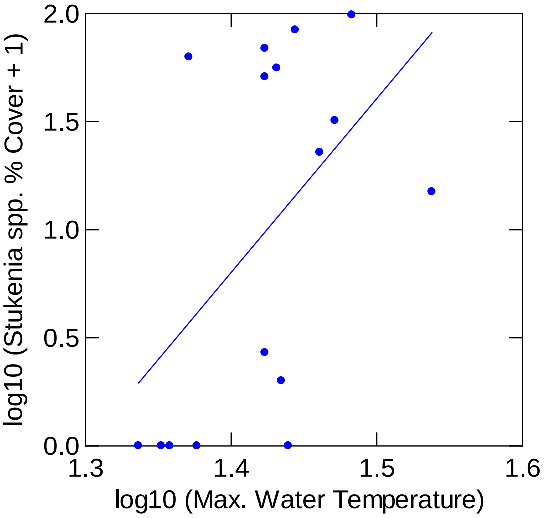


Figure 25. T. latifolia % Cover andMax. Water Temp.

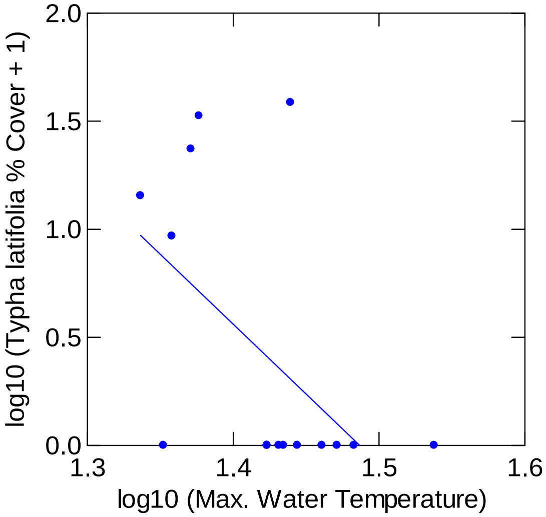


Figure 26. P. australis Height and pH

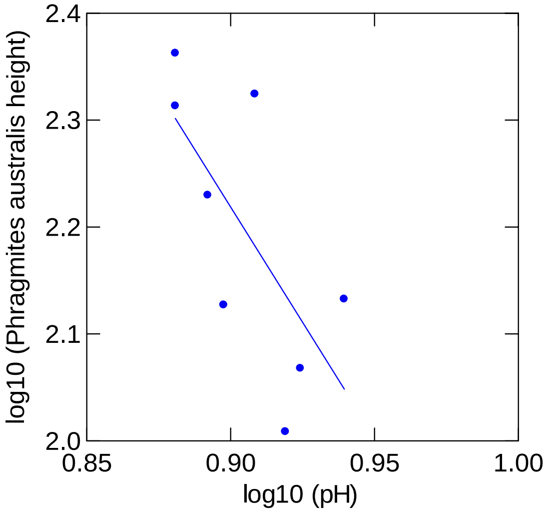


Figure 27. Stukenia spp. Height and pH

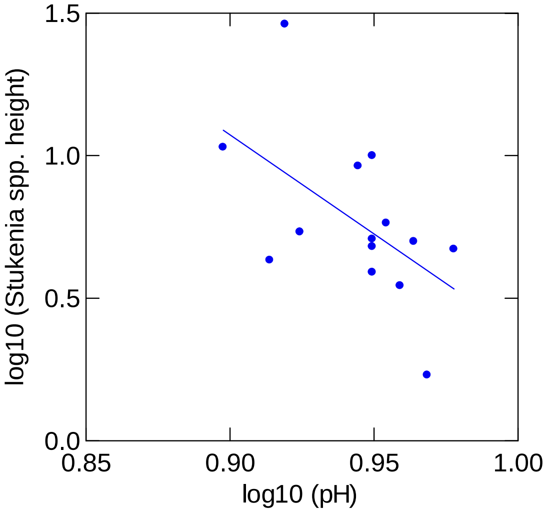


Figure 28. T. latifolia Height and TDS

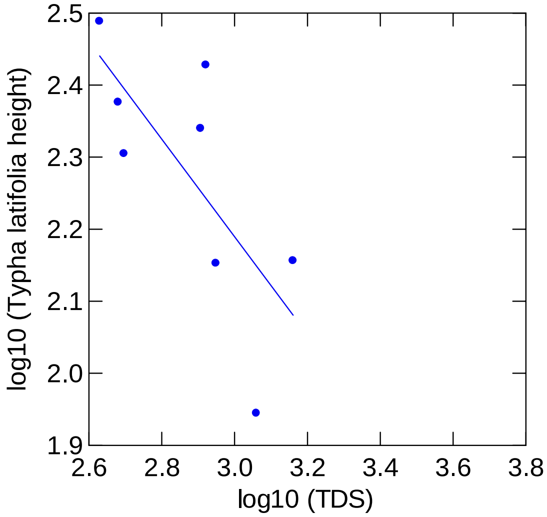


Figure 29. T. latifolia Height and Total N

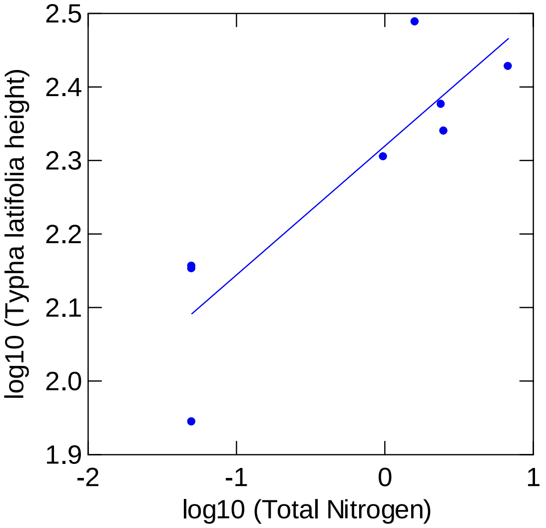


Figure 30. T. latifolia Height and Max. Water Temp.

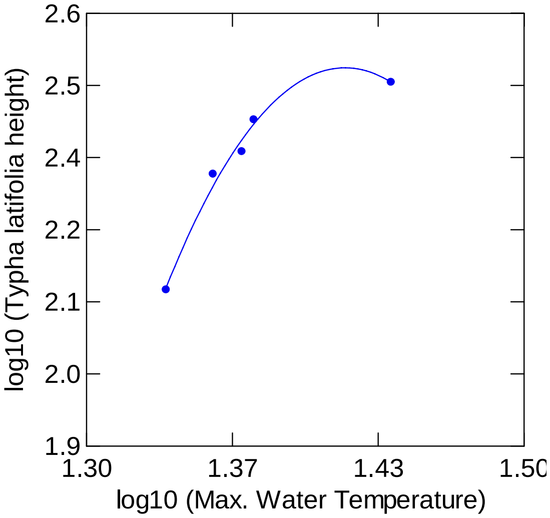


Figure 31. Gastropod Numbers and Soil pH

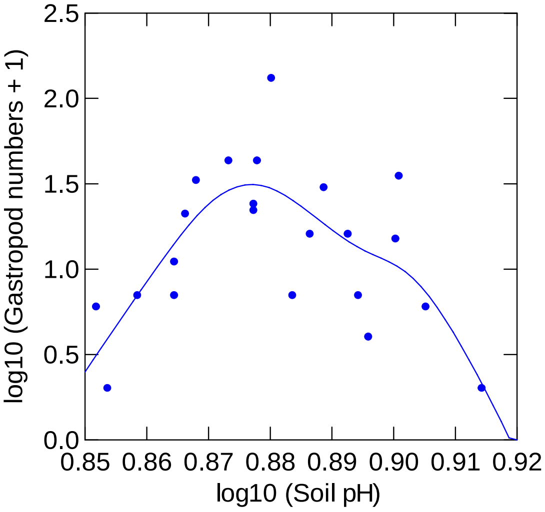


Figure 32. Platyhelminthes Numbers and Soil pH

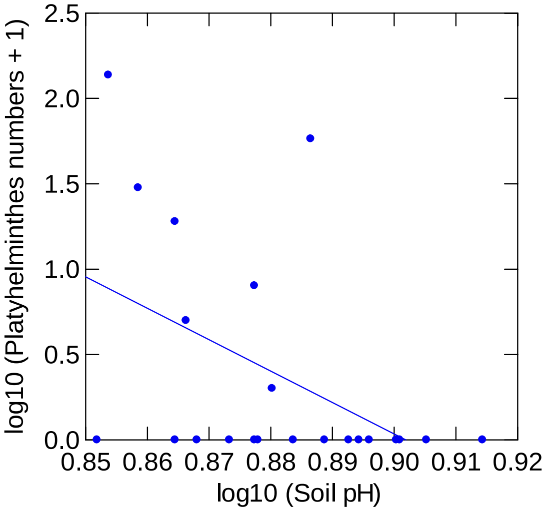


Figure 33. Ephemeropteran Numbers and Soil Conductivity

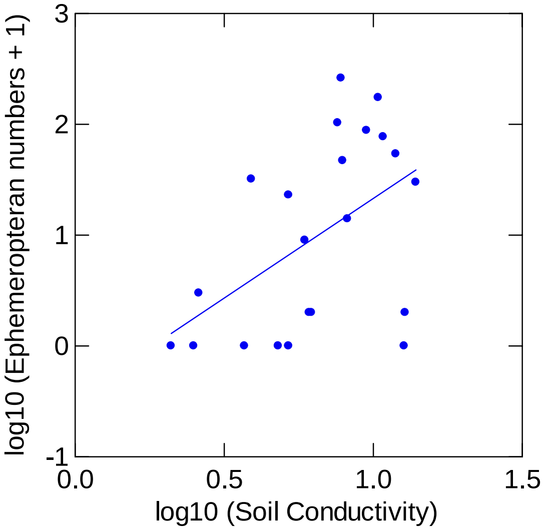


Figure 34. Gastropod Numbers and Soil Conductivity

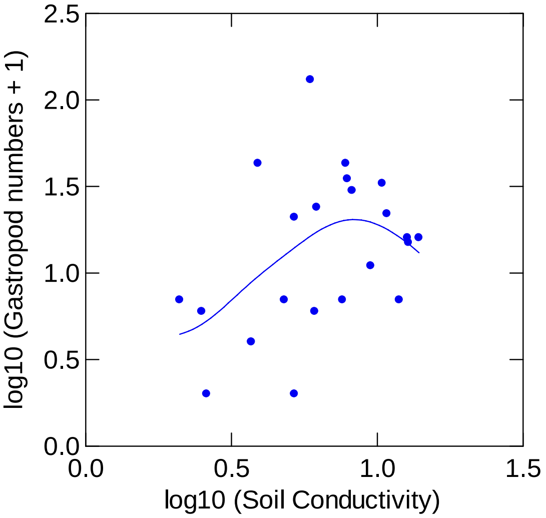


Figure 35. Crustacean Numbers and Soil Conductivity

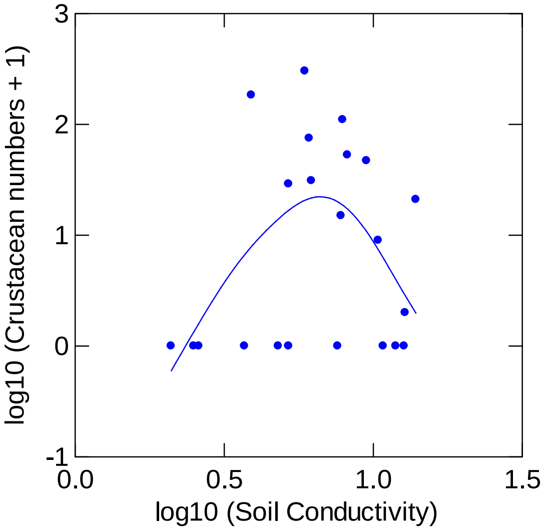


Figure 36. Annelid Numbers and Soil Conductivity

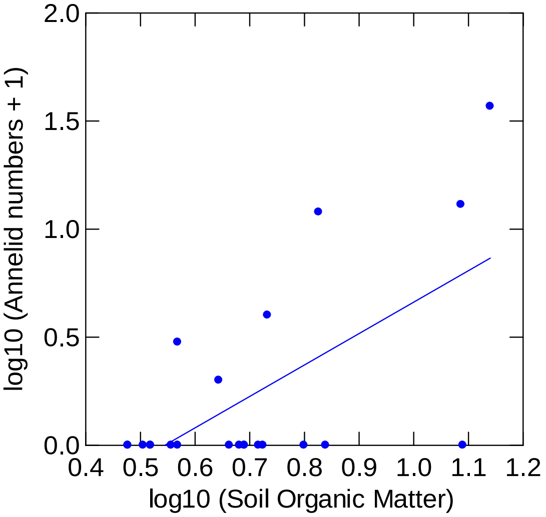


Figure 37. Ephemeropteran Numbers and pH

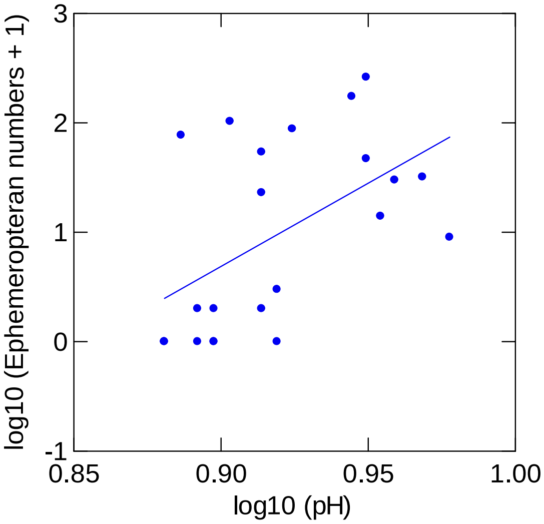


Figure 38. Ephemeropteran Numbers and pH – DWLS

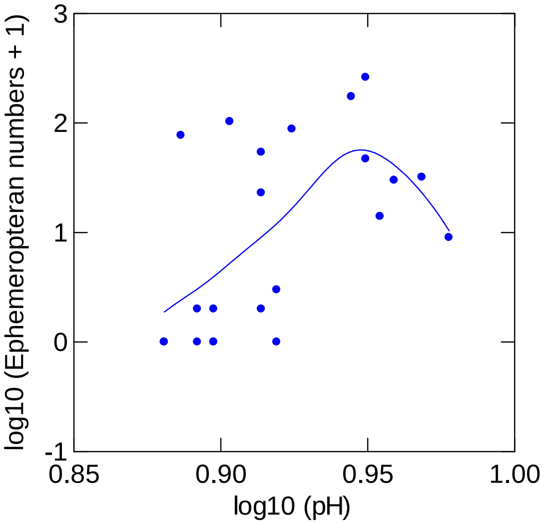


Figure 39. Hemipteran Numbers and pH

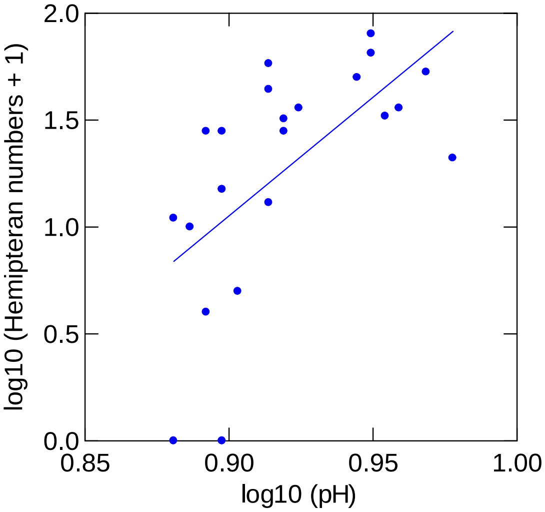


Figure 40. Hemipteran Numbers and pH – DWLS

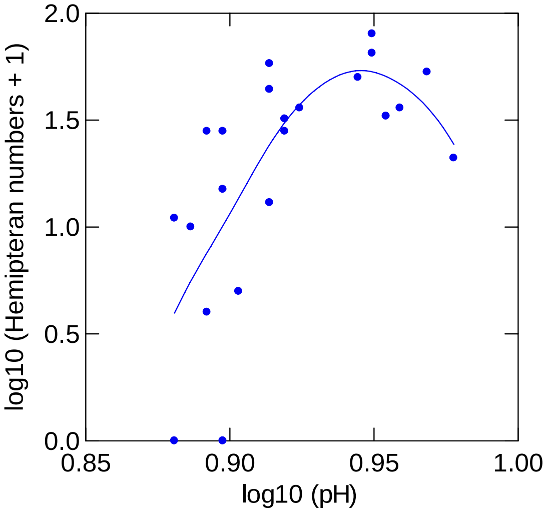


Figure 41. Chironomid Numbers and pH

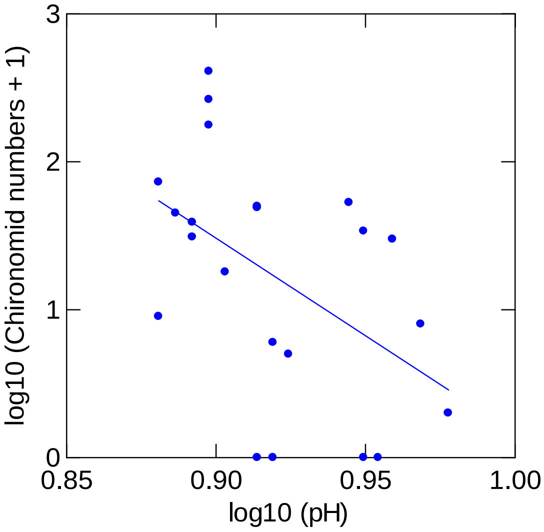


Figure 42. Gastropod Numbers and pH

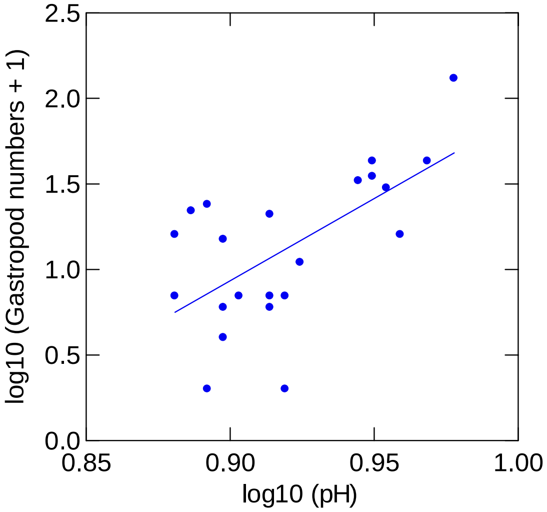


Figure 43. Crustacean Numbers and pH

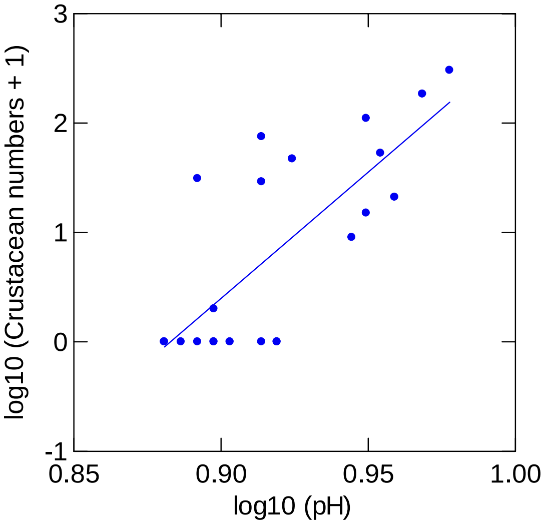


Figure 44. Annelid Numbers and pH

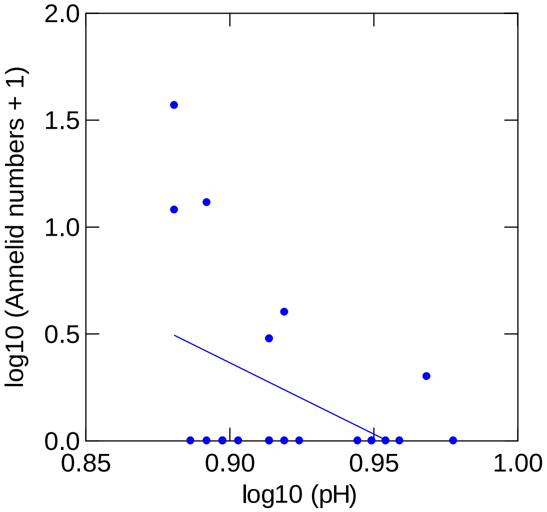


Figure 45. Annelid Numbers and pH - DWLS

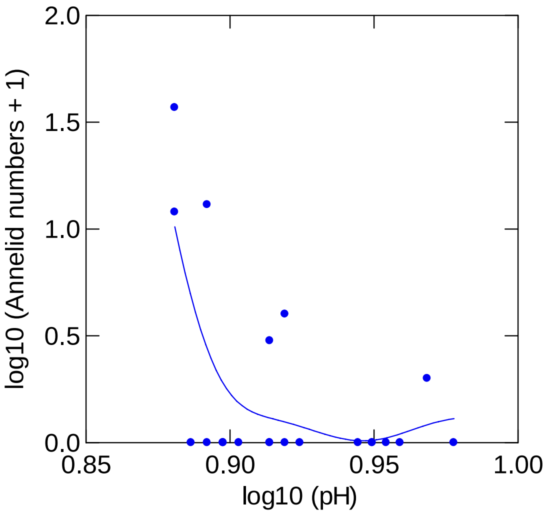


Figure 46. Ephemeropteran Numbers and TDS

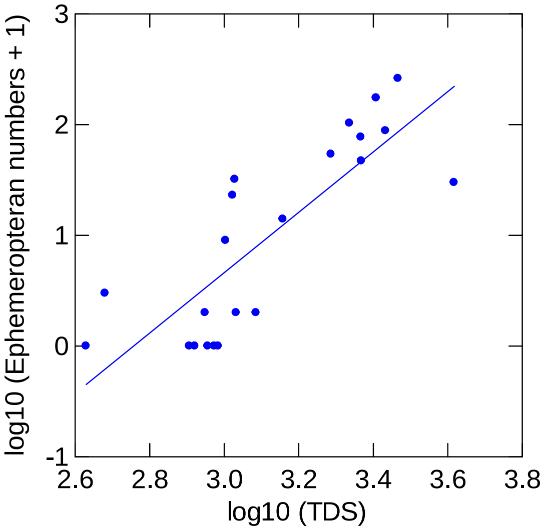


Figure 47. Ephemeropteran Numbers and TDS – DWLS

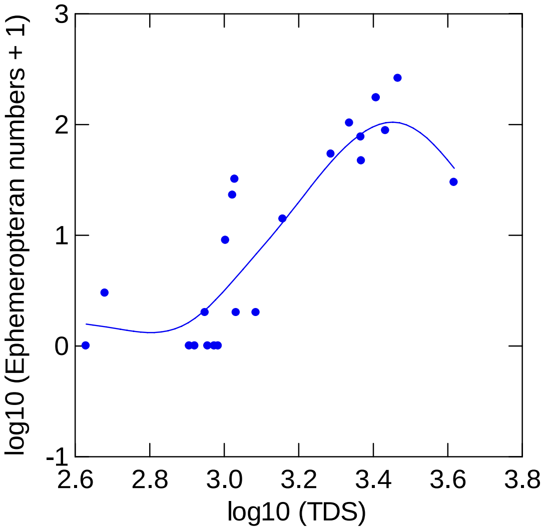


Figure 48. Odonate Numbers and TDS

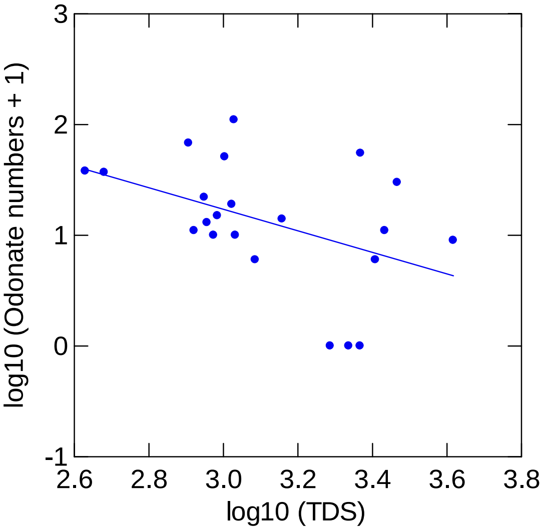


Figure 49. Platyhelminthes Numbers and TDS

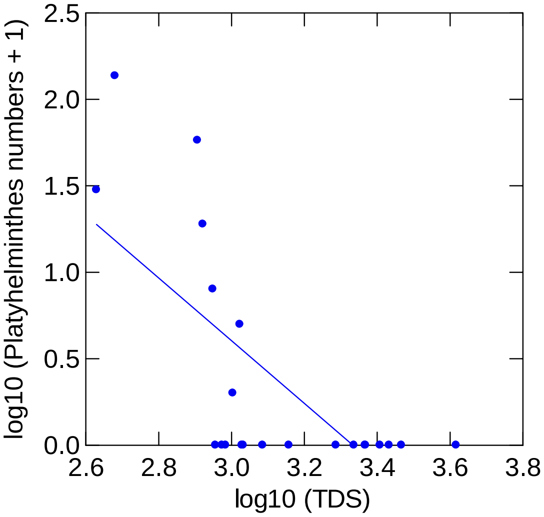


Figure 50. Platyhelminthes Numbers and TDS - DWLS

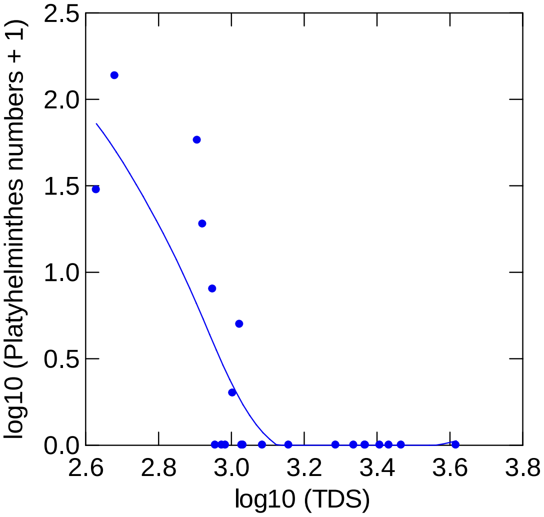


Figure 51. Annelid Numbers and TDS

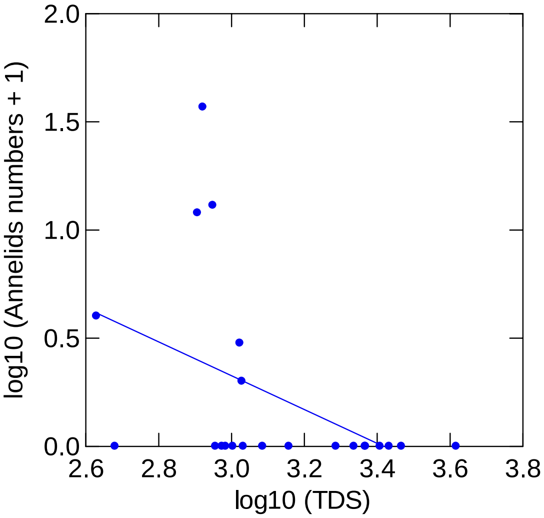


Figure 52. Annelid Numbers and TDS - DWLS

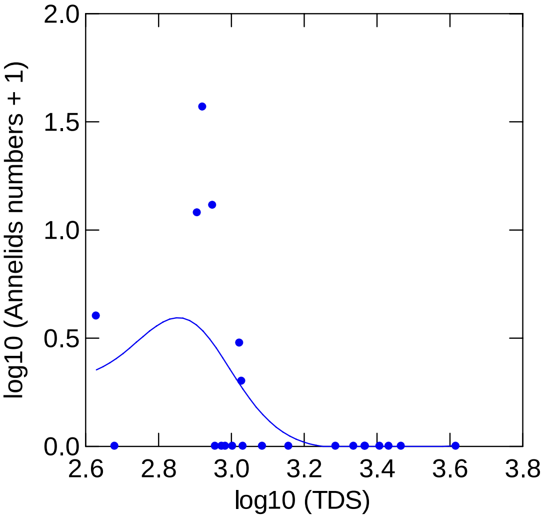


Figure 53. Ephemeropteran Numbers and D. O.

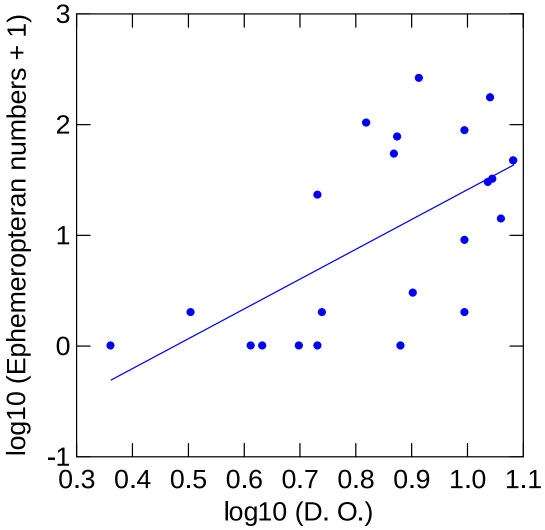


Figure 54. Hemipteran Numbers and D. O.

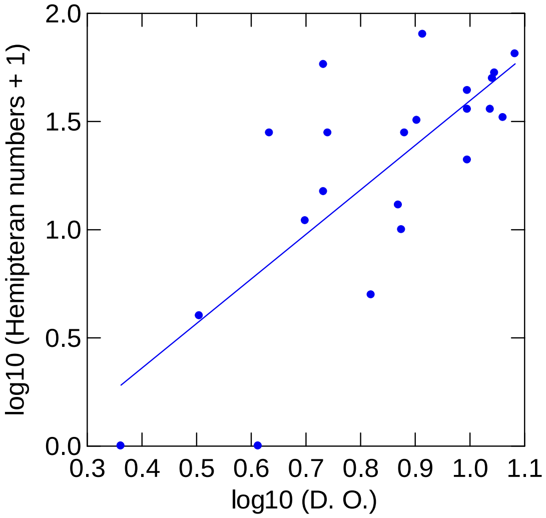
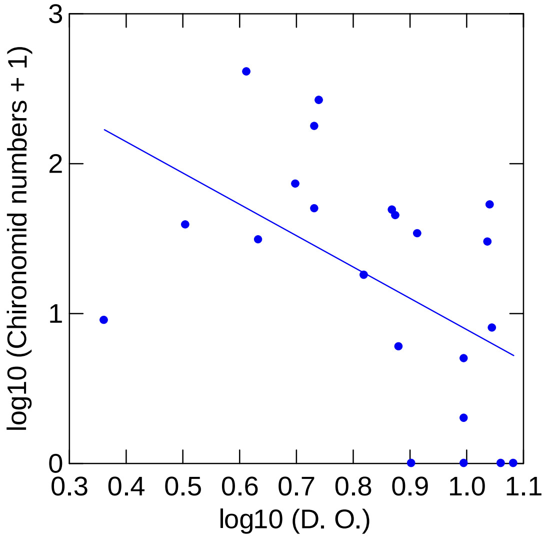


Figure 55. Chironomid Numbers and D.O.



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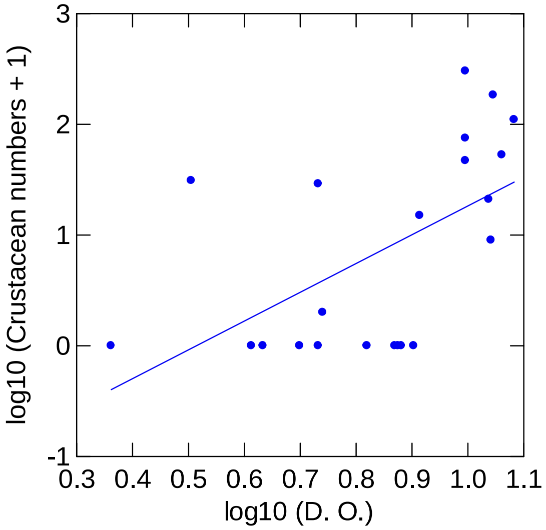


Figure 57. Platyhelminthes Numbers and D.O.

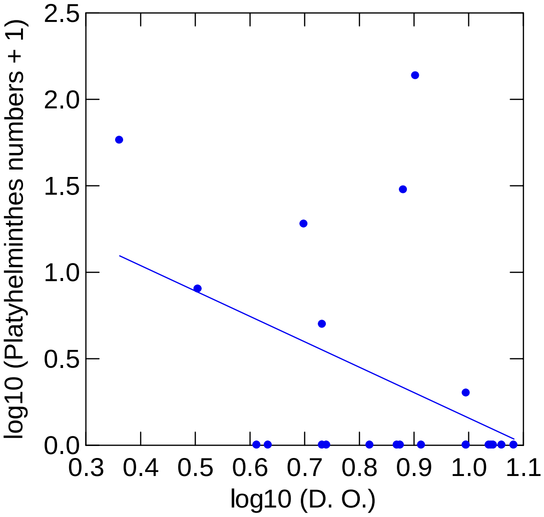


Figure 58. Annelid Numbers and D.O.

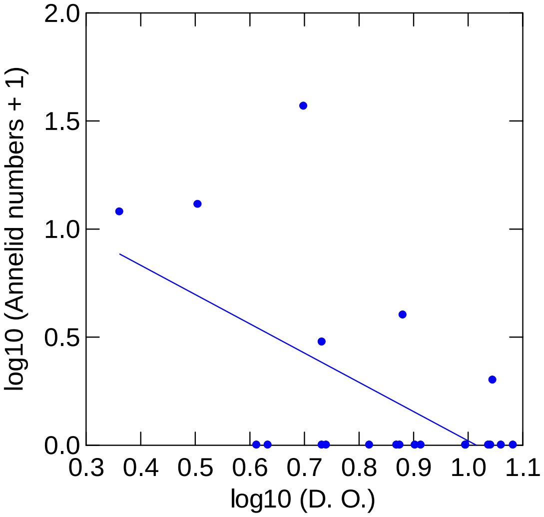


Figure 59. Ephemeropteran Numbers and Total P

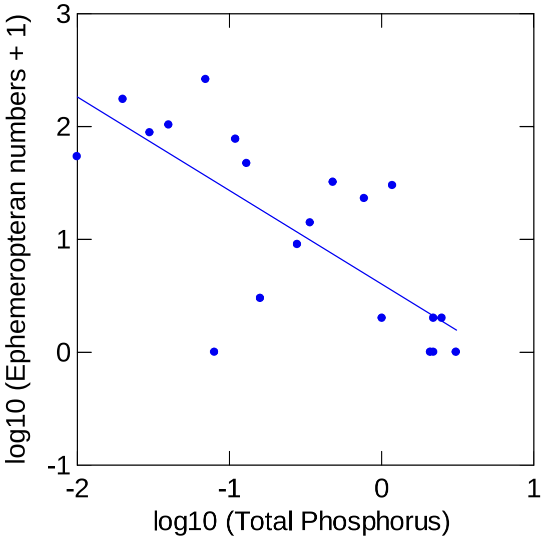


Figure 60. Hemipteran Numbers and Total P

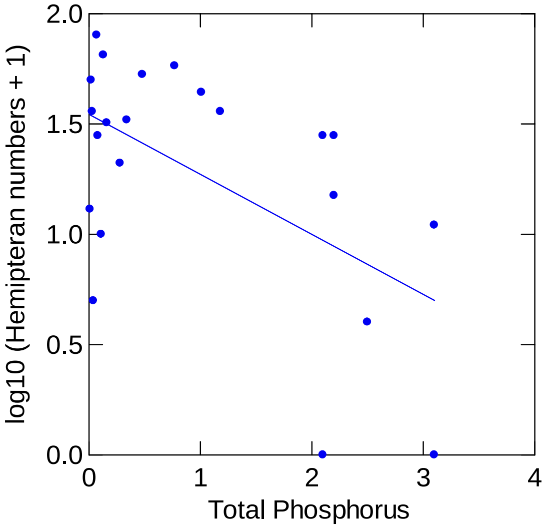


Figure 61. Chironomid Numbers and Total P

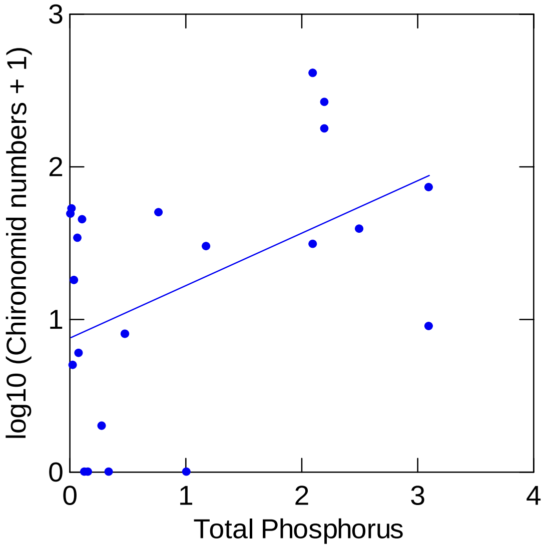


Figure 62. Crustacean Numbers and Total P

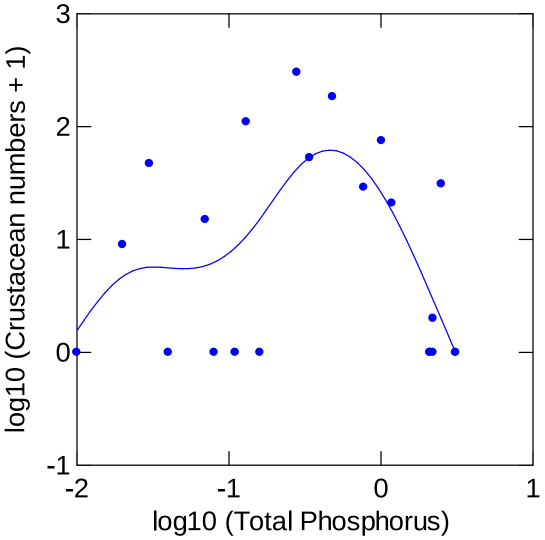


Figure 63. Annelid Numbers and Total P

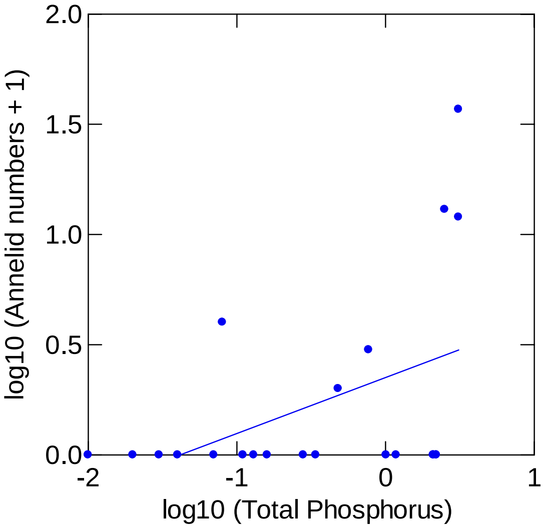


Figure 64. Annelid Numbers and Total P - DWLS

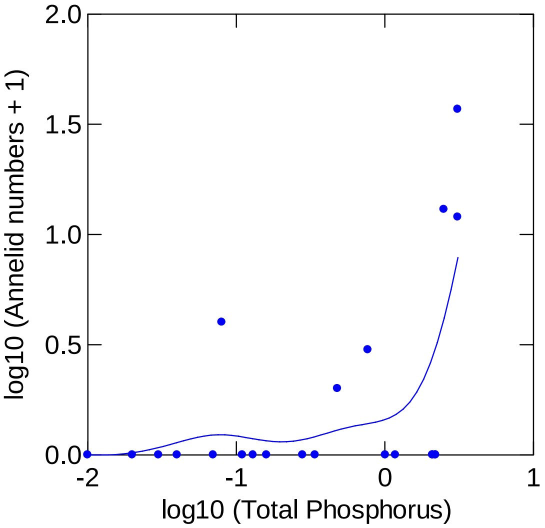


Figure 65. Ephemeropteran Numbers and Total N

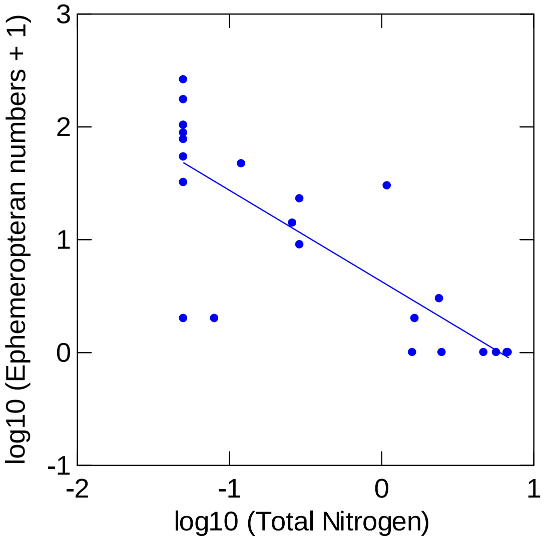


Figure 66. Gastropod Numbers and Total N

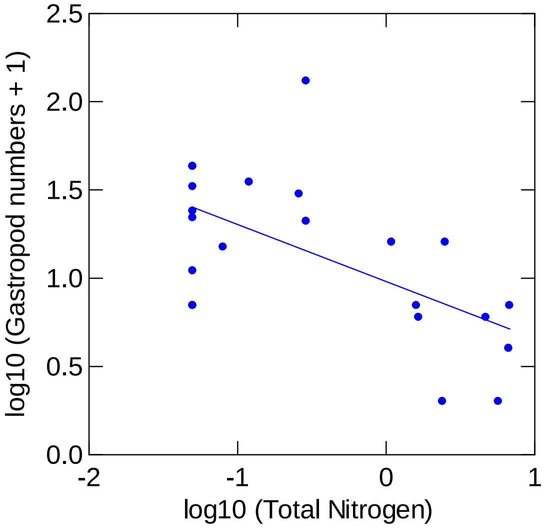


Figure 67. Crustacean Numbers and Total N

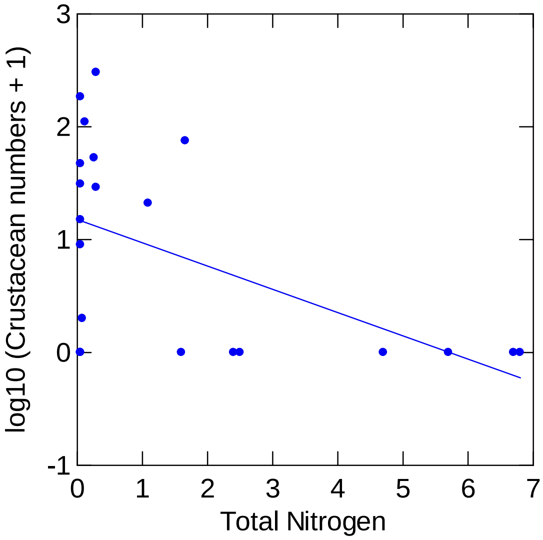


Figure 68. Ephemeropteran Numbers and Max. Temp.

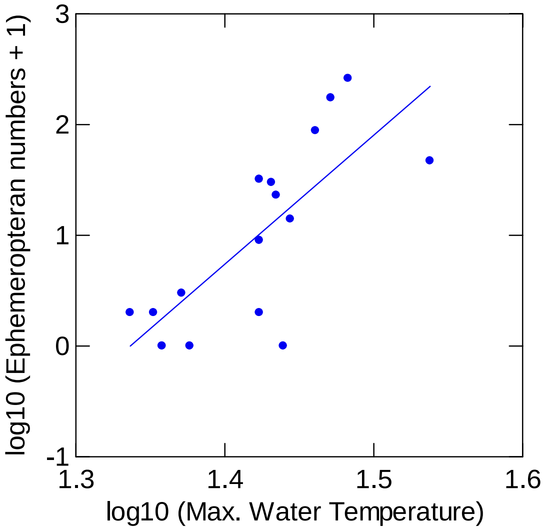


Figure 69. Ephemeropteran Numbers and Max. Temp. – DWLS

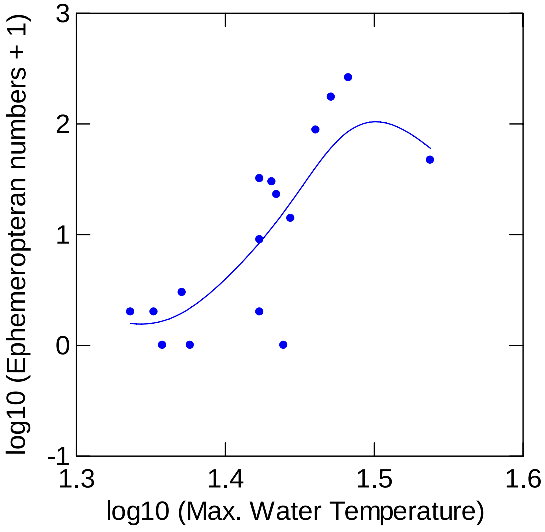


Figure 70. Hemipteran Numbers and Max. Temp.

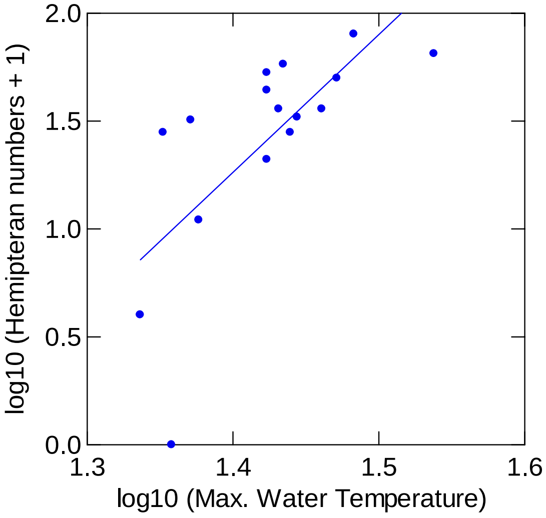


Figure 71. Hemipteran Numbers and Max. Temp. – DWLS

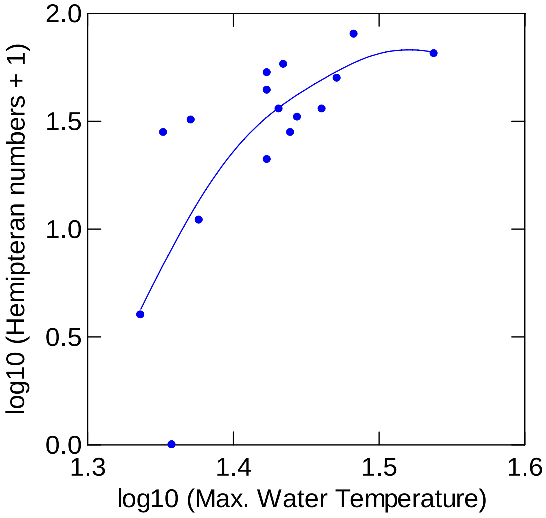


Figure 72. Platyhelminthes Numbers and Max. Temp.

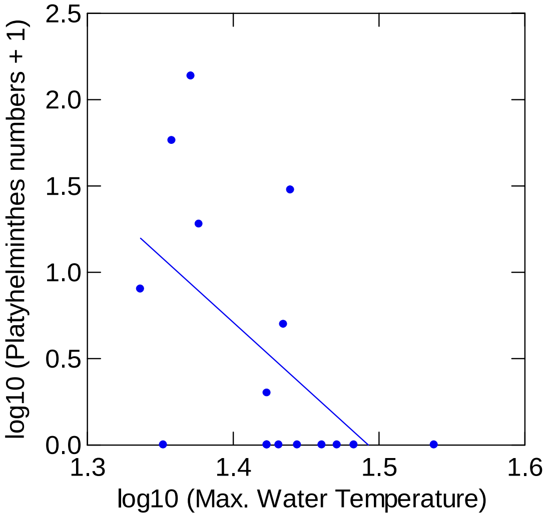


Figure 73. Annelid Numbers and Max. Temp.

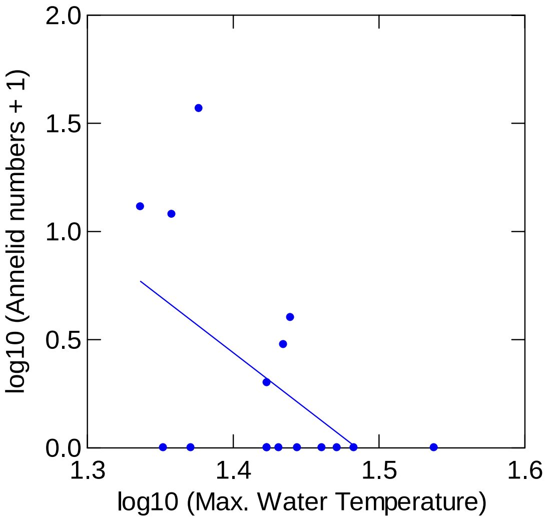


Figure 74. Ephemeropterans and T. latifolia % Cover

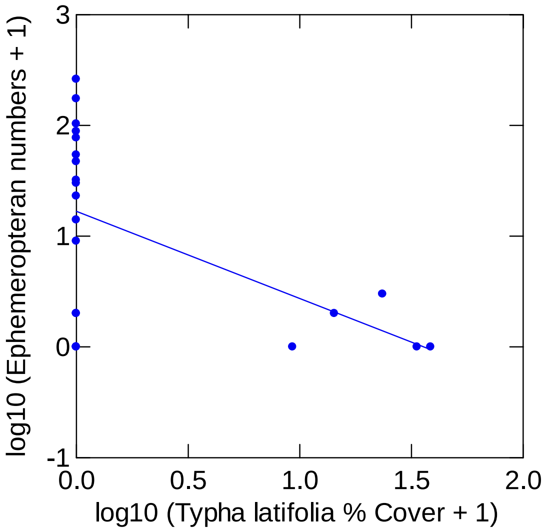


Figure 75. Platyhelminthes and T.latifolia % Cover

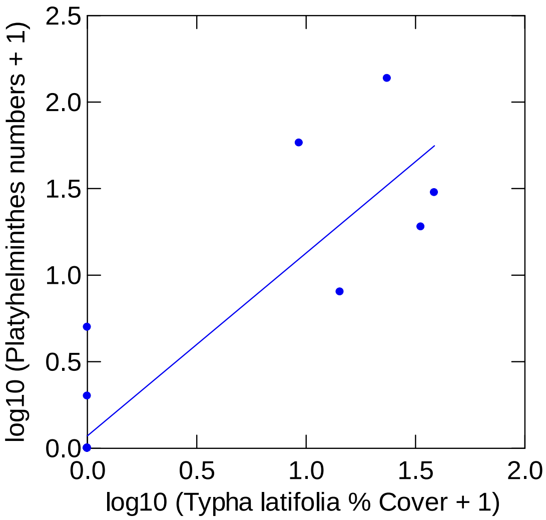


Figure 76. Annelids and T. latifolia % Cover

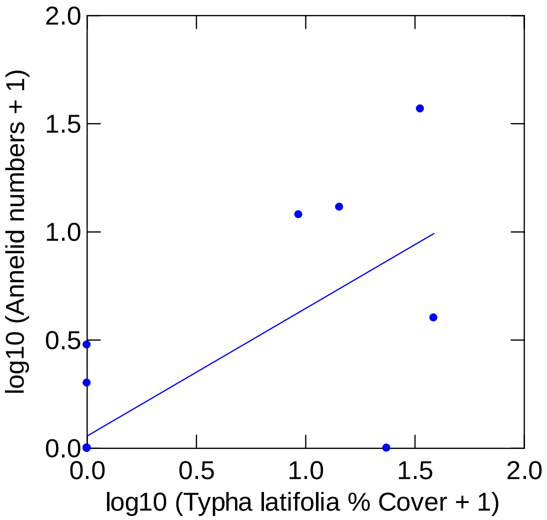
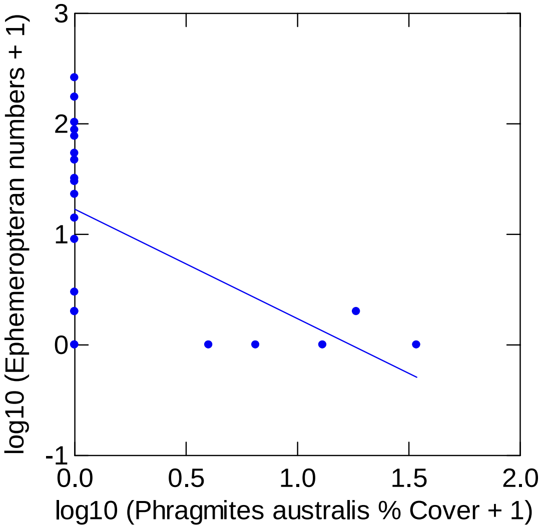


Figure 77. Ephemeropterans and P. australis % Cover



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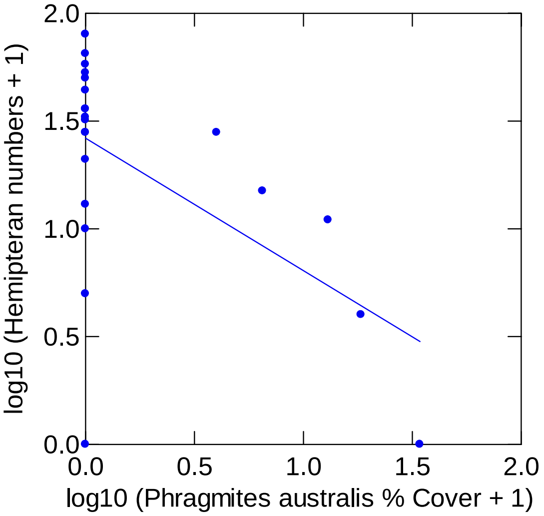

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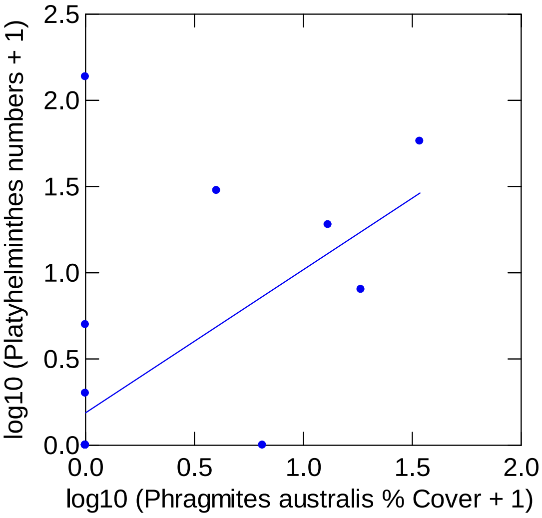


Figure 80. Annelids and P. australis % Cover

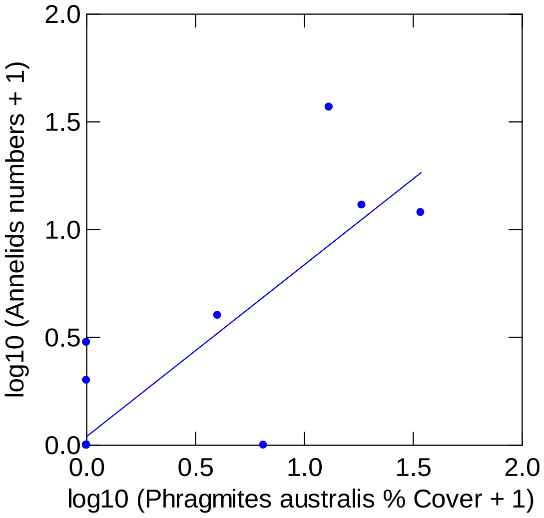


Figure 81. Odonates and D. spicata % Cover

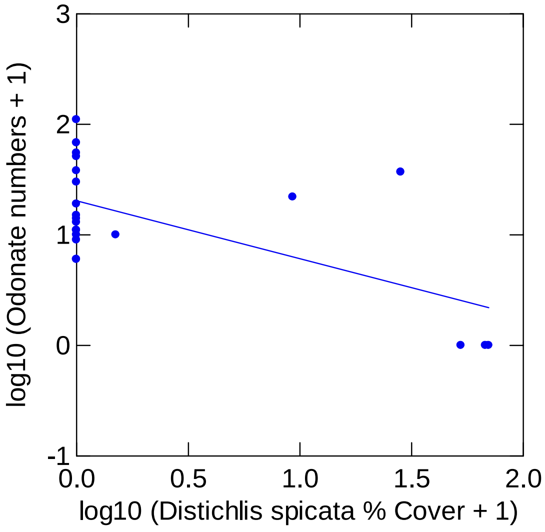


Figure 82. Gastropods and S. americanus % Cover

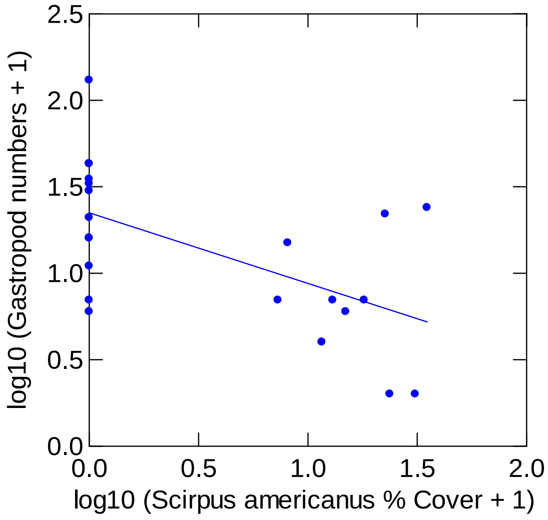


Figure 83. Crustaceans and S. americanus % Cover

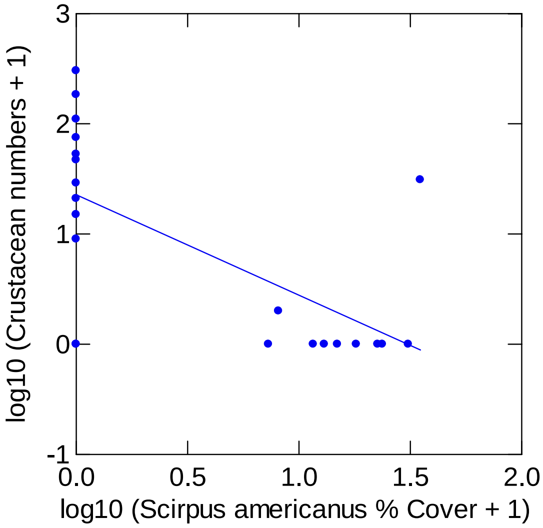


Figure 84. Ephemeropterans and Stukenia spp. % Cover

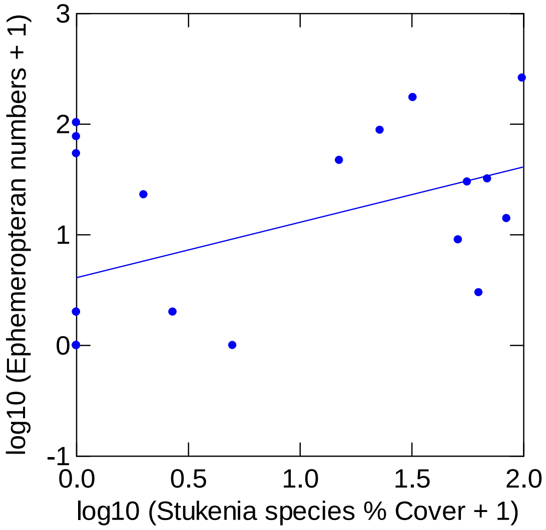


Figure 85. Hemipterans and Stukenia spp. % Cover

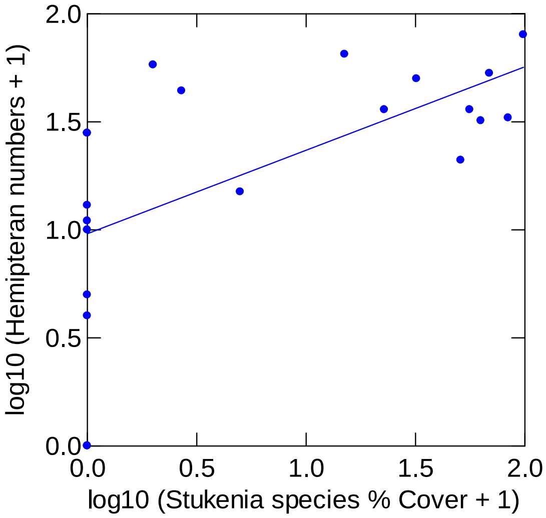


Figure 86. Chironomids and Stukenia spp. % Cover

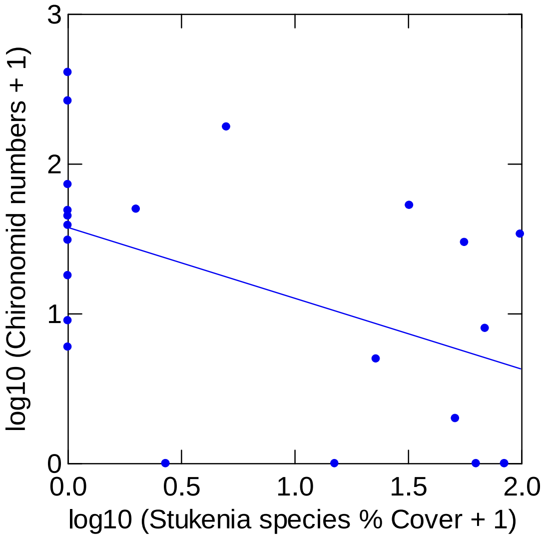


Figure 87. Gastropods and Stukenia spp. % Cover

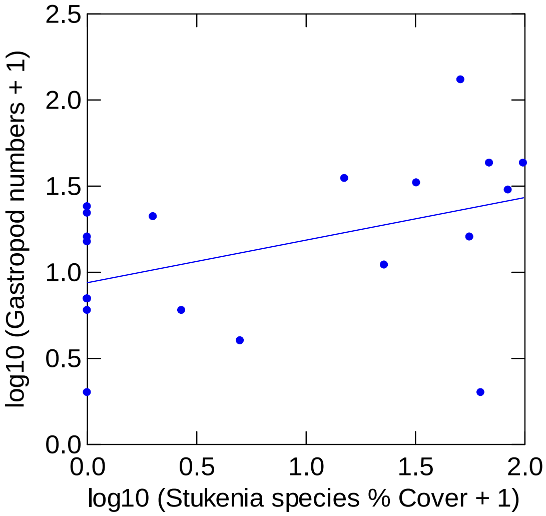


Figure 88. Crustaceans and Stukenia spp. % Cover

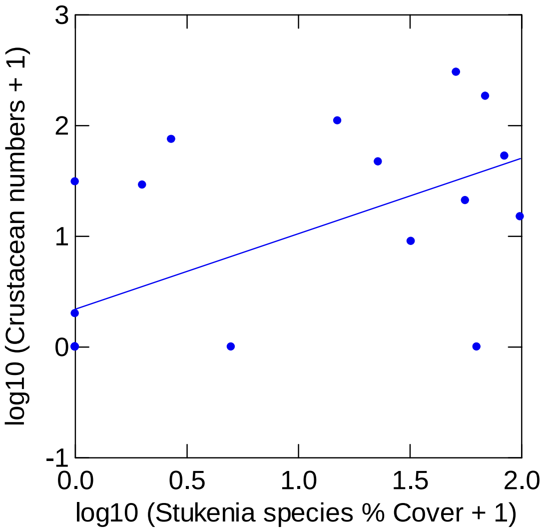


Figure 89. FACTOR ANALYSES: Vegetation and Water Quality

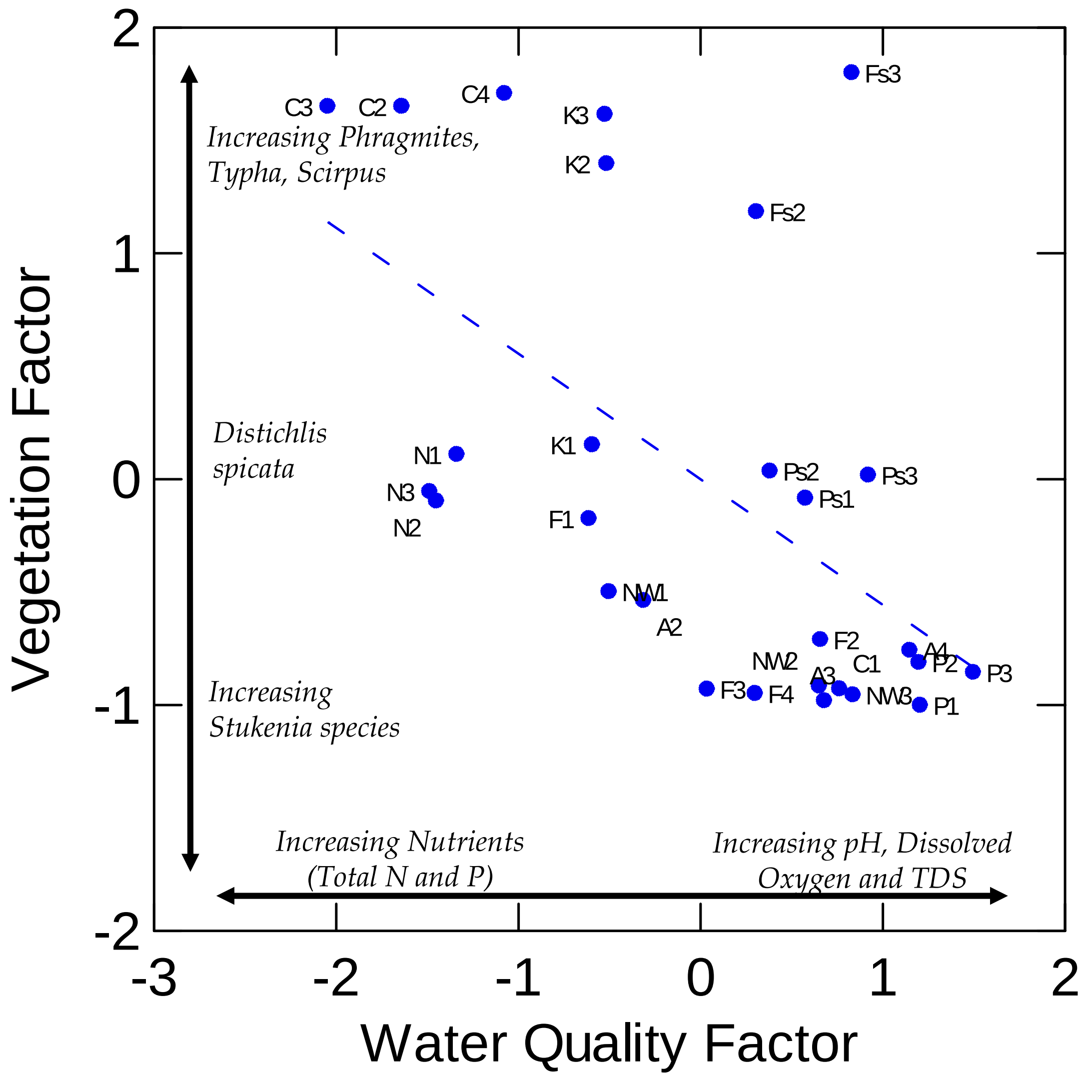


Figure 90. FACTOR ANALYSES: Invertebrates and Water Quality

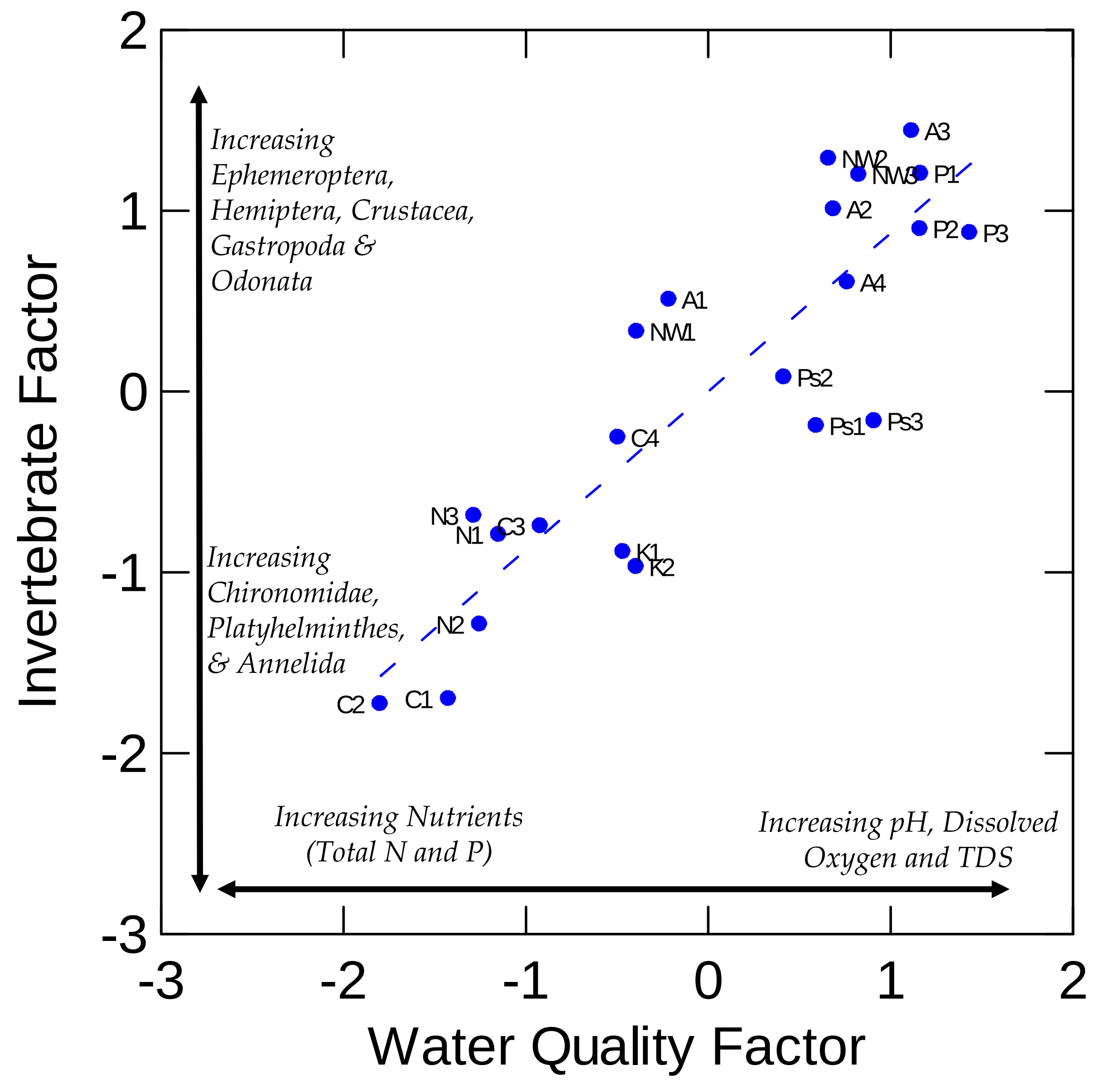


Figure 91. FACTOR ANALYSES: Invertebrates and Vegetation

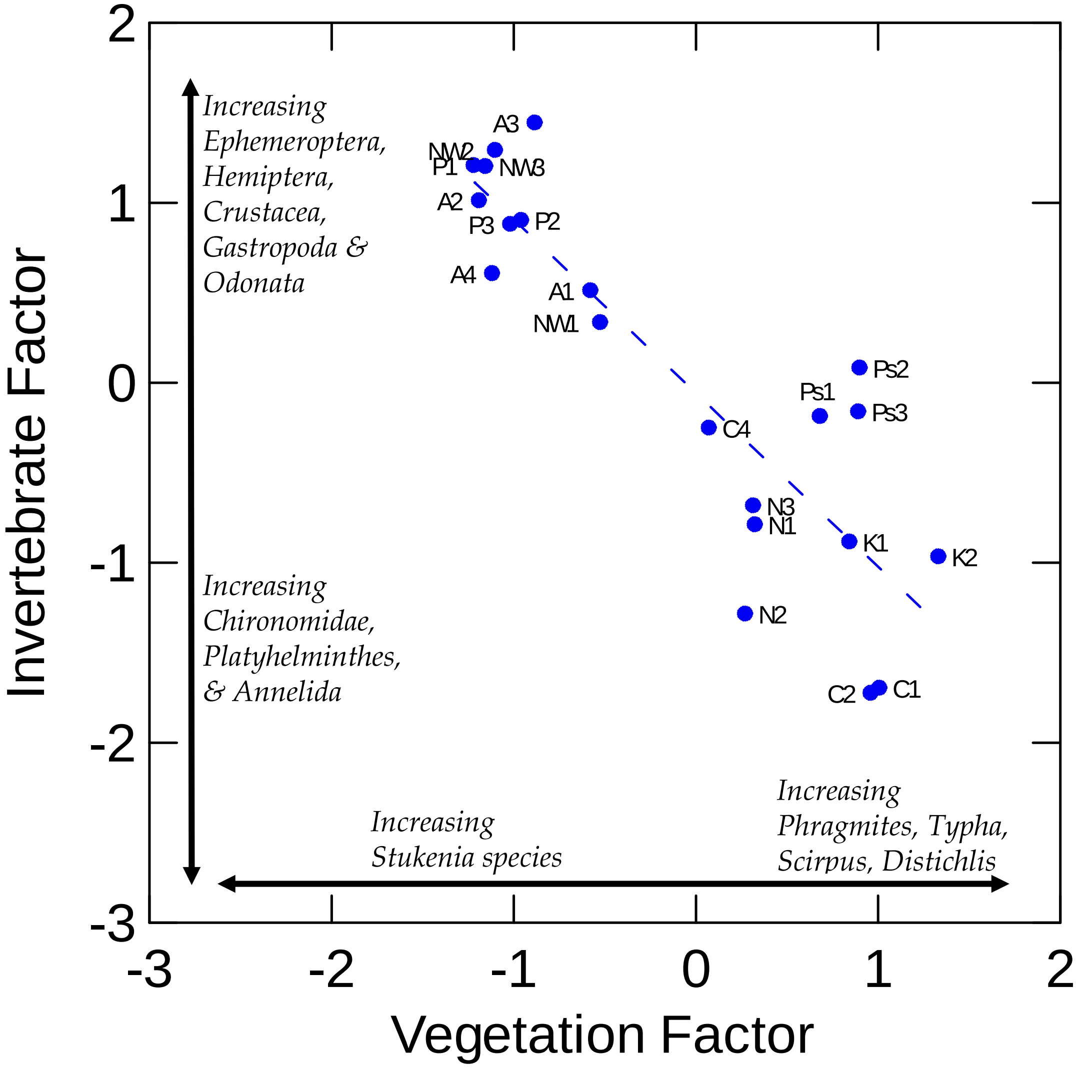


Figure 92. FACTOR ANALYSES: Invertebrates, Vegetation and Water Quality

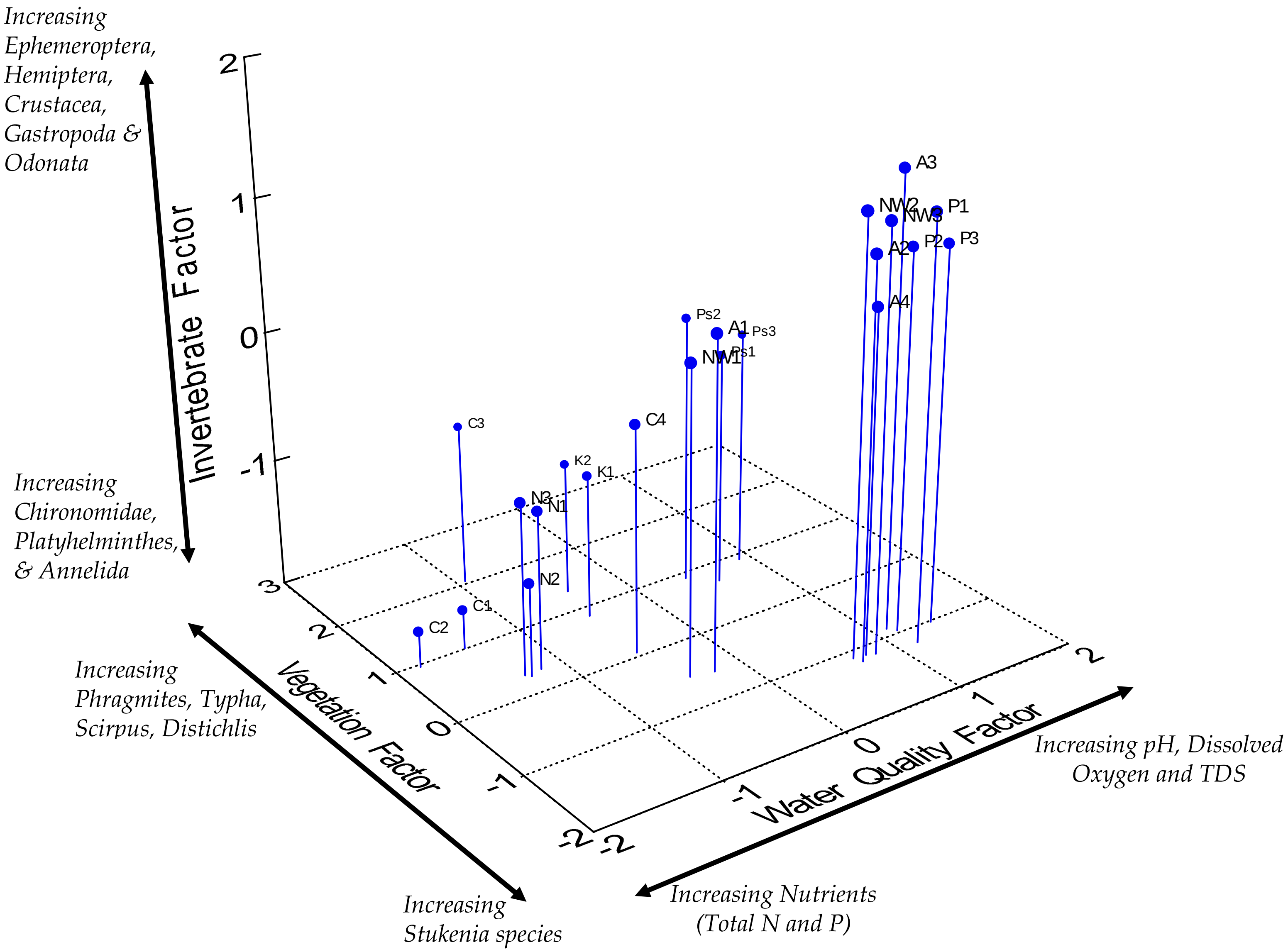


Figure 93. FACTOR ANALYSIS: Water Quality and Vegetation – Sheet-flow Sites

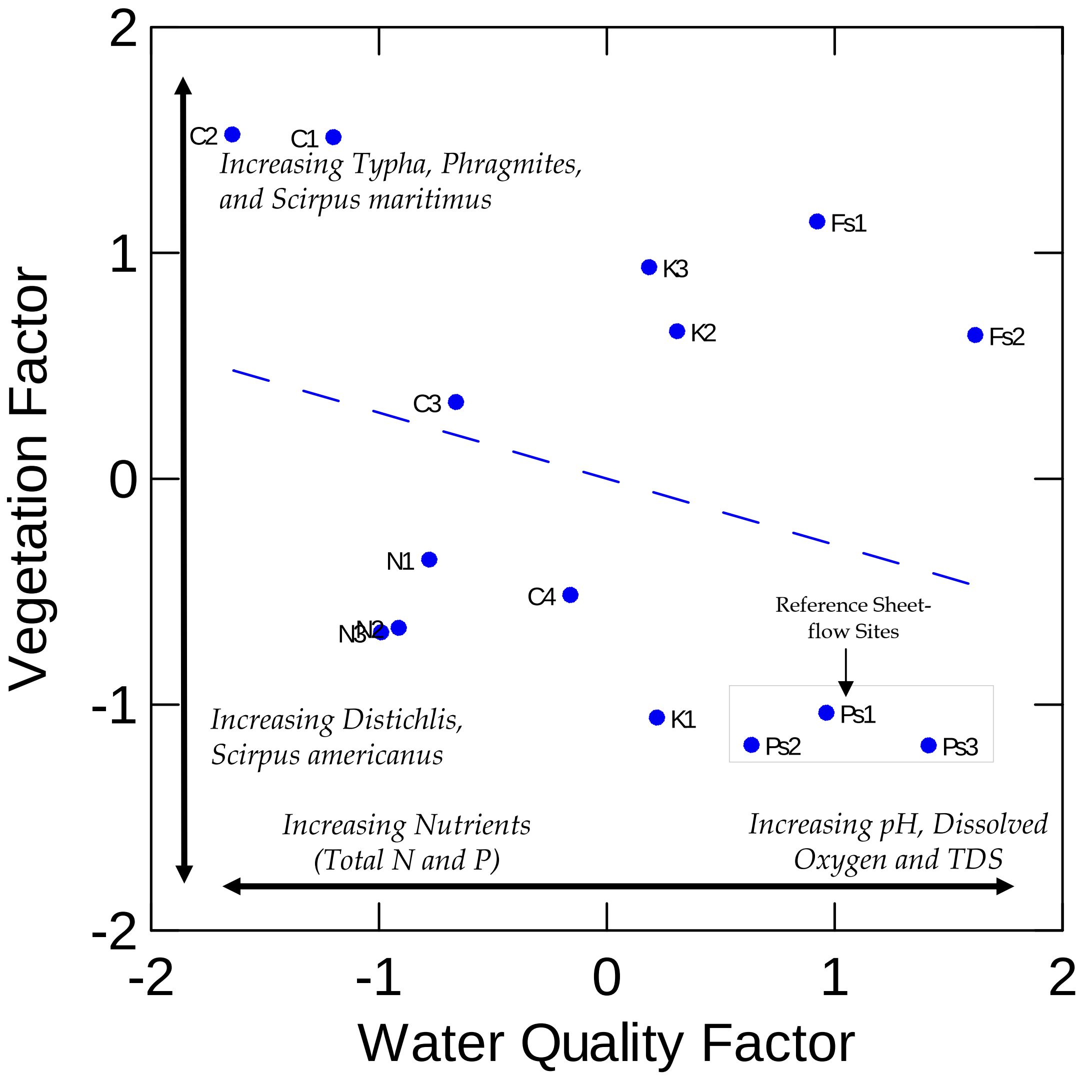


Figure 94. FACTOR ANALYSIS - Invertebrates and Water Quality - Sheet-Flow Sites

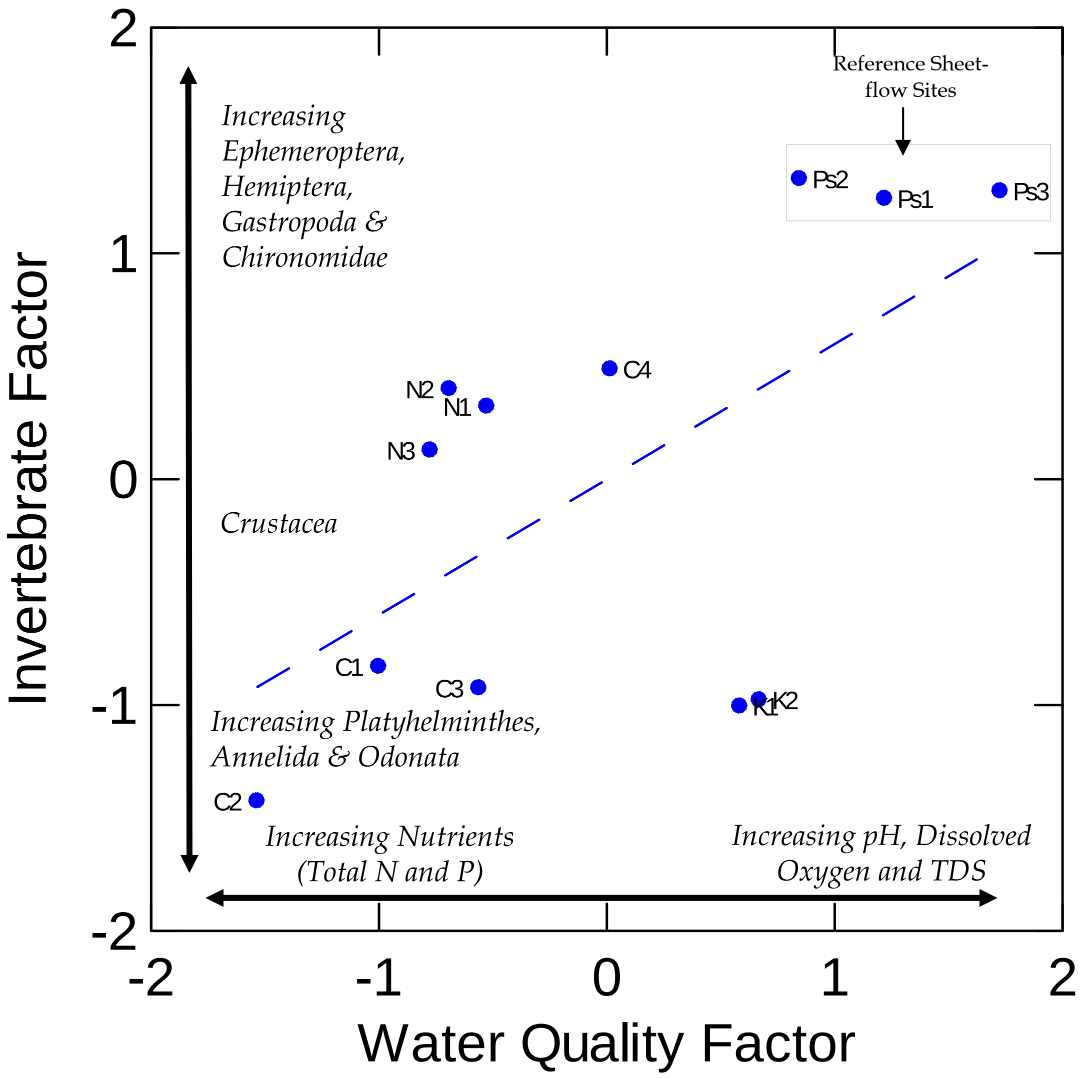


Figure 95. FACTOR ANALYSIS - Invertebrates and Water Quality - Impounded Sites

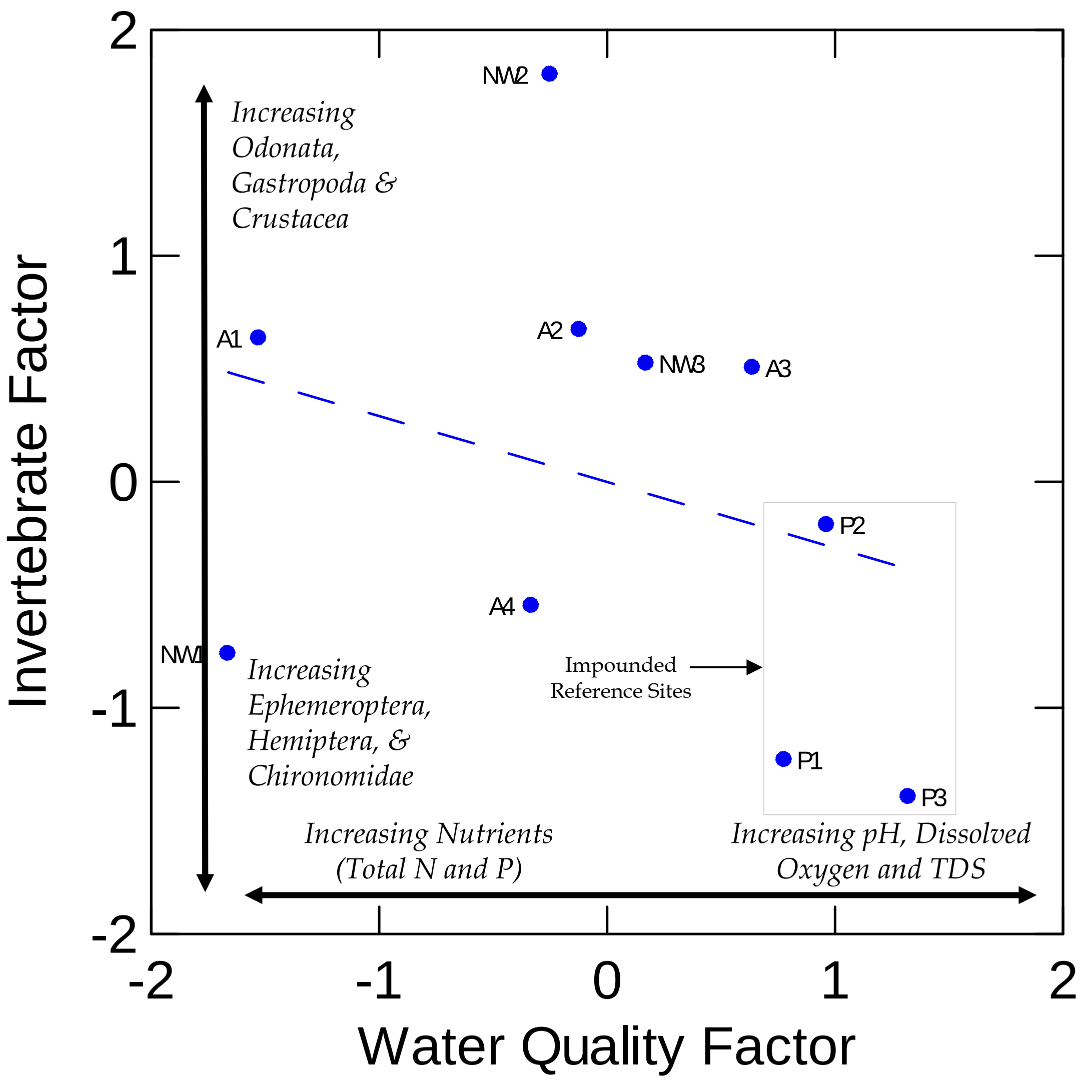


Figure 96. FACTOR ANALYSIS. Invertebrates and Vegetation - Sheet-Flow Sites

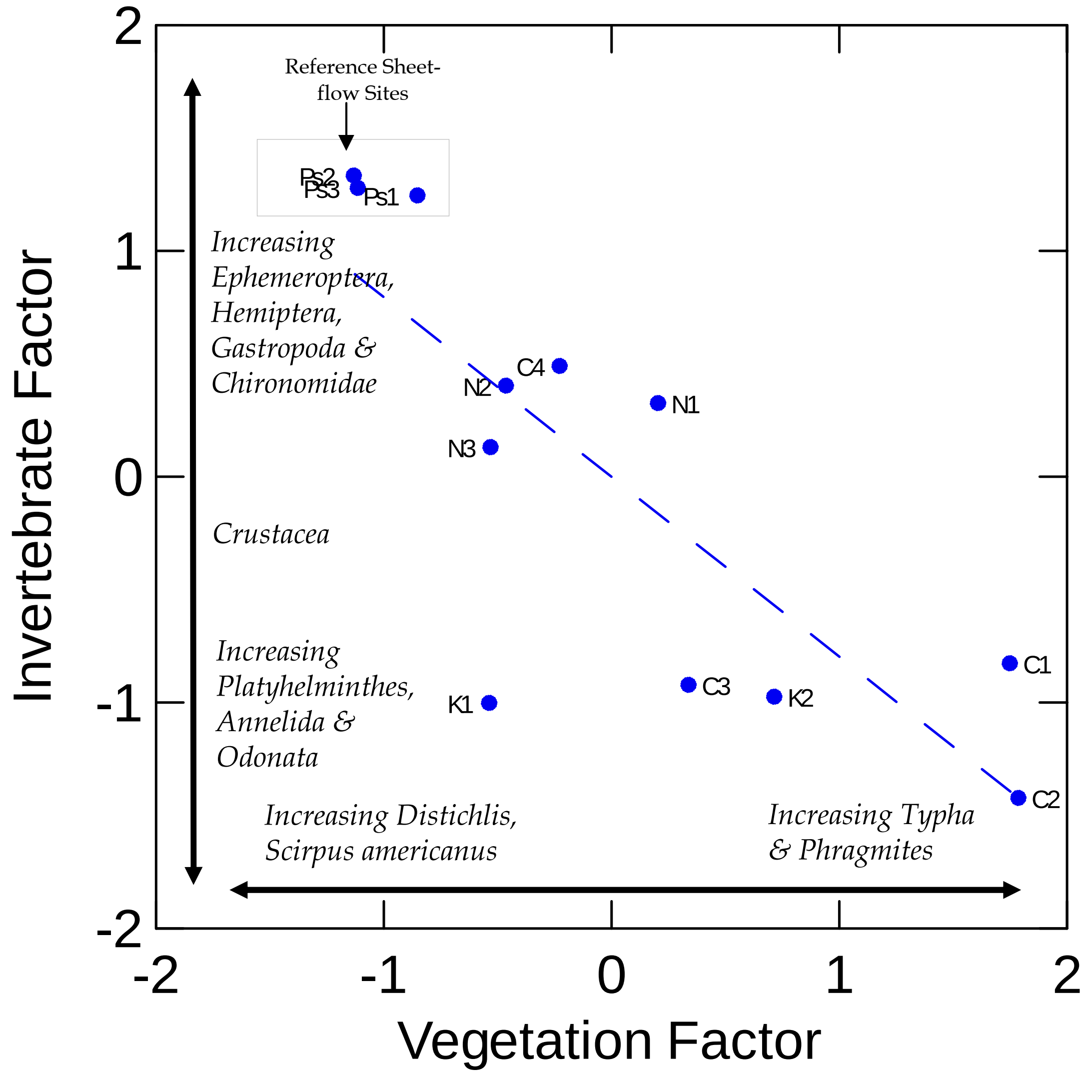
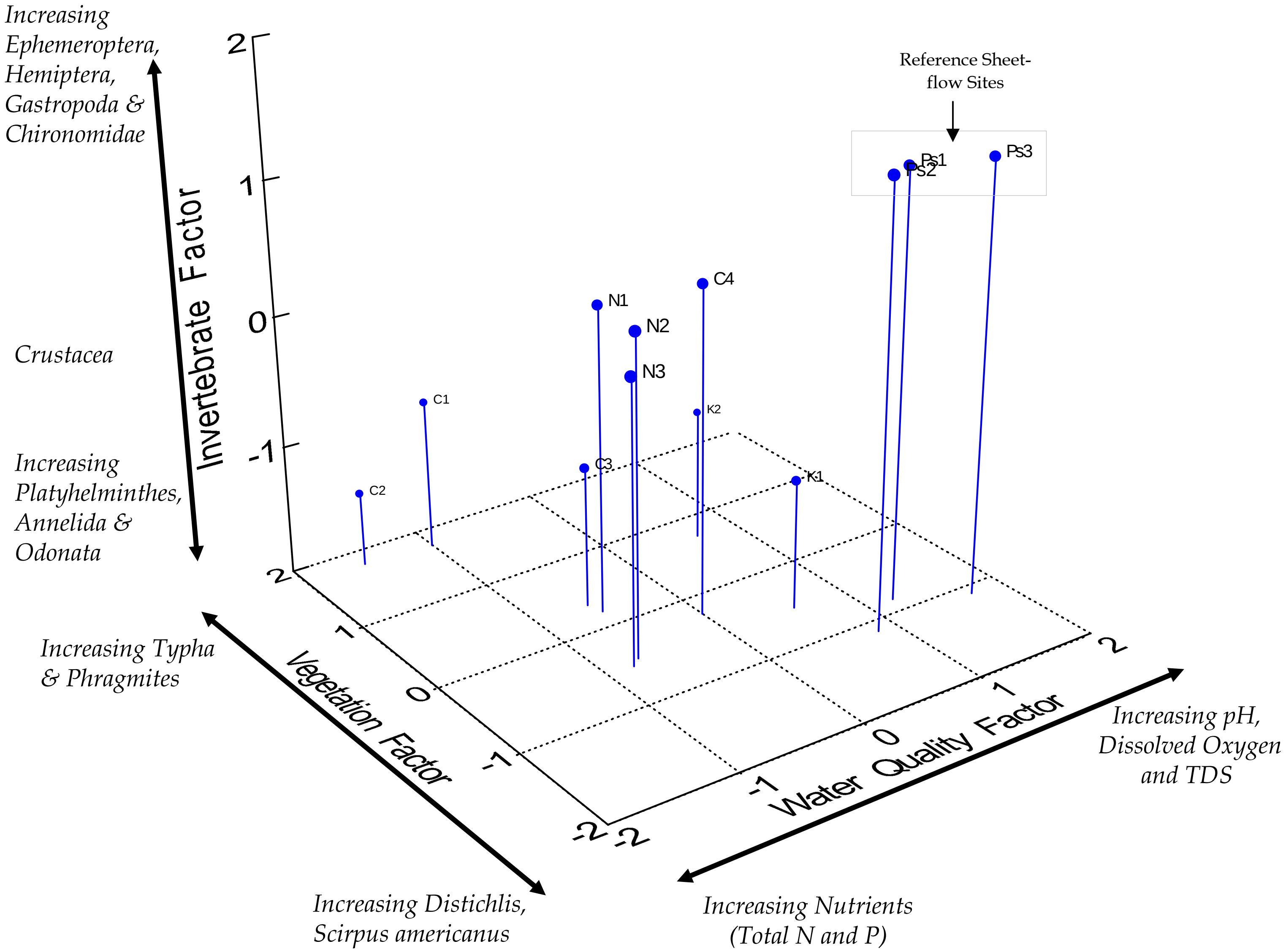


Figure 97. FACTOR ANALYSIS - Invertebrates, Vegetation & Water Quality - Sheet-Flow Sites



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APENDIX A.2

ANALYSIS OF 2005 DATA ON WETLAND BIOTA AND WATER QUALITY IN FARMINGTON BAY, GREAT SALT LAKE, UTAH

Sharook Madon, Ph.D.
CH2M - Hill

Analyses of 2005 Data on Wetland Biota and Water Quality in Farmington Bay, Great Salt Lake, Utah.

PREPARED FOR:	Leland Myers/Central Davis Sewer District, Utah Theron Miller/Utah Department of Water Quality
PREPARED BY:	Sharook Madon/CH2M HILL, San Diego Office
COPIES:	Heidi Hoven/The Institute for Watershed Sciences, Utah Jeff DenBleyker/CH2M HILL, Salt Lake City Office
DATE:	November 29, 2006
PROJECT NUMBER:	322512

Introduction

An integral part of the Great Salt Lake ecosystem, the Farmington Bay wetlands are valued as important feeding and nesting areas for migratory birds and for support of aquatic life and various recreational activities. The construction of a causeway in 1969 subsequently reduced natural mixing between Farmington Bay and the Great Salt Lake, often causing nutrients to remain concentrated in Farmington Bay. In recent years, there has also been growing concern among natural resource agencies and local stakeholders about the effects of nutrient loads from publicly-owned treatment works (POTWs) and other natural and anthropogenic sources on the assimilative capacity of the Farmington Bay wetlands. In response to these concerns, the Utah Division of Water Quality began a program in 2004 to characterize the wetland ecosystems of Farmington Bay.

The ongoing program includes intensive sampling of multiple wetlands sites that represent a cross-section of the different wetland ecosystems along Farmington Bay. The first year of sampling to characterize water quality, wetland soils, plants and macroinvertebrates along Farmington Bay was completed in 2004 and included sites that received sheet-flow hydrology and impounded wetlands. The results of the 2004 survey were described in a draft technical memorandum (CH2M HILL 2005, Appendix A) and provided a preliminary evaluation of the ecological relationships and patterns between key biological and water quality parameters. Additionally, the 2004 results also offered useful insights into potential metrics that may be useful in evaluating wetland function in relation to changes in water quality.

All of the sheetflow and impounded wetland sites sampled in 2004 were subsequently sampled multiple times between June and November of 2005 to assess wetland plants and macroinvertebrates in relation to water quality. This technical memorandum describes the analyses and results of the wetland plant and macroinvertebrate data collected from Farmington Bay in 2005, and reflects the second year of a 3-year effort aimed at characterizing the wetlands of Farmington Bay.

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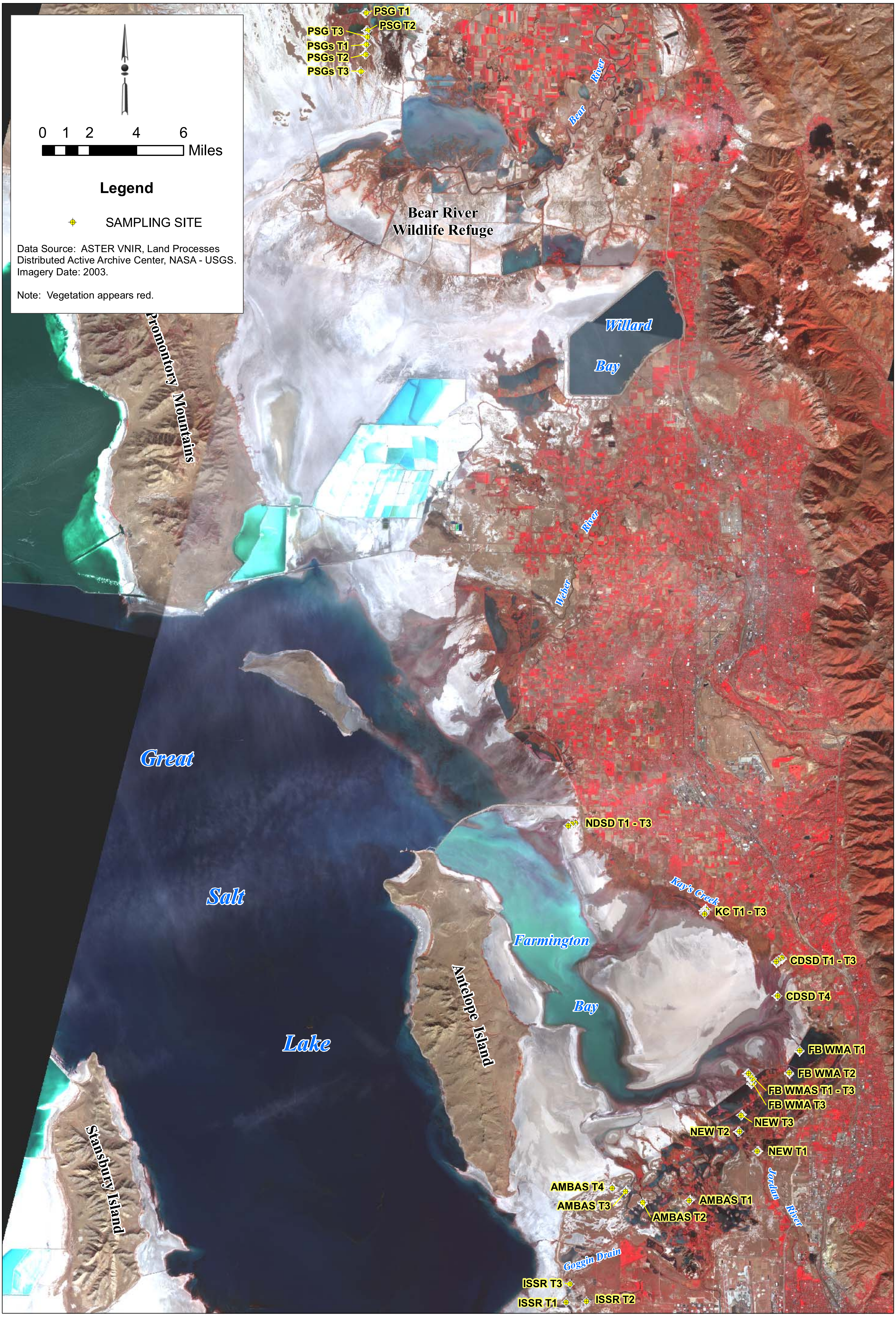


Data Source: ASTER VNIR, Land Processes Distributed Active Archive Center, NASA - USGS. Imagery Date: 2003.

Note: Vegetation appears red.

EXHIBIT 1

WETLANDS SAMPLING SITES

STATISTICAL ANALYSES OF 2005 DATA ON WETLAND PLANTS
AND INVERTEBRATES IN FARMINTON BAY, GREAT SALT LAKE, UTAH

Study Roles

Many personnel were involved in the planning and execution of this study in 2004-2005. The primary roles of key staff involved in this study and their respective affiliations are noted in Table 1.

TABLE 1. SUMMARY OF KEY STAFF INVOLVED WITH THEIR AFFILIATIONS AND THEIR LEAD ROLES IN THE 2004-2005 STUDY

Staff	Affiliation	Roles
Sharook Madon, Ph.D.	CH2M HILL, Inc.	Study planning, experimental design, data organization, data analyses and draft & final reports.
Heidi Hoven, Ph.D.	SWCA	Study planning, experimental design, field sampling and data support.
Theron Miller, Ph.D.	Utah Department of Environmental Quality (UDEQ)	Study planning, experimental design, field sampling and data support.
Samuel Rushforth, Ph.D.	Utah Valley State College (UVSC)	Laboratory analysis and enumeration of phytoplankton samples[1]
Lawrence Gray, Ph.D.	Utah Valley State College (UVSC)	Laboratory analysis and enumeration of macroinvertebrate samples
John Cavitt, Ph.D.	Weber State University (WSU)	Bird data[2]

[1] Phytoplankton analysis is not included in this or the 2004 report by CH2M HILL, but are in separate reports produced by Dr. Rushforth.

[2] Bird data analysis is not specifically included in this report, but forms an important component of the overall study and reference is made to it in this report.

Data Analyses

This technical memorandum focuses on an exploratory analysis of relationships between plant invertebrate and water chemistry variables measured during 2005 at various sites in the wetlands of Farmington Bay.

Wetland Sites

Plant, macroinvertebrate and water quality data from the following wetland sites (Exhibit 1, Table 2) reflecting both impounded and sheetflow hydrology were incorporated into the analyses.

TABLE 2. SUMMARIES OF WETLAND SITES SAMPLED IN 2004 AND 2005.

Site	Hydrology	Abbreviation for Exhibit 1	Abbreviation for Figures	Sampled in 2004 (Y/N)	Sampled in 2005 (Y/N)	Comments
Ambassador Transects 1-4	Impounded	AMBAS T1 - T3	A1-4	Y	Y	
Farmington Bay Waterfowl Management Area Transects 1-3	Impounded	FBWMA T1-T3	F1-4	Y	Y	
Inland Sea Shorebird Refuge Transects 1-3	Impounded	ISSR T1-T3	I1-3	N	Y	
Newstate Transects 1-3	Impounded	NEW T1-T3	N1-3	Y	Y	
Public Shooting Grounds Transects 1-3	Impounded	PSG T1-T3	P1-3	Y	Y	Reference sites for impounded wetlands
Central Davis Sewer District Transects 1-4	Sheetflow	CDSD T1-T4	C1-4	Y	Y	POTW discharge sites
Farmington Bay Waterfowl Management Area Sheetflow Transects 1-3	Sheetflow	FBWMAs T1-T4	Fs1-4	Y	Y	
Kays Creek Transects 1-3	Sheetflow	KC T1-T3	K1-3	Y	Y	
North Davis Sewer District Transects 1-3	Sheetflow	NDSD T1-T3	N1-3	Y	Y	POTW discharge sites
Public Shooting Grounds Sheetflow Transects 1-3	Sheetflow	PSG T1-T3	Ps1-3	Y	Y	Reference sites for sheetflow wetlands

Wetlands Variables Used in Data Analysis

Plant Variables

Percent cover data of all plant species observed in quadrats placed in each transect were recorded. However, only percent cover data of plant species frequently observed at the sites were included in the statistical analysis. Plant species with rare occurrences, for example, found at low percent cover only on one occasion, were eliminated from statistical analysis to conserve the robustness of the analysis. The plant species displayed in Table 3 were all included in the analysis. Additionally, for both 2004 and 2005 data, plant species were also categorized by status (native, introduced or invasive) for analysis.

TABLE 3. SUMMARY OF PLANT SPECIES SAMPLED IN THE WETLANDS OF FARMINGTON BAY IN 2005
Species listed here include those that were used in the statistical data analysis.

Plant Species Name	Common Name	Comments
Alopecurus aequalis	Short awn Foxtail	Native, found at sheetflow sites
Atriplex micrantha	Two scale Saltbush	Introduced, found at sheetflow sites
Bidens cernua	Nodding Beggars-tick	Native, Invasive, found at sheetflow sites
Distichlis spicata	Desert Saltgrass	Native, Invasive, found at sheetflow sites
Horduem jubatum	Foxtail Barley	Native, Invasive, found at sheetflow sites
Phalaris arundinacea	Reed Canary Grass	Native, Invasive, found at sheetflow sites
Phragmites australis	Common Reed	Native, Invasive, found at sheetflow sites
Polygonium lapathifolium	Curlytop Knotweed	Native, Invasive, found at sheetflow sites
Rumex crispus	Curly Dock	Introduced, Invasive, found at sheetflow sites
Salicornia rubra	Red Swampfire	Native, found at sheetflow sites. A type of pickleweed
Schoenoplectus acutus	Hardstem Bulrush	Native, found at sheetflow sites
Schoenoplectus americanus	Olney's Bulrush	Native, found at sheetflow sites
Schoenoplectus maritimus	Cosmopolitan Bulrush or Alkali Bulrush	Native, found at sheetflow sites
Typha dominghensis	Southern Cattail	Native, Invasive, found at sheetflow sites
Typha latifolia	Broadleaf Cattail	Native, Invasive, found at sheetlow sites
Lemna minor	Lesser Duckweed	Floating aquatic vegetation

TABLE 3. SUMMARY OF PLANT SPECIES SAMPLED IN THE WETLANDS OF FARMINGTON BAY IN 2005
Species listed here include those that were used in the statistical data analysis.

Plant Species Name	Common Name	Comments
Azola mexicanus	Mexican mosquitofern	Floating aquatic vegetation
Ceratophyllum demersum	Coon's Tail	Native, found at impounded sites
Chara species	Muskgrass species	Native, a multicellular macro-alga, not a true plant. Found at impounded sites
Ruppia cirrhosa	Ditch Grass	Native, found at impounded sites
Stuckenia species	Pondweed species	Native, mostly consisted of *Stuckenia filiformis,* fineleaf pondweed. Found at impounded sites

Algae were also recorded and included in the analysis involving sheetflow sites.

Wetland Macroinvertebrate Variables

Macroinvertebrates were collected at each of the wetlands sites and later enumerated to genus, or whenever possible, to species level. The number of individuals per sample for various macroinvertebrate taxa observed in the samples (Table 4) were recorded and included in the analyses. Macroinvertebrates such as *Ephydra, Ylodes, Oecetis, Holorusia,* and Stratiomyidae, were rarely observed in the samples and were included in the category titled "other" for the statistical analyses.

TABLE 4. SUMMARY OF MACROINVERTEBRATE TAXA SAMPLED IN THE WETLANDS OF FARMINGTON BAY IN 2005.

Taxanomical Category	Taxanomical Descriptions	Representative Genus/Species Observed †
Ephemeropterans	Order Ephemeroptera, represented by mayflies	*Callibaetis* sp. (CG), *Caenis* sp. (CG)
Odonates	Order Odonata, represented by damselflies and dragonflies	*Ischnura* sp. (PR), *Erythemis* sp. (PR), *Aeshna* sp. (PR)
Hemipterans	Order Hemiptera, represented by corixids (water boatman) and notonectids (Backswimmers)	Corixids: *Corisella* sp. (PR), *Hesperocorixa* sp. (PR), *Trichocorixa* sp. (PR) Notonectids: *Notonecta* sp. (PR), few *Limnoporus* sp. (PR)
Chironomids	Order Diptera*, represented by the Family Chironomidae	Mainly *Chironomus* sp. (CG) Fewer individuals of Orthocladiinae (CG), Tanytarsini (CG), and Tanypodinae (PR).
Gastropods	Class Gastropoda, represented by various snail species	*Physella* sp. (SH), *Stagnicola* sp. (SH), and *Gyraulus* sp. (SH)

TABLE 4. SUMMARY OF MACROINVERTEBRATE TAXA SAMPLED IN THE WETLANDS OF FARMINGTON BAY IN 2005.

Taxanomical Category	Taxanomical Descriptions	Representative Genus/Species Observed †
Crustaceans	Family Hyalellidae, and a few members belonging to Family Asellidae	Hyalellidae: *Hyallela azeteca* (CG) Asellidae: *Caecidotea occidentalis* (CG)
Platyhelminthes	Phylum Platyhelminthes, represented by planarian flatworms	*Phagocota* sp. (PR), *Dugesia* sp. (PR)
Annelids	Phylum Annelida, represented by leeches	*Erpobdella parva* complex (PR), *Helobdella stagnalis* (PR), and *Glossophonia complanata* (PR)
Coleopterans	Represented by beetles of families Dytiscidae, Hydrophilidae, Haliplidae, Gyrinidae	Dytiscidae: *Agabus* sp. (PR), *Hydroporus* sp. (PR), *Hydaticus* sp. (PR), *Laccophilus* sp. (PR), *Graphoderus* sp. (PR) Hydrophilidae: *Ametor* sp. (CG), *Enochrus* sp. (CG), *Berosus* sp. (CG), *Tropisternis* sp. (Adults CG, larvae PR), *Hydrophilus* sp. (Adults CG, larvae PR) Halipidae: *Haliplus* sp. (SH) Gyrinidae: *Gyrinus* sp. (PR)
Acari	Represented by mites and ticks	Individuals were rare, and were not identified by species, but grouped under the sub-class Acari (PR)
Ostracods	Represented by crustaceans with laterally compressed body and undifferentiated heads	Individuals were rare, and were not identified by species, but grouped under the class Ostracoda (CG)

*Members of the Order Diptera that included Families such as Ephydridae, Tabanidae, Stratiomyidae and Tipulidae were also observed, but were rare and included in the "Others" category.

† Trophic classifications for the various species are provided in parenthesis. CG = collector-gatherers, FC = Filterer-collector, PR = predators, SH = Shredders.

Water Quality Variables

Physical/chemical data on water samples were collected to assess the responses of plant and invertebrate variables to a range of environmental conditions across wetland sites. These water quality parameters included:

- pH
- Total dissolved solids (TDS), mg/L
- Total suspended solids (TSS), mg/L
- Dissolved oxygen (DO), mg/L
- Phosphorus as total-P (TP), mg/L

- Nitrogen as total-N (TN, nitrite and nitrate), mg/L
- Water temperature (^{0}C)

All water quality data is log$_{10}$-transformed for the analyses, except in a few cases, as noted.

Data Analyses Approach

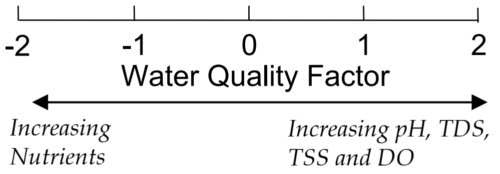
Consistent with analysis conducted on 2004 data, both univariate and multivariate statistical tests were used to explore relationships between water quality and biological variables measured at various wetland sites in Farmington Bay 2005.

In general, multivariate statistical tests such as factor analysis were used to convert multiple water quality variables (pH, TDS, TSS, DO, TP, TN, and water temperature) into a single water quality factor. The water quality factor, as such, conveniently describes the range of water quality variables in a single factor (axis) by scaling these variables across a range of factor scores. Once water quality variables are described by a single water quality factor, biotic variables that describe plants and invertebrate communities can be conveniently scaled against the water quality factor to assess wetland biotic responses to water quality. The overall analytical approach involved:

The Water Quality Factor

A multivariate test known as factor analysis (Systat ver. 11) was used to generate the principal components of the water quality variables including pH, TDS, TSS, DO, nutrients (TP and TN), and water temperature, and also to generate a single factor that described water quality (Exhibit 2). The water quality factor was derived from log-transformed data on individual water quality variables. As such, water quality variables such as pH, TDS, TSS, and water temperature were log$_{10}$ (X) transformed, whereas TN, TP, and DO were log$_{10}$ (X+1) transformed to account for data values that included 0. The water quality factor was used in subsequent univariate and multivariate analyses conducted to explore the relationships of biotic variables (plants and invertebrates) to water quality across the various wetland sites.

EXHIBIT 2. Descriptive example of the water quality factor used in the analysis



Univariate Analysis of Biotic Variables and Water Quality

Univariate regression analysis was used to explore the relationships between water quality and plant and macroinvertebrate variables across impounded and sheetflow wetland sites in 2004 and 2005. Specifically, simple regression analysis was conducted to explore the relationships between water quality and functional categories of plants and macroinvertebrates (Table 5) for both 2004 and 2005 data sets.

TABLE 5. SUMMARY OF TYPES OF UNIVARIATE ANALYSIS CONDUCTED TO EXPLORE RELATIONSHIPS BETWEEN WATER QUALITY, PLANT AND MACROINVERTEBRATE DATA.

All relationships of biotic variables (plants and macroinvertebrates) were explored in relation to information on water quality variables (pH, TDS, TSS, nutrients, DO, and water temperature) contained in the Water Quality Factor.

Type of Analysis	Site Hydrology Type	Year of Data Set	Statistical analysis	Comments
Plants				
Number of Native Plant Species vs. Water quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Analysis was conducted on both non-transformed and $\log_{10}$ (X+1) transformed plant data.
Percent of Native Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Number of native plant species as a percent of the total number of species at each wetland site was calculated. Analysis was conducted on both non-transformed and Arcsin-transformed† plant data.
Number of Introduced Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Analysis was conducted on both non-transformed and $\log_{10}$ (X+1) transformed plant data.
Percent of Introduced Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Number of introduced plant species as a percent of the total number of species at each wetland site was calculated. Analysis was conducted on both non-transformed and Arcsin-transformed† plant data.
Number of Invasive Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Analysis was conducted on both non-transformed and $\log_{10}$ (X+1) transformed plant data.

TABLE 5. SUMMARY OF TYPES OF UNIVARIATE ANALYSIS CONDUCTED TO EXPLORE RELATIONSHIPS BETWEEN WATER QUALITY, PLANT AND MACROINVERTEBRATE DATA.

All relationships of biotic variables (plants and macroinvertebrates) were explored in relation to information on water quality variables (pH, TDS, TSS, nutrients, DO, and water temperature) contained in the Water Quality Factor.

Type of Analysis	Site Hydrology Type	Year of Data Set	Statistical analysis	Comments
Percent of Invasive Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	Individual plants species observed at each site were grouped into categories such as natives, introduced and invasive for this analysis. Number of invasive plant species as a percent of the total number of species at each wetland site was calculated. Analysis was conducted on both non-transformed and Arcsin-transformed† plant data.
Total Number of Plant Species vs. Water Quality	Sheetflow Sites Only*	2004 and 2005	Simple Linear Regression or DWLS**	The total number of plant species observed at each wetland site was recorded. Analysis was conducted on both non-transformed and $\log_{10}$ (X+1) transformed plant data.
Macroinvertebrates				
Percent Relative Abundance of Tolerant Species	Impounded and Sheetflow Sites	2004 and 2005	Simple Linear Regressions or DWLS	Macroinvertebrates were grouped into functional categories such as tolerant species, numbers of Ephemeropterans (sensitive species), and trophic categories such as numbers of collector-gatherers, predators, and shredders. Percent relative abundance†† of macroinvertebrate species (arcsin-transformed) belonging to these functional categories was then calculated for each wetland site.
Percent Relative Abundance of Ephemeropterans	Impounded and Sheetflow Sites	2004 and 2005	Simple Linear Regressions or DWLS	Macroinvertebrates were grouped into functional categories such as tolerant species, numbers of Ephemeropterans (sensitive species), and trophic categories such as numbers of collector-gatherers, predators, and shredders. Percent relative abundance†† of macroinvertebrate species (arcsin-transformed) belonging to these functional categories was then calculated for each wetland site.
Percent Relative Abundance of Collector-Gatherer Species	Impounded and Sheetflow Sites	2004 and 2005	Simple Linear Regressions or DWLS	Macroinvertebrates were grouped into functional categories such as tolerant species, numbers of Ephemeropterans (sensitive species), and trophic categories such as numbers of collector-gatherers, predators, and shredders. Percent relative abundance†† of macroinvertebrate species (arcsin-transformed) belonging to these functional categories was then calculated for each wetland site.
Percent Relative Abundance of Predatory Species	Impounded and Sheetflow	2004 and 2005	Simple Linear Regressions	Macroinvertebrates were grouped into functional categories such as tolerant species, numbers of Ephemeropterans (sensitive species), and trophic categories such as

TABLE 5. SUMMARY OF TYPES OF UNIVARIATE ANALYSIS CONDUCTED TO EXPLORE RELATIONSHIPS BETWEEN WATER QUALITY, PLANT AND MACROINVERTEBRATE DATA.
All relationships of biotic variables (plants and macroinvertebrates) were explored in relation to information on water quality variables (pH, TDS, TSS, nutrients, DO, and water temperature) contained in the Water Quality Factor.

Type of Analysis	Site Hydrology Type	Year of Data Set	Statistical analysis	Comments
	Sites		or DWLS	numbers of collector-gatherers, predators, and shredders. Percent relative abundance†† of macroinvertebrate species (arcsin-transformed) belonging to these functional categories was then calculated for each wetland site.
Percent Relative Abundance of Shredder Species	Impounded and Sheetflow Sites	2004 and 2005	Simple Linear Regressions or DWLS	Macroinvertebrates were grouped into functional categories such as tolerant species, numbers of Ephemeropterans (sensitive species), and trophic categories such as numbers of collector-gatherers, predators, and shredders. Percent relative abundance†† of macroinvertebrate species (arcsin-transformed) belonging to these functional categories was then calculated for each wetland site.

* Impounded Sites had only native plant species, so no analysis was conducted on these sites. ** DWLS: Distance Weighted Least Squares.

† Arcsin Transformation = (2/∏) * Arcsin(√X_{ij}), where X_{ij} = proportion of relative abundance or relative density of species.

†† Percent Relative Abundance = (n/N)*100, where n is the number of invertebrates belonging to each functional category (e.g., predators) and N is the total number of macroinvertebrates, at each wetland site.

A preliminary visual examination of scatterplots of plant and macroinvertebrate variables on the water quality factor often indicated non-linear relationships between these variables. In such cases, a distance-weighted least squares (DWLS) curve fitting method (Systat ver. 11) was used to define these non-linear relationships. DWLS is a powerful and versatile method that fits a line to a set of points in a scatterplot by least squares methodology, where the line is allowed to flex locally to fit the data. The DWLS method produces a true, locally-weighted curve running through a set of points and does not assume the shape of the curve, as in the case of linear least squares and polynomial regressions. As such, the DWLS method provides a true representation of relationships between sets of observed ecological data.

Summaries of macroinvertebrate tolerances to various environmental variables that were used to derive functional groups in the analyses outlined in Table 5 are also provided in Table 6. Summaries of macroinvertebrate trophic categories used to derive functional groups used in the analyses summarized in Table 5 are provided in Table 4.

TABLE 6. TOLERANCES OF SELECTED MACROINVERTEBRATE TAXA TO ENVIRONMENTAL VARIABLES.
Data on tolerances and preferred habitat of macroinvertebrates are obtained from Gray (2005).
Tolerances to eutrophication, anaerobic conditions, water temperature, pH and conductivity were used in the analysis.

Macroinvertebrate Taxa	Preferred Habitat	Eutrophication (Nutrients)	Anaerobic Conditions	Water Temperature > 30^0C	pH > (.0	Conductivity > 5000 mS	Pesticides (e.g., malathion)	Bti (Bacillus thurengiensis)
EPHEMEROPTERA								
Callibaetis sp.	Lentic +/- aquatic vegetation	(S)	S	V	V	V	S	T
ODONATA								
Ischnura barberi/cervula	Climbers on aquatic vegetation	T	T	T	T	V	S	T
Aeshna californica	Climbers on aquatic vegetation	T	S	T	T	T?	S	T
Erythemis collocata	Sprawlers in silt/mud	(S)	S	T	T	S	S	T
Tramea lacerata	Sprawlers in silt, detritus and vegetation	(S)	S	S	S	S	S	T
HEMIPTERA								
Corisella inscripta	Ponds	V	V	T	V	V	S	T
Hesperocorixa laevigata	Ponds with dense submerged vegetation	T	V	T	V	T	S	T
Notonecta undulate	Ponds	T	V	T	V	T	S	T
Trichocorixa verticalis	Highly saline ponds and the Great Salt Lake	V	V	T	V	V	S	T
DIPTERA								
Chironomus sp.	Lentic benthos	V	T	V	T	T	S	S
Orthocladiinae sp.	Lentic/lotic benthos	V	T	T	T	T	S	S
Tanytarsini sp.	Lentic/lotic benthos	V	T	T	T	T	S	S
GASTROPODA (Pulmonate Snails)								
Physella sp.	Lentic/lotic benthos	V	V	V	V	V	T	T
Stagnicola sp.	Lentic/lotic benthos	V	V	V	V	V	T	T
Gyraulus sp.	Lentic/lotic benthos	V	V	V	V	V	T	T
ANNELIDA (Leeches)								
Erpobdella parva (complex)	Lentic/lotic benthos	V	V	S	T	S	T	T
Glossophonia complanata	Lentic/lotic benthos (rocks)	V	V	S	T	S	T	T
Helobdella stagnalis	Lentic/lotic benthos	V	V	S	T	S	T	T

TABLE 6. TOLERANCES OF SELECTED MACROINVERTEBRATE TAXA TO ENVIRONMENTAL VARIABLES.
Data on tolerances and preferred habitat of macroinvertebrates are obtained from Gray (2005).
Tolerances to eutrophication, anaerobic conditions, water temperature, pH and conductivity were used in the analysis.

Macroinvertebrate Taxa	**Preferred Habitat**	**Eutrophication (Nutrients)**	**Anaerobic Conditions**	**Water Temperature > 30^{0}C**	**pH > (.0**	**Conductivity > 5000 mS**	**Pesticides (e.g., malathion)**	**Bti (Bacillus thurengiensis)**
OLIGOCHAETA	Lentic/lotic benthos (muds)	V	V	T	S	S	T	T
CRUSTACEA								
Hyallela azteca	Lentic/lotic benthos	T	S	T	T	S	S	T
Caecidotea occidentalis	Lentic/lotic benthos	T	S	S	S	S	S	T
PLATYHELMINTHES (Planarian flatworms)								
Phagocota sp.	Lentic/lotic benthos	V	T	V	V	(S)	V	T
Dugesia sp.	Lentic/lotic benthos	V	T	V	V	(S)	V	T

KEY: S = Sensitive to the noted environmental variable, as determined from literature, (S) = sensitive to the noted environmental variable, as determined from field data, T = tolerant to the noted environmental variable, V = very tolerant to the noted environmental variable

Multivariate Analysis of Biotic Variables and Water Quality

Factor analysis is used to explore relationships between the plant and macroinvertebrate community and water quality across wetland sites in the Farmington Bay. Factor analysis is a useful method for assessing complex ecological community data with multiple dependent and independent variables. The factor model explains variation within and relations among observed variables as partly common variation among factors and partly specific variation among random errors (Systat ver. 11). Factor analysis allows exploration of multivariate biological community and environmental data and has many advantages:

- Correlations of large number of variables can be studied by grouping the variables in factors (i.e., water quality factor, macroinvertebrate factor, plant factor), so that variables within each factor are more tightly correlated with other variables in that factor than with variables in other factors.
- Many variables can be parsimoniously summarized by a few factors. For example, pH, DO, TDS, TSS, conductivity and nutrients, can potentially be summarized into a single water quality factor.

- Each factor can be interpreted according to the meaning of the variables. For example, a water quality factor may scale increasing pH, DO and TDS on positive factor loadings and increasing nutrients on negative factor loadings (shown earlier in Exhibit 2).

A summary of the types of multivariate analyses (Factor Analysis) that were conducted to explore the relationships between water quality, plants and macroinvertebrates across wetland sites in 2005 is provided (Table 7).

TABLE 7. SUMMARY OF TYPES OF MULTIVARIATE ANALYSIS CONDUCTED TO EXPLORE RELATIONSHIPS BETWEEN WATER QUALITY, PLANT AND MACROINVERTEBRATE DATA.

Type of Analysis	Site Hydrology Type	Year of Data Set	Statistical analysis	Comments
Plants				
Plant species distributions in relation to water quality across wetland sites	Impounded and Sheetflow sites	2005	Factor Analysis	Percent cover data on plant species observed at each wetland site was Arcsin-transformed† for multivariate analysis to generate a plant species factor. The plant species factor was then scaled against the water quality factor to explore how various plants species grouped across water quality at specific wetland sites.
Macroinvertebrates				
Macroinvertebrate taxa distributions in relation to water quality across wetland sites	Impounded and Sheetflow sites	2005	Factor Analysis	Abundances (X) of macroinvertebrate taxa observed at each wetland site was $\log_{10}(X+1)$ transformed for multivariate analysis to generate a macroinvertebrate taxa factor. The macroinvertebrate factor was then scaled against the water quality factor to explore how various invertebrate taxa grouped across water quality at specific wetland sites.
Macroinvertebrate species diversity in relation to water quality across wetland sites	Impounded and Sheetflow sites	2004 and 2005	Factor Analysis	Species diversity indices (Y) of macroinvertebrates observed at each wetland site was calculated and then $\log_{10}(Y+1)$ transformed for multivariate analysis to generate a macroinvertebrate diversity factor. The macroinvertebrate diversity factor was then scaled against the water quality factor to explore how invertebrate diversity grouped across water quality at specific wetland sites.

† Arcsin Transformation = $(2/\prod) * \text{Arcsin}(\sqrt{X_{ij}})$, where X_{ij} = percent cover of plant species.

Data on the types and numbers of macroinvertebrate species observed at each wetland site was used to estimate species diversity, species richness and species evenness indices for 2004 and 2005. These measures of species diversity, richness and evenness were converted to a single integrated species diversity factor using factor analysis and then used in the multivariate analysis to explore the relationships between species diversity and water quality across wetland sites in 2004 and 2005.

Macroinvertebrate species diversity was estimated using the Shannon-Wiener Diversity index, (N′) (Shannon and Weaver 1963, Krebs 1989, McCune and Grace 2002).

$$N' = 10^{H'}$$

$$H' = -\sum_{i=1}^{S} Pi \log Pi$$

where P_i = the proportion of the total number of individuals in the i^{th} species; and S = the number of species.

Species richness (d) was also estimated for macroinvertebrates as an additional measure of diversity (Atlas and Bartha 1981, Krebs, 1989).

$$d = \frac{S - 1}{\log_{10} N}$$

where S = the number of species; and N = the number of individuals.

Species evenness (J) was also calculated (Pielou 1966, 1969; McCune and Grace 2002).

$$J = \frac{H'}{\log_{10} S}$$

where S is the number of species in the sample, and H′ is as noted above in the formula for the Shannon-Wiener Diversity Index.

Results

The section presents the results of the analyses conducted on 2004 and 2005 Farmington Bay wetlands data. Presentation of the results follows the analytical approach described in the methods section.

Figures referenced in this section are available at the end of this document.

Site Specific Summary of Plant Percent Cover, 2005

Percent covers of plant species were averaged across site transects and multiple sampling dates to generate a mean percent cover value for each species at a particular site.

SHEETFLOW SITES

All of the sheetflow sites had floating aquatic vegetation, often at high percent covers relative to emergent wetland macrophytes. However, floating aquatic vegetation tends to accumulate in certain spots due to wind effects and water flow. Thus, measures of percent cover of floating aquatic vegetation (*Lemna minor*, *Azola mexicanus,* and also algae) observed in transects may not be true representations of its abundance or density in a particular transect. Thus, the following discussion on plant percent covers in sheetflow sites focuses primarily on emergent wetland plants.

Central Davis Sewer District Site (CDSD)

The emergent macrophytes, *Phragmites australis* and *Typha latifolia* dominated the CDSD site, followed by *Schoenoplectus americanus* and *Schoenoplectus maritimus* (Figure 1). Other macrophytes such as *Salicornia rubra* and *Rumex crispus* represented less than 10 percent of the mean plant cover and algae was also present at this site (Figure 1). Floating aquatic vegetation, *Lemna minor*, had the highest percent cover at the CDSD site (Figure 1), but this may be an artifact of wind and/or flow effects.

Farmington Bay Waterfowl Management Area Sheetflow Site (FBWMAs)

The emergent macrophytes, *Phragmites australis* and *Schoenoplectus maritimus* dominated the FBWMAs site, followed by *Typha dominghensis* and *Schoenoplectus americanus* (Figure 2). Other macrophytes such as *Atriplex micrantha, Bidens cernua, Polygonium lapathifolium, Rumex crispus, Salicornia rubra* were also present at this site but represented less than 5 percent of the mean plant cover (Figure 2). Floating aquatic vegetation, *Lemna minor* and *Azola mexicanus,* and algae were also present at the FBWMAs site (Figure 2).

Kays Creek Site (KC)

Typha latifolia, Phragmites australis and *Schoenoplectus americanus* had the highest percent coves at the KC site, followed by *Schoenoplectus maritimus* and *Bidens cernua* (Figure 3). *Schoenoplectus acutus* represented less than 1 percent of mean plant cover at this site (Figure 3). Floating aquatic vegetation, *Lemna minor*, and algae were also present at the KC site (Figure 3).

North Davis Sewer District Site (NDSD)

The NDSD site had, in general, more plant species than other sites. *Alopecurus aequalis, Phalaris arundanecea, Phragmites australis, Salicornia rubra* and *Schoenoplectus maritimus* had the highest mean percent covers (12-35 percent cover range), followed by *Atriplex micrantha, Bidens cernua, Polygonium lapathifolium, Schoenoplectus acutus, Schoenoplectus americanus* and *Typha dominghensis* (5-10 percent cover range) (Figure 4). *Rumex crispus and Typha latifolia* were also present but represented less than 3 percent of mean plant cover collectively (Figure 4). Floating aquatic vegetation, *Lemna minor* was also present at the NDSD site (Figure 4).

Public Shooting Grounds Sheetflow Sites (PSGs)

Desert saltgrass, *Distichlis spicata,* dominated the PSGs site, followed by *Schoenoplectus americanus* and *Schoenoplectus maritimus* (Figure 5). *Hordeum jubatum* was also present but represented less than 4 percent of the mean plant cover at the PSGs site (Figure 5). Floating aquatic vegetation, *Azola mexicanus*, and algae were also present at the PSGs site (Figure 5).

IMPOUNDED SITES

The impounded wetland sites had, in general, far fewer plant species than sheetflow sites. All four plant species observed at the impounded sites were native species.

Ambassador Site (AMBAS)

Stuckenia species (pondweeds) had the highest percent cover at the AMBAS site, followed by *Ruppia cirrhosa* and *Ceratophyllum demersum*, both of which had percent covers below 5 percent (Figure 6). *Chara* species was not observed in the transects at the AMBAS site.

Farmington Bay Waterfowl Management Area Impounded Site (FBWMA)

Stuckenia species was the only dominant plant at the FBWMA site, followed by *Ceratophyllum demersum* at less than 1 percent cover (Figure 7). Both *Chara* and *Ruppia cirrhosa* were absent from the transects sampled at the FBWMA site.

Inland Sea Shorebird Refuge Site (ISSR)

Stuckenia species had the highest percent cover at the ISSR site, followed by *Ruppia cirrhosa* and *Chara* species, both of which had a combined percent cover below 6 percent (Figure 8). *Ceratophyllum demersum* was not observed in the transects at the ISSR site.

New State Site (NEW)

Stuckenia species was the only dominant plant at the NEW site, followed by *Ceratophyllum demersum* at less than 1 percent cover (Figure 9). Both *Chara* and *Ruppia cirrhosa* were absent from the transects sampled at the NEW site.

Public Shooting Grounds Impounded Site (PSG)

Both *Stuckenia* and *Chara* species had relatively high percent covers and were the only two plant species observed at the PSG site (Figure 10). *Ruppia cirrhosa* and *Ceratophyllum demersum* were both absent in the transects at the PSG site.

Site Specific Summary of Macroinvertebrate Numbers, 2005

Numbers of macroinvertebrates were averaged across site transects and multiple sampling dates to generate a mean number (abundance) for each taxa at a particular site.

SHEETFLOW SITES

Central Davis Sewer District Site (CDSD)

Crustaceans (*Hyallela azteca)* and chironomids (midges) were the most abundant macroinvertebrate taxa observed in samples collected at CDSD, followed by annelids (leeches), gastropods (snails) and odonates (damselflies and dragonflies) (Figure 11).

Ephemeropterans (mayflies), hemipterans (corixids and notonectids), Platyhelminthes (flatworms) and coleopterans (beetles) were relatively far less abundant (Figure 11).

Farmington Bay Waterfowl Management Area Sheetflow Site (FBWMAs)

Crustaceans (*Hyallela azteca)* were the most abundant macroinvertebrate taxon observed in samples collected at FBWMAs, followed by gastropods, chironomids, and hemipterans (Figure 12). Ephemeropterans, odonates, annelids and coleopterans were relatively far less abundant (Figure 12).

Kays Creek Site (KC)

The Kays Creek site was dominated by hemipterans, mostly corixids (Figure 13). Ephemeropterans, odonates, chironomids, gastropods, crustaceans, platyhelminthes, annelids and coleopterans were also observed in the samples, their mean numbers were relatively lower (Figure 13).

North Davis Sewer District Site (NDSD)

Compared to other sheetflow sites, relatively fewer macroinvertebrate taxa were observed at the NDSD site. This site was overwhelmingly dominated by chironomids, followed by hemipterans, the next most abundant taxon (Figure 14). Odonates, gastropods, annelids, and coleopterans were also observed in samples collected at this site, but in far fewer numbers (Figure 14).

Public Shooting Grounds Sheetflow Sites (PSGs)

Hemipterans and ephemeropterans were the most abundant taxa at the PSGs site, followed by gastropods and chironomids (Figure 15). Odonates, crustaceans and coleopterans were also observed, but in relatively lower numbers (Figure 15).

IMPOUNDED SITES

Ambassador Site (AMBAS)

The AMBAS site was dominated by crustaceans, chironomids and hemipterans (Figure 16). Ephemeropterans, odonates and gastropods were also observed, but in relatively fewer numbers, whereas annelids and coleopterans were rare in the samples (Figure 16).

Farmington Bay Waterfowl Management Area Impounded Site (FBWMA)

Crustaceans, odonates and hemipterans were abundant at the FBWMA site, followed by relatively fewer numbers of ephemeropterans and gastropods (Figure 17). Chironomids, annelids, and coleopterans were also observed, but were relatively rare in the samples collected at FBWMA(Figure 17).

Inland Sea Shorebird Refuge Site (ISSR)

The ISSR site was dominated by chironomids and hemipterans (Figure 18). Ephemeropterans, odonates, gastropods, crustaceans and coleopterans were also observed but in relatively fewer numbers (Figure 18). In contrast to other impounded sites, large numbers of the dipteran *Ephydra*, were observed in the June 22 sample collected at the ISSR site; this was included in the “other” category (Figure 18).

New State Site (NEW)

Samples of macroinvertebrates collected at the NEW site were mainly represented by hemipterans, odonates, gastropods, crustaceans and chironomids (Figure 19). Ephemeropterans, annelids and coleopterans are also observed, but at relatively lower abundances (Figure 19).

Public Shooting Grounds Impounded Site (PSG)

Crustaceans, chironomids, hemipterans, gastropods and odonates were all abundant at the PSG site, followed by fewer numbers of ephemeropterans, annelids and platyhelminthes (Figure 20). Coleoptera and acari (mites) were also observed in the samples, but were extremely rare (Figure 20).

Univariate Analysis of Biotic Variables and Water Quality

Simple regression analysis or DWLS analysis was conducted to explore the relationships between water quality and functional categories of plants and macroinvertebrates (Table 5) for both 2004 and 2005 data sets. All biotic variables were scaled to the water quality factor (EXHIBIT 2).

Native, Introduced and Invasive Plant Species in Relation to Water Quality: 2004

All impounded sites had only native plant species (of which none were invasive plants), so this analysis focused on sheetflow sites which had a mix of native, introduced and invasive (NII) plant species. No significant linear relationships were observed between the numbers or proportions of native, introduced or invasive plant species and the water quality factor at sheetflow sites. However, distance-weighted least squares (DWLS) revealed a number of non-linear relationships between the numbers or proportions of NII plant species and water quality (Figures 21-32). For each category of plant species, the analysis was conducted on species numbers and proportions, as well as their $\log_{10}$-transformed or arcsin-transformed values (for example, native species – Figures 21-24).

The number of native species observed was lower on both extremes of the water quality factor, where nutrient levels were high on one end and where nutrient levels were low but pH, TDS, and DO were high on the other end (Figures 21-22). However, in relation to the number of native plant species, the proportion of native species showed an inverted curve trend across the water quality factor (Figures 23-24), mostly due to the increase in the numbers and proportions of introduced plant species at sites that fell in the mid-range of the water quality factor (Figures 25-28). The PSGs reference sites had 100 percent native plant species, along with other sites that included some transects of the NDSD and CDSD sites (POTW sites) (Figure 23). However, some transects at the POTW sites (N1, N2, C3, C4) and KC site (K1, K3) had reduced percent native plant species (Figure 23) and an increased proportion of introduced plant species (Figure 27).

Invasive plant species were present at most of the sites sampled, including the reference (Ps1-Ps3) and POTW sites (C1-C3, N1-N3) (Figures 29-30). Some of the POTW site transects (N1, N2, and C3) and the KC site transects (K1-K3) had higher numbers of invasive plants than other sites (Figures 29-30). No strong trends were observed between water quality and the percent of invasive plant species observed at specific sites (Figures 31-32). The slight non-linear trend in percent invasive plant species across water quality is likely an artifact of one POTW transect (C4), which had no invasive plant species (Figures 31-32).

The total number of plant species (a measure of species diversity) was non-linearly correlated with water quality, with plant diversity lower at both extremes of the water quality factor, with nutrient levels on one end and low nutrient levels but higher pH, TDS, and DO on the other end (Figures 33-34), indicating that high nutrients may be limiting species diversity on one end, with high TDS likely limiting plant diversity on the other extreme.

Native, Introduced and Invasive Plant Species in Relation to Water Quality: 2005

As was the case in 2004, all impounded sites in 2005 had only native plant species (of which none were invasive plants). Therefore, the analysis for 2005 data focused on sheetflow sites where a mixture of native, introduced and invasive (NII) plant species were observed. In general, no significant relationships (linear or non-linear) were observed between the numbers or proportions of native, introduced or invasive plant species and the water quality factor at sheetflow sites in 2005. The plant dataset for 2005 generally had a lot of variability as it included data from multiple seasons (the 2004 data, in contrast was mainly from only one season). Seasonal variability in plant species will likely dilute any trends of species across water quality. However, in spite of seasonal variability, this analysis is still useful as it allows insights into how various sites cluster together in relation to water quality. The 2005 analysis will thus focus on site clustering based on NII plant species in relation to water quality. For each category of plant species, the analysis was conducted on species numbers and proportions, as well as their $\log_{10}$-transformed or arcsin-transformed values (Figures 35-48).

Generally, the number of native plant species is higher at some of the nutrient-rich POTW sites (particularly NDSD sites N1 and N2) than at the PSGs reference sites (Ps1-Ps3) (Figures 35-36). The number of native plant species declines in general with decreasing nutrients and increasing pH, TDS, conductivity and DO (Figures 35-36). Native plant species in proportion to the total number of plant species (percent native species) are generally high, with 100 percent native plants observed in most sites through the different seasons sampled (Figures 37-38). Some of the POTW sites (N1-N3 and C3) including two reference site transects (Ps1 and Ps3 sampled in September) had fewer percent native plant species (Figures 37-38), likely due to the presence of introduced species at those sites (Figures 3-42).

Consistent with 2004 data, invasive plant species were present at most of the sites sampled in 2005, including the reference (Ps1-Ps3) and POTW sites (C1-C3, N1-N3) (Figures 43-46). Some of the POTW site transects (N1 and C3), the KC (K1) and the FBWMAs (Fs1) site transects had higher numbers of invasive plants than other sites (Figures 43-44). No strong trends were observed between water quality and the percent of invasive plant species observed at specific sites but notably, the PSGs reference site (Ps1-Ps3) had a high proportion of invasive plant species (30-70 percent), even exceeding the percent of invasive plants found at several of the POTW sites (Figures 45-46). Consistent with 2004 data, the C4 (CDSD) POTW site transect had no invasive species (Figures 45-46).

The total number of plant species (a measure of species diversity) was correlated with water quality, with plant diversity generally higher at several of the high nutrient POTW sites (particularly NDSD site) than at the reference sites (Ps) with lower nutrient levels and high pH, TDS, conductivity and DO (Figures 47-48), indicating that high TDS, among other factors, may be limiting plant species diversity at the reference sites.

Functional Categories of Invertebrates in Relation to Water Quality: 2004

IMPOUNDED SITES - 2004

Relative Abundance of Tolerant Macroinvertebrate Species: The relative abundance of tolerant macroinvertebrate species (percent tolerant species) generally declined with decreasing nutrient levels and increasing pH, TDS, conductivity and DO (Figure 49). However, the relationship between the water quality factor and relative abundance of tolerant macroinvertebrate species was not statistically significant (at $\alpha = 0.05$ level) due to variability in the data (Table 8). The PSG reference sites (P1-P3) generally had relatively fewer tolerant macroinvertebrate species than the nutrient-rich sites (Figure 49).

Relative Abundance of Ephemeroptera (Mayflies): Mayflies are extremely sensitive to various water quality parameters, including eutrophication and anaerobic conditions (Table 5) and are a useful indicator of conditions in aquatic ecosystems. The relative abundance of mayflies (primarily *Callibaetis* sp.) generally increased with decreasing nutrient levels and increasing pH, TDS, conductivity and DO (Figure 50), and the relationship between the water quality factor and relative abundance of mayflies was statistically significant (at $\alpha = 0.05$ level) (Table 7). The PSG reference sites (P1-P3) had the highest numbers of mayflies relative to other sites (Figure 50), indicating generally favorable water quality (low nutrients, high DO) at those sites.

Relative Abundance of Collector-Gatherer Macroinvertebrate Species: A non-linear relationship was observed between the relative abundance of collector-gatherers (functional feeding group) and water quality (Table 8). The relative abundance of collector-gatherers was constant across sites with relatively high nutrient levels, but increased sharply with declining nutrient loads at the PSG reference sites, P1-P3 (Figure 51). Collector-gatherers at the reference sites were primarily represented by mayflies and *Hyallela,* both of which are relatively sensitive invertebrate taxa, and some of the more tolerant chironomids.

TABLE 8. REGRESSION ESTIMATES OF MACROINVERTEBRATE COMMUNITY RESPONSES TO THE WATER QUALITY FACTOR AT IMPOUNDED SITES IN 2004.

Regressions are of the form: Invertebrate Community Factor (Y) = $\alpha + \beta$*Water Quality Factor Score (X), where α is the Y intercept and β is the slope of the relationship. For each functional group analysis, arcsin-transformed values of invertebrate functional parameters were regressed on the water quality factor scores.

Invertebrate Community Factor	α	β	N	R^2	F	p
FUNCTIONAL GROUP ANALYSIS						
Independent variable (X):						
Percent Relative Abundance of Tolerant Species	0.49	-0.05	10	0.346	4.23	0.074 (49)
Percent Relative Abundance of Ephemeroptera	0.28	0.13	10	0.562	10.27	0.013** † (50)
Percent Relative Abundance of Collector-Grazers	0.56	0.03	10	0.270	2.96	0.124 † (51)

TABLE 8. REGRESSION ESTIMATES OF MACROINVERTEBRATE COMMUNITY RESPONSES TO THE WATER QUALITY FACTOR AT IMPOUNDED SITES IN 2004.
Regressions are of the form: Invertebrate Community Factor (Y) = α + β*Water Quality Factor Score (X), where α is the Y intercept and β is the slope of the relationship. For each functional group analysis, arcsin-transformed values of invertebrate functional parameters were regressed on the water quality factor scores.

Invertebrate Community Factor	α	β	N	R^2	F	p
FUNCTIONAL GROUP ANALYSIS						
Independent variable (X):						
Percent Relative Abundance of Tolerant Species	0.49	-0.05	10	0.346	4.23	0.074 (49)
Percent Relative Abundance of Ephemeroptera	0.28	0.13	10	0.562	10.27	0.013** † (50)
Percent Relative Abundance of Predators	0.36	-0.03	10	0.233	2.43	0.157 (52)
Percent Relative Abundance of Shredders	0.21	0.003	10	0.002	0.01	0.910 † (53)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. ** denotes a significant linear relationship between the variables. † indicates that a non-linear relationship may also exists between the variables. Corresponding Figure numbers (in parentheses) are also referenced.

Relative Abundance of Predator Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of macroinvertebrate predators and water quality (Figure 52, Table 8).

Relative Abundance of Shredder Macroinvertebrate Species: A significant non-linear relationship was observed between shredder macroinvertebrates and water quality (Figure 53, Table 8). The highest numbers of shredders were observed at intermediate levels of the water quality factor, primarily in transects at the AMBAS (A2) and NEW (NW2) sites (Figure 53).

SHEETFLOW SITES - 2004

Relative Abundance of Tolerant Macroinvertebrate Species: A significant non-linear relationship was observed between tolerant species and water quality (Figure 54, Table 9). The relative abundance of tolerant macroinvertebrate species was constant across sites with high nutrient loads and then rapidly declined with decreasing nutrient levels and increasing pH, TDS, conductivity and DO (Figure 54). The PSGs reference sites (Ps1-Ps3) had the lowest abundance of tolerant species (Figure 54).

Relative Abundance of Ephemeroptera (Mayflies): A significant non-linear relationship was observed between the relative abundance of mayflies and water quality (Figure 55, Table 8). Mayflies were relatively rare at sites with high nutrient loads (primarily POTW sites C1-C4 and N1-N3), bur rapidly increased at the PSGs reference sites where nutrient levels were low and pH, TDS, conductivity and DO were all relatively higher (Figure 55).

TABLE 9. REGRESSION ESTIMATES OF MACROINVERTEBRATE COMMUNITY RESPONSES TO THE WATER QUALITY FACTOR AT SHEET FLOW SITES IN 2004.
Regressions are of the form: Invertebrate Community Factor (Y) = α + β*Water Quality Factor Score (X), where α is the Y intercept and β is the slope of the relationship. For each functional group analysis, arcsin-transformed values of invertebrate functional parameters were regressed on the water quality factor scores.

Invertebrate Community Factor	α	β	N	R^2	F	p
FUNCTIONAL GROUP ANALYSIS						
Independent variable (X):						
Percent Relative Abundance of Tolerant Species	0.84	-0.114	10	0.275	3.04	0.120 † (54)
Percent Relative Abundance of Ephemeroptera	0.09	0.09	10	0.187	1.84	0.213 † (55)
Percent Relative Abundance of Collector-Grazers	0.50	0.17	10	0.361	4.53	0.066 (56)
Percent Relative Abundance of Predators	0.45	-0.18	10	0.421	5.81	0.042 ** (57)
Percent Relative Abundance of Shredders	0.13	0.013	10	0.035	0.30	0.602 (58)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. ** denotes a significant linear relationship between the variables. † indicates that a non-linear relationship may exist between the variables. Corresponding Figure numbers (in parentheses) are also referenced.

Relative Abundance of Collector-Gatherer Macroinvertebrate Species: The relative abundance of collector-grazer macroinvertebrate species generally increased with decreasing nutrient levels and increasing pH, TDS, conductivity and DO (Figure 56). However, the relationship between the water quality factor and relative abundance of collector-grazer macroinvertebrate species was not statistically significant (at α = 0.05 level) due to variability in the data (Table 9). The PSG reference sites (P1-P3) generally had relatively more collector-grazer macroinvertebrate species than some of the nutrient-rich sites, with the exception of the NDSD sites (N1 and N2) (Figure 56).

Relative Abundance of Predator Macroinvertebrate Species: A significant linear relationship was observed between the relative abundance of macroinvertebrate predators and water quality (Figure 57, Table 9). The relative abundance of macroinvertebrate predators was typically higher at some of the nutrient-rich POTW sites than at the PSGs reference sites. Most of the macroinvertebrates at those POTW sites were flatworms, leeches and odonates, all of which are functionally classified as predators. In addition, the KC sites were dominated by predatory macroinvertebrates (Figure 57).

Relative Abundance of Shredder Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of shredder macroinvertebrates and water quality (Figure 58, Table 9).

Functional Categories of Invertebrates in Relation to Water Quality: 2005

IMPOUNDED SITES - 2005

Typically, no significant relationships were observed between functional categories of macroinvertebrates and water quality in 2005, likely due to variation caused by the inclusion of macroinvertebrate data from multiple seasons for each site (Figures 59-62, Table 9).

Relative Abundance of Tolerant Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of tolerant macroinvertebrate species and water quality (Figure 59, Table 10).

TABLE 10. REGRESSION ESTIMATES OF MACROINVERTEBRATE COMMUNITY RESPONSES TO THE WATER QUALITY FACTOR AT IMPOUNDED SITES IN 2005.
Regressions are of the form: Invertebrate Community Factor (Y) = α + β*Water Quality Factor Score (X), where α is the Y intercept and β is the slope of the relationship. For each functional group analysis, arcsin-transformed values of invertebrate functional parameters were regressed on the water quality factor scores.

Invertebrate Community Factor	α	β	N	R^2	F	p
FUNCTIONAL GROUP ANALYSIS						
Independent variable (X):						
Percent Relative Abundance of Tolerant Species	0.62	0.01	45	0.001	0.05	0.821 (59)
Percent Relative Abundance of Ephemeroptera	0.09	0.002	45	0.001	0.03	0.856 (60)
Percent Relative Abundance of Collector-Grazers	0.45	0.03	45	0.038	1.71	0.198 (61)
Percent Relative Abundance of Predators	0.50	0.01	45	0.001	0.04	0.837 (62)
Percent Relative Abundance of Shredders	0.13	-0.05	45	0.165	8.47	0.006 ** (63)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. ** denotes a significant linear relationship between the variables. † indicates that a non-linear relationship may also exists between the variables. Corresponding Figure numbers (in parentheses) are also referenced.

Relative Abundance of Ephemeroptera (Mayflies): No significant linear or non-linear relationships were observed between the relative abundance of mayflies and water quality (Figure 60, Table 10).

Relative Abundance of Collector-Gatherer Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of collector-gatherer macroinvertebrate species and water quality (Figure 61, Table 10).

Relative Abundance of Predator Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of macroinvertebrate predators and water quality (Figure 62, Table 10).

Relative Abundance of Shredder Macroinvertebrate Species: A significant linear relationship was observed between shredder macroinvertebrates and water quality

(Figure 63, Table 10). High numbers of shredders were generally observed at more nutrient-rich (Figure 63).

SHEETFLOW SITES - 2005

Relative Abundance of Tolerant Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of tolerant macroinvertebrate species and water quality (Figure 64, Table 11).

Relative Abundance of Ephemeroptera (Mayflies): Consistent with observations at sheetflow sites in 2004, a significant non-linear relationship was also observed between the relative abundance of mayflies and water quality in 2005 (Figure 65, Table 11). Mayflies were relatively rare at sites with high nutrient loads (primarily POTW sites C1-C4 and N1-N3), bur rapidly increased at the PSGs reference sites where nutrient levels were low and pH, TDS, conductivity and DO were all relatively higher (Figure 65). Some mayflies were also found at the KC (K3) site (Figure 65).

TABLE 11. REGRESSION ESTIMATES OF MACROINVERTEBRATE COMMUNITY RESPONSES TO THE WATER QUALITY FACTOR AT SHEET FLOW SITES IN 2005.
Regressions are of the form: Invertebrate Community Factor (Y) = α + β*Water Quality Factor Score (X), where α is the Y intercept and β is the slope of the relationship. For each functional group analysis, arcsin-transformed values of invertebrate functional parameters were regressed on the water quality factor scores.

Invertebrate Community Factor	α	β	N	R^2	F	p
FUNCTIONAL GROUP ANALYSIS						
Independent variable (X):						
Percent Relative Abundance of Tolerant Species	0.66	-0.004	30	0.001	0.01	0.942 (64)
Percent Relative Abundance of Ephemeroptera	0.07	0.08	30	0.312	12.70	0.001 ** (65)
Percent Relative Abundance of Collector-Grazers	0.49	-0.114	30	0.246	9.13	0.005 ** (66)
Percent Relative Abundance of Predators	0.42	0.11	30	0.220	7.91	0.009 ** (67)
Percent Relative Abundance of Shredders	0.19	0.03	30	0.039	1.14	0.294 (68)

NOTES: p values > 0.05 indicate that a linear relationship between variables is not significant. ** denotes a significant linear relationship between the variables. † indicates that a non-linear relationship may exist between the variables. Corresponding Figure numbers (in parentheses) are also referenced.

Relative Abundance of Collector-Gatherer Macroinvertebrate Species: A significant linear relationship was observed between the relative abundance of collector-gatherers and water quality. The relative abundance of collector-grazer macroinvertebrate species declined with decreasing nutrient levels and increasing pH, TDS, conductivity and DO (Figure 66, Table 11). The PSG reference sites (P1-P3) generally had relatively lower abundances of collector-grazer macroinvertebrate species than several of the nutrient-rich POTW sites (Figure 66).

Relative Abundance of Predator Macroinvertebrate Species: A significant linear relationship was observed between the relative abundance of macroinvertebrate predators and water quality (Figure 67, Table 11). The relative abundance of macroinvertebrate predators was typically lower at most of the nutrient-rich POTW sites than at the PSGs reference sites (Figure 67).

Relative Abundance of Shredder Macroinvertebrate Species: No significant linear or non-linear relationships were observed between the relative abundance of shredder macroinvertebrates and water quality (Figure 68, Table 11).

Multivariate Analysis of Biotic Variables and Water Quality

Factor analysis was used to explore relationships between water quality and species distributions of plants and macroinvertebrates across sheetflow and impounded wetland sites (Table 6). Factor analysis involved the computation of biotic factor variables such as the plant factor which parsimoniously summarized the percent covers of various species and the macroinvertebrate diversity and macroinvertebrate species factors which contained information on species diversity indices and macroinvertebrate abundances, respectively, across wetland sites.

Plant Species Distributions in Relation to Water Quality – 2005

SHEETFLOW SITES - 2005

The plant factor included arcsin-transformed percent covers of the various plant species observed across the sheetflow sites. The water quality factor included pH, dissolved oxygen, total dissolved solids, conductivity, total N and total P (nutrients) concentrations. Plots of wetland sampling sites that are based on the plant and water quality factor scores for each site is shown in Figures 69 and 70 (without and with DWLS line). Low values on the water quality factor axis reflect freshwater habitats (low TDS, low conductivity, low pH, low dissolved oxygen) with high nutrient (N+P) loads. High values represent more saline habitats that are relatively low in nutrients. Sites in-between represent more moderate water chemistry.

On the plant factor axis, three distinct groupings of plant species were observed. Overall, the factor plots (Figures 69 and 70) indicated a trend of plant groupings changing from more freshwater, eutrophic sites to more oligotrophic, saline sites. In general, freshwater, eutrophic sites (including the POTW sites, NDSD, and CDSD) were dominated by plant species such *Alopecurus aqualis, Atriplex micrantha, Bidens cernua, Phalaris arundinacea, Polygonium lapathifolium, Salicornia rubra and Schoenoplectus acutus* and another plant group characterized by species such as *Phragmites australis, Rumex crispus, Typha dominghensis and Lemna minor*. Conversely, more oligotrophic and saline sites (including the reference sites at PSGs) were dominated by plant species such as *Distichlis spicata, Hordeum jubatum, Schoenoplectus americanus, Schoenoplectus maritimus, Typha latifolia.* The floating plants *Azola mexicanus* and algae were also more dominant at these sites.

IMPOUNDED SITES – 2005

No distinct trends in plant species groupings were observed in relation to the water quality factor at impounded wetland sites in 2005. However, two plant groupings were observed across sites, one with *Ruppia cirrhosa* which was present at some of the AMBAS (A3 and A4) and ISSR (I1 and I3) sites, and the other plant group consisting of *Stuckenia* species, *Chara* sp. and *Ceratophyllum demersum* which were found at the remainder of the sites, including the PSG reference sites (Figure 71).

Macroinvertebrate Taxa Distributions in Relation to Water Quality – 2005

IMPOUNDED SITES - 2005

No distinct trends in invertebrate taxa groupings were observed in relation to the water quality factor at impounded wetland sites in 2005. However, two macroinvertebrate taxa groupings were observed across sites, mainly due to the presence of relatively large numbers of annelids (leeches), platyhelminthes (flatworms) and gastropods (snails) at a transect in the reference PSG (P3) site, which were not as abundant at other sites (Figure 72). While crustaceans were also present at most of the other impounded wetland sites, these were mostly characterized by Ephemeropterans (mostly at the reference PSG (P1-3) sites), hemipterans, odonates, coleopterans and chironomids (Figure 72).

SHEETFLOW SITES – 2005

Macroinvertebrate species distributions across sheetflow sites were distinctly related to the water quality factor. Low values on the invertebrate factor axis (Figure 73) represent sites dominated crustaceans (mainly *Hyallela azteca*), flatworms (Platyhelminthes) and leeches (Annelida) whereas high values reflect sites dominated by mayflies (Ephemeroptera), water boatman and backswimmers (Hemiptera), beetles (Coleoptera), snails (Gastropoda), damselflies and dragonflies (odonates) and midges (chironomids). Overall, a general trend was observed, where more eutrophic, freshwater sheetflow sites (including some of the POTW sites, especially some CDSD sites) were dominated by crustaceans, flatworms and leeches, while more saline, oligotrophic sites were characterized by mayflies, water boatman, backswimmers, beetles, snails damselflies/dragonflies and chironomids. (Figure 73). Chironomids were especially abundant at the NDSD (N1-N3) site.

Macroinvertebrate Species Diversity in Relation to Water Quality

The macroinvertebrate species diversity factor included information on species diversity (Shannon-Wiener diversity index), species richness (d) and species evenness (J) in a single factor. High values on the species diversity factor indicate relatively high species diversity, richness and evenness, low values indicate relatively low species diversity, richness and evenness across wetland sites (Figures 74-77).

IMPOUNDED SITES – 2004

No distinct trend in invertebrate species diversity groupings was observed in relation to the water quality factor at impounded wetland sites in 2004. Species diversity factor values were lower at some of the PSG reference wetland transects (P1 and P2) (Figure 74).

SHEETFLOW SITES – 2004

No trend in invertebrate species diversity groupings was observed in relation to the water quality factor at sheetflow wetland sites in 2004. Species diversity factor values for the POTW sites (NDSD and CDSD) were approximately equal to or lower than those for the

PSGs reference sites (Figure 75). For example, certain POTW site transects (C2, C3 and N3) had species diversity factor values that were approximately equal to or higher than the reference sites (Ps1-Ps3), while other POTW transects (C1, C4, N1, N2) had lower diversity factor values than the reference sites (Figure 75).

IMPOUNDED SITES – 2005

A slight trend in invertebrate species diversity groupings was observed in relation to the water quality factor at impounded wetland sites in 2005, but this was likely influenced by two Newstate site transects (NW1 and NW2) with high species diversity factor values (Figure 76).

SHEETFLOW SITES – 2005

Invertebrate species diversity was linearly related the water quality factor at sheetflow wetland sites in 2005. Species diversity factor values for some the POTW sites (mostly all of the NDSD sites, N1-N3) were lower than those for the PSGs reference sites (Figure 77). However, certain POTW site transects (e.g., C1 and C3) had species diversity factor values that were approximately equal to or higher than the reference sites (Ps1-Ps3) (Figure 77).

Conclusions

This technical memorandum mainly represents the second year of an ongoing effort to characterize the wetland systems of Farmington Bay. The purpose of this analysis was to provide an in-depth evaluation of key biological and water quality parameters components in the Farmington Bay wetlands that – as part of an ongoing effort – would assist in characterizing the wetlands and defining its beneficial uses. Together, with the first year of analysis conducted on 2004 data (CH2M HILL 2005), this analysis offers useful insights into potential biological and environmental metrics that may be useful in evaluating wetland function in relation to water quality at POTW, other test sites and reference sites.

Conclusions based on the analysis conducted in this study are:

- While impounded wetland sites provided valuable information on variances in water quality conditions and the general response of plants and macroinvertebrate communities to those conditions, the sheetflow sites which included both the POTW effluent discharge sites (CDSD and NDSD), overall provided a better range of conditions to facilitate the comparison of wetland plant and invertebrate responses to water quality.
- At both impounded and sheetflow wetland sites, water quality conditions differed among the wetland sites and ranged from mostly freshwater, nutrient-rich (eutrophic) conditions to more saline, nutrient-poor (oligotrophic) conditions. This range of water quality conditions allowed an assessment of how plant and invertebrate communities responded to water quality in Farmington Bay wetlands. Sheetflow sites included the POTW sites (CDSD and NDSD) with freshwater and high nutrient (total N and P) loads, sites with more intermediate water quality (KC and FBWMAs) and the PSGs reference sites which were more saline and oligotrophic. These sites provided a wide range of water quality conditions under which one could assess the responses of the plant and

macroinvertebrate communities. In general, compared to impounded sites, a stronger set of biotic metrics and responses emerged from the evaluation of sheetflow sites.

- Impounded sites were characterized by four plant species, *Stuckenia* sp., *Chara* sp., *Ruppia cirrhosa*, and *Ceratophyllum demersum*. Of these, the pondweed *Stuckenia* sp. dominated all of the impounded wetland sites in terms of percent cover. In contrast, plant species diversity was higher at the sheetflow wetland sites, which collectively contained in excess of fifteen emergent macrophyte species.
- Among the sheetflow sites, plant species diversity in both years (2004 and 2005) was higher at some transects in the freshwater, nutrient-rich POTW sites than at any of the more saline, oligotrophic reference sites. High nutrient levels and freshwater conditions at these sites may be promoting plant species diversity. It is likely that higher salinity at the reference sites, among other factors, may be limiting plant species diversity.
- For both 2004 and 2005, the number of invasive plant species was higher at some transects in the freshwater, nutrient-rich POTW sites than at some of the more saline, oligotrophic reference sites. High nutrient levels and freshwater conditions at these sites may overall be promoting plant species diversity, but at the same time may be contributing to the establishment of more aggressive invasive plant species.
- In terms of some of the beneficial uses of Farmington Bay wetlands, the wetland macrophytes serve an important function by providing structural habitat for nesting bird species. Ongoing field studies have indicated that bird species such as American Avocets and Black-neck Stilts will often nest among stands of *Typha* and *Schonoeplectus*. Both these plant species are thrive at the POTW sites and could potentially be used by birds for refuge and nesting. Data on the nesting success of birds at the POTW sites in relation to the reference sites at the PSGs is needed to more directly assess beneficial uses.
- There are several unknowns that may be affecting plant community dynamics at the impounded sites. These are the presence of herbivorous carp in the impounded sites and the periodic draining and hydrological management of impounded reference sites at the PSG. More information on these factors is needed to evaluate how these may be affecting plant community dynamics at those sites.
- Some of the macroinvertebrate invertebrate taxa observed at the wetland sites served as extremely sensitive indicators of water quality. A consistently sensitive indicator of water quality (both in 2004 and 2005) was the number of Ephemeropterans (mayflies). In both impounded and sheetflow sites, mayflies were typically far more abundant at the relatively saline, oligotrophic reference sites, than at the freshwater, more eutrophic, POTW sites.
- Generally, tolerant macroinvertebrate species were more abundant at the freshwater nutrient-rich sites (including POTW sites), than at the more saline, oligotrophic reference sites. Tolerant macroinvertebrates such as flatworms, leeches, gastropods and chironomids were usually abundant at POTW sites. These sites also contained some hemipterans and crustaceans. While the reference sites also contained some of the macroinvertebrate taxa observed at the POTW sites, they were dominated by pollution

sensitive species such as Ephemeropterans (mayflies) and odonates (damselflies and dragonflies.

- Invertebrate species diversity was generally higher at the more saline, oligotrophic reference sites than at some of the POTW site transects (2005 data). Some of the NDSD POTW site transects had the lowest macroinvertebrate species diversity, and were overwhelmingly dominated by chironomids, a tolerant species.
- In terms of the beneficial uses of Farmington Bay wetlands, wetland macroinvertebrates serve an important function by providing forage for bird species. Ongoing field studies have indicated that chironomids and corixids (hemiptera) are important prey items in the diets of bird species such as American Avocets and Black-neck Stilts, with chironomids contributing in excess of 95 percent of the diet of the American avocets sampled (data provided by John Cavitt, Weber State University). Chironomids and corixids thrive at the POTW sites and could potentially be used by birds for forage. Additional data on the feeding habits of birds at the POTW sites in relation to the reference sites at the PSGs is needed to more directly assess these beneficial uses.
- There are some unknowns that may be affecting macroinvertebrate community dynamics at the wetland sites. Many of these sites are treated for vector control which includes treatment with the biotic agent *Bacillus thurengiensis (Bti)*, as well as chemical pesticides. Depending on the vector control agent used, these can eliminate or reduce the abundance of certain types of macroinvertebrates (chironomids, mayflies, odonates, hemipterans and crustaceans) that are sensitive to these vector control agents. More information on these vector control schedules, locations and agents used is needed to evaluate how these may be affecting invertebrate community dynamics at those sites.

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Figures

Figure 1. Mean percent cover (± SE) of plant species at the Central Davis Sewer District sheetflow wetlands site in 2005, averaged across transects and sampling dates.

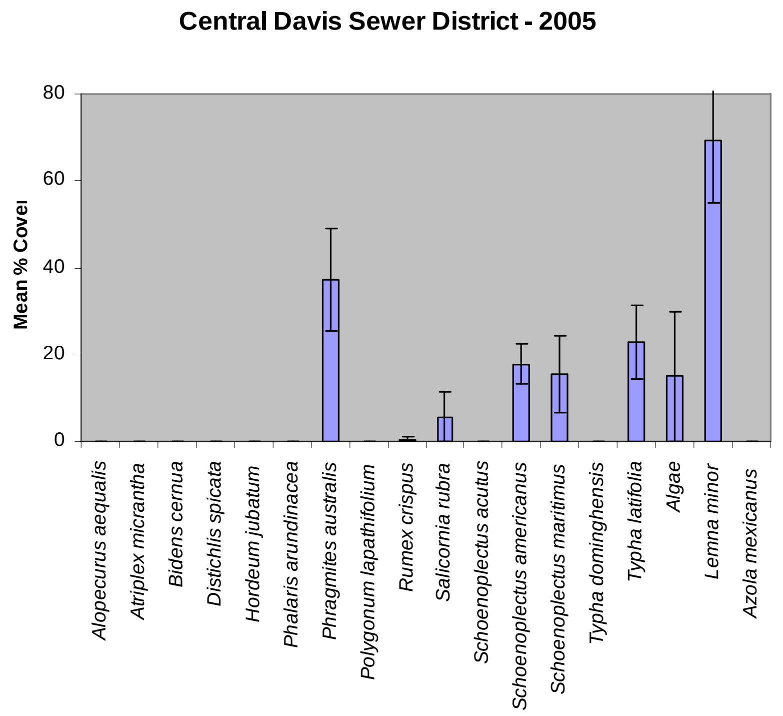


Figure 2. Mean percent cover (± SE) of plant species at the Farmington Bay Waterfowl Management Area sheetflow wetlands site in 2005, averaged across transects and sampling dates.

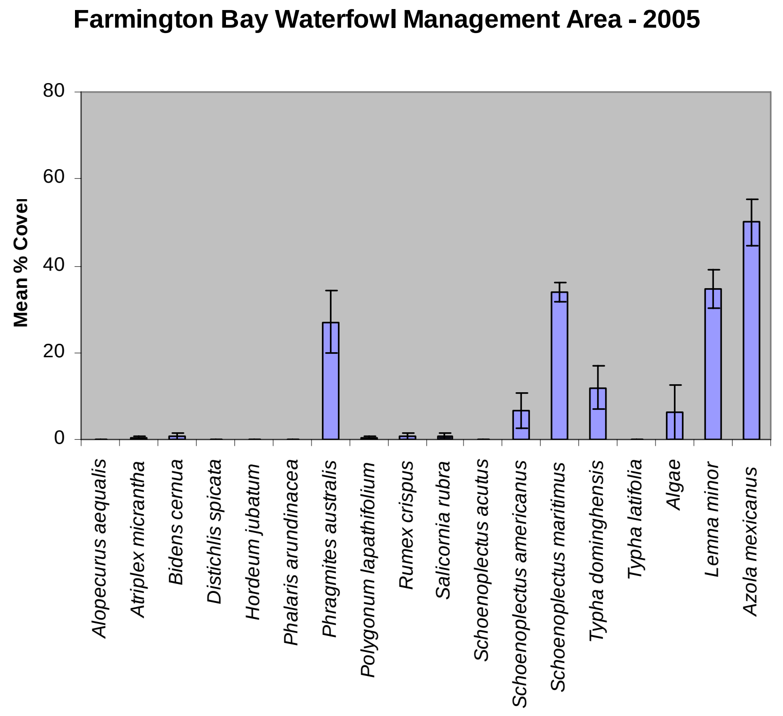


Figure 3. Percent cover (± SE) of plant species at the Kays Creek sheetflow wetlands site in 2005, averaged across transects and sampling dates.

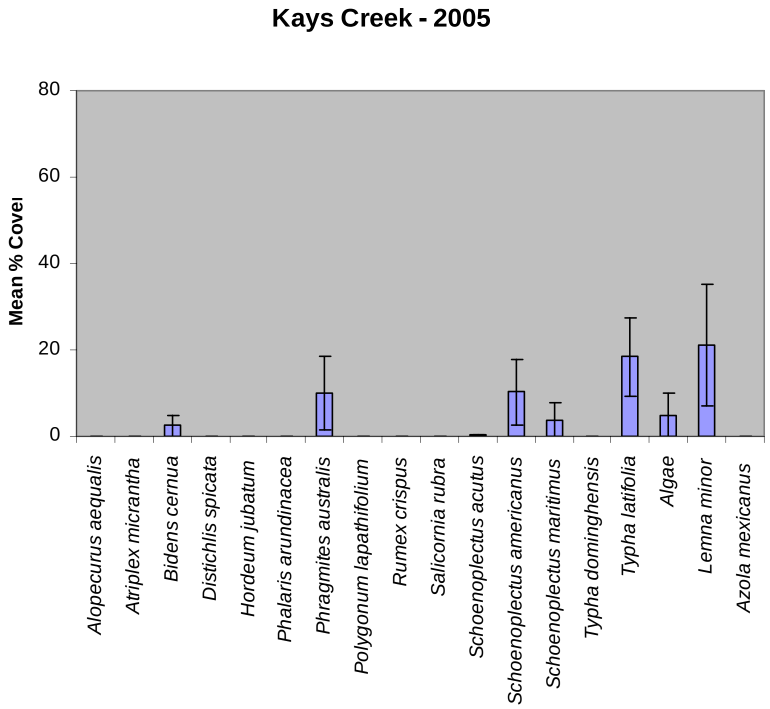


Figure 4. Percent cover (± SE) of plant species at the North Davis Sewer District sheetflow wetlands site in 2005, averaged across transects and sampling dates.

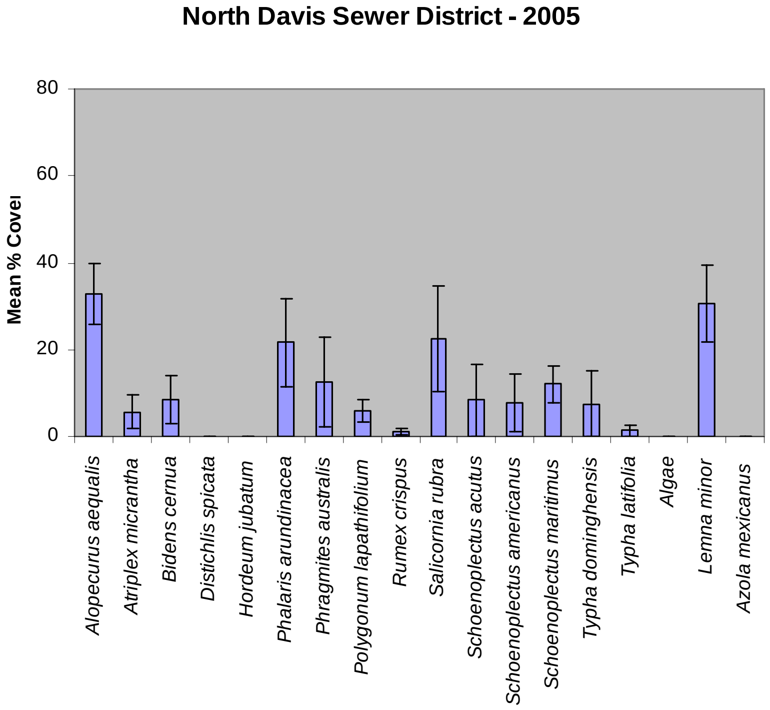


Figure 5. Percent cover (± SE) of plant species at the Public Shooting Grounds sheetflow wetlands site in 2005, averaged across transects and sampling dates.

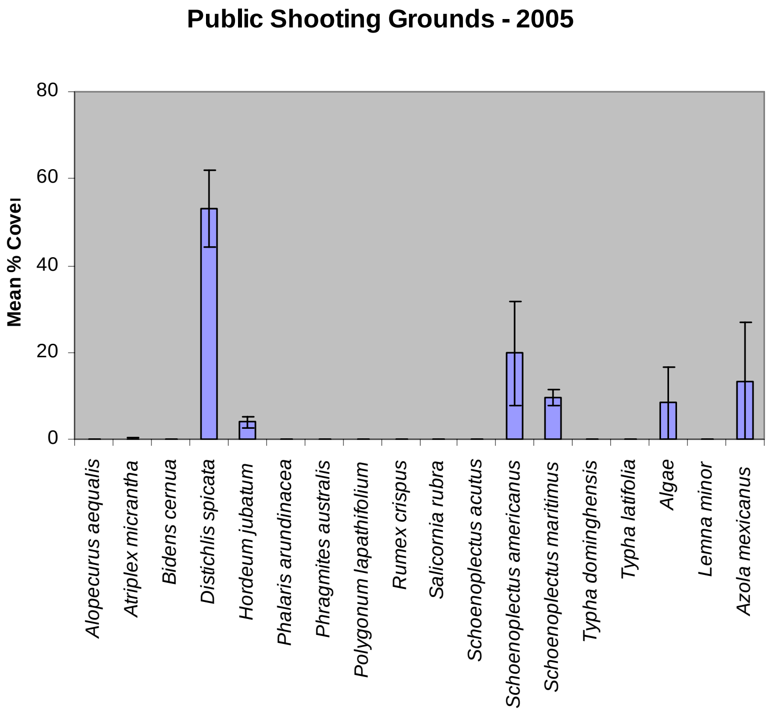


Figure 6. Percent cover (± SE) of plant species at the Ambassador Ponds impounded wetlands site in 2005, averaged across transects and sampling dates.

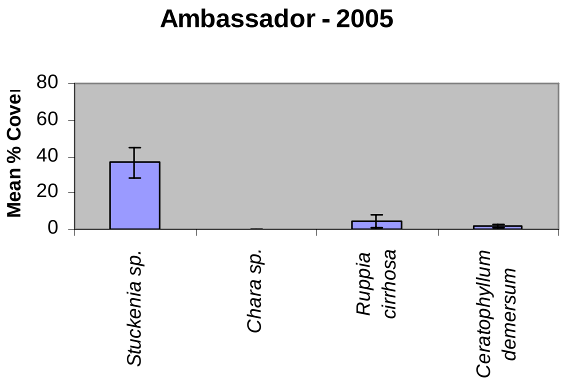


Figure 7. Percent cover (± SE) of plant species at the Farmington Bay Waterfowl Management Area impounded wetlands site in 2005, averaged across transects and sampling dates.

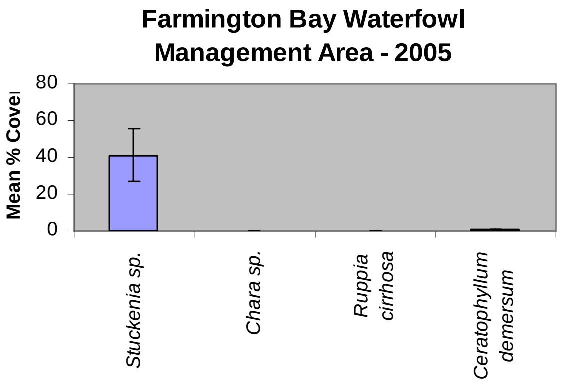


Figure 8. Percent cover (± SE) of plant species at the Inland Sea Shorebird Reserve impounded wetlands site in 2005, averaged across transects and sampling dates.

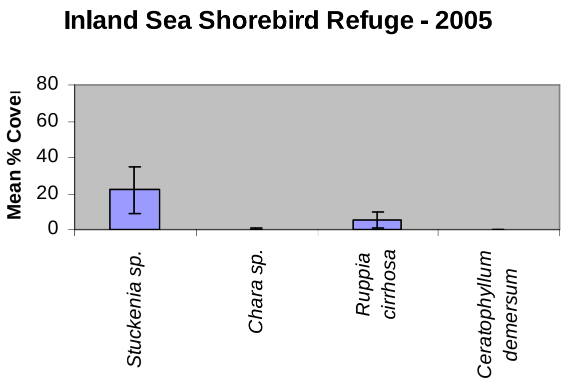


Figure 9. Percent cover (± SE) of plant species at the New State impounded wetlands site in 2005, averaged across transects and sampling dates.

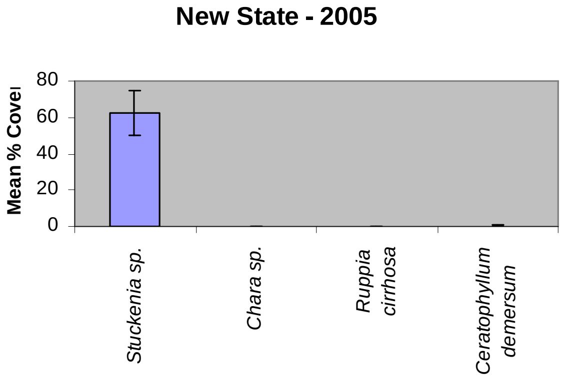


Figure 10. Percent cover (± SE) of plant species at the Public Shooting Grounds impounded wetlands site in 2005, averaged across transects and sampling dates.

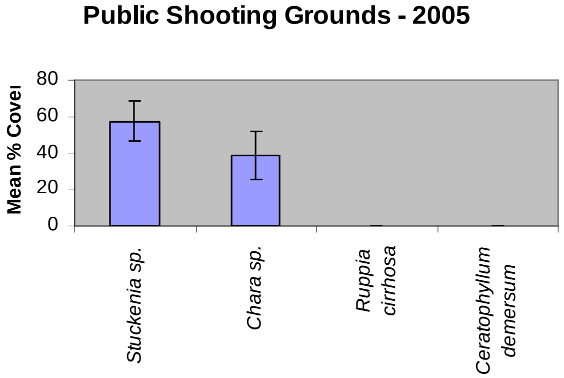


Figure 11. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Central Davis Sewer District sheetflow wetlands site in 2005, averaged across transects and sampling dates.

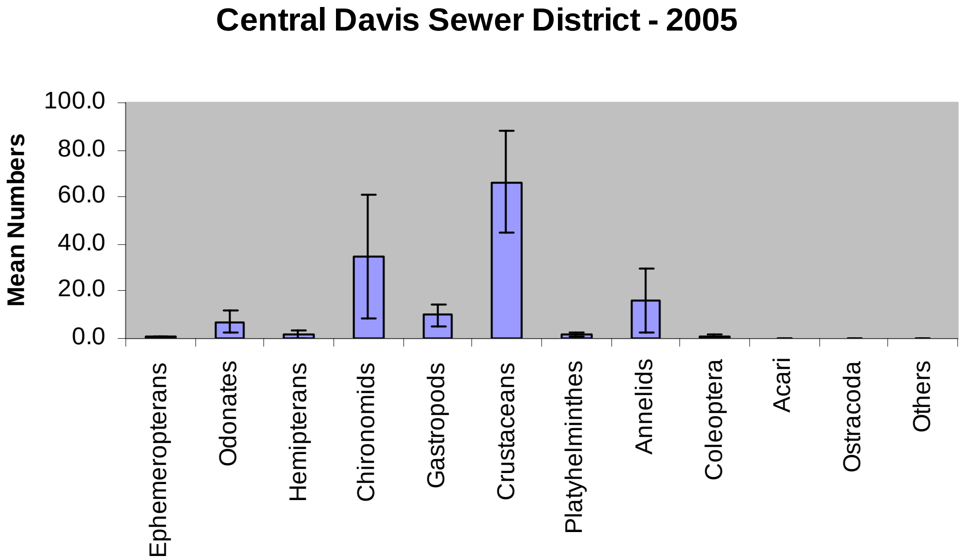


Figure 12. Mean number of individuals (± SE) of macroinvertebrate taxa at the Farmington Bay Waterfowl Management Area sheetflow wetlands site in 2005, averaged across transects and sampling dates.

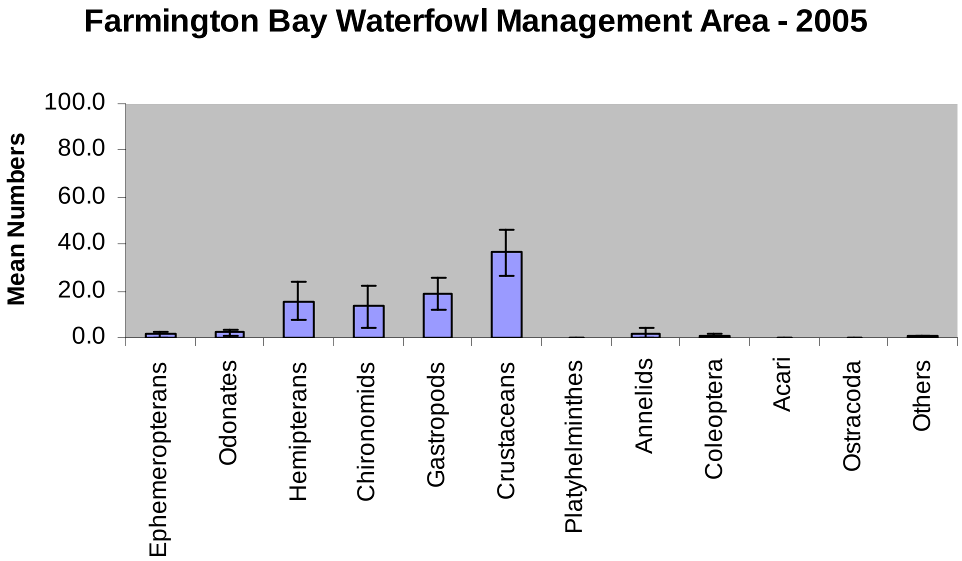


Figure 13. Mean number of individuals (± SE) of macroinvertebrate taxa at the Kays Creek sheetflow wetlands site in 2005, averaged across transects and sampling dates.

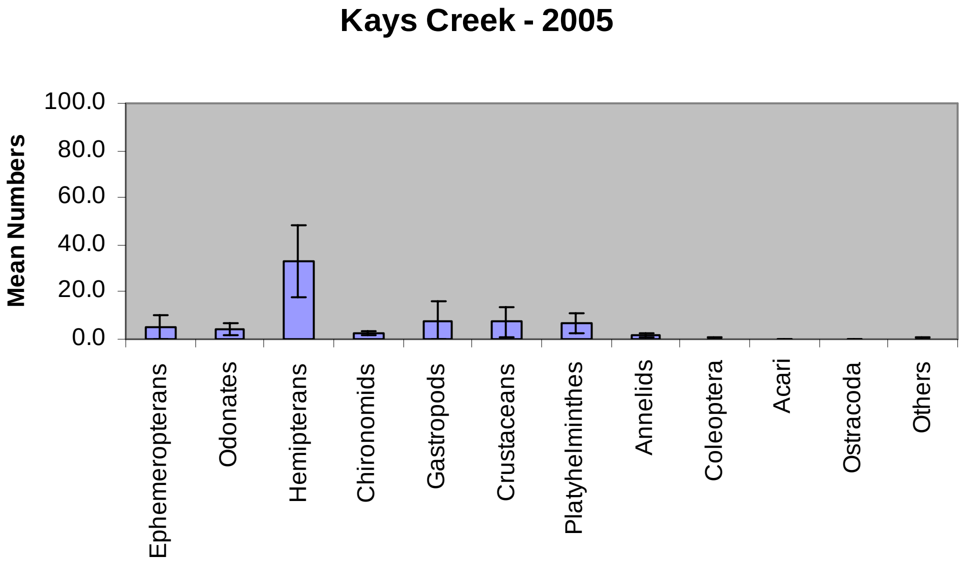


Figure 14. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the North Davis Sewer District sheetflow wetlands site in 2005, averaged across transects and sampling dates.

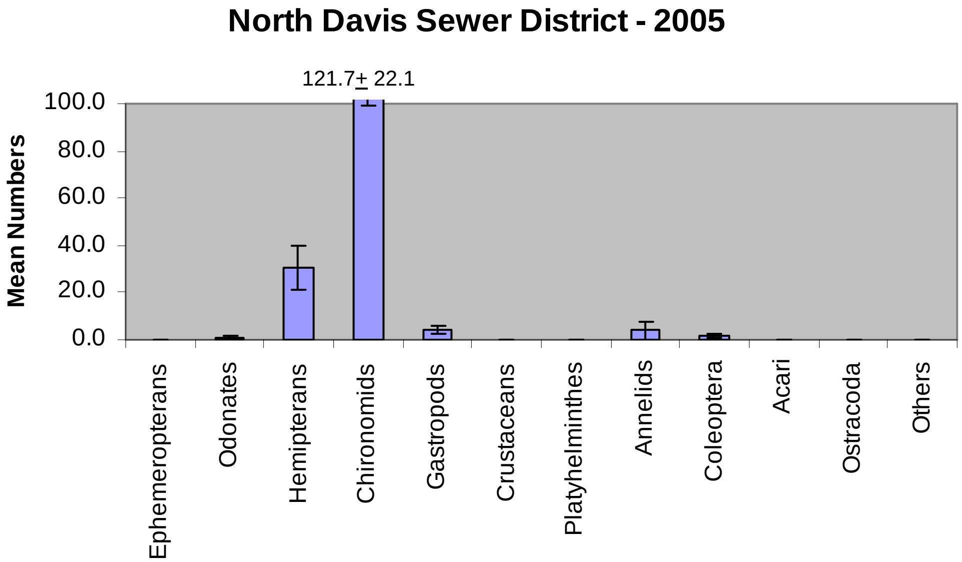


Figure 15. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Public Shooting Grounds sheetflow wetlands site in 2005, averaged across transects and sampling dates.

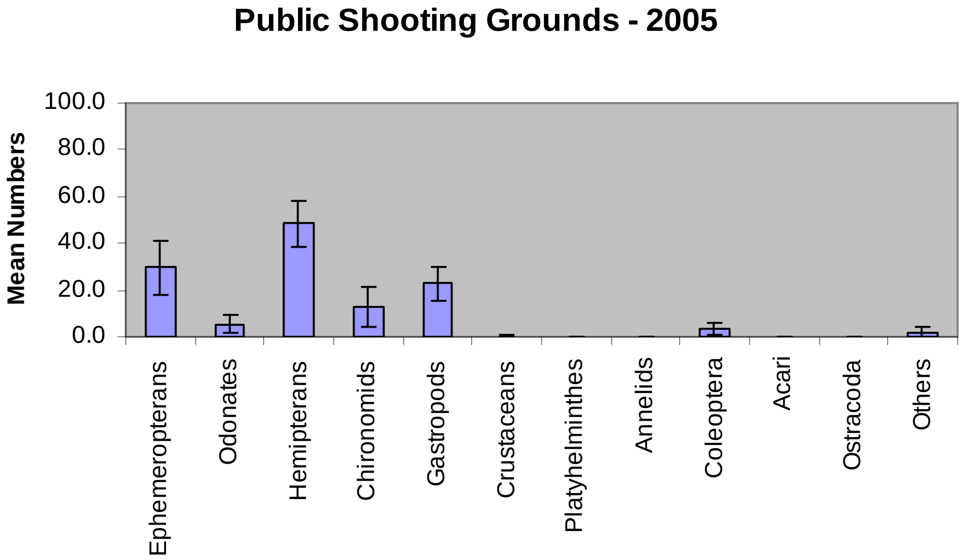


Figure 16. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Ambassador Ponds impounded wetlands site in 2005, averaged across transects and sampling dates.

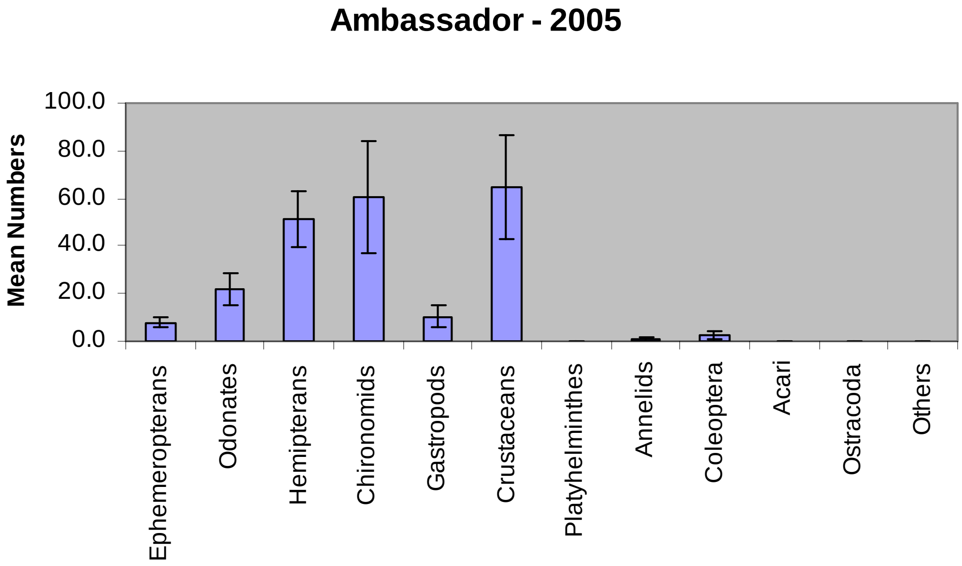


Figure 17. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Farmington Bay Waterfowl Management Area impounded wetlands site in 2005, averaged across transects and sampling dates.

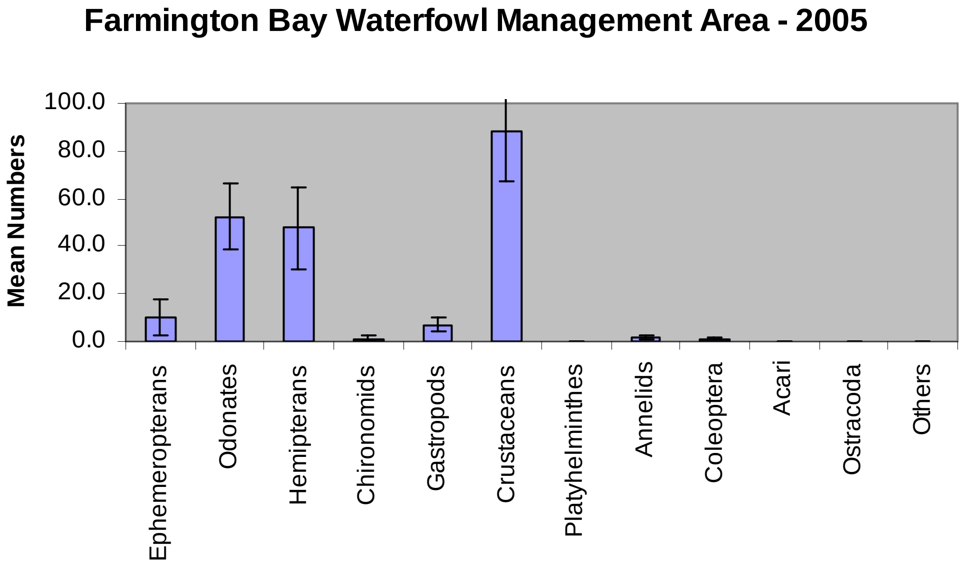


Figure 18. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Inland Sea Shorebird Refuge impounded wetlands site in 2005, averaged across transects and sampling dates.

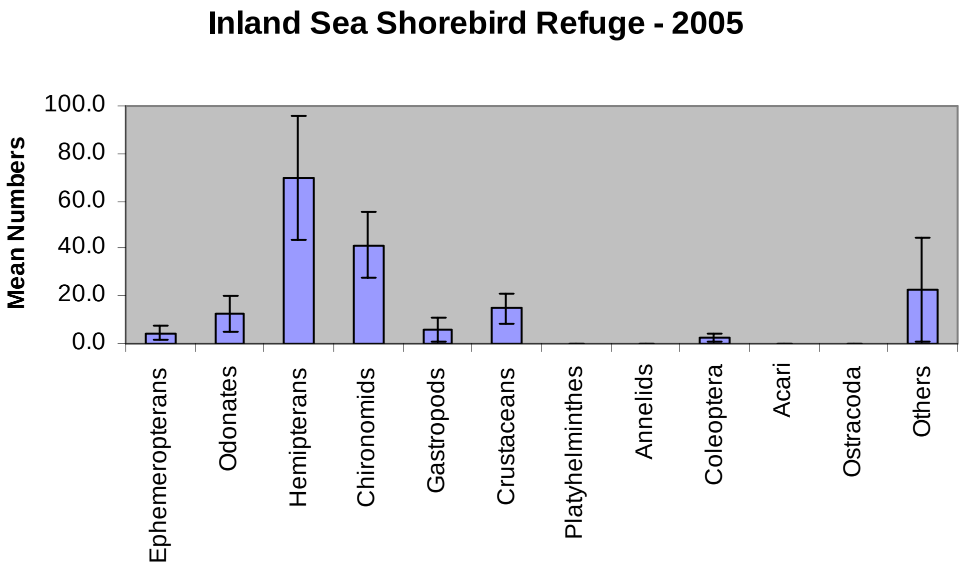


Figure 19. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the New State impounded wetlands site in 2005, averaged across transects and sampling dates.

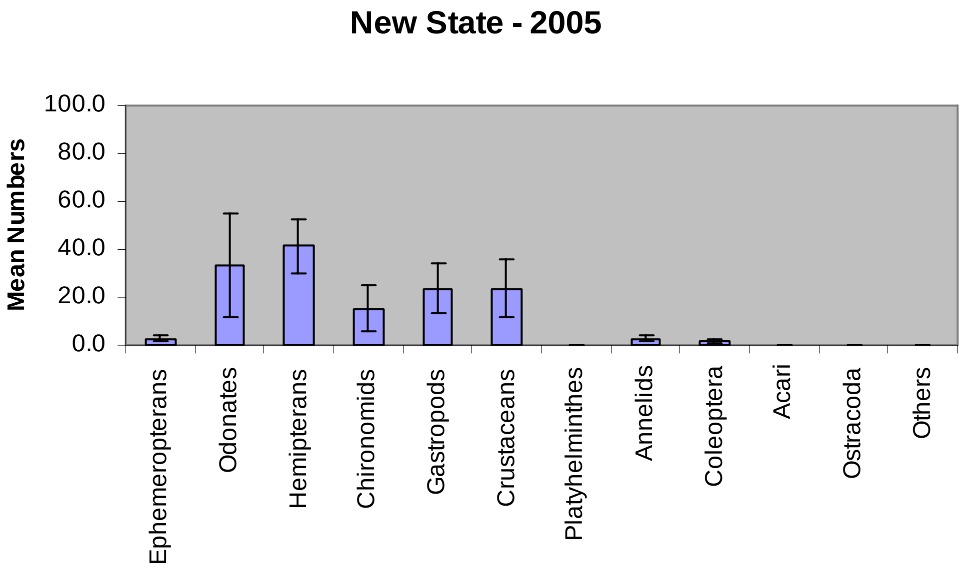
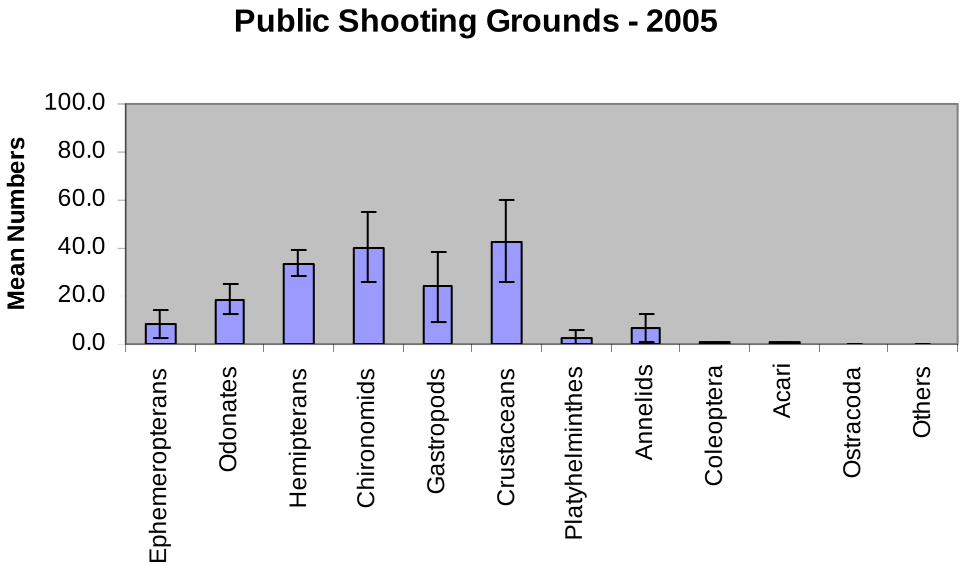


Figure 20. Mean numbers of individuals (± SE) of macroinvertebrate taxa at the Public Shooting Grounds impounded wetlands site in 2005, averaged across transects and sampling dates.



Native, Introduced and Invasive Plant Species Analysis - Sheetflow Sites, 2004

Figure 21. Native Plants & Water Quality(WQ)

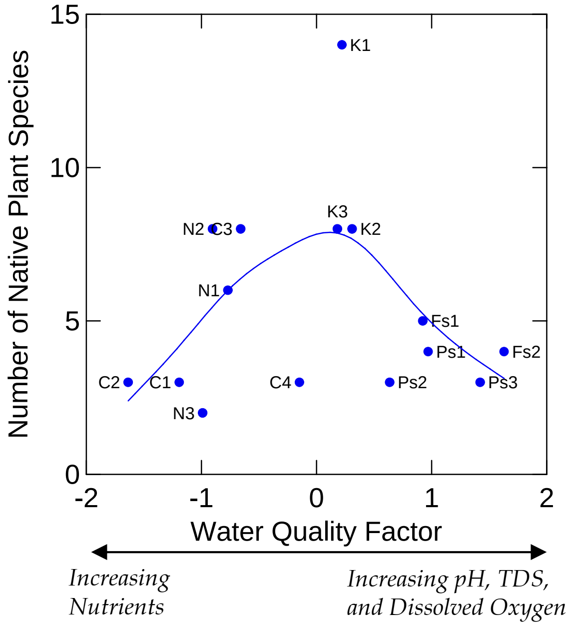


Figure 22. Log_{10} Native Plants & WQ

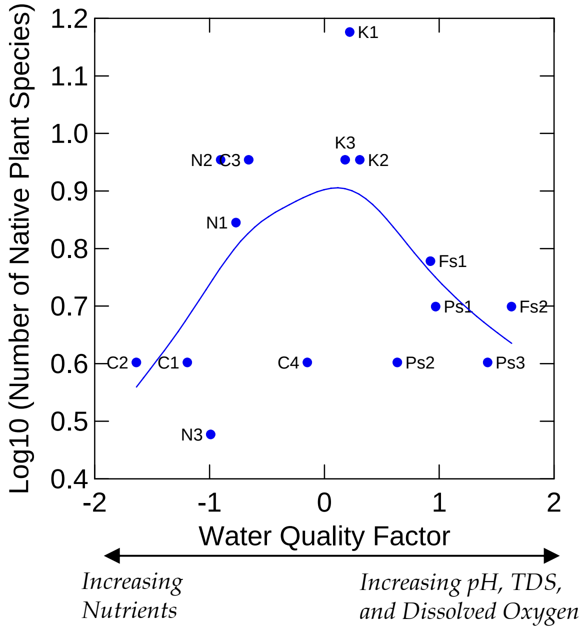


Figure 23. % Native Plants & WQ

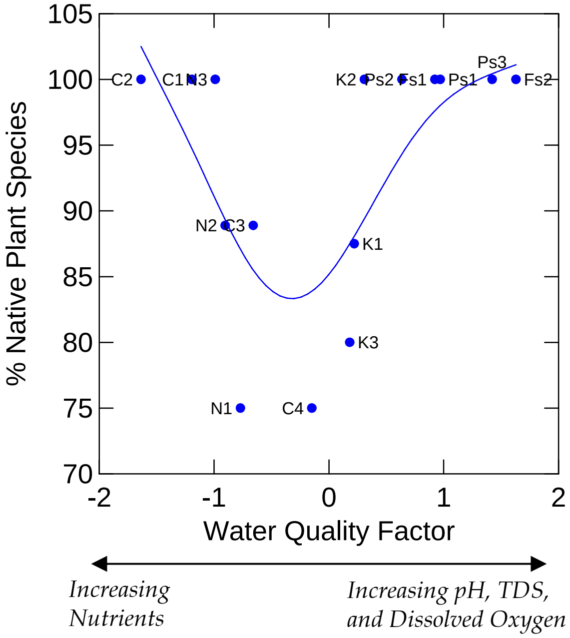
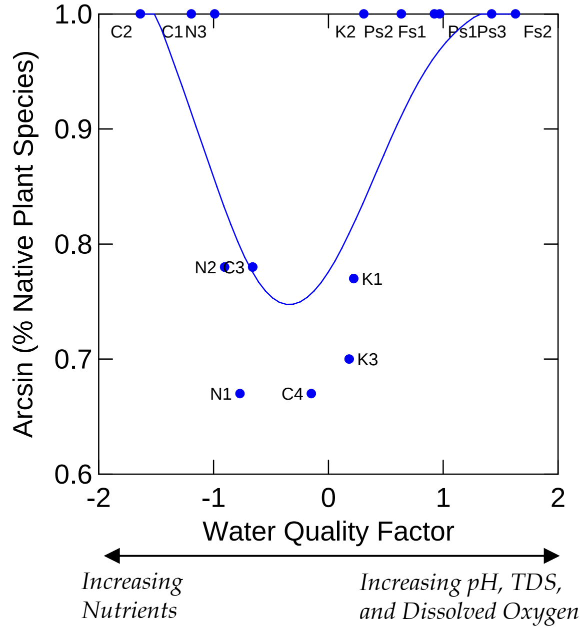


Figure 24. Arcsin % Native Plants & WQ



Native, Introduced and Invasive Plant Species Analysis - Sheetflow Sites, 2004

Figure 25. Introduced Plants and WQ

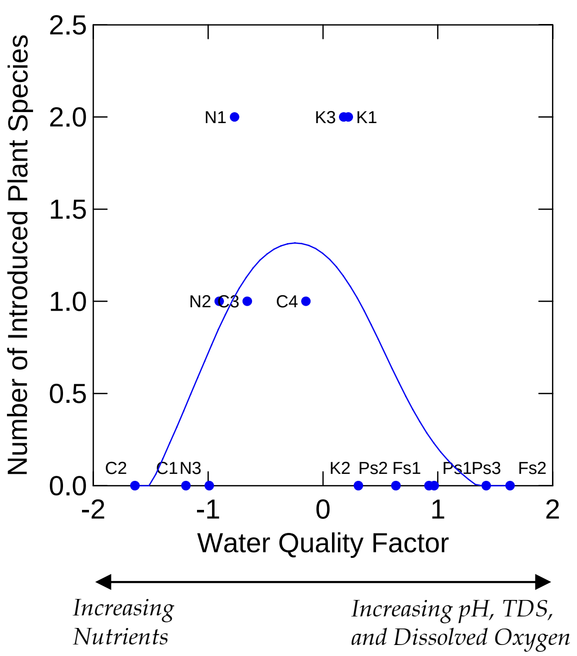


Figure 26. Log$_{10}$ Introduced Plants & WQ

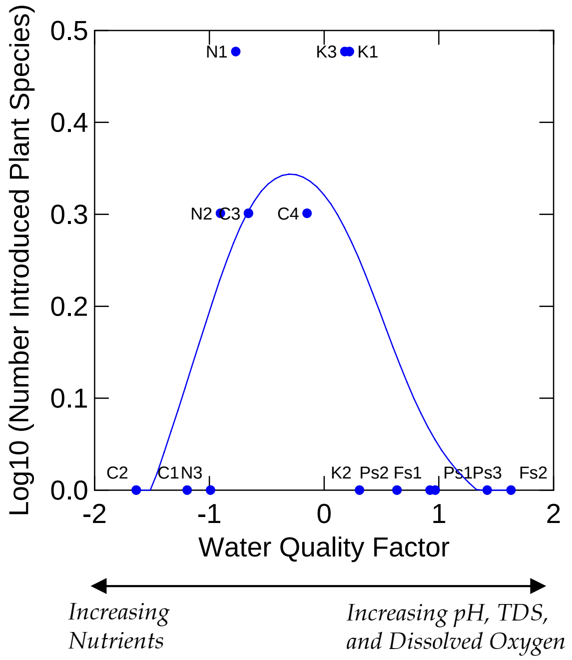


Figure 27. % Introduced Plants & WQ

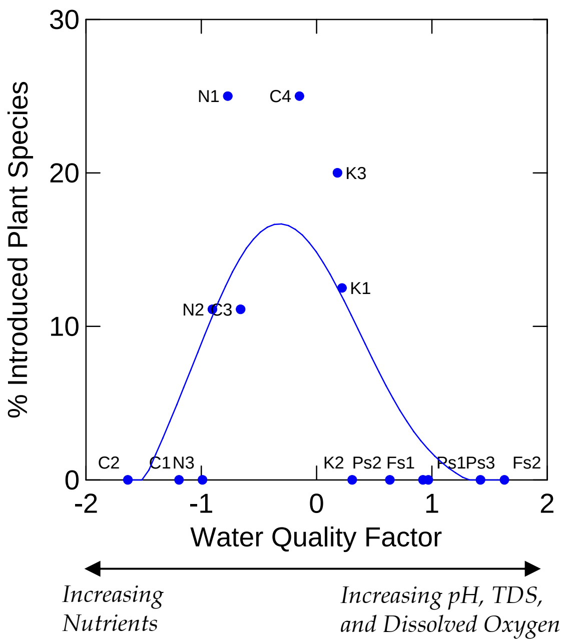
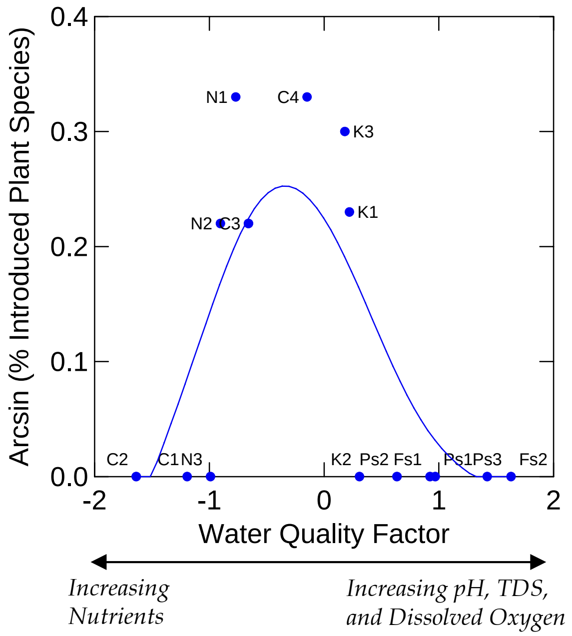


Figure 28. Arcsin % Introduced Plants & WQ



Native, Introduced and Invasive Plant Species Analysis - Sheetflow Sites, 2004

Figure 29. Invasive Plants and WQ

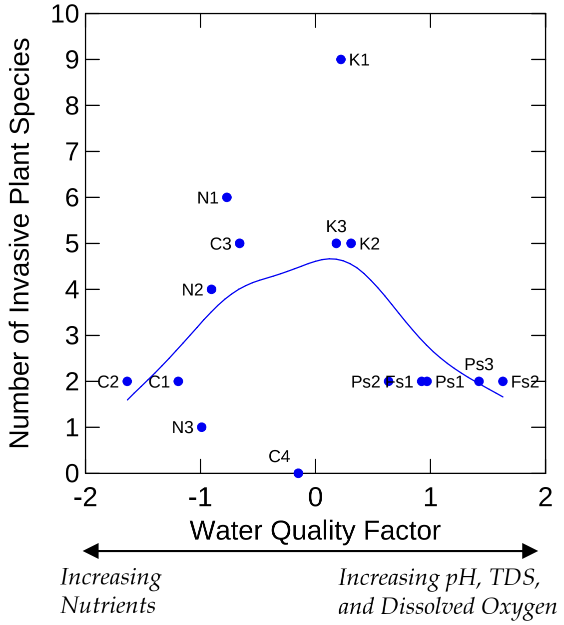


Figure 30. Log_{10} Invasive Plants & WQ

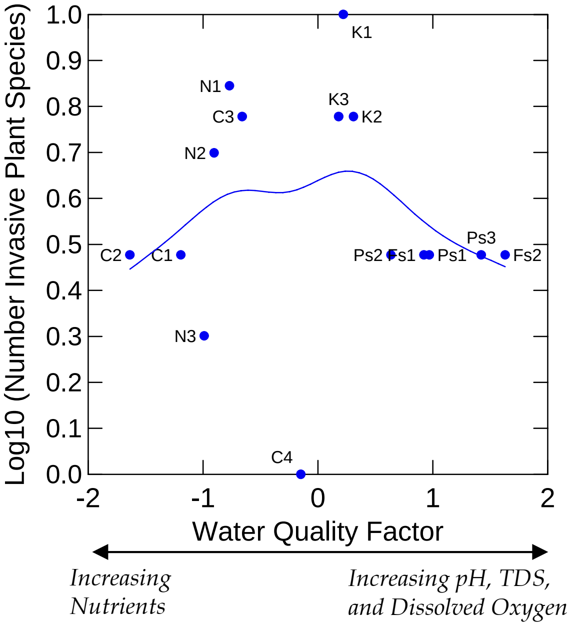


Figure 31. % Invasive Plants & WQ

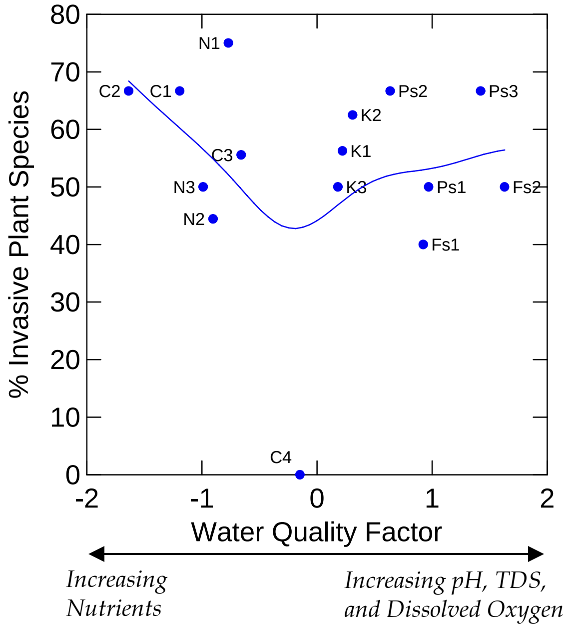


Figure 32. Arcsin % Invasive Plants & WQ

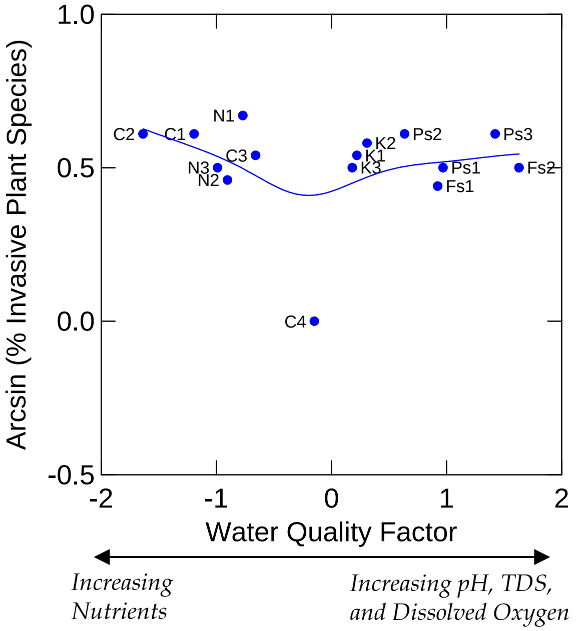


Figure 33. Total Plant Species and WQ

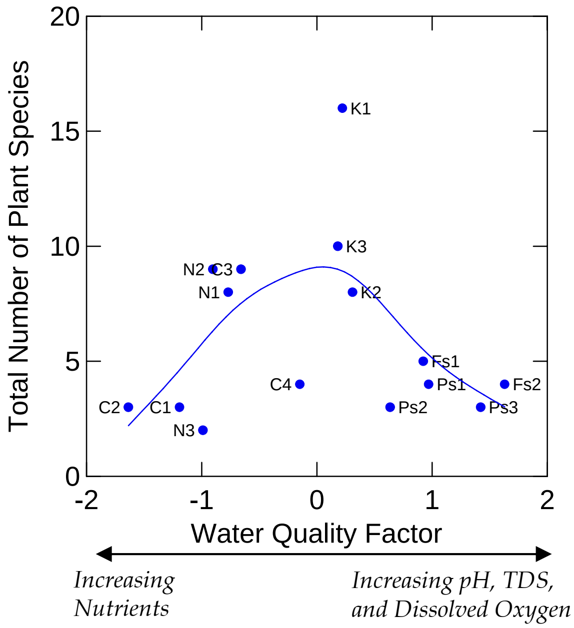


Figure 34. Log$_{10}$ Total Plant Species & WQ

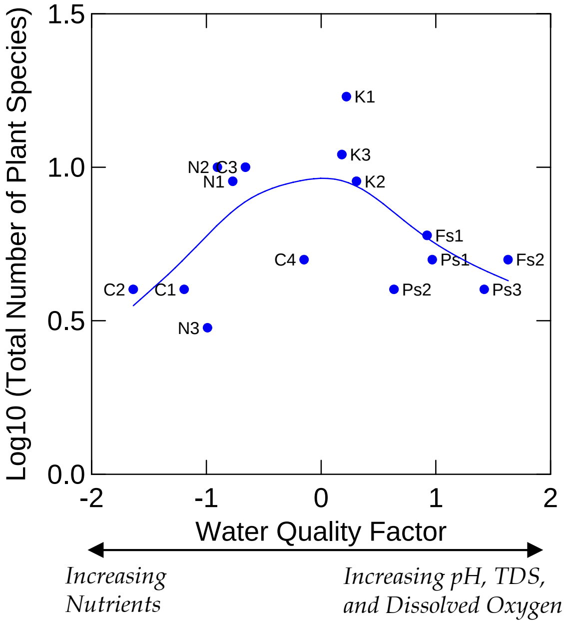


Figure 35. Native Plants & Water Quality(WQ)

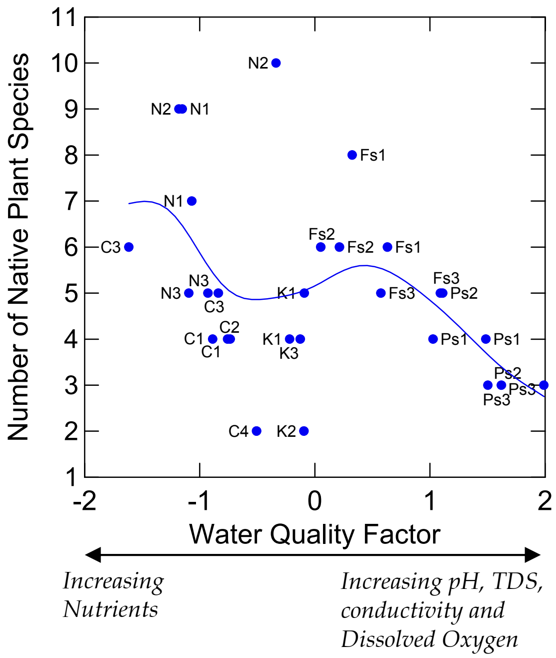


Figure 36. Log₁₀ Native Plants & WQ

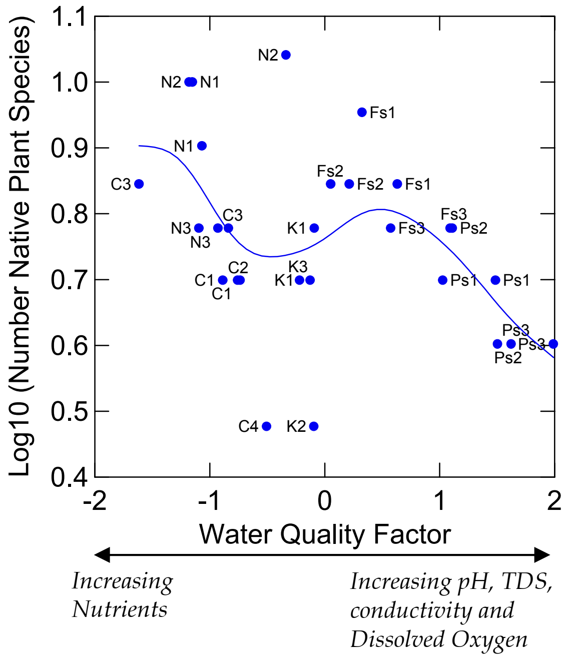


Figure 37. % Native Plants & WQ

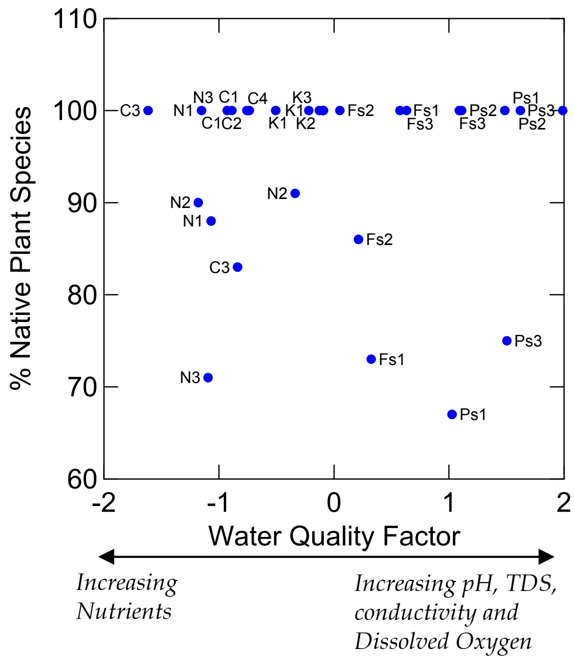


Figure 38. Arcsin % Native Plants & WQ

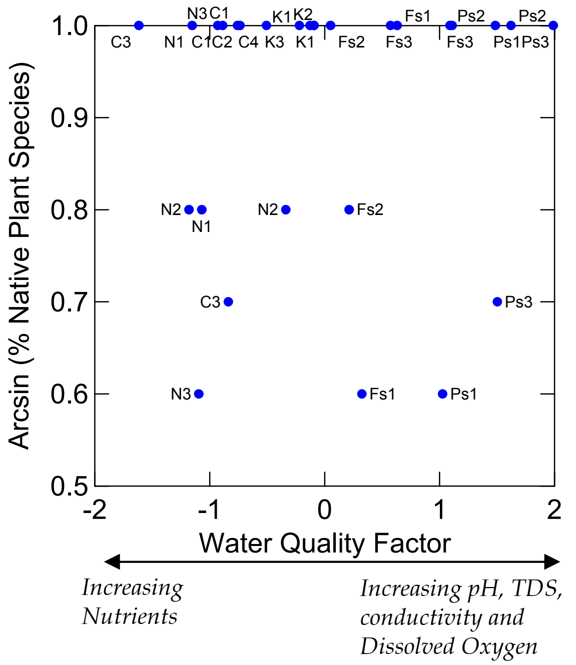
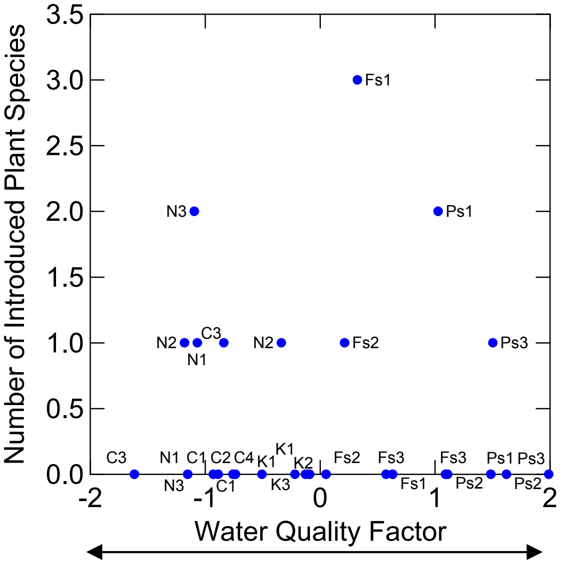


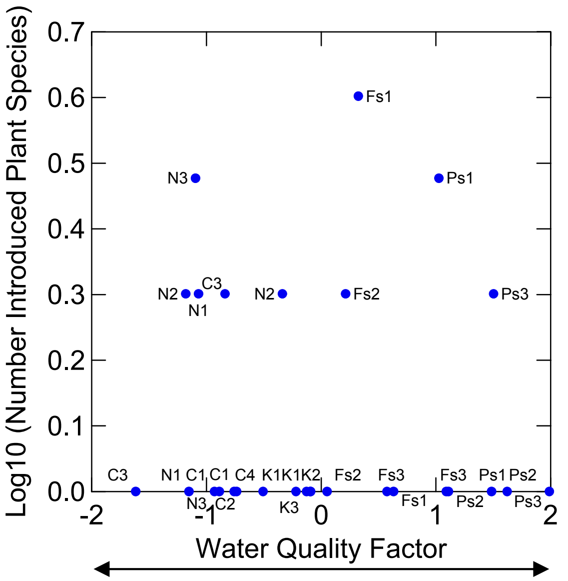
Figure 39. Introduced Plants and WQ



Increasing Nutrients

Increasing pH, TDS, conductivity and Dissolved Oxygen

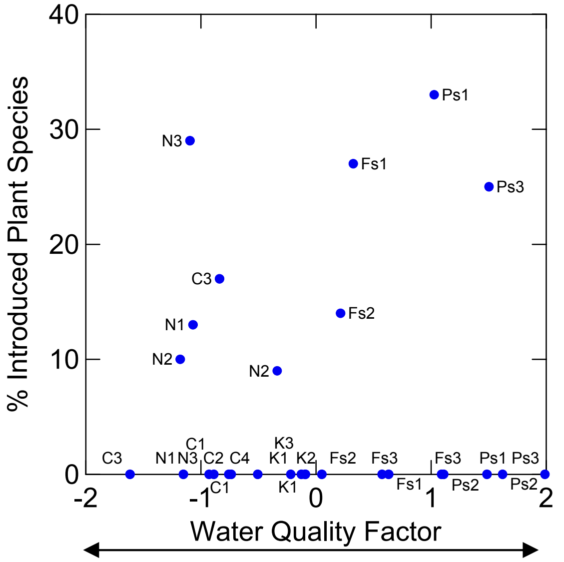
Figure 40. Log$_{10}$ Introduced Plants & WQ



Increasing Nutrients

Increasing pH, TDS, conductivity and Dissolved Oxygen

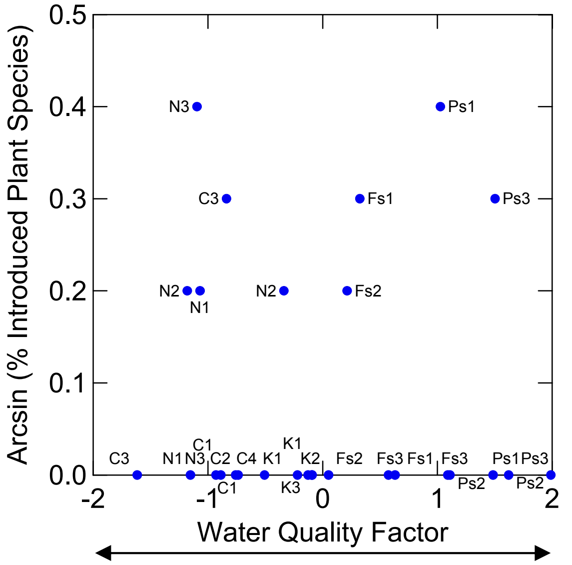
Figure 41. % Introduced Plants & WQ



Increasing Nutrients

Increasing pH, TDS, conductivity and Dissolved Oxygen

Figure 42. Arcsin % Introduced Plants & WQ



Increasing Nutrients

Increasing pH, TDS, conductivity and Dissolved Oxygen

Figure 43. Invasive Plants and WQ

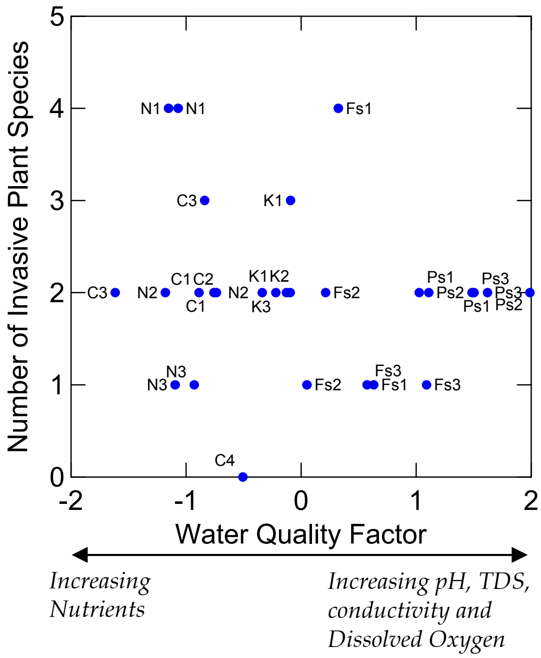


Figure 44. Log$_{10}$ Invasive Plants & WQ

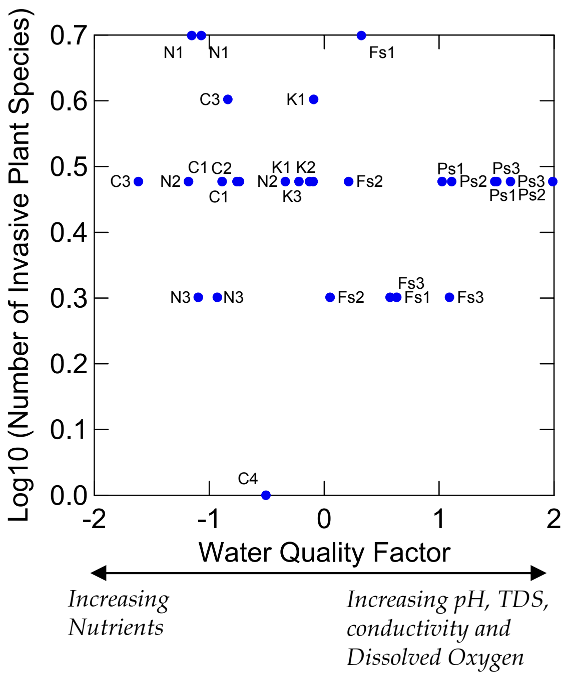


Figure 45. % Invasive Plants & WQ

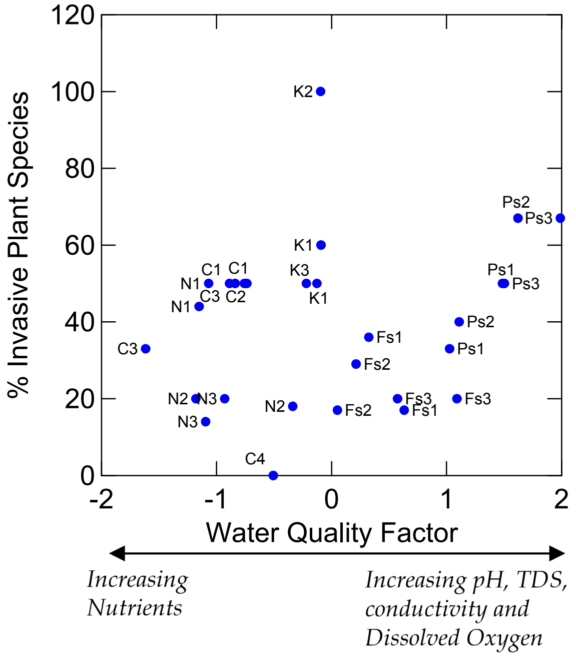


Figure 46. Arcsin % Invasive Plants & WQ

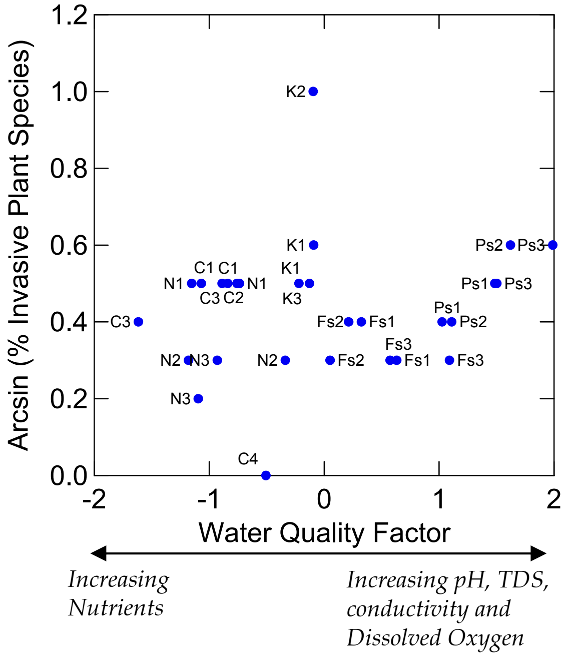


Figure 47. Total Plant Species and WQ

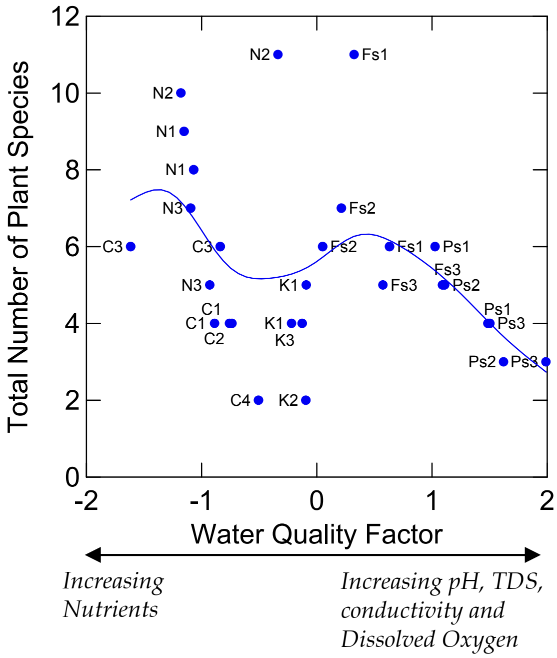
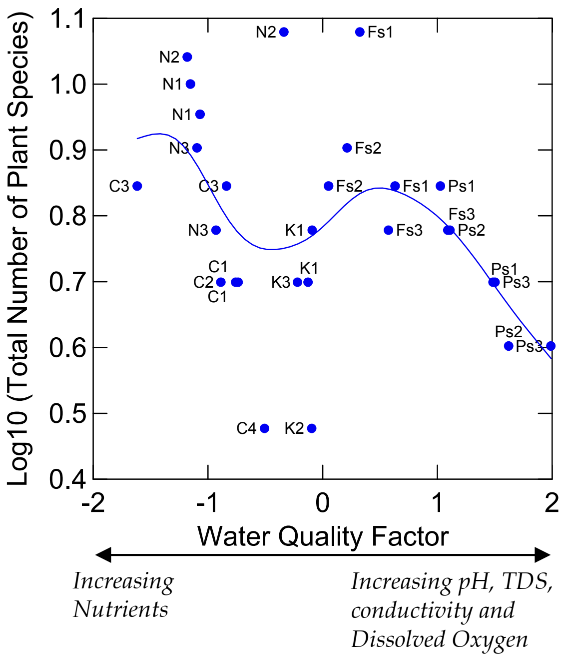


Figure 48. Log$_{10}$ Total Plant Species & WQ



Impounded Sites – 2004

Figure 49. Tolerant Species: Impounded Sites, 2004.

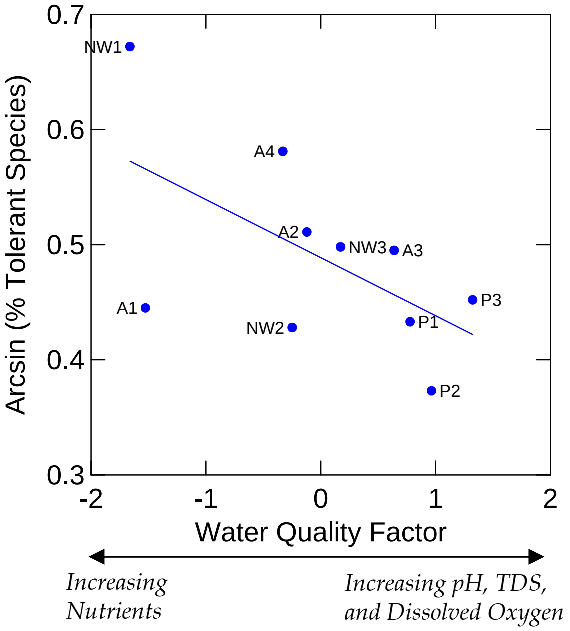


Figure 50. Ephemeroptera: Impounded Sites, 2004

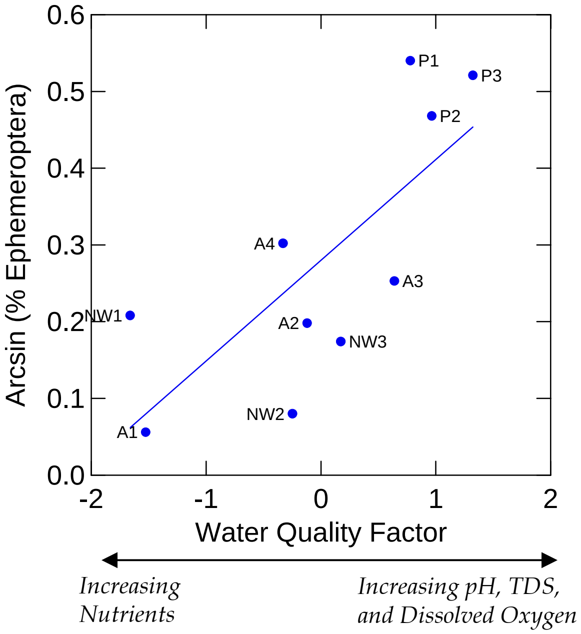


Figure 51. Collector-Gatherers: Impounded Sites, 2004

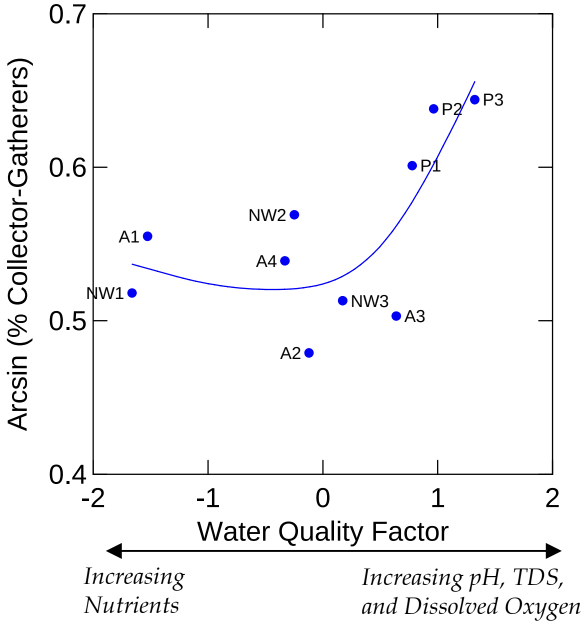


Figure 52. Predators: Impounded Sites, 2004

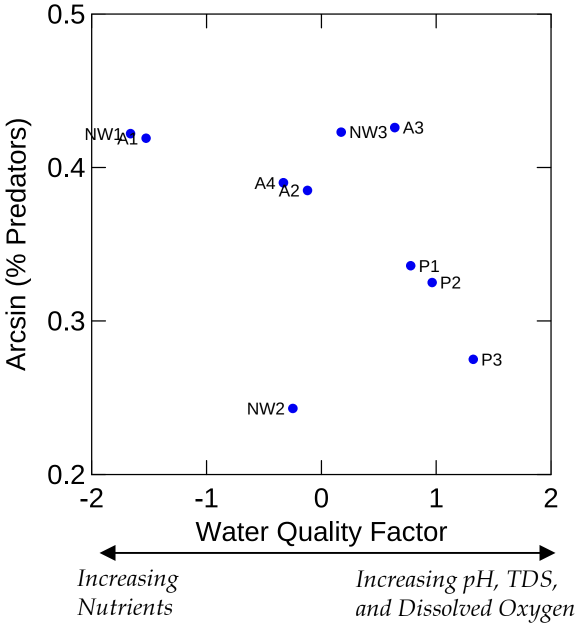
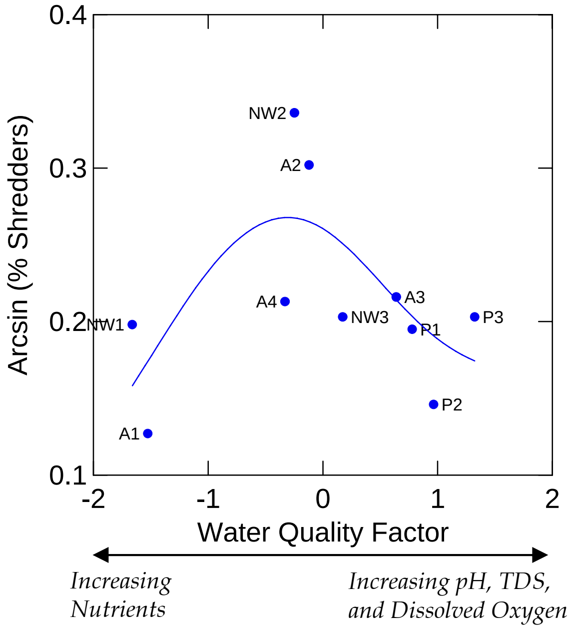


Figure 53. Shredders: Impounded Sites, 2004



Sheetflow Sites – 2004

Figure 54. Tolerant Species: Sheetflow Sites, 2004

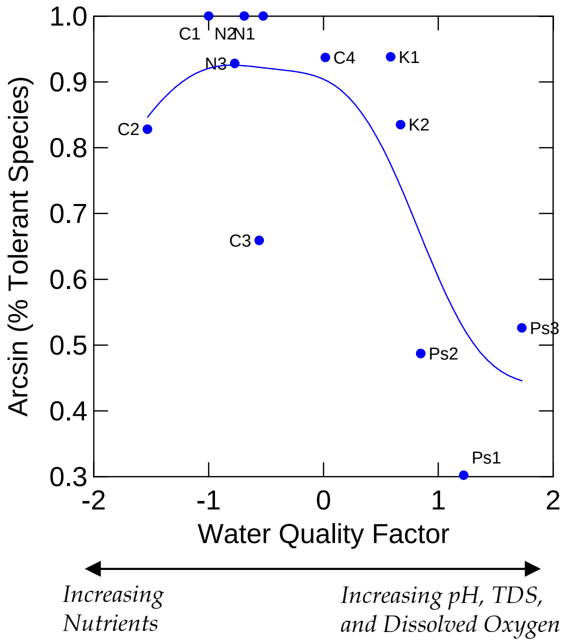


Figure 55. Ephemeroptera: Sheetflow Sites, 2004

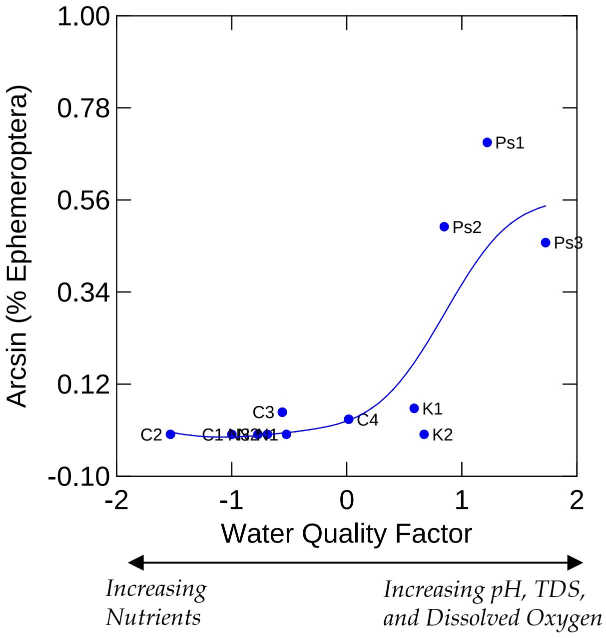


Figure 56. Collector-Gatherers: Sheetflow Sites, 2004

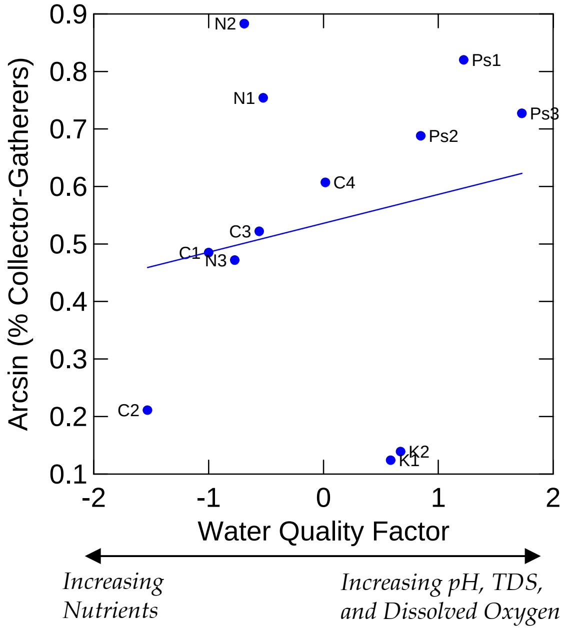


Figure 57. Predators: Sheetflow Sites, 2004

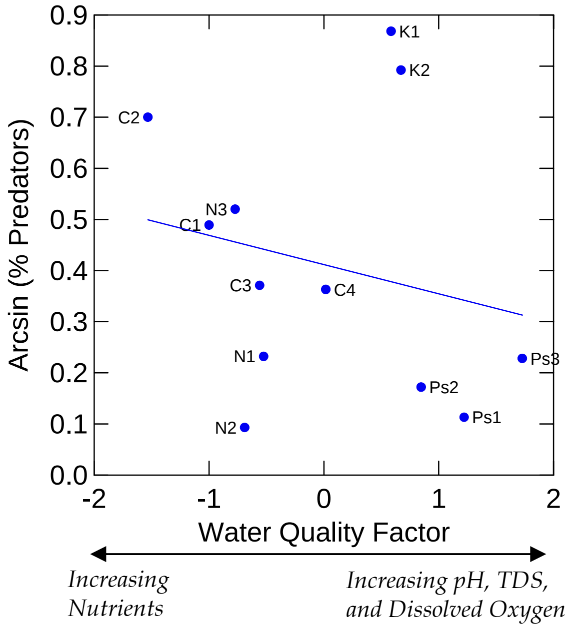
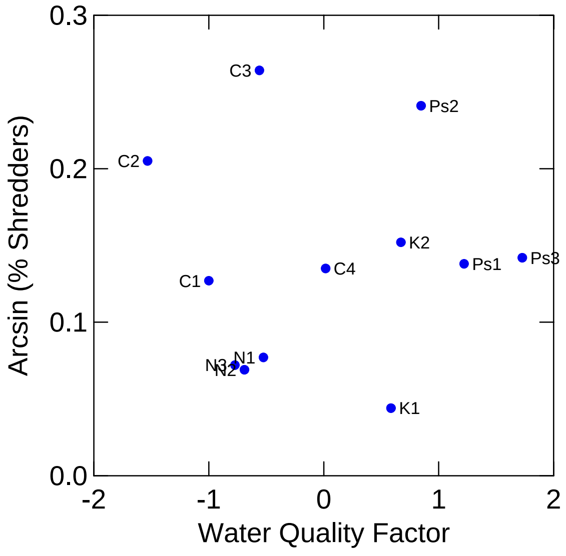


Figure 58. Shredders: Sheetflow sites, 2004



Increasing Nutrients

Increasing pH, TDS, and Dissolved Oxygen

Impounded Sites – 2005

Figure 59. Tolerant Species: Impounded Sites, 2005

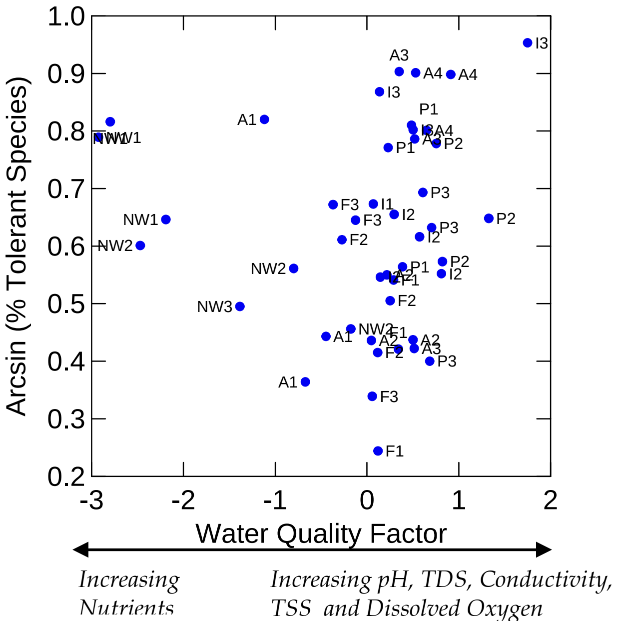


Figure 60. Ephemeroptera: Impounded Sites, 2005

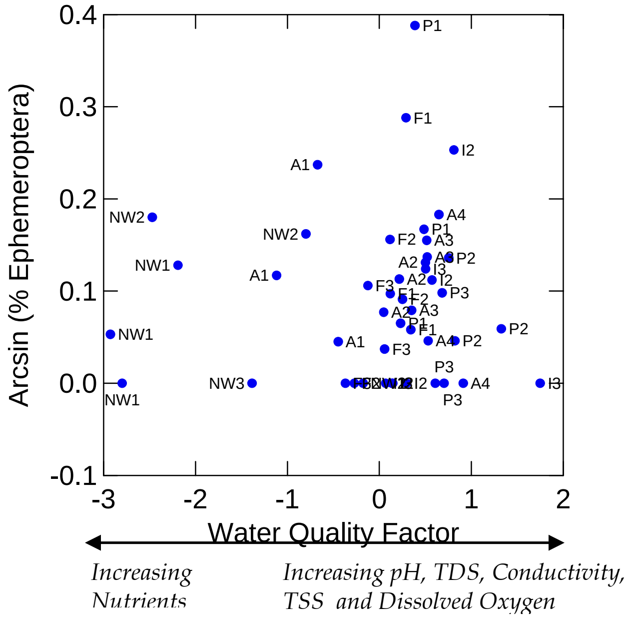


Figure 61. Collector-Gatherers: Impounded Sites, 2005

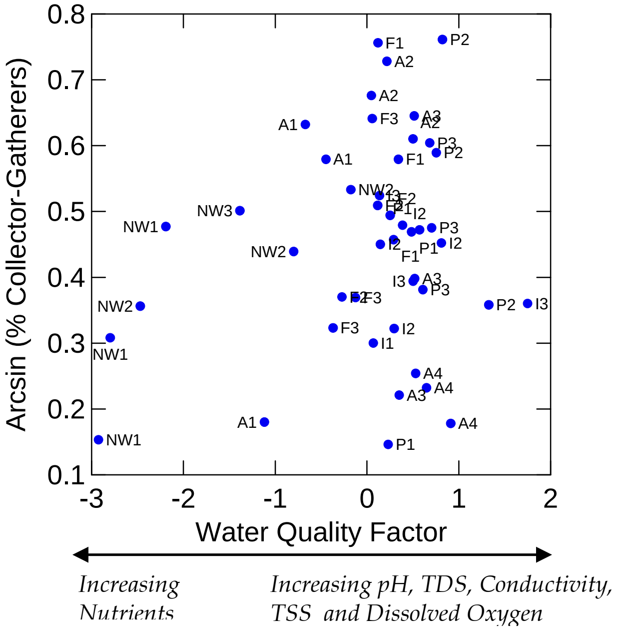


Figure 62. Predators: Impounded Sites, 2005

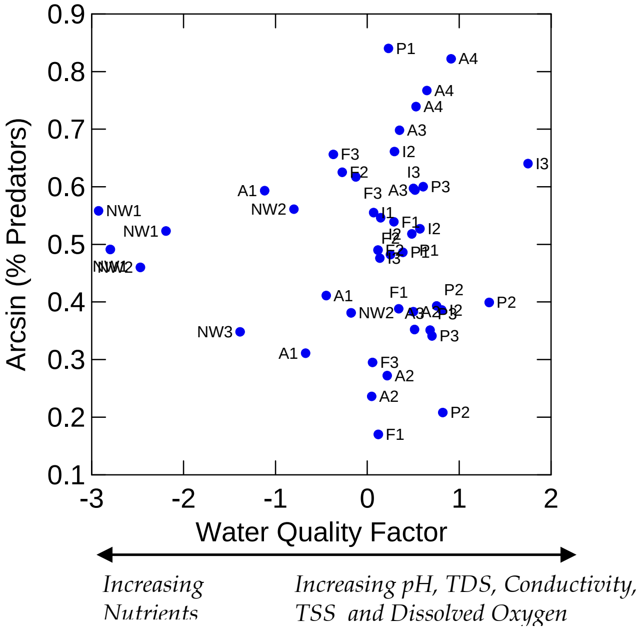
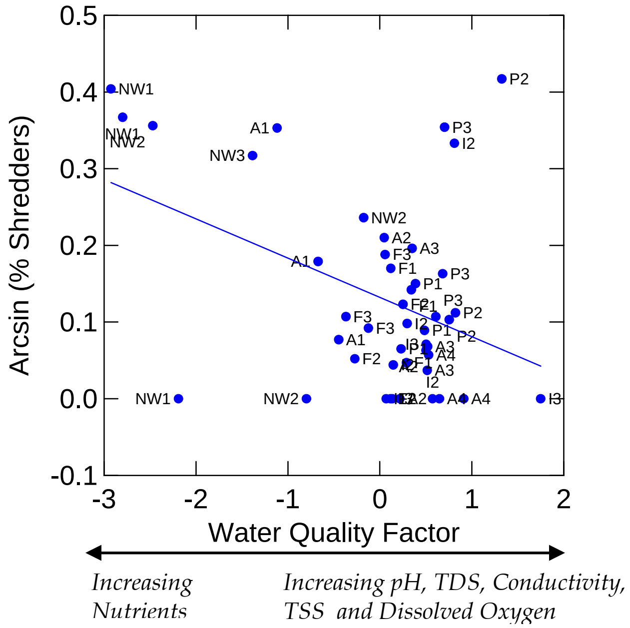


Figure 63. Shredders: Impounded Sites, 2005



Sheetflow Sites – 2005

Figure 64. Tolerant Species: Sheetflow Sites, 2005

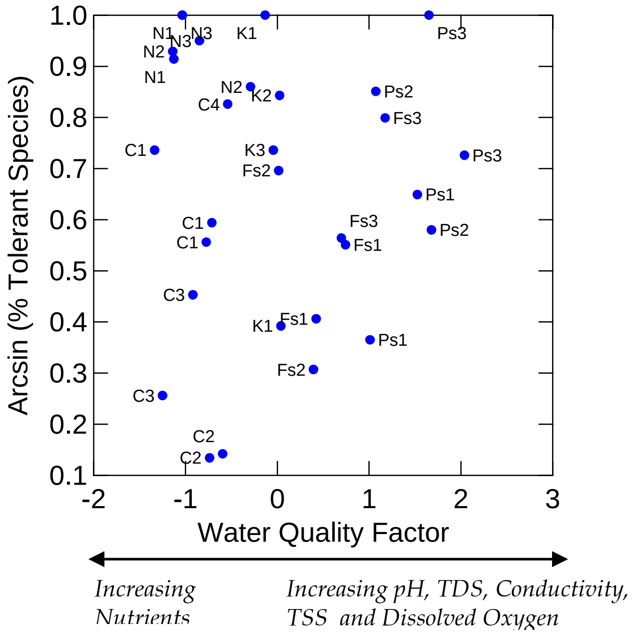


Figure 65. Ephemeroptera: Sheetflow Sites, 2005

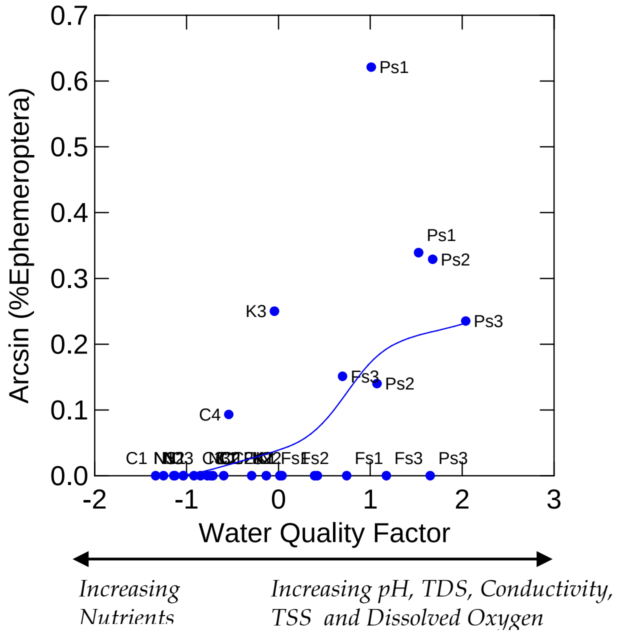


Figure 66. Collector-Gatherers: Sheetflow Sites, 2005

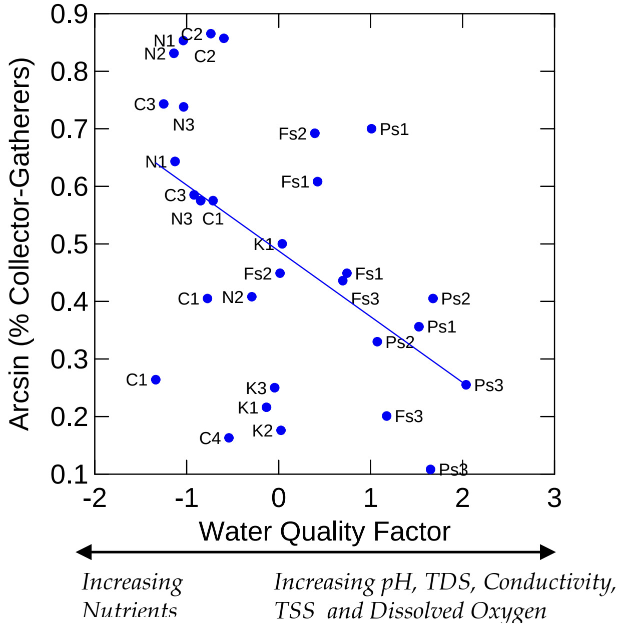


Figure 67. Predators: Sheetflow Sites, 2005

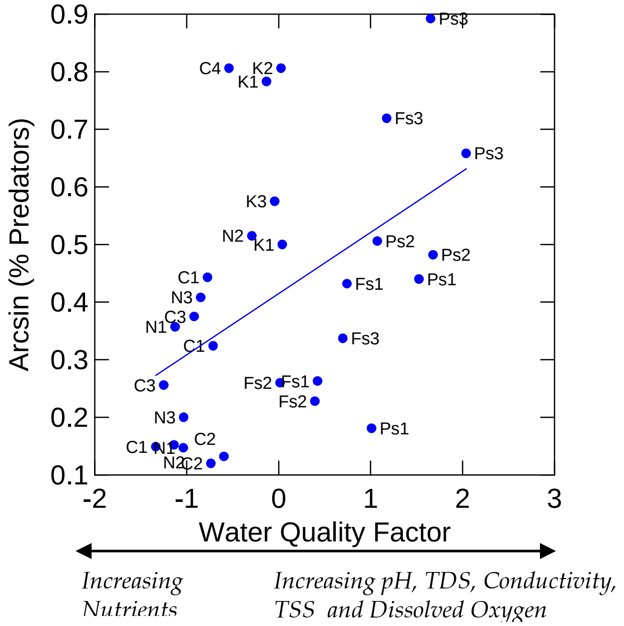


Figure 68. Shredders: Sheetflow Sites, 2005

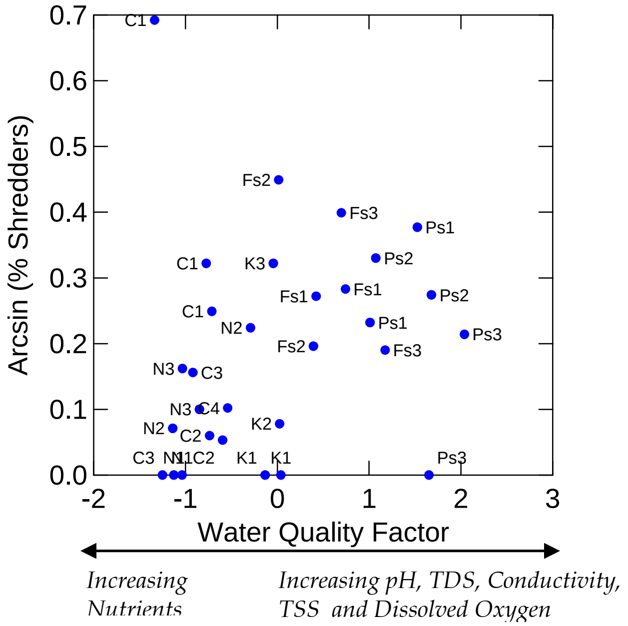
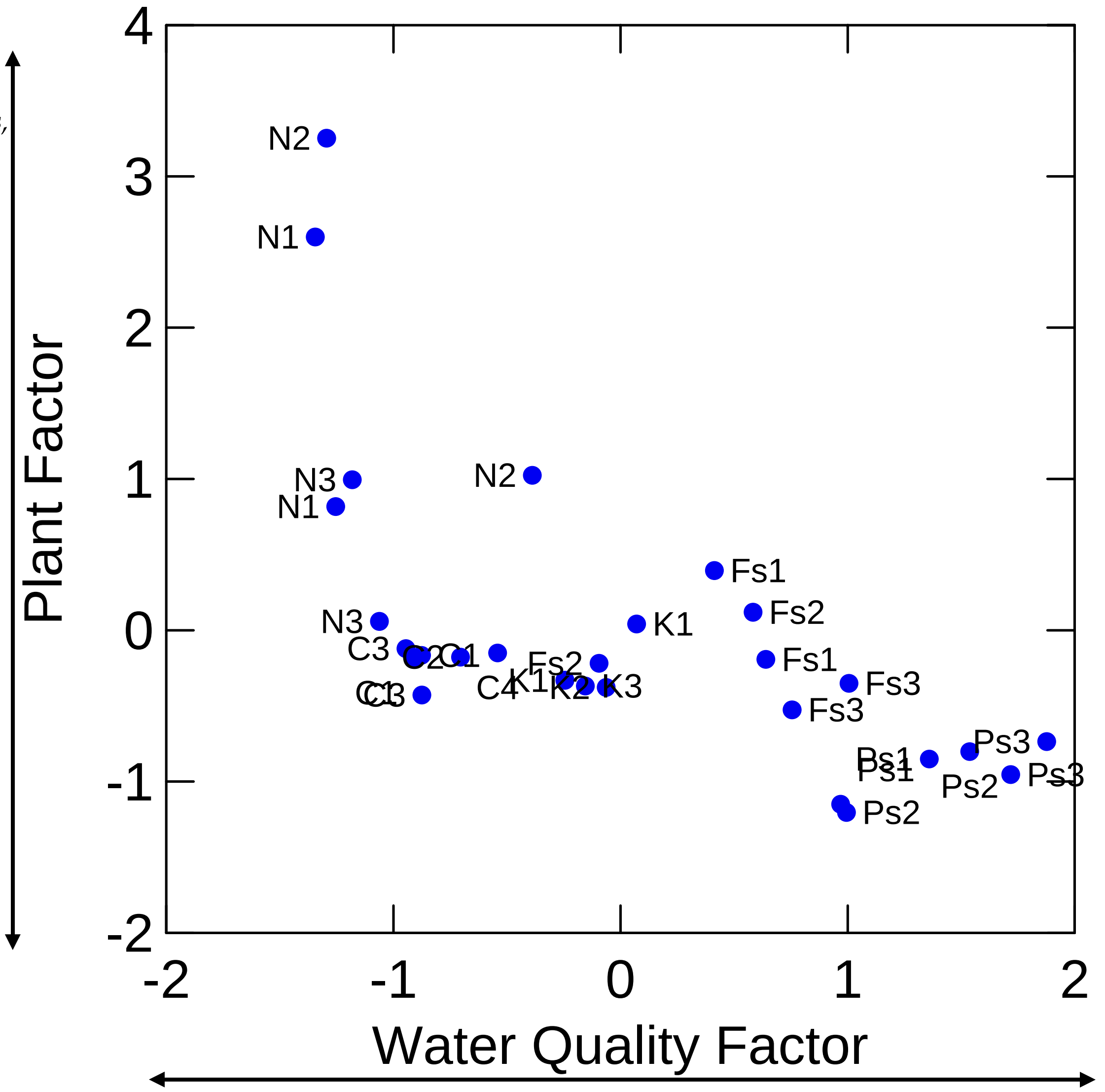


Figure 69. FACTOR ANALYSIS: Plants and Water Quality – Sheetflow Sites, 2005.



Increasing Alopecurus aqualis, Atriplex micrantha, Bidens cernua, Phalaris arundinacea, Polygonium lapathifolium, Salicornia rubra and Schoenoplectus acutus

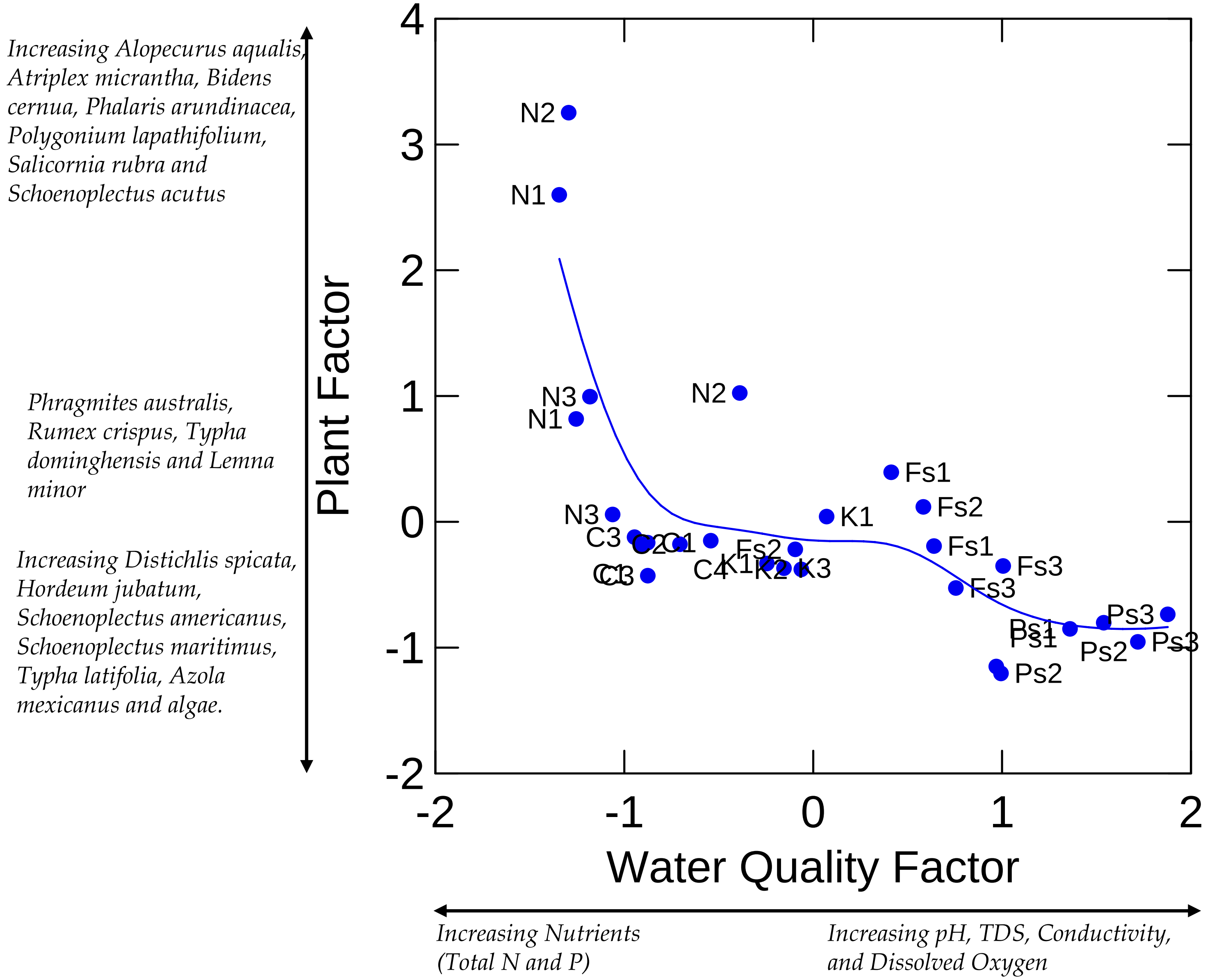
Phragmites australis, Rumex crispus, Typha dominghensis and Lemna minor

Increasing Distichlis spicata, Hordeum jubatum, Schoenoplectus americanus, Schoenoplectus maritimus, Typha latifolia, Azola mexicanus and algae.

Increasing Nutrients (Total N and P)

Increasing pH, TDS, Conductivity, and Dissolved Oxygen

Figure 70. FACTOR ANALYSIS: Plants and Water Quality – Sheetflow 2005, with DWLS line fitted.



Increasing Alopecurus aqualis, Atriplex micrantha, Bidens cernua, Phalaris arundinacea, Polygonium lapathifolium, Salicornia rubra and Schoenoplectus acutus

Phragmites australis, Rumex crispus, Typha dominghensis and Lemna minor

Increasing Distichlis spicata, Hordeum jubatum, Schoenoplectus americanus, Schoenoplectus maritimus, Typha latifolia, Azola mexicanus and algae.

Increasing Nutrients (Total N and P)

Increasing pH, TDS, Conductivity, and Dissolved Oxygen

Figure 71. FACTOR ANALYSIS: Plants and Water Quality – Impounded Sites, 2005.

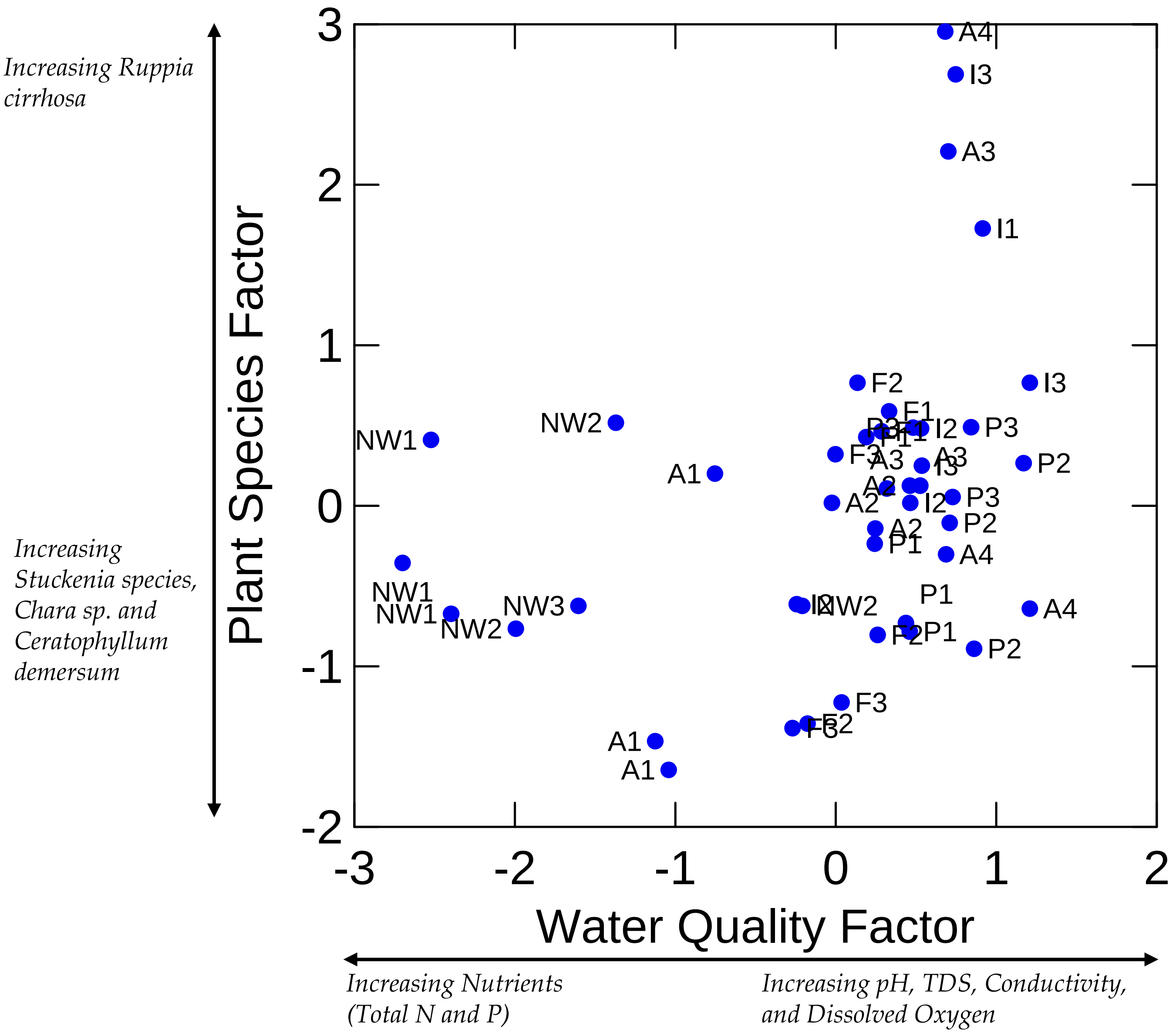


Figure 72. FACTOR ANALYSIS: Invertebrates and Water Quality, Impounded Sites, 2005

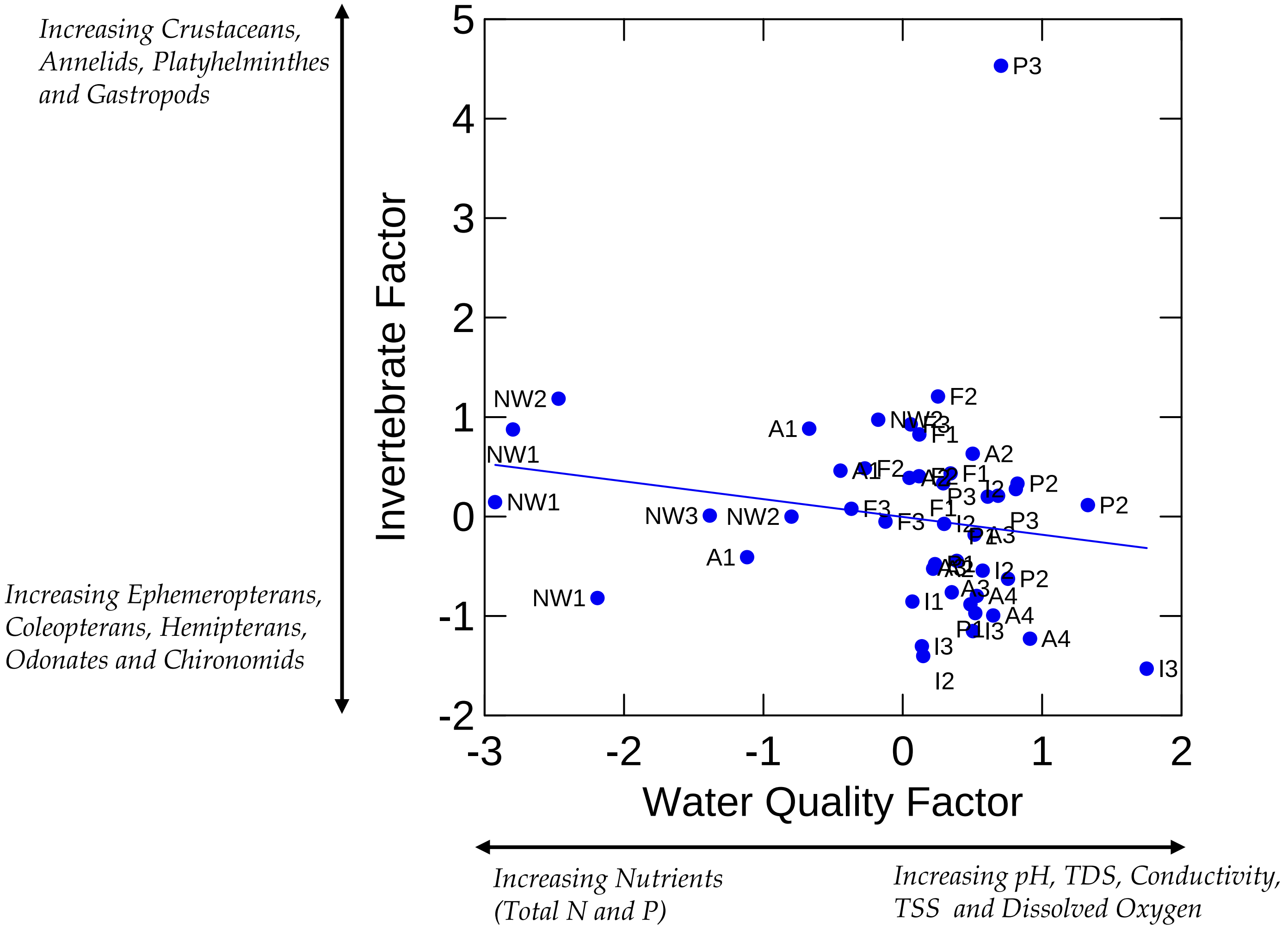


Figure 73. FACTOR ANALYSIS: Invertebrates and Water Quality, Sheetflow Sites, 2005

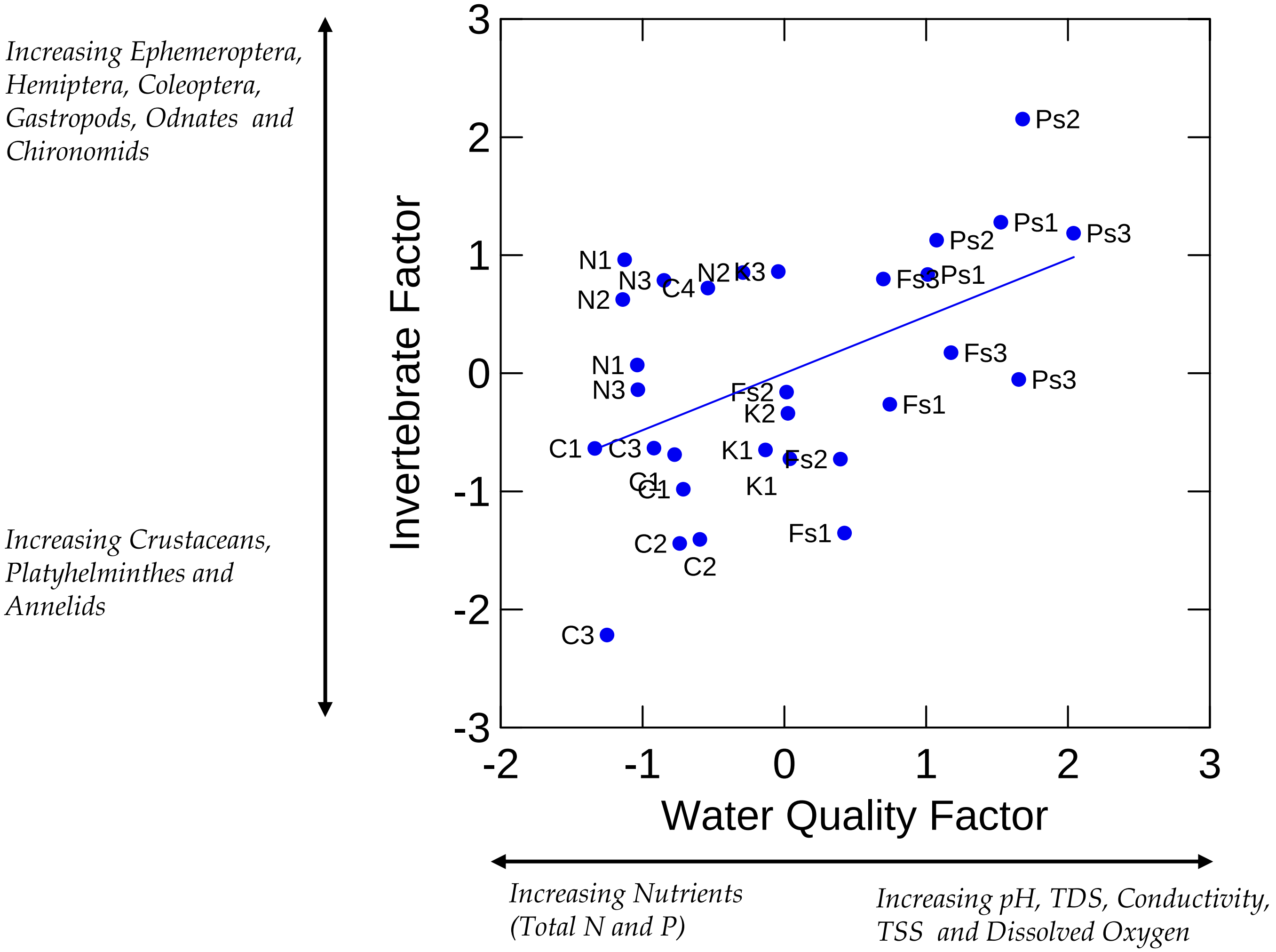


Figure 74. Macroinvertebrate Species Diversity Analysis – Impounded Sites, 2004.

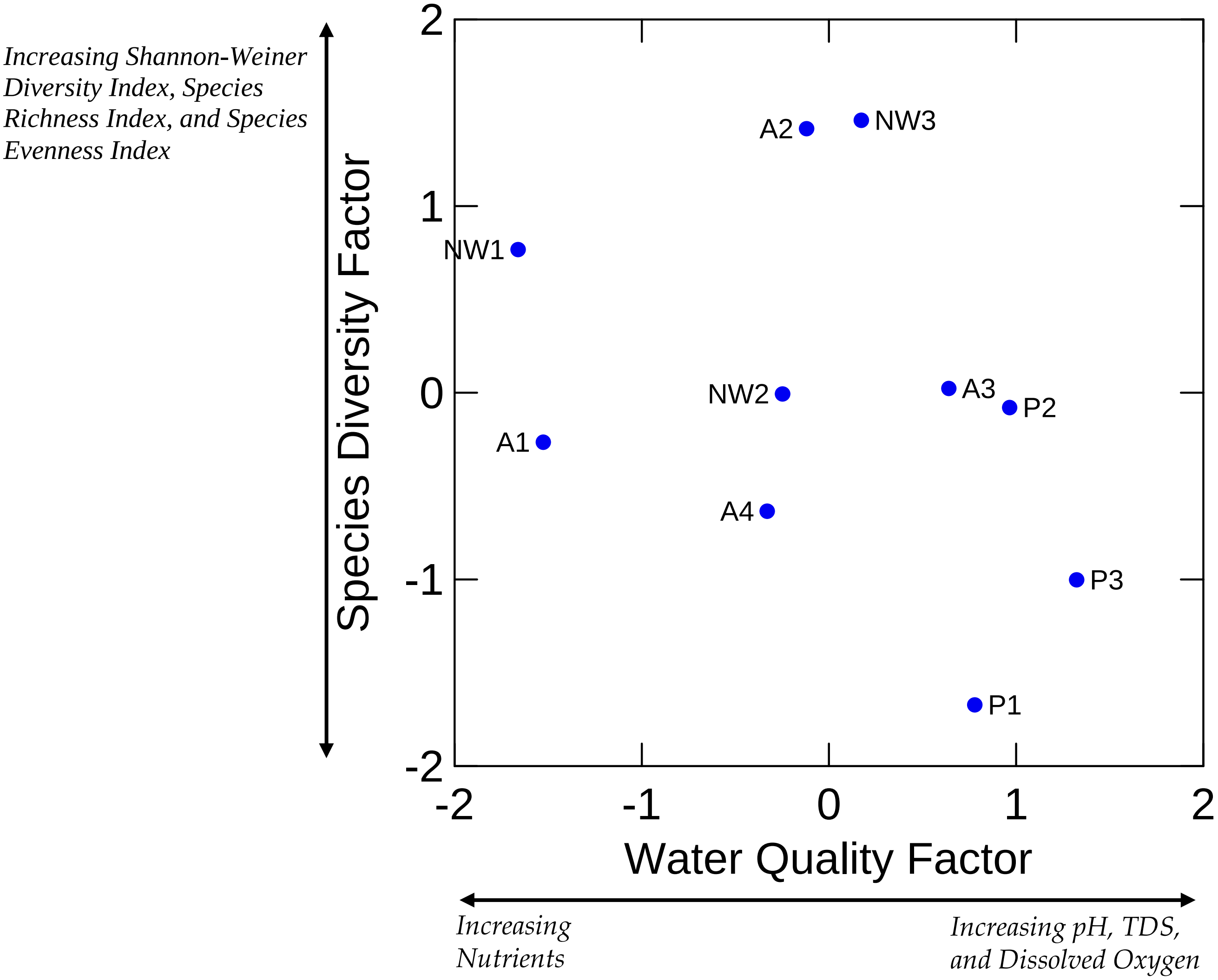


Figure 75. Macroinvertebrate Species Diversity Analysis – Sheetflow Sites, 2004.

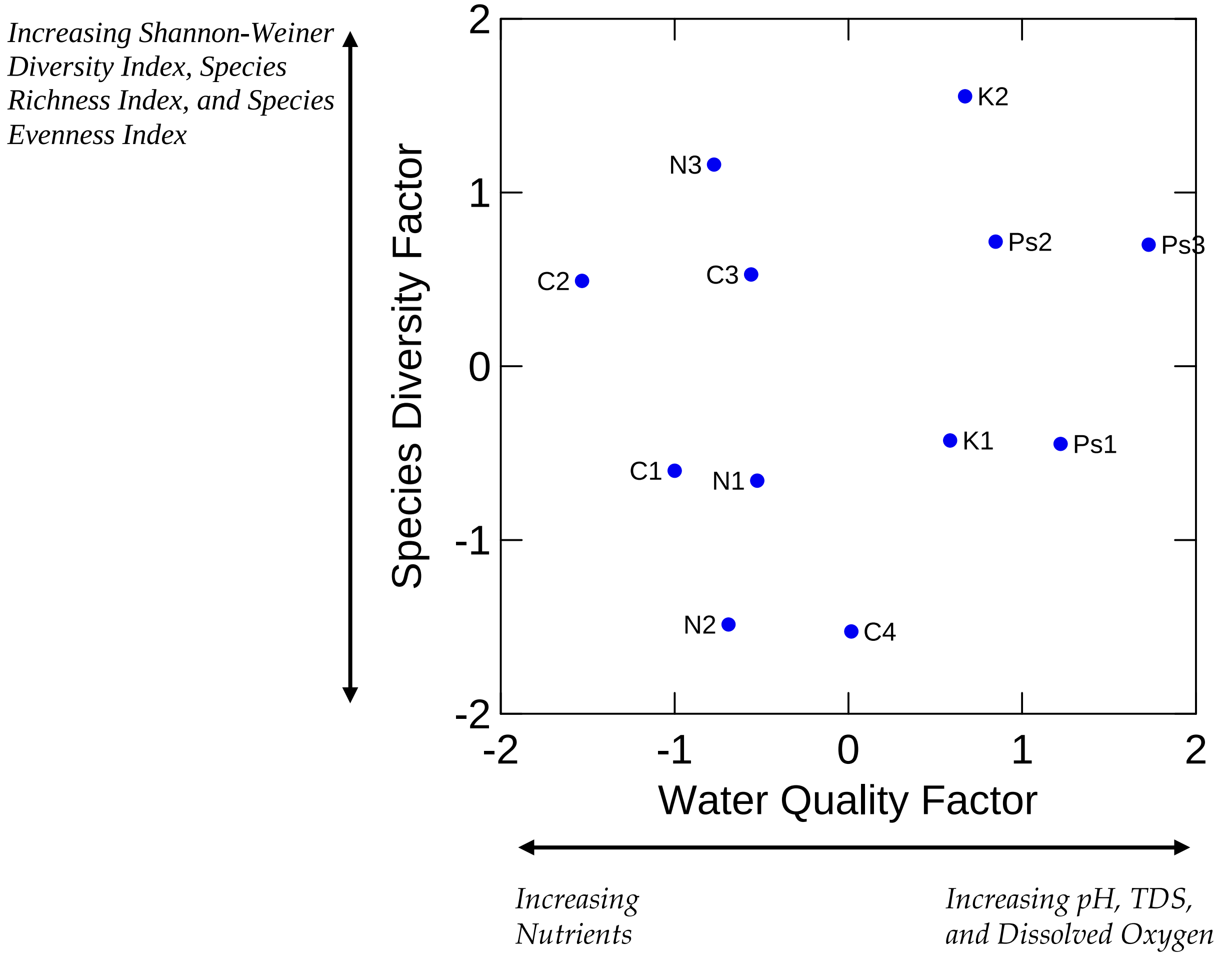


Figure 76. Macroinvertebrate Species Diversity Analysis: Impounded Sites, 2005

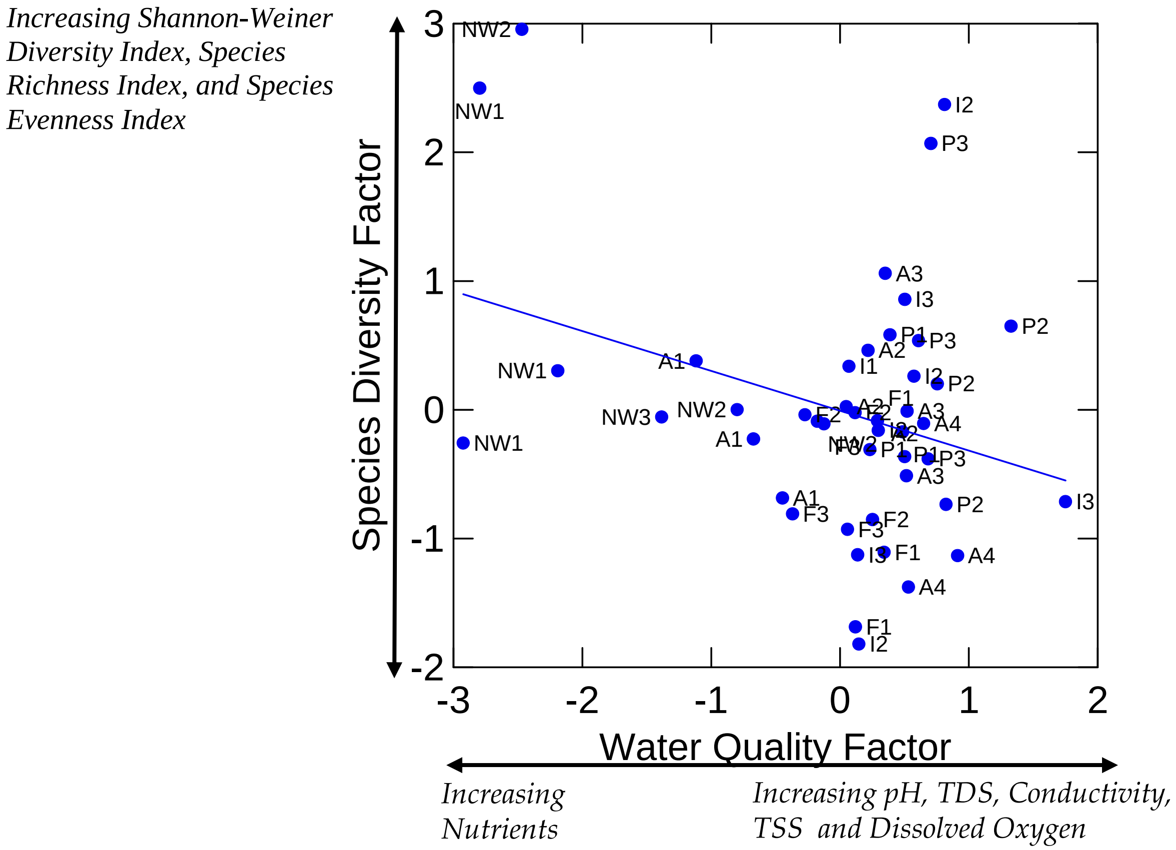
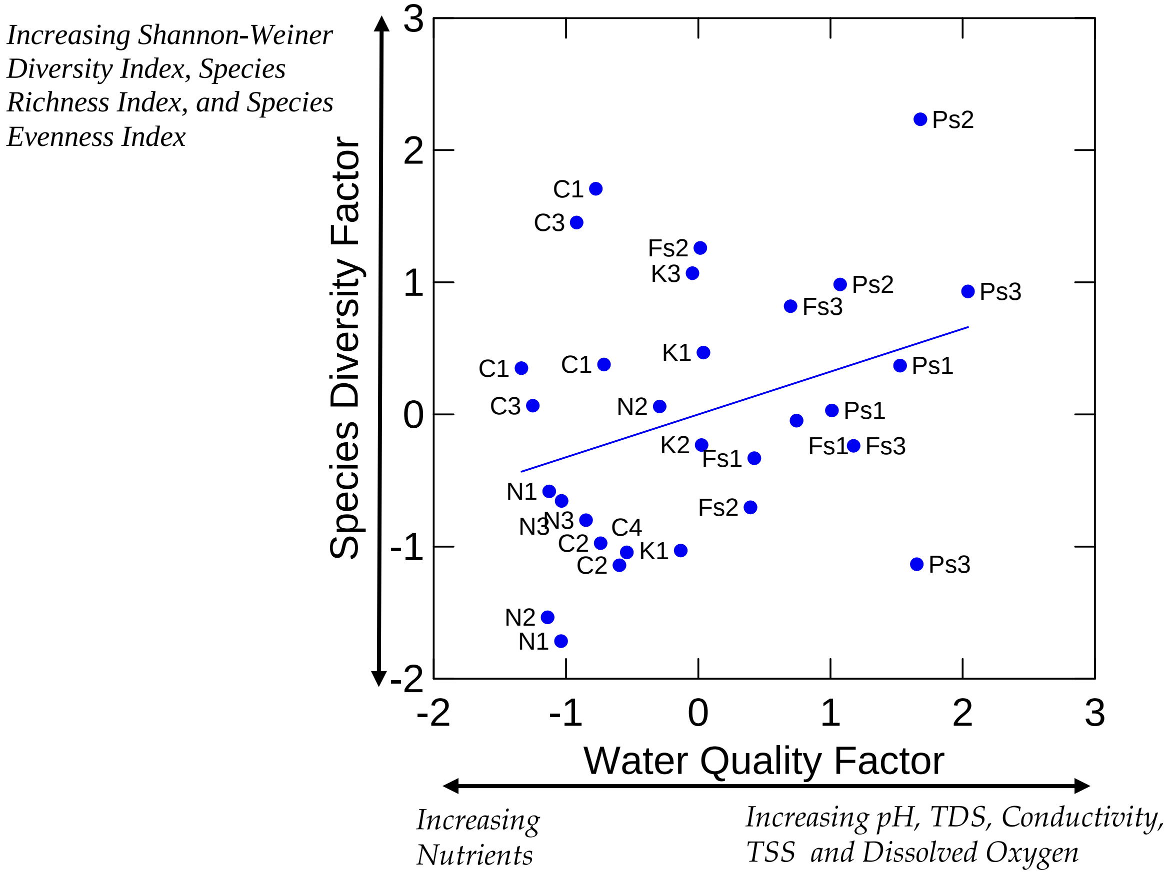


Figure 77. Macroinvertebrate Species Diversity Analysis: Sheetflow Sites, 2005



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APENDIX B

COMPOSITION OF MICROINVERTEBRATE COMMUNITIES OF THE GREAT SALT LAKE WETLANDS AND RELATIONSHIP TO WATER QUALITY

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Composition of Macroinvertebrate Communities of the Great Salt Lake Wetlands and Relationships to Water Chemistry

Prepared for the Utah Department of Environmental Quality
Water Quality Management Section

Prepared by
Dr. Lawrence J. Gray
Senior Ecologist (ESA)

March 2005

Introduction

This report presents data on the macroinvertebrate community composition of samples taken at a variety of sites in the Great Salt Lake wetlands. A complete list of the macroinvertebrate taxa found in the samples is given in Table 1. Table 2 contains the number of each taxon in each of the samples. Table 3 has the calculated community statistics for each sample. Physical/chemical data were taken from STORET information for 2004 at sites corresponding to the sampling locations is given in Table 4. These parameters were chosen to represent gradients in overall water chemistry, including salinity (as conductivity), pH, and overall "enrichment" from nutrients (phosphorus and dissolved oxygen). Individual taxa are plotted against these chemical parameters and water temperature to examine general trends in abundance and relate these to community composition.

Taxonomic Notes

Identifications were taken to the lowest possible level given the limitations in terms of number of specimens (for rare taxa), condition of species, and/or life stage. Notes on individual taxa are given below.

1) *Callibaetis* (Ephemeroptera): possibly *C. americanus,* but adults are needed to confirm the species.
2) Chironomidae: possible genera of subfamilies are listed below, but additional work is needed.
    a) Tanypodinae keys to *Tanypus* sp. in Epler (1995). Ecologically, I listed the Tanypodinae as predators, although some regard *Tanypus* to be omnivorous.
    b) Tanytarsini sp. keys to *Tanytarsus* sp. in Epler (1995).
    c) Orthocladiinae sp. keys to *Cricotopus* sp. in Epler (1995).
3) The leech *Erpobdella parva* is listed here as "*E. parva* complex" based on proposed revisions by Hovingh (2004). Specimens were present that would fit the "old" descriptions for both *E. parva* and *Dina dubia*, which Hovingh considers to be conspecific.
4) Snails were not taken to species. None of the specimens deviated from common forms for the 3 genera listed, and no additional ecological information would be gained beyond knowing the genus of each one.
5) Specimens of flatworms were variable in shape and difficult to identify due to changes caused by preservatives. Some resembled *Phagocota* and others *Dugesia*. Ecologically, both are similar in tolerance.
6) Some diptera (e.g., Culicidae, Dolichopodidae, and Stratiomyidae) were left at family level due to lack of specimens. Ecologically, all species in this area within these families are similar.
7) Using Musser's (1962) key based on nymphal characteristics, *Erythemis collocata* and *Tramea lacerata* are the two species present in these genera. Adults collected in Summer 2005 indicate that *Aeshna californica*, *Ischnura cervula*, and *I. barberi* are the other odonate species present.

Distributions of Macroinvertebrates in the GSL Wetlands and Relationships to Chemical Parameters

Figures 1 to 9 show the relationships between abundance of individual taxa and the principal chemical factors.

Mayflies (*Callibaetis*)

The distribution of *Callibaetis* was strongly related to conductivity (Fig. 1). In general, it was most abundant, and comprised a significant portion of the macroinvertebrate community, where conductivity was >4000 but <10000 μmhos/cm. *Callibaetis* was absent enriched (i.e., high phosphorus + low oxygen) habitats, suggesting it was intolerant of eutrophic conditions. However, spraying for mosquitoes may have affected this distribution, because baetid mayflies are known to be highly sensitive to malathion (Toxicity references below).

Caenis was uncommon and primarily found in the New State ponds 20 and 5_6. *Caenis* is a typical “spring” species that favors habitats with groundwater inputs.

Odonates

The damselfly *Ischnura* was the most abundant odonate. Of the physical/chemical variables examined, odonates showed the strongest relationship to conductivity (Fig. 2). In general, odonates were rare in habitats were conductivity exceeded 6000 μmhos/cm. The relationships between odonates and the other physical/chemical variables were weak, indicating a broad tolerance to nutrient enrichment and water temperatures. Of interest is the negative relationship between odonate and *Callibaetis* mayfly densities (Fig. 3). This trend may simply reflect differing tolerance to high salinities by the two taxa. It may also reflect predation by odonates on mayflies, suggesting that mayflies have a refuge in habitats too saline for odonates.

Chironomidae

Chironomus was the most abundant midge and was widely distributed in the study area. *Chironomus* and other chironomids were most abundant at the North and Central Davis WWTP sites, thus correlating with high nutrient levels and resulting eutrophic conditions. In general, chironomid abundance was highest in waters with relatively low conductivity and pH and relatively high phosphorus levels (Fig. 4). Its abundance relative to dissolved oxygen, however, indicates that it was intolerant to extreme enrichment that resulted in very low oxygen levels. As with mayflies, trends between chironomids and physical/chemical factors may have been affected by spraying for mosquitoes, because *Chironomus* is known to be highly sensitive to malathion (Toxicity references). Another potential factor affecting the results is that many chironomids are too small to be reliably collected with the mesh size of the D-net used.

Hemiptera

Hemipteran abundance was generally correlated with several physical/chemical parameters, and it is difficult to determine if one was more important than another. Hemipterans were tolerant of a wide range of pH and conductivity conditions, but avoided enriched habitats with low oxygen (Fig. 5). In addition, hemipteran abundance showed a distinct, positive correlation with water temperature. Another general trend for this taxon, particularly the notonectids, was to be more abundant in ponds rather than in "sheet flow" habitats (which may reflect higher temperatures in pond habitats).

Snails

Snails were widespread in the study area and present (at least one species) at all sites. Individual snail species appeared to show some generally trends with respect to conductivity, e.g., *Stagnicola* sp. tended to predominate in the more saline habitats, whereas *Physella* was more common in less saline habitats. As a group, pulmonate snails are generally indicative of eutrophic conditions. In the wetlands, however, there was not a distinct trend between snail abundance and enrichment (Fig. 6). This lack of a trend with enrichment may have been influenced by leeches. Snails are common prey for leeches, and snail numbers were negatively correlated with leech abundance (Fig. 7).

Leeches

Leeches were widespread but most abundant in the Central Davis transects, primarily because of the abundance of *Helobdella stagnalis*. Leeches typically increase with nutrient enrichment, and their abundance in the wetlands showed a general increase in number with increasing phosphorus levels (Fig. 8).

Hyallela azteca

Hyallela is primarily found where groundwater reaches the surface through springs or shallow water tables. In the wetlands, *Hyallela* was most common in ponds, and it was rare or absent in sheet-flow areas (e.g., North and Central Davis WTTP). Hyallela did show some relationships to the physical/chemical parameters; in particular, it was intolerant of enriched conditions and was rare in habitats where conductivity was >5000 μmhos/cm (Fig. 9). It also was generally rare in habitats with high water temperatures. The distribution of *Hyallela* may also have been influenced by mosquito spraying, because amphipods are sensitive to malathion (Toxicity references).

Other Taxa

Flatworms were primarily found in Kays Creek and the Central Davis transects. Flatworms typically are found in habitats with some current present and are tolerant of enrichment.

Other taxa, including various dipterans, isopods, and aquatic beetles, were too rare or limited in distribution to draw any conclusions regarding their relationships to physical/chemical parameters. All of these other taxa are considered to be tolerant of a wide range of habitats based on salinity and nutrient enrichment.

One of the Farmington Bay samples had a high number of the cranefly *Holorusia hespera*, the only "shredder" macroinvertebrate collected. The abundance of these cranefly larvae in the one sample suggests an accumulation of leaves, either terrestrial or from aquatic macrophytes.

Community Statistics

The community-level metrics and indices for each sample are given in Table 3. All of the taxa present in the wetlands would be considered either “tolerant” or “highly tolerant” of pollution based on the usual tolerance indices (both HBI and CTQ). As such, there is little difference between sites in the values for these community tolerance indices.

There were no significant correlations between tolerance/diversity/trophic indices and the physical/chemical parameters that were not already reflected more clearly in the trends of individual taxa discussed above.

Community Composition and Physical/Chemical Parameters

Factor analysis was used to combine data into a single variable each for the macroinvertebrate and chemical data to further examine overall gradients. The macroinvertebrate factor included mayflies (*Callibaetis*), odonates, hemipterans, and chironomids as included variables. Other taxa, such as leeches, *Hyallela*, and snails, typically were similar in response to one or more of the included groups, and, for the sake of parsimony, were not directly included in the analysis. The chemical factor included pH, conductivity, and phosphorus. Dissolved oxygen was indirectly included as it was highly correlated with pH and phosphorus. Temperature was not included, because data were not available for all of the sites.

A plot of the wetlands sampling sites according to the factor scores for each site is shown in Figure 10. Low values on the x-axis for water chemistry reflect eutrophic, “freshwater” habitats (i.e., high phosphorus + low dissolved oxygen +low pH + relatively low conductivity); high values indicate low nutrient/saline habitats (i.e., low phosphorus + high dissolved oxygen + high pH + high conductivity). The y-axis represents the macroinvertebrate factor. Low values on this axis indicate a community dominated by chironomids and leeches, whereas higher values indicate increasing numbers of hemipterans and mayflies. Overall, the graph indicates the general trend from the eutrophic sites (Central and North Davis) dominated the most by chironomids and leeches to the oligotrophic, saline sites (Widgeon inflow and outflow, Pintail, and Ambassador Ponds 2 and 5) dominated by mayflies and hemipterans. Sites in-between these extremes reflect more moderate water chemistry. Most of these “in-between” sites showed the influence of groundwater inputs as indicated by the relatively high numbers of *Hyallela* (e.g., Ambassador 1, New State 5_6, New State 20, Farmington Bay sites) or flatworms (e.g., Kays Creek sites).

At areas where multiple samples were taken in transects, a few trends are apparent. In Widgeon Lake, the macroinvertebrate community generally reflected the reduced salinities of the interior transects compared to the inflow and outflow habitats (Fig. 11). The most noticeable changes in the macroinvertebrates were the reduced numbers of hemipterans, odonates and *Hyallela* in the transects compared to the inflow and outflow sites. These differences may also reflect a temperature gradient, particularly for the hemipterans, but temperature data were not available for the transects.

In the Central Davis transects, differences in the macroinvertebrate communities correlated with dissolved oxygen levels (Fig. 12). Although *Chironomus* is tolerant of low oxygen, it apparently was intolerant of the very low levels found in Transect 2.

There was little difference in the physical/chemical conditions between the three North Davis transects. Consequently, the differences in the macroinvertebrate communities indicated in Figure 10 likely reflect normal sample variation.

Conclusions and Recommendations

The preliminary data suggest that some macroinvertebrates may be useful for indicating certain habitat conditions. In particular, *Callibaetis* and odonates show opposite trends in abundance with respect to conductivity, and thus these two taxa could serve as general indicators of salinity. *Callibaetis* may also indicate enrichment, but this trend may be influenced by pesticide use. Chironomids and leeches had their greatest abundance in habitats with high nutrient levels and thus could serve a indicators of enrichment, at least up to a point. Hemipterans may also be useful as indicators of nutrient enrichment. In addition, their strong relationship to temperature may be useful in indicating increased water temperatures due to reduced flows, for example. *Callibaetis*, *Chironomus*, and *Hyallela* are the most sensitive macroinvertebrates to malathion of the taxa present, so any sampling regime would need to keep track of spraying schedules to account for potential toxic effects.

The data suggest that identification of macroinvertebrates to genus or species level would not be necessary, i.e., identification to the subclass/order (Odonata, Hemiptera, Hirudinea) and family (Baetidae, Chironomidae) levels would be sufficient for meaningful conclusions relative to salinity and enrichment gradients. The data also indicate that the application of typical macroinvertebrate community metrics and indices typically used with lotic macroinvertebrate communities are of little value in distinguishing impacts on communities in these wetland/pond habitats.

Among the physical/chemical parameters, it would be useful to know aspects of water permanence at the various sites (e.g., depth of water or seasonal drying) to account for the possibility that some habitats may not have certain taxa due to larval/nymphal developmental times that are too long with respect to water availability. Dissolved oxygen was shown to be an important variable, but its measurement requires diel sampling to determine if nighttime concentrations fall to low levels or even zero, especially in enriched habitats. The macroinvertebrate data indicate that dissolved oxygen levels below 4 mg/L are likely to be limiting to several taxa. Diel water temperature variation, measured with a HOBO probe, for example, would also be useful, particularly to determine potentially limiting maximum temperatures.

General Literature

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Table 1 **List of Taxa** **2004-2005**

Insecta				**Taxon Code**	**Trophic Category**	**(insects only) Life Stage(s) Collected**
Order	**Family**	**Genus**	**Species**			
Ephemeroptera	Baetidae	*Callibaetis*	sp.	273	GC	nymph
	Caenidae	*Caenis*	sp.	286	GC	nymph
Trichoptera	Leptoceridae	*Ylodes*	sp.	432	SH	larva
	Leptoceridae	*Oecetis*	sp.	431	PR	larva
Odonata	Coenagrionidae	*Ischnura*	*barberi*	350	PR	nymph
	Coenagrionidae	*Ischnura*	*cervula*	350	PR	nymph
	Aeshnidae	*Aeshna*	*californica*	345	PR	nymph
	Libellulidae	*Erythemis*	*collocata*	356	PR	nymph
	Libellulidae	*Tramea*	*lacerata*	356	PR	nymph
Hemiptera	Corixidae	*Corisella*	*inscripta*	330	PR	nymph & adult
	Corixidae	*Trichocorixa*	*verticalis*	330	PR	nymph & adult
	Corixidae	*Hesperocorixa*	*laevigata*	330	PR	nymph & adult
	Notonectidae	*Notonecta*	*undulata*	335	PR	nymph & adult
	Belostomatidae	*Lethocerus*	sp.	329	PR	nymph
	Gerridae	*Limnoporus*	sp.	lim	PR	adult
	Nepidae	*Ranatra*	sp.	334	PR	adult
Diptera	Tipulidae	*Holorusia*	*hespera*	hol	SH	larva
	Stratiomyidae	*Caloparyphus*	sp.	245	GC	larva
	Dolichopodidae		sp.	226	PR	larva
	Simuliidae		sp.	244	FC	larva
	Culicidae		sp.	221	FC	larva
	Ephydridae	*Ephydra*	sp.	235	GC	larva
	Tabanidae		sp.	249	PR	larva
	Chironomidae	*Chironomus*	sp.	84	GC	larva
	Chironomidae	Orthocladiinae	sp.	86	GC	larva
	Chironomidae	Tanytarsini	sp.	84	GC	larva
	Chironomidae	Tanypodinae	sp.	89	PR	larva

List of Taxa (con't.)						
Insecta				**Taxon Code**	**Trophic Category**	**(insects only) Life Stage(s) Collected**
Order	**Family**	**Genus**	**Species**			
Coleoptera	Dytiscidae	*Agabus*	sp.	16	PR	larva & adult
	Dytiscidae	*Hydroporus*	sp.	hyd	PR	larva & adult
	Dytiscidae	*Hydaticus*	sp.	hyt	PR	larva & adult
	Dytiscidae	*Laccophilus*	sp.	23	PR	larva & adult
	Dytiscidae	*Graphoderus*	sp.	19	PR	adult
	Hydrophilidae	*Ametor*	sp.	58	CG	adult
	Hydrophilidae	*Enochrus*	sp.	eno	CG	larva & adult
	Hydrophilidae	*Berosus*	sp.	59	CG	larva
	Hydrophilidae	*Tropisternus*	sp.	69	A-CG, L-PR	larva & adult
	Hydrophilidae	*Hydrophilus*	sp.	hyp	A-CG, L-PR	larva
	Haliplidae	*Haliplus*	sp.	52	SH	larva & adult
	Gyrinidae	*Gyrinus*	sp.	50	PR	adult
Crustacea	Hyalellidae	*Hyallela*	*azteca*	489	GC	
	Asellidae	*Caecidotea*	*occidentalis*	493	GC	
	Artemiidae	*Artemia*	*franciscana*	art	FC	
Gastropoda	Physidae	*Physella*	sp.	504	SC	
	Lymnaeidae	*Stagnicola*	sp.	503	SC	
	Planorbidae	*Gyraulus*	sp.	505	SC	
Annelida	Erpobdellidae	*Erpobdella*	*parva* complex	1	PR	
	Glossiphoniidae	*Glossophonia*	*complanata*	3	PR	
	Glossiphoniidae	*Helobdella*	*stagnalis*	3	PR	
"Oligochaeta"			sp.	5	GC	
Turbellaria			sp.	513	PR	
Ostracoda			sp.	495	GC	
Acari			sp.	7	PR	

Trophic Categories

SH = shredder	**PR = predator**
GC = gatherer-collector	**FC = filterer-collector**

Table 2: Number per sample for each taxon

Trophic Category	HBI Tolerance Index	CTQ Tolerance Index	Taxon	Widgeon L. PSG inflow	Widgeon L. PSG outflow	Widgeon L. PSG Transect 4	Widgeon L. PSG Transect 5	Widgeon L. PSG Transect 6
GC	9	72	*Callibaetis* sp.	87	173	102	76	53
GC	7	72	*Caenis* sp.					
PR	9	72	*Ischnura* sp.	9	5			
PR	8	72	*Aeshna* sp.	1				
PR	8	72	*Erythemis* sp.					
PR	9	72	*Tramea* sp.					
PR	8	108	*Corisella* sp.	3	10			
PR	8	108	*Hesperocorixa* sp.	29	29	3	7	11
PR	8	108	*Notonecta* sp.	3	10	1	2	1
SH	5	72	*Holorusia hespera*					
GC	8	108	Stratiomyidae sp.					
PR	4	108	Dolichopodidae sp.					
FC	6	108	Simuliidae sp.		1			
FC	8	108	Culicidae sp.		1		2	
GC	10	108	*Chironomus* sp.	4	49	3	24	44
GC	10	108	Orthocladiinae sp.		2	3		
GC	10	108	Tanytarsini sp.		1	11	20	4
PR	10	108	Tanypodinae sp.					
PR	8	72	*Agabus* sp.	1	3		2	1
PR	5	72	*Hydroporus* sp.					2
PR	5	72	*Hydaticus* sp.					
SC	8	108	*Physella* sp.	6	18			
SC	10	108	*Stagnicola* sp.	4	14	6	21	6
SC	8	108	*Gyraulus* sp.					
GC	8	108	*Hyallela azteca*	46	8			
GC	8	108	*Caecidotea occidentalis*					
PR	8	108	*Erpobdella parva* complex					
PR	8	108	*Glossophonia complanata*					
PR	6	108	*Helobdella stagnalis*					
GC	10	108	Naididae/Tubificidae sp.					
PR	7.5	108	*Phagocota/Dugesia* sp.					

Trophic Categories
SH = shredder **GC = gatherer-collector** **FC = filterer-collector** **PR = predator; SC = scraper**

Table 2 (continued)

Taxon	Pintail L. PSG ourfall	Farmington Bay WMA Turpin Unit Culvert 7, Site 1	Farmington Bay WMA Turpin Unit Culvert 17, Site 1	Farmington Bay WMA Turpin Unit Culvert 7, Transect 6	Ambassador 1 Pond	Ambassador 100 Pond
Callibaetis sp.	260				1	13
Caenis sp.		1				
Ischnura sp.	29	42	50	10	5	11
Aeshna sp.		2		2		
Erythemis sp.						2
Tramea sp.			3			
Corisella sp.	53	18	7	25	43	20
Hesperocorixa sp.	5		8			3
Notonecta sp.	21	5	3	1		9
Holorusia hespera				22		
Stratiomyidae sp.	1					
Dolichopodidae sp.		1				
Simuliidae sp.						
Culicidae sp.						
Chironomus sp.	22	2		5		
Orthocladiinae sp.	5	2	2	2		
Tanytarsini sp.	1		2			
Tanypodinae sp.	5			5		
Agabus sp.	3					
Hydroporus sp.	1		1			
Hydaticus sp.		2				
Physella sp.	30	29	25	34	1	14
Stagnicola sp.	4			9	3	12
Gyraulus sp.	8	2	4		1	3
Hyallela azteca	14	164	231	44	74	52
Caecidotea occidentalis						
Erpobdella parva complex			1			
Glossophonia complanata		1	5			
Helobdella stagnalis						
Naididae/Tubificidae sp.						
Phagocota/Dugesia sp.		20				

Table 2 (continued)

Taxon	Ambassador W2 Pond	Ambassador W5 Pond	New State 47 Pond	New State 20 Pond	New State 5-6 Pond
Callibaetis sp.	46	29	22		24
Caenis sp.				8	7
Ischnura sp.	51	7	18	45	109
Aeshna sp.	2	1		2	
Erythemis sp.	1			3	
Tramea sp.					
Corisella sp.	58	31	54	17	47
Hesperocorixa sp.	1			3	5
Notonecta sp.	5	4	3		
Holorusia hespera					
Stratiomyidae sp.					
Dolichopodidae sp.					
Simuliidae sp.					
Culicidae sp.					
Chironomus sp.		26	46	1	
Orthocladiinae sp.		2	2		7
Tanytarsini sp.		1	1		
Tanypodinae sp.					
Agabus sp.		1			
Hydroporus sp.					
Hydaticus sp.		2			
Physella sp.	25	12	20	60	24
Stagnicola sp.	9	3			
Gyraulus sp.				70	18
Hyallela azteca	109	20	28	302	183
Caecidotea occidentalis			2		
Erpobdella parva complex			2		1
Glossophonia complanata					
Helobdella stagnalis					
Naididae/Tubificidae sp.			12		
Phagocota/Dugesia sp.			4	1	

Table 2 (continued)

Taxon	North Davis WWTP Transect 1	North Davis WWTP Transect 2	North Davis WWTP Transect 3	Kays Creek Transect 1	Kays Creek Transect 2
Callibaetis sp.				2	
Caenis sp.					
Ischnura sp.	12	9	13	35	30
Aeshna sp.			1	1	
Erythemis sp.					7
Tramea sp.					
Corisella sp.	13		23	30	17
Hesperocorixa sp.				1	
Notonecta sp.	1		4		10
Holorusia hespera					
Stratiomyidae sp.					
Dolichopodidae sp.					
Simuliidae sp.					
Culicidae sp.					
Chironomus sp.	176	384	30		
Orthocladiinae sp.					1
Tanytarsini sp.		24			4
Tanypodinae sp.					
Agabus sp.					
Hydroporus sp.					
Hydaticus sp.			1		
Physella sp.	3	5	1	1	1
Stagnicola sp.					5
Gyraulus sp.					
Hyallela azteca					
Caecidotea occidentalis					
Erpobdella parva complex					3
Glossophonia complanata					
Helobdella stagnalis					
Naididae/Tubificidae sp.		1	6	6	
Phagocota/Dugesia sp.				136	29

Table 2 (continued)

Taxon	Central Davis WWTP Transect 1	Central Davis WWTP Transect 2	Central Davis WWTP Transect 3	Central Davis WWTP Transect 4
Callibaetis sp.			1	1
Caenis sp.				
Ischnura sp.	9	61	16	9
Aeshna sp.	1	6	5	
Erythemis sp.				
Tramea sp.				
Corisella sp.				25
Hesperocorixa sp.	8		3	
Notonecta sp.	2			2
Holorusia hespera		2		
Stratiomyidae sp.				
Dolichopodidae sp.				
Simuliidae sp.				
Culicidae sp.				
Chironomus sp.	64	8	9	56
Orthocladiinae sp.				150
Tanytarsini sp.	8		29	1
Tanypodinae sp.				56
Agabus sp.				
Hydroporus sp.				
Hydaticus sp.				
Physella sp.	3	8	22	14
Stagnicola sp.	3	7	1	
Gyraulus sp.				
Hyallela azteca			30	1
Caecidotea occidentalis		10	6	1
Erpobdella parva complex	3	11	7	
Glossophonia complanata				
Helobdella stagnalis	33		5	
Naididae/Tubificidae sp.	1		1	
Phagocota/Dugesia sp.	18	57	7	

Table 3: Macroinvertebrate community summary statistics by sample

Sampling Site	Sampling Date	Number in Sample	Total Taxa	Margalef Index	Menhinick Index	Simpson's Diversity Index	Shannon-Weaver Diversity Index	Hill's Evenness	% Contrib. by Top 3 Taxa	SC/Total Number ratio	PR/Total Number ratio	Mod. HBI	CTQ$_a$	CTQ$_d$
Widgeon L. PSG inflow	16-Nov-04	193	11	4.38	0.79	3.53	1.58	0.66	83.9	0.052	0.238	8.6	95	90
Widgeon L. PSG outflow	16-Nov-04	324	14	5.18	0.78	3.11	1.63	0.62	77.5	0.099	0.176	9.0	100	88
Widgeon L. PSG Transect 4	18-Oct-04	129	7	2.84	0.62	1.58	0.84	0.43	92.2	0.047	0.031	9.1	103	80
Widgeon L. PSG Transect 5	18-Oct-04	154	8	3.20	0.64	3.32	1.48	0.71	78.6	0.136	0.071	9.3	99	90
Widgeon L. PSG Transect 6	20-Oct-04	122	8	3.36	0.72	3.07	1.35	0.65	88.5	0.049	0.123	9.3	95	91
Pintail L. PSG ourfall	16-Nov-04	462	16	5.63	0.74	2.92	1.65	0.59	74.2	0.091	0.253	8.8	98	85
Farmington Bay WMA Turpin Unit Culvert 7, Site 1	4-Oct-04	291	14	5.28	0.82	2.81	1.49	0.56	80.8	0.107	0.313	8.1	98	102
Farmington Bay WMA Turpin Unit Culvert 17, Site 1	4-Oct-04	342	13	4.74	0.70	2.07	1.20	0.47	89.5	0.085	0.228	8.2	100	102
Farmington Bay WMA Turpin Unit Culvert 7, Transect 6	21-Oct-04	159	11	4.54	0.87	5.87	1.95	0.81	64.8	0.270	0.270	7.9	97	100
New State 47 Pond	17-Nov-04	214	13	5.15	0.89	6.52	2.06	0.80	59.8	0.093	0.379	8.7	102	101
New State 20 Pond	17-Nov-04	512	11	3.69	0.49	2.58	1.33	0.56	84.4	0.254	0.139	8.1	95	104
New State 5-6 Pond	17-Nov-04	425	10	3.62	0.57	4.61	1.71	0.74	79.8	0.099	0.381	8.3	97	96

Table 3 (continued)

Sampling Site	Sampling Date	Number in Sample	Total Taxa	Margalef Index	Menhinick Index	Simpson's Diversity Index	Shannon-Weaver Diversity Index	Hill's Evenness	% Contrib. by Top 3 Taxa	SC/Total Number ratio	PR/Total Number ratio	Mod. HBI	CTQ_a	CTQ_d
Ambassador 1 Pond	17-Nov-04	128	7	2.85	0.62	2.25	1.01	0.52	95.3	0.039	0.375	8.1	98	106
Ambassador 100 Pond	17-Nov-04	139	10	4.20	0.85	5.19	1.92	0.83	61.9	0.209	0.324	8.3	97	101
Ambassador W2 Pond	17-Nov-04	307	10	3.62	0.57	4.61	1.71	0.74	71.0	0.111	0.384	8.4	94	96
Ambassador W5 Pond	17-Nov-04	139	13	5.60	1.10	6.46	2.03	0.79	61.9	0.108	0.331	8.7	94	98
North Davis WWTP Transect 1	4-Nov-04	205	5	1.73	0.35	1.34	0.56	0.35	98.0	0.015	0.127	9.8	101	106
North Davis WWTP Transect 2	8-Nov-04	423	5	1.52	0.24	1.21	0.40	0.25	98.6	0.012	0.021	10.0	101	107
North Davis WWTP Transect 3	8-Nov-04	79	8	3.69	0.90	3.91	1.54	0.74	83.5	0.013	0.532	9.0	95	101
Kays Creek Transect 1	22-Oct-04	212	8	3.01	0.55	2.19	1.08	0.52	94.8	0.005	0.958	7.9	95	102
Kays Creek Transect 2	26-Oct-04	107	10	4.43	0.97	5.34	1.86	0.81	71.0	0.056	0.897	8.3	101	96
Central Davis WWTP Transect 1	29-Oct-04	153	12	5.04	0.97	4.15	1.78	0.71	75.2	0.039	0.484	8.6	102	106
Central Davis WWTP Transect 2	28-Oct-04	170	9	3.59	0.69	3.97	1.67	0.76	75.9	0.088	0.794	8.3	96	93
Central Davis WWTP Transect 3	1-Nov-04	142	14	6.04	1.17	7.65	2.21	0.84	57.0	0.162	0.303	8.6	100	102
Central Davis WWTP Transect 4	2-Nov-04	316	11	4.00	0.62	3.39	1.51	0.63	82.9	0.044	0.291	9.7	101	107

Table 4 Physical/Chemical Data

STORET No.	**Site Name**	Dissolved Oxygen, mg/L (mean)	pH (mean)	Phosphorus-P, mg/L (mean)	Conductivity, μmhos/cm (mean)	Max. Water Temp., C
4985621	Widgeon L. PSG inflow	11.1	8.53	0.05	4551	28.9
4985620	Widgeon L. PSG outflow	10.97	9.02	0.02	5663	29.6
4985623	Widgeon L. PSG Transect 4	6.63	8.06	0.044	3668	nd
4985624	Widgeon L. PSG Transect 5	7.5	7.68	0.112	3899	nd
4985625	Widgeon L. PSG Transect 6	7.37	8.23	0	3162	nd
4985630	Pintail L. PSG outfall	7.83	8.98	0.12	6102	30.42
4985540	Farmington Bay WMA Turpin Unit Culvert 17, Site 1	5.83	8.95	0.34	2351	23.8
4985515	Farmington Bay WMA Turpin Unit Culvert 7, Site 1	8.42	8.92	0.714	2340	nd
4985517	Farmington Bay WMA Turpin Unit Culvert 7, Transect 6	nd	8.7	0.526	1836	nd
4985320	Ambassador 1 Pond	8.31	8.38	1.04	1553	26.48
4985330	Ambassador 100 Pond	7.74	9.35	0.19	2121	27.79
4985340	Ambassador W2 Pond	10.44	9.37	0.06	4235	34.5
4985350	Ambassador W5 Pond	7.24	9.55	0.05	11294	27
4985870	New State 47 Pond	4.53	8.25	0.59	1467	27.21
4985880	New State 20 Pond	7.27	9.88	0.11	1450	26.54
4985890	New State 5-6 Pond	8.16	9.43	0.2	1630	26.5
4985590	North Davis WWTP Transect 1	5.38	7.88	2.16	1507	nd
4985591	North Davis WWTP Transect 2	4.06	7.86	2.08	1559	nd
4985592	North Davis WWTP Transect 3	4.33	7.76	2.1	1584	nd
4985800	Kays Creek Transect 1	7.7	8.29	0.26	827	23.5
4985810	Kays Creek Transect 2	7.14	8.29	0.098	855	27.51
4985660	Central Davis WWTP Transect 1	5.05	7.55	4.45	1297	23.8
4985670	Central Davis WWTP Transect 2	1.37	7.27	4.52	1503	22.83
4985680	Central Davis WWTP Transect 3	2.71	7.56	2.58	1640	21.7
4985690	Central Davis WWTP Transect 4	5.94	7.72	2.54	1757	22.5

(nd = not determined)

Figure Legends

Figure 1: Abundance of the mayfly *Callibaetis* in relation to physical/chemical variables (Fig. 1a: conductivity; Fig. 1b: pH; Fig. 1c: phosphorus; Fig. 1d: dissolved oxygen; Fig. 1e: maximum water temperature)

Figure 2: Abundance of odonates in relation to physical/chemical variables (Figures 2 a-e as in Fig. 1).

Figure 3: Relationship between the abundance of *Callibaetis* mayflies and odonates.

Figure 4: Abundance of chironomids in relation to physical/chemical variables (Figures 4 a-e as in Fig. 1).

Figure 5: Abundance of hemipterans in relation to physical/chemical variables (Figures 5 a-e as in Fig. 1).

Figure 6: Abundance of snails in relation to phosphorus concentrations.

Figure 7: Relationship between the abundance of snails and leeches.

Figure 8: Abundance of leeches in relations to phosphorus concentrations.

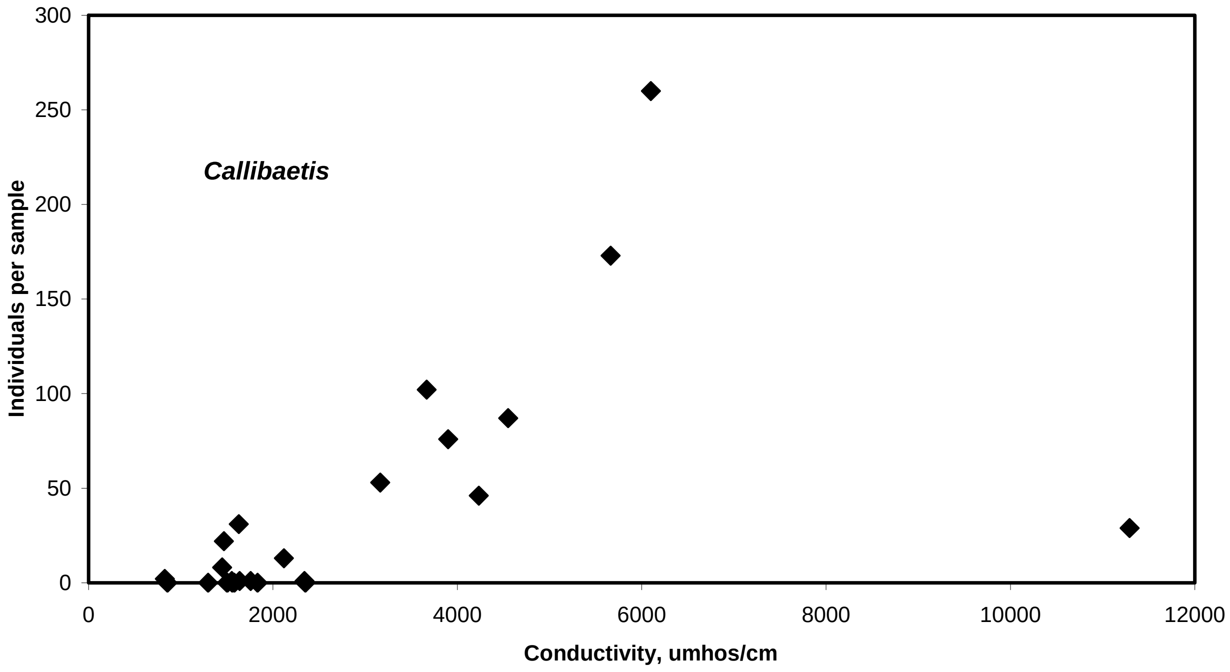
Figure 9: Abundance of the amphipod *Hyallela azteca* in relation to physical/chemical variables (Figures 9 a-e as in Fig. 1).

Figure 10: Plot of macroinvertebrate community and chemical parameter factor scores for each sampling site.

Figure 11: Plot of macroinvertebrate community and chemical parameter factor scores for each sampling site in Widgeon Lake.

Figure 12: Plot of macroinvertebrate community factor scores versus dissolved oxygen for each Central Davis sampling site.

Figure 1a



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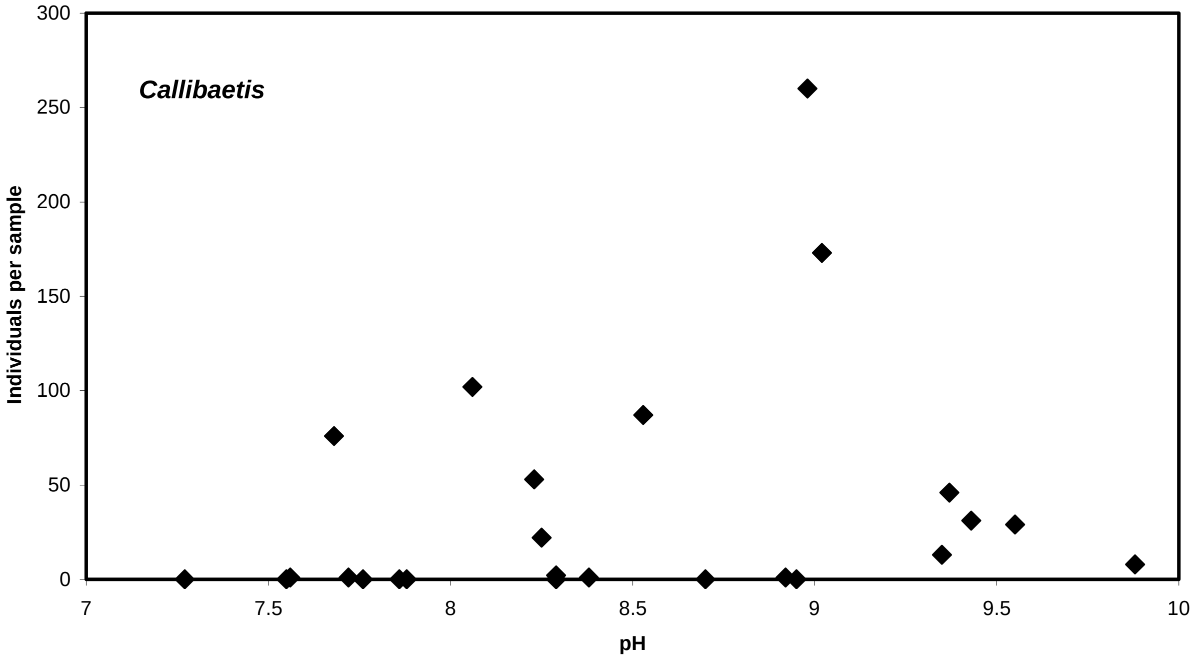


Figure 1c

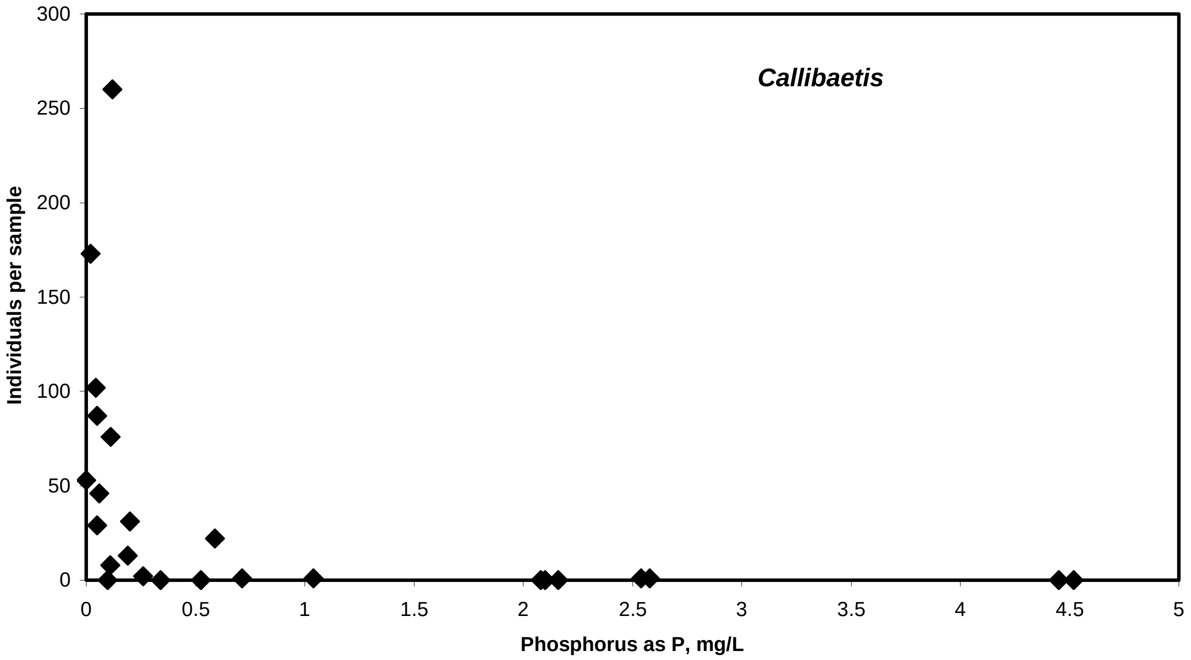
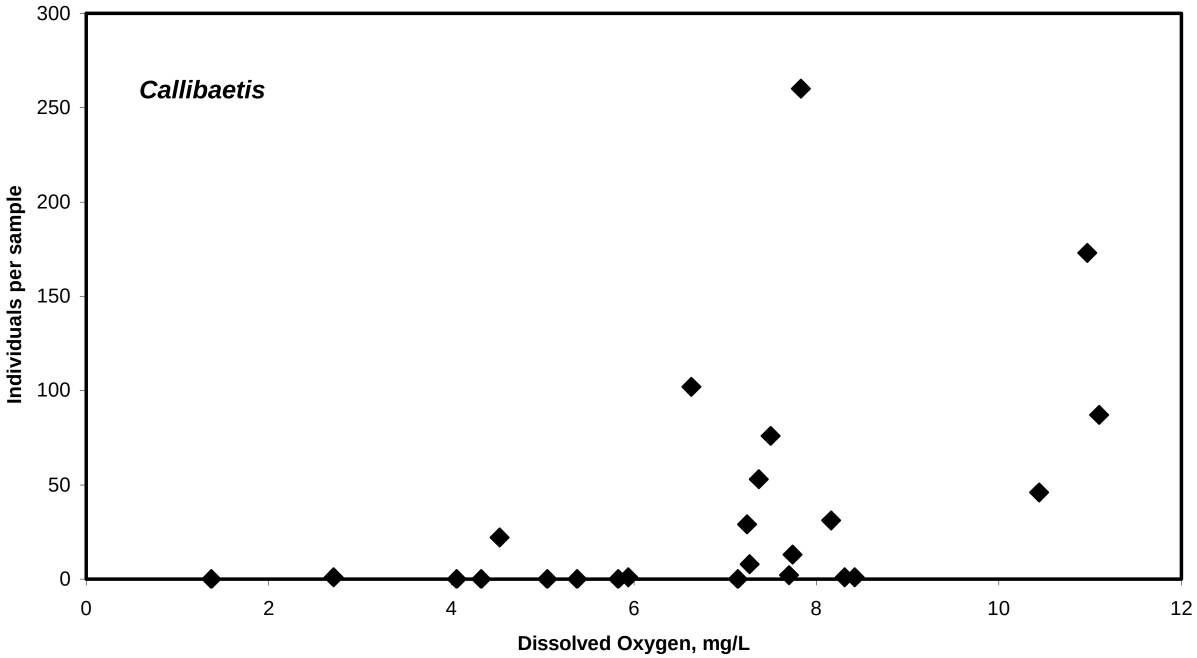


Figure 1d



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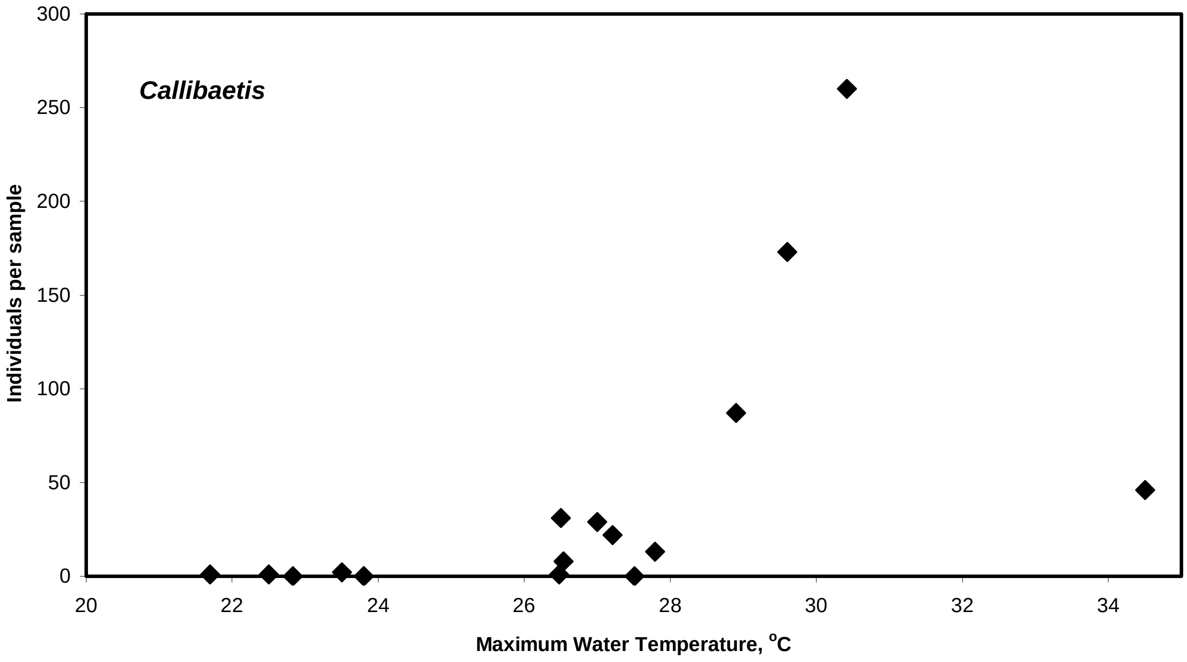

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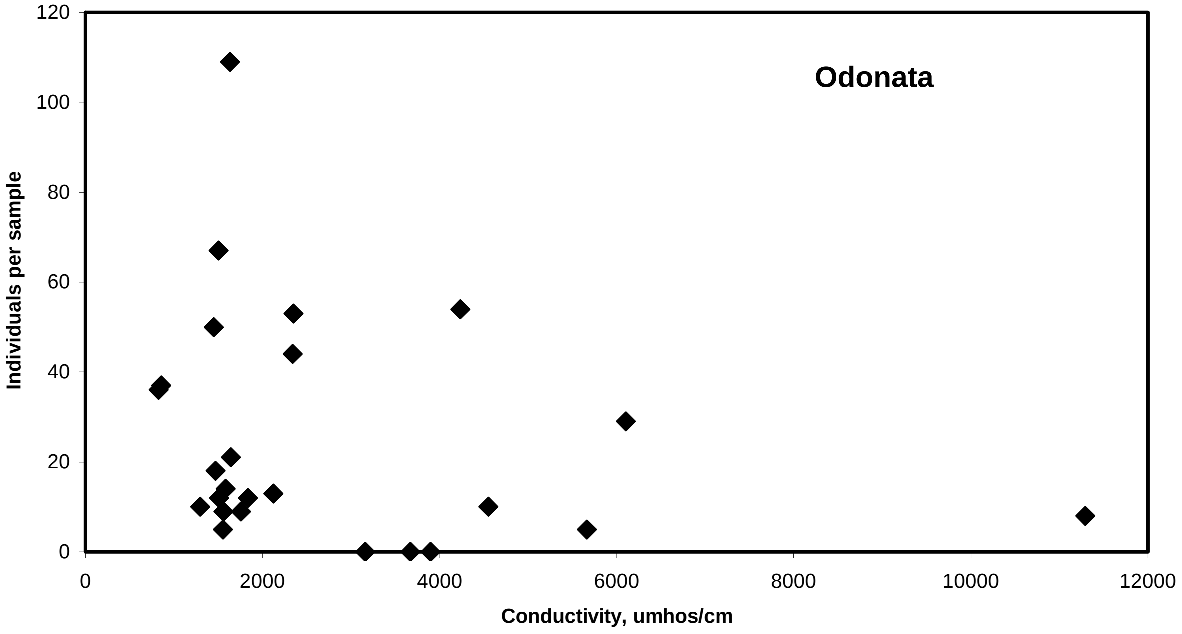

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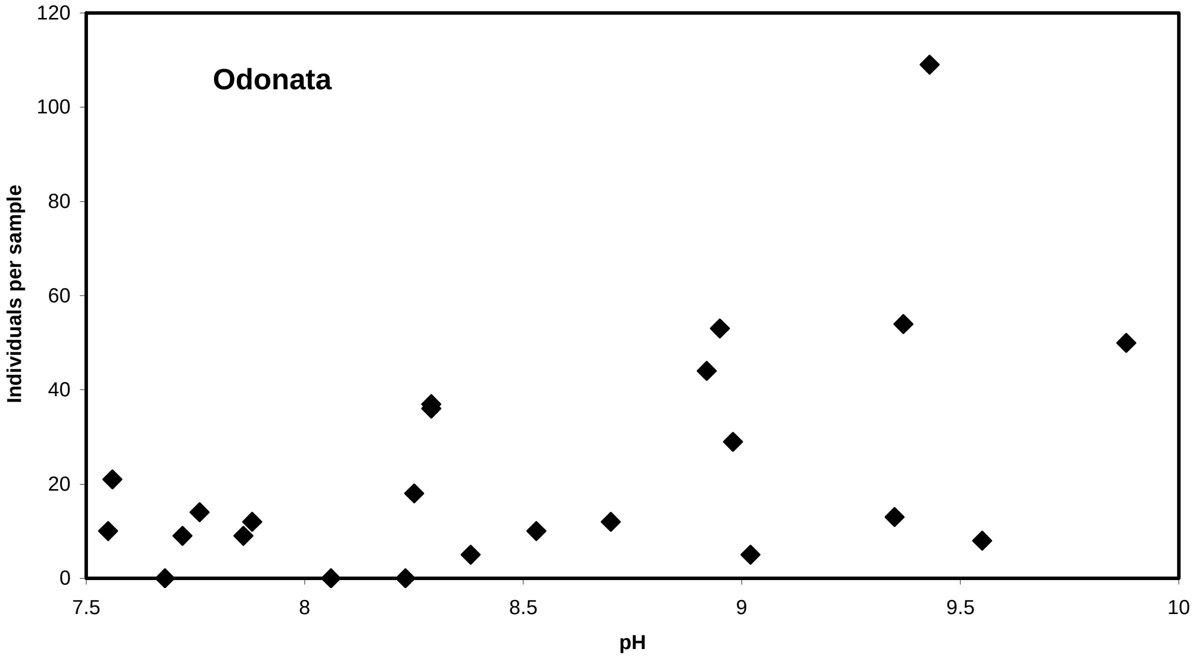

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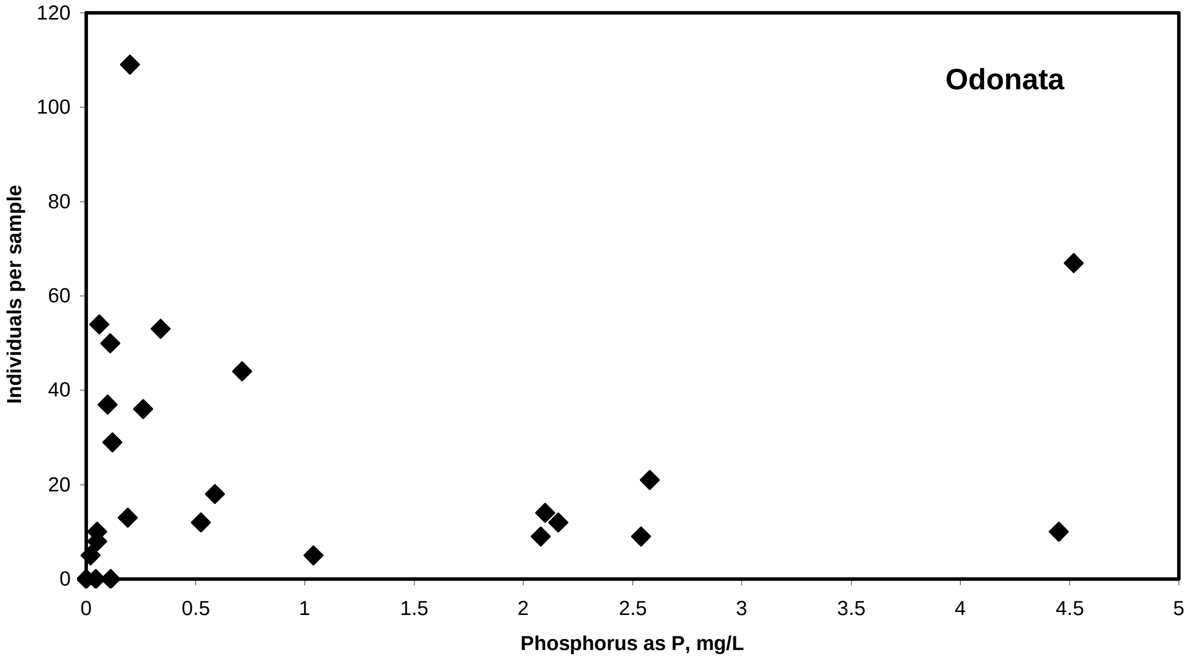

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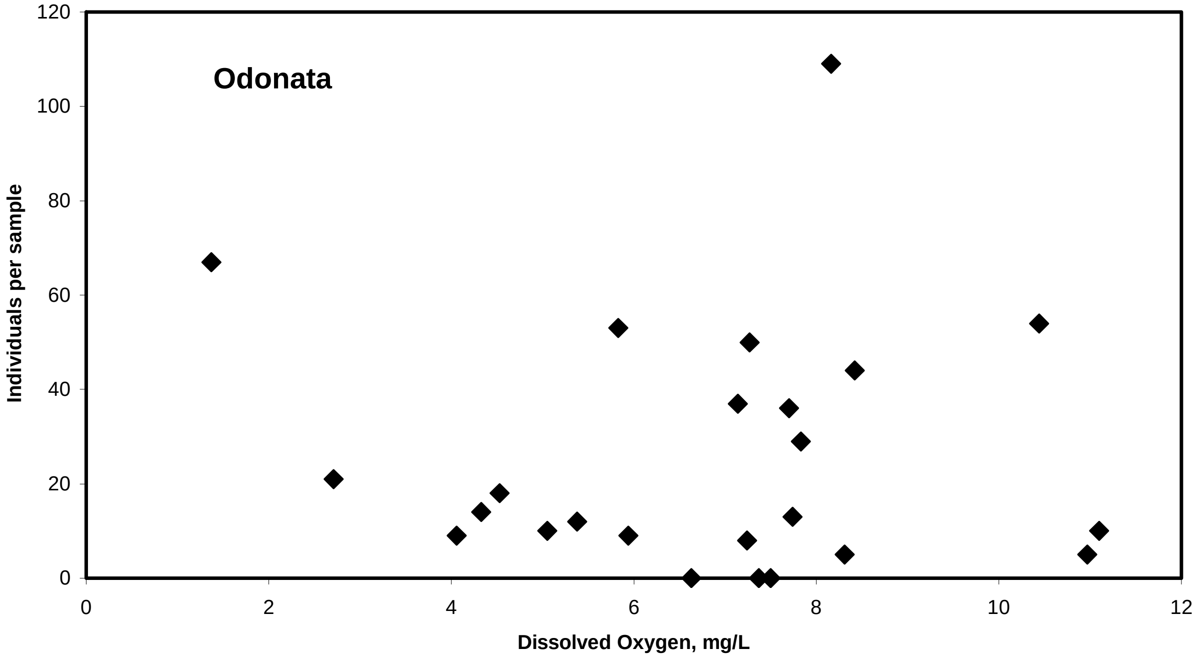

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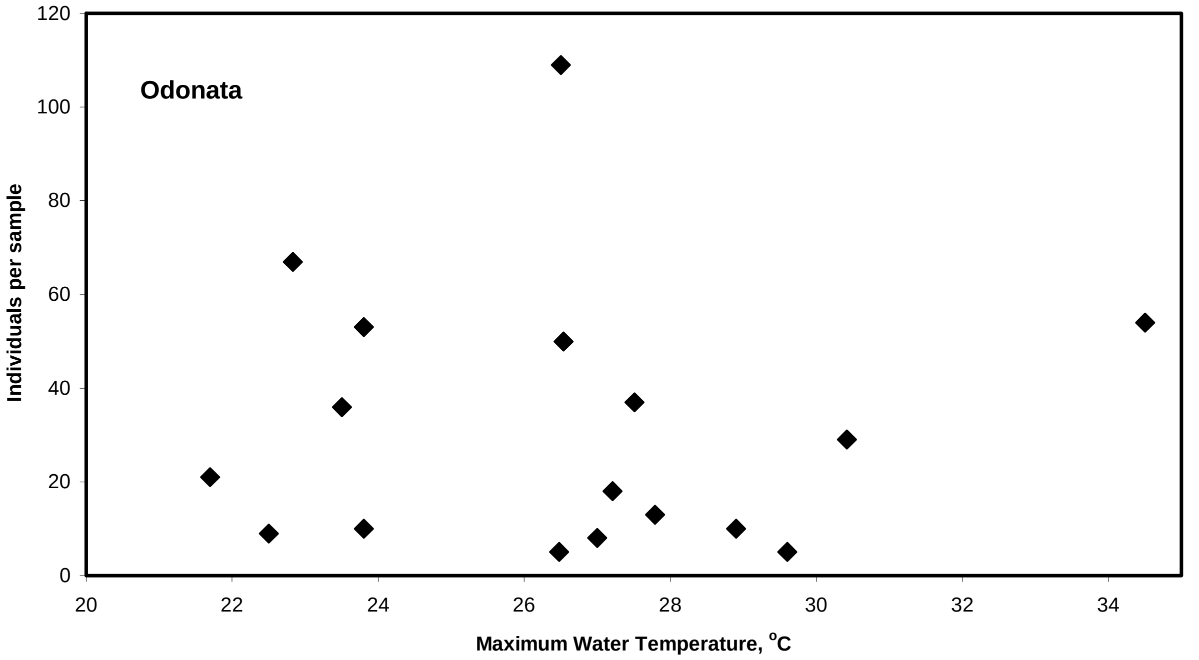
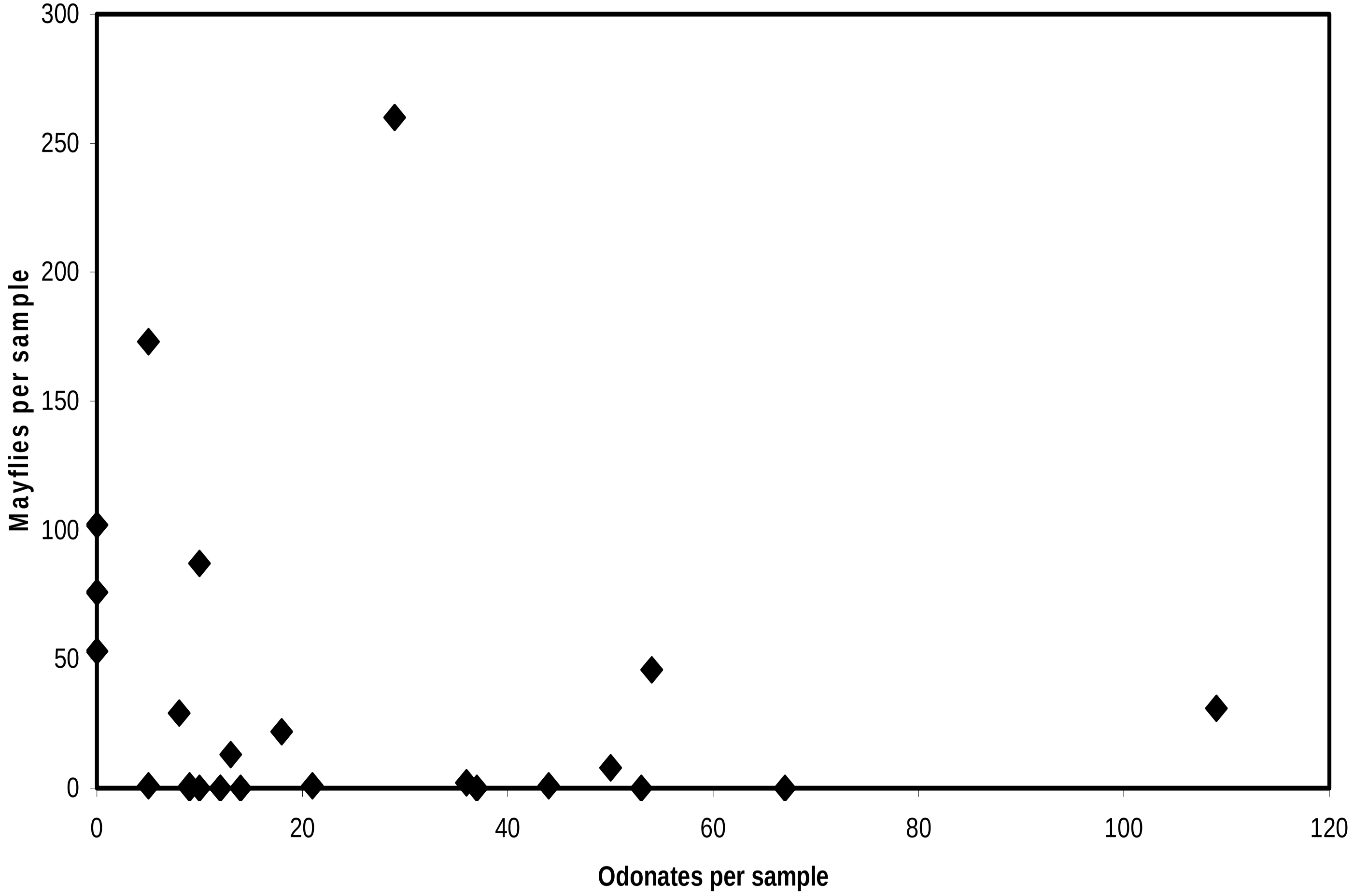


Figure 3: *Callibaetis* and Odonates



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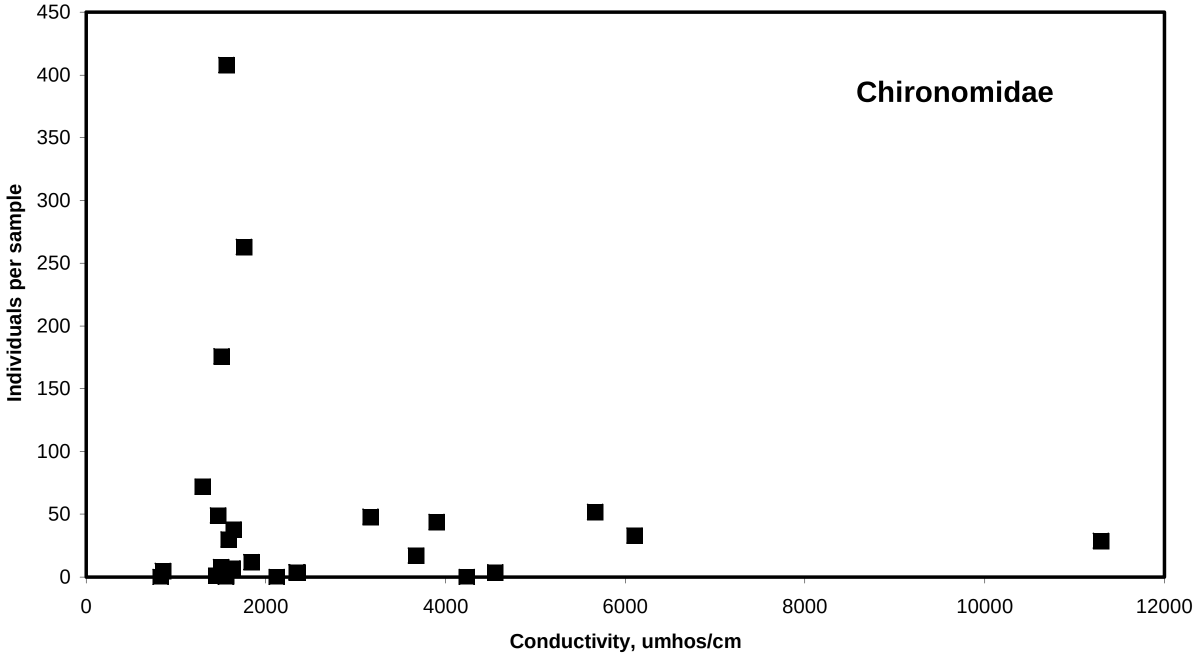

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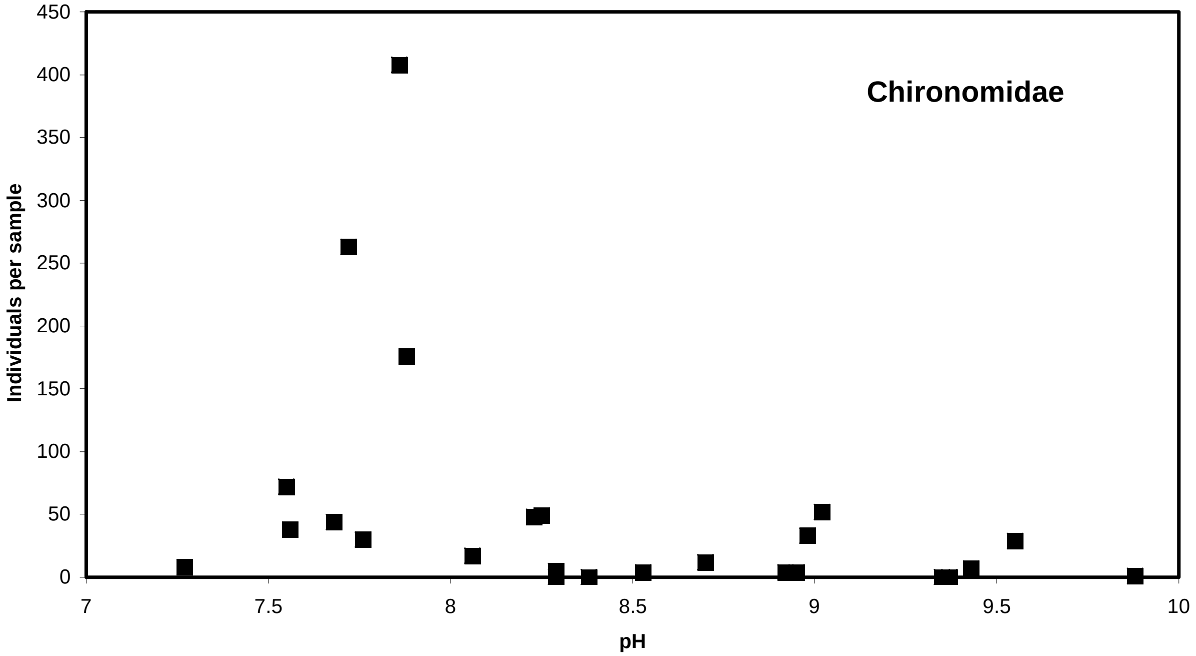

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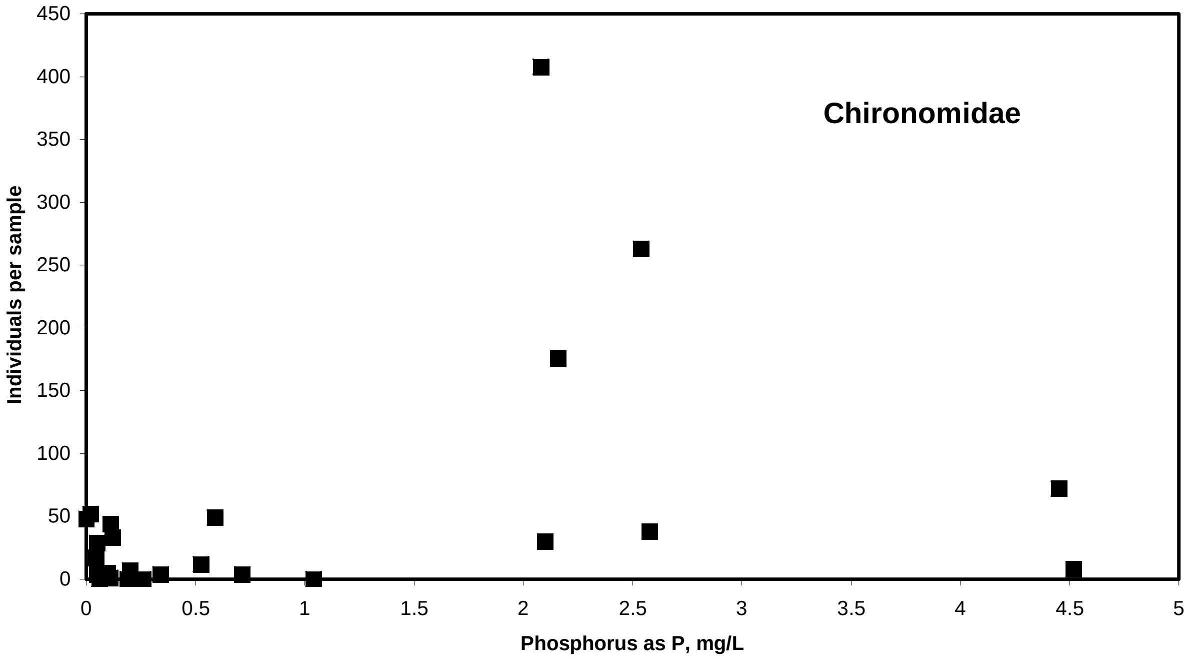

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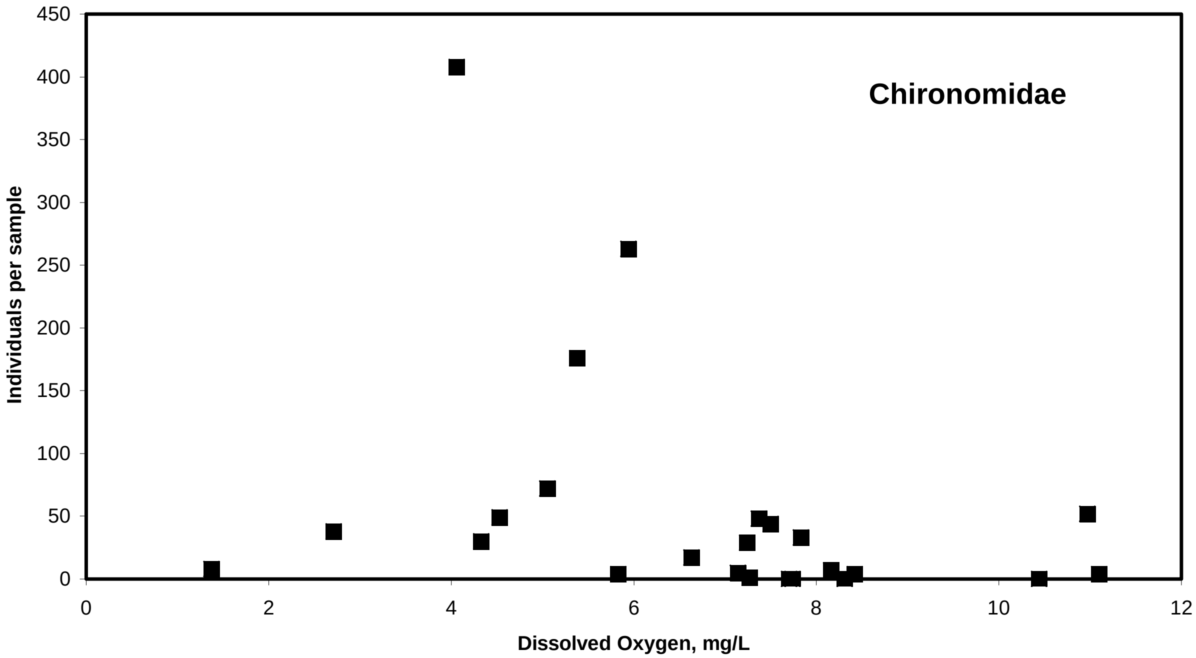

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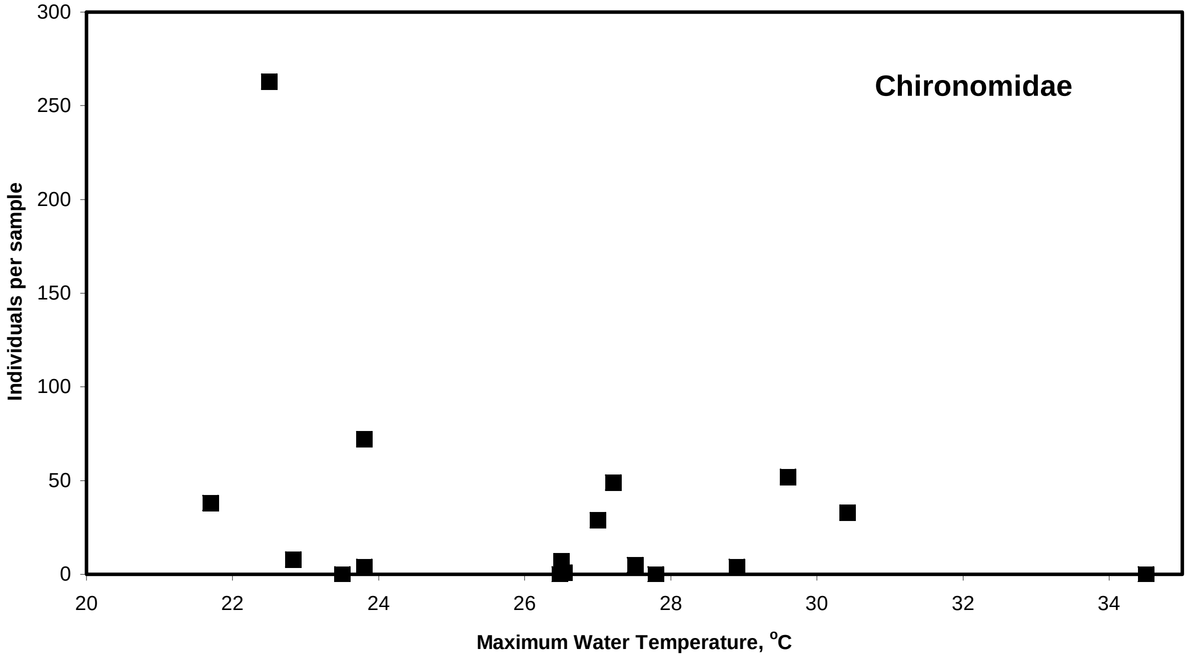

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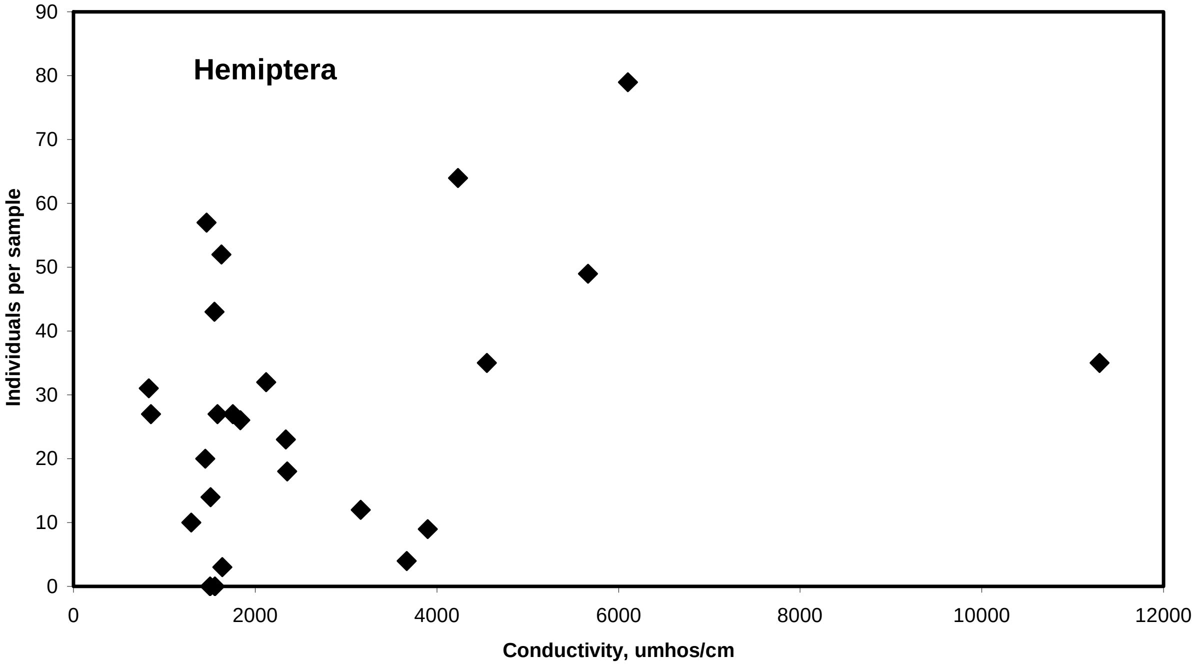

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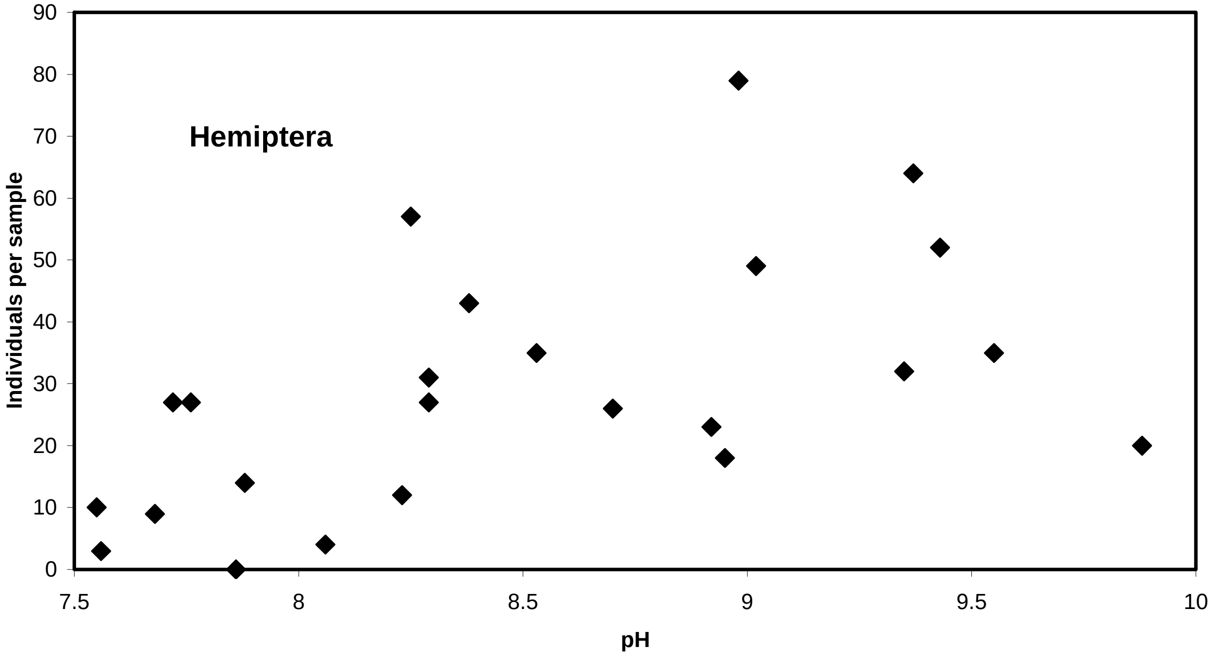

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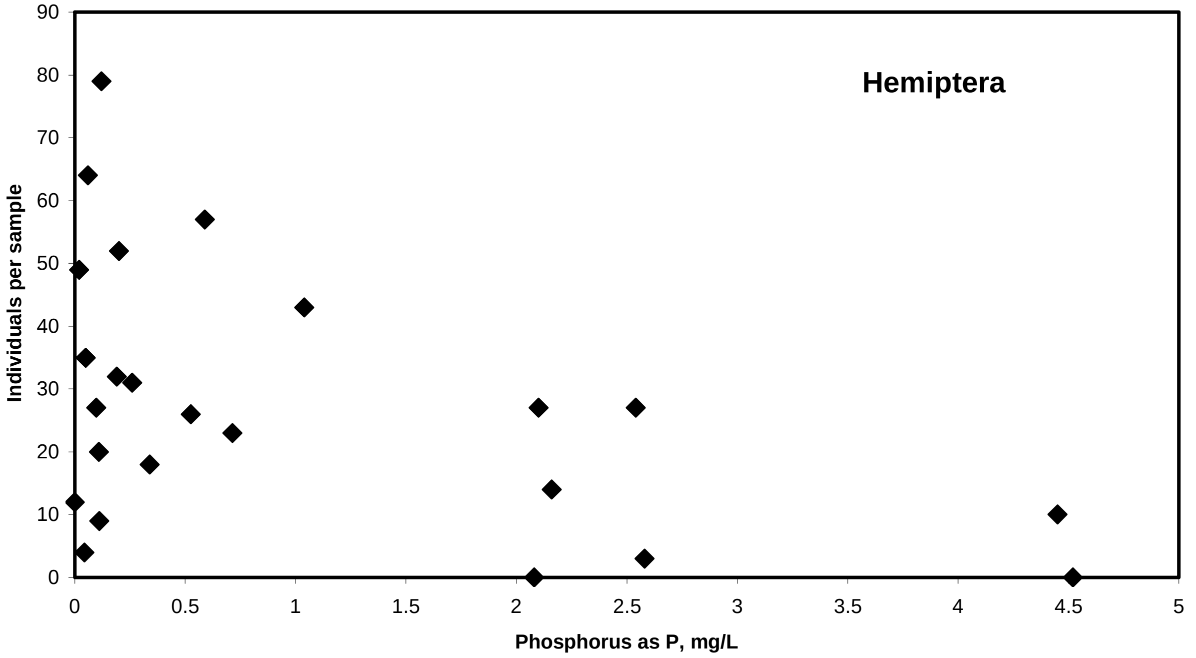

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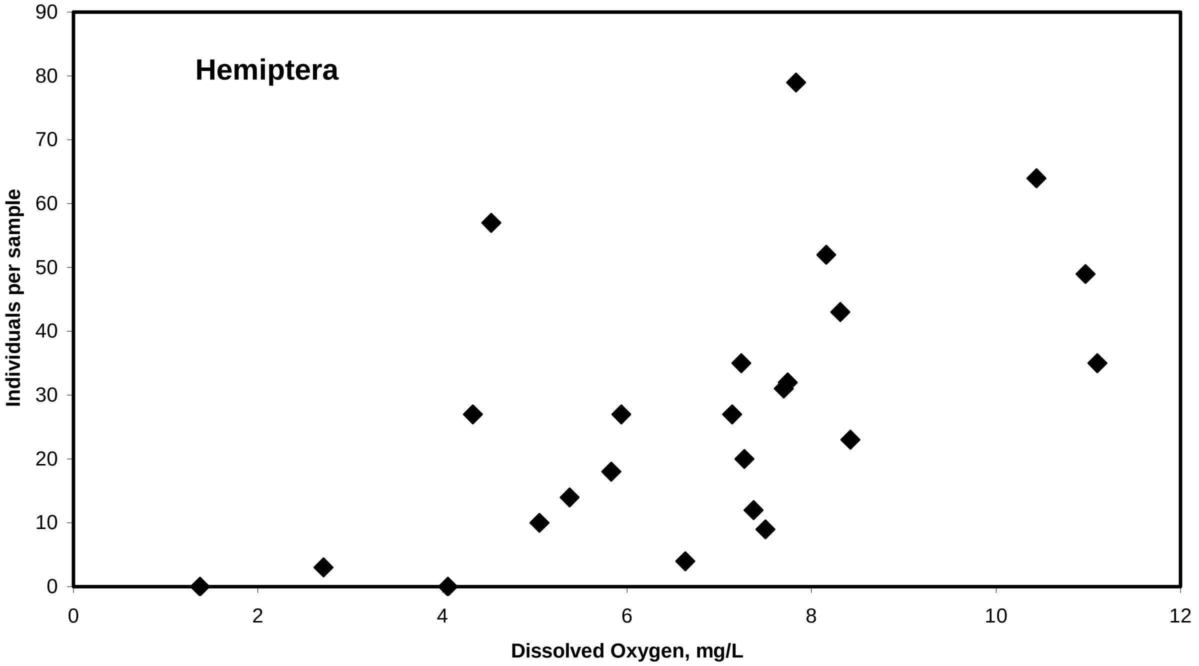

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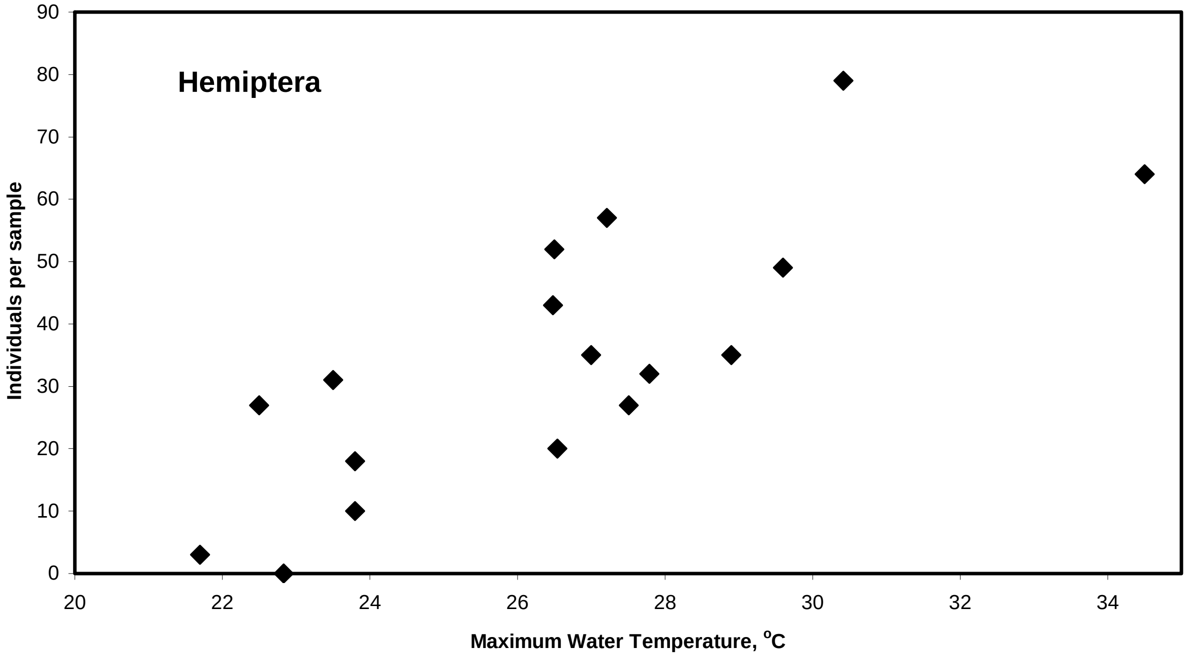

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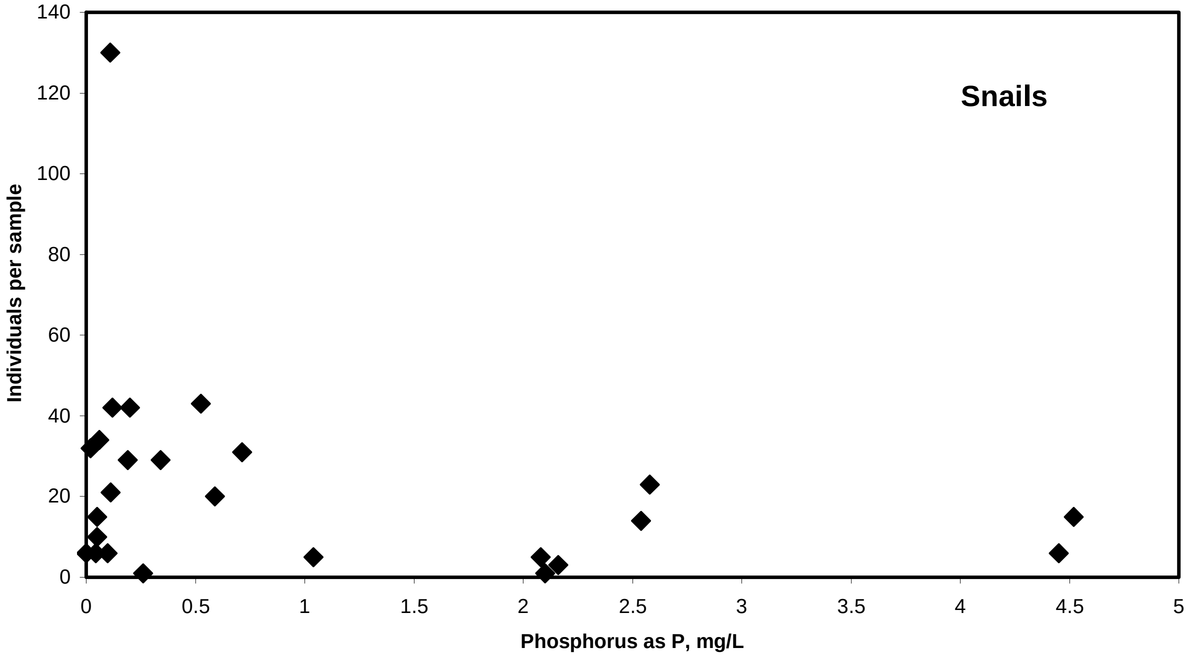
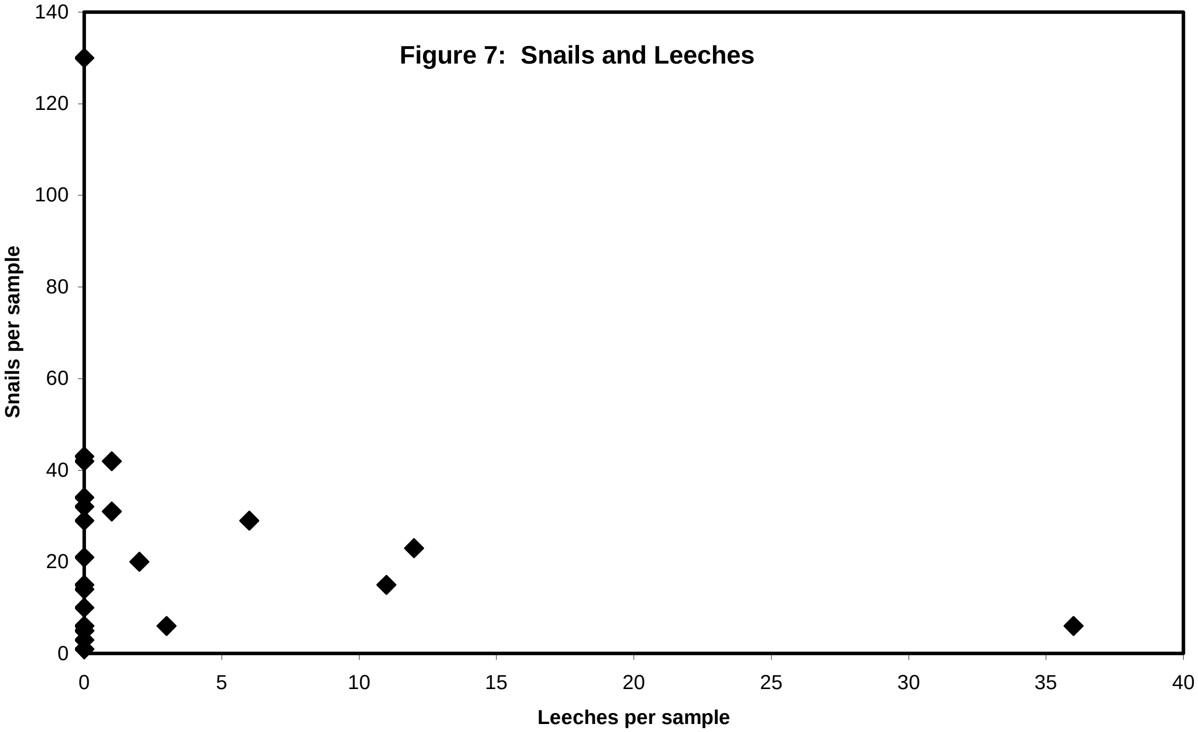


Figure 7: Snails and Leeches



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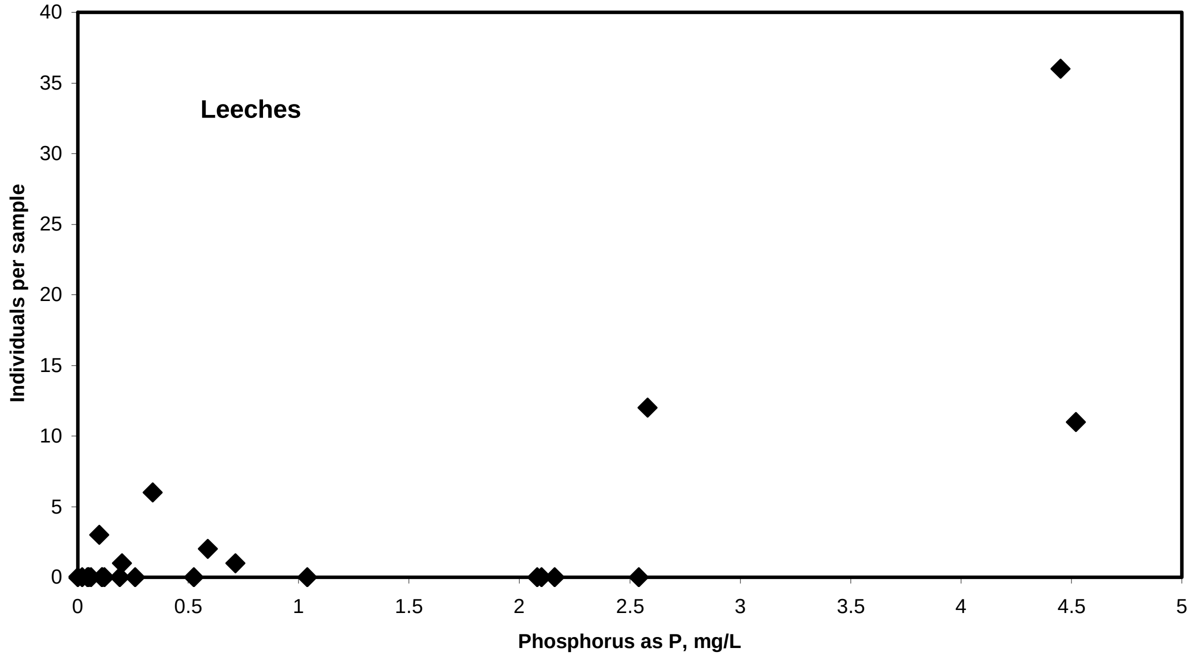

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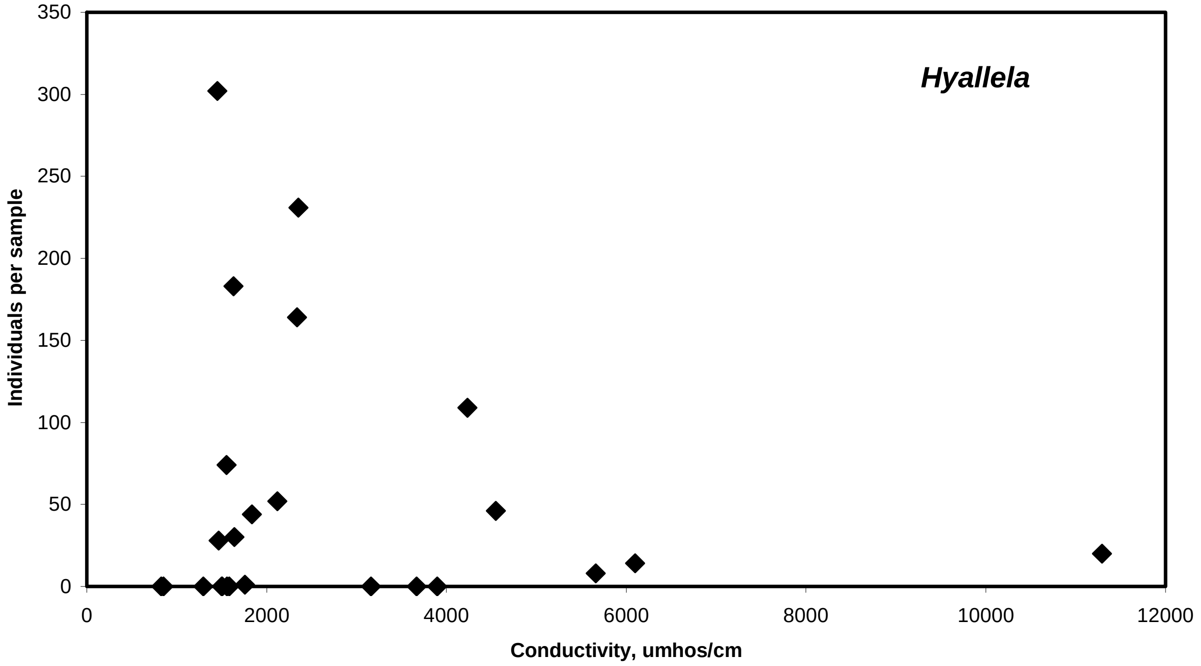

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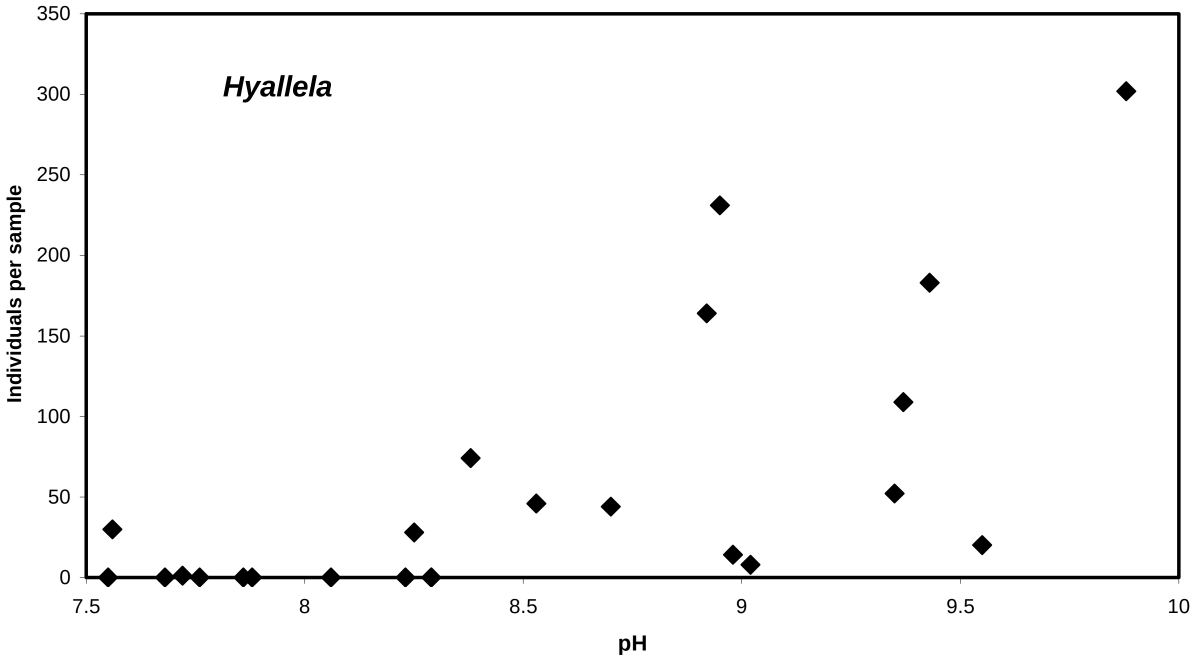

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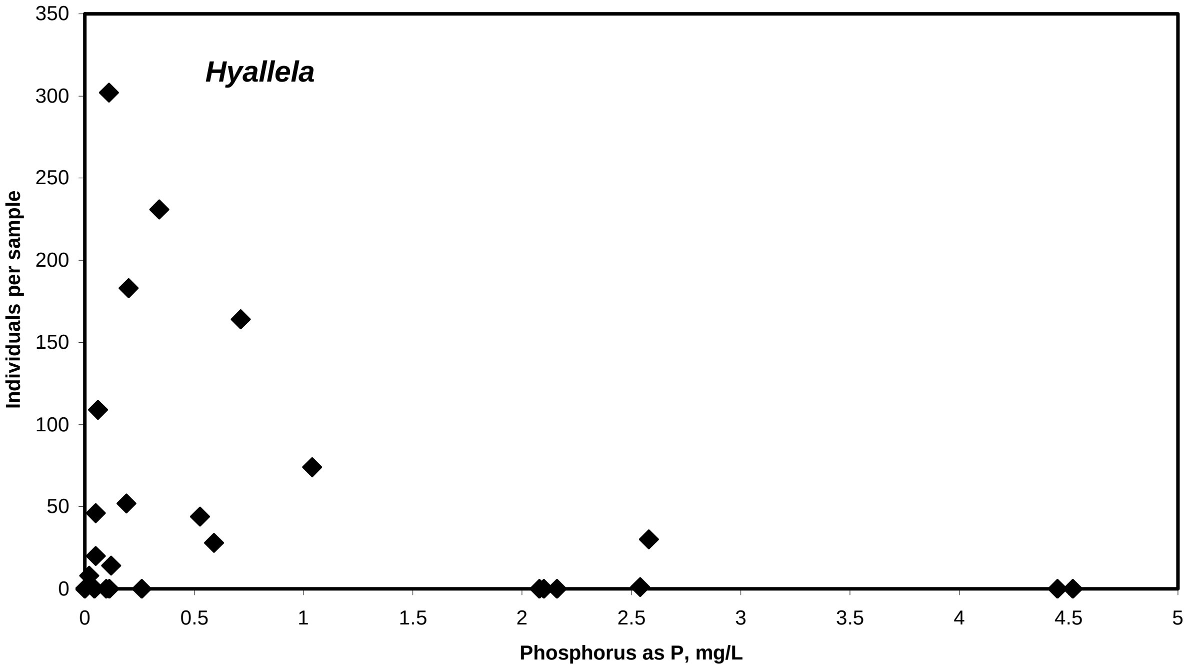

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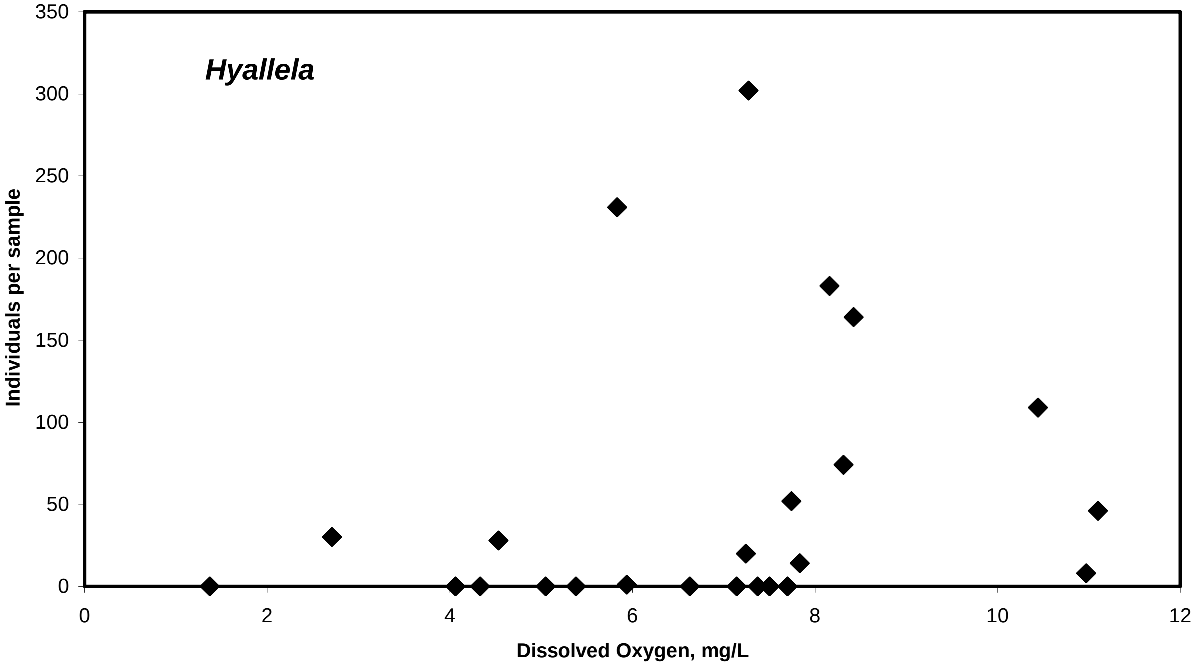

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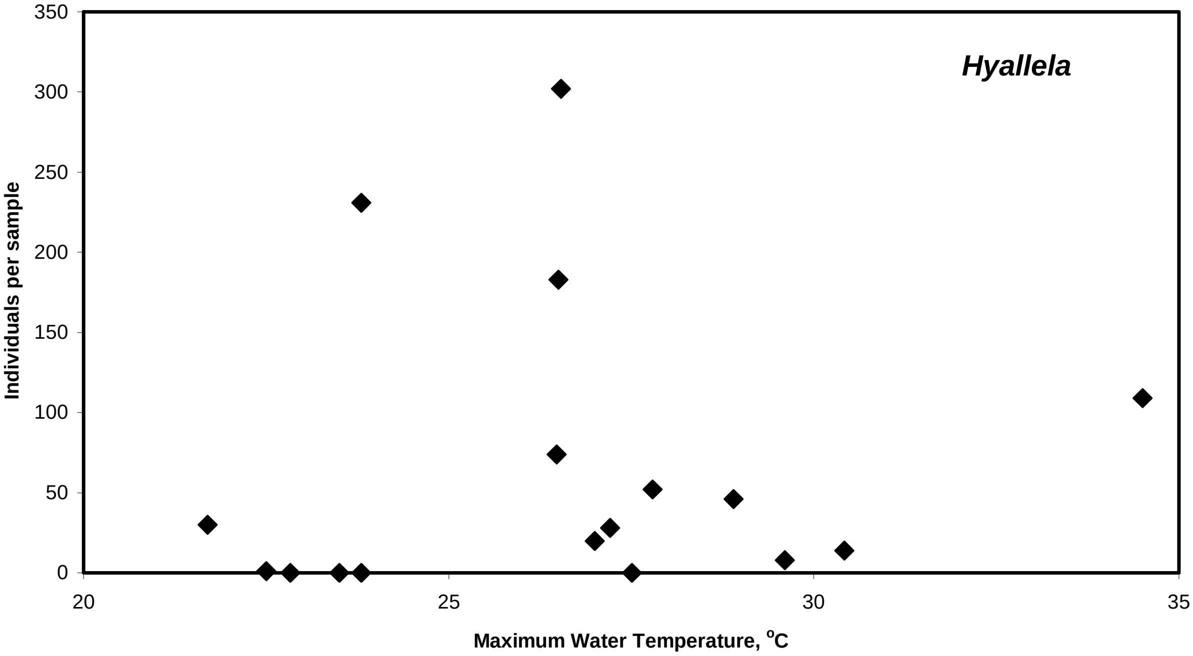


Figure 10

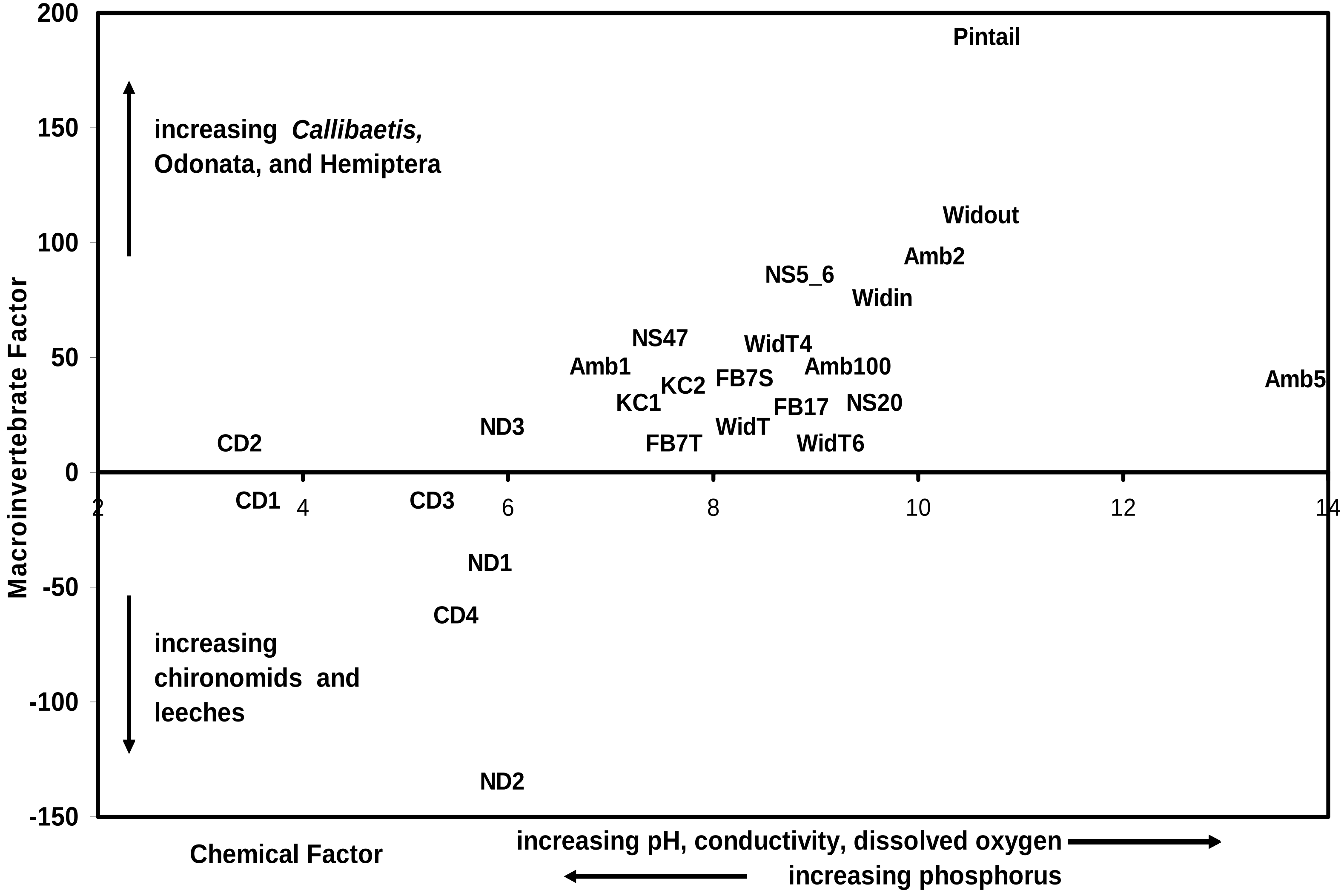

Macroinvertebrate Factor
200
150
100
50
0
-50
-100
-150
2
4
6
8
10
12
14
increasing *Callibaetis*, Odonata, and Hemiptera
increasing chironomids and leeches
Pintail
Widout
Amb2
NS5_6
Widin
NS47
WidT4
Amb1
Amb100
KC2
FB7S
Amb5
KC1
FB17
NS20
ND3
WidT
CD2
FB7T
WidT6
CD1
CD3
ND1
CD4
ND2
Chemical Factor
increasing pH, conductivity, dissolved oxygen
increasing phosphorus

Figure 11: Widgeon Lake

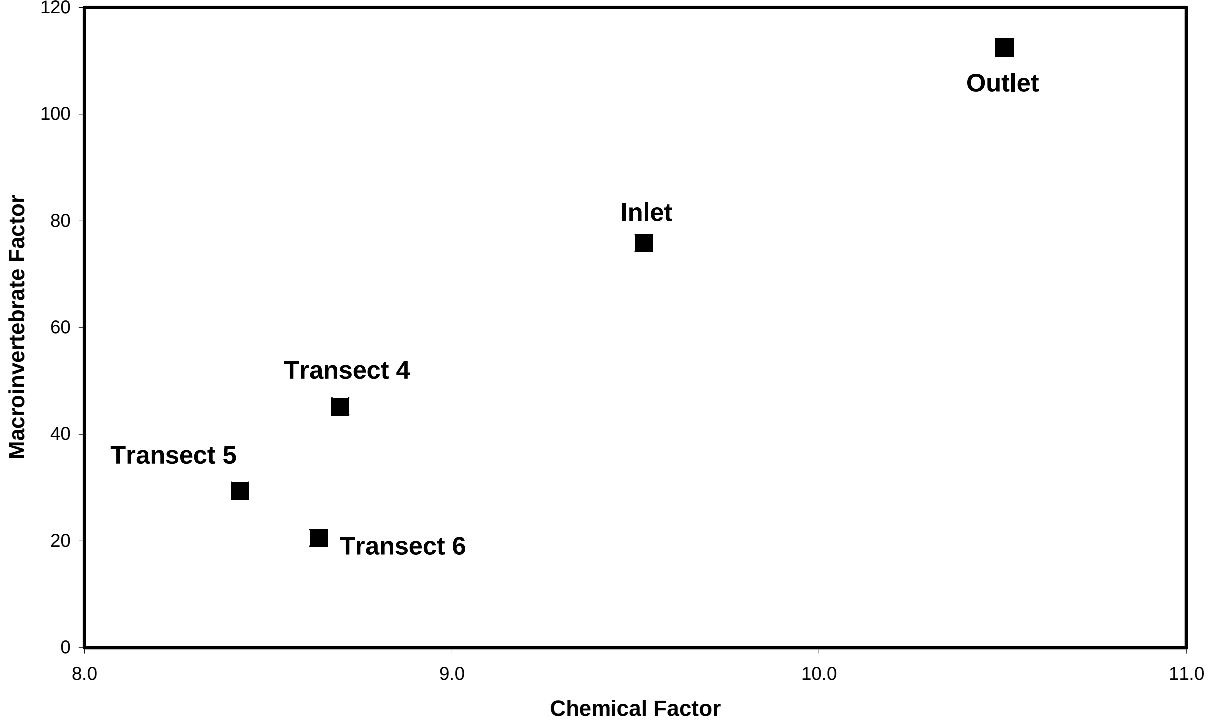
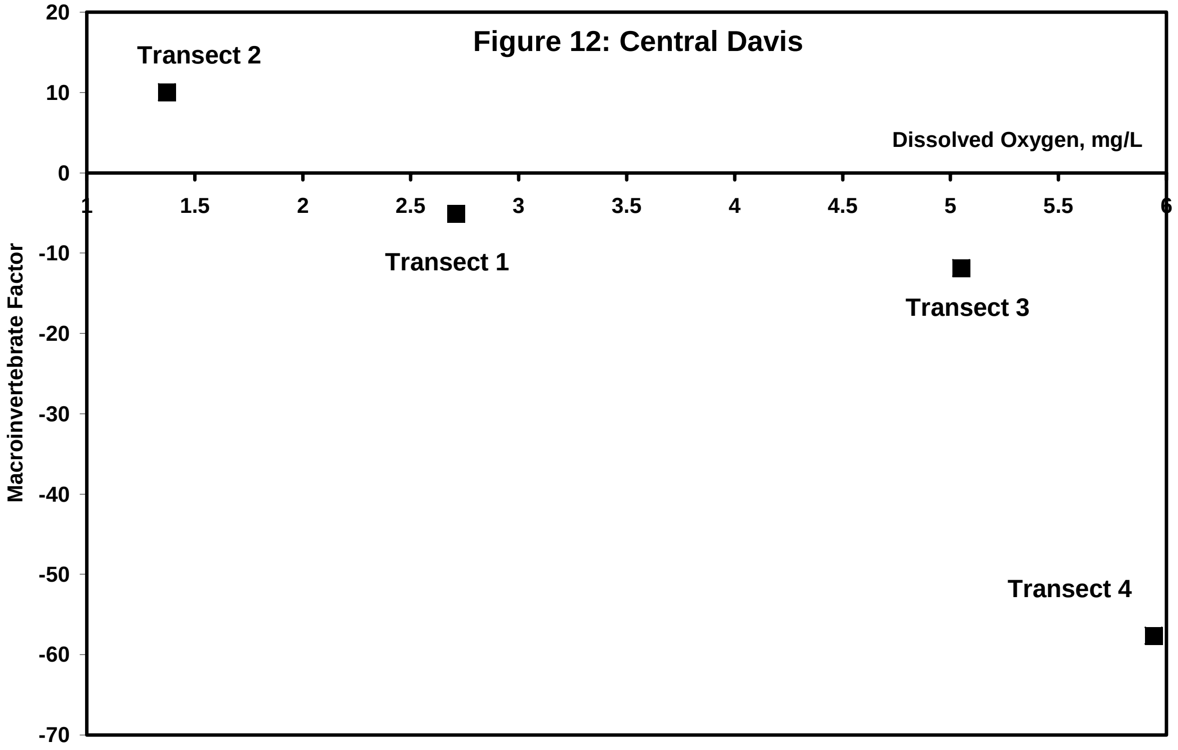


Figure 12: Central Davis



APENDIX C

PRODUCTIVITY AND FORAGING ECOLOGY OF TWO CO-EXISTING SHOREBIRDS BREEDING AT GREAT SALT LAKE, UTAH

2005 - 2006

John Cavitt, Ph.D.
Weber State University

Productivity and Foraging Ecology of Two Co-existing Shorebirds Breeding at Great Salt Lake, Utah
2005 - 2006

John F. Cavitt
Weber State University
Ogden, UT

Productivity and Foraging Ecology of Two Co-existing Shorebird Species Breeding at Great Salt Lake, Utah
2005 - 2006
Report

John F. Cavitt
Avian Ecology Laboratory,
Department of Zoology,
Weber State University
Ogden, UT 84408-2505

Cover Photo: **Foraging Black-necked Stilt. Photo by Tom Grey.**

Project Funded By: **Utah Department of Environmental Quality, Division of Water Quality.**

Avian Ecology Laboratory
Weber State University

Project Partners:

Weber State University

Division of Water Quality

U.S. FISH & WILDLIFE SERVICE

U.S. DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service
NATIONAL WILDLIFE REFUGE SYSTEM

National Science Foundation
WHERE DISCOVERIES BEGIN

Utah Division of Wildlife Resources

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

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EXECUTIVE SUMMARY

Farmington Bay is a 260 km^2 embayment of the Great Salt Lake. Recent studies have suggested that this Bay is hypereutrophic and thus may negatively impact wildlife species dependent on it for foraging and reproduction (e.g. Macarelli et al. 2003, Wurtsbaugh and Marcarelli 2006). To examine the potential impacts on breeding shorebirds, we compared productivity of two abundant species of shorebirds using Farmington Bay Waterfowl Management Area, American Avocets (*Recurvirostra american*) and Black-necked Stilts (*Himantopus mexicanus*), to other breeding sites within the Great Salt Lake Ecosystem. In addition we examined the diet of birds within the Farmington Bay to those at other reference locations.

The results of this study suggest that American Avocet and Black-necked Stilt productivity, as measured by hatchability, number of young to nest-leaving and daily survival rate of nests, were among the highest reported for the entire Great Salt Lake Ecosystem. In fact, productivity is as high or higher than other published productivity data for these species. This high level of productivity is likely due to a successful predator control program implemented at FARM to reduce mammalian nest predators.

Dietary data indicated that the volume of food items recovered from American Avocet digestive tracts was dominated by Corixidae (23%), Hydrophilidae (5%), Chironomidae (33.7%), Ephydridae (6%) and seeds (15%). The digestive tracts of Black-necked Stilts were also dominated by the same taxa, Corixidae (30%), Hydrophilidae (7%), Chironomidae (17%), Ephydridae (5.6%), and seeds (4%). American Avocets were found to take invertebrates in proportion to their availability. However, Black-necked Stilts were more selective in their diet. The proportion of Corixidae recovered from Black-necked Stilt digestive tracts were much greater than would be predicted based on their availability within the foraging sites.

BACKGROUND

Context

The Great Salt Lake (GSL) is well known as one of North America's most important inland shorebird sites. At least 22 species of shorebirds utilize the GSL during migration and another eight species nest in habitats associated with the lake. The breeding populations of American Avocets (*Recurvirostra american*) and Black-necked Stilts (*Himantopus mexicanus*) are among the highest in North America (Aldrich and Paul 2002). Consequently, the GSL is recognized as a site of hemispheric importance within the Western Hemisphere Shorebird Reserve Network (Andres et al. 2006). Despite the importance of the GSL to North American shorebird populations, little effort has focused on determining the factors that support healthy, self-sustaining populations. This knowledge is essential for the successful conservation and management of these populations.

Breeding biology and dietary information is needed to estimate population health and predict the vulnerability of species to habitat alteration, but such information is lacking for most species. In addition, concern over water quality and eutrophication within the Farmington Bay at GSL has prompted questions related to the effects on bird populations. The most important effects of degradation in water quality for birds will likely occur through changes in food availability and or quality. In addition, heavy metal and other contaminants can also affect bird populations by reducing hatchability of eggs, increasing young mortality and the incidence of developmental deformities (Ohlendorf et al. 1989).

Unfortunately, detailed, direct dietary information coupled with productivity data is not available for shorebirds utilizing the GSL. Indirect inferences about diets, based on bill morphology, behavior or general food availability has been questioned in several empirical studies (Rotenberry 1980, Rosenberg et al. 1982). Because we lack clear understanding of the connections between foraging site-selection, food availability and diet, any assumptions made without empirical study are unfounded (Rosenberg and Cooper 1990). Shorebirds forage primarily on macroinvertebrates, so it is expected that these birds will respond negatively to reductions in water quality. Impacts that reduce the abundance and or quality of macroinvertebrates used may reduce shorebird abundance and/or impact their productivity. To ensure that water quality is sufficient to maintain healthy viable shorebird populations it is critical to have this data. This detailed knowledge will provide managers an assessment tool for ensuring water quality and the maintenance of Farmington Bay as an important breeding and foraging site for shorebirds and all waterbirds using the area.

Objectives

This project monitored the breeding productivity, foraging ecology and diets of American Avocets and Black-necked Stilts using a standardized sampling protocol. This methodology allows for 1) assessment of current population health based on breeding productivity, 2) identification of species' dietary requirements, and 3) projection of species vulnerability to habitat disturbance and changes in water quality.

METHODS

Species

Both the American Avocet and Black-necked Stilt were chosen as focal species for this study because 1) they are both abundant throughout the managed wetland complexes of the GSL during the breeding season, 2) productivity can be easily measured, and 3) they rely heavily on aquatic macroinvertebrates and thus are likely affected by changes in water quality.

The American Avocet is a semi-colonial shorebird with a distinctive appearance (Figure 1). This species has a long recurved bill, bluish legs, and a black-and-white chevron pattern on its back. Breeding adults have a rusty to salmon colored head and neck which is replaced by white to light gray plumage during the pre-basic molt. AMAV are common summer residents of the GSL. Local breeders arrive in middle to late March with first eggs laid in April. Pairs select nest sites in areas with little to no vegetation, thus providing an unobstructed view by the attending adult (Cavitt 2005) . Consequently nests are frequently located in shallow emergent wetlands, vegetated mudflats, sparsely vegetated islands or along dikes. The modal clutch size of AMAV is 4 eggs and incubation commences following laying of the penultimate egg (Cavitt 2004, 2005). Both sexes alternate incubation for 23 days. Young are precocial and remain in the nest for only 24 hr. after hatching. At nest-leaving, adults lead young to brooding/nursery sites which contain shallow water and dense vegetation for cover (Cavitt 2005).

Figure 1. American Avocet adult. Photo by Tom Grey.

Black-necked Stilts are a loosely colonial shorebird that can be found breeding throughout western North America. Its black and white patterning and long reddish colored legs readily distinguish this bird from any other. BNSTs are also a common summer resident within the GSL. Adults begin arriving in early April with first eggs laid in late April to early May. There is some overlap in nest site selection with AMAV, but BNST tend to select sites with slightly taller and denser vegetation. Both shallow emergent wetlands and vegetated mudflats are used frequently for nesting. Modal clutch size is 4 eggs and incubation commences following laying of the penultimate egg. Both sexes alternate incubation for 23 days. Young are precocial and remain in the nest for only 24 hr. after hatching. At nest-leaving, adults lead young to brooding/nursery sites which contain shallow water and dense vegetation for cover (Cavitt 2005).

Figure 2. Black-necked Stilt. Photo by TomGrey

Study Sites

A total of seven sites were used for this study (Figure 3). Four sites were monitored for breeding productivity. Dietary information was collected at all seven sites.

The first site, the Bear River Migratory Bird Refuge (BEAR), is located 15 miles west of Brigham City, Utah. The refuge covers nearly 30,000 ha and consists of impounded wetlands, marshes, uplands, and open water. Adults were collected at this site for dietary analysis during the late summer of 2005. Productivity data was collected during both the 2005 and 2006 breeding seasons. This site has an active predator management program. Mammalian nest predators such as raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*) and fox (*Vulpes vulpes*) are removed throughout the breeding season.

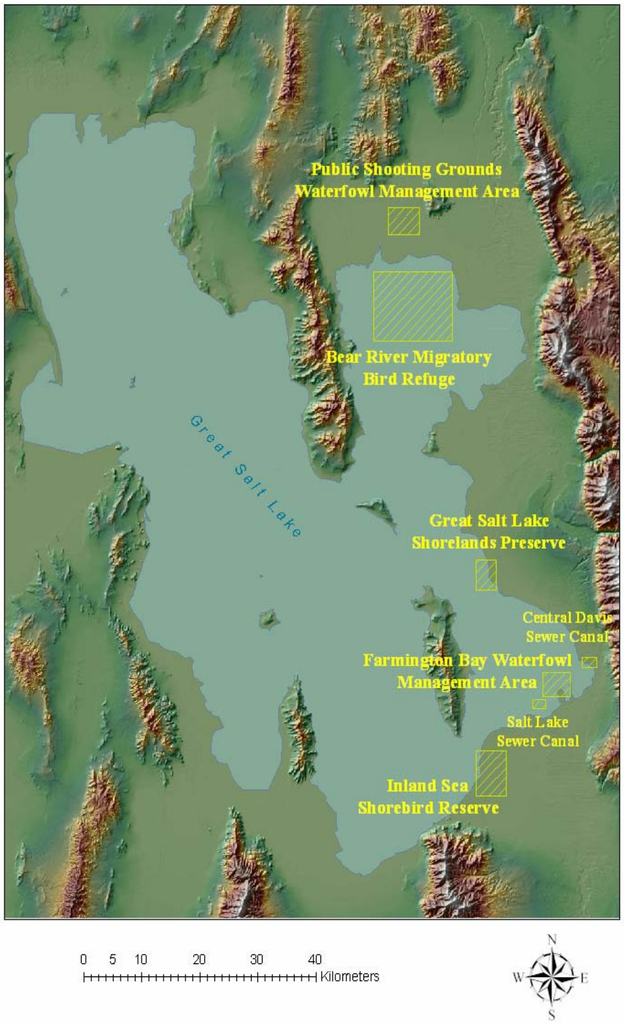

Figure 3. Study Sites used for dietary and productivity studies. See text for descriptions.

The Great Salt Lake Shorelands Preserve (SHORE) is a 1600 ha Nature Conservancy site located south of the Antelope Island causeway. SHORE does not contain water control structures and thus water levels fluctuate depending on annual precipitation. This site consists of uplands, marshes, and mudflats. Adults were collected at this site for dietary analysis during the late summer of 2006 near the drainage canal for the North Davis County Sewage Treatment Plant (NDSC) and at three sites along Kays Creek (KACR). Productivity data were collected during the 2005 and 2006 breeding season.

Farmington Bay Wildlife Management Area (FARM) is located west of Farmington, Utah and covers about 5,000 ha. Farmington Bay is managed by the Utah Division of Wildlife Resources and hosts an array of impounded wetland habitats including fresh water ponds, marshes, expansive flats and open salt water. Productivity monitoring occurred west of the Turpin dike on the expansive mudflats and shallow emergent marshes. Both productivity data and adults were collected at this site during the 2005 and 2006 breeding season. This site has an active predator management program. Mammalian nest predators such as raccoon, skunk and fox are removed throughout the breeding season.

The Salt Lake Sewer Canal (SL CANAL) or Northwest Oil Drain, is located south of FARM and covers the area immediately surrounding the canal. The 9-mile canal is a major storm water and industrial wastewater discharge point for Salt Lake City's Water Reclamation Plant treated effluent. Sediment deposits containing hydrocarbons were found in certain segments of the canal in 1999. Local state and federal agencies addressed the problem and instituted a sediment removal remediation project which was completed in 2005. Because of this history and because large numbers of waterbirds use the canal and surrounding wetlands, this site was chosen to monitor breeding productivity and diet of shorebirds. Productivity data and adults were collected at this site during the 2005 and 2006 breeding season.

Public Shooting Grounds Waterfowl Management Area (PSGR) is located north of BEAR and 10.5 miles west of Corrine, UT. PSGR covers approximately 3200 ha of impounded wetlands, marshes, uplands, and open water. Adults were collected for dietary analysis during the 2006 breeding season at both Avocet Pond and Wigeon Lake.

Central Davis County Sewage Treatment Plant (CDSC) is located south of Kays Creek and north of FARM in Davis County. The treatment plant effluent is drained into the GSL through emergent marsh and playa. The terminus of this canal creates a shallow emergent marsh that is frequently used by both AMAV and BNST. Adults were collected for dietary analysis during the summer of 2006 at the terminus of the canal.

Inland Sea Shorebird Reserve (ISSR) – This study site is a 1485 ha of impounded wetlands and is managed by Kennecott Utah Copper. ISSR is located on the southeast corner of lake, west of the Salt Lake City International Airport. Water control structures are present. Adults and productivity data were collected during the 2006 breeding season.

General Procedures

Each study site utilized for breeding productivity consists of replicated plots that were visited every three to four days from late April until early August 2005 and 2006. Sites used only for collecting dietary data were visited a single time during the breeding season.

Productivity

Nests were located by either systematic searches of potential nesting sites or by observing the behavior of adults. We recorded the location of each nest with a Magellan Explorist 100 Global Positioning System (GPS) unit. To facilitate relocating nests in dense colonies, each nest was marked with a 10cm wooden tag, placed in the ground at the edge of the nest so only the top 3-4cm was visible (Figure 4). A unique nest identification number was written on each tag with permanent marker.

Because shorebirds lay only 1 egg/day, the laying date of first eggs (clutch initiation date) was determined by back dating when nests were found prior to clutch completion. Clutch size was only assigned for a nesting attempt when the same number of eggs was recorded on two consecutive visits and there was evidence that incubation had commenced (i.e. adult behavior and egg temperature). Clutch initiation dates were also estimated for nests located after clutch completion and in which young successfully hatched. The incubation stages of nests found with complete clutches were estimated by egg floatation, which allowed for the prediction of hatching date.

Figure 4. American Avocet nest illustrating nest marker used to uniquely identify nests.

The status of extant nests was determined by visitations every 3-4 days until either eggs hatched or the nest failed. Nests were defined as successful if at least one young hatched and survived to nest-leaving. Nests were presumed successful if eggs disappeared near the expected date of hatching and there was evidence of a successful hatching. This evidence included the presence of young, the presence of eggshell tops and bottoms near the nest, egg shell fragments ~1-5mm in size and detached egg membrane within the nest lining (Mabee 1997, Mabee et al. 2006). A failed nest was classified as depredated if all eggs disappeared prior to the expected date of nest-leaving and there was no basis for weather or flood induced mortality. Further evidence of egg depredation included eggshell pieces in the nest (> 5mm in size), and yolk within the nest material.

For each nest we recorded the following information - date of clutch initiation, maximum number of eggs, clutch size, date of hatching, number of eggs hatched, number of young produced, and nest fate. From this data I was able to calculate hatchability, daily nest survival rate and nesting success. Hatchability of eggs is defined as the proportion of eggs present at hatching time that produce young (Koenig 1982). Consequently, eggs taken by nest predators or those flooded are not included in the calculation.

Dietary Analysis

AMAV and BNST were randomly collected by shotgun after 15min. of active foraging. Following the collection, birds were dissected in the field. The mouth and pharynx were rinsed with 80% ethanol and the wash collected into plastic containers. In addition, the esophagus, proventriculus and ventriculus were removed and preserved with 80% ethanol. Birds were collected throughout the breeding season (May through August) to examine seasonal variation in diet.

Food items were sorted and identified to family and order (Merritt and Cummins 1984, Voshell 2002). Invertebrates were counted and volumes determined for each taxa. Data from samples were summarized as aggregate % volume.

Foraging Behavior

During the 2005 breeding season, we conducted foraging observations during a 5 minute sampling period prior to collecting adults. Observations of each individual were made with 7x35 binoculars. During the feeding observation, we recorded the amount of time each bird spent within the following foraging microhabitats: vegetated mudflat, unvegetated mudflat, shallow emergent wetland, mid-depth emergent wetland, or shallow submergent wetland. In addition, we recorded the frequency of each feeding method used. We classified feeding methods after Davis and Smith (2001) as:

- Pecking - < ¼ bill length penetrating substrate
- Probing - > ¼ bill lengths penetrating substrate
- Plunging – head submerged below water surface
- Scything - bill slightly open, moved from side to side
- Filtering – bill opens and closes rapidly while moving over mud

Feeding method diversity was calculated for each individual using the reciprocal of Simpson's index (Krebs 1998):

$$B = 1 / \sum p^2i$$

where B = Feeding method diversity
pi = the proportion of ith feeding method of a given individual

The microhabitat of the foraging area was delineating by the point the bird was first detected foraging to the point where it was collected. A transect was established within this foraging sampling area (FSA) and water depths recorded at random points along the length. In addition each FSA was classified according to habitat (vegetated mudflat, unvegetated mudflat, shallow emergent wetland, mid-depth emergent wetland, or shallow submergent wetland). Although we were able to collect behavioral data on some of the birds collected, it was often difficult relocating the same individual prior to collection.

Invertebrate availability

After each shorebird observation/collection, invertebrates were collected from the mudflat, benthos and water column within each foraging area. Two invertebrate samples were collected at each FSA using D-frame net (Figure 5). The net was lowered so that the frame lay flat on the bottom. It was then quickly moved forward for a distance of 1m and then back again. The net was lifted up to the surface and the contents poured into a collecting bucket. The sample was washed through a 0.5mm sieve and the contents labeled and preserved with 80% ethanol. Invertebrates were sorted and identified to order and family using Merritt and Cummins (1984) and Voshell (2002). Invertebrates were counted and volumes determined for each taxa.


Figure 5. Sweep sample technique.

Statistical analyses

Tests of significance were set at $\alpha = 0.05$. Parametric analyses were used unless transformations were unable to correct for deviations in normality or heterogeneous variances.

I examined nesting success by estimating daily survival rates (DSR) and their associated standard errors according to Mayfield's (1961, 1975) method as modified by Johnson (1979) and Hensler and Nichols (1986). Variation in DSR between sites was compared using the program CONTRAST (Sauer and Williams 1989). The program is based on establishing variance-covariance matrices that contrast two or more DSR and then comparing their differences with a chi-square distribution.

RESULTS

Productivity

A total of 239 nests were located and monitored at BEAR, 647 at FARM, 27 at SL CANAL and 6 at SHORE during the 2005 breeding season. During the 2006 breeding season, 327 nests were monitored at BEAR, 935 at FARM, 19 at SL CANAL, 198 at ISSR, and 120 at SHORE. Distribution of nests at each site for the 2006 breeding season are in Appendix 1.

Nest Fate – The most common source of nest failure for both species at all sites was nest predation. Nest predation accounted for 67 - 90% of all nest failures (Figure 6). Other sources of nest failure included flooding, 0 – 12%, and nest abandonments, 0 – 17%.

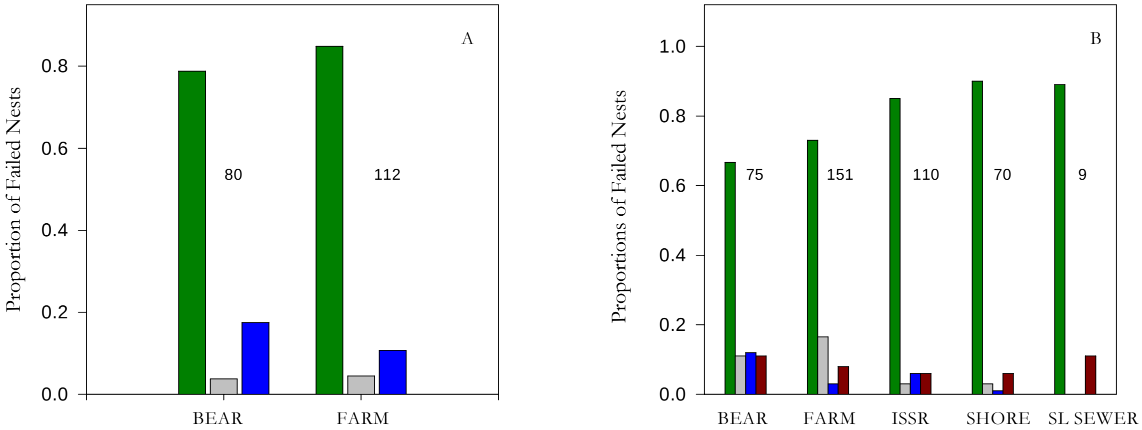

Figure 6. Proportion of failed nests during the 2005 (A) and 2006 (B) breeding seasons attributed to predation (green bars), flooding (blue), abandonment (gray) and unknown failures (red). The total numbers of failed nests are reported next to bars for each site. See text for site abbreviations.

Clutch Size, Number of Young to Nest-leaving, and Hatchability – The modal clutch size of both AMAV and BNST was 4 eggs. Measures of productivity are listed in Table 1. by species, site and year.

In 2005, 54.4% of all AMAV eggs laid at FARM produced young to nest-leaving. This compares to 75% at BEAR, 44% at SL CANAL, and 0 % at SHORE. For BNST 96% of eggs laid produced young to nest-leaving at FARM, 77% at BEAR, 0 % at SHORE, and 77% at SL CANAL. However, there were no significant differences in hatchability between sites for AMAV (H =1.2, df =2, P = 0.550) or for BNST (U =979.5, df =1, P = 1.0)

In 2006, 72% of all AMAV eggs laid at FARM produced young to nest-leaving. This compares to 65% at BEAR, 51% at SL SEWER, 24% at ISSR and 20% at SHORE. For BNST 82% of eggs laid produced young to nest-leaving at FARM, 77% at BEAR, 75% at SHORE, and 18% at ISSR. However, there were no significant differences in AMAV hatchability between sites (H = 5.175, df = 3, P = 0.159). BNST hatchability was significantly higher at FARM relative to BEAR (H =4.6, df =1, P = 0.03; Table 1).

Table 1. Measures of productivity for each site, year and species. Mean clutch size, hatchability and number of young produced to nest leaving (± standard error) for successful nests.

Site	Year	Species	Total Eggs Laid (total nests)	Clutch Size (n)	Hatchability (n)	Total Young Produced (average # eggs hatched / nest)	# Young Leaving/Nest (n)
BEAR	2005	AMAV	715 (311)	3.92 ± 0.67 (143)	0.96 ± 0.10 (143)	536 (1.7)	3.75 ± 0.72 (143)
		BNST	94 (29)	3.9 ± 0.57 (10)	0.98 ± 0.06 (10)	38 (1.3)	3.8 ± 0.42 (10)
	2006	AMAV	924 (302)	3.92 ± 0.52 (171)	0.94 ± 0.15 (151)	596 (1.97)	3.68 ± (162)
		BNST	84 (23)	4 ± 0 (18)	0.91 ± 0.15 (18)	65 (2.8)	3.61 ± (18)
FARM	2005	AMAV	1681 (481)	3.86 ± 0.51 (247)	0.96 ± 0.13 (247)	914 (1.9)	3.75 ± 0.57 (247)
		BNST	769 (411)	3.87 ± 0.48 (201)	0.97 ± 0.11 (201)	737 (1.79)	3.76 ± 0.62 (201)
	2006	AMAV	2146 (641)	3.93 ± 0.30 (413)	0.93 ± 0.15 (369)	1538 (2.4)	3.55 ± (435)
		BNST	1123 (313)	3.97 ± 0.21 (232)	0.96 ± 0.12 (221)	916 (2.9)	3.77 ± (243)
ISSR	2006	AMAV	507 (158)	3.9 ± .037 (42)	0.98 ± 0.08 (29)	122 (0.77)	3.59 ± (34)
		BNST	22 (8)	4 ± 0 (3)	-	4 (0.5)	4 ± 0 (1)
SHORE	2005	AMAV	18 (6)	4.0 ± 0.0 (3)	-		-
		BNST	-	-	-		-
	2006	AMAV	295 (106)	3.88 ± 0.33 (25)	0.89 ± 0.16 (14)	60 (0.57)	3.53 ± (17)
		BNST	20 (7)	4 ± 0 (4)	0.94 ± 0.13 (4)	15 (2.14)	3.75 ± (4)
SL CANAL	2005	AMAV	36 (11)	3.6 ± 0.70 (10)	1 ± 0.0 (5)	16 (1.45)	3.2 ± 0.84 (5)
		BNST	61 (16)	3.81 ± 0.54 (16)	0.98 ± 0.07 (13)	47 (2.9)	3.62 ± 0.65 (13)
	2006	AMAV	61 (19)	3.71 ± 0.76 (7)	1 ± 0 (8)	31 (1.63)	3.88 ± (8)
		BNST	-	-	-	-	-

Nest Success - Sites differed in DSR during both the 2005 and 2006 breeding season. In 2005, AMAV DSR was significantly higher at BEAR, FARM and SL CANAL relative to SHORE (X^2 = 10.47, df = 3, P = 0.015). There were no differences between sites for BNST nest DSR (X^2 =3.46, df = 2, P = 0.20; Table x). In 2006, AMAV nest DSRs differed between study sites (X^2 = 149.71, df = 4, P = 0.0001). Both FARM and BEAR had the highest DSR relative to the other sites (Table 2). However, the DSR of BNST nests did not significantly differ between sites (X^2 = 7.11, df = 3, P = 0.07; Table 2).

Table 2. Nest daily survival rate (DSR ± SE) of each species by site and year. DSRs with the same letter are not significantly different (P > 0.05; statistical comparisons are made within each column). Mayfield estimates of nesting success are located below each DSR.

Site	AMAV 2005 DSR ± SE Nesting Success	BNST 2005 DSR ± SE Nesting Success	AMAV 2006 DSR ± SE Nesting Success	BNST 2006 DSR ± SE Nesting Success
BEAR	0.97 ± 0.004 a 0.45	0.97 ± 0.13 a 0.45	0.98 ± 0.002 a 0.56	0.99 ± 0.004 a 0.76
FARM	0.98 ± 0.002 a 0.56	0.98 ± 0.002 a 0.56	0.98 ± 0.001 a 0.56	0.99 ± 0.001 a 0.76
ISSR	--	--	0.90 ± 0.009 b 0.06	0.83 ± 0.06 a 0.01
SL CANAL	0.95 ± 0.02 a,b 0.25	--	0.92 ± 0.02 b 0.11	--
SHORE	0.85 ± 0.06 b 0.01	--	0.88 ± 0.01 b 0.03	0.98 ± 0.01 a 0.56

Diet and Aquatic Invertebrate Availability

A total of 34 AMAV and 46 BNST were collected for dietary analyses. On September 12, 2006 the CDSC was visited and eight birds (3 AMAV, 5 BNST) were collected. However, many of the birds congregating near the CDSC were suffering from an outbreak of avian botulism. Several thousand shorebirds and waterfowl were found dead in the area during collection. Because we are unsure how this disease could affect foraging behavior and diet selection, birds collected at CDSC are not included in the remaining analyses.

A total of 16 different taxa were identified within the digestive tracts of AMAV and BNST (Table 3). The most important aquatic invertebrates consumed by AMAV and BNST were Corixidae and Chironomidae. In fact, 63% of AMAV diet was made up of just three invertebrate taxa, Chironomidae, Corixidae, and Ephydridae (Table 3). BNST diet was slightly more varied, but 65% of the food material recovered consisted of four taxa, Corixidae, Chironomidae, Hydrophilidae, and miscellaneous Coleoptera parts (Table 3). Seeds made up 15% of the volume of food items collected from AMAV digestive tracts but only 4% of BNST. A small percentage of the material recovered (5 – 7%) included very small or shredded objects that could not be identified (Table 3). A summary of the aggregate % volume of each species by site and year are found in Appendix 2. A complete listing of the volume of taxa collected from each bird is presented in Appendix 3 and 4.

Table 3. Mean aggregate % volume of food items recovered from the digestive tracts of American Avocets and Black-necked Stilts.

Taxa	AMAV N = 31	BNST N = 41
	Mean Aggregate % Volume	Mean Aggregate % Volume
Gastropoda	0.4	1.6
Odonata	0.2	5
Hemiptera		
Corixidae	23.2	30
Coleoptera		
Carabidae	3	0.6
Dytiscidae	0	2
Hydrophilidae	4.7	7.5
Coleoptera Parts	3	10.5
Trichoptera		
Limnephilidae	0.1	0
Diptera		
Culicidae	0.8	0.5
Ceratopogonidae	0	0.2
Chironomidae	33.7	17.2
Stratiomyidae	0	0.01
Syrphidae	0	3.6
Ephydridae	6.1	5.6
Muscidae	1.4	3.3
Misc. Diptera	0	2.6
Hymenoptera		
Braconidae	0.9	0.01
Seeds	15.2	4.2
Unidentifiable Parts	7	5.2

Because Corixidae, Hydrophilidae, Chironomidae, Ephydridae, and seeds made up the largest proportion of food items in the diet of both AMAV and BNST, I focused on these taxa in site comparisons. There were no significant effects of year on the aggregate volume of food items consumed ($P > 0.1$), so data collected from 2005 and 2006 were pooled.

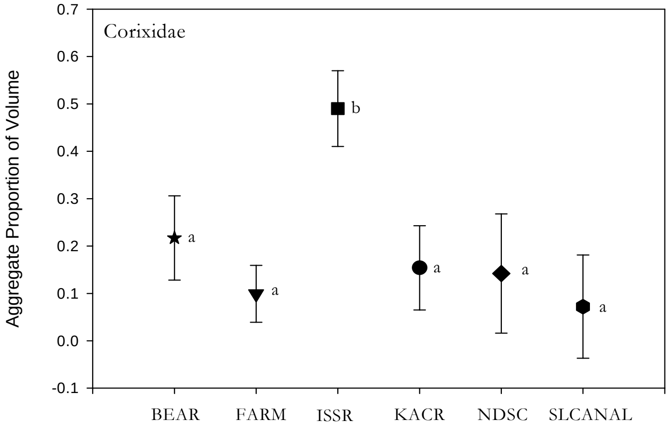

Figure 7. Mean Corixidae aggregate proportional volume (± SE) recovered from digestive tracts of AMAV at each site. Means with the same letter are not significantly different ($P < 0.02$).

For AMAV, the aggregate proportional volume of Corixidae was significantly higher at ISSR relative to all other sites ($F_{5,21}=4.03$, $P = 0.01$; Figure 7). The aggregate proportional volume of Chironomidae and Ephydridae recovered from AMAV digestive tracts also differed between sites (Chironomidae - $H = 11.29$, $df = 5$, $P = 0.046$, Figure 8a; Ephydridae - $H = 11.60$, $df = 5$, $P = 0.041$; Figure 8b). Chironomidae made up a greater proportional volume of food items at FARM and BEAR relative to KACR (Figure 8A). The aggregate proportional volume of Ephydridae was significantly greater at SL CANAL relative to all other sites but not different from NDSC (Figure 8B). There were no significant differences between sites in the aggregate proportional volume of Hydrophilidae ($H = 10.3$, $df = 5$, $P = 0.067$) or seeds ($H = 9.36$, $df = 5$, $P = 0.10$) recovered from AMAV digestive tracts.

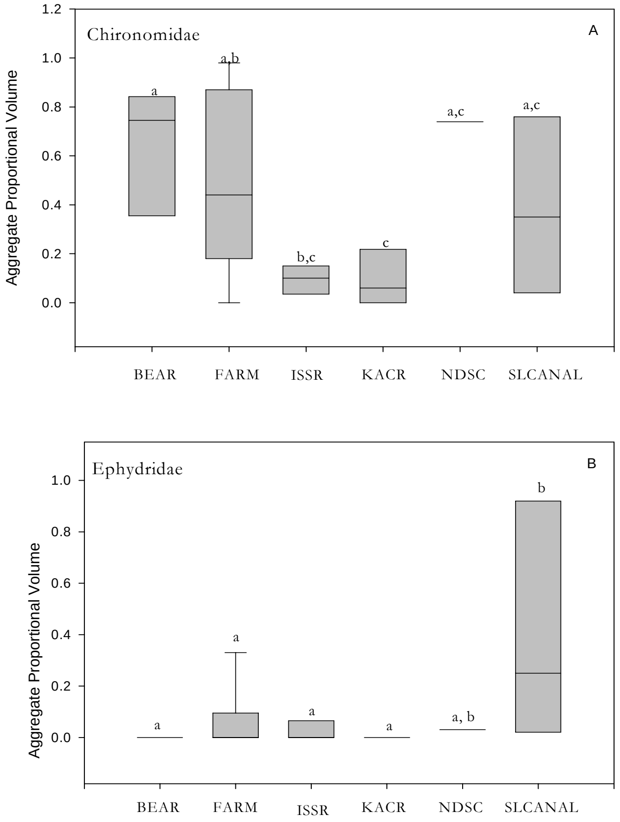

Figure 8. Median Chironomidae (A) and Ephydridae (B) aggregate proportional volume (upper, lower quartiles) recovered from digestive tracts of AMAV at each site. Medians with the same letter are not significantly different ($P < 0.05$).

The aggregate proportional volume of Chironomidae was significantly higher in BNST collected at SL CANAL relative to KACR ($H = 18.9$, $df = 5$, $P = 0.002$). There were no significant differences between sites in the aggregate proportional volume of Corixidae (H =10.3, df = 5, P = 0.067), Hydrophilidae (H =9.32, df = 5, P = 0.097) , Ephydridae (H =10.3, df = 5, P = 0.067) or seeds (H =5.06, df = 5, P = 0.41) recovered from BNST digestive tracts.

There was a significant difference between sites in the proportion of Chironomidae recovered from sweep samples ($F_{8, 31}$ = 2.5, P = 0.04) but no significant year affect (Figure 9). Chironomidae were significantly more abundant in samples collected at SL CANAL and at the NDSC relative to other sites (Figure 9). There were no significant year or site differences in the availability of Corixidae ($F_{8, 31}$ = 1.6, P = 0.19).

The proportion of Chironomidae consumed by AMAV did not differ from the proportion available within sweep samples ($F_{1, 54}$ = 0.308, P = 0.581). Likewise, there were no differences in the proportion of Corixidae consumed relative to the proportion available within sweep samples ($F_{1, 62}$ = 0.232, P = 0.632). However, BNST digestive tracts had fewer Chironomidae than would be expected if they were consuming invertebrates based on availability ($F_{1, 65}$ = 14.77, P = 0.001). There was a significant year by sample (diet and sweep sample) interaction term when comparing BNST consumption of Corixidae ($F_{1, 69}$ = 6.1, P = 0.02). In 2005, BNST consumed more Corixidae than would be expected based on availability but not in 2006.

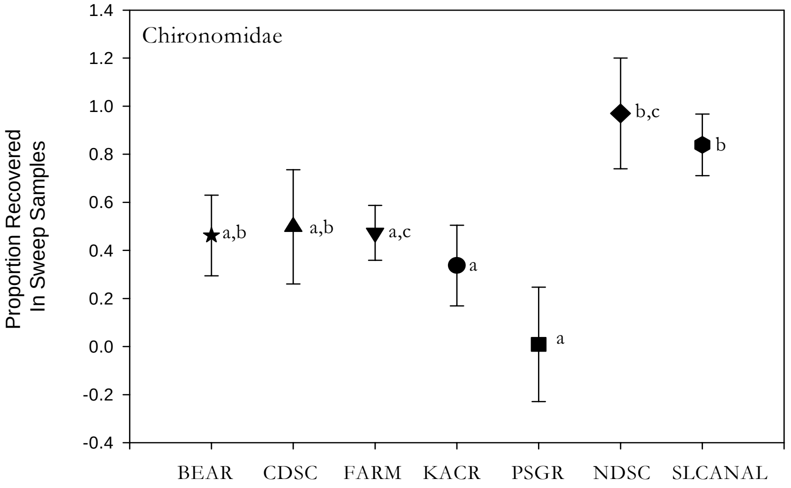

Figure 9. Mean proportion (± SE) of chironomidae recovered from sweep samples at each site. Means with the same letter are not significantly different (P < 0.05).

Foraging Behavior

There were significant differences in the feeding methods utilized by each species. BNST utilized "pecking" more frequently ($F_{1,88}$ = 23.45, P = 0.001), whereas AMAV engaged in "plunging" ($F_{1,88}$ = 9.04, P = 0.003) and "scything" more frequently ($F_{1,88}$ = 8.43, P = 0.005; Figure 10). There was no difference between species in the frequency of "probing" ($F_{1,88}$ = 0.45, P = 0.505). As a result, feeding method diversity was significantly greater for AMAV relative to BNST (t = 2.4, df = 1, 90, P = 0.018; Figure 11).

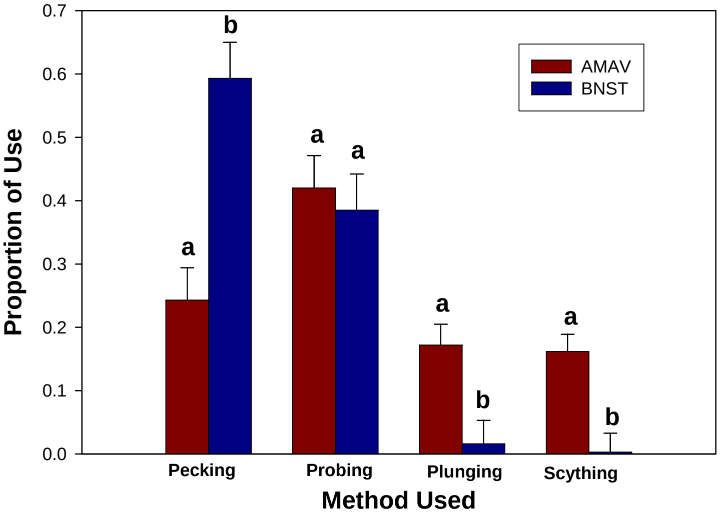

Figure 10. Foraging method utilized by AMAV and BNST.

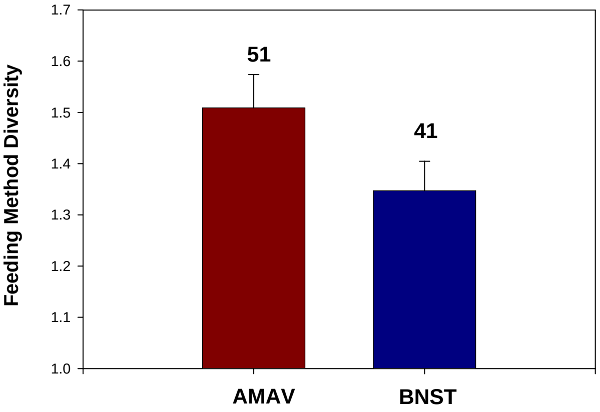

Figure 11. Feeding method diversity of AMAV and BNST.

DISCUSSION

The results of this study suggest that all measures of AMAV and BNST breeding productivity are high at FARM. Hatchability rates at FARM are among the highest found within the GSL ecosystem and daily survival rates of nests at FARM and BEAR are significantly higher than all other sites studied.

At FARM the average number of eggs hatched per nest ranged from 1.9 – 2.4 for AMAV and 1.8 – 2.9 for BNST. In comparison, the average number of AMAV eggs hatched per nest at BEAR ranged from 1.7 – 1.97 and 1.3 – 2.8 for BNST. These data are higher than reported in other similar studies. For example, Robinson et al. (1997) report a range of 0 – 1.48 AMAV eggs hatched per nest on study sites in California and Nevada. At these same sites, only 1.2 – 2.2 BNST eggs hatched per nest (Robinson et al. 1999).

Hatchability of BNST eggs at BEAR during the 1980's was 0.95 for 24 nests (Sordahl 1996). In central Oregon, AMAV hatchability was only 0.9 for 59 nests monitored (Gibson 1971). In contrast, Ohlendorf et al. (1989) reported hatchability rates of .876 for BNST breeding at Kesterson Reservoir, a selenium contaminated site in California. BNST breeding at this site had high rates of embryo mortality and deformity attributable to the contamination. On average the hatchability for uncontaminated populations of aquatic birds averages ~ 0.91 (Ohlendorf 1989). The rates of hatchability found for AMAV and BNST at FARM during this study were greater (AMAV = 0.93 – 0.96; BNST = 0.96 – 0.97) and suggest egg viability is not a factor affecting breeding productivity at FARM.

The high rates of productivity at FARM and BEAR are partly due to the predator management program employed at these sites. Nest predation is the most important source of egg loss for all species at each site. This is a typical pattern seen for most breeding bird populations (e.g. Cavitt and Martin 2002). Nesting success was found to be highly variable, and two sites (SHORE and ISSR) had only 1% nesting success. In contrast, nesting success ranged from 45 – 76% at BEAR and 56 – 76% at FARM. Data from sites in California and Nevada where predators are not managed suggest much lower nesting success rates for both AMAV, 0 – 51% (Robinson et al. 1997) and BNST, 38 – 67% (Robinson et al. 1999). Consequently, AMAV and BNST at FARM and BEAR are able to successfully produce a large number of young each year.

The most important food items consumed by AMAV and BNST were Chironomidae and Corixidae. At FARM Chironomidae made up ~ 50% of the volume of food items recovered from the digestive tracts of AMAV and ~30 % of BNST. In comparison, Corixidae accounted for ~ 10% of AMAV diet at FARM and ~22% of BNST. Many other aquatic invertebrates were recovered but large volumes of Chironomidae and Corixidae were consistently recovered from the digestive tracts at the majority of sites monitored for this study.

Dietary information obtained by this study suggests that AMAV select food items in proportion to their availability within their foraging sites, whereas BNST are more selective in their diet. Chironomidae were consumed by BNST less frequently than would be expected based on their availability, but Corixidae made up a greater than expected proportion of the diet. This dietary information corresponds with the foraging behavior observed. BNST spent significantly more time "pecking" food items off the surface of the water whereas AMAV penetrated deeper into the foraging substrate by using a "plunging" behavior as well as sweeping motions (scything) to acquire food items. It may be that BNST are attracted to prey movement and thus select moving food items and not necessarily the most abundant. Corixidae are very active swimmers and thus would attract the attention of a visually oriented predator. However, Chironomidae larvae are generally benthic organisms and thus are not actively swimming through the water column. Chrionomidae would be more likely captured with broad sweeping motions that skim through the benthos.

In conclusion, the results of this research suggest that all measures of breeding productivity at FARM included in this report are either comparable or higher than at reference sites throughout the GSL. Furthermore, breeding productivity at FARM is also equivalent or greater than published data available for other breeding locations throughout North America. Dietary data suggest that AMAV are highly adaptable to local food resources and generally consume their major prey items in proportion to their availability. BNST may be more selective and tended to favor more active prey.

PRIORITIES FOR FUTURE RESEARCH

It is important to note that productivity in this study only included the period from egg laying to the departure of young (i.e. the brood) from the nest. However, the time from nest-leaving to independence is likely to be a critical factor influencing breeding productivity of these species. Parents of both species lead young from the nest to brooding areas. These areas can be near the nest site but may be up to 1km away (Sordahl 1996). Parents continue to defend the brood but young forage and feed themselves. Unfortunately, we know very little about the selection of these brooding sites and the factors influencing brood survival following nest-leaving (Sordahl 1996, Robinson et al. 1997). Furthermore, food availability in these brooding areas and its relationship to young-feeding has never been studied. This information is critical to accurately project the vulnerability of these species to habitat alteration and the potential degradation of water quality.

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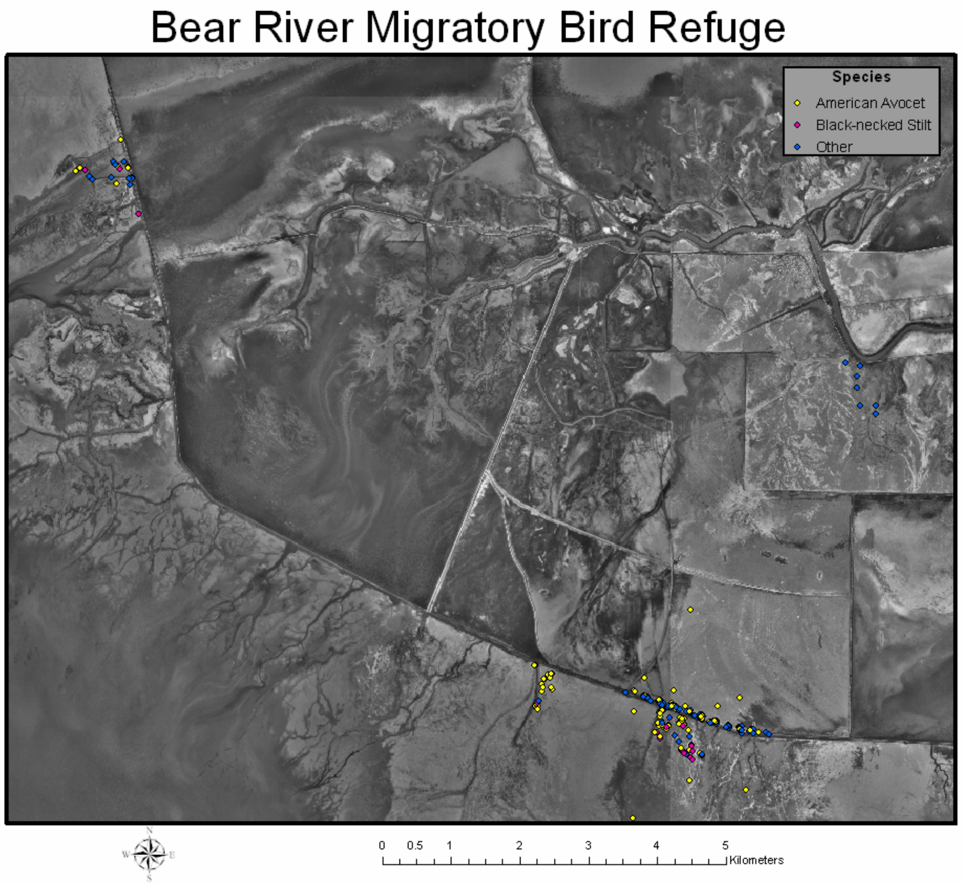
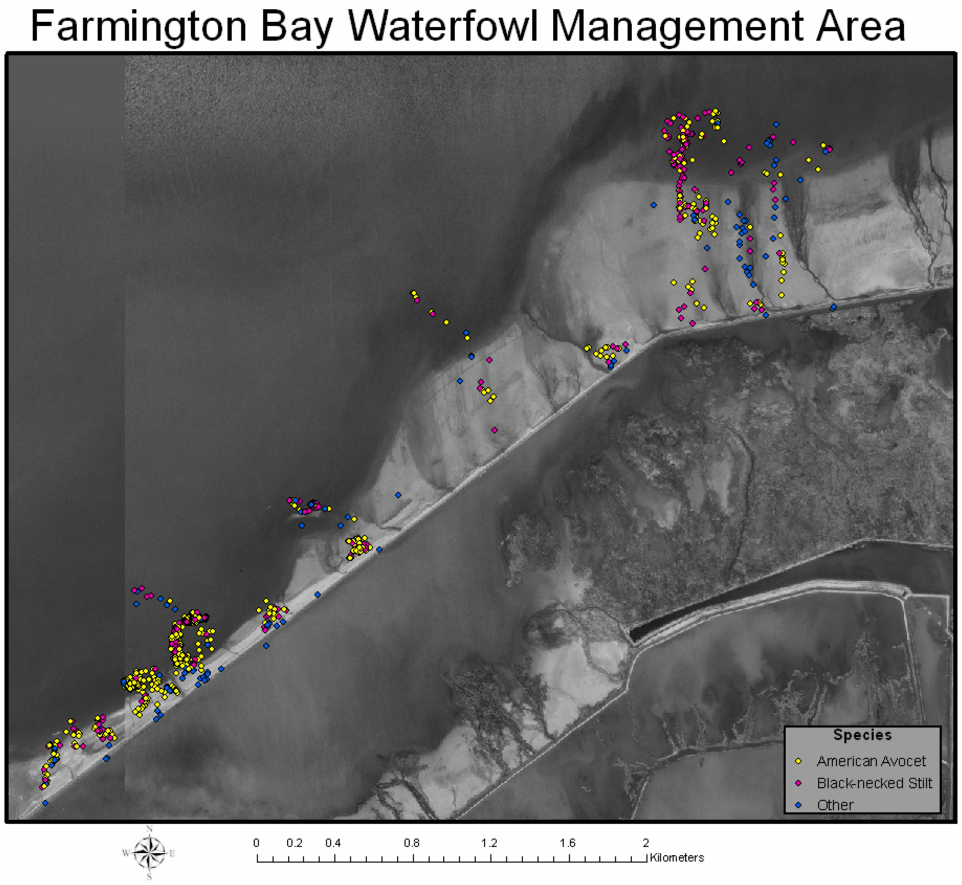
Appendix 1. Distribution of nests at each study site for the 2006 breeding season.




Farmington Bay Waterfowl Management Area
Species
● American Avocet
● Black-necked Stilt
● Other
N
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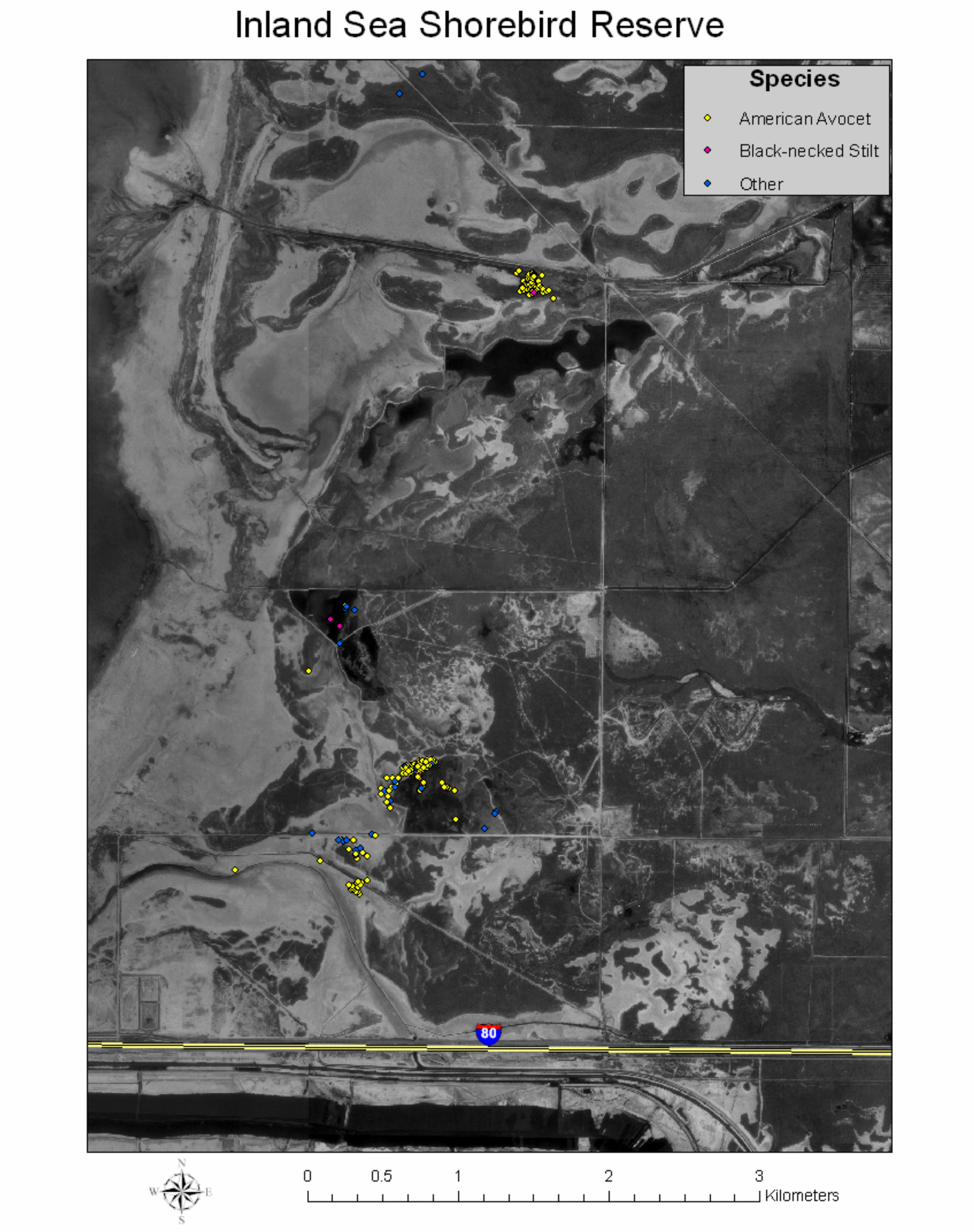
Inland Sea Shorebird Reserve
Species
American Avocet
Black-necked Stilt
Other
80
N
W
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0
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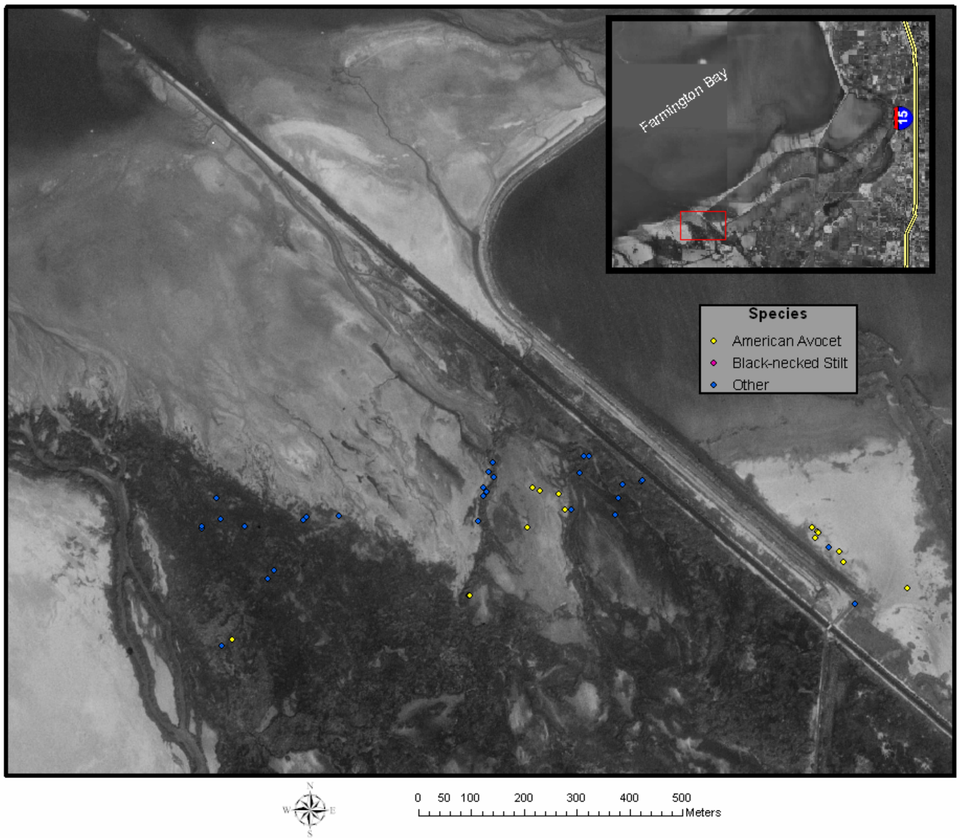
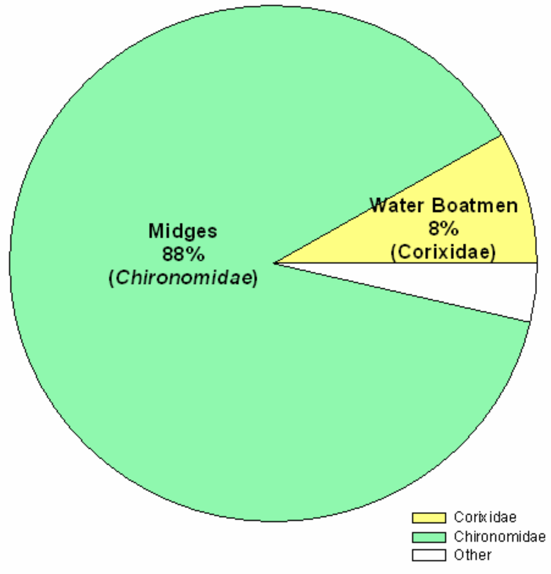
1
2
3
Kilometers


Great Salt Lake Shorelands Preserve

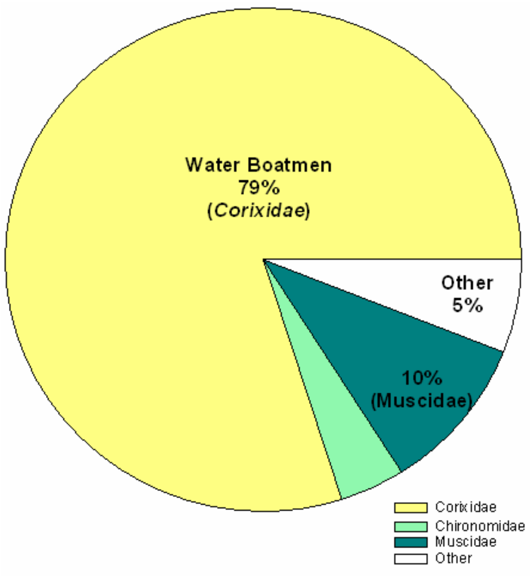
Salt Lake Sewer Canal



Appendix 2a Bear River Migratory Bird Refuge



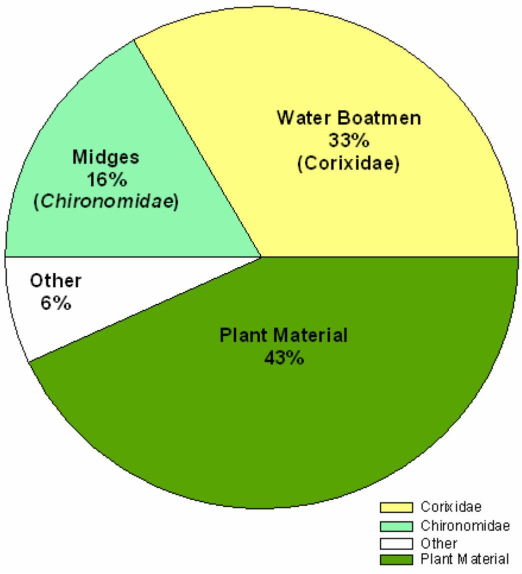
AMAV



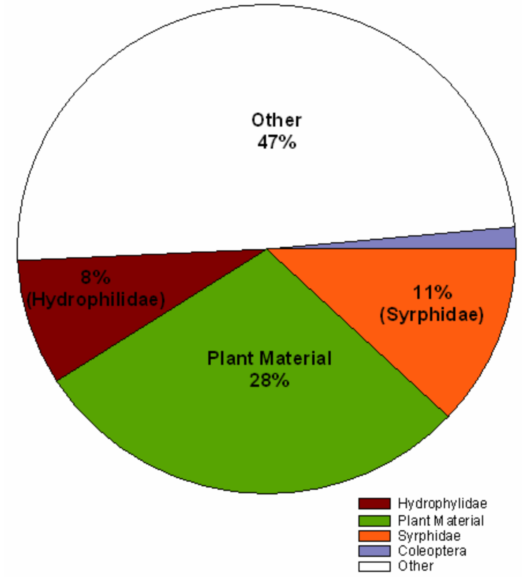
BNST

2005

Appendix 2b Central Davis Sewer Canal



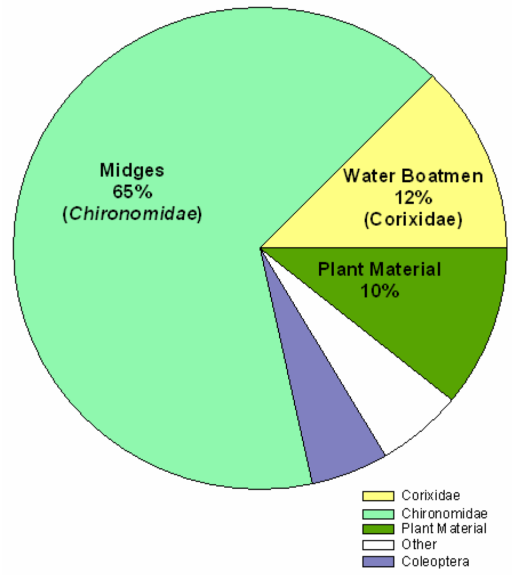
AMAV



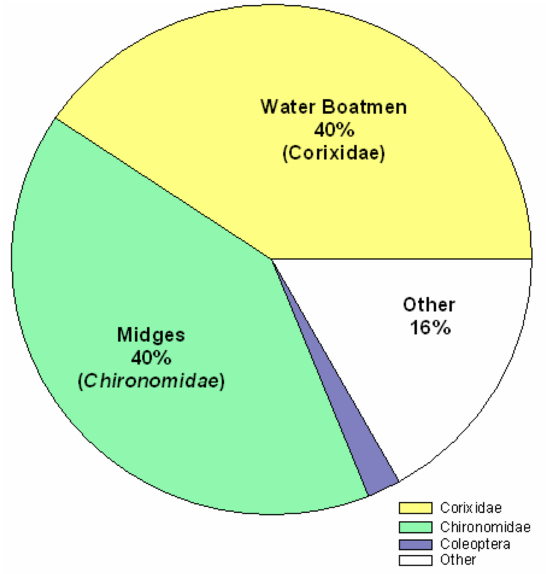
BNST

2006

Appendix 2c Farmington Bay Waterfowl Management Area

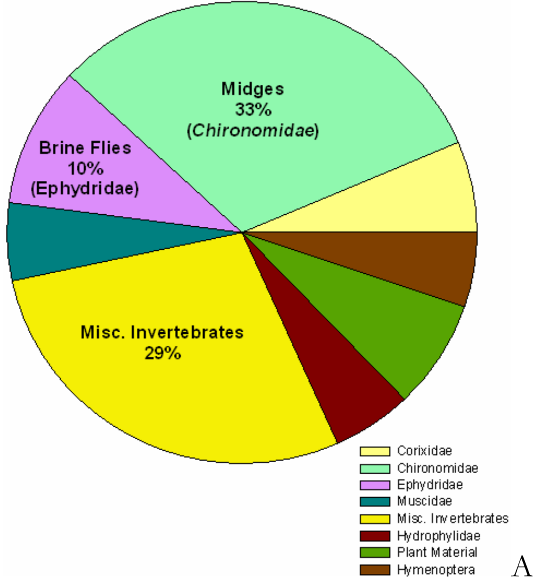


AMAV

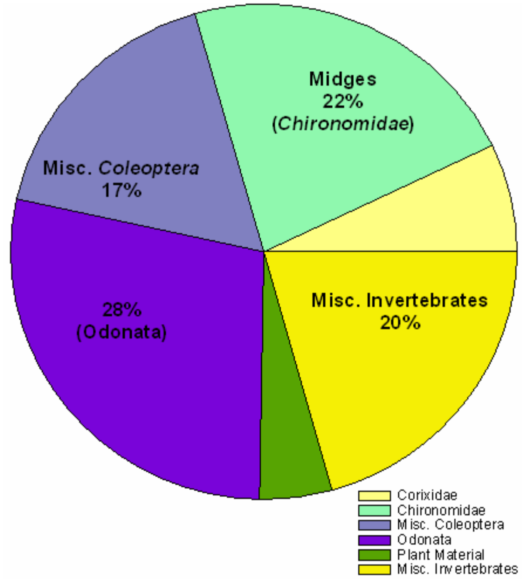


BNST

2005



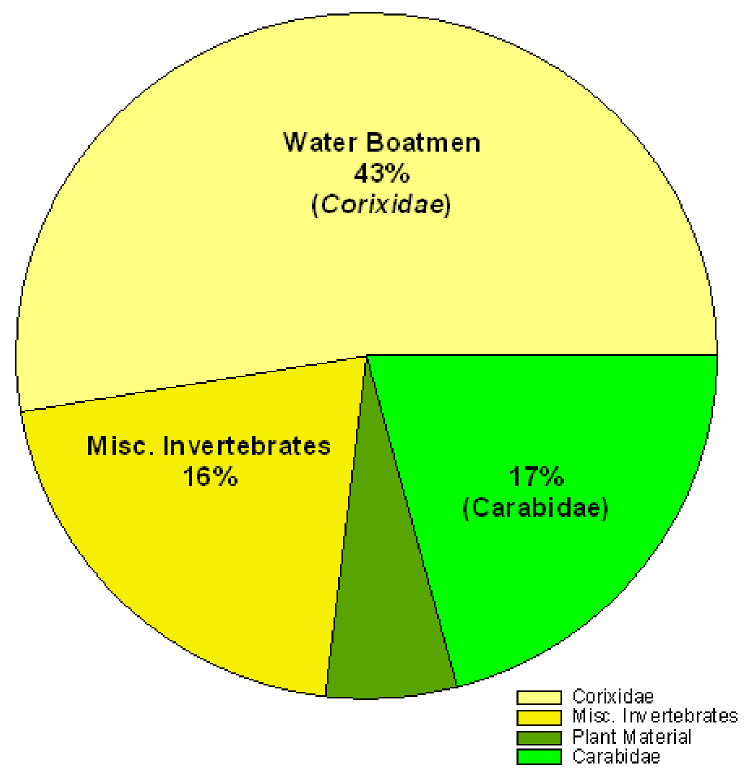
AMAV



BNST

2006

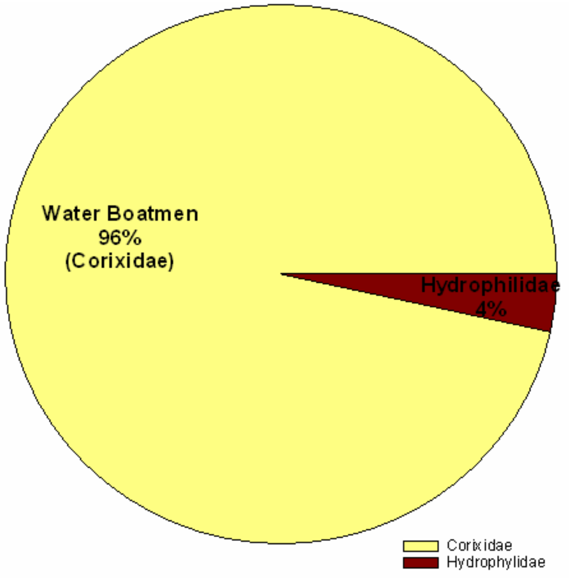
Appendix 2d Inland Sea Shorebird Reserve



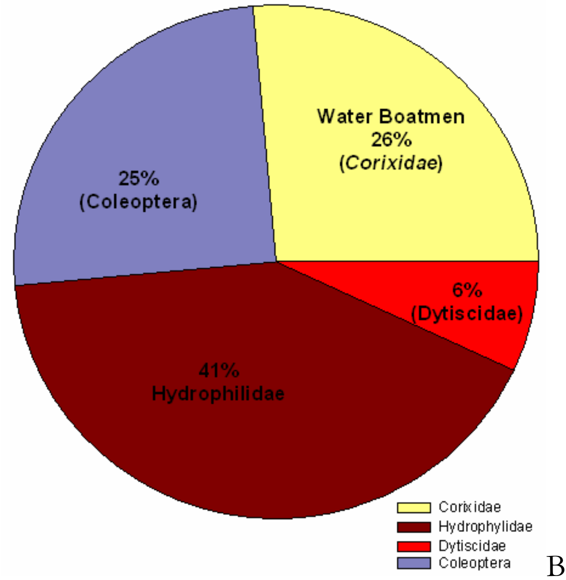
AMAV

2006

Appendix 2e Kay's Creek North



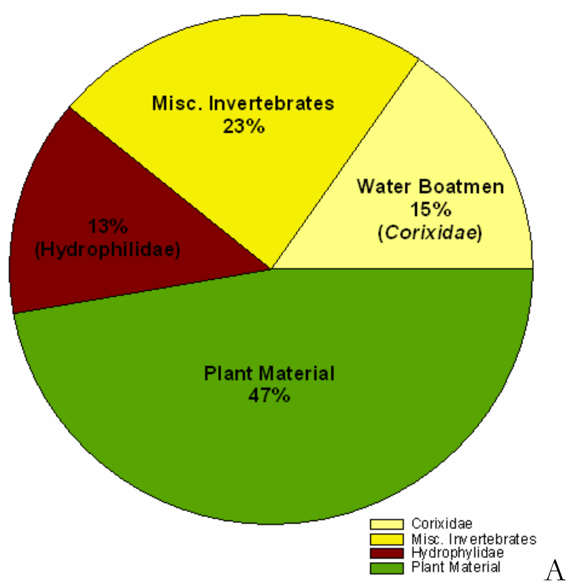
AMAV



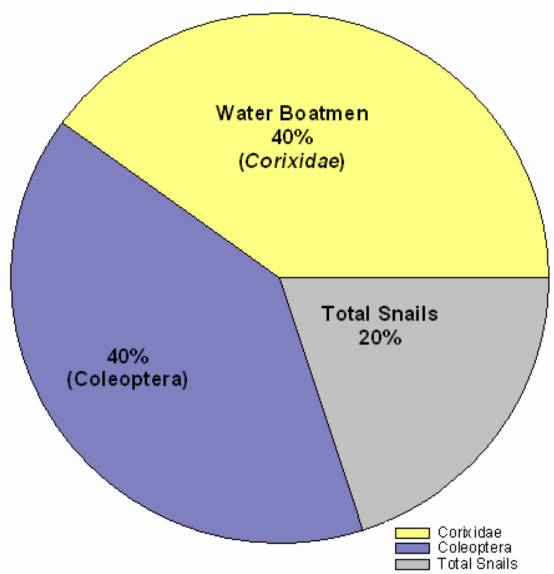
BNST

2006

Appendix 2f Kay's Creek South



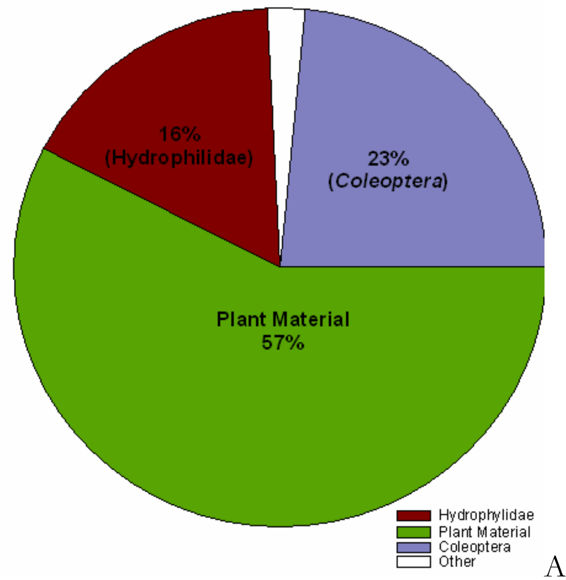
AMAV



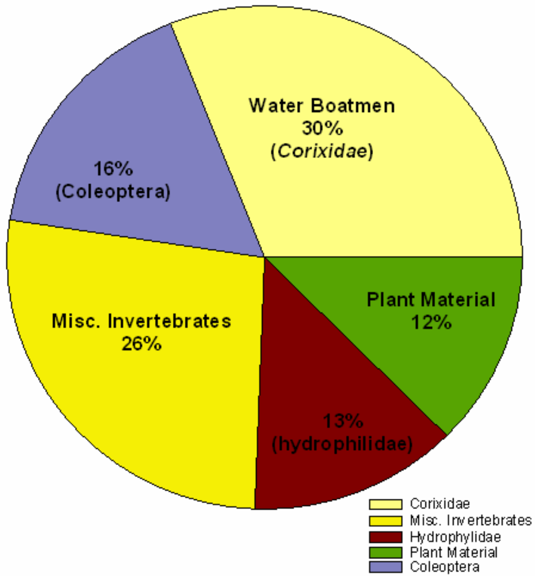
BNST

2006

Appendix 2g Kay's Creek West



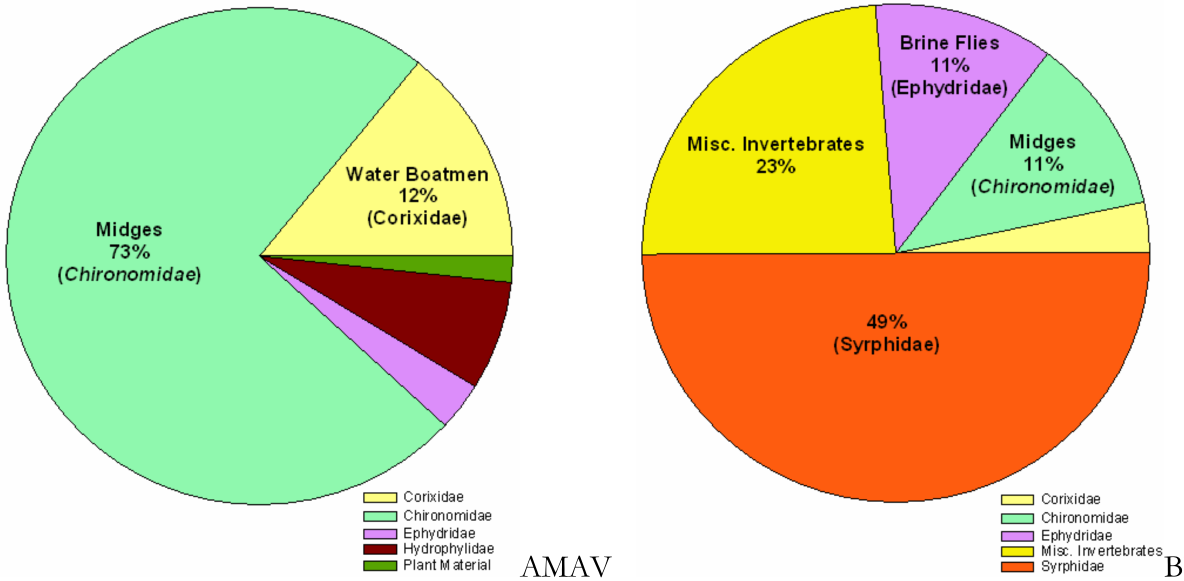
AMAV



BNST

2006

Appendix 2h North Davis Sewer Canal

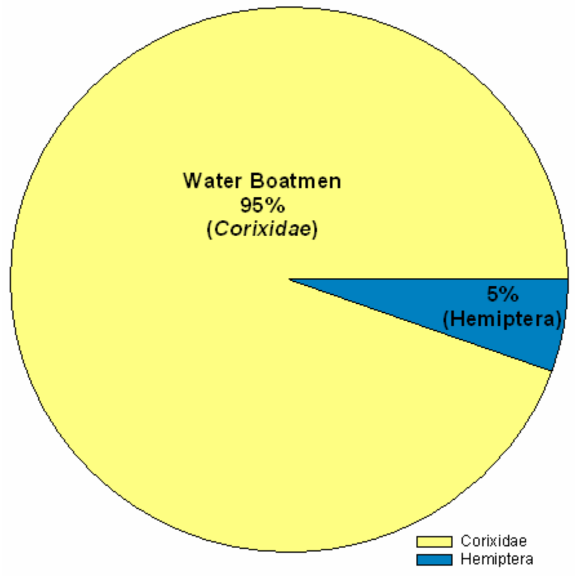


AMAV

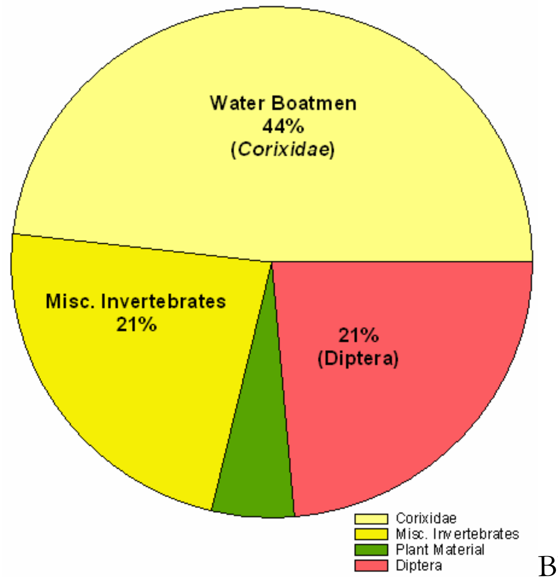
BNST

2006

Appendix 2i Public Shooting Grounds



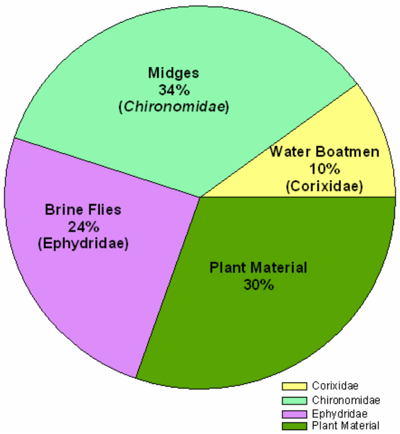
AMAV



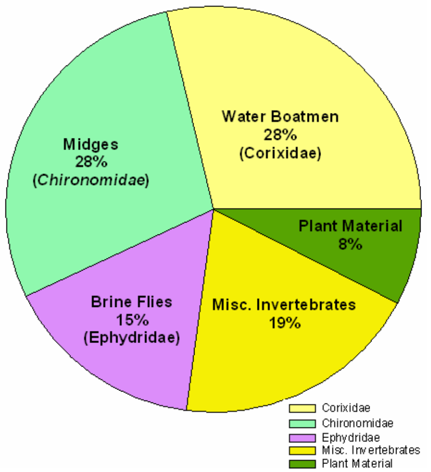
BNST

2006

Appendix 2j Salt Lake Sewer Canal

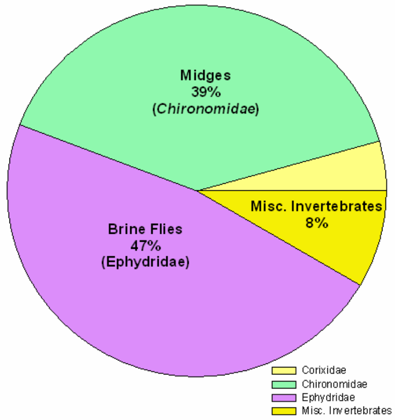


AMAV

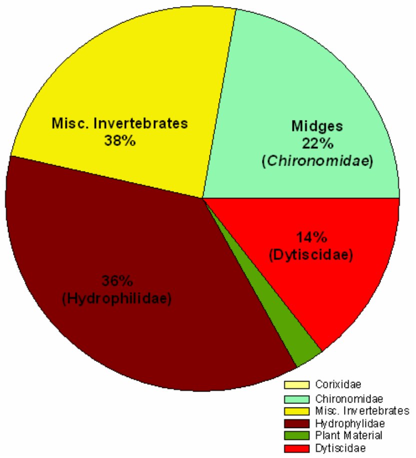


BNST

2005



AMAV



BNST

2006

Appendix 3. Volume (cm^3) of material removed from the digestive tract of each bird collected in 2005. The bird ID # contains the date of collection (first and second digits – month, third and fourth digits – day, fifth and sixth digits – bird number).

Bird ID #	Species	Location	Bithyniidae	Planorbidae	Odonata	Corixidae	Coleoptera Parts	Chironomidae	Ephydridae	Muscidae	Seeds	Other	Sum(cm^3)
0809-05	AMAV	FARM	0	0	0	0.09	0.27	0.6	0	0	0.1	0	1.06
0809-06	AMAV	FARM	0	0	0	0	0	0.12	0	0	0.01	0	0.13
0809-07	AMAV	FARM	0	0	0	0	0	0.89	0	0	0.2	0	1.09
0809-08	AMAV	FARM	0	0	0	0.18	0	0.18	0	0	0.04	0.01	0.41
0810-03	AMAV	BEAR	0	0	0	0.09	0	0.5	0	0	0.04	0	0.63
0810-04	AMAV	BEAR	0	0	0	0.15	0.04	0.67	0	0	0.1	0	0.96
0810-05	AMAV	BEAR	0	0	0	0.2	0	0.1	0	0	0	0.12	0.42
0810-06	AMAV	BEAR	0	0	0	0.23	0	2.1	0	0	0.1	0.02	2.45
0826-01	AMAV	SLCANAL	0	0	0	0.09	0	0.31	0.22	0	0.27	0	0.89
0809-01	BNST	FARM	0	0	0	0	0	0.02	0	0	0	0	0.02
0809-02	BNST	FARM	0	0	0.05	0.02	0	0.09	0	0	0	0	0.16
0809-03	BNST	FARM	0.02	0.08	0	0.18	0.03	0.02	0	0	0	0	0.33
0809-04	BNST	FARM	0	0	0	0.1	0	0	0	0	0	0	0.1
0810-01	BNST	BEAR	0	0	0	0.24	0	0	0	0	0	0.06	0.3
0810-02	BNST	BEAR	0	0	0	0.38	0.1	0	0	0	0	0.02	0.5
0810-07	BNST	BEAR	0	0	0	0.18	0	0.06	0	0	0	0	0.24
0810-08	BNST	BEAR	0	0	0	0.05	0	0	0	0.05	0	0.01	0.11
0817-01	BNST	SLCANAL	0	0	0	0.06	0.2	0.2	0	1.23	0	0	1.69
0817-02	BNST	SLCANAL	0	0	0	0	0	0.2	1.31	0	0	0.13	1.64
0817-03	BNST	SLCANAL	0	0	0	0	0.18	0.01	0	0	0.18	0.02	0.39
0817-04	BNST	SLCANAL	0	0	0	0	0	0.05	0.87	0	0	0.01	0.93
0825-01	BNST	SLCANAL	0	0	0	0	0	0.2	0.01	0	0.01	0	0.22
0825-02	BNST	SLCANAL	0	0	0	0	0.02	0.26	0	0	0.03	0	0.31
0825-03	BNST	SLCANAL	0	0	0	0.62	0	0.01	0	0	0	0	0.63
0826-02	BNST	SLCANAL	0	0	0	0.34	0	0.04	0	0	0.08	0	0.46
0826-04	BNST	SLCANAL	0	0	0	0.28	0	0.08	0	0	0	0.04	0.4
0826-05	BNST	SLCANAL	0	0	0	0.13	0	0.1	0	0	0	0.04	0.27
0830-01	BNST	SLCANAL	0	0	0	0	0.32	0.49	0	0	0.08	0	0.89

Appendix 4. Volume (cm3) of material removed from the digestive tract of each bird collected in 2006. The bird ID # contains the date of collection (first and second digits – month, third and fourth digits – day, fifth and sixth digits – year, seventh and eighth – bird number).

Bird ID #	Species	Sex	Location	Gastropoda	Odonata	Corixidae	Carabidae	Dytiscidae	Hydrophilidae	Coleoptera parts	Limnephilidae	Culicidae	Ceratopogonidae	Chironomidae	Stratiomyidae	Syrphidae	Ephydridae	Muscidae	Misc. Diptera	Braconidae	Shells	Eggshell	Seeds	Other	Sum Contents
091206-01	AMAV	U	CDSC	0	0	0.01	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0.02
091206-02	AMAV	U	CDSC	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.02
091206-03	AMAV	U	CDSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.27	0.07	0.34
091206-04	BNST	U	CDSC	0.02	0	0	0	0	0.04	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.14
091206-05	BNST	U	CDSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0.01	0.06
091206-06	BNST	U	CDSC	0	0	0	0	0	0.02	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0.03	0.02	0.17
091206-07	BNST	U	CDSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0.08
091206-08	BNST	U	CDSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.09	0.12
06706-06	AMAV	F	FARM	0	0	0	0	0	0.02	0	0	0	0	0.01	0	0	0	0.02	0	0.03	0	0	0.08	0.04	0.2
06706-08	AMAV	M	FARM	0	0	0.01	0	0	0	0	0	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0.03
06706-11	AMAV	M	FARM	0	0	0	0	0	0.03	0	0	0	0	0.05	0	0	0.03	0.03	0	0.02	0	0	0	0	0.16
06706-13	AMAV	M	FARM	0.05	0	0.03	0	0	0.02	0	0	0.02	0	7.95	0	0	0	0	0	0	0	0.01	0.03	0	8.11
06706-15	AMAV	M	FARM	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04
06706-09	BNST	M	FARM	0.03	0	0	0	0	0	0	0	0	0	0.64	0	0	0	0	0	0	0	0	0	0.32	0.99
06706-07	BNST	M	FARM	0	0.59	0	0	0.02	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0.02	0	0.65
06706-10	BNST	M	FARM	0	0.05	0	0	0	0.02	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0.01	0.1
06706-12	BNST	F	FARM	0	0	0.06	0	0.01	0	0.01	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0.01	0.17
06706-14	BNST	M	FARM	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.05
052406-01	AMAV	F	ISSR	0	0	0.09	0	0	0	0	0	0	0	0.01	0	0	0.02	0	0	0	0	0.05	0.02	0.01	0.2
052406-02	AMAV	M	ISSR	0	0	0.22	0	0	0	0	0.01	0	0	0.03	0	0	0	0	0	0	0	0	0.02	0.02	0.3

052406-03	AMAV	M	ISSR	**0**	**0**	**0.06**	**0.27**	**0**	**0.05**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.38**
052406-05	AMAV	F	ISSR	**0**	**0**	**0.1**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.04**	**0**	**0.01**	**0.2**
052406-04	AMAV	M	ISSR	**0**	**0**	**0.04**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0.05**	**0.12**
071206-01	AMAV	M	KACR-N	**0**	**0**	**0.28**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.29**
071206-02	BNST	M	KACR-N	**0**	**0**	**0.04**	**0**	**0.02**	**0**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.09**
071206-03	BNST	M	KACR-N	**0**	**0**	**0.04**	**0**	**0.03**	**1.78**	**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.95**
071206-04	BNST	F	KACR-N	**0**	**0**	**0.02**	**0**	**0.04**	**0.75**	**0.19**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
071206-05	BNST	F	KACR-N	**0**	**0**	**0.04**	**0**	**0**	**0**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.07**
071906-08	AMAV	M	KACR-S	**0**	**0**	**0.01**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0.01**	**0.04**
071906-07	AMAV	M	KACR-S	**0**	**0**	**0.02**	**0**	**0**	**0.03**	**0**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0**	**0.17**
071906-09	AMAV	M	KACR-S	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.04**	**0**	**0.05**
071906-06	AMAV	F	KACR-S	**0**	**0**	**0.02**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0.01**	**0**	**0**	**0**	**0**	**0.02**	**0**	**0.08**
071906-10	BNST	M	KACR-S	**0.01**	**0**	**0.02**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.05**
072606-02	AMAV	F	KACR-W	**0**	**0**	**0**	**0**	**0**	**0**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.18**	**0.01**	**0.22**
072606-01	AMAV	F	KACR-W	**0**	**0**	**0**	**0**	**0**	**0.03**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.03**	**0**	**0.09**
072606-05	BNST	F	KACR-W	**0**	**0**	**0.03**	**0**	**0.01**	**0.01**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.02**	**0.07**
072606-03	BNST	F	KACR-W	**0**	**0**	**0.04**	**0**	**0.01**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0**	**0.08**
072606-04	BNST	F	KACR-W	**0**	**0**	**0**	**0.01**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.01**	**0**	**0.04**
071306-05	AMAV	F	PSGR	**0**	**0.03**	**0.52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.55**
071306-03	BNST	F	PSGR	**0**	**0.02**	**0.1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.12**
071306-04	BNST	F	PSGR	**0**	**0**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.03**	**0**	**0.02**	**0**	**0**	**0**	**0.08**
071306-02	BNST	M	PSGR	**0.01**	**0**	**0.09**	**0**	**0.02**	**0.02**	**0**	**0**	**0**	**0.02**	**0**	**0**	**0**	**0**	**0**	**0.05**	**0**	**0.02**	**0**	**0.03**	**0.01**	**0.27**
071306-01	BNST	M	PSGR	**0.01**	**0.03**	**0.03**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.04**	**0**	**0**	**0**	**0.01**	**0.01**	**0.13**

051806-02	AMAV		SLCANAL	0	0	0.04	0	0	0	0	0	0	0	0.07	0	0	1.69	0.01	0	0	0	0	0	0.02	1.83
051806-1	AMAV	F	SLCANAL	0.18	0.01	0.11	0	0	0	0	0	0	0	1.29	0	0	0.03	0.02	0	0	0.02	0	0	0.05	1.71
051806-3	BNST	M	SLCANAL	0	0	0	0	0.06	0.03	0	0	0	0	0.13	0	0	0.04	0.02	0.02	0	0	0	0.02	0.09	0.41
051806-4	BNST	M	SLCANAL	0	0	0	0	0.17	0.77	0	0	0	0	0.15	0	0	0.07	0.01	0	0	0	0	0	0	1.17
062806-1	AMAV	M	NDSC	0	0	0.04	0	0	0.02	0	0	0	0	0.09	0	0	0.01	0	0	0	0	0	0	0	0.16
062806-2	AMAV	M	NDSC	0	0	0.02	0	0	0.01	0	0	0	0	0.54	0	0	0	0	0	0	0	0	0.02	0	0.59
062806-5	BNST	F	NDSC	0	0	0	0	0	0	0.03	0	0	0	0	0	0.26	0	0.01	0	0	0	0	0	0.03	0.33
062806-4	BNST	M	NDSC	0	0	0.02	0	0	0	0.05	0	0	0	0	0	0.22	0	0	0	0	0	0	0	0.02	0.31
062806-3	BNST	F	NDSC	0	0	0.01	0	0	0	0	0	0	0	0.1	0	0	0.1	0.02	0	0.01	0	0	0	0.05	0.29

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APENDIX D.1

A STUDY OF THE PERIPHYTON FLORA OF SAMPLES COLLECTED FROM EAST-SHORE GREAT SALT LAKE WETLANDS
FALL 2004

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A STUDY OF THE PERIPHYTON FLORA OF SAMPLES COLLECTED FROM EAST-SHORE GREAT SALT LAKE WETLANDS
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by

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May 2006

ABSTRACT

A total of 16 periphyton samples was collected from wetlands along the east shore of the Great Salt Lake in October and November, 2004. Thirty-eight algal taxa were observed in the sample set. Due to periphyton laboratory methods, several diatoms were not identified to the genus or species level but counted in the categories pennate and centric diatoms.

Pennate diatoms were the most abundant taxa in periphyton samples collected from Great Salt Lake wetlands during 2004, occurring in 100% of the 16 samples. Pennate diatoms occurred 75% of the time as abundant, 19% of the time as common, and 6% of the time as rare. Centric diatoms were also important, occurring in 14 of 16 samples, 14% of the time as abundant 36% of the time as common and 50% of the time as rare.

Non-diatom algae were dominated by the chlorophytes ***Cladophora glomerata*** (occurring ten times, 20% of the time as abundant, 30% of the time as common, and 50% of the time as rare), ***Ulothrix*** species (occurring in six of the samples, abundant in 33% and common in 17% of those occurrences); ***Chlamydomonas*** species (occurring six times, 33% of the time as common and 67% of the time as rare), and ***Spirogyra*** species (occurring five times, 40% of the time as abundant and 40% of the time as common); and by the cyanophytes ***Lyngbya birgei*** , occurring in five of the samples, at rates of 40% abundant and 20% common; and ***Oscillatoria amphibia*** (occurring seven times, 43% of the time as abundant and 57% of the time as common).

Additionally, ***Beggiatoa*** species occurred in four of the samples, abundant in 25% of those occurrences and common in 50%.

INTRODUCTION

Water quality in both standing and flowing waters is complex, encompassing several categories of parameters. Inorganic and organic chemical factors (including toxic substances), nutrients, density dependent factors, and physical factors (including water temperature, velocity, depth, light penetration, etc.) all can play important roles in determining the nature and health of aquatic ecosystems.

Because of this complexity, it often makes sense to study a parameter or subset of parameters that may be predictive or reflective of the suite of chemical and physical factors important in shaping the system. The study of ecosystem indicator taxa, macroinvertebrates, algae and diatoms, is a relatively cost-effective way of gathering significant information concerning the health of aquatic systems. For example, many laboratories now study the floras and/or faunas of streams or lakes and reservoirs in order to provide information concerning water quality. The organisms that live in an aquatic ecosystem serve as effective indicators of the water quality of the system. Furthermore, changes in floras and/or faunas over time can provide good measures of water quality.

In order to study periphyton composition in Great Salt Lake wetlands, attached algal communities (periphyton) have been sampled from 16 locations on the eastern shore of the Great Salt Lake during October and November, 2004. These periphyton communities have been examined, identified and scored according to relative abundance. Specific data from this analysis can be found in the appendix of this report.

FIELD METHODS

During the 2004 study period, algal populations were sampled from established sites in wetlands along the eastern shore of the Great Salt Lake by scientists from the Utah Department of Environmental Quality, Division of Water Quality. Samples were obtained by scraping stones and other attached substrata directly from the collection sites. Visible algae and vascular plants were also collected from each site. Samples were placed in 100ml bottles and returned to the laboratory on the day of collection and were kept under dark refrigeration until the time of processing.

Samples were collected from the following 16 locations, on the dates indicated:

Site Name	Site #	Date
GSL Wetlands Near CDSD Outfall Transect 1	4985660	10/29/04
GSL Wetlands Near CDSD Outfall Transect 2	4985670	10/28/04
GSL Wetlands Near CDSD Outfall Transect 3	4985680	11/1/04
GSL Wetlands Near CDSD Outfall Transect 4	4985690	11/2/04
Public Shooting Grounds Widgeon Lake T4	4985623	10/19/04
Public Shooting Grounds Widgeon Lake T5	4985624	10/18/04
Public Shooting Grounds Widgeon Lake T6	4985625	10/20/04
North Davis Transect 1	4985590	11/4/04
GSL Wetlands Near Mouth of Kays Ck TNC Transect 1	4985800	10/22/04
GSL Wetlands Near Mouth of Kays Ck TNC Transect 2	4985810	10/27/04
GSL Wetlands Near Mouth of Kays Ck TNC Transect 3	4985820	10/27/04
FBT7T5	N/A	10/21/04
FBT7T6	N/A	10/21/04
North Davis Transect 2	4985591	11/8/04
GSL Wetlands Pub. Shooting Ground Widgeon Lake 02 inflow	N/A	11/16/04
GSL Wetlands Newstate Duck Club Pond 47	4985870	11/12/04

LABORATORY METHODS

After delivery to our laboratory, periphyton samples were studied as soon as possible to ensure freshness of the samples. Samples were subsampled several times in the laboratory and subsamples were placed on 1X3 inch glass microscope slides and examined directly using a Nikon Eclipse E200 microscope equipped with Nikon's CFI60 infinity optical system. Algal taxa were identified to specific level when possible. Several taxa could not be identified to species level due to the absence of reproductive cells or a small number of cells present in the sample. Such taxa were therefore identified to the generic level and are listed in this report as “species” following the generic name.

A relative abundance for each taxon was estimated during microscopic examination of the subsamples and recorded as rare, common or abundant. In general, if a taxon was observed only as a single or very few specimens, it was recorded as rare. If a taxon was present in up to approximately 10% of the microscopic examination fields, it was recorded as common. If a taxon was present in more than 10% of the examination fields it was recorded as abundant. Samples were also analyzed for total biomass present (estimated as low, moderate or high), conspicuous odors, and the presence of vascular plants. This information was recorded and is presented according to sample in the section entitled "**notes**" at the end of each data sheet appended to this report.

The examination of periphyton samples is a qualitative process intended to generate a comprehensive list of algal taxa in a sample, providing an estimate of the species composition of the habitat from which the sample was collected. As specified in the Academy of Natural Sciences, Philadelphia publication “*Protocols for the Analysis of Algal Samples Collected as Part of the U.S. Geological Survey National Water-Quality Assessment Program*,” identification of every algal taxon in a sample will most likely not occur in a qualitative analysis of a periphyton sample. It is generally agreed, however, that a majority of the species in a sample will be encountered in a “reasonable search.”

RESULTS

During the fall, 2004 study period, diatoms comprised the most abundant algal groups in Great Salt Lake wetland samples. Pennate diatoms occurred in each of the 16 samples, 75% of the time as abundant, 19% of the time as common, and 6% of the time as rare. Centric diatoms occurred in 14 of the samples, 14% of the time as abundant, 36% of the time as common and 50% of the time as rare.

Non-diatom algal flora was dominated by the chlorophytes ***Cladophora glomerata*** (occurring ten times, 20% of the time as abundant, 30% of the time as common, and 50% of the time as rare), ***Ulothrix*** species (occurring in six of the samples, abundant in 33% and common in 17% of those occurrences), ***Chlamydomonas*** species (occurring six times, 33% of the time as common and 67% of the time as rare), and ***Spirogyra*** species (occurring five times, 40% of the time as abundant and 40% of the time as common). and by the cyanophytes ***Lyngbya birgei*** (occurring in five of the samples, at rates of 40% abundant and 20% common) and ***Oscillatoria amphibia*** (occurring seven times, 43% of the time as abundant and 57% of the time as common). Additionally, ***Beggiatoa*** species occurred in four of the samples, abundant in 25% of those occurrences and common in 50% (**Figure 1**).

A total of 38 algal taxa was observed in the samples collected during the period October − November 2004. In addition, many additional taxa included in the categories pennate and centric diatoms were present in the samples but most were not identified to the specific level due to periphyton laboratory methods. Thus, the count of taxa reported herein for the October − November 2004 period is lower than actually occurred in the sampled Great Salt Lake wetlands.

Table 1. Alphabetical list and number of occurrences of algal species found in periphyton samples collected from east-shore Great Salt Lake wetland sites in October and November of 2004. The categories centric and pennate diatoms contain many additional species. A total of 16 samples were collected October − November 2004.

Taxon	Number of Occurrences
Anabaena species	2
Ankistrodesmus falcatus	3
Ankistrodesmus species	1
Beggiatoa species	4
Calothrix species	1
Chamaesiphon incrustans	1
Chlamydomonas species	6
Cladophora glomerata	10
Closteriopsis longissima	1
Closterium ehrenbergii	3
Closterium species	2
Closterium species 2	1
Diatoma vulgare	3
Diatoms, centric	14
Diatoms, pennate	16
Euglena species	2
Lyngbya birgei	5
Melosira granulata	4
Melosira granulata var. ***angustissima***	2
Melosira varians	1
Oedogonium species	2
Oscillatoria aghardi	1
Oscillatoria amphibia	7
Oscillatoria princes	2
Oscillatoria species	3
Oscillatoria species 2	1
Pediastrum duplex	2
Pediastrum species	1
Phacus species	2
Phormidium incrustatum	4
Scenedesmus species	3
Spirogyra species	5
Spirogyra species 2	1
Stigeoclonium species	2
Tolypothrix species	1
Ulothrix aequalis	1
Ulothrix cylindricum	1
Ulothrix species	6
Ulothrix species 2	2
Zygnema species	1

Table 2. Abundance categories of taxa found in periphyton samples collected from east-shore Great Salt Lake wetland sites in October and November, 2004.

Division and Species	Number of Occurrences
Cyanophyta	
Anabaena species	2
Calothrix species	1
Chamaesiphon incrustans	1
Lyngbya birgei	5
Oscillatoria aghardi	1
Oscillatoria amphibia	7
Oscillatoria princeps	2
Oscillatoria species	3
Oscillatoria species 2	1
Phormidium species	4
Tolypothrix species	1
Total Cyanophyta Species	11
Total Cyanophyta Occurrences in 16 Samples	28

Chlorophyta	
Ankistrodesmus falcatus	3
Ankistrodesmus species	1
Chlamydomonas species	6
Cladophora glomerata	10
Closteriopsis longissima	1
Closterium ehrenbergii	3
Closterium species	2
Closterium species 2	1
Oedogonium species	2
Pediastrum duplex	2
Pediastrum species	1
Scenedesmus species	3
Spirogyra species	5
Spirogyra species 2	1
Stigeoclonium species	2
Ulothrix aequalis	1
Ulothrix cylindricum	1
Ulothrix species	6
Ulothrix species 2	2
Zygnema species	1
Total Chlorophyta Species	20
Total Chlorophyta Occurrences in 16 Samples	54

Division and Species	**Number of Occurrences**
Bacillariophyta	
Diatoma vulgare	3
Diatoms, centric	14
Diatoms, pennate	16
Melosira granulata	4
Melosira granulata var. angustissima	2
Melosira varians	1
Total Bacillariophyta Species and Categories	6
Total Bacillariophyta Occurrences in 16 Samples	40

Euglenophyta	
Euglena species	2
Phacus species	2
Total Euglenophyta Species	2
Total Euglenophyta Occurrences in 16 Samples	4

Other	
Beggiatoa species	4
Total “Other” Species	1
Total “Other” Occurrences in 16 Samples	4

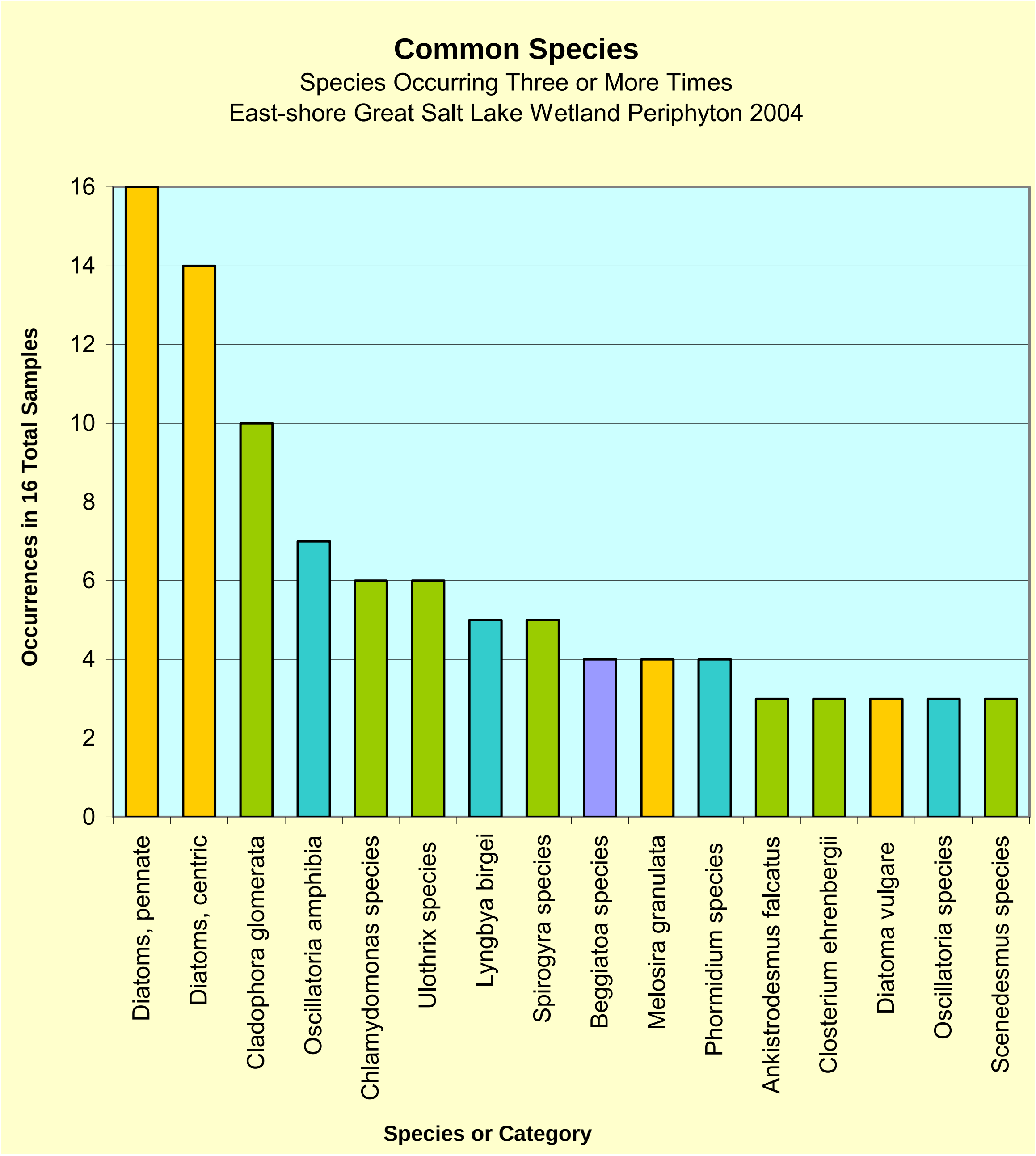

Figure 1. Important species (occurring in at least 10% of all samples) in periphyton samples collected from east-shore Great Salt Lake wetland sites in October and November, 2004.

References

The Academy of Natural Sciences. 2002. Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program. Patrick Center for Environmental Research. Philadelphia, PA. Report No. 02-06.

American Public Health Association. Standard Methods for Examination of Water & Wastewater. 2005. Andrew D. Eaton, Lenore S. Clesceri, Eugene W. Rice, Arnold E. Greenberg, Mary Ann H. Franson (Editors). 20th Edition. Washington, D.C.

APPENDIX: SPECIFIC DATA FROM PERIPHTYON SAMPLES COLLECTED FROM EAST-SHORE GREAT SALT LAKE WETLANDS
FALL 2004

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near CDSD Outfall Transect 1
Site Number:	4985660
Date:	10/29/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Common
Cladophora glomerata	Common
Closterium species	Rare
Melosira granulata	Common
pennate diatoms	Abundant
Spirogyra species	Abundant
Spirogyra species 2	Common
Ulothrix aequalis	Common

Notes:
Sample with moderate to high biomass. No detectable odor present. Majority of biomass comprised of organic debris and algae. ***Spirogyra*** species most abundant species in sample.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near CDSD Outfall Transect 2
Site Number:	4985670
Date:	10/28/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Closterium species	Common
Closterium species 2	Rare
Melosira species	Rare
Oscillatoria amphibia	Common
Oscillatoria species	Rare
Oscillatoria species 2	Common
pennate diatoms	Abundant
Phormidium species	Rare

Notes:

Sample with light to moderate biomass. No detectable odor present. Biomass comprised of algae and organic debris. ***Oscillatoria*** species 2 is very small and attached to other filaments.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near CDSD Outfall Transect 3
Site Number:	4985680
Date:	11/1/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Cladophora glomerata	Abundant
Closterium ehrenbergii	Common
Oedogonium species	Common
Oscillatoria amphibia	Abundant
Oscillatoria princeps	Abundant
pennate diatoms	Common
Spirogyra species	Common
Stigeoclonium species	Rare

Notes:

The most abundant species in the sample is ***Oscillatoria*** species, which seems to appear both in clusters and as individuals, but there is not noticeable sheath around trichomes, ruling out an identification of ***Phormidium*** species.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near CDSD Outfall Transect 4
Site Number:	4985690
Date:	11/2/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Cladophora glomerata	Rare
Oscillatoria amphibia	Common
pennate diatoms	Abundant
Ulothrix species	Common
Ulothrix species 2	Common

Notes:

Sample with high biomass, primarily organic debris (vascular plants). Fresh "vegetable" odor present and strong.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	Public Shooting Grounds Widgeon Lake T4
Site Number:	4985623
Date:	10/19/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
centric diatoms	Common
Cladophora glomerata	Rare
Chlamydomonas species	Rare
Melosira granulata v. ***angustissima***	Abundant
Melosira varians	Abundant
pennate diatoms	Abundant
Phormidium species	Rare

Notes:
Sample with moderate biomass. Moderate “organic” odor present. Very murky sample.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	Public Shooting Grounds Widgeon Lake T5
Site Number:	4985624
Date:	10/18/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Abundant
Cladophora glomerata	Rare
Lyngbya birgei	Common
Oscillatoria amphibia	Common
Oscillatoria princeps	Common
pennate diatoms	Abundant
Spirogyra species	Common
Ulothrix cylindricum	Abundant
Zygnema species	Abundant

Notes:
Sample with moderate to low biomass. Moderate to strong “organic” odor present.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	Public Shooting Grounds Widgeon Lake T6
Site Number:	4985625
Date:	10/20/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Beggiatoa species	Abundant
Calothrix species	Rare
centric diatoms	Common
Lyngbya birgei	Rare
Melosira granulata var. ***angustissima***	Rare
Oedogonium species	Rare
Pediastrum duplex	Rare
Phacus species	Common
Phormidium species	Abundant
pennate diatoms	Abundant
Tolypothrix species	Abundant
Ulothrix species	Rare

Notes:
Sample with low to moderate biomass. Strong “sulfur” odor present. ***Anabaena*** species and ***Phormidium*** species were both attached to a reed included as substrate in the sample.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	North Davis Transect 1
Site Number:	4985590
Date:	11/4/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Abundant
centric diatoms	Rare
Cladophora glomerata	Rare
Euglena species	Rare
Oscillatoria aghardi	Rare
pennate diatoms	Common
Ulothrix species	Rare

Notes:
Sample with moderate to high biomass. No detectable odor present. Biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near Mouth of Kays Ck TNC Transect 1
Site Number:	4985800
Date:	10/22/04
Analyst:	Sarah Rushforth

Species Name:

Beggiatoa species	Common
centric diatoms	Common
Chlamydomonas species	Common
Cladophora glomerata	Rare
Diatoma vulgare	Common
Melosira granulata	Common
Oscillatoria amphibia	Abundant
pennate diatoms	Abundant
Scenedesmus species	Rare
Spirogyra species	Rare

Notes:
Sample with moderate biomass, including grasses. Moderate "organic" odor present. Majority of biomass comprised of diatoms and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near Mouth of Kays Ck TNC Transect 2
Site Number:	4985810
Date:	10/27/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus species	Rare - common
Beggiatoa species	Common
Chlamydomonas species	Rare
Cladophora glomerata	Abundant
Closteriopsis longissima	Rare
Closterium ehrenbergii	Rare
Diatoma vulgare	Rare
Euglena species	Rare
Lyngbya birgei	Abundant
Melosira granulata	Rare
Oscillatoria princeps	Common
Pediastrum duplex	Rare
pennate diatoms	Abundant
Phormidium incrustatum	Common
Spirogyra species	Abundant

Notes:
Sample with moderate biomass. No detectable odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Near Mouth of Kays Ck TNC Transect 3
Site Number:	4985820
Date:	10/27/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Common
Cladophora glomerata	Common
Closterium ehrenbergii	Rare
Diatoma vulgare	Abundant
pennate diatoms	Abundant
Ulothrix species	Rare

Notes:
Sample with moderate biomass. No detectable odor. Majority of biomass comprised of algae and organic debris. High density of pennate diatoms.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	FBT7T5
Site Number:	
Date:	10/21/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Beggiatoa species	Rare
centric diatoms	Rare
Chamaesiphon incrustans	Common
Cladophora glomerata	Common
Oscillatoria amphibia	Abundant
pennate diatoms	Abundant
Scenedesmus species	Rare
Ulothrix species	Abundant

Notes:
Sample with moderate to low biomass. Very slight "organic" odor present. Majority of biomass comprised of algae and organic debris. ***Chamaesiphon incrustans*** common on ***Ulothrix*** species

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	FBT7T6
Site Number:	
Date:	10/21/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Rare
Lyngbya birgei	Abundant
Oscillatoria amphibia	Common
Oscillatoria species	Common
Pediastrum species	Rare
pennate diatoms	Abundant
Phacus species	Rare
Phormidium species	Rare
Ulothrix species	Abundant
Ulothrix species 2	Abundant

Notes:
Sample with moderate to low biomass. No detectable odor present. The ***Oscillatoria*** species present is a small variety, but not as small as ***O. amphibia***.. Majority of biomass comprised of algae and organic debris. Lots of ***Ulothrix*** species. Also some inorganic debris like Styrofoam in the sample.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	North Davis Transect 2
Site Number:	4985591
Date:	11/8/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Abundant
centric diatoms	Abundant
Chlamydomonas species	Common
Lyngbya birgei	Rare
Oscillatoria species	Rare
pennate diatoms	Abundant
Stigeoclonium species	Rare

Notes:

Sample with low biomass. No detectable odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Public Shooting Ground Widgeon Lake 02 In
Site Number:	
Date:	11/16/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Common
pennate diatoms	Common

Notes:
Sample with very low biomass.

Great Salt Lake Periphyton Community Composition Analysis 2004

Project Name:	Great Salt Lake Periphyton
Site Name:	GSL Wetlands Newstate Duck Club Pond 47
Site Number:	4985870
Date:	11/12/2004
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Rare
pennate diatoms	Rare
Scenedesmus species	Rare

Notes:

Sample with very low, sparse biomass. Majority of biomass comprised of organic debris and diatoms.

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APENDIX D.2

A STUDY OF THE PHYTOPLANKTON FLORAS OF GREAT SALT LAKE

FALL 2004

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A STUDY OF THE PHYTOPLANKTON FLORAS OF GREAT SALT LAKE
FALL 2004

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ABSTRACT

During October and November of 2004, phytoplankton samples were collected and examined from established wetlands sites along the shores of Great Salt Lake. Collections were made by scientist from the Utah Department of Environmental Quality, Water Quality Division. Ten individual sites were collected across five collection dates for a total of ten phytoplankton samples during the collecting period.

A total of 19 taxa was identified in the plankton flora. The two common categories centric diatoms and pennate diatoms each contained many additional taxa. The most important plankters (species with an ISI value of 0.9 or greater) as determined by calculating Important Species Indices (ISIs) from all combined phytoplankton samples from Great Salt Lake wetlands during 2004 were: the diatom categories pennate diatom (ISI = 37.3) and centric diatoms (ISI = 27.7); the chlorophytes ***Scenedesmus*** species (ISI = 3.9), ***Ankistrodesmus falcatus***, and an unknown filamentous Chlorophyta (ISI = 1.6); and the cyanophyte ***Aphanizomenon flos-aquae*** (ISI = 0.9) (**Table 2, Figure 1**).

Together these top two categories and four plankters comprised approximately 95% of the phytoplankton flora (as determined by summing importance values) in samples collected from Great Salt Lake wetlands during the 2004 study period. The ISI measurement is figured by multiplying the percent relative density by the frequency of occurrence for each species in all samples across the year.

The algal category Bacillariophyta (diatoms) dominated the phytoplankton flora of the sample set, comprising just over 83% of the summed Important Species Index. Chlorophyta (green algae) comprised 15% of the summed ISI and Cyanophyta (blue-green algae or cyanobacteria) comprised 1%. A fourth algal category, Euglenophyta, comprised only 0.4% of the summed Important Species Index during the study period.

INTRODUCTION

Covering about 1,500 square miles, Great Salt Lake is the largest US lake West of the Mississippi River and the largest saline lake in the Western Hemisphere. The lake receives inflow from the Jordan River, the Bear River, and the Weber River, but is a terminal lake and has no outlet. Salinity is affected only by changes in lake elevation caused by inflow, precipitation, and evaporation and the lake is a hyper-saline system. These conditions represent a unique environment for the study of algal communities.

The 2004 phytoplankton study reports data on samples collected from October 6th through November 18th at ten wetlands sampling locations on the Great Salt Lake. The study mostly involved direct observation and enumeration of the dominant algae present in Great Salt Lake wetlands.

We determined the number of each alga present in each sample and the number of each alga per milliliter of lake water. We also determined the biovolume of the total number of each individual organism in cubic micrometers, the relative density of each taxon according to its biovolume, and the rank of each taxon according to biovolume (biomass) in each sample. We also performed several descriptive statistical assessments of each sample. These results are reported in the appendix following this report.

FIELD METHODS

Algal populations from ten wetlands sampling sites on Great Salt Lake were sampled by scientists from the Utah State Department of Environmental Quality, Division of Water Quality. Each site was collected once during the study period. Samples were collected on five collecting dates. Collection sites were: Farmington Wetlands Ambassador W1 (4985320), Farmington Wetlands Ambassador 100 (4985330), Farmington Wetlands Ambassador W5 (4985350), Farmington Wetlands FBWMA Unit 1 Outfall (4985520) GSL Wetlands Public Shooting Ground Widgeon Lake 01 Outfall (4985620), GSL Wetlands Public Shooting Ground Pintail Lake (4985630), GSL Wetlands Newstate Duck Club Pond 20 (4985880), GSL Wetlands Newstate Duck Club Unit 5-6 (4985890), Farmington Wetlands Ambassador W 2 (5985340), and GSL Wetlands FBWMA near 17th Outfall Lakeside Transect 1. Collection dates were October 6, October 18, November 16, November 17, and November 18, 2004. All collections were taken as surface total plankton samples.

LABORATORY METHODS

After collection, samples were delivered to our lab and kept in cold storage until the time of processing. Samples were processed as quickly as possible to ensure that algal populations were not changed appreciably by zooplankton predation or algal population growth.

At the time of processing, a 500 milliliter subsample was removed after mixing. This subsample was suction filtered through a 1.2 micrometer pore size

Millipore filter. The algal cells retained on the filter were re-suspended in 5 ml of water in a 50 ml beaker.

Aliquots were removed from this subsample and placed into a Palmer counting chamber for enumeration (Palmer and Maloney 1954). The Palmer cell is advantageous for counting total plankton samples since the algae can be studied at 400 magnifications rather than 160X. Counting at a greater magnification facilitates species identification, especially of smaller taxa. This increased resolution can be an important factor, especially for nanoplankton work. Furthermore, studies of total plankton in standing water at high magnification are often important since they generally contain a more comprehensive suite of organisms than net plankton samples which tend to lose small organisms through the net mesh.

One transect from each Palmer cell subsample was studied to determine the mean number of cells per transect. The number of algal cells present per milliliter of lake water was then calculated by multiplying the mean number of cells per transect by appropriate multiplication factors.

A separate determination of biomass was made by determining the biovolume of each taxon in each sample and multiplying the average biovolume (in cubic micrometers) for that taxon by its number per milliliter. These figures are reported in individual sample reports in **Appendix I** and in tables in **Appendix II** of this report.

Microscopy on phytoplankton samples was performed using a Nikon

Eclipse E200 microscope equipped with Nikon's CFI60 infinity optical system. Identifications were performed using standard taxonomic works and personal reference slide collections.

Numerical Analyses − The number of species in each sample was tallied and recorded. A percent relative density for each taxon was calculated using the biovolume (biomass) for that taxon in the sample. The rank of each taxon in that sample was also calculated based upon the biovolume per milliliter.

A Shannon-Wiener diversity index was calculated for each stand (Margalef 1958; Patten 1962; Shannon and Weaver 1963). The formula for this index is

$$H' = -\sum_{i=1}^{S} P_i \text{ LOG } P_i$$

where; P_i = the proportion of the total number of individuals in the i^{th} species; and S = the number of species.

A species richness factor was calculated after Atlas and Bartha (1981). This factor is similar to many other diversity factors and may be considered to be a second measure of diversity by many biologists. The formula for calculation of this evenness factor is

$$d = \frac{S - 1}{\log N}$$

where S = the number of species; and N = the number of individuals. The number of species per sample was also tallied and recorded. A species evenness factor was calculated (Atlas and Bartha 1981) according to the formula

$$e = \frac{\text{Shannon-Weaver index}}{\log S}$$

where S is the number of species in the sample.

Important species indices (ISIs) were calculated for each taxon by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983). This index is often preferable to comparing average density alone since it reflects both the distribution and abundance of a taxon in the ecosystem. Important species indices were calculated for all taxa from all sites.

RESULTS AND DISCUSSION

The plankton flora of samples collected from Great Salt Lake during 2004 contained a total of 19 taxa (**Table 1**). This represents only those species that were identifiable in our analyses. Many additional diatom taxa were present in the flora, recorded in our counts as pennate diatoms or centric diatoms. Plankton flora was comprised of two diatom (Bacillariophyta) categories, 14 green algae (Chlorophyta), two cyanobacteria or blue-green algae (Cyanophyta), and three eugelnophytes (Euglenophyta) (**Table 1**).

The most important plankters (with an ISI value of 0.9 or higher) as determined by calculating Important Species Indices (or ISIs) from all combined Great Salt Lake plankton during 2004 were: the diatom categories pennate diatom (ISI = 37.3) and centric diatoms (ISI = 27.7); the chlorophytes

Scenedesmus species (ISI = 3.9), ***Ankistrodesmus falcatus***, and an unknown filamentous Chlorophyta (ISI = 1.6); and the cyanophyte ***Aphanizomenon flos-aquae*** (ISI = 0.9) (**Table 2; Figure 1**). These two categories and four planters comprised approximately 95% of the phytoplankton flora (as determined by summing importance values) of the phytoplankton flora of Great Salt Lake samples collected during the 2004 study period.

Pennate diatoms were the most important plankters in Great Salt Lake wetlands phytoplankton samples collected during 2004. As a group, pennate diatoms had an Important Species Index value of 37.3. The algal category Bacillariophyta (diatoms) dominated the algal flora of phytoplankton samples collected from Great Salt Lake wetlands during the 2004 study period. This division comprised approximately 83% of the summed Important Species Index (**Figure 2**). This study of Great Salt Lake wetlands phytoplankton is continuing for some years in the future. Results and discussion will be provided as further data are analyzed.

Table 1. List of the algal taxa present in plankton samples collected from Great Salt Lake wetlands, late Fall, 2004.

Bacillariophyta

Centric diatoms
Pennate diatoms

Chlorophyta

Ankistrodesmus falcatus
Chlamydomonas species
Cosmarium species
Crucigenia species
Oedogonium species
Oocystis species
Oocytis borgei
Pediastrum duplex
Pediastrum species
Pteromonas species
Scenedesmus species
Tetraedron species
Unknown filamentous Chlorophyta
Unknown spherical Chlorophyta

Cyanophyta

Aphanizomenon flos-aquae
Oscillatoria species

Euglenophyta

Euglena species
Phacus species
Trachellomonas species

Table 2. List of species with an Important Species Index value of 0.1 or greater in phytoplankton samples collected from Great Salt Lake wetlands during the 2004 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

TAXON	**IMPORTANCE VALUE**
Pennate diatoms	37.3
Centric diatoms	27.7
Scenedesmus species	3.9
Ankistrodesmus falcatus	2.9
Unknown filamentous Chlorophyta	1.6
Aphanizomenon flos-aquae	0.9
Unknown spherical Chlorophyta	0.8
Chlamydomonas species	0.7
Oedogonium species	0.6
Pediastrum duplex	0.5
Oocystis species	0.5
Euglena species	0.3
Oocytis borgei	0.2
Cosmarium species	0.2
Crucigenia species	0.1

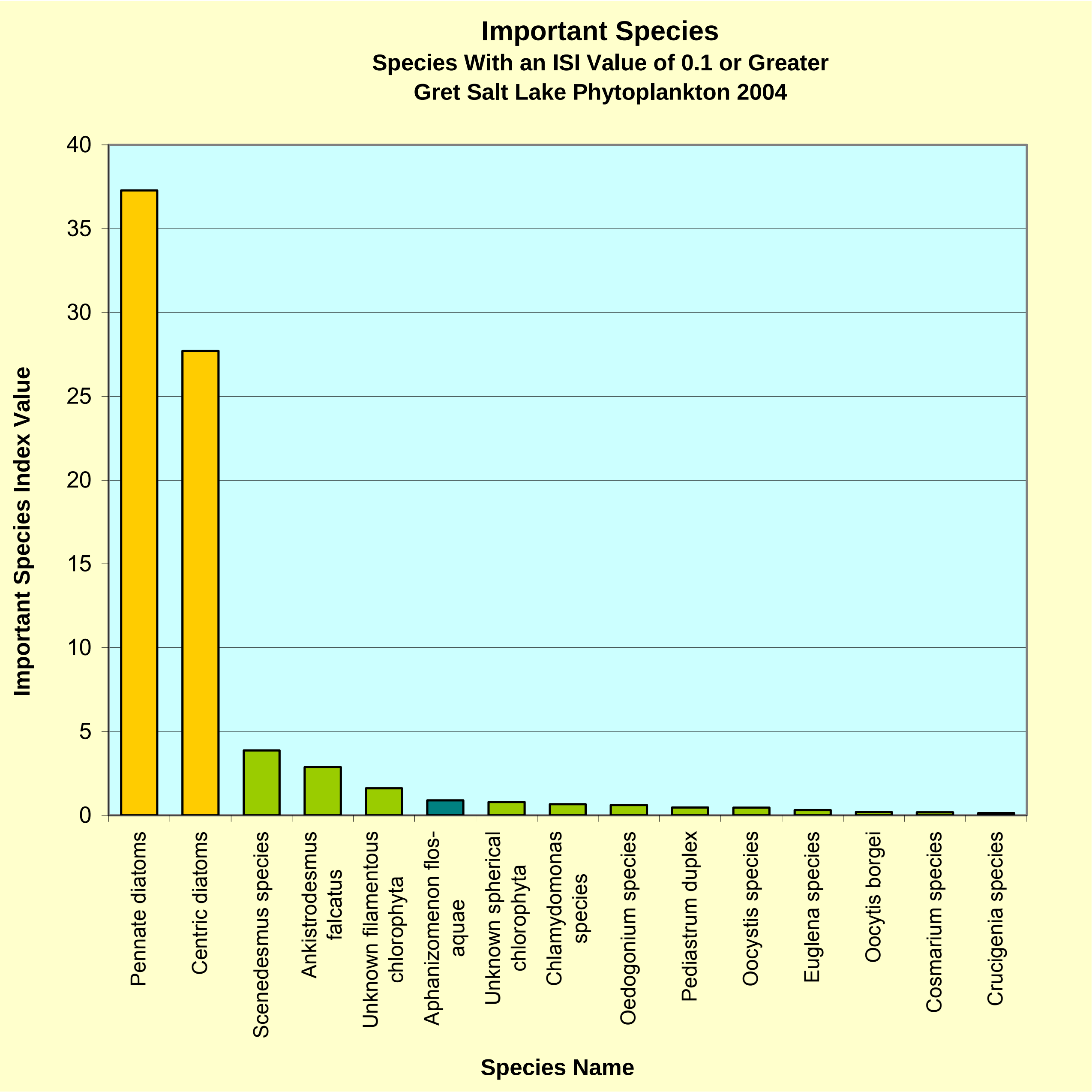

Figure 1. Important Species Index of the major species (ISI = 0.1 or greater) in phytoplankton samples collected from Great Salt Lake wetlands during the 2004 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

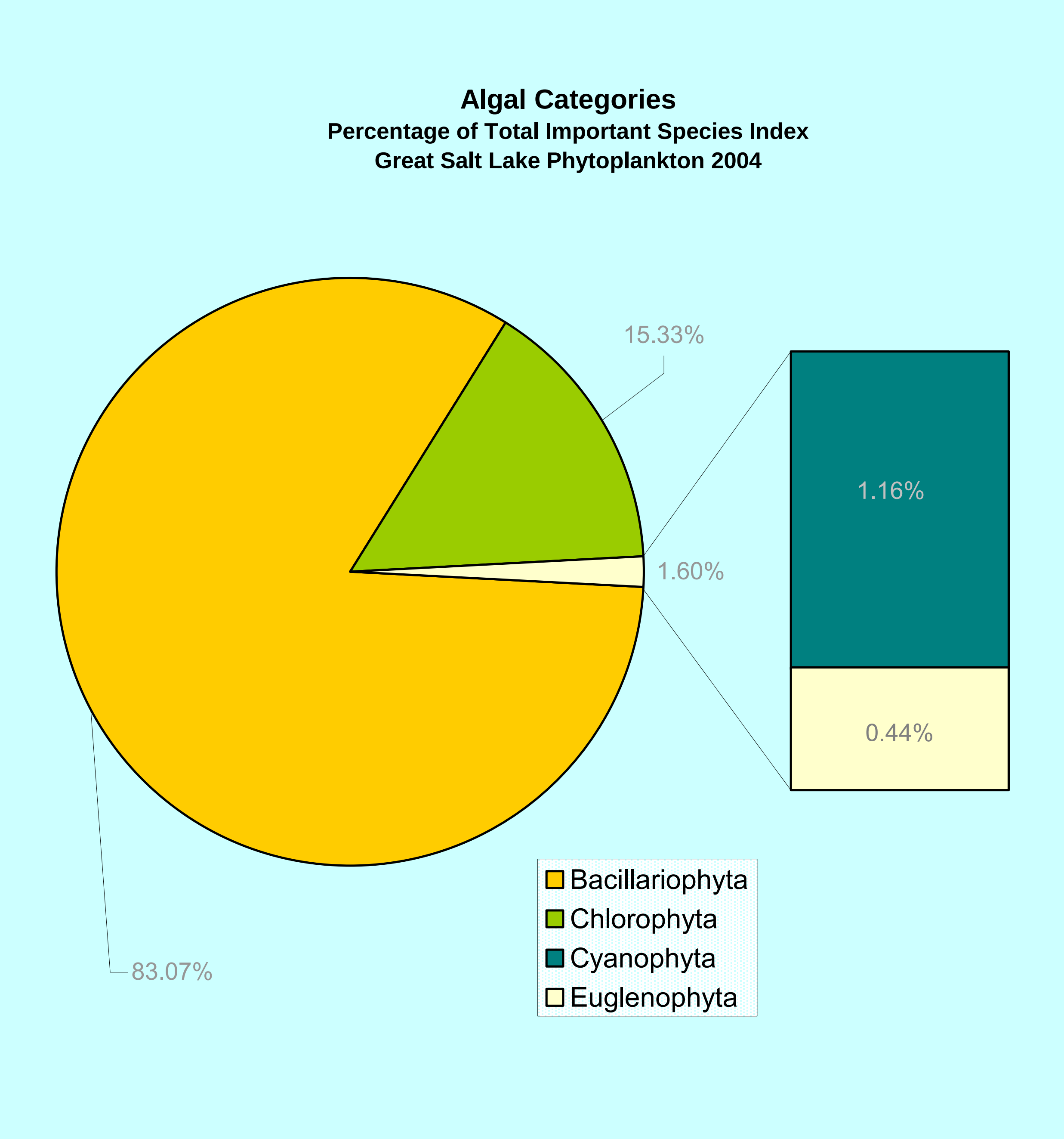

Figure 2. Percent of the sum Important Species Index comprised by the major groups of phytoplankton from samples collected from Great Salt Lake wetlands during the 2004 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

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APPENDIX I: Specific Data from Individual Phytoplankton Samples Collected from Great Salt Lake Wetlands
Late Fall 2004

Algal taxa present in a total plankton sample collected from Great Salt Lake, **Pintail E. Outfall 498563** on **11/16/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	1	67.1	180.0	126000.0
PENNATE DIATOMS	2	14.3	33.6	26880.0
Total Bacillariophyta		**81.4**	**213.6**	**152880.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	5	2.0	4.8	3768.0
OOCYTIS BORGEI	4	5.1	2.4	9600.0
SCENEDESMUS SPECIES	3	11.5	14.4	21600.0
Total Chlorophyta		**18.6**	**21.6**	**34968.0**
TOTAL FOR ALL GROUPS		**100.0**	**235.2**	**187848.0**

Shannon-Wiener Index =0.78
Species Evenness =0.48
Species Richness =0.87
Number of Species =5

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **Ambass W5** on **10/18/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	3	9.1	26.4	18480.0
PENNATE DIATOMS	1	49.3	124.8	99840.0
Total Bacillariophyta		**58.4**	**151.2**	**118320.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	2	26.0	67.2	52752.0
OOCYTIS BORGEI	5	4.7	2.4	9600.0
SCENEDESMUS SPECIES	4	8.9	12.0	18000.0
TETRAEDRON SPECIES	6	1.9	4.8	3840.0
Total Chlorophyta		**41.6**	**86.4**	**84192.0**
TOTAL FOR ALL GROUPS		**100.0**	**237.6**	**202512.0**

Shannon-Wiener Index	=1.22
Species Evenness	=0.68
Species Richness	=1.09
Number of Species	=6

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **Ambass W1 4985320** on **11/18/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	2	30.0	715.2	500640.0
PENNATE DIATOMS	1	51.3	1070.4	856320.1
Total Bacillariophyta		**81.3**	**1785.6**	**1356960.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	6	1.7	36.0	28260.0
CRUCIGENIA SPECIES	8	0.2	4.8	3360.0
PEDIASTRUM SPECIES	3	8.6	2.4	144000.0
SCENEDESMUS SPECIES	5	3.5	38.4	57600.0
UNKNOWN SPHERICAL CHLOROPHYTA	7	0.4	7.2	7200.0
Total Chlorophyta		**14.4**	**88.8**	**240420.0**
Euglenophyta				
EUGLENA SPECIES	4	4.3	9.6	71040.0
Total Euglenophyta		**4.3**	**9.6**	**71040.0**
TOTAL FOR ALL GROUPS		**100.0**	**1884.0**	**1668420.0**

Shannon-Wiener Index =0.92
Species Evenness =0.44
Species Richness =1.05
Number of Species =8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **Ambass 100 4985330** on **11/18/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	1	81.7	945.6	661920.0
PENNATE DIATOMS	2	12.8	129.6	103680.0
Total Bacillariophyta		**94.5**	**1075.2**	**765600.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	4	2.3	24.0	18840.0
CHLAMYDOMONAS SPECIES	5	0.5	9.6	3840.0
SCENEDESMUS SPECIES	3	2.7	14.4	21600.0
Total Chlorophyta		**5.5**	**48.0**	**44280.0**
TOTAL FOR ALL GROUPS		**100.0**	**1123.2**	**809880.0**

Shannon-Wiener Index	=0.57
Species Evenness	=0.36
Species Richness	=0.65
Number of Species	=5

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **PSG NL Out 4985620** on **11/16/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	1.7	3.6	2520.0
PENNATE DIATOMS	1	52.7	97.2	77760.0
Total Bacillariophyta		**54.4**	**100.8**	**80280.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	7	0.6	1.2	942.0
CHLAMYDOMONAS SPECIES	4	2.0	7.2	2880.0
CRUCIGENIA SPECIES	8	0.6	1.2	840.0
SCENEDESMUS SPECIES	6	1.2	1.2	1800.0
UNKNOWN FILAMENTOUS CHLOROPHYTA	2	38.8	3.6	57340.8
UNKNOWN SPHERICAL CHLOROPHYTA	3	2.4	3.6	3600.0
Total Chlorophyta		**45.6**	**18.0**	**67402.8**
TOTAL FOR ALL GROUPS		**100.0**	**118.8**	**147682.8**

Shannon-Wiener Index	=0.79
Species Evenness	=0.38
Species Richness	=1.52
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake**, New Street 20 pd 4985880** on **11/17/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	4	0.8	4.8	3360.0
PENNATE DIATOMS	1	90.7	463.2	370560.0
Total Bacillariophyta		**91.5**	**468.0**	**373920.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	3	3.5	36.0	14400.0
UNKNOWN SPHERICAL CHLOROPHYTA	5	0.6	2.4	2400.0
Total Chlorophyta		**4.1**	**38.4**	**16800.0**
Euglenophyta				
EUGLENA SPECIES	2	4.3	2.4	17760.0
Total Euglenophyta		**4.3**	**2.4**	**17760.0**
TOTAL FOR ALL GROUPS		**100.0**	**508.8**	**408480.0**

Shannon-Wiener Index	=0.37
Species Evenness	=0.23
Species Richness	=0.75
Number of Species	=5

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **Ambass W2 4985340** on **11/18/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	6	3.7	24.0	16800.0
PENNATE DIATOMS	4	13.4	76.8	61440.0
Total Bacillariophyta		**17.1**	**100.8**	**78240.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	2	15.2	88.8	69708.0
CHLAMYDOMONAS SPECIES	10	0.8	9.6	3840.0
OOCYSTIS SPECIES	7	2.4	7.2	10800.0
PEDIASTRUM DUPLEX	3	14.3	1.2	65356.8
SCENEDESMUS SPECIES	5	5.1	15.6	23400.0
UNKNOWN FILAMENTOUS CHLOROPHYTA	1	41.8	12.0	191136.0
UNKNOWN SPHERICAL CHLOROPHYTA	9	1.3	6.0	6000.0
Total Chlorophyta		**81.0**	**140.4**	**370240.8**
Euglenophyta				
EUGLENA SPECIES	8	1.9	1.2	8880.0
Total Euglenophyta		**1.9**	**1.2**	**8880.0**
TOTAL FOR ALL GROUPS		**100.0**	**242.4**	**457360.8**

Shannon-Wiener Index	=1.66
Species Evenness	=0.72
Species Richness	=1.70
Number of Species	=10

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **New Street 5-6 pond 4985890** on **11/17/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	1	59.6	2894.4	2026080.0
PENNATE DIATOMS	2	25.4	1080.0	864000.1
Total Bacillariophyta		**85.1**	**3974.4**	**2890080.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	5	0.3	28.8	11520.0
OEDOGONIUM SPECIES	3	12.3	28.8	416563.2
PTEROMONAS SPECIES	8	0.0	1.2	552.0
SCENEDESMUS SPECIES	7	0.1	2.4	3600.0
Total Chlorophyta		**12.7**	**61.2**	**432235.2**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	4	2.0	3.6	68400.0
Total Cyanophyta		**2.0**	**3.6**	**68400.0**
Euglenophyta				
PHACUS SPECIES	6	0.2	1.2	6000.0
Total Euglenophyta		**0.2**	**1.2**	**6000.0**
TOTAL FOR ALL GROUPS		**100.0**	**4040.4**	**3396716.0**

Shannon-Wiener Index	=0.68
Species Evenness	=0.33
Species Richness	=0.86
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **FBWMA Unit 1 Outfall 4985520** on **10/6/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	8	2.2	6.0	4200.0
PENNATE DIATOMS	1	19.0	44.4	35520.0
Total Bacillariophyta		**21.2**	**50.4**	**39720.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	11	0.5	2.4	960.0
COSMARIUM SPECIES	3	18.0	2.4	33600.0
CRUCIGENIA SPECIES	9	2.2	6.0	4200.0
OEDOGONIUM SPECIES	2	18.6	2.4	34713.6
OOCYSTIS SPECIES	4	12.5	15.6	23400.0
SCENEDESMUS SPECIES	7	5.8	7.2	10800.0
UNKNOWN SPHERICAL CHLOROPHYTA	6	8.3	15.6	15600.0
Total Chlorophyta		**65.9**	**51.6**	**123273.6**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	5	12.2	1.2	22800.0
OSCILLATORIA SPECIES	10	0.7	1.2	1320.0
Total Cyanophyta		**12.9**	**2.4**	**24120.0**
TOTAL FOR ALL GROUPS		**100.0**	**104.4**	**187113.6**

Shannon-Wiener Index	=1.81
Species Evenness	=0.75
Species Richness	=2.24
Number of Species	=11

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from Great Salt Lake, **FBWMA 7th Outfall** on **10/6/2004**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	2	21.0	216.0	151200.0
PENNATE DIATOMS	1	44.0	396.0	316800.0
Total Bacillariophyta		**64.9**	**612.0**	**468000.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	7	1.9	34.8	13920.0
CRUCIGENIA SPECIES	11	0.1	1.2	840.0
OOCYSTIS SPECIES	8	0.5	2.4	3600.0
PEDIASTRUM DUPLEX	4	9.1	1.2	65356.8
PTEROMONAS SPECIES	9	0.4	6.0	2760.0
SCENEDESMUS SPECIES	5	4.2	20.4	30600.0
UNKNOWN SPHERICAL CHLOROPHYTA	10	0.3	2.4	2400.0
Total Chlorophyta		**16.6**	**68.4**	**119476.8**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	3	15.8	6.0	114000.0
Total Cyanophyta		**15.8**	**6.0**	**114000.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	6	2.7	2.4	19200.0
Total Euglenophyta		**2.7**	**2.4**	**19200.0**
TOTAL FOR ALL GROUPS		**100.0**	**688.8**	**720676.8**

Shannon-Wiener Index =1.10
Species Evenness =0.46
Species Richness =1.57
Number of Species =11

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

APPENDIX II: Specific Data Table
Phytoplankton Samples
Great Salt Lake Wetlands
Late Fall, 2004

Great Salt Lake
Phytoplankton Analysis
Fall, 2004

Project	Site Name	Site Number	Date	Taxa	Rank in Stand	Relative Density	# Per mil	Cell Volume
GSL	Pintail E. Outfall	4985630	11/16/2004	Ankistrodesmus falcatus	5	2	4.8	3768
GSL	Pintail E. Outfall	4985630	11/16/2004	Centric diatoms	1	67.1	180	126000
GSL	Pintail E. Outfall	4985630	11/16/2004	Oocytis borgei	4	5.1	2.4	9600
GSL	Pintail E. Outfall	4985630	11/16/2004	Pennate diatoms	2	14.3	33.6	26880
GSL	Pintail E. Outfall	4985630	11/16/2004	Scenedesmus species	3	11.5	14.4	21600
GSL	Ambass W5	4985350	10/18/2004	Ankistrodesmus falcatus	2	26	67.2	52752
GSL	Ambass W5	4985350	10/18/2004	Centric diatoms	3	9.1	26.4	18480
GSL	Ambass W5	4985350	10/18/2004	Oocytis borgei	5	4.7	2.4	9600
GSL	Ambass W5	4985350	10/18/2004	Pennate diatoms	1	49.3	125	99840
GSL	Ambass W5	4985350	10/18/2004	Scenedesmus species	4	8.9	12	18000
GSL	Ambass W5	4985350	10/18/2004	Tetraedron species	6	1.9	4.8	3840
GSL	Amb. W1	4985320	11/18/2004	Ankistrodesmus falcatus	6	1.7	36	28260
GSL	Amb. W1	4985320	11/18/2004	Centric diatoms	2	30	715	500640
GSL	Amb. W1	4985320	11/18/2004	Crucigenia species	8	0.2	4.8	3360
GSL	Amb. W1	4985320	11/18/2004	Euglena species	4	4.3	9.6	71040
GSL	Amb. W1	4985320	11/18/2004	Pediastrum species	3	8.6	2.4	144000
GSL	Amb. W1	4985320	11/18/2004	Pennate diatoms	1	51.3	1070	856320
GSL	Amb. W1	4985320	11/18/2004	Scenedesmus species	5	3.5	38.4	57600
GSL	Amb. W1	4985320	11/18/2004	Unknown spherical chlorophyta	7	0.4	7.2	7200
GSL	Amb. 100	4985330	11/18/2004	Ankistrodesmus falcatus	4	2.3	24	18840
GSL	Amb. 100	4985330	11/18/2004	Centric diatoms	1	81.7	946	661920
GSL	Amb. 100	4985330	11/18/2004	Chlamydomonas species	5	0.5	9.6	3840
GSL	Amb. 100	4985330	11/18/2004	Pennate diatoms	2	12.8	130	103680
GSL	Amb. 100	4985330	11/18/2004	Scenedesmus species	3	2.7	14.4	21600
GSL	PSG NL Out	4985620	11/16/2004	Ankistrodesmus falcatus	7	0.6	1.2	942
GSL	PSG NL Out	4985620	11/16/2004	Centric diatoms	5	1.7	3.6	2520
GSL	PSG NL Out	4985620	11/16/2004	Chlamydomonas species	4	2	7.2	2880
GSL	PSG NL Out	4985620	11/16/2004	Crucigenia species	8	0.6	1.2	840
GSL	PSG NL Out	4985620	11/16/2004	Pennate diatoms	1	52.7	97.2	77760

GSL	PSG NL Out	4985620	11/16/2004	Scenedesmus species	6	1.2	1.2	1800
GSL	PSG NL Out	4985620	11/16/2004	Unknown filamentous chlorophyta	2	38.8	3.6	57341
GSL	PSG NL Out	4985620	11/16/2004	Unknown spherical chlorophyta	3	2.4	3.6	3600
GSL	New Street 20 pd	4985880	11/17/2004	Centric diatoms	4	0.8	4.8	3360
GSL	New Street 20 pd	4985880	11/17/2004	Chlamydomonas species	3	3.5	36	14400
GSL	New Street 20 pd	4985880	11/17/2004	Euglena species	2	4.3	2.4	17760
GSL	New Street 20 pd	4985880	11/17/2004	Pennate diatoms	1	90.7	463	370560
GSL	New Street 20 pd	4985880	11/17/2004	Unknown spherical chlorophyta	5	0.6	2.4	2400
GSL	Amb. W2	4985340	11/18/2004	Ankistrodesmus falcatus	2	15.2	88.8	69708
GSL	Amb. W2	4985340	11/18/2004	Centric diatoms	6	3.7	24	16800
GSL	Amb. W2	4985340	11/18/2004	Chlamydomonas species	10	0.8	9.6	3840
GSL	Amb. W2	4985340	11/18/2004	Euglena species	8	1.9	1.2	8880
GSL	Amb. W2	4985340	11/18/2004	Oocystis species	7	2.4	7.2	10800
GSL	Amb. W2	4985340	11/18/2004	Pediastrum duplex	3	14.3	1.2	65357
GSL	Amb. W2	4985340	11/18/2004	Pennate diatoms	4	13.4	76.8	61440
GSL	Amb. W2	4985340	11/18/2004	Scenedesmus species	5	5.1	15.6	23400
GSL	Amb. W2	4985340	11/18/2004	Unknown filamentous chlorophyta	1	41.8	12	191136
GSL	Amb. W2	4985340	11/18/2004	Unknown spherical chlorophyta	9	1.3	6	6000
GSL	New Street 5-6 pond	4985890	11/17/2004	Aphanizomenon flos-aquae	4	2	3.6	68400
GSL	New Street 5-6 pond	4985890	11/17/2004	Centric diatoms	1	59.6	2894	2E+06
GSL	New Street 5-6 pond	4985890	11/17/2004	Chlamydomonas species	5	0.3	28.8	11520
GSL	New Street 5-6 pond	4985890	11/17/2004	Oedogonium species	3	12.3	28.8	416563
GSL	New Street 5-6 pond	4985890	11/17/2004	Pennate diatoms	2	25.4	1080	864000
GSL	New Street 5-6 pond	4985890	11/17/2004	Phacus species	6	0.2	1.2	6000
GSL	New Street 5-6 pond	4985890	11/17/2004	Pteromonas species	8	0	1.2	552
GSL	New Street 5-6 pond	4985890	11/17/2004	Scenedesmus species	7	0.1	2.4	3600
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Aphanizomenon flos-aquae	5	12.2	1.2	22800
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Centric diatoms	8	2.2	6	4200
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Chlamydomonas species	11	0.5	2.4	960
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Cosmarium species	3	18	2.4	33600
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Crucigenia species	9	2.2	6	4200
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Oedogonium species	2	18.6	2.4	34714
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Oocystis species	4	12.5	15.6	23400
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Oscillatoria species	10	0.7	1.2	1320
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Pennate diatoms	1	19	44.4	35520

GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Scenedesmus species	7	5.8	7.2	10800
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	Unknown spherical chlorophyta	6	8.3	15.6	15600
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Aphanizomenon flos-aquae	3	15.8	6	114000
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Centric diatoms	2	21	216	151200
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Chlamydomonas species	7	1.9	34.8	13920
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Crucigenia species	11	0.1	1.2	840
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Oocystis species	8	0.5	2.4	3600
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Pediastrum duplex	4	9.1	1.2	65357
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Pennate diatoms	1	44	396	316800
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Pteromonas species	9	0.4	6	2760
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Scenedesmus species	5	4.2	20.4	30600
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Trachellomonas species	6	2.7	2.4	19200
GSL	FBWMA 17th Outfall	4985550	10/6/2004	Unknown spherical chlorophyta	10	0.3	2.4	2400

Project	Site Name	Site #	Date	Shannon-Wiener Index	Species Evenness	Species Richness	# Taxa in Stand
GSL	Pintail E. Outfall	4985630	11/16/2004	0.78	0.48	0.87	5
GSL	Ambass W5	4985350	10/18/2004	1.22	0.68	1.09	6
GSL	Amb. W1	4985320	11/18/2004	0.92	0.44	1.05	8
GSL	Amb. 100	4985330	11/18/2004	0.57	0.36	0.65	5
GSL	PSG NL Out	4985620	11/16/2004	0.79	0.38	1.52	8
GSL	New Street 20 pd	4985880	11/17/2004	0.37	0.23	0.75	5
GSL	Amb. W2	4985340	11/18/2004	1.66	0.72	1.7	10
GSL	New Street 5-6 pond	4985890	11/17/2004	0.68	0.33	0.86	8
GSL	FBWMA Unit 1 Outfall	4985520	10/6/2004	1.81	0.75	2.24	11
GSL	FBWMA 17th Outfall	4985550	10/6/2004	1.1	0.46	1.57	11

APENDIX D.3

A STUDY OF THE PERIPHYTON FLORA OF SAMPLES COLLECTED FROM EAST-SHORE GREAT SALT LAKE WETLANDS
SUMMER 2005

by

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Utah Department of Environmental Quality
Division of Water Quality
Salt Lake City, Utah

May 2006

ABSTRACT

Thirty-five periphyton samples were collected from east-shore Great Salt Lake wetlands during the summer of 2005. Sixty algal taxa were observed in the sample set. Due to periphyton laboratory methods, several diatoms were not identified to the genus or species level but counted in the categories pennate and centric diatoms. Separate studies were conducted on phytoplankton and diatom populations across the same collection sites and dates as the periphyton study. In the diatom study, diatom species were identified to the species level. Data on these studies can be found in the appendices of the reports “A Study of the Diatom Population of Great Salt Lake, 2005” and “A Study of the Phytoplankton Population of Great Salt Lake, 2005.”

Pennate diatoms were the most abundant algal category in periphyton samples collected from Great Salt Lake wetlands during 2005, occurring in 34 of the 35 samples. Pennate diatoms occurred 71% of the time as abundant, 15% of the time as common, and 15% of the time as rare (percentages may exceed 100% due to rounding). Centric diatoms occurred in 18 samples, 17% of the time as abundant 11% of the time as common and 72% of the time as rare.

Non-diatom algae were dominated by the chlorophytes ***Cladophora glomerata*** (occurring 21 times, 71% of the time as abundant, 10% of the time as common, and 19% of the time as rare), and ***Chlamydomonas*** species (occurring 26 times, 65% of the time as common, and 35% of the time as rare); and by the cyanophytes ***Oscillatoria amphibia*** (occurring 13 times, 69% of the time as abundant, and 31% of the time as common) and ***Oscillatoria*** species (present in 22 samples at rates of 14%

abundant, 32% common and 55% rare). Additionally, ***Beggiatoa*** species occurred in 11 of the samples, abundant in 18% of those occurrences, common in 18%, and rare in 64%.

INTRODUCTION

Water quality in both standing and flowing waters is complex, encompassing several categories of parameters. Inorganic and organic chemical factors (including toxic substances), nutrients, density dependent factors, and physical factors (including water temperature, velocity, depth, light penetration, etc.) all can play important roles in determining the nature and health of aquatic ecosystems. Because of this, it often makes sense to study a parameter or subset of parameters that may be predictive or reflective of the suite of chemical and physical factors important in shaping the system.

The study of ecosystem indicator taxa, macroinvertebrates, algae and diatoms, is a cost-effective method of gathering significant information concerning the health of aquatic systems. For example, many laboratories now study the floras and/or faunas of streams or lakes and reservoirs in order to provide information concerning water quality. The organisms that live in an aquatic ecosystem serve as effective indicators of the water quality of the system. Furthermore, changes in floras and/or faunas over time can provide good measures of water quality.

In order to study periphyton composition in east-shore Great Salt Lake wetlands, 35 attached algal communities (periphyton) were sampled from locations in Great Salt Lake during the summer of 2005. These periphyton communities have been examined, identified and scored according to relative abundance. Specific data from this analysis can be found in the appendix of this report.

FIELD METHODS

During the 2005 study period, algal populations were sampled from established sites in east-shore Great Salt Lake wetlands by scientists from the Utah Department of Environmental Quality, Division of Water Quality. Samples were obtained by scraping stones and other attached substrata directly from the collection sites. Visible algae and vascular plants were also collected from each site. Samples were placed in 100ml bottles and returned to the laboratory on the day of collection and were kept under dark refrigeration until the time of processing.

Samples were collected from the following locations in east-shore Great Salt Lake Wetlands on the indicated dates:

Site Name	Collection Date
CDSD Site 3	6/28/2005
FB AMB W4	7/1/2005
AMBAST1	7/1/2005
AMBASST2	7/5/2005
CDSD T2	7/7/2005
NDST T1	7/8/2005
N Davis T2	7/8/2005
N Davis T3	7/8/2005
WIDGEON IN	7/14/2005
PINTAIL PN	7/14/2005
PSG T2	7/14/2005
PSG ST1	7/15/2005
PSG T3	7/15/2005
PSG-S-T2	7/15/2005
WIDGEON OUT	7/18/2005
Kays Ck T1	7/19/2005
RAYSCK T2	7/19/2005
Kays Creek T3	7/19/2005
New St 47 pd	7/20/2005
New St 20 PD	7/20/2005
New State 5 - 6 Pond	7/20/2005
AMBAS 1 OU	7/21/2005
AMBAS W2	7/21/2005

AMBASW1	7/21/2005
AMBW5 Pond	7/21/2005
CD SD T1	7/21/2005
SWPONDS	7/27/2005
SBPOND	7/27/2005
WPOND A	7/27/2005
NDSD T1	8/11/2005
FBWMA - CUL7 T2	8/19/2005
FBWMA - CUL7 T1	8/19/2005
FBWMA Unit One Outfall	8/29/2005
CDSD T4	8/31/2005
PSG T1	9/7/2005

LABORATORY METHODS

After delivery to our laboratory, periphyton samples were studied as soon as possible to ensure freshness of the samples. Samples were subsampled several times and subsamples were placed on 1X3 inch glass microscope slides and examined directly using a Nikon Eclipse E200 microscope equipped with Nikon's CFI60 infinity optical system. Filamentous, colonial, and single celled algal forms were identified to the lowest taxonomic level possible. Several taxa could not be identified to species level due to the absence of reproductive cells or a small number of cells present in the sample. Such taxa were therefore identified to the generic level and are listed in this report as “species” following the generic name.

A relative abundance for each taxon was estimated during microscopic examination of the subsamples and recorded as rare, common or abundant. In general, if a taxon was observed only as a single or very few specimens, it was recorded as rare. If a taxon was present in up to approximately 10% of the microscopic examination fields, it was recorded as common. If a taxon was present in more than 10% of the examination fields it was recorded as abundant. Samples were also analyzed for total biomass present (estimated as low, moderate or high), conspicuous odors, and the presence of vascular plants. This information was recorded and is presented according to sample in the section entitled "**notes**" at the end of each data sheet appended to this report.

The examination of periphyton samples is a qualitative process intended to generate a comprehensive list of algal taxa in a sample, providing an estimate of the species composition of the habitat from which the sample was collected. As specified in the Academy of Natural Sciences, Philadelphia publication “*Protocols for the Analysis of Algal Samples Collected as Part of the U.S. Geological Survey National Water-Quality Assessment Program*,” identification of every algal taxon in a sample will most likely not occur in a qualitative analysis of a periphyton sample. It is generally agreed, however, that a majority of the species in a sample will be encountered in a “reasonable search.”

RESULTS

During the summer 2005 study period, pennate diatoms were the most abundant algal category in periphyton samples collected from east-shore Great Salt Lake wetlands, occurring in 34 of the 35 samples. Pennate diatoms occurred 71% of the time as abundant, 15% of the time as common, and 15% of the time as rare. Centric diatoms occurred in 18 samples, 17% of the time as abundant 11% of the time as common and 72% of the time as rare.

Non-diatom algae were dominated by the chlorophytes ***Cladophora glomerata*** (occurring 21 times, 71% of the time as abundant, 10% of the time as common, and

19% of the time as rare), and ***Chlamydomonas*** species (occurring 26 times, 65% of the time as common, and 35% of the time as rare); and by the cyanophytes ***Oscillatoria amphibia*** (occurring 13 times, 69% of the time as abundant, and 31% of the time as common) and ***Oscillatoria*** species (present in 22 samples at rates of 14% abundant, 32% common and 55% rare). Additionally, ***Beggiatoa*** species occurred in 11 of the samples, abundant in 18% of those occurrences, common in 18%, and rare in 64% (**Figure 1**).

A total of 60 algal taxa was observed in the samples collected during the 2005 study period. Many additional taxa included in the categories pennate and centric diatoms were present in the samples but most were not identified to the specific level due to periphyton laboratory methods. Thus, the count of taxa reported herein for the study period is lower than actually occurred in the wetlands.

This study of Great Salt Lake algal populations, including separate studies on phytoplankton, periphyton, and diatom communities, is continuing for some years in the future. Results and discussion will be provided as further data are analyzed.

Table 1. Alphabetical list and number of occurrences of algal species found in periphyton samples collected from east-shore Great Salt Lake wetland sites in summer, 2005. The categories centric and pennate diatoms contain many additional species. A total of 35 samples were collected in all.

Taxon	Number of Occurrences
Anabaena species	11
Ankistrodesmus falcatus	9
Beggiatoa species	11
Calothrix species	3
Chamaesiphon incrustans	4
Chlamydomonas species	26
Chroococcus species	5
Chroococcus turgidus	2
Cladophora glomerata	21
Closterium cf. ***ehrenbergii***	1
Closterium ehrenbergii	2
Closterium species	1
Cosmarium species	5
Crucigenia species	2
Cylindrocapsa geminella	1
diatoms, centric	18
diatoms, pennate	34
Enteromorpha intestinalis	1
Euastrum species	8
Euglena species	4
Gomphosphaeria species	2
Hydrodictyon reticulatum	1
Lyngbya birgei	4
Lyngbya species	2
Merismopedia convoluta	1
Merismopedia glauca	2
Merismopedia tenuissima	7
Microcystis aeruginosa	2
Microcystis incerta	5
Mougeotia species	3
Nodularia spumigena	5
Nostoc species	2
Oedogonium species	3
Oocystis cf. ***borgei***	5
Oocystis species	1
Oscillatoria amphibia	13
Oscillatoria princeps	1
Oscillatoria species	22

Oscillatoria species 2	7
Oscillatoria species 3	1
Pandorina morum	2
Pediastrum duplex	6
Phacus species	6
Phormidium species	2
Pteromonas species	5
Scenedesmus bijuga	4
Scenedesmus quadricuada v. ***quadrispina***	6
Scenedesmus species	7
Scenedesmus species 2	1
Sphaerocystis schroeteri	5
Spirogyra species	7
Spirogyra species 2	1
Spirulina species	2
Stigeoclonium species	6
Tetraedron species	3
Trachelomonas species	1
Ulothrix aequalis	1
Ulothrix species	2
Ulothrix species 2	1
Ulothrix zonata	1
Unknown filamentous Chlorophyta	3
Unknown spherical Chlorophyta	1

Table 2. Abundance categories of taxa found in periphyton samples collected from Great Salt Lake wetlands in 2005.

Division and Species	**Total Occurrences**
Cyanophyta	
Oscillatoria species	22
Oscillatoria amphibia	13
Anabaena species	11
Merismopedia tenuissima	7
Oscillatoria species 2	7
Chroococcus species	5
Microcystis incerta	5
Nodularia spumigena	5
Chamaesiphon incrustans	4
Lyngbya birgei	4
Calothrix species	3
Chroococcus turgidus	2
Lyngbya species	2
Merismopedia glauca	2
Microcystis aeruginosa	2
Nostoc species	2
Phormidium species	2
Spirulina species	2
Merismopedia convoluta	1
Oscillatoria princeps	1
Oscillatoria species 3	1
Gomphosphaeria species	2
Total Cyanophyta Species	22
Total Cyanophyta Occurrences in 35 Samples	105
Chlorophyta	
Chlamydomonas species	26
Cladophora glomerata	21
Ankistrodesmus falcatus	9
Euastrum species	8
Scenedesmus species	7
Spirogyra species	7
Pediastrum duplex	6
Scenedesmus quadricuada v. ***quadrispina***	6
Stigeoclonium species	6
Cosmarium species	5
Oocystis cf. borgei	5
Pteromonas species	5
Sphaerocystis schroeteri	5

Scenedesmus bijuga	4
Mougeotia species	3
Oedogonium species	3
Tetraedron species	3
Unknown filamentous Chlorophyta	3
Closterium ehrenbergii	2
Pandorina morum	2
Ulothrix species	2
Crucigenia species	2
Closterium cf. ***ehrenbergii***	1
Closterium species	1
Oocystis species	1
Scenedesmus species 2	1
Spirogyra species 2	1
Ulothrix aequalis	1
Ulothrix species 2	1
Ulothrix zonata	1
Unknown spherical Chlorophyta	1
Hydrodictyon reticulatum	1
Cylindrocapsa geminella	1
Enteromorpha intestinalis	1
Total Chlorophyta Species	34
Total Chlorophyta Occurrences in 35 Samples	152
Bacillariophyta	
pennate diatoms (category)	34
centric diatoms (category)	18
Total Bacillariophyta Categories	
Total Bacillariophyta Occurrences in 35 Samples	52

Euglenophyta	
Phacus species	6
Euglena species	4
Trachelomonas species	1
Total Euglenophyta Species	3
Total Euglenophyta Occurrences in 35 samples	11
Other	
Beggiatoa species	11
Total “Other” Species	1
Total “Other” Occurrences in 35 Samples	11

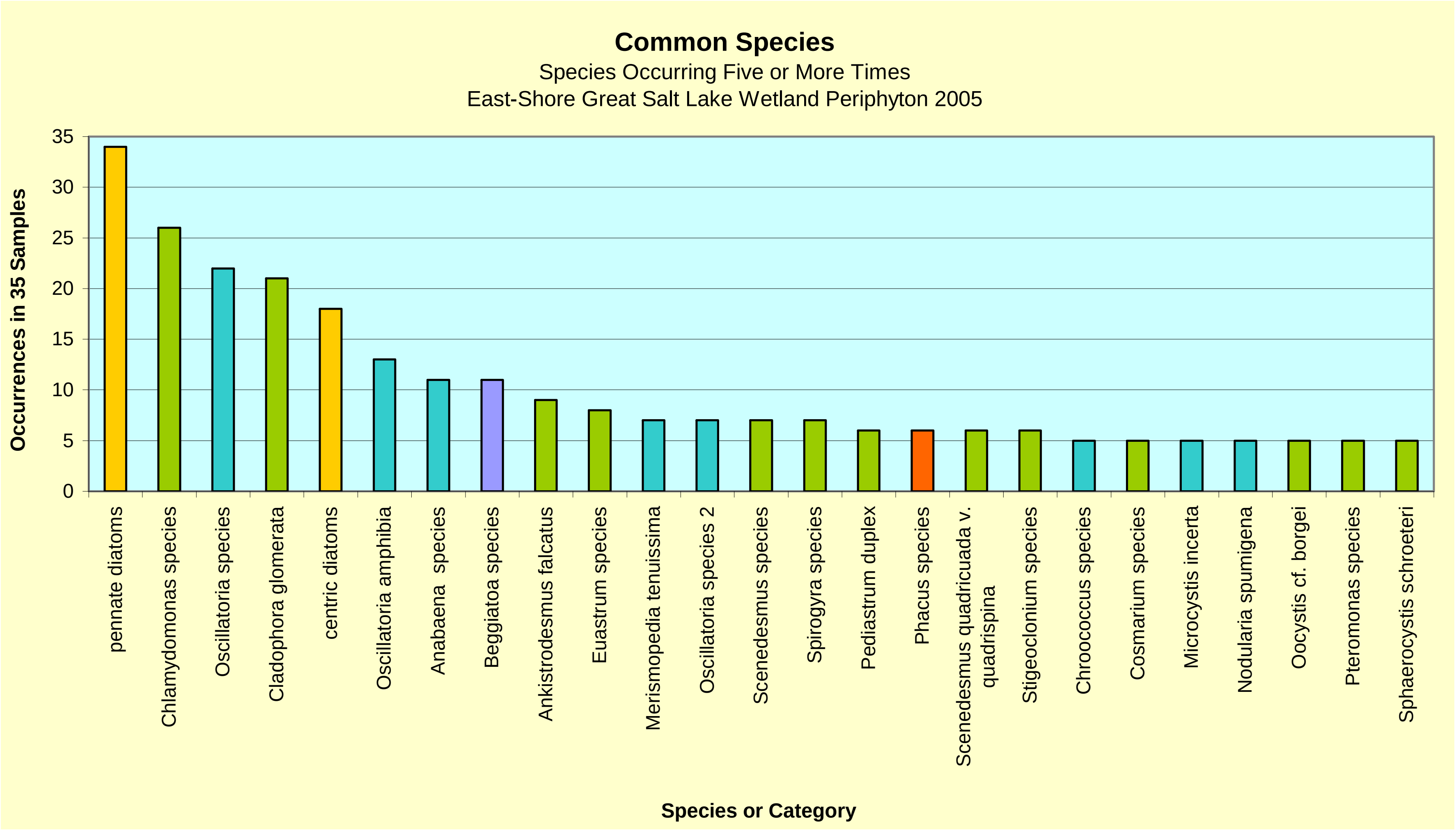

Figure 1. Important species (occurring in at least 10% of all samples) in periphyton samples collected from east-shore Great Salt Lake wetland samples in 2005.

References:

The Academy of Natural Sciences. 2002. Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program. Patrick Center for Environmental Research. Philadelphia, PA. Report No. 02-06.

American Public Health Association. Standard Methods for Examination of Water & Wastewater. 2005. Andrew D. Eaton, Lenore S. Clesceri, Eugene W. Rice, Arnold E. Greenberg, Mary Ann H. Franson (Editors). 20th Edition. Washington, D.C.

APPENDIX: SPECIFIC DATA FROM PERIPHTYON SAMPLES COLLECTED FROM EAST-SHORE GREAT SALT LAKE WETLANDS
SUMMER 2005

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	WIDGEON IN
Site Number:	4985621
Date:	7/14/05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Beggiatoa species	Common
Chlamydomonas species	Rare
Chroococcus species	Rare
Chroococcus turgidus	Rare
Cladophora glomerata	Abundant
Lyngbya birgei	Abundant
Merismopedia tenuissima	Rare
Mougeotia species	Abundant
Oscillatoria amphibia	Abundant
Oscillatoria species	Rare
pennate diatoms	Abundant

Notes:
Sample with moderate to high biomass. Strong "organic" odor present. Biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PINTAIL PN
Site Number:	4985630
Date:	14-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Beggiatoa species	Abundant
Chlamydomonas species	Common
Chroococcus turgidus	Rare
Cylindrocapsa geminella	Abundant
Lyngbya species	Abundant
Merismopedia tenuissima	Rare
Microcystis aeruginosa	Abundant
Nodularia spumigena	Rare
Oocystis cf. ***borgei***	Rare
Oscillatoria species	Abundant
pennate diatoms	Abundant
Phacus species	Rare
Spirogyra species	Common
Unknown spherical Chlorophyta	Abundant

Notes:
Sample with high biomass. Biomass comprised mostly of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	WIDGEON OUT
Site Number:	498620
Date:	18-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Beggiatoa species	Rare
Chamaesiphon incrustans	Rare
Cladophora glomerata	Abundant
Mougeotia species	Abundant
Oocystis cf. ***borgei***	Rare
pennate diatoms	Common

Notes:
Sample with moderate to high biomass. Strong "organic" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMBASW1
Site Number:	4895520
Date:	21-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Rare
centric diatoms	Rare
Cladophora glomerata	Abundant
Cosmarium species	Rare
Merismopedia tenuissima	Rare
Oscillatoria species	Abundant
Pediastrum duplex	Rare
pennate diatoms	Abundant
Scenedesmus bijuga	Rare
Scenedesmus quadricuada v. ***quadrispina***	Rare
Scenedesmus species	Rare
Sphaerocystis schroeteri	Rare

Notes:

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PSG ST1
Site Number:	
Date:	15-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Abundant
Beggiatoa species	Abundant
Lyngbya birgei	Abundant
Nodularia spumigena	Common
Oscillatoria species	Abundant
Oscillatoria species 2	Common
pennate diatoms	Abundant
Spirogyra species	Abundant
Unknown filamentous Chlorophyta	Common

Notes:
Sample with moderate to high biomass. Majority of biomass comprised of algae and organic debris. Strong fetid smell present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMBAS W2
Site Number:	
Date:	21-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Common
Chlamydomonas species	Rare
Euglena species	Rare
Microcystis incerta	Rare
Nodualria spumigena	Abundant
Oscillatoria species	Rare
Oscillatoria species 2	Rare
Pandorina morum	Rare
pennate diatoms	Abundant
Scenedesmus species	Rare
Spirulina species	Common

Notes:
Sample with very low biomass. Majority of biomass comprised of organic debris. Strong "pungent" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	SWPONDS
Site Number:	4985410
Date:	27-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
pennate diatoms	Rare
Spirulina species	Abundant

Notes:
Sample with low biomass. Strong "organic" odor present. Biomass comprised primarily of organic debris. Some algae present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	RAYSCK T2
Site Number:	4985810
Date:	19-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Abundant
Chlamydomonas species	Rare
Cladophora glomerata	Rare
Oedogonium species	Rare
Oscillatoria species	Common
Oscillatoria species 2	Rare
Oscillatoria species 3	Rare
pennate diatoms	Abundant

Notes:
Sample with low biomass. Majority of biomass comprised of organic debris. Abundance of diatoms, both pennate and centric. Moderate "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	CD SD T1
Site Number:	
Date:	21-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Beggiatoa species	Common
centric diatoms	Rare
Chlamydomonas species	Common
Euastrum species	Rare
Oscillatoria amphibia	Abundant
Oscillatoria species	Common
pennate diatoms	Abundant
Pteromonas species	Rare

Notes:
Sample with high biomass. Majority of biomass comprised of organic debris and algae. Moderate "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	New State 5 - 6 Pond
Site Number:	4985890
Date:	20-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Chlamydomonas species	Rare
Cladophora glomerata	Abundant
Oscillatoria amphibia	Abundant
pennate diatoms	Rare
Scenedesmus species	Rare

Notes:
Sample with low to moderate biomass. Majority of biomass comprised of organic debris and algae. Vascular plants included as scrapoings. Slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMBAS 1 OU
Site Number:	4985330
Date:	21-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Rare
Beggiatoa species	Rare
centric diatoms	Rare
Chlamydomonas species	Rare
Cladophora glomerata	Abundant
Cosmarium species	Rare
Euastrum species	Rare
Gomphosphaeria species	Rare
Merismopedia tenuissima	Rare
Microcystis incerta	Rare
Oscillatoria amphibia	Abundant
Oscillatoria species	Rare
Pediastrum duplex	Rare
pennate diatoms	Common
Pteromonas species	Rare
Scenedesmus bijuga	Rare
Scenedesmus quadricuada v. ***quadrispina***	Rare
Sphaerocystis schroeteri	Rare
Tetraedron species	Rare

Notes:
Sample with moderate to high biomass. Moderate "sulfur" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	NDST T1
Site Number:	4985590
Date:	8-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Abundant
Cladophora glomerata	Rare
Euglena species	Rare
pennate diatoms	Abundant

Notes:
Sample with moderate to high biomass. Majority of biomass comprised of organic debris and diatoms. Super-abundance of pennate diatoms. Strong "sulfur" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	CDSD T2
Site Number:	4985670
Date:	7-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Rare
Chlamydomonas species	Rare
Cladophora glomerata	Abundant
Oscillatoria amphibia	Common
pennate diatoms	Abundant
Spirogyra species	Abundant
Spirogyra species 2	Abundant
Stigeoclonium species	Rare
Ulothrix zonata	Rare

Notes:
Sample with high biomass. Majority of biomass comprised of organic debris and algae. Strong "sulfur" odor present. Vascular plants prevalent.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	New St 20 PD
Site Number:	4985880
Date:	20-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Rare
centric diatoms	Rare
Cladophora glomerata	Abundant
Oscillatoria amphibia	Abundant
Oscillatoria species	Rare
pennate diatoms	Common
Pteromonas species	Rare
Stigeoclonium species	Common
Tetraedron species	Rare

Notes:
Sample with low to moderate biomass. Majority of biomass comprised of algae and organic debris. Strong "sulfur" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	SBPOND
Site Number:	4985430
Date:	27-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Chlamydomonas species	Common
Cladophora glomerata	Abundant
Cosmarium species	Rare
Merismopedia tenuissima	Rare
Oedogonium species	Rare
Oscillatoria species	Rare
Oscillatoria species 2	Rare
pennate diatoms	Abundant
Phacus species	Rare
Sphaerocystis schroeteri	Rare
Trachelomonas species	Rare

Notes:
Sample with moderate biomass. Strong "organic" odor present. Majority of biomass comprised of organic debris and algae. Vascular plants common.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	WPOND A
Site Number:	4985440
Date:	27-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Common
Chroococcus species	Rare
Cladophora glomerata	Common
Enteromorpha intestinalis	Abundant
Euastrum species	Rare
Nodularia spumigena	Rare
Oocystis species	Rare
Oscillatoria species	Common
pennate diatoms	Abundant
Phacus species	Rare

Notes:
Sample with moderate biomass. Slight to moderate "organic" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMBW5 Pond
Site Number:	4985350
Date:	21-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Rare
Cladophora glomerata	Common
Euastrum species	Rare
Nostoc species	Rare
Oedogonium species	Common
Oscillatoria amphibia	Common
pennate diatoms	Abundant

Notes:
Sample with very low biomass. Majority of biomass comprised of algae and organic debris. Slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PSG T3
Site Number:	
Date:	15-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Common
Cladophora glomerata	Abundant
Oscillatoria amphibia	Abundant
pennate diatoms	Abundant
Phormidium species	Rare

Notes:
Sample with low to moderate biomass. Strong "sulfur" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	New St 47 pd
Site Number:	4985870
Date:	20-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Hydrodictyon reticulatum	Abundant
pennate diatoms	Rare

Notes:
Sample with very low biomass. Almost all of biomass comprised of ***Hydrodictyon reticulatum***. Very slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PSG-S-T2
Site Number:	
Date:	15-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Common
Chroococcus species	Rare
Cladophora glomerata	Rare
Lyngbya birgei	Abundant
Merismopedia convoluta	Common
Microcystis incerta	Rare
Oscillatoria species	Common
pennate diatoms	Abundant
Pteromonas species	Rare
Scenedesmus species	Rare
Spirogyra species	Rare
Unknown filamentous Chlorophyta	Rare

Notes:
Sample with high biomass. Strong "organic" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	Kays Ck T1
Site Number:	4985800
Date:	19-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Abundant
Chlamydomonas species	Rare
pennate diatoms	Abundant

Notes:
Sample with very low biomass. Majority of biomass comprised of algae and organic debris. Slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	N Davis T3
Site Number:	5985592
Date:	8-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Abundant
Chroococcus species	Rare
pennate diatoms	Abundant

Notes:
Sample with very little biomass. Majority of biomass comprised of vascular plants, organic debris, and algae (diatoms). Slight "sulfur" odor present. Sample empty of filamentous algae.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	N Davis T2
Site Number:	4985591
Date:	8-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Common
Chlamydomonas species	Common
Oscillatoria amphibia	Abundant
Oscillatoria species	Rare
pennate diatoms	Abundant

Notes:
Sample with moderate biomass. Abundance of diatoms. Slight "organic" odor present. Nearly empty of filamentous algae.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	Kays Creek T3
Site Number:	4985820
Date:	19-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Rare
centric diatoms	Common
Chlamydomonas species	Common
Oscillatoria species	Rare
pennate diatoms	Abundant

Notes:
Sample with low to moderate biomass. Majority of biomass comprised of organic debris and algae. Vascular plants common. Slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PSG T2
Site Number:	
Date:	14-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Chlamydomonas species	Common
Euastrum species	Rare
Euglena species	Abundant
Microcystis incerta	Rare
Oscillatoria amphibia	Common
Pandorina morum	Common
pennate diatoms	Common
Scenedesmus species	Rare

Notes:
Sample with low to moderate biomass. Reddish in color. Majority of biomass comprised of algae and organic debris. Abundance of ***Euglena*** species in sample.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMDAST1
Site Number:	
Date:	1-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Chlamydomonas species	Common
Cladophora glomerata	Abundant
Euastrum species	Rare
Euglena species	Rare
Merismopedia tenuissima	Rare
Oscillatoria species	Rare
Pediastrum duplex	Rare
pennate diatoms	Common
Scenedesmus quadricuada v. ***quadrispina***	Rare
Sphaerocystis schroeteri	Rare

Notes:
Sample with high biomass. Strong "organic" odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	AMBASST2
Site Number:	
Date:	5-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Ankistrodesmus falcatus	Rare
Beggiatoa species	Rare
Chlamydomonas species	Common
Chroococcus species	Rare
Cladophora glomerata	Abundant
Closterium cf. ***ehrenbergii***	Rare
Cosmarium species	Common
Crucigenia species	Rare
Euastrum species	Rare
Gomphosphaeria species	Common
Merismopedia tenuissima	Common
Oocystis cf. ***borgei***	Rare
Oscillatoria princes	Rare
Oscillatoria species	Common
Pediastrum duplex	Rare
Phacus species	Rare
Scenedesmus quadricuada v. ***quadrispina***	Rare
Sphaerocystis schroeteri	Rare
Tetraedron species	Rare

Notes:
Sample with high biomass. Strong "organic" odor present. Majority of biomass comprised of algae and organic debris. Algal population diverse.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	CDSD Site 3
Site Number:	4985690
Date:	28-Jun-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
centric diatoms	Rare
Chlamydomonas species	Common
Cladophora glomerata	Abundant
Oscillatoria amphibia	Abundant
pennate diatoms	Abundant
Spirogyra species	Common

Notes:
Sample with moderate biomass. Majority of biomass comprised of algae and organic debris. Strong "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	FB AMB W4
Site Number:	4985320
Date:	1-Jul-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Chamaesiphon incrustans	Common
Chlamydomonas species	Common
Cladophora glomerata	Abundant
pennate diatoms	Rare

Notes:
Sample with moderate to high biomass. Majority of biomass comprised of algae and organic debris. Slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	FBWMA - CUL7 T2
Site Number:	4985510
Date:	19-Aug-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Common
Beggiatoa species	Rare
Calothrix species	Common
centric diatoms	Rare
Chlamydomonas species	Common
pennate diatoms	Abundant
Oscillatoria amphibia	Abundant
Oscillatoria species	Common
Oscillatoria species 2	Rare
Scenedesmus species	Rare
Unknown filamentous Chlorophyta	Rare

Notes:
Sample with moderate biomass, lots of vascular plants. Majority of biomass comprised of organic debris and algae. Very slight "organic" odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	FBWMA - CUL7 T1
Site Number:	4985514
Date:	19-Aug-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Beggiatoa species	Rare
Calothrix species	Rare
centric diatoms	Common
Chamaesiphon incrustans	Common
Chlamydomonas species	Common
Closterium ehrenbergii	Rare
Lyngbya birgei	Common
Merismopedia glauca	Rare
Microcystis aeruginosa	Rare
Microcystis incerta	Rare
Nodularia spumigena	Rare
Oscillatoria species	Rare
Oscillatoria species 2	Rare
Pediastrum duplex	Rare
pennate diatoms	Abundant
Phacus species	Rare
Scenedesmus bijuga	Rare
Scenedesmus quadricuada v. ***quadrispina***	Rare
Scenedesmus species 2	Rare
Stigeoclonium species	Rare
Ulothrix species	Abundant
Ulothrix species 2	Rare

Notes:
Sample with moderate to high biomass. Lots of vascular plants present. Majority of biomass comprised of algae and organic debris. Strong "organic" odor present. More filamentous algae present in this sample than in the previous sample, which is a different transect of the same site.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	FBWMA Unit One Outfall
Site Number:	4985520
Date:	29-Aug-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Calothrix species	Rare
centric diatoms	Rare
Chamaesiphon incrustans	Common
Chlamydomonas species	Common
Cladophora glomerata	Abundant
Closterium species	Rare
Cosmarium species	Rare
Crucigenia species	Rare
pennate diatoms	Rare
Euastrum species	Rare
Merismopedia glauca	Rare
Oocystis cf. ***borgei***	Rare
Oscillatoria species	Rare
Pediastrum duplex	Rare
Pteromonas species	Rare
Scenedesmus bijuga	Rare
Scenedesmus quadricuada v. ***quadrispina***	Rare
Scenedesmus species	Rare
Stigeoclonium species	Common

Notes:
Sample with moderate biomass. No detectable odor present. Majority of biomass comprised of algae and organic debris.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	PSG T1
Site Number:	4985623
Date:	7-Sep-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Anabaena species	Rare
Chlamydomonas species	Rare
Cladophora glomerata	Abundant
Oscillatoria amphibia	Common
Oscillatoria species	Rare
pennate diatoms	Abundant
Phormidium species	Common
Spirogyra species	Rare
Stigeoclonium species	Rare
Ulothrix species	Abundant

Notes:
Sample with moderate to low biomass. Sample included vascular plants. Majority of biomass comprised of algae and organic debris. No detectable odor present.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	NDSD T1
Site Number:	4985590
Date:	11-Aug-05
Analyst:	Sarah Rushforth

Species Name:	**Frequency:**
Ankistrodesmus falcatus	Common
Beggiatoa species	Rare
centric diatoms	Rare
Chlamydomonas species	Common
Cladophora glomerata	Rare
Oocystis cf. ***borgei***	Rare
Oscillatoria species	Common
pennate diatoms	Abundant

Notes:

Sample with high biomass. Very strong "putrid" odor present. Majority of biomass comprised of organic debris) and algae. Super-abundance of pennate diatoms. Vascular plants very common in the sample.

Great Salt Lake Periphyton Community Composition Analysis 2005

Project Name:	Great Salt Lake Periphyton
Site Name:	CDSD T4
Site Number:	4985690
Date:	31-Aug-05
Analyst:	

Species Name:	**Frequency:**
Anabaena species	Rare
Beggiatoa species	Rare
centric diatoms	Rare
Closterium ehrenbergii	Rare
Lyngbya species	Common
Mougeotia species	Rare
Nostoc species	Common
Oscillatoria species	Common
Oscillatoria species 2	Rare
pennate diatoms	Abundant
Phacus species	Rare
Spirogyra species	Rare
Stigeoclonium species	Rare
Ulothrix aequalis	Rare

Notes:
Sample with moderate biomass. Moderate "organic" odor present. Majority of biomass comprised of organic debris and algae. Abundance of pennate diatoms. Vascular plants common.

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APENDIX D.4

A STUDY OF THE PHYTOPLANKTON FLORAS OF GREAT SALT LAKE

SUMMER 2005

by

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and

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Utah Department of Environmental Quality
Division of Water Quality
Salt Lake City, Utah

May 2006

ABSTRACT

From June to November of 2005, phytoplankton samples were collected and examined from established sites in Great Salt Lake wetlands along the east shore of the lake. Collections were made by scientist from the Utah Department of Environmental Quality, Water Quality Division. Twenty-two individual sites were collected once each across five collection dates for a total of 22 phytoplankton samples during the collecting period.

Forty- six taxa were identified in the phytoplankton flora of Great Salt Lake during the 2005 study period. This represents only those species that were identifiable in our analyses. Many additional diatom taxa were present in the flora, recorded in our counts as pennate diatoms or centric diatoms. Separate studies were conducted on periphyton and diatom populations across the same collection sites and dates as the phytoplankton study. In the diatom study, species were identified to the lowest taxonomic level possible.. Data on these studies can be found in the appendices of the reports "A Study of the Diatom Population of Great Salt Lake, 2005" and "A Study of the Periphyton Population of Great Salt Lake, 2005."

The most important plankters (species with an ISI value of 0.9 or greater) as determined by calculating Important Species Indices (ISIs) from all combined phytoplankton samples from the Great Salt Lake during 2005 were: the diatom categories pennate diatoms (ISI = 36.6) and centric diatoms (ISI = 5.4); the cyanophytes ***Anabaena*** species (ISI = 5.1) and ***Microcystis incerta*** (ISI = 2.3); and the chlorophytes ***Pediastrum duplex*** (ISI = 1.4) and ***Euastrum*** species (ISI = 1.0) (**Table 2, Figure 1**).

Together these top two algal categories and four plankters comprised approximately 90% of the phytoplankton flora (as determined by summing importance values) in samples collected from Great Salt Lake during the 2005 study period. The ISI measurement is figured by multiplying the percent relative density by the frequency of occurrence for each species in all samples across the year. The algal category Bacillariophyta (diatoms) dominated the phytoplankton flora of the sample set, comprising 73% of the summed Important Species Index.

INTRODUCTION

The 2005 phytoplankton study of Great Salt Lake continues a project initiated by the Utah Department of Environmental Quality, Division of Water Quality in the late fall of 2004. Sample sites and dates were increased in 2005 and a separate study was initiated to examine the diatom populations of the same region of the lake.

Covering about 1,500 square miles, the Great Salt Lake is the largest US Lake West of the Mississippi River and the largest saline lake in the Western Hemisphere. The lake receives inflow from the Jordan River, the Bear River, and the Weber River, but is a terminal lake and has no outlet. Salinity is affected only by changes in lake elevation caused by inflow, precipitation, and evaporation. The lake is a hyper-saline system creating rather unique conditions for the study of algal communities.

The 2005 study reports data on phytoplankton samples collected between June 29 and October 5, 2005 at 22 established collection locations in east-shore Great Salt Lake wetlands. The study mostly involved direct observation and enumeration of the dominant algae present in phytoplankton samples.

We counted the number of each alga present in each sample and calculated the number of each alga per milliliter of lake water. We also determined the biovolume of the total number of each taxon in cubic micrometers, the relative density of each taxon according to its biovolume, and the rank of each taxon in each sample according to biovolume (biomass) in each sample. We also performed several descriptive statistical assessments of each sample. These results are reported in the appendix following this report.

FIELD METHODS

Algal populations from 22 localities in east-shore Great Salt Lake wetlands were sampled by scientists from the Utah State Department of Environmental Quality, Division of Water Quality. A total of 22 phytoplankton samples was collected across eleven collecting dates. Collection sites were: GSL Wetlands Public Shooting Ground Pintail Lake (4985630), Farmington Wetlands Ambassador W 1 (4985320), Farmington Wetlands Ambassador 100 (4985330), Farmington Wetlands Ambassador W 2 (4985340), Farmington Wetlands Ambassador W 5 (4985350), SW Ponds (4985410), SB Pond (4985430), W Pond A (4985440), Farmington Wetlands FBWMA Unit 2 Outfall (4985500), FBWMA CUL7 T1 (4985514), FBWMA CUL7 T2 (4985516), FBWMA CUL7 T3 (4985517), Farmington Wetlands FBWMA Unit 1 Outfall (4985520), GSL Wetlands Public Shooting Ground Widgeon Lake 02 inflow (4985621), PSG WLT1 (4985623), PSG T5 (4985625), CDSDT4 (4985690), CDSDT5 (4985700), Farmington Wetlands Ambassador W 2 (4985340), Farmington Wetlands Ambassador 100 (4985330), Farmington Wetlands Ambassador W 5 (4985350), and GSL Wetlands Newstate Duck Club Unit 5-6 (4985890).

Collection dates were: June 29, July 5, July 14, July 27, August 18, August 22, August 25, August 29, August 31, September 9, and October 5, 2005. Phytoplankton samples were collected as surface “grabs” and stored in one-liter bottles.

LABORATORY METHODS

After collection, samples were delivered to our lab where they were held under dark refrigeration until processing. Samples were processed as quickly as possible to ensure algal populations were not changed appreciably by zooplankton predation or algal population growth.

Numerical Analyses

The number of species in each sample was tallied and recorded. A percent relative density for each taxon was calculated using the biovolume (biomass) for that taxon in the sample. The rank of each taxon in each sample was also calculated based upon the biovolume per milliliter.

A Shannon-Wiener diversity index was calculated for each stand (Margalef 1958; Patten 1962; Shannon and Weaver 1963). The formula for this index is

$$H' = -\sum_{i=1}^{S} P_i \text{ LOG } P_i$$

where P_i = the proportion of the total number of individuals in the i^{th} species; and
S = the number of species.

A species richness factor was calculated after Atlas and Bartha (1981). This factor is similar to many other diversity factors and may be considered to be a second measure of diversity by many biologists. The formula for calculation of this evenness factor is

$$d = \frac{S - 1}{\log N}$$

where S = the number of species; and N = the number of individuals. A species evenness factor was calculated (Atlas and Bartha 1981) according to the formula

$$e = \frac{\text{Shannon-Weaver index}}{\log S}$$

where S is the number of species in the sample.

Important species indices (ISIs) were calculated for each taxon by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983). This index is often preferable to comparing average density alone since it reflects both the distribution and abundance of a taxon in the ecosystem. Important Species Indices were calculated for all taxa from all sites throughout the reservoir through the year to provide a list of the most important algae in the Deer Creek system. ISIs were also calculated for taxa present in net plankton samples considered separately and for taxa in total plankton samples.

RESULTS AND DISCUSSION

The “composite” phytoplankton flora of samples collected from the Great Salt Lake during 2005 contained a total of 46 taxa (**Table 1**). The two common categories centric diatoms and pennate diatoms each contained many additional taxa. Separate studies were conducted on periphyton and diatom populations across the same collection sites and dates as the phytoplankton study. In the diatom study, species were identified to the lowest taxonomic level possible. Data on these studies can be found in the appendices of the reports “A Study of the Diatom Population of Great Salt Lake, 2005” and “A Study of the Periphyton Population of Great Salt Lake, 2005.”

The phytoplankton flora of samples collected from Great Salt Lake during 2005 was comprised of three diatoms (Bacillariophyta), two diatom categories, 25 green algae (Chlorophyta), 14 cyanobacteria or blue-green algae (Cyanophyta), three eugelnophytes (Euglenophyta), and one unspecified alga (**Table 1**).

The most important plankters (with an ISI value of 0.9 or higher) as determined by calculating Important Species Indices (or ISIs) from all combined Great Salt Lake plankton during 2005 were: the diatom categories pennate diatoms (ISI = 36.6) and centric diatoms (ISI = 5.4); the cyanophytes ***Anabaena*** species (ISI = 5.1) and ***Microcystis incerta*** (ISI = 2.3); and the chlorophytes ***Pediastrum duplex*** (ISI = 1.4) and ***Euastrum*** species (ISI = 1.0) (**Table 2, Figure 1**). Together these algal categories and four plankters comprised approximately 90% of the phytoplankton flora (as determined by summing importance values) in samples collected from east-shore wetland sites of the Great Salt Lake during the 2005 study period.

The algal category Bacillariophyta (diatoms) dominated the phytoplankton flora of the 2005 phytoplankton sample set, comprising 73% of the summed Important Species Index (**Figure 2**).   This category also dominated the plankton in the 2004 Great Salt Lake phytoplankton study when it comprised 83% of the summed Important Species Index. Cyanophyta was the second most important category in the 2005 sample set at 15% summed ISI, a significant increase from the 2004 study period when that category comprised only 1% of the flora. Chlorophyta decreased in importance from 15% in 2004 to 11% in 2005.

Similar to 2004, pennate diatoms were the most important plankters in Great Salt Lake phytoplankton samples collected during 2005 with an ISI value of 36.6 (**Table 2, Figure 1**). Centric diatoms fell from an ISI of 27.7 in 2004 to only 5.4 in 2005. The cyanophytes ***Anabaena*** species and ***Microcystis incerta*** both increased substantially in importance, (from ISI values of 0 in 2004 to 5.1 and 2.3 respectively in 2005), contributing to the overall greater importance of Cyanophyta in Great Salt Lake samples collected during 2005.

This study of Great Salt Lake algal populations, including separate studies on phytoplankton, periphyton, and diatom communities, is continuing for some years in the future. Results and discussion will be provided as further data are analyzed.

Table 1. List of the algal taxa present in phytoplankton samples collected from east-shore Great Salt Lake wetland sites during 2005.

Bacillariophyta

Centric diatoms
Fragilaria virescens
Melosira granulata var. ***angustissima***
Pennate diatoms
Stephanodiscus niagarae

Chlorophyta

Ankistrodesmus falcatus
Botryococcus species
Chlamydomonas species
Closterium species
Cosmarium species
Crucigenia species
Euastrum species
Gonatozygon species
Lyngbya birgei
Mougeotia species
Oedogonium species
Oocystis species
Oocystis borgei
Pandorina morum
Pediastrum duplex
Pteromonas species
Scenedesmus bijuga
Scenedesmus quadricauda var. ***quadrispina***
Scenedesmus species
Schroederia setigera
Sphaerocystis schroeteri
Staurastrum gracile
Tetraedron species
Unknown filamentous Chlorophyta
Unknown spherical Chlorophyta

Cyanophyta

Anabaena species
Aphanizomenon flos-aquae
Calothrix species
Chroococcus species
Gomphosphaeria species
Merismopedia glauca
Merismopedia species
Merismopedia tenuissima
Microcystis incerta
Nostoc species
Oscillatoria species
Oscillatoria species 2
Spirulina species
Unknown spherical Cyanophyta

Euglenophyta

Euglena species
Phacus species
Trachellomonas species

Unspecified algae

Beggiatoa species

Table 2. List of species with an Important Species Index value of 0.1 or greater in phytoplankton samples collected from east-shore Great Salt Lake wetland sites during the 2005 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

TAXON	**IMPORTANCE VALUE**
Pennate diatoms	36.6
Centric diatoms	5.4
Anabaena species	5.1
Microcystis incerta	2.3
Pediastrum duplex	1.4
Euastrum species	1.1
Chlamydomonas species	0.8
Scenedesmus species	0.8
Sphaerocystis schroeteri	0.6
Aphanizomenon flos-aquae	0.6
Mougeotia species	0.5
Oscillatoria species	0.4
Oocystis borgei	0.4
Beggiatoa species	0.4
Pteromonas species	0.3
Chroococcus species	0.3
Trachellomonas species	0.2
Stephanodiscus niagarae	0.2
Ankistrodesmus falcatus	0.2
Spirulina species	0.1
Merismopedia tenuissima	0.1

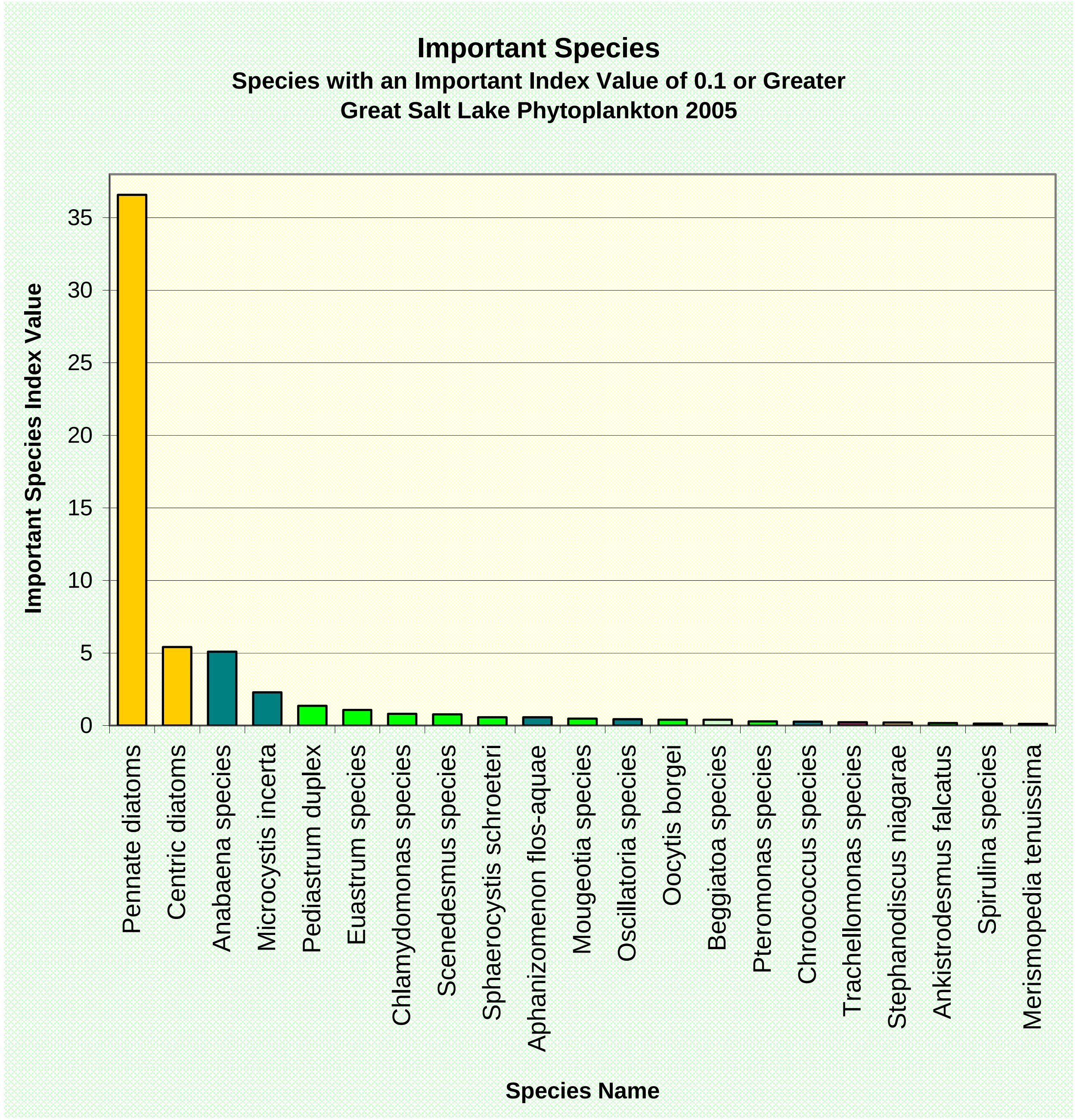

Figure 1. Important Species Index values of the major species (ISI = 0.1 or greater) in phytoplankton samples collected from east-shore Great Salt Lake wetland sites during the 2005 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

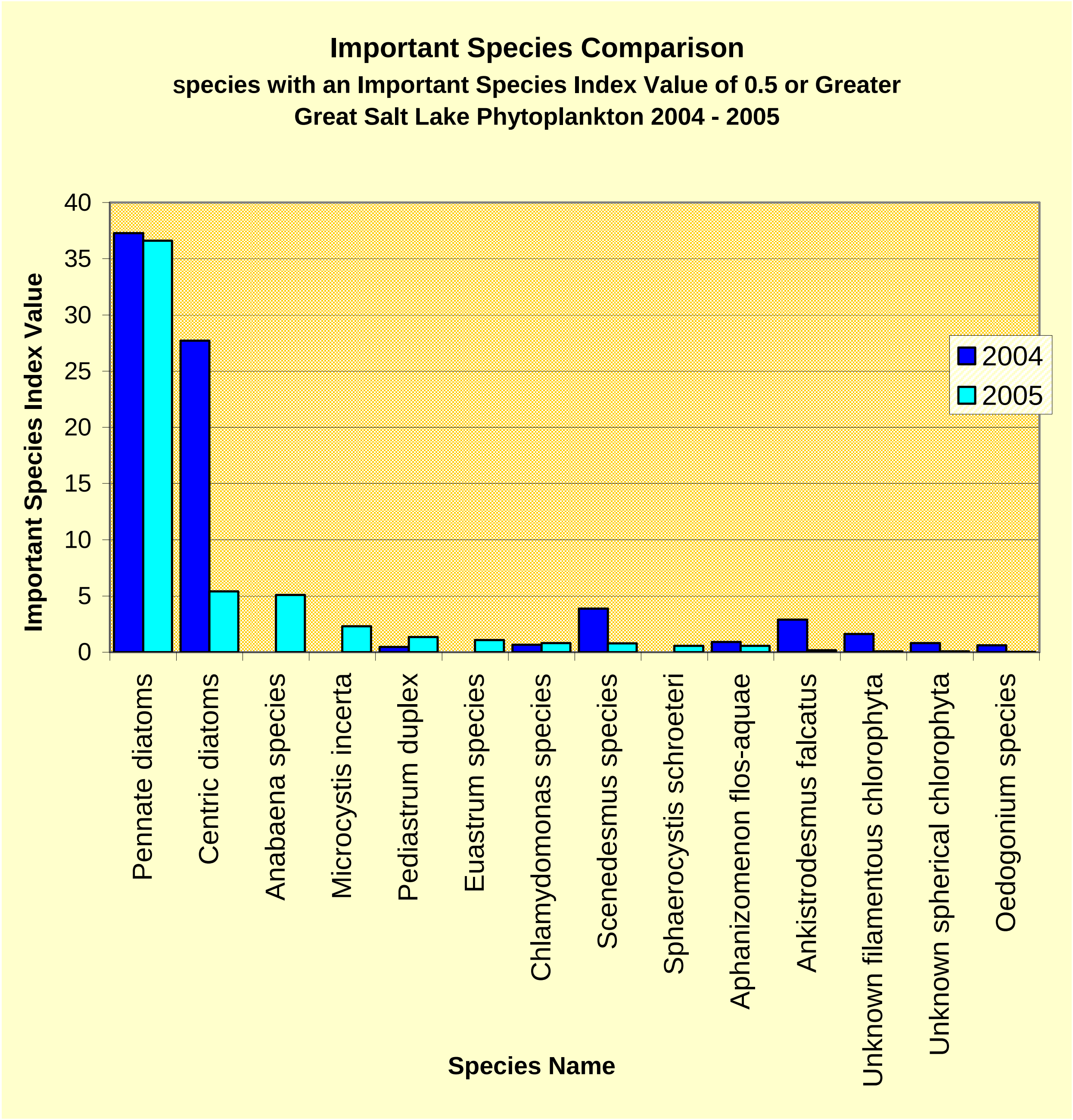

Figure 2. Comparison of Important Species Index values of the major species (ISI = 0.1 or greater) in phytoplankton samples collected from east-shore Great Salt Lake wetland sites during the 2004 study period and the 2005 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

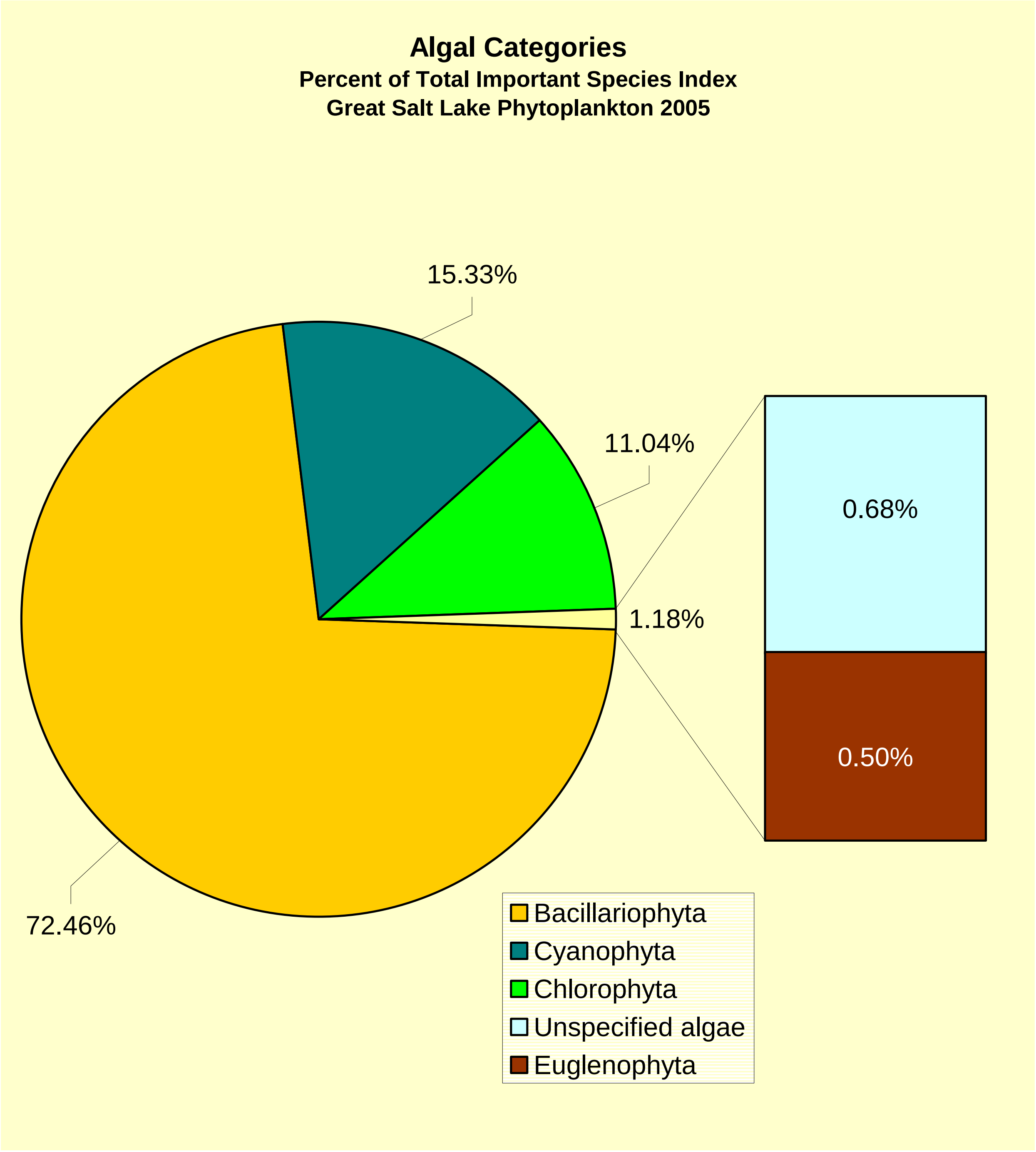

Figure 3. Percent of the sum Important Species Index comprised by the major groups of phytoplankton from samples collected from east-shore Great Salt Lake wetland sites during the 2005 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

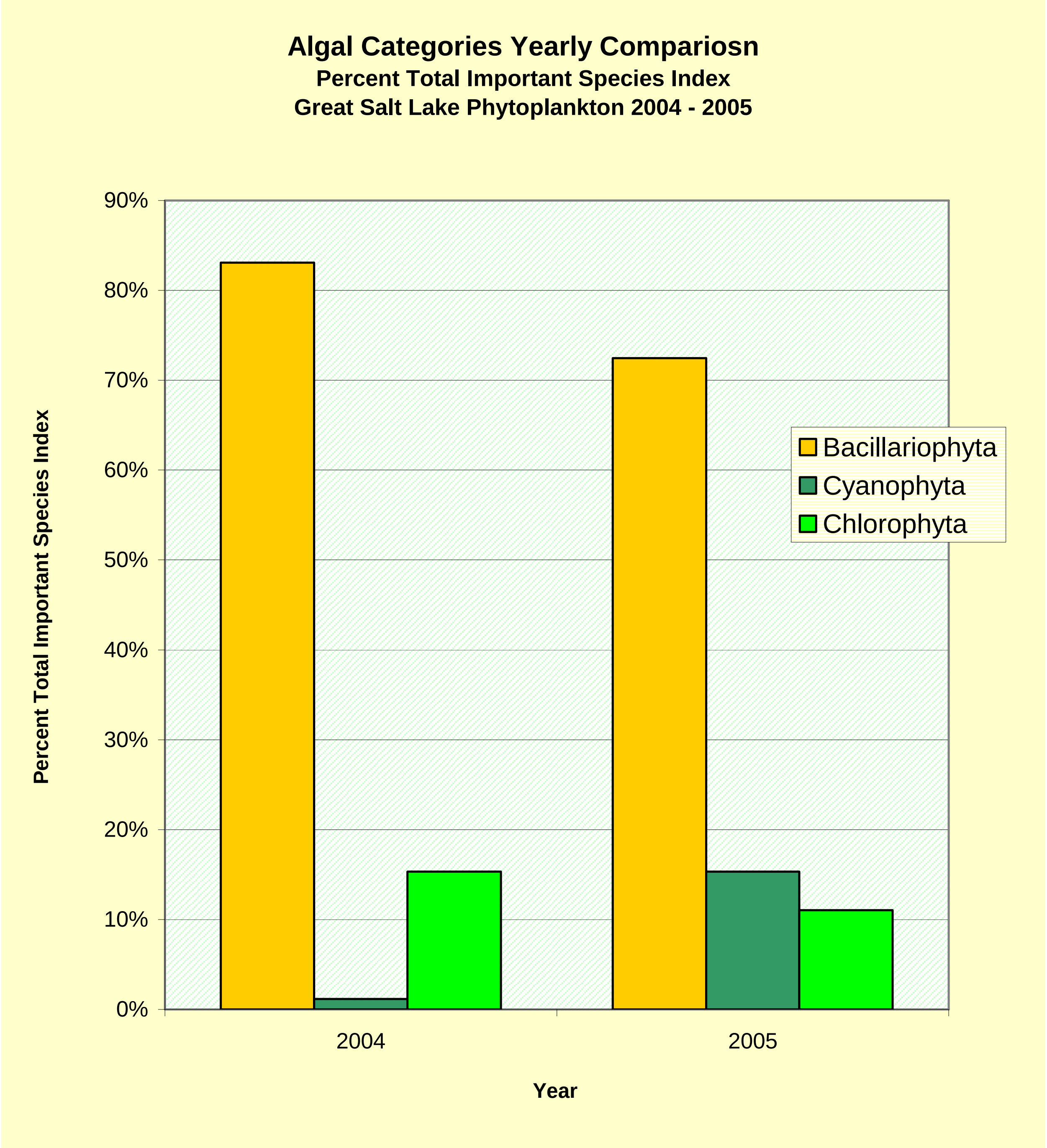

Figure 4. Comparison of the percent of the sum Important Species Index comprised by the major groups of phytoplankton from samples collected from east-shore Great Salt Lake sites during the 2004 study period and the 2005 study period. Important species indices (ISIs) were calculated by multiplying the percent frequency of the taxon by its average relative density (Kaczmarska and Rushforth 1983).

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APPENDIX: Specific Data from Individual Phytoplankton Samples Collected from The Great Salt Lake
2005

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **CDSD New Site 5** on **6/29/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	7	0.1	19.2	13440.0
PENNATE DIATOMS	1	88.8	10929.6	8743680.0
Total Bacillariophyta		**89.0**	**10948.8**	**8757120.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	4	0.3	43.2	33912.0
CHLAMYDOMONAS SPECIES	3	2.3	576.0	230400.0
UNKNOWN FILAMENTOUS CHLOROPHYTA	2	7.8	48.0	764544.0
Total Chlorophyta		**10.5**	**667.2**	**1028856.0**
Cyanophyta				
MERISMOPEDIA TENUISSIMA	8	0.0	4.8	4800.0
OSCILLATORIA SPECIES	5	0.3	24.0	26400.0
OSCILLATORIA SPECIES 2	6	0.3	24.0	26400.0
Total Cyanophyta		**0.6**	**52.8**	**57600.0**
TOTAL FOR ALL GROUPS		**100.0**	**11668.8**	**9843576.0**

Shannon-Wiener Index	=0.29
Species Evenness	=0.14
Species Richness	=0.90
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMBW2** on **7/5/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	7	0.8	14.4	10080.0
PENNATE DIATOMS	1	79.3	1180.8	944640.1
Total Bacillariophyta		**80.2**	**1195.2**	**954720.1**
Chlorophyta				
ANKISTRODESMUS FALCATUS	3	5.7	86.4	67824.0
EUASTRUM SPECIES	4	5.6	4.8	67200.0
SCENEDESMUS SPECIES	5	1.2	9.6	14400.0
TETRAEDRON SPECIES	8	0.3	4.8	3840.0
Total Chlorophyta		**12.9**	**105.6**	**153264.0**
Cyanophyta				
MICROCYSTIS INCERTA	2	6.0	4.8	72000.0
OSCILLATORIA SPECIES	6	0.9	9.6	10560.0
Total Cyanophyta		**6.9**	**14.4**	**82560.0**
TOTAL FOR ALL GROUPS		**100.0**	**1315.2**	**1190544.0**

Shannon-Wiener Index	=0.46
Species Evenness	=0.22
Species Richness	=1.25
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMBW100** on **7/5/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	15	0.1	144.0	100800.0
PENNATE DIATOMS	5	1.2	2059.2	1647360.0
Total Bacillariophyta		**1.3**	**2203.2**	**1748160.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	11	0.2	278.4	218544.0
CHLAMYDOMONAS SPECIES	19	0.0	134.4	53760.0
CLOSTERUM SPECIES	14	0.1	4.8	144000.0
COSMARIUM SPECIES	8	0.7	62.4	873600.1
CRUCIGENIA SPECIES	21	0.0	57.6	40320.0
EUASTRUM SPECIES	7	0.9	81.6	1142400.0
OOCYTIS BORGEI	10	0.3	100.8	403200.0
PEDIASTRUM DUPLEX	6	1.2	28.8	1568563.0
PTEROMONAS SPECIES	23	0.0	28.8	13248.0
SCENEDESMUS BIJUGA	24	0.0	4.8	9600.0
SCENEDESMUS QUADRICAUDA VAR. QUADRISPINA	17	0.0	52.8	63360.0
SCENEDESMUS SPECIES	22	0.0	19.2	28800.0
SPHAEROCYSTIS SCHROETERI	4	2.7	81.6	3628263.0
TETRAEDRON SPECIES	18	0.0	76.8	61440.0
UNKNOWN SPHERICAL CHLOROPHYTA	16	0.1	86.4	86400.0
Total Chlorophyta		**6.2**	**1099.2**	**8335498.0**
Cyanophyta				
ANABAENA SPECIES	1	83.0	2227.2	111360000.0
APHANIZOMENON FLOS-AQUAE	3	3.0	211.2	4012800.0
CHROOCOCCUS SPECIES	13	0.2	201.6	201600.0
GOMPHOSPHAERIA SPECIES	2	5.7	763.2	7632001.0
MERISMOPEDIA GLAUCA	20	0.0	57.6	51840.0
MERISMOPEDIA TENUISSIMA	9	0.4	532.8	532800.0
MICROCYSTIS INCERTA	12	0.2	14.4	216000.0
OSCILLATORIA SPECIES	25	0.0	4.8	5280.0
Total Cyanophyta		**92.5**	**4012.8**	**124012300.0**
TOTAL FOR ALL GROUPS		**100.0**	**7315.2**	**134096000.0**

Shannon-Wiener Index	=2.12
Species Evenness	=0.66
Species Richness	=3.27
Number of Species	=25

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMBW5** on **7/5/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
PENNATE DIATOMS	1	55.7	5544.0	4435200.0
Total Bacillariophyta		**55.7**	**5544.0**	**4435200.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	12	0.1	19.2	7680.0
COSMARIUM SPECIES	6	1.7	9.6	134400.0
GONATOZYGON SPECIES	8	0.3	4.8	26227.2
OOCYTIS BORGEI	7	0.5	9.6	38400.0
PTEROMONAS SPECIES	15	0.0	4.8	2208.0
SCENEDESMUS SPECIES	13	0.1	4.8	7200.0
SCHROEDERIA SETIGERA	3	9.0	72.0	720000.0
SPHAEROCYSTIS SCHROETERI	4	2.7	4.8	213427.2
TETRAEDRON SPECIES	10	0.1	14.4	11520.0
UNKNOWN SPHERICAL CHLOROPHYTA	9	0.2	14.4	14400.0
Total Chlorophyta		**14.8**	**158.4**	**1175462.0**
Cyanophyta				
ANABAENA SPECIES	2	27.1	43.2	2160000.0
MERISMOPEDIA TENUISSIMA	14	0.1	4.8	4800.0
OSCILLATORIA SPECIES	11	0.1	9.6	10560.0
Total Cyanophyta		**27.3**	**57.6**	**2175360.0**
Euglenophyta				
EUGLENA SPECIES	5	2.2	24.0	177600.0
Total Euglenophyta		**2.2**	**24.0**	**177600.0**
TOTAL FOR ALL GROUPS		**100.0**	**5784.0**	**7963623.0**

Shannon-Wiener Index	=0.26
Species Evenness	=0.10
Species Richness	=1.97
Number of Species	=15

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **WIDGEON IN 4985621** on **7/14/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	4	6.3	39.6	27720.0
PENNATE DIATOMS	1	40.2	219.6	175680.0
Total Bacillariophyta		**46.5**	**259.2**	**203400.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	8	2.2	12.0	9420.0
CHLAMYDOMONAS SPECIES	7	2.6	28.8	11520.0
COSMARIUM SPECIES	6	3.8	1.2	16800.0
GONATOZYGON SPECIES	9	1.5	1.2	6556.8
SCENEDESMUS SPECIES	11	0.8	2.4	3600.0
TETRAEDRON SPECIES	14	0.2	1.2	960.0
UNKNOWN FILAMENTOUS CHLOROPHYTA	3	8.7	2.4	38227.2
UNKNOWN SPHERICAL CHLOROPHYTA	12	0.5	2.4	2400.0
Total Chlorophyta		**20.5**	**51.6**	**89484.0**
Cyanophyta				
ANABAENA SPECIES	2	27.4	2.4	120000.0
MERISMOPEDIA TENUISSIMA	13	0.3	1.2	1200.0
OSCILLATORIA SPECIES	10	0.9	3.6	3960.0
Total Cyanophyta		**28.6**	**7.2**	**125160.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	5	4.4	2.4	19200.0
Total Euglenophyta		**4.4**	**2.4**	**19200.0**
TOTAL FOR ALL GROUPS		**100.0**	**320.4**	**437244.0**

Shannon-Wiener Index	=1.17
Species Evenness	=0.44
Species Richness	=2.33
Number of Species	=14

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **Pintail Pond 498530** on **7/14/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	4	3.5	12.0	8400.0
PENNATE DIATOMS	2	23.5	69.6	55680.0
STEPHANODISCUS NIAGARAE	3	16.2	1.2	38400.0
Total Bacillariophyta		**43.2**	**82.8**	**102480.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	9	0.8	2.4	1884.0
CHLAMYDOMONAS SPECIES	7	2.0	12.0	4800.0
OOCYTIS BORGEI	8	2.0	1.2	4800.0
Total Chlorophyta		**4.8**	**15.6**	**11484.0**
Cyanophyta				
CHROOCOCCUS SPECIES	10	0.5	1.2	1200.0
MERISMOPEDIA TENUISSIMA	6	2.5	6.0	6000.0
MICROCYSTIS INCERTA	1	45.6	7.2	108000.0
OSCILLATORIA SPECIES	5	3.3	7.2	7920.0
Total Cyanophyta		**51.9**	**21.6**	**123120.0**
TOTAL FOR ALL GROUPS		**100.0**	**120.0**	**237084.0**

Shannon-Wiener Index	=1.48
Species Evenness	=0.64
Species Richness	=1.95
Number of Species	=10

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **SW Ponds 4985410** on **7/27/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	10	1.4	52.8	36960.0
PENNATE DIATOMS	6	6.3	216.0	172800.0
STEPHANODISCUS NIAGARAE	7	5.6	4.8	153600.0
Total Bacillariophyta		**13.3**	**273.6**	**363360.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	14	0.3	9.6	7536.0
CHLAMYDOMONAS SPECIES	2	24.4	1660.8	664320.0
OOCYTIS BORGEI	9	1.4	9.6	38400.0
UNKNOWN SPHERICAL CHLOROPHYTA	12	0.7	19.2	19200.0
Total Chlorophyta		**26.8**	**1699.2**	**729456.0**
Cyanophyta				
ANABAENA SPECIES	3	8.8	4.8	240000.0
CHROOCOCCUS SPECIES	11	0.7	19.2	19200.0
MERISMOPEDIA TENUISSIMA	13	0.4	9.6	9600.0
MICROCYSTIS INCERTA	5	7.9	14.4	216000.0
OSCILLATORIA SPECIES	4	8.5	211.2	232320.0
SPIRULINA SPECIES	1	30.7	278.4	835200.1
Total Cyanophyta		**57.0**	**537.6**	**1552320.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	8	2.8	9.6	76800.0
Total Euglenophyta		**2.8**	**9.6**	**76800.0**
TOTAL FOR ALL GROUPS		**100.0**	**2520.0**	**2721936.0**

Shannon-Wiener Index =1.23
Species Evenness =0.47
Species Richness =2.08
Number of Species =14

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **SB Pond 4985430** on **7/27/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	8.3	177.6	124320.0
PENNATE DIATOMS	6	4.4	81.6	65280.0
Total Bacillariophyta		**12.6**	**259.2**	**189600.0**
Chlorophyta				
CHLAMYDOMONAS SPECIES	3	17.2	643.2	257280.0
GONATOZYGON SPECIES	4	12.2	33.6	183590.4
SCENEDESMUS SPECIES	9	1.9	19.2	28800.0
SPHAEROCYSTIS SCHROETERI	1	28.5	9.6	426854.4
TETRAEDRON SPECIES	12	0.3	4.8	3840.0
Total Chlorophyta		**60.0**	**710.4**	**900364.9**
Cyanophyta				
CHROOCOCCUS SPECIES	11	1.3	19.2	19200.0
MERISMOPEDIA TENUISSIMA	7	2.6	38.4	38400.0
MICROCYSTIS INCERTA	2	19.2	19.2	288000.0
SPIRULINA SPECIES	10	1.9	9.6	28800.0
Total Cyanophyta		**25.0**	**86.4**	**374400.0**
Euglenophyta				
EUGLENA SPECIES	8	2.4	4.8	35520.0
Total Euglenophyta		**2.4**	**4.8**	**35520.0**
TOTAL FOR ALL GROUPS		**100.0**	**1060.8**	**1499885.0**

Shannon-Wiener Index	=1.38
Species Evenness	=0.56
Species Richness	=2.04
Number of Species	=12

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **W Pond A 4985440** on **7/27/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	9	0.7	69.6	48720.0
PENNATE DIATOMS	3	14.2	1197.6	958080.1
STEPHANODISCUS NIAGARAE	4	3.4	7.2	230400.0
Total Bacillariophyta		**18.3**	**1274.4**	**1237200.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	15	0.1	4.8	3768.0
CHLAMYDOMONAS SPECIES	11	0.6	98.4	39360.0
COSMARIUM SPECIES	8	0.7	3.6	50400.0
CRUCIGENIA SPECIES	16	0.0	4.8	3360.0
OOCYTIS BORGEI	12	0.4	6.0	24000.0
PTEROMONAS SPECIES	20	0.0	2.4	1104.0
SCENEDESMUS BIJUGA	17	0.0	1.2	2400.0
SCENEDESMUS QUADRICAUDA VAR. QUADRISPINA	19	0.0	1.2	1440.0
SPHAEROCYSTIS SCHROETERI	7	0.8	1.2	53356.8
TETRAEDRON SPECIES	21	0.0	1.2	960.0
UNKNOWN SPHERICAL CHLOROPHYTA	18	0.0	2.4	2400.0
Total Chlorophyta		**2.7**	**127.2**	**182548.8**
Cyanophyta				
ANABAENA SPECIES	1	55.9	75.6	3780000.0
APHANIZOMENON FLOS-AQUAE	2	18.5	66.0	1254000.0
CHROOCOCCUS SPECIES	6	1.0	64.8	64800.0
MERISMOPEDIA TENUISSIMA	14	0.2	13.2	13200.0
NOSTOC SPECIES	5	2.5	4.8	168000.0
OSCILLATORIA SPECIES	13	0.2	13.2	14520.0
UNKNOWN SPHERICAL CYANOPHYTA	22	0.0	4.8	14.4
Total Cyanophyta		**78.3**	**242.4**	**5294535.0**
Euglenophyta				
PHACUS SPECIES	10	0.7	9.6	48000.0
Total Euglenophyta		**0.7**	**9.6**	**48000.0**
TOTAL FOR ALL GROUPS		**100.0**	**1653.6**	**6762284.0**

Shannon-Wiener Index	=1.20
Species Evenness	=0.39
Species Richness	=2.91
Number of Species	=22

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **CDSDT4 4985690** on **8/31/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	6.8	19.2	13440.0
PENNATE DIATOMS	2	22.3	55.2	44160.0
Total Bacillariophyta		**29.1**	**74.4**	**57600.0**
Chlorophyta				
MOUGEOTIA SPECIES	3	20.9	1.2	41356.8
SCENEDESMUS SPECIES	7	0.9	1.2	1800.0
Total Chlorophyta		**21.8**	**2.4**	**43156.8**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	4	11.5	1.2	22800.0
MICROCYSTIS INCERTA	1	36.3	4.8	72000.0
OSCILLATORIA SPECIES	6	1.3	2.4	2640.0
Total Cyanophyta		**49.2**	**8.4**	**97440.0**
TOTAL FOR ALL GROUPS		**100.0**	**85.2**	**198196.8**

Shannon-Wiener Index	=1.06
Species Evenness	=0.54
Species Richness	=1.41
Number of Species	=7

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **FBWMA CUL7 T1 4985514** on **8/19/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	2	32.7	777.6	544320.0
PENNATE DIATOMS	1	47.5	988.8	791040.1
Total Bacillariophyta		**80.1**	**1766.4**	**1335360.0**
Chlorophyta				
MOUGEOTIA SPECIES	3	9.9	4.8	165427.2
SCENEDESMUS SPECIES	6	2.2	24.0	36000.0
Total Chlorophyta		**12.1**	**28.8**	**201427.2**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	4	5.5	4.8	91200.0
Total Cyanophyta		**5.5**	**4.8**	**91200.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	5	2.3	4.8	38400.0
Total Euglenophyta		**2.3**	**4.8**	**38400.0**
TOTAL FOR ALL GROUPS		**100.0**	**1804.8**	**1666387.0**

Shannon-Wiener Index	=0.80
Species Evenness	=0.44
Species Richness	=0.84
Number of Species	=6

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **FBWMA Unit 1 out 4985520** on **8/29/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
PENNATE DIATOMS	5	2.2	302.4	241920.0
STEPHANODISCUS NIAGARAE	6	1.1	3.6	115200.0
Total Bacillariophyta		**3.3**	**306.0**	**357120.0**
Chlorophyta				
CLOSTERUM SPECIES	7	1.0	3.6	108000.0
EUASTRUM SPECIES	3	4.2	32.4	453600.0
OEDOGONIUM SPECIES	2	5.3	39.6	572774.4
OOCYTIS BORGEI	11	0.3	7.2	28800.0
PEDIASTRUM DUPLEX	4	3.6	7.2	392140.8
SCENEDESMUS SPECIES	8	0.7	46.8	70200.0
UNKNOWN SPHERICAL CHLOROPHYTA	10	0.3	32.4	32400.0
Total Chlorophyta		**15.4**	**169.2**	**1657915.0**
Cyanophyta				
ANABAENA SPECIES	1	80.3	172.8	8640000.0
APHANIZOMENON FLOS-AQUAE	9	0.6	3.6	68400.0
MERISMOPEDIA SPECIES	13	0.1	3.6	7200.0
OSCILLATORIA SPECIES	12	0.2	21.6	23760.0
Total Cyanophyta		**81.3**	**201.6**	**8739360.0**
TOTAL FOR ALL GROUPS		**100.0**	**676.8**	**10754400.0**

Shannon-Wiener Index	=1.67
Species Evenness	=0.65
Species Richness	=2.29
Number of Species	=13

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMBW2 4985340** on **8/22/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	2	13.5	39.6	27720.0
PENNATE DIATOMS	1	75.5	194.4	155520.0
Total Bacillariophyta		**89.0**	**234.0**	**183240.0**
Chlorophyta				
OOCYTIS BORGEI	3	7.0	3.6	14400.0
PTEROMONAS SPECIES	4	4.0	18.0	8280.0
Total Chlorophyta		**11.0**	**21.6**	**22680.0**
TOTAL FOR ALL GROUPS		**100.0**	**255.6**	**205920.0**

Shannon-Wiener Index	=0.74
Species Evenness	=0.54
Species Richness	=0.70
Number of Species	=4

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **FBWMA Unit 2 Out 4985500** on **8/29/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	19	0.0	2.4	1680.0
PENNATE DIATOMS	5	4.5	288.0	230400.0
Total Bacillariophyta		**4.5**	**290.4**	**232080.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	21	0.0	1.2	942.0
BOTRYOCOCCUS SPECIES	15	0.3	2.4	16281.6
CLOSTERUM SPECIES	8	1.4	2.4	72000.0
CRUCIGENIA SPECIES	13	0.5	34.8	24360.0
EUASTRUM SPECIES	2	24.6	90.0	1260000.0
OEDOGONIUM SPECIES	12	0.7	2.4	34713.6
OOCYTIS BORGEI	6	3.5	44.4	177600.0
PANDORINA MORUM	10	0.9	1.2	48000.0
PEDIASTRUM DUPLEX	4	7.7	7.2	392140.8
PTEROMONAS SPECIES	20	0.0	3.6	1656.0
SCENEDESMUS SPECIES	7	1.9	63.6	95400.0
SPHAEROCYSTIS SCHROETERI	9	1.0	1.2	53356.8
STAURASTRUM GRACILE	1	29.0	22.8	1482000.0
TETRAEDRON SPECIES	16	0.3	19.2	15360.0
UNKNOWN SPHERICAL CHLOROPHYTA	18	0.1	7.2	7200.0
Total Chlorophyta		**71.9**	**303.6**	**3681011.0**
Cyanophyta				
ANABAENA SPECIES	3	22.3	22.8	1140000.0
CHROOCOCCUS SPECIES	11	0.7	36.0	36000.0
MERISMOPEDIA SPECIES	17	0.2	4.8	9600.0
Total Cyanophyta		**23.2**	**63.6**	**1185600.0**
Euglenophyta				
EUGLENA SPECIES	14	0.3	2.4	17760.0
Total Euglenophyta		**0.3**	**2.4**	**17760.0**
TOTAL FOR ALL GROUPS		**100.0**	**660.0**	**5116451.0**

Shannon-Wiener Index =1.99
Species Evenness =0.65
Species Richness =3.17
Number of Species =21

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **CDSDT5 4985700** on **8/31/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
CENTRIC DIATOMS	3	3.5	33.6	23520.0
PENNATE DIATOMS	1	69.1	580.8	464640.0
Total Bacillariophyta		**72.6**	**614.4**	**488160.0**
Chlorophyta				
MOUGEOTIA SPECIES	2	24.6	4.8	165427.2
SCENEDESMUS SPECIES	4	2.1	9.6	14400.0
Total Chlorophyta		**26.7**	**14.4**	**179827.2**
Cyanophyta				
CHROOCOCCUS SPECIES	5	0.7	4.8	4800.0
Total Cyanophyta		**0.7**	**4.8**	**4800.0**
TOTAL FOR ALL GROUPS		**100.0**	**633.6**	**672787.3**

Shannon-Wiener Index	=0.37
Species Evenness	=0.23
Species Richness	=0.82
Number of Species	=5

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMB1 4985320** on **8/22/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	1	40.2	322.8	225960.0
FRAGILARIA VIRESCENS	6	3.1	3.6	17640.0
MELOSIRA GRANULATA VAR. ANGUSTISSIMA	3	13.7	16.8	77280.0
PENNATE DIATOMS	2	22.7	159.6	127680.0
Total Bacillariophyta		**79.8**	**502.8**	**448560.0**
Chlorophyta				
BOTRYOCOCCUS SPECIES	7	1.4	1.2	8140.8
CRUCIGENIA SPECIES	9	0.3	2.4	1680.0
OOCYSTIS SPECIES	8	1.0	3.6	5400.0
SCENEDESMUS SPECIES	5	8.0	30.0	45000.0
SPHAEROCYSTIS SCHROETERI	4	9.5	1.2	53356.8
Total Chlorophyta		**20.2**	**38.4**	**113577.6**
TOTAL FOR ALL GROUPS		**100.0**	**541.2**	**562137.6**

Shannon-Wiener Index	=1.05
Species Evenness	=0.48
Species Richness	=1.31
Number of Species	=9

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **CUL7 T3 4985517** on **8/25/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	6	0.9	28.8	20160.0
PENNATE DIATOMS	1	50.6	1344.0	1075200.0
Total Bacillariophyta		**51.6**	**1372.8**	**1095360.0**
Chlorophyta				
BOTRYOCOCCUS SPECIES	5	1.5	4.8	32563.2
SCENEDESMUS SPECIES	3	2.4	33.6	50400.0
Total Chlorophyta		**3.9**	**38.4**	**82963.2**
Cyanophyta				
CHROOCOCCUS SPECIES	4	1.6	33.6	33600.0
Total Cyanophyta		**1.6**	**33.6**	**33600.0**
Unspecified Algae				
BEGGIATOA SPECIES	2	42.9	24.0	912000.1
Total Unspecified Algae		**42.9**	**24.0**	**912000.1**
TOTAL FOR ALL GROUPS		**100.0**	**1468.8**	**2123923.0**

Shannon-Wiener Index	=0.42
Species Evenness	=0.23
Species Richness	=0.87
Number of Species	=6

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **FBWMA CUL7 T2 4985516** on **8/19/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	3.3	72.0	50400.0
PENNATE DIATOMS	1	57.5	1104.0	883200.1
Total Bacillariophyta		**60.7**	**1176.0**	**933600.1**
Chlorophyta				
OOCYTIS BORGEI	9	1.2	4.8	19200.0
SCENEDESMUS SPECIES	10	0.9	9.6	14400.0
SCHROEDERIA SETIGERA	6	3.1	4.8	48000.0
TETRAEDRON SPECIES	11	0.2	4.8	3840.0
Total Chlorophyta		**5.6**	**24.0**	**85440.0**
Cyanophyta				
APHANIZOMENON FLOS-AQUAE	4	5.9	4.8	91200.0
CALOTHRIX SPECIES	3	11.9	4.8	182400.0
OSCILLATORIA SPECIES	8	1.7	24.0	26400.0
Total Cyanophyta		**19.5**	**33.6**	**300000.0**
Euglenophyta				
EUGLENA SPECIES	7	2.3	4.8	35520.0
Total Euglenophyta		**2.3**	**4.8**	**35520.0**
Unspecified Algae				
BEGGIATOA SPECIES	2	11.9	4.8	182400.0
Total Unspecified Algae		**11.9**	**4.8**	**182400.0**
TOTAL FOR ALL GROUPS		**100.0**	**1243.2**	**1536960.0**

Shannon-Wiener Index	=0.53
Species Evenness	=0.22
Species Richness	=1.80
Number of Species	=11

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMB100 4985330** on **8/22/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	1.5	10.8	7560.0
PENNATE DIATOMS	3	7.8	49.2	39360.0
Total Bacillariophyta		**9.3**	**60.0**	**46920.0**
Chlorophyta				
EUASTRUM SPECIES	2	9.9	3.6	50400.0
PEDIASTRUM DUPLEX	1	77.4	7.2	392140.8
PTEROMONAS SPECIES	6	1.0	10.8	4968.0
SCENEDESMUS SPECIES	4	1.8	6.0	9000.0
TETRAEDRON SPECIES	8	0.2	1.2	960.0
Total Chlorophyta		**90.3**	**28.8**	**457468.8**
Cyanophyta				
CHROOCOCCUS SPECIES	7	0.5	2.4	2400.0
Total Cyanophyta		**0.5**	**2.4**	**2400.0**
TOTAL FOR ALL GROUPS		**100.0**	**91.2**	**506788.8**

Shannon-Wiener Index =1.50
Species Evenness =0.72
Species Richness =1.62
Number of Species =8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **AMBW5 4985350** on **8/22/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	4	4.2	9.6	6720.0
PENNATE DIATOMS	2	35.9	72.0	57600.0
Total Bacillariophyta		**40.0**	**81.6**	**64320.0**
Chlorophyta				
EUASTRUM SPECIES	1	41.8	4.8	67200.0
PTEROMONAS SPECIES	3	15.1	52.8	24288.0
Total Chlorophyta		**57.0**	**57.6**	**91488.0**
Cyanophyta				
CHROOCOCCUS SPECIES	5	3.0	4.8	4800.0
Total Cyanophyta		**3.0**	**4.8**	**4800.0**
TOTAL FOR ALL GROUPS		**100.0**	**144.0**	**160608.0**

Shannon-Wiener Index	=1.12
Species Evenness	=0.70
Species Richness	=1.18
Number of Species	=5

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **PSG T5 4985625** on **9/9/2005**.. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	7	1.1	2.4	1680.0
PENNATE DIATOMS	3	16.4	32.4	25920.0
Total Bacillariophyta		**17.5**	**34.8**	**27600.0**
Chlorophyta				
OOCYTIS BORGEI	5	3.0	1.2	4800.0
PEDIASTRUM DUPLEX	1	41.4	1.2	65356.8
UNKNOWN SPHERICAL CHLOROPHYTA	6	2.3	3.6	3600.0
Total Chlorophyta		**46.8**	**6.0**	**73756.8**
Cyanophyta				
CHROOCOCCUS SPECIES	8	0.8	1.2	1200.0
MICROCYSTIS INCERTA	2	22.8	2.4	36000.0
Total Cyanophyta		**23.6**	**3.6**	**37200.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	4	12.2	2.4	19200.0
Total Euglenophyta		**12.2**	**2.4**	**19200.0**
TOTAL FOR ALL GROUPS		**100.0**	**46.8**	**157756.8**

Shannon-Wiener Index	=1.19
Species Evenness	=0.57
Species Richness	=1.91
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Great Salt Lake**, **PSG WLT 1 4985623** on **10/5/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	**Number Per Milliliter**	**Cell Volume (μ^3/ml)**
Bacillariophyta				
CENTRIC DIATOMS	5	2.3	331.2	231840.0
PENNATE DIATOMS	1	79.3	9979.2	7983360.0
Total Bacillariophyta		**81.6**	**10310.4**	**8215200.0**
Chlorophyta				
ANKISTRODESMUS FALCATUS	9	0.1	10.8	8478.0
LYNGBYA BIRGEI	6	1.8	3.6	180000.0
MOUGEOTIA SPECIES	4	2.5	7.2	248140.8
SCENEDESMUS SPECIES	10	0.1	3.6	5400.0
Total Chlorophyta		**4.4**	**25.2**	**442018.8**
Cyanophyta				
ANABAENA SPECIES	3	3.6	7.2	360000.0
CHROOCOCCUS SPECIES	12	0.0	3.6	3600.0
MICROCYSTIS INCERTA	7	0.5	3.6	54000.0
OSCILLATORIA SPECIES	11	0.0	3.6	3960.0
Total Cyanophyta		**4.2**	**18.0**	**421560.0**
Euglenophyta				
TRACHELLOMONAS SPECIES	8	0.3	3.6	28800.0
Total Euglenophyta		**0.3**	**3.6**	**28800.0**
Unspecified Algae				
BEGGIATOA SPECIES	2	9.5	25.2	957600.0
Total Unspecified Algae		**9.5**	**25.2**	**957600.0**
TOTAL FOR ALL GROUPS		**100.0**	**10382.4**	**10065180.0**

Shannon-Wiener Index	=0.20
Species Evenness	=0.08
Species Richness	=1.38
Number of Species	=12

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

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APENDIX D.5

A Taxonomic and Bioassessment Survey of the Diatom Floras of Farmington Bay, Great Salt Lake

by

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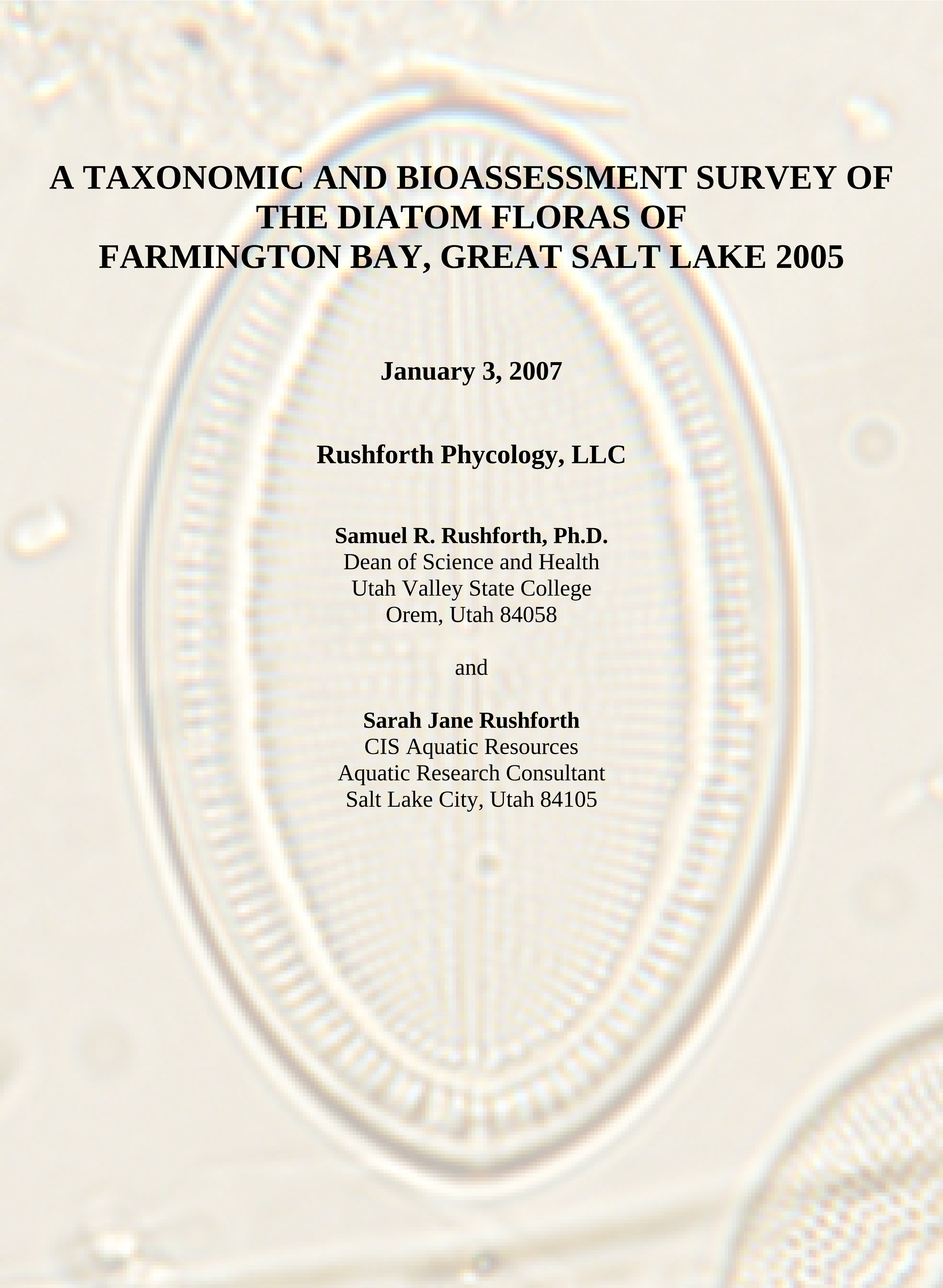

A TAXONOMIC AND BIOASSESSMENT SURVEY OF THE DIATOM FLORAS OF FARMINGTON BAY, GREAT SALT LAKE 2005

January 3, 2007

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INTRODUCTION

Under the management of the Utah Department of Environmental Quality, Division of Water Quality, samples were collected from established sites along the shores of Farmington Bay wetlands. A taxonomic and bioassessment study of the diatom floras from these established reference sites was performed.

FIELD METHODS

Samples are collected by Utah State DWQ staff according to EPA WMAP or DWQ protocols. At each site, field staff collect a sample according to the appropriate method for the existing. Pieces of visible algae from each site are placed in the collection jar to create a “composite periphyton sample”. Once collections are complete, the total sample volume is recorded, the sample is thoroughly mixed, and subsampled into a diatom sample and a soft algal periphyton sample.

Latitude and longitude are recorded for each site. Samples are labeled on the outside of the collecting jar. In addition to the outside label, a small piece of waterproof paper with the STORET number and date is placed inside each sample jar.

LABORATORY METHODS

Preparation

Each periphyton sample is divided in the laboratory into two subsamples. One is analyzed for soft algae and one is analyzed for diatoms.

Permanent, archival quality diatom slides (strewn mounts) are prepared following standard nitric acid oxidation (summarized below). Strewn mounts will be deposited in the diatom herbarium of the California Academy of Sciences, San Francisco, California.

Strewn mounts are prepared by boiling a 15-20 ml subsample of the stream reference site collection in approximately an equal volume of concentrated nitric acid (Sgro and Johansen, 1995). The acidified sample is boiled until it has lost approximately 5 ml of total volume. At this stage, a pinch of potassium dichromate is added and the sample is boiled for approximately 5 more minutes.

Boiled samples are cooled and transferred to lidded disposable centrifuge tubes**.** The sample is then centrifuged and the acid decanted into an acid-safe container for later proper disposal. The centrifuge tube with the diatom pellet is then filled with deionized water, shaken to break the pellet and centrifuged again. This water rinsing is repeated 6 times.

On the last rinse, the sample is agitated to distribute the diatoms in the acid-free deionized water. A subsample of this preparation should be diluted with deionized water (when necessary) to create a lightly clouded diatom suspension. This suspension is subsequently pipetted to entirely cover thin (number 1) cover slips and allowed to dry overnight. These cover slips are mounted on thin microscope slides using Naphrax diatom mountant (Sgro and Johansen, 1995).

Microscopy

Microscopy was performed using Nikon Eclipse E200 microscopes equipped with Nikon's CFI60 infinity optical systems and a Zeiss RA research microscope equipped with a differential interference phase-contrast optical system.

Permanent strewn mounts were examined along linear, horizontal transects of the slide. Each species with at least 50% of a single valve present was counted until a minimum total of 600 valves was obtained. Identifications were performed using standard taxonomic works and personal reference slide collections.

NUMERICAL ANALYSIS

EPL

Ecology Program Library is proprietary software developed by Andrew Evenson for Rushforth Phycology, LLC. This program calculates the % relative density of each taxon in the sample based on cell volumes calculated using BIOVOL software developed by David Kirschtel (1992). To account for the substantial variation in shape between diatom taxa, Kirschtel established a set of equations to more accurately approximate the average volume of each diatom taxon. Average measures of cell height (= thickness or depth), length, and width are entered and one of eight shape equations selected for each taxon. BIOVOL then calculates cell volume in um^3.

Based on these cell biovolumes and the frequency of each species in the sample, EPL also determines the rank of each taxon in each sample. A Shannon-Wiener Index, species evenness, and species richness are calculated for each sample using the following formulas:

Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{S} Pi \ln Pi$$

where; *Pi* = the proportion of the total number of individuals in the *i*th species; and *S* = the number of species.

Species Richness (Atlas and Bartha 1981):

$$d = \frac{S - 1}{\log N}$$

where; ***S*** = the number of species; and ***N*** = the number of individuals.

Species evenness (Atlas and Bartha 1981) according to the formula:

$$e = \frac{\text{Shannon-Weiner index}}{\log S}$$

where ***S*** is the number of species in the sample.

Each diatom count conducted in this reference survey has been processed with EPL, results of which are included in Appendix I.

OMNIDIA

OMNIDIA software was developed by Catherine Lecointe to aid in taxonomic evaluation of diatom taxa, calculate water quality indices based upon diatom populations, and calculate selected ecological parameters as mirrored by diatom populations and assist in database management. Each diatom count conducted in this study has been processed with OMNIDIA, results of which are included in the Appendix I.

Bioindices calculated by OMNIDIA are listed in the following table. A reference is provided for each index calculated.

CEE	Indice CEE (Descy et al. 1998)
DESCY	Descy (1979)
DI-CH	Hurlimann Suisse (2002)
EPI-D	Dell'Uomo A. (1996)
GENRE	Indice diatomique generique (Cemagref 1982 - 90)
IBD	Indice biologique diatomees (Lenoir & Coste 1995)
IDAP	Indice diatomique Artois Picardie (Prygiel et al. 1988)
IDP	Pampean diatom index (Gomez N. Licursi M. 2001)
IPS	Indice de pulluo-sensibilite (Cemagref 1982)
LMA	Leclercq et Maquet (1987)
LOBO	Lobo et al. Bresil (2003)
SHE	Steinberg et Schiefele (1988 - 91)
SID	Rott, E., G. Hofmann, K. Pall, P. Pfister & E Pipp Ind. saprobique (1997)
SLA	Sladecek (1986)
TDI	Trophic Diatom Index (Kelly & Whitton 1995)
TID	Rott, E., G. Hofmann, K. Pall, P. Pfister & E Pipp Ind. Trophique (1999)
WAT	Watanabe (1982 - 90)

Numeric values of the diatom bioindices are transformed in OMNIDIA from their original numeric index calculated values (which vary between 0-4 and 1-100) to an index range between 1 and 20 for ease of comparison. For the equation used to calculate the original index value, see the OMNIDIA references in the appendix and/or the above table. The table below summarizes the formulae used to transform the bioindices into the 1-20 scale in OMNIDIA.

Eutrophication/organic load or water quality estimates	Original bioindex scale	OMNIDIA equation used to calculate a 1-20 scale (Y) (V = initial index value)
CEE	0 (worst) to 10 (best)	Y = 1.9V+1
DESCY	1 (best) to 4 (worst)	Y = 4.75V-3.75
DI-CH	1 (best) to 8 (worst)	Y = 22.714 - 2.714V
EPI-D	0 (best) to 4 (worst)	Y = 20 - 4.75V
GENRE	1 (worst) to 5 (best)	Y = 4.75V - 3.75
IBD	1 (worst) to 7 (best)	Y = 4.75V - 8.5 (scale 2 - 6)
IDAP	1 (worst) to 5 (best)	Y = 4.75V - 3.75
IDP	1 (best) to 4 (worst)	Y = 20 - 4.75V
IPS	1 (worst) to 5 (best)	Y = 4.75V - 3.75
LMA	1 (worst) to 5 (best)	Y = 4.75V - 3.75
LOBO	1 (best) to 4 (worst)	Y = 6.33V – 5.333
SHE	1 (worst) to 7 (best)	Y = 3.167V - 2.167
SID	1 (best) to 3.8 (worst)	Y = 26.786 – 6.786V
SLA	0 (best) to 4 (worst)	Y = 20 - 4.75V
TDI	1 (clean) to 5 (most polluted)	Y = -4.75V + 24.75
TID	0.3 (best) to 3.9 (worst)	Y = 21.583 – 5.278V
WAT	0 (worst) to 100 (best)	Y = 0.190V +1

OMNIDIA also calculates select ecological values as indicated by diatom populations. These are summarized in the following table and a “key” to interpretation of these values is included in the following pages.

Ecolocigal values

Van Dam 1994	PH Salinity Nitrogen uptake Oxygen requirements Saprobity Trophic state Moisture
Lange-Bertalot 1979	Differential species
Hofmann 1994	Trophic state Saprobity
Håkansson 1993	pH classes
Denys 1991	Habitat Current
Lange-Bertalot 1996	Species prevalence
Watanabe 1990	Saprobic index
Steinberg Schiefele 1988	Trophic sensitivity

Van Dam 1994

Classification of ecological indicator values
(Van Dam, Mertens & Sinkeldam 1994)

pH	Classes	pH range
1	acidobiontic	optimal occurrence at pH <5.5
2	acidophilous	mainly occurring at pH <7
3	circumneutral	mainly occurring at pH = aprox. 7
4	alkaliphilous	mainly occuring at pH > 7
5	alkalbiontic	exclusively ocurring at pH > 7
6	indefferent	no apparent optimum

Salinity		Cl- [mgl-1]	Salinity [%]
1	fresh	< 100	< 0.2
2	fresh brackish	< 500	< 0.9
3	brackish fresh	500 - 1000	0.9 - 1.8
4	brackish	1000 - 5000	1.9 - 9.0

Nitrogen Uptake Metabolism	
1	Nitrogen - autotrophic taxa, tolerating very small concentrations of organically bound nitrogen
2	Nitrogen - autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen
3	Facultatievely nitrogern - heterotrophic taxa, needing periodicaaly elevated concentrations of organicaaly bound nitrogen
4	Obligately nitrogen - heterotrophic taxa, needing coninuously elevated concentrations of organiccaly bound nitrogen

Oxygen requirements	
1	continuously high [100% saturation]
2	fairly high [> 75 % concentration]
3	moderate [> 50 % saturation]
4	low [> 30 % saturation]
5	very low [10% saturation]

Saprobity		Oxygen sat.	BOD5 [mgl - 1]
1	oligosaprobous	> 85	< 2
2	mesosaprobous	70 - 85	2 -4
3	alpha-mesosaprobous	25 - 70	4 - 13
4	alpha - meso/polysaprobous	10 - 25	13 - 22
5	polysaprobous	< 10	> 22

Trophic State	
1	oligotraphentic
2	oligo-mesotraphentic
3	mesotraphentic
4	meso-eutraphentic
5	eutraphentic
6	hypereutraphentic
7	oligo to eutraphentic [hypereutraphentic]

Moisture	
1	never or very rarely occurrring outside water bodies
2	mainly occurring in water bodies, sometimes on wet places
3	mainly occurring in water bodies, also rather regularly on wet and moist places
4	mainly occurring on wet and moist or temporarily dry places
5	nearly exclusively occurring outside water bodies

Lange Bertalot 1979

1	most pollution tolerant
2a	alpha-mesosaprobic a
2b	alpha-mesosaprobic b
2c	ecological questionable
3a	more sensitive (abundant)
3b	more sensitive (less frequent)

Hofmann 1994

Trophic conditions	
0	unknown
1	ot = Oligatrophic
2	ol-bmt = oligo - ß -mesotrophic
3	ol-amt = oligo - alpha -mesotropic
4	am-eut = alpha meso eutrophic
5	aeut = eutrophic
6	tol = tolerant
7	ind = indifferent
8	sap = saprotrophic

Saprobic conditions	
0	unknown
1	os = oligasoprob
2	os/bms = oligo - ß - mesosaprob
3	bms = ß - mesosaprob
4	bms/barns = ß - meso - ß - alpha mesosaprob
5	barns = ß - alpha mesosapron
6	barns/ams = ß - alpha - meso - alpha meso
7	ams = alpha mesosaprob
8	ams/ps = alpha - meso polysaprob
9	ps = polysaprob

Håkanson 1993

pH classes

Håkanson's 9 pH classes		
1	acidobiontic	(ACB)
2	acidobiontic to aciophilous	(ACP/ACB)
3	acidophilous	(ACP)
4	indifferent to acidophilous	(IND/ACP)
5	indifferent (nutral circumstance)	(IND)
6	alcaliphilous to indifferent	(AKP/IND)
7	alcaliphilous	(AKO)
8	alcaliphilous to alcalibiontic	(AKP/AKB)
9	alcalibiontic	(AKB)

Inferred pH (multiple regression Håkanson 1993):
pH=5.116+0.03121*AKB+0.03418*AKP*IND-0.0007765*ACP-0.05*ACB

Denys 1991

Habitat - Lifeform	
0	unknown
2	euplanktonic
3	tychoplanktonic, epontic origin
4	tychoplanktonic, benthic origin
5	tychoplanktonic, both epontic and benthic origin
6	epontic
7	epontic and benthic
8	benthic

Current	
0	unknown
1	not relevant
2	rheobiontic
3	rheophilous
4	indifferent
5	liniophilous

Lange-Bertalot & al. 1996

Roteliste der Limnischen Kieselalgen (Bacillariophyceae)

0	Quasiment disparu	almost vanished
1	menacé de disparition	threatened with dissapearance
2	fortement menacé	strongly threatened
3	en danger	in danger
G	risque existant	existing risk
R	très rare	very rare
V	en régression	in regression
*	risque non estimé	risk not estimated
?	non menacé	not threatened

Watanabe (1982 - 1990)

Method Sapr = 3 groups
1 = saprophile species
2 = saproxene species
0 = indifferent

$$\mathrm{DAIpo} = 50 + 1/2 \left(\sum_{i=1}^{p} X_i - \sum_{j=1}^{q} S_j \right)$$

$\sum_{i=1} X_i$ = sum in % of saproxene species from 1 to p

$\sum_{j=1}^{q} S_j$ = sum in % of saprophile species from 1 to q

Steinberg and Schiefele 1988

1	mt	most tolerant
2	ht	highly tolerant
3	tt	tolerant
4	ls	less sensitive
5	eu	eutrophic
6	ss	sensitive
7	ol	oligosaprobic
0	unknown	unknown

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2005 Farmington Bay Diatom Species List

Achnanthes affinis Grunow in Cleve & Grunow (Achnanthidium)
Achnanthes exigua Grunow in Cl. & Grun.
Achnanthes hauckiana Grunow in Cl. & Grun.
Achnanthes lanceolata (Breb.) Grunow
Achnanthes lanceolata (Breb.) Grunow ssp. *dubia* (Grunow) Lange-Bertalot
Achnanthes linearis (W. Sm.) Grunow
Achnanthes minutissima Kützing (Achnanthidium)
Achnanthes species
Amphora coffeaeformis (Agardh) Kützing
Amphora ovalis (Kützing) Kützing
Amphora perpusilla Grunow
Amphora veneta Kützing
Anomoeoneis costata (Kützing) Grunow
Anomoeoneis sphaerophora (Ehr.) Pfitzer
Bacillaria paradoxa Gmelin
Caloneis bacillum (Grunow) Cleve
Cocconeis pediculus Ehrenberg
Cocconeis placentula Ehrenberg
Cocconeis placentula Ehrenberg var. *euglypta* (Ehr.) Grunow
Cyclotella atomus Hustedt
Cyclotella comta (Ehr.) Kützing
Cyclotella meneghiniana Kützing
Cyclotella species
Cymatopleura solea (Brebisson) W. Smith
Cymbella cistula (Ehrenberg) Kirchner
Cymbella cymbiformis Agardh
Cymbella minuta Hilse ex Rabenhorst (Encyonema)
Cymbella pusilla Grunow in A.Schmidt & al.
Denticula elegans Kützing
Diatoma tenuis Agardh
Diatoma tenuis Agardh var. *elongatum* Lyngbye
Entomoneis alata Ehrenberg
Epithemia turgida (Ehr.) Kützing
Eunotia curvata (Kützing) Lagerstedt
Fragilaria brevistriata Grunow var. *inflata* (Pantocsek) Hustedt
Fragilaria capucina Desmazieres
Fragilaria construens (Ehr.) Grunow (Staurosira)
Fragilaria construens (Ehr.) Grunow f. *venter* (Ehr.) Hustedt
Fragilaria leptostauron (Ehr.) Hustedt
Fragilaria vaucheriae (Kützing) Petersen
Fragilaria virescens Ralfs
Gomphonema acuminatum Ehrenberg
Gomphonema affine Kützing
Gomphonema parvulum Kützing

Gyrosigma spencerii (Quekett) Griffith et Henfrey
Mastogloia elliptica (Agardh) Cleve var. *dansei* (Thwaites) Cleve
Melosira granulata (Ehr.) Ralfs
Melosira granulata (Ehr.) Ralfs var. *angustissima* O. Muller
Melosira varians Agardh
Navicula capitata Ehrenberg (Hippodonta)
Navicula circumtexta Meister ex Hustedt
Navicula cryptocephala Kützing
Navicula cryptocephala Kützing var. *veneta* (Kutz.) Rabenhorst
Navicula cuspidata Kützing
Navicula exigua (Gregory) Grunow
Navicula exigua (Gregory) Grunow var. *capitata* Patrick
Navicula halophila (Grunow) Cleve
Navicula halophila (Grunow) Cleve f. *tenuirostris* Hustedt
Navicula lanceolata (Agardh) Ehrenberg
Navicula mutica Kützing
Navicula pelliculosa (Brebisson ex Kützing) Hilse
Navicula peregrina (Ehr.) Kützing
Navicula pupula Kützing
Navicula pygmaea Kützing
Navicula radiosa Kützing var. *tenella* (Brebisson) Cleve & Möller
Navicula rhyncocephala Kützing
Navicula salinarum Grunow in Cleve et Grunow
Navicula salinarum Grunow var. *intermedia* (Grunow) Cleve
Navicula secreta Pantocsek. var. *apiculata* Patrick
Navicula speceis
Navicula subinflatoides Hustedt
Navicula tripunctata (O.F. Müller) Bory
Navicula tripunctata var. *schizomenoides* (Van Heurck) Patrick
Nitzschia acicularis (Kützing) W.M. Smith
Nitzschia acuminata (W. M. Smith) Grunow
Nitzschia amphibia Grunow f. amphibia
Nitzschia apiculata (Gregory) Grunow
Nitzschia communis Rabenhorst
Nitzschia dissipata (Kützing) Grunow
Nitzschia fasciculata (Grunow)Grunow in V.Heurck
Nitzschia frustulum (Kützing) Grunow
Nitzschia hungarica Grunow
Nitzschia inconspicua Grunow
Nitzschia intermedia Hantzsch ex Cleve & Grunow
Nitzschia linearis (Agardh) W. M. Smith
Nitzschia lorenziana var. *subtilis* Grunow
Nitzschia microcephala Grunow in Cleve & Moller
Nitzschia palea (Kützing) W. Smith
Nitzschia paleacea (Grunow) Grunow in van Heurck
Nitzschia pseudostagnorum Hustedt

Nitzschia romana Grunow
Nitzschia scalaris (Ehr.) W. M. Smith
Nitzschia species
Nitzschia subtilis Grunow in Cleve et Grunow
Nitzschia tryblionella Hantzsch
Pinnularia borealis Ehrenberg
Pinnularia brebissonii (Kutz.) Rabenhors
Pleurosigma delicatulum W. Smith
Rhoicosphenia curvata (Kützing) Grunow
Rhopalodia gibba (Ehr.) O. Müller
Stephanodiscus species
Surirella ovalis Brebisson
Surirella striatula Turpin sensu Schmidt
Synedra delicatissima W. Smith
Synedra fasciculata (Ag.) Kützing var. *truncata* (Greville) Patrick
Synedra fasciculata Kützing
Synedra pulchella (Ralfs ex Kützing) Kützing
Synedra rumpens Kützing
Synedra ulna (Nitzsch.) Ehr.

APPENDIX I

Diatom taxa present in a composite sample collected from the **Farmington Bay, Great Salt Lake**, **AMB100 4985330** on **8/22/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	2	14.6	104
Cymbella cymbiformis Agardh	8	1.6	8
Cymbella pusilla Grunow in A.Schmidt & al.	14	0.7	6
Cyclotella species	17	0.5	10
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	16	0.6	4
Cocconeis placentula Ehrenberg	13	0.7	4
Cocconeis pediculus Ehrenberg	9	1.5	2
Fragilaria vaucheriae (Kützing) Petersen	19	0.3	6
Gomphonema parvulum Kützing	5	5.4	104
Nitzschia romana Grunow	6	4.7	26
Nitzschia paleacea (Grunow) Grunow in van Heurck	12	0.8	12
Nitzschia palea (Kützing) W. Smith	3	13.0	192
Nitzschia inconspicua Grunow	11	1.1	96
Nitzschia frustulum (Kützing) Grunow	21	0.3	22
Nitzschia fasciculata (Grunow)Grunow in V.Heurck	27	0.0	2
Nitzschia acuminata (W. M. Smith) Grunow	26	0.0	2
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	25	0.0	2
Navicula tripunctata (O.F. Müller) Bory	7	1.8	8
Navicula rhyncocephala Kützing	18	0.3	2
Navicula cuspidata Kützing	23	0.0	10
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	22	0.2	2
Navicula cryptocephala Kützing	10	1.1	14
Navicula capitata Ehrenberg (Hippodonta)	20	0.3	2
Pinnularia borealis Ehrenberg	28	0.0	2
Synedra ulna (Nitzsch.) Ehr.	4	12.0	8
Synedra rumpens Kützing	15	0.6	22
Surirella ovalis Brebisson	1	37.7	8
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	24	0.0	6

Population 686

Shannon-Wiener Index	=2.35
Species Evenness	=0.71
Species Richness	=4.13
Number of Species	=28

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **AMB W1 4985330** on **8/22/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis sphaerophora (Ehr.) Pfitzer	12	1.6	2
Amphora veneta Kützing	9	1.8	24
Amphora ovalis (Kützing) Kützing	7	1.9	6
Achnanthes lanceolata (Breb.) Grunow	27	0.0	2
Cymatopleura solea (Brebisson) W. Smith	11	1.6	2
Cyclotella species	20	0.3	10
Cyclotella meneghiniana Kützing	2	25.5	272
Cocconeis placentula Ehrenberg	3	17.4	176
Fragilaria leptostauron (Ehr.) Hustedt	25	0.2	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	16	0.8	70
Gomphonema parvulum Kützing	6	2.2	76
Melosira granulata (Ehr.) Ralfs var. angustissima O. Muller	14	1.2	2
Melosira granulata (Ehr.) Ralfs	5	2.6	2
Nitzschia romana Grunow	23	0.2	2
Nitzschia palea (Kützing) W. Smith	4	8.7	238
Nitzschia frustulum (Kützing) Grunow	26	0.1	10
Nitzschia fasciculata (Grunow)Grunow in V.Heurck	22	0.2	2
Nitzschia amphibia Grunow f. amphibia	24	0.2	8
Nitzschia acuminata (W. M. Smith) Grunow	13	1.2	2
Navicula tripunctata (O.F. Müller) Bory	21	0.2	2
Navicula salinarum Grunow in Cleve et Grunow	18	0.7	6
Navicula cuspidata Kützing	8	1.9	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	19	0.6	14
Navicula capitata Ehrenberg (Hippodonta)	17	0.8	10
Synedra ulna (Nitzsch.) Ehr.	10	1.6	2
Synedra rumpens Kützing	28	0.0	2
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	15	1.0	6
Surirella ovalis Brebisson	1	25.5	10

Population 962

Shannon-Wiener Index	=2.05
Species Evenness	=0.62
Species Richness	=3.93
Number of Species	=28

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **AMB W2** on **8/22/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	8	1.0	6
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	2	22.4	128
Cyclotella meneghiniana Kützing	10	0.4	2
Cymbella pusilla Grunow in A.Schmidt & al.	5	7.6	118
Gomphonema parvulum Kützing	9	1.0	16
Navicula circumtexta Meister ex Hustedt	12	0.2	2
Navicula cryptocephala Kützing	7	3.0	30
Navicula lanceolata (Agardh) Ehrenberg	4	12.8	34
Navicula pupula Kützing	11	0.3	2
Nitzschia inconspicua Grunow	13	0.0	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	3	19.0	218
Nitzschia tryblionella Hantzsch	6	4.7	2
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	1	27.5	74

Population 634

Shannon-Wiener Index	=1.78
Species Evenness	=0.70
Species Richness	=1.86
Number of Species	=13

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **AMB W5** on **8/22/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora ovalis (Kützing) Kützing	5	11.3	14
Amphora coffeaeformis (Agardh) Kützing	10	0.9	18
Amphora perpusilla Grunow	15	0.0	4
Amphora veneta Kützing	1	21.5	110
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	2	19.0	96
Cymbella minuta Hilse ex Rabenhorst (Encyonema)	11	0.9	22
Cymbella pusilla Grunow in A.Schmidt & al.	7	6.3	86
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	13	0.4	14
Navicula cryptocephala Kützing	9	2.1	18
Navicula lanceolata (Agardh) Ehrenberg	6	8.5	20
Nitzschia inconspicua Grunow	8	2.6	164
Nitzschia intermedia Hantzsch ex Cleve & Grunow	12	0.6	2
Nitzschia linearis (Agardh) W. M. Smith	14	0.2	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	4	12.6	128
Surirella ovalis Brebisson	3	13.2	2

Population 700

Shannon-Wiener Index	=2.11
Species Evenness	=0.78
Species Richness	=2.14
Number of Species	=15

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **CDSD T1 4985660** on **8/2/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	2	4.5	290
Achnanthes minutissima Kützing (Achnanthidium)	14	0.2	22
Amphora veneta Kützing	8	1.0	16
Anomoeoneis sphaerophora (Ehr.) Pfitzer	3	2.7	4
Cocconeis placentula Ehrenberg	15	0.2	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	13	0.3	4
Cyclotella meneghiniana Kützing	4	2.4	30
Cyclotella species	18	0.1	4
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	12	0.3	30
Gomphonema parvulum Kützing	16	0.1	6
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	9	0.5	12
Navicula pupula Kützing	10	0.4	6
Navicula rhyncocephala Kützing	11	0.3	4
Navicula salinarum Grunow var. intermedia (Grunow) Cleve	5	2.0	12
Navicula mutica Kützing	17	0.1	2
Nitzschia amphibia Grunow f. amphibia	21	0.0	2
Nitzschia frustulum (Kützing) Grunow	19	0.1	10
Nitzschia inconspicua Grunow	20	0.0	8
Nitzschia paleacea (Grunow) Grunow in van Heurck	7	1.1	32
Nitzschia romana Grunow	6	1.5	18
Synedra ulna (Nitzsch.) Ehr.	1	82.1	11

Population 632

Shannon-Wiener Index	=1.97
Species Evenness	=0.65
Species Richness	=3.10
Number of Species	=21

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Algal taxa present in a total plankton sample collected from the **Farmington Bay, Great Salt Lake**, **CDSD T2 4985680** on **8/2/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	4	6.9	264
Achnanthes linearis (W. Sm.) Grunow	25	0.1	4
Achnanthes minutissima Kützing (Achnanthidium)	14	0.9	60
Amphora perpusilla Grunow	26	0.0	2
Amphora veneta Kützing	9	1.8	16
Anomoeoneis sphaerophora (Ehr.) Pfitzer	8	2.3	2
Caloneis bacillum (Grunow) Cleve	20	0.3	4
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	13	0.9	8
Cyclotella meneghiniana Kützing	5	3.3	24
Eunotia curvata (Kützing) Lagerstedt	16	0.6	4
Fragilaria virescens Ralfs	17	0.6	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	7	2.5	142
Gomphonema parvulum Kützing	12	0.9	22
Nitzschia romana Grunow	18	0.6	4
Nitzschia paleacea (Grunow) Grunow in van Heurck	10	1.7	30
Nitzschia inconspicua Grunow	21	0.3	30
Nitzschia frustulum (Kützing) Grunow	23	0.1	14
Navicula peregrina (Ehr.) Kützing	11	1.0	2
Navicula pelliculosa (Brebisson ex Kützing) Hilse	27	0.0	2
Navicula rhyncocephala Kützing	19	0.5	4
Navicula radiosa Kützing var. tenella (Brebisson) Cleve & Möller	15	0.9	6
Navicula pupula Kützing	22	0.2	2
Navicula halophila (Grunow) Cleve	2	15.7	52
Navicula cryptocephala Kützing	24	0.1	2
Rhopalodia gibba (Ehr.) O. Müller	6	2.8	2
Synedra ulna (Nitzsch.) Ehr.	1	40.1	34
Surirella ovalis Brebisson	3	14.9	4

Population 742

Shannon-Wiener Index	=2.23
Species Evenness	=0.68
Species Richness	=3.93
Number of Species	=27

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **CDSD T4 4985690** on **8/31/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	4	5.6	40
Achnanthes species	21	0.1	16
Achnanthes minutissima Kützing (Achnanthidium)	22	0.1	4
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	13	1.1	32
Cyclotella meneghiniana Kützing	19	0.3	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	14	0.8	6
Cocconeis placentula Ehrenberg	17	0.4	2
Diatoma tenuis Agardh	16	0.5	8
Eunotia curvata (Kützing) Lagerstedt	15	0.8	4
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	3	6.4	290
Gomphonema parvulum Kützing	5	5.3	102
Gyrosigma spencerii (Quekett) Griffith et Henfrey	7	3.8	4
Nitzschia tryblionella Hantzsch	6	3.8	2
Nitzschia romana Grunow	18	0.4	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	9	3.1	44
Nitzschia frustulum (Kützing) Grunow	23	0.0	4
Navicula peregrina (Ehr.) Kützing	12	1.3	2
Navicula halophila (Grunow) Cleve	10	3.0	8
Navicula cryptocephala Kützing	20	0.2	2
Rhopalodia gibba (Ehr.) O. Müller	8	3.6	2
Synedra ulna (Nitzsch.) Ehr.	1	47.6	32
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	11	2.4	8
Surirella ovalis Brebisson	2	9.4	2

Population 618

Shannon-Wiener Index	=1.91
Species Evenness	=0.61
Species Richness	=3.42
Number of Species	=23

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **CDSD T5 4985700** on **8/31/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	1	60.8	256
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	8	0.6	10
Cymbella pusilla Grunow in A.Schmidt & al.	11	0.2	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Husted	3	9.4	250
Gomphonema parvulum Kützing	7	0.7	8
Nitzschia tryblionella Hantzsch	4	6.5	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	9	0.4	3
Nitzschia inconspicua Grunow	5	1.7	88
Nitzschia frustulum (Kützing) Grunow	10	0.3	16
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	6	1.1	8
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	2	18.3	36

Population **679**

Shannon-Wiener Index	=1.47
Species Evenness	=0.61
Species Richness	=1.53
Number of Species	=11

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **FBWMA CULT T1 4985514** on **8/19/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	5	10.7	120
Amphora ovalis (Kützing) Kützing	7	2.2	6
Achnanthes species	24	0.0	8
Achnanthes minutissima Kützing (Achnanthidium)	25	0.0	2
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	19	0.2	8
Cymatopleura solea (Brebisson) W. Smith	9	1.9	2
Cyclotella meneghiniana Kützing	1	24.9	226
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	3	13.9	154
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	23	0.1	6
Gomphonema parvulum Kützing	15	0.5	14
Nitzschia palea (Kützing) W. Smith	12	1.1	26
Nitzschia linearis (Agardh) W. M. Smith	22	0.1	2
Nitzschia intermedia Hantzsch ex Cleve & Grunow	16	0.3	2
Nitzschia inconspicua Grunow	13	1.0	136
Nitzschia frustulum (Kützing) Grunow	21	0.1	12
Navicula peregrina (Ehr.) Kützing	10	1.6	4
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	14	0.9	4
Navicula cuspidata Kützing	8	2.2	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	17	0.2	4
Navicula cryptocephala Kützing	20	0.1	2
Navicula capitata Ehrenberg (Hippodonta)	18	0.2	2
Rhopalodia gibba (Ehr.) O. Müller	6	6.9	6
Synedra ulna (Nitzsch.) Ehr.	4	11.4	12
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	11	1.5	8
Surirella ovalis Brebisson	2	18.0	6

Population 774

Shannon-Wiener Index	=2.07
Species Evenness	=0.64
Species Richness	=3.61
Number of Species	=25

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **FBWMA CULT T2 4985516** on **8/19/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis sphaerophora (Ehr.) Pfitzer	4	5.7	4
Amphora veneta Kützing	3	7.5	54
Amphora ovalis (Kützing) Kützing	5	4.5	8
Achnanthes linearis (W. Sm.) Grunow	13	1.4	36
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	27	0.1	2
Cyclotella meneghiniana Kützing	8	2.7	16
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	1	45.7	328
Caloneis bacillum (Grunow) Cleve	16	0.8	8
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	15	0.9	40
Gomphonema parvulum Kützing	23	0.4	8
Gomphonema acuminatum Ehrenberg	18	0.6	2
Gomphonema affine Kützing	22	0.4	2
Gyrosigma spencerii (Quekett) Griffith et Henfrey	10	1.9	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	7	3.3	48
Nitzschia inconspicua Grunow	26	0.1	8
Nitzschia frustulum (Kützing) Grunow	28	0.0	4
Nitzschia communis Rabenhorst	24	0.2	2
Nitzschia apiculata (Gregory) Grunow	12	1.6	10
Nitzschia acuminata (W. M. Smith) Grunow	9	2.3	2
Nitzschia amphibia Grunow f. amphibia	25	0.1	2
Navicula rhyncocephala Kützing	17	0.7	4
Navicula pupula Kützing	11	1.8	14
Navicula lanceolata (Agardh) Ehrenberg	14	1.2	4
Navicula exigua (Gregory) Grunow var. capitata Patrick	19	0.6	2
Navicula exigua (Gregory) Grunow	20	0.6	2
Navicula cuspidata Kützing	2	10.2	6
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	6	4.2	52
Navicula cryptocephala Kützing	21	0.5	6

Population 676

Shannon-Wiener Index	=2.06
Species Evenness	=0.62
Species Richness	=4.14
Number of Species	=28

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **FBWMA CULT T3 4985517** on **8/25/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis costata (Kützing) Grunow	2	11.9	2
Anomoeoneis sphaerophora (Ehr.) Pfitzer	6	7.9	2
Amphora veneta Kützing	12	2.3	6
Amphora ovalis (Kützing) Kützing	10	3.1	2
Cymbella pusilla Grunow in A.Schmidt & al.	20	0.3	2
Cyclotella meneghiniana Kützing	15	1.9	4
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	11	3.1	8
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	1	13.6	226
Gomphonema parvulum Kützing	14	2.0	14
Gomphonema affine Kützing	9	4.7	8
Nitzschia inconspicua Grunow	3	10.8	352
Nitzschia hungarica Grunow	7	7.7	2
Navicula rhyncocephala Kützing	18	0.9	2
Navicula pupula Kützing	19	0.7	2
Navicula exigua (Gregory) Grunow	16	1.6	2
Navicula cuspidata Kützing	5	9.4	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	13	2.2	10
Navicula cryptocephala Kützing	17	1.3	6
Rhopalodia gibba (Ehr.) O. Müller	4	9.8	2
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	8	4.9	6

Population 660

Shannon-Wiener Index	=1.29
Species Evenness	=0.43
Species Richness	=2.93
Number of Species	=20

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the ith species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **FBWMA Unit 1 Out 4985520** on **8/29/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis costata (Kützing) Grunow	7	4.4	2
Amphora veneta Kützing	1	31.7	224
Cyclotella species	22	0.1	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	18	0.3	2
Denticula elegans Kützing	16	0.4	2
Epithemia turgida (Ehr.) Kützing	4	6.2	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	23	0.0	2
Fragilaria brevistriata Grunow var. inflata (Pantocsek) Hustedt	20	0.1	4
Gomphonema parvulum Kützing	21	0.1	2
Nitzschia scalaris (Ehr.) W. M. Smith	2	19.0	2
Nitzschia subtilis Grunow in Cleve et Grunow	11	1.3	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	3	11.8	166
Nitzschia intermedia Hantzsch ex Cleve & Grunow	12	1.3	6
Nitzschia inconspicua Grunow	15	0.5	40
Nitzschia hungarica Grunow	5	5.7	4
Nitzschia frustulum (Kützing) Grunow	6	5.3	426
Nitzschia communis Rabenhorst	19	0.2	2
Nitzschia apiculata (Gregory) Grunow	17	0.3	2
Navicula subinflatoides Hustedt	14	0.5	2
Navicula cuspidata Kützing	9	3.5	2
Rhopalodia gibba (Ehr.) O. Müller	8	3.7	2
Synedra pulchella (Ralfs ex Kützing) Kützing	13	1.1	2
Synedra fasciculata Kützing	10	2.3	2

Population 902

Shannon-Wiener Index	=1.45
Species Evenness	=0.46
Species Richness	=3.23
Number of Species	=23

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **FBWMA Unit 2 Out 4985500** on **8/29/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	1	64.7	446
Cyclotella species	13	0.1	2
Cyclotella meneghiniana Kützing	10	0.4	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	6	1.2	8
Epithemia turgida (Ehr.) Kützing	2	19.2	6
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	15	0.0	2
Fragilaria brevistriata Grunow var. inflata (Pantocsek) Hustedt	14	0.1	2
Gomphonema parvulum Kützing	8	0.7	12
Gomphonema affine Kützing	3	4.9	22
Nitzschia paleacea (Grunow) Grunow in van Heurck	5	3.1	42
Nitzschia inconspicua Grunow	12	0.2	14
Nitzschia frustulum (Kützing) Grunow	7	1.1	84
Nitzschia communis Rabenhorst	9	0.4	4
Navicula mutica Kützing	11	0.3	2
Rhopalodia gibba (Ehr.) O. Müller	4	3.7	2

Population 650

Shannon-Wiener Index	=1.21
Species Evenness	=0.45
Species Richness	=2.16
Number of Species	=15

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **KC T1 4985800** on **8/28/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora perpusilla Grunow	34	0.0	6
Achnanthes species	35	0.0	4
Achnanthes minutissima Kützing (Achnanthidium)	28	0.3	16
Achnanthes linearis (W. Sm.) Grunow	12	1.9	60
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	10	2.8	100
Achnanthes lanceolata (Breb.) Grunow	23	0.4	14
Bacillaria paradoxa Gmelin	3	9.7	40
Cymbella minuta Hilse ex Rabenhorst (Encyonema)	32	0.1	4
Cyclotella species	29	0.2	6
Cyclotella meneghiniana Kützing	27	0.3	2
Cyclotella comta (Ehr.) Kützing	18	0.8	4
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	21	0.5	4
Cyclotella atomus Hustedt	30	0.2	2
Gomphonema parvulum Kützing	17	1.0	22
Gyrosigma spencerii (Quekett) Griffith et Henfrey	13	1.6	2
Melosira varians Agardh	2	12.9	12
Navicula salinarum Grunow in Cleve et Grunow	25	0.4	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	14	1.3	18
Nitzschia subtilis Grunow in Cleve et Grunow	6	5.5	10
Nitzschia paleacea (Grunow) Grunow in van Heurck	9	3.4	56
Nitzschia lorenziana var. subtilis Grunow	11	2.2	4
Nitzschia inconspicua Grunow	26	0.3	32
Nitzschia hungarica Grunow	8	4.8	4
Nitzschia frustulum (Kützing) Grunow	19	0.6	58
Nitzschia acicularis (Kützing) W.M. Smith	33	0.1	2
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	20	0.6	2
Navicula secreta Pantocsek. var. apiculata Patrick	24	0.4	2
Navicula radiosa Kützing var. tenella (Brebisson) Cleve & Möller	16	1.2	8
Navicula pupula Kützing	22	0.4	4
Navicula lanceolata (Agardh) Ehrenberg	4	8.3	32
Navicula halophila (Grunow) Cleve f. tenuirostris Hustedt	5	7.2	16
Navicula cryptocephala Kützing	15	1.3	18
Navicula circumtexta Meister ex Hustedt	31	0.1	2
Synedra ulna (Nitzsch.) Ehr.	7	5.1	4
Surirella ovalis Brebisson	1	24.1	6

Population 578

Shannon-Wiener Index =2.91
Species Evenness =0.82
Species Richness =5.35
Number of Species =35

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **NDSD T1 4985590** on **8/11/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes minutissima Kützing (Achnanthidium)	7	0.2	4.0
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	5	0.6	2.0
Fragilaria capucina Desmazieres	8	0.1	2.0
Gomphonema parvulum Kützing	2	15.0	142
Nitzschia paleacea (Grunow) Grunow in van Heurck	1	70.3	494
Navicula pupula Kützing	6	0.5	2
Navicula halophila (Grunow) Cleve f. tenuirostris Hustedt	4	2.1	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	3	11.3	68

Population 716

Shannon-Wiener Index	=0.90
Species Evenness	=0.43
Species Richness	=1.06
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **NDSD T2 4985591** on **8/11/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes minutissima Kützing (Achnanthidium)	6	0.2	8
Achnanthes linearis (W. Sm.) Grunow	8	0.1	2
Gomphonema parvulum Kützing	3	9.5	158
Nitzschia paleacea (Grunow) Grunow in van Heurck	2	27.5	342
Nitzschia dissipata (Kützing) Grunow	7	0.1	2
Nitzschia communis Rabenhorst	4	1.8	16
Navicula halophila (Grunow) Cleve	1	60.2	138
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	5	0.6	6

Population 672

Shannon-Wiener Index	=1.23
Species Evenness	=0.59
Species Richness	=1.08
Number of Species	=8

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **NDSD T3 4985592** on **8/11/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms coutned are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	12	0.4	6
Achnanthes linearis (W. Sm.) Grunow	13	0.3	4
Achnanthes minutissima Kützing (Achnanthidium)	16	0.1	2
Cyclotella meneghiniana Kützing	6	1.5	4
Gomphonema parvulum Kützing	2	11.8	102
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	3	9.0	50
Navicula pupula Kützing	4	6.8	24
Navicula salinarum Grunow in Cleve et Grunow	7	0.9	2
Nitzschia communis Rabenhorst	11	0.4	2
Nitzschia dissipata (Kützing) Grunow	15	0.3	2
Nitzschia frustulum (Kützing) Grunow	17	0.1	2
Nitzschia inconspicua Grunow	10	0.5	20
Nitzschia intermedia Hantzsch ex Cleve & Grunow	8	0.9	2
Nitzschia pseudostagnorum Hustedt	5	2.5	4
Nitzschia paleacea (Grunow) Grunow in van Heurck	1	63.6	410
Nitzschia species	14	0.3	2
Rhoicosphenia curvata (Kützing) Grunow	9	0.5	2

Population 640

Shannon-Wiener Index	=1.29
Species Evenness	=0.46
Species Richness	=2.48
Number of Species	=17

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **New St 20 4985880** on **9/8/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes minutissima Kützing (Achnanthidium)	17	0.0	2
Amphora veneta Kützing	6	4.1	42
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	2	26.6	270
Cyclotella meneghiniana Kützing	8	1.7	14
Epithemia turgida (Ehr.) Kützing	1	34.4	16
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	16	0.0	2
Gomphonema parvulum Kützing	12	0.6	16
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	14	0.1	2
Nitzschia amphibia Grunow f. amphibia	11	0.6	20
Nitzschia frustulum (Kützing) Grunow	15	0.1	6
Nitzschia inconspicua Grunow	9	1.6	198
Nitzschia intermedia Hantzsch ex Cleve & Grunow	10	0.9	6
Nitzschia paleacea (Grunow) Grunow in van Heurck	7	3.2	66
Nitzschia species	13	0.5	10
Rhopalodia gibba (Ehr.) O. Müller	4	7.6	6
Surirella ovalis Brebisson	3	13.1	4
Synedra fasciculata Kützing	5	4.8	6

Population 686

Shannon-Wiener Index	=1.79
Species Evenness	=0.63
Species Richness	=2.45
Number of Species	=17

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the ith species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **New State 5-6 4985890** on **11/6/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes minutissima Kützing (Achnanthidium)	12	0.5	24
Amphora veneta Kützing	11	0.6	4
Bacillaria paradoxa Gmelin	10	0.6	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	1	65.0	422
Cyclotella meneghiniana Kützing	9	0.8	4
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	16	0.0	2
Gomphonema parvulum Kützing	15	0.1	2
Navicula cryptocephala Kützing	13	0.4	4
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	6	1.4	16
Navicula halophila (Grunow) Cleve	8	0.8	2
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	5	2.2	6
Nitzschia amphibia Grunow f. amphibia	14	0.2	4
Nitzschia frustulum (Kützing) Grunow	17	0.0	2
Nitzschia inconspicua Grunow	7	0.9	70
Nitzschia palea (Kützing) W. Smith	3	3.4	46
Surirella ovalis Brebisson	2	20.5	4
Synedra fasciculata Kützing	4	2.5	2

Population 616

Shannon-Wiener Index	=1.24
Species Evenness	=0.44
Species Richness	=2.49
Number of Species	=17

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **New St T1 4985870** on **9/7/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Bacillaria paradoxa Gmelin	1	62.6	508
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	3	8.5	138
Cyclotella meneghiniana Kützing	9	0.6	8
Fragilaria construens (Ehr.) Grunow (Staurosira)	14	0.1	2
Fragilaria vaucheriae (Kützing) Petersen	18	0.0	2
Gomphonema parvulum Kützing	12	0.3	12
Melosira varians Agardh	2	16.4	30
Navicula circumtexta Meister ex Hustedt	17	0.1	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	16	0.1	2
Navicula lanceolata (Agardh) Ehrenberg	8	0.8	6
Navicula pygmaea Kützing	5	1.9	8
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	11	0.3	2
Nitzschia amphibia Grunow f. amphibia	15	0.1	4
Nitzschia frustulum (Kützing) Grunow	19	0.0	2
Nitzschia inconspicua Grunow	13	0.1	28
Nitzschia paleacea (Grunow) Grunow in van Heurck	6	1.6	52
Nitzschia species	10	0.3	10
Stephanodiscus species	4	5.2	2
Synedra fasciculata Kützing	7	1.0	2

Population 820

Shannon-Wiener Index	=1.39
Species Evenness	=0.47
Species Richness	=2.68
Number of Species	=19

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG Pintail 4985630** on **9/28/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Count
Achnanthes affinis Grunow in Cleve & Grunow (Achnanthidium)	36	0.0	4
Achnanthes exigua Grunow in Cl. & Grun.	43	0.0	2
Achnanthes minutissima Kützing (Achnanthidium)	41	0.0	4
Amphora coffeaeformis (Agardh) Kützing	33	0.1	10
Amphora ovalis (Kützing) Kützing	18	0.4	4
Amphora veneta Kützing	11	1.1	40
Bacillaria paradoxa Gmelin	25	0.2	4
Cocconeis pediculus Ehrenberg	15	0.9	6
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	14	0.9	32
Cyclotella meneghiniana Kützing	27	0.2	6
Cymbella cistula (Ehrenberg) Kirchner	24	0.2	4
Cymbella pusilla Grunow in A.Schmidt & al.	16	0.6	66
Diatoma tenuis Agardh var. elongatum Lyngbye	17	0.6	10
Entomoneis alata Ehrenberg	8	1.3	4
Epithemia turgida (Ehr.) Kützing	1	37.3	64
Fragilaria capucina Desmazieres	38	0.0	4
Fragilaria brevistriata Grunow var. inflata (Pantocsek) Hustedt	42	0.0	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	29	0.1	32
Gomphonema parvulum Kützing	19	0.4	40
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	5	4.1	28
Navicula circumtexta Meister ex Hustedt	37	0.0	2
Navicula cryptocephala Kützing	34	0.1	4
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	28	0.2	12
Navicula lanceolata (Agardh) Ehrenberg	23	0.2	4
Navicula rhyncocephala Kützing	30	0.1	4
Nitzschia acicularis (Kützing) W.M. Smith	40	0.0	2
Nitzschia amphibia Grunow f. amphibia	39	0.0	2
Nitzschia frustulum (Kützing) Grunow	44	0.0	2
Nitzschia hungarica Grunow	10	1.1	4
Nitzschia inconspicua Grunow	32	0.1	36
Nitzschia intermedia Hantzsch ex Cleve & Grunow	31	0.1	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	20	0.3	20
Nitzschia subtilis Grunow in Cleve et Grunow	22	0.2	2
Nitzschia species	6	3.6	34
Pinnularia brebissonii (Kutz.) Rabenhors	13	0.9	2
Pleurosigma delicatulum W. Smith	12	1.0	2
Rhoicosphenia curvata (Kützing) Grunow	35	0.0	2
Rhopalodia gibba (Ehr.) O. Müller	2	18.4	54
Surirella striatula Turpin sensu Schmidt	4	9.6	4
Surirella ovalis Brebisson	7	1.8	2
Synedra fasciculata Kützing	3	12.2	56
Synedra ulna (Nitzsch.) Ehr.	9	1.1	4
Synedra delicatissima W. Smith	21	0.3	4
Synedra pulchella (Ralfs ex Kützing) Kützing	26	0.2	2

Population 628

Shannon-Wiener Index	=3.11
Species Evenness	=0.82
Species Richness	=6.67
Number of Species	=44

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

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Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG T1 4985623** on **9/7/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	27	0.1	4
Amphora coffeaeformis (Agardh) Kützing	25	0.1	4
Amphora veneta Kützing	16	0.8	14
Bacillaria paradoxa Gmelin	6	5.7	50
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	14	1.1	20
Cyclotella meneghiniana Kützing	21	0.3	4
Cymbella pusilla Grunow in A.Schmidt & al.	22	0.2	10
Diatoma tenuis Agardh var. elongatum Lyngbye	9	2.1	16
Epithemia turgida (Ehr.) Kützing	5	7.5	6
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	29	0.0	2
Fragilaria vaucheriae (Kützing) Petersen	24	0.1	4
Gomphonema parvulum Kützing	20	0.3	14
Navicula cryptocephala Kützing	18	0.5	14
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	8	2.2	66
Navicula cuspidata Kützing	12	1.4	2
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	10	1.6	12
Navicula speceis	23	0.1	6
Nitzschia frustulum (Kützing) Grunow	28	0.0	4
Nitzschia hungarica Grunow	3	8.0	14
Nitzschia inconspicua Grunow	15	0.8	182
Nitzschia paleacea (Grunow) Grunow in van Heurck	13	1.3	44
Nitzschia species	26	0.1	2
Rhoicosphenia curvata (Kützing) Grunow	11	1.5	30
Rhopalodia gibba (Ehr.) O. Müller	7	2.9	4
Surirella ovalis Brebisson	4	7.6	4
Synedra fasciculata Kützing	1	33.5	72
Synedra ulna (Nitzsch.) Ehr.	2	19.3	32
Synedra delicatissima W. Smith	17	0.6	4
Synedra pulchella (Ralfs ex Kützing) Kützing	19	0.4	2

Population 642

Shannon-Wiener Index	=2.60
Species Evenness	=0.77
Species Richness	=4.33
Number of Species	=29

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG T2 4985624** on **9/7/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora coffeaeformis (Agardh) Kützing	24	0.2	10
Amphora ovalis (Kützing) Kützing	17	0.7	2
Amphora veneta Kützing	19	0.5	6
Bacillaria paradoxa Gmelin	2	19.6	108
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	21	0.4	4
Cyclotella meneghiniana Kützing	12	2.0	18
Cymbella pusilla Grunow in A.Schmidt & al.	29	0.1	2
Epithemia turgida (Ehr.) Kützing	8	4.0	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	15	1.6	114
Gomphonema parvulum Kützing	23	0.3	8
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	4	7.9	16
Navicula cryptocephala Kützing	18	0.7	14
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	6	5.0	96
Navicula halophila (Grunow) Cleve	7	4.9	20
Navicula lanceolata (Agardh) Ehrenberg	20	0.4	2
Navicula pupula Kützing	25	0.2	2
Nitzschia communis Rabenhorst	27	0.1	2
Nitzschia frustulum (Kützing) Grunow	28	0.1	16
Nitzschia hungarica Grunow	5	5.4	6
Nitzschia inconspicua Grunow	16	0.8	106
Nitzschia microcephala Grunow in Cleve & Moller	26	0.1	8
Nitzschia paleacea (Grunow) Grunow in van Heurck	11	2.1	46
Nitzschia scalaris (Ehr.) W. M. Smith	1	24.1	4
Rhoicosphenia curvata (Kützing) Grunow	22	0.3	4
Rhopalodia gibba (Ehr.) O. Müller	10	2.3	2
Synedra fasciculata Kützing	3	8.8	12
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	13	1.9	10
Synedra pulchella (Ralfs ex Kützing) Kützing	9	3.5	10
Synedra ulna (Nitzsch.) Ehr.	14	1.9	2

Population 652

Shannon-Wiener Index	=2.53
Species Evenness	=0.75
Species Richness	=4.32
Number of Species	=29

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG T2 4985624** on **10/15/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes lanceolata (Breb.) Grunow	26	0.0	2
Amphora coffeaeformis (Agardh) Kützing	18	0.2	16
Bacillaria paradoxa Gmelin	5	2.8	36
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	19	0.2	4
Cyclotella meneghiniana Kützing	13	0.4	8
Cymbella pusilla Grunow in A.Schmidt & al.	23	0.0	2
Epithemia turgida (Ehr.) Kützing	7	1.7	2
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	15	0.3	46
Fragilaria vaucheriae (Kützing) Petersen	24	0.0	2
Gomphonema parvulum Kützing	14	0.4	26
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	1	44.4	212
Navicula cryptocephala Kützing	17	0.2	8
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	12	0.5	22
Navicula cuspidata Kützing	6	1.9	4
Navicula halophila (Grunow) Cleve	8	1.7	16
Nitzschia communis Rabenhorst	22	0.1	2
Nitzschia frustulum (Kützing) Grunow	25	0.0	6
Nitzschia hungarica Grunow	9	1.5	4
Nitzschia inconspicua Grunow	21	0.1	34
Nitzschia paleacea (Grunow) Grunow in van Heurck	20	0.2	8
Rhoicosphenia curvata (Kützing) Grunow	16	0.3	8
Rhopalodia gibba (Ehr.) O. Müller	4	3.9	8
Synedra delicatissima W. Smith	11	0.6	6
Synedra fasciculata Kützing	2	32.6	104
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	10	1.1	14
Synedra pulchella (Ralfs ex Kützing) Kützing	3	5.0	34

Population 634

Shannon-Wiener Index	=2.40
Species Evenness	=0.74
Species Richness	=3.87
Number of Species	=26

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG T5** on **9/9/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora coffeaeformis (Agardh) Kützing	14	0.3	36
Amphora ovalis (Kützing) Kützing	10	0.5	4
Amphora veneta Kützing	12	0.3	12
Anomoeoneis costata (Kützing) Grunow	7	0.9	2
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	8	0.8	28
Cyclotella meneghiniana Kützing	18	0.1	2
Fragilaria capucina Desmazieres	23	0.0	2
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	9	0.6	4
Navicula cryptocephala Kützing	21	0.0	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	6	1.0	58
Navicula cuspidata Kützing	5	1.4	4
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	13	0.3	4
Nitzschia communis Rabenhorst	17	0.1	4
Nitzschia frustulum (Kützing) Grunow	20	0.0	16
Nitzschia hungarica Grunow	2	14.2	50
Nitzschia inconspicua Grunow	15	0.2	100
Nitzschia microcephala Grunow in Cleve & Moller	22	0.0	6
Nitzschia paleacea (Grunow) Grunow in van Heurck	11	0.4	30
Nitzschia species	19	0.1	4
Rhopalodia gibba (Ehr.) O. Müller	4	2.2	6
Surirella striatula Turpin sensu Schmidt	3	5.1	2
Synedra delicatissima W. Smith	16	0.1	2
Synedra fasciculata Kützing	1	71.5	310

Population 688

Shannon-Wiener Index	=1.98
Species Evenness	=0.63
Species Richness	=3.37
Number of Species	=23

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG T6 4985625** on **10/5/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Achnanthes linearis (W. Sm.) Grunow	16	0.0	2
Amphora veneta Kützing	13	0.5	8
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	4	2.4	36
Fragilaria virescens Ralfs	6	2.2	12
Gomphonema parvulum Kützing	15	0.0	2
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	8	1.4	4
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	10	0.8	20
Navicula radiosa Kützing var. tenella (Brebisson) Cleve & Möller	11	0.7	8
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	12	0.6	4
Nitzschia frustulum (Kützing) Grunow	17	0.0	6
Nitzschia hungarica Grunow	3	2.7	4
Nitzschia inconspicua Grunow	14	0.4	72
Nitzschia microcephala Grunow in Cleve & Moller	5	2.3	188
Nitzschia paleacea (Grunow) Grunow in van Heurck	2	5.8	176
Rhopalodia gibba (Ehr.) O. Müller	7	1.7	2
Synedra fasciculata Kützing	1	77.4	144
Synedra pulchella (Ralfs ex Kützing) Kützing	9	1.0	4

Population 692

Shannon-Wiener Index	=1.91
Species Evenness	=0.67
Species Richness	=2.45
Number of Species	=17

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG WID IN 4985621** on **9/28/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis costata (Kützing) Grunow	10	1.2	2
Amphora veneta Kützing	19	0.3	8
Amphora ovalis (Kützing) Kützing	18	0.3	2
Amphora coffeaeformis (Agardh) Kützing	23	0.1	14
Achnanthes minutissima Kützing (Achnanthidium)	28	0.0	2
Cymbella pusilla Grunow in A.Schmidt & al.	11	1.1	76
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	8	2.1	52
Epithemia turgida (Ehr.) Kützing	4	12.3	14
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	21	0.3	44
Gomphonema affine Kützing	15	0.6	10
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	2	21.5	98
Nitzschia paleacea (Grunow) Grunow in van Heurck	14	0.8	40
Nitzschia microcephala Grunow in Cleve & Moller	13	1.0	128
Nitzschia inconspicua Grunow	25	0.1	41
Nitzschia hungarica Grunow	9	1.6	4
Nitzschia frustulum (Kützing) Grunow	29	0.0	2
Nitzschia amphibia Grunow f. amphibia	27	0.0	2
Navicula halophila (Grunow) Cleve	22	0.2	2
Navicula cuspidata Kützing	12	1.0	2
Navicula cryptocephala Kützing	24	0.1	6
Rhopalodia gibba (Ehr.) O. Müller	1	21.7	42
Rhoicosphenia curvata (Kützing) Grunow	26	0.1	2
Synedra ulna (Nitzsch.) Ehr.	7	4.3	10
Synedra pulchella (Ralfs ex Kützing) Kützing	20	0.3	2
Synedra fasciculata (Ag.) Kützing var. truncata (Greville) Patrick	17	0.3	4
Synedra fasciculata Kützing	5	7.9	24
Synedra delicatissima W. Smith	16	0.6	6
Surirella striatula Turpin sensu Schmidt	3	14.6	4
Surirella ovalis Brebisson	6	5.4	4

Population 647

Shannon-Wiener Index	=2.61
Species Evenness	=0.78
Species Richness	=4.33
Number of Species	=29

Shannon-Wiener = -Sum(P_i log P_i)
Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S
Where: S is the number of species

Species Richness = S-1 / log N
Where: S is the number of species and N is the number of individuals

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Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **PSG WID OUT 4985620** on **9/28/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Amphora veneta Kützing	7	1.6	40
Amphora coffeaeformis (Agardh) Kützing	15	0.2	24
Achnanthes minutissima Kützing (Achnanthidium)	25	0.0	4
Bacillaria paradoxa Gmelin	14	0.5	6
Cymbella pusilla Grunow in A.Schmidt & al.	11	0.8	52
Cyclotella meneghiniana Kützing	18	0.2	4
Cocconeis placentula Ehrenberg var. euglypta (Ehr.) Grunow	9	0.9	22
Epithemia turgida (Ehr.) Kützing	3	8.6	10
Fragilaria virescens Ralfs	5	2.4	22
Fragilaria construens (Ehr.) Grunow f. venter (Ehr.) Hustedt	20	0.1	10
Gomphonema parvulum Kützing	23	0.0	2
Gomphonema affine Kützing	13	0.5	8
Mastogloia elliptica (Agardh) Cleve var. dansei (Thwaites) Cleve	2	36.7	172
Nitzschia paleacea (Grunow) Grunow in van Heurck	10	0.9	44
Nitzschia inconspicua Grunow	22	0.0	10
Nitzschia microcephala Grunow in Cleve & Moller	16	0.2	31
Nitzschia frustulum (Kützing) Grunow	24	0.0	8
Nitzschia communis Rabenhorst	21	0.1	2
Navicula halophila (Grunow) Cleve	17	0.2	2
Navicula cuspidata Kützing	8	1.0	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	19	0.1	6
Rhopalodia gibba (Ehr.) O. Müller	1	37.1	74
Rhoicosphenia curvata (Kützing) Grunow	12	0.7	22
Synedra rumpens Kützing	26	0.0	2
Synedra pulchella (Ralfs ex Kützing) Kützing	4	5.4	36
Synedra fasciculata Kützing	6	1.9	6

Population 621

Shannon-Wiener Index	=2.58
Species Evenness	=0.79
Species Richness	=3.89
Number of Species	=26

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

Diatom taxa present in a composite sample collected from **Farmington Bay, Great Salt Lake**, **WGS5 A Pond 4985440** on **9/28/2005**. The percent relative density based on cell volume, species rank in the sample, and the number of organisms counted are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	**Rank**	**Relative Density**	Count
Anomoeoneis sphaerophora (Ehr.) Pfitzer	3	16.9	10
Anomoeoneis costata (Kützing) Grunow	2	20.3	8
Amphora veneta Kützing	11	1.3	8
Amphora ovalis (Kützing) Kützing	5	6.7	10
Amphora coffeaeformis (Agardh) Kützing	19	0.1	2
Achnanthes lanceolata (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	20	0.1	2
Achnanthes hauckiana Grunow in Cl. & Grun.	18	0.1	2
Cymbella pusilla Grunow in A.Schmidt & al.	16	0.2	4
Cyclotella meneghiniana Kützing	14	0.4	2
Gyrosigma spencerii (Quekett) Griffith et Henfrey	9	2.2	2
Nitzschia paleacea (Grunow) Grunow in van Heurck	17	0.2	2
Nitzschia inconspicua Grunow	21	0.0	2
Nitzschia hungarica Grunow	1	23.0	14
Navicula tripunctata var. schizomenoides (Van Heurck) Patrick	4	12.5	32
Navicula pupula Kützing	15	0.3	2
Navicula lanceolata (Agardh) Ehrenberg	13	0.7	2
Navicula cryptocephala Kützing var. veneta (Kutz.) Rabenhorst	8	3.0	32
Navicula cryptocephala Kützing	10	1.3	14
Rhopalodia gibba (Ehr.) O. Müller	7	4.2	2
Synedra pulchella (Ralfs ex Kützing) Kützing	12	1.3	2
Synedra fasciculata Kützing	6	5.3	4

Population 158

Shannon-Wiener Index	=2.52
Species Evenness	=0.83
Species Richness	=3.95
Number of Species	=21

Shannon-Wiener = -Sum(P_i log P_i)

Where: P_i is the proportion of the total number of indivuals in the i^{th} species

Species Evenness = Shannon-Wiener / log S

Where: S is the number of species

Species Richness = S-1 / log N

Where: S is the number of species and N is the number of individuals

APPENDIX II

SLIDE NUMBER	**1**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	AMB 100
STORET NUMBER	4985330
DATE	22/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
4.5	9.4	7.7	8.6	5.9	4.0	5.5	8.3	4.9
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
92.0	6.6	3.2	7.4	4.1	14.2	7.8	3.9	

QUALITY NOTES / 20

Number of species	28	Diversity	3.39	Genera number	11
Population	686	Evenness	0.71		

Number	%	Code	ou	Designation	* : taxon IBD
192	27.99	NIPA	-	Nitzschia palea (Kutzing) W.Smith	*
104	15.16	AMVE	-	Amphora veneta Kutzing	*
104	15.16	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
96	13.99	NIIN	-	Nitzschia inconspicua Grunow	*
26	3.79	NIRO	NFON	Nitzschia romana Grunow	*
22	3.21	SYRU	FCRP	Synedra rumpens Kutzing	*
22	3.21	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
14	2.04	NACR	-	Navicula cryptocephala Kutzing	*
12	1.75	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
10	1.46	NACU	CRCU	Navicula cuspidata Kutzing	*
10	1.46	CYSP	-	Cyclotella species	
8	1.17	CYCY	-	Cymbella cymbiformis Agardh	
8	1.17	SUOV	-	Surirella ovalis Brebisson	*
8	1.17	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
8	1.17	NATR	-	Navicula tripunctata (O.F.Müller) Bory	*
6	0.87	FRVA	FCVA	Fragilaria vaucheriae (Kutzing) Petersen	*
6	0.87	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
6	0.87	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
4	0.58	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.58	COPL	-	Cocconeis placentula Ehrenberg var. placentula	*
2	0.29	PIBO	-	Pinnularia borealis Ehrenberg var. borealis	
2	0.29	NACA	HCAP	Navicula capitata Ehrenberg (=Hippodonta)	*
2	0.29	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
2	0.29	NARH	-	Navicula rhynchocephala Kutzing	*
2	0.29	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
2	0.29	NICU	-	Nitzschia acuminata (WM.Smith) Grunow	
2	0.29	NIFA	-	Nitzschia fasciculata (Grunow)Grunow in V.Heurck	
2	0.29	COPE	-	Cocconeis pediculus Ehrenberg	*

SLIDE NUMBER	**2**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	AMB W1
STORET NUMBER	4985330
DATE	22/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
5.1	9.1	8.1	9.1	9.2	3.9	7.6	6.5	8.2
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
75.8	8.4	3.9	7.7	6.5	12.9	7.8	5.7	

QUALITY NOTES / 20

Number of species	28	Diversity	2.96	Genera number	13
Population	962	Evenness	0.62		

Number	%	Code	ou	Designation	* : taxon IBD
272	28.27	CYME	-	Cyclotella meneghiniana Kutzing	*
238	24.74	NIPA	-	Nitzschia palea (Kutzing) W.Smith	*
176	18.30	COPL	-	Cocconeis placentula Ehrenberg var. placentula	*
76	7.90	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
70	7.28	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
24	2.49	AMVE	-	Amphora veneta Kutzing	*
14	1.46	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
10	1.04	CYSP	-	Cyclotella species	
10	1.04	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
10	1.04	SUOV	-	Surirella ovalis Brebisson	*
10	1.04	NACA	HCAP	Navicula capitata Ehrenberg (=Hippodonta)	*
8	0.83	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
6	0.62	NASL	-	Navicula stroesei (Ostrup) Cleve var.lanceolata Foged	
6	0.62	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
6	0.62	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
2	0.21	NATR	-	Navicula tripunctata (O.F.Müller) Bory	*
2	0.21	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.21	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
2	0.21	SYRU	FCRP	Synedra rumpens Kutzing	*
2	0.21	NICU	-	Nitzschia acuminata (WM.Smith) Grunow	
2	0.21	NIFA	-	Nitzschia fasciculata (Grunow)Grunow in V.Heurck	
2	0.21	NIRO	NFON	Nitzschia romana Grunow	*
2	0.21	MEGR	AUGR	Melosira granulata (Ehr.) Ralfs	*
2	0.21	MEGA	AUGA	Melosira granulata (Ehr.) Ralfs var.angustissima O.Muller	*
2	0.21	FRLE	SSLE	Fragilaria leptostauron(Ehr.)Hustedt var. leptostauron	*
2	0.21	CYSO	-	Cymatopleura solea (Brebisson) W.Smith var.solea	*
2	0.21	ACLA	PTLA	Achnanthes lanceolata(Breb.)Grunow var. lanceolata Grunow	*
2	0.21	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	

SLIDE NUMBER	**3**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	AMB W2
STORET NUMBER	4985340
DATE	22/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
13.1	11.8	10.8	11.5	9.4	10.3	8.3	12.4	7.0
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
68.9	13.1	4.8	10.6	7.5	7.3	8.7	8.9	

QUALITY NOTES / 20

Number of species	13	Diversity	2.57	Genera number	8
Population	634	Evenness	0.69		

Number	%	Code	ou	Designation	* : taxon IBD
218	34.38	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
128	20.19	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
118	18.61	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
74	11.67	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
34	5.36	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
30	4.73	NACR	-	Navicula cryptocephala Kutzing	*
16	2.52	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
6	0.95	AMVE	-	Amphora veneta Kutzing	*
2	0.32	NACI	-	Navicula circumtexta Meister ex Hustedt	
2	0.32	NAPU	SPUP	Navicula pupula Kutzing	*
2	0.32	NIIN	-	Nitzschia inconspicua Grunow	*
2	0.32	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.32	NITR	TGRL	Nitzschia tryblionella Hantzsch	

SLIDE NUMBER	**4**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	AMB W5
STORET NUMBER	4985350
DATE	22/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
10.9	11.6	13.4	11.3	7.8	6.7	9.5	12.0	5.2
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
72.5	8.3	6.4	8.1	7.0	6.3	9.1	7.4	

QUALITY NOTES / 20

Number of species	15	Diversity	3.04	Genera number	7
Population	700	Evenness	0.78		

Number	%	Code	ou	Designation	* : taxon IBD
164	23.43	NIIN	-	Nitzschia inconspicua Grunow	*
128	18.29	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
110	15.71	AMVE	-	Amphora veneta Kutzing	*
96	13.71	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
86	12.29	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
22	3.14	CYMI	ENMI	Cymbella minuta Hilse ex Rabenhorst (Encyonema)	*
20	2.86	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
18	2.57	NACR	-	Navicula cryptocephala Kutzing	*
18	2.57	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
14	2.00	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
14	2.00	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
4	0.57	AMPE	APED	Amphora perpusilla Grunow	*
2	0.29	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
2	0.29	NILI	-	Nitzschia linearis(Agardh) W.M.Smith var.linearis	*
2	0.29	SUOV	-	Surirella ovalis Brebisson	*

SLIDE NUMBER	**5**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	CDSD T1
STORET NUMBER	4985660
DATE	02/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
8.7	10.3	10.5	10.2	13.4	7.3	13.0	10.0	7.6
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
88.2	11.0	9.6	13.4	7.3	13.0	8.1	4.5	

QUALITY NOTES / 20

Number of species 21
Population 632

Diversity 2.84
Evenness 0.65

Genera number 11

Number	%	Code	ou	Designation	* : taxon IBD
290	45.89	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
118	18.67	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
32	5.06	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
30	4.75	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
30	4.75	CYME	-	Cyclotella meneghiniana Kutzing	*
22	3.48	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
18	2.85	NIRO	NFON	Nitzschia romana Grunow	*
16	2.53	AMVE	-	Amphora veneta Kutzing	*
12	1.90	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
12	1.90	NASI	NCPR	Navicula salinarum Grunow var.intermedia (Grunow) Cleve	*
10	1.58	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
8	1.27	NIIN	-	Nitzschia inconspicua Grunow	*
6	0.95	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
6	0.95	NAPU	SPUP	Navicula pupula Kutzing	*
4	0.63	NARH	-	Navicula rhynchocephala Kutzing	*
4	0.63	CYSP	-	Cyclotella species	
4	0.63	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.63	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	
2	0.32	NAMU	LMUT	Navicula mutica Kutzing	*
2	0.32	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
2	0.32	COPL	-	Cocconeis placentula Ehrenberg var. placentula	*

SLIDE NUMBER	**6**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	CDSD T2
STORET NUMBER	4985680
DATE	02/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
9.8	10.2	12.7	11.1	13.6	8.0	13.4	8.6	5.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
83.2	9.7	7.8	12.8	8.3	9.6	8.8	5.9	

QUALITY NOTES / 20

Number of species	27	Diversity	3.22	Genera number	15
Population	742	Evenness	0.68		

Number	%	Code	ou	Designation	* : taxon IBD
264	35.58	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
142	19.14	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
60	8.09	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
52	7.01	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
34	4.58	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
30	4.04	NIIN	-	Nitzschia inconspicua Grunow	*
30	4.04	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
24	3.23	CYME	-	Cyclotella meneghiniana Kutzing	*
22	2.96	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
16	2.16	AMVE	-	Amphora veneta Kutzing	*
14	1.89	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
8	1.08	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
6	0.81	NART	NCTE	Navicula radiosa Kutzing var.tenella(Brebisson)Cleve & Möller	*
4	0.54	NARH	-	Navicula rhynchocephala Kutzing	*
4	0.54	SUOV	-	Surirella ovalis Brebisson	*
4	0.54	NIRO	NFON	Nitzschia romana Grunow	*
4	0.54	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	
4	0.54	EUCU	EBIL	Eunotia curvata(Kutzing)Lagerstedt	*
4	0.54	CABA	-	Caloneis bacillum (Grunow) Cleve	*
2	0.27	AMPE	APED	Amphora perpusilla Grunow	*
2	0.27	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.27	NACR	-	Navicula cryptocephala Kutzing	*
2	0.27	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	
2	0.27	NAPU	SPUP	Navicula pupula Kutzing	*
2	0.27	NAPE	FPEL	Navicula pelliculosa (Brebisson ex Kutzing) Hilse	*
2	0.27	NAPG	-	Navicula pseudoanglica Cleve-Euler	
2	0.27	FRVI	-	Fragilaria virescens Ralfs	*

SLIDE NUMBER	**7**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	CDSD T4
STORET NUMBER	4985690
DATE	31/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
10.9	11.7	9.0	11.0	12.0	8.0	13.4	6.2	5.3
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
67.2	11.6	7.1	11.5	5.6	8.4	6.7	6.6	

QUALITY NOTES / 20

Number of species	23	Diversity	2.76	Genera number	15
Population	618	Evenness	0.61		

Number	%	Code	ou	Designation	* : taxon IBD
290	46.93	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
102	16.50	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
44	7.12	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
40	6.47	AMVE	-	Amphora veneta Kutzing	*
32	5.18	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
32	5.18	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
16	2.59	ACSP	-	Achnanthes sp.	
8	1.29	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
8	1.29	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
8	1.29	DITE	-	Diatoma tenuis Agardh	*
6	0.97	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.65	EUCU	EBIL	Eunotia curvata(Kutzing)Lagerstedt	*
4	0.65	GYSP	-	Gyrosigma spencerii (Quekett) Griffith et Henfrey	
4	0.65	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
4	0.65	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.32	SUOV	-	Surirella ovalis Brebisson	*
2	0.32	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.32	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.32	NACR	-	Navicula cryptocephala Kutzing	*
2	0.32	NAPG	-	Navicula pseudoanglica Cleve-Euler	
2	0.32	COPL	-	Cocconeis placentula Ehrenberg var. placentula	*
2	0.32	NIRO	NFON	Nitzschia romana Grunow	*
2	0.32	NITR	TGRL	Nitzschia tryblionella Hantzsch	

SLIDE NUMBER	**8**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	CDSD T5
STORET NUMBER	4985700
DATE	31/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.1	10.5	14.9	11.5	9.1	3.9	11.5	7.0	2.0
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
73.5	6.5	10.0	6.8	3.9	1.3	5.7	5.3	

QUALITY NOTES / 20

Number of species	11	Diversity	2.12	Genera number	8
Population	679	Evenness	0.61		

Number	%	Code	ou	Designation	* : taxon IBD
256	37.70	AMVE	-	Amphora veneta Kutzing	*
250	36.82	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
88	12.96	NIIN	-	Nitzschia inconspicua Grunow	*
36	5.30	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
16	2.36	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
10	1.47	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
8	1.18	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
8	1.18	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
3	0.44	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
2	0.29	NITR	TGRL	Nitzschia tryblionella Hantzsch	
2	0.29	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	

SLIDE NUMBER	**9**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	FBWMA CULT T1
STORET NUMBER	4985514
DATE	19/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.6	9.6	11.9	10.2	9.3	2.9	7.9	9.2	4.2
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
75.1	6.8	5.5	7.3	7.2	10.0	8.2	6.0	

QUALITY NOTES / 20

Number of species	25	Diversity	2.99	Genera number	13
Population	774	Evenness	0.64		

Number	%	Code	ou	Designation	* : taxon IBD
226	29.20	CYME	-	Cyclotella meneghiniana Kutzing	*
154	19.90	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
136	17.57	NIIN	-	Nitzschia inconspicua Grunow	*
120	15.50	AMVE	-	Amphora veneta Kutzing	*
26	3.36	NIPA	-	Nitzschia palea (Kutzing) W.Smith	*
14	1.81	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
12	1.55	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
12	1.55	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
8	1.03	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
8	1.03	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
8	1.03	ACSP	-	Achnanthes sp.	
6	0.78	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
6	0.78	SUOV	-	Surirella ovalis Brebisson	*
6	0.78	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
6	0.78	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
4	0.52	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
4	0.52	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
4	0.52	NAPG	-	Navicula pseudoanglica Cleve-Euler	
2	0.26	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.26	NACR	-	Navicula cryptocephala Kutzing	*
2	0.26	NACA	HCAP	Navicula capitata Ehrenberg (=Hippodonta)	*
2	0.26	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
2	0.26	NILI	-	Nitzschia linearis(Agardh) W.M.Smith var.linearis	*
2	0.26	CYSO	-	Cymatopleura solea (Brebisson) W.Smith var.solea	*
2	0.26	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	

SLIDE NUMBER	**10**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	FBWMA CULT T2
STORET NUMBER	4985516
DATE	19/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
10.0	10.4	14.5	13.1	11.2	9.4	9.0	14.5	4.5
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
56.9	10.0	7.8	9.4	8.2	9.6	7.2	7.3	

QUALITY NOTES / 20

Number of species	28	Diversity	2.98	Genera number	11
Population	676	Evenness	0.62		

Number	%	Code	ou	Designation	* : taxon IBD
328	48.52	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
54	7.99	AMVE	-	Amphora veneta Kutzing	*
52	7.69	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
48	7.10	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
40	5.92	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
36	5.33	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	
16	2.37	CYME	-	Cyclotella meneghiniana Kutzing	*
14	2.07	NAPU	SPUP	Navicula pupula Kutzing	*
10	1.48	NIAP	TAPI	Nitzschia apiculata(Gregory)Grunow	*
8	1.18	CABA	-	Caloneis bacillum (Grunow) Cleve	*
8	1.18	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
8	1.18	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
8	1.18	NIIN	-	Nitzschia inconspicua Grunow	*
6	0.89	NACU	CRCU	Navicula cuspidata Kutzing	*
6	0.89	NACR	-	Navicula cryptocephala Kutzing	*
4	0.59	NARH	-	Navicula rhynchocephala Kutzing	*
4	0.59	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
4	0.59	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
4	0.59	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	
2	0.30	NAEC	-	Navicula exigua (Gregory) Grunow var.capitata Patrick	
2	0.30	NAEX	PEXI	Navicula exigua (Gregory) Grunow	
2	0.30	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
2	0.30	NICU	-	Nitzschia acuminata (WM.Smith) Grunow	
2	0.30	NICO	-	Nitzschia communis Rabenhorst	
2	0.30	GYSP	-	Gyrosigma spencerii (Quekett) Griffith et Henfrey	
2	0.30	GOAF	-	Gomphonema affine Kutzing	
2	0.30	GOAC	GNEN	Gomphonema acuminatum (Kutz.) Rabh.var.turris (Ehr.) Wolle	
2	0.30	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*

SLIDE NUMBER	**11**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	FBWMA CULT T3
STORET NUMBER	4985517
DATE	25/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
11.3	13.3	15.0	10.9	5.9	5.8	13.6	7.2	5.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
72.5	8.9	8.2	9.4	6.7	8.2	11.5	7.2	

QUALITY NOTES / 20

Number of species	20	Diversity	1.86	Genera number	11
Population	660	Evenness	0.43		

Number	%	Code	ou	Designation	* : taxon IBD
352	53.33	NIIN	-	Nitzschia inconspicua Grunow	*
226	34.24	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
14	2.12	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
10	1.52	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
8	1.21	GOAF	-	Gomphonema affine Kutzing	
8	1.21	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
6	0.91	NACR	-	Navicula cryptocephala Kutzing	*
6	0.91	AMVE	-	Amphora veneta Kutzing	*
6	0.91	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
4	0.61	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.30	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.30	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.30	NAEX	PEXI	Navicula exigua (Gregory) Grunow	
2	0.30	NAPU	SPUP	Navicula pupula Kutzing	*
2	0.30	NARH	-	Navicula rhynchocephala Kutzing	*
2	0.30	NIHU	THUN	Nitzschia hungarica Grunow	*
2	0.30	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
2	0.30	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
2	0.30	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	
2	0.30	ANCO	-	Anomoeoneis costata (Kutzing) Grunow	

SLIDE NUMBER	**12**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	FBWMA Unit 1 Out
STORET NUMBER	4985520
DATE	29/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
4.6	11.4	14.0	10.5	3.2	3.5	8.3	10.5	4.4
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
80.9	5.5	8.1	5.9	8.5	1.2	9.1	4.4	

QUALITY NOTES / 20

Number of species	23	Diversity	2.09	Genera number	13
Population	902	Evenness	0.46		

Number	%	Code	ou	Designation	* : taxon IBD
426	47.23	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
224	24.83	AMVE	-	Amphora veneta Kutzing	*
166	18.40	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
40	4.43	NIIN	-	Nitzschia inconspicua Grunow	*
6	0.67	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
4	0.44	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.44	FRBI	PBIF	Fragilaria brevistriata Grunow var.inflata (Pantocsek) Hustedt	
2	0.22	NICO	-	Nitzschia communis Rabenhorst	
2	0.22	NIAP	TAPI	Nitzschia apiculata(Gregory)Grunow	*
2	0.22	NASU	-	Navicula subinflatoides Hustedt	
2	0.22	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.22	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.22	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
2	0.22	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
2	0.22	NISB	-	Neidium iridis (Ehrenberg) Cleve var.subampliatum (Grun.) A.Cleve	
2	0.22	NISC	-	Nitzschia scalaris (Ehr.)W.M.Smith	
2	0.22	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
2	0.22	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
2	0.22	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
2	0.22	DEEL	-	Denticula elegans Kutzing 1844	
2	0.22	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
2	0.22	CYSP	-	Cyclotella species	
2	0.22	ANCO	-	Anomoeoneis costata (Kutzing) Grunow	

SLIDE NUMBER	**13**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	FBWMA Unit 2 Out
STORET NUMBER	4985500
DATE	29/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
3.0	9.1	13.5	10.5	7.3	2.9	5.4	10.5	2.0
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
89.8	2.9	6.8	5.0	4.9	1.7	4.9	3.3	

QUALITY NOTES / 20

Number of species	15	Diversity	1.74	Genera number	9
Population	650	Evenness	0.45		

Number	%	Code	ou	Designation	* : taxon IBD
446	68.62	AMVE	-	Amphora veneta Kutzing	*
84	12.92	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
42	6.46	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
22	3.38	GOAF	-	Gomphonema affine Kutzing	
14	2.15	NIIN	-	Nitzschia inconspicua Grunow	*
12	1.85	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
8	1.23	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
6	0.92	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
4	0.62	NICO	-	Nitzschia communis Rabenhorst	
2	0.31	FRBI	PBIF	Fragilaria brevistriata Grunow var.inflata (Pantocsek) Hustedt	
2	0.31	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
2	0.31	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.31	CYSP	-	Cyclotella species	
2	0.31	NAMU	LMUT	Navicula mutica Kutzing	*
2	0.31	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	

SLIDE NUMBER	**14**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	KC T1
STORET NUMBER	4985800
DATE	28/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
10.7	10.9	14.9	10.5	10.5	9.4	10.3	11.6	7.7
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
78.6	9.4	7.8	10.4	9.3	8.2	10.2	5.3	

QUALITY NOTES / 20

Number of species	35	Diversity	4.20	Genera number	16
Population	578	Evenness	0.82		

Number	%	Code	ou	Designation	* : taxon IBD
100	17.30	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
60	10.38	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	
58	10.03	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
56	9.69	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
40	6.92	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
32	5.54	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
32	5.54	NIIN	-	Nitzschia inconspicua Grunow	*
22	3.81	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
18	3.11	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
18	3.11	NACR	-	Navicula cryptocephala Kutzing	*
16	2.77	NAHT	CVXV	Navicula halophila (Grunow) Cleve fo.tenuirostris Hustedt	
16	2.77	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
14	2.42	ACLA	PTLA	Achnanthes lanceolata(Breb.)Grunow var. lanceolata Grunow	*
12	2.08	MEVA	-	Melosira varians Agardh	*
10	1.73	NISB	-	Neidium iridis (Ehrenberg) Cleve var.subampliatum (Grun.) A.Cleve	
8	1.38	NART	NCTE	Navicula radiosa Kutzing var.tenella(Brebisson)Cleve & Möller	*
6	1.04	AMPE	APED	Amphora perpusilla Grunow	*
6	1.04	SUOV	-	Surirella ovalis Brebisson	*
6	1.04	CYSP	-	Cyclotella species	
4	0.69	NAPU	SPUP	Navicula pupula Kutzing	*
4	0.69	ACSP	-	Achnanthes sp.	
4	0.69	CYMI	ENMI	Cymbella minuta Hilse ex Rabenhorst (Encyonema)	*
4	0.69	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.69	NILS	NLOR	Nitzschia lorenziana Grunow var.subtilis Grunow	
4	0.69	CYCO	DCOS	Cymbella costei Maillard	
4	0.69	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.69	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
2	0.35	NACI	-	Navicula circumtexta Meister ex Hustedt	
2	0.35	NASA	-	Navicula secreta Pantocsek.var.apiculata Patrick	
2	0.35	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
2	0.35	NIAC	-	Nitzschia acicularis(Kutzing) W.M.Smith	*
2	0.35	NASL	-	Navicula stroesei (Ostrup) Cleve var.lanceolata Foged	
2	0.35	GYSP	-	Gyrosigma spencerii (Quekett) Griffith et Henfrey	
2	0.35	CYAT	CBYA	Cymbella yateana Maillard	
2	0.35	CYME	-	Cyclotella meneghiniana Kutzing	*

SLIDE NUMBER	**15**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	NDSD T1
STORET NUMBER	4985590
DATE	11/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.5	10.5	9.9	10.1	4.3	10.1	6.4	10.5	5.7
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
85.6	11.5	3.1	8.7	6.5	3.2	7.6	7.9	

QUALITY NOTES / 20

Number of species 8
Population 716

Diversity 1.29
Evenness 0.43

Genera number 6

Number	%	Code	ou	Designation	* : taxon IBD
494	68.99	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
142	19.83	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
68	9.50	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
4	0.56	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
2	0.28	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
2	0.28	FRCA	-	Fragilaria capucina Desmazieres	*
2	0.28	NAPU	SPUP	Navicula pupula Kutzing	*
2	0.28	NAHT	CVXV	Navicula halophila (Grunow) Cleve fo.tenuirostris Hustedt	

SLIDE NUMBER	**16**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	NDSD T2
STORET NUMBER	4985591
DATE	11/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.4	9.3	9.7	9.8	6.1	6.3	6.3	10.6	5.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
87.2	7.4	2.7	6.8	7.1	4.0	7.3	5.7	

QUALITY NOTES / 20

Number of species 8
Population 672

Diversity 1.77
Evenness 0.59

Genera number 6

Number	%	Code	ou	Designation	* : taxon IBD
342	50.89	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
158	23.51	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
138	20.54	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
16	2.38	NICO	-	Nitzschia communis Rabenhorst	
8	1.19	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
6	0.89	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
2	0.30	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	
2	0.30	NIDI	-	Nitzschia dissipata(Kutzing)Grunow var.dissipata	*

SLIDE NUMBER **17**
PROJECT NAME Farmington Bay, GSL
SITE NAME NDSD T3
STORET NUMBER 4985592
DATE 11/08/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.9	10.7	10.4	10.0	4.3	6.1	6.5	10.2	5.9
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
85.4	11.2	3.5	8.7	6.5	3.0	8.1	7.4	

QUALITY NOTES / 20

Number of species 17
Population 640

Diversity 1.86
Evenness 0.46

Genera number 8

Number	%	Code	ou	Designation	* : taxon IBD
410	64.06	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
102	15.94	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
50	7.81	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
24	3.75	NAPU	SPUP	Navicula pupula Kutzing	*
20	3.13	NIIN	-	Nitzschia inconspicua Grunow	*
6	0.94	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
4	0.63	CYME	-	Cyclotella meneghiniana Kutzing	*
4	0.63	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	
4	0.63	NIPS	-	Nitzschia pseudostagnorum Hustedt	
2	0.31	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
2	0.31	NISP	-	Nitzschia species	
2	0.31	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
2	0.31	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.31	NIDI	-	Nitzschia dissipata(Kutzing)Grunow var.dissipata	*
2	0.31	NICO	-	Nitzschia communis Rabenhorst	
2	0.31	NASL	-	Navicula stroesei (Ostrup) Cleve var.lanceolata Foged	
2	0.31	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	

SLIDE NUMBER	**18**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	New St 20
STORET NUMBER	4985880
DATE	08/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
9.6	12.4	13.0	12.1	7.0	6.5	9.0	14.0	4.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
67.8	9.2	6.0	9.6	8.2	9.7	10.1	7.1	

QUALITY NOTES / 20

Number of species	17	Diversity	2.58	Genera number	12
Population	686	Evenness	0.63		

Number	%	Code	ou	Designation	* : taxon IBD
270	39.36	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
198	28.86	NIIN	-	Nitzschia inconspicua Grunow	*
66	9.62	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
42	6.12	AMVE	-	Amphora veneta Kutzing	*
20	2.92	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
16	2.33	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
16	2.33	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
14	2.04	CYME	-	Cyclotella meneghiniana Kutzing	*
10	1.46	NISP	-	Nitzschia species	
6	0.87	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
6	0.87	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
6	0.87	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
6	0.87	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
4	0.58	SUOV	-	Surirella ovalis Brebisson	*
2	0.29	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
2	0.29	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
2	0.29	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*

SLIDE NUMBER	**20**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	New St 5-6
STORET NUMBER	4985890
DATE	07/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
9.5	11.8	9.4	13.5	10.2	4.8	6.9	16.2	5.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
59.6	11.2	6.8	11.2	8.6	11.1	9.1	8.1	

QUALITY NOTES / 20

Number of species	17	Diversity	1.79	Genera number	11
Population	616	Evenness	0.44		

Number	%	Code	ou	Designation	* : taxon IBD
422	68.51	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
70	11.36	NIIN	-	Nitzschia inconspicua Grunow	*
46	7.47	NIPA	-	Nitzschia palea (Kutzing) W.Smith	*
24	3.90	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
16	2.60	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
6	0.97	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
4	0.65	SUOV	-	Surirella ovalis Brebisson	*
4	0.65	NACR	-	Navicula cryptocephala Kutzing	*
4	0.65	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
4	0.65	AMVE	-	Amphora veneta Kutzing	*
4	0.65	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.32	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.32	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
2	0.32	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
2	0.32	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
2	0.32	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
2	0.32	BAPA	BPAX	Bacillaria paradoxa Gmelin	*

SLIDE NUMBER **19**
PROJECT NAME Farmington Bay, GSL
SITE NAME New St T1
STORET NUMBER 4985870
DATE 07/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.6	11.8	11.5	12.3	6.5	7.8	5.3	12.0	7.9
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
70.3	7.6	5.9	6.5	10.7	10.8	10.9	6.7	

QUALITY NOTES / 20

Number of species 19
Population 820

Diversity 2.01
Evenness 0.47

Genera number 10

Number	%	Code	ou	Designation	* : taxon IBD
508	61.95	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
138	16.83	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
52	6.34	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
30	3.66	MEVA	-	Melosira varians Agardh	*
28	3.41	NIIN	-	Nitzschia inconspicua Grunow	*
12	1.46	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
10	1.22	NISP	-	Nitzschia species	
8	0.98	CYME	-	Cyclotella meneghiniana Kutzing	*
8	0.98	NAPY	-		
6	0.73	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
4	0.49	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
2	0.24	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
2	0.24	STSP	-	Stephanodiscus species	
2	0.24	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
2	0.24	NACI	-	Navicula circumtexta Meister ex Hustedt	
2	0.24	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
2	0.24	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.24	FRVA	FCVA	Fragilaria vaucheriae (Kutzing) Petersen	*
2	0.24	FRCO	SCON	Fragilaria construens (Ehr.) Grunow f.construens (Staurosira)	*

SLIDE NUMBER	**21**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG Pintail
STORET NUMBER	4985630
DATE	28/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
12.5	11.0	12.1	11.4	12.0	8.8	9.4	10.6	5.1
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
58.0	6.8	6.8	11.7	8.4	6.9	10.5	7.8	

QUALITY NOTES / 20

Number of species	44	Diversity	4.48	Genera number	23
Population	628	Evenness	0.82		

Number	%	Code	ou	Designation	* : taxon IBD
66	10.51	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
64	10.19	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
56	8.92	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
54	8.60	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
40	6.37	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
40	6.37	AMVE	-	Amphora veneta Kutzing	*
36	5.73	NIIN	-	Nitzschia inconspicua Grunow	*
34	5.41	NISP	-	Nitzschia species	
32	5.10	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
32	5.10	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
28	4.46	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
20	3.18	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
12	1.91	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
10	1.59	DITL	-	Diatoma tenuis Agardh var.elongatum Lyngbye	*
10	1.59	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
6	0.96	CYME	-	Cyclotella meneghiniana Kutzing	*
6	0.96	COPE	-	Cocconeis pediculus Ehrenberg	*
4	0.64	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
4	0.64	NARH	-	Navicula rhynchocephala Kutzing	*
4	0.64	SUST	-	Surirella striatula Turpin sensu Schmidt	
4	0.64	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.64	NACR	-	Navicula cryptocephala Kutzing	*
4	0.64	ACAF	ADMF	Achnanthes affinis Grunow in Cleve & Grunow (Achnanthidium)	*
4	0.64	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
4	0.64	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
4	0.64	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
4	0.64	CYCI	-	Cymbella cistula(Ehrenberg)Kirchner	*
4	0.64	ENAL	-	Entomoneis alata Ehrenberg	
4	0.64	FRCA	-	Fragilaria capucina Desmazieres	*
4	0.64	SYDE	-	Synedra delicatissima W.Smith	*
4	0.64	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
2	0.32	SUOV	-	Surirella ovalis Brebisson	*
2	0.32	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
2	0.32	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
2	0.32	PLDE	-	Pleurosigma delicatulum W.Smith	
2	0.32	PIBR	-	Pinnularia brebissonii (Kutz.) Rabenhorst var. brebissonii	*
2	0.32	NISB	-	Neidium iridis (Ehrenberg) Cleve var.subampliatum (Grun.) A.Cleve	
2	0.32	NINT	-	Nitzschia intermedia Hantzsch ex Cleve & Grunow	*
2	0.32	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.32	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
2	0.32	NIAC	-	Nitzschia acicularis(Kutzing) W.M.Smith	*
2	0.32	NACI	-	Navicula circumtexta Meister ex Hustedt	
2	0.32	FRBI	PBIF	Fragilaria brevistriata Grunow var.inflata (Pantocsek) Hustedt	

2	0.32	ACEX	ADEG	Achnanthes exigua Grunow in Cl. & Grun.var. exigua

SLIDE NUMBER	**22**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG T1
STORET NUMBER	4985623
DATE	07/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
7.7	10.2	13.6	10.5	7.0	6.1	9.1	11.2	6.9
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
81.2	6.3	6.2	7.7	8.7	8.7	10.4	5.5	

QUALITY NOTES / 20

Number of species	29	Diversity	3.75	Genera number	16
Population	642	Evenness	0.77		

Number	%	Code	ou	Designation	* : taxon IBD
182	28.35	NIIN	-	Nitzschia inconspicua Grunow	*
72	11.21	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
66	10.28	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
50	7.79	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
44	6.85	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
32	4.98	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
30	4.67	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
20	3.12	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
16	2.49	DITL	-	Diatoma tenuis Agardh var.elongatum Lyngbye	*
14	2.18	NIHU	THUN	Nitzschia hungarica Grunow	*
14	2.18	NACR	-	Navicula cryptocephala Kutzing	*
14	2.18	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
14	2.18	AMVE	-	Amphora veneta Kutzing	*
12	1.87	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
10	1.56	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
6	0.93	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
6	0.93	NASP	-	Navicula sp.	
4	0.62	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
4	0.62	SYDE	-	Synedra delicatissima W.Smith	*
4	0.62	CYME	-	Cyclotella meneghiniana Kutzing	*
4	0.62	FRVA	FCVA	Fragilaria vaucheriae (Kutzing) Petersen	*
4	0.62	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
4	0.62	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
4	0.62	SUOV	-	Surirella ovalis Brebisson	*
4	0.62	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
2	0.31	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
2	0.31	NISP	-	Nitzschia species	
2	0.31	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.31	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*

SLIDE NUMBER	**24**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG T2
STORET NUMBER	4985624
DATE	15/10/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
7.8	9.6	12.0	10.2	9.9	6.3	10.6	9.8	6.8
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
81.9	7.3	5.3	7.9	8.5	8.5	9.3	5.7	

QUALITY NOTES / 20

Number of species 26
Population 634

Diversity 3.46
Evenness 0.74

Genera number 15

Number	%	Code	ou	Designation	* : taxon IBD
212	33.44	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
104	16.40	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
46	7.26	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
36	5.68	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
34	5.36	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
34	5.36	NIIN	-	Nitzschia inconspicua Grunow	*
26	4.10	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
22	3.47	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
16	2.52	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
16	2.52	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
14	2.21	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
8	1.26	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
8	1.26	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
8	1.26	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
8	1.26	NACR	-	Navicula cryptocephala Kutzing	*
8	1.26	CYME	-	Cyclotella meneghiniana Kutzing	*
6	0.95	SYDE	-	Synedra delicatissima W.Smith	*
6	0.95	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
4	0.63	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.63	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.63	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.32	NICO	-	Nitzschia communis Rabenhorst	
2	0.32	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
2	0.32	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
2	0.32	FRVA	FCVA	Fragilaria vaucheriae (Kutzing) Petersen	*
2	0.32	ACLA	PTLA	Achnanthes lanceolata(Breb.)Grunow var. lanceolata Grunow	*

SLIDE NUMBER	**23**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG T2
STORET NUMBER	4985624
DATE	07/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
7.0	9.5	13.3	10.6	7.5	5.6	9.7	8.7	6.1
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
72.1	7.0	6.6	6.9	9.3	7.0	9.6	6.4	

QUALITY NOTES / 20

Number of species	29	Diversity	3.65	Genera number	14
Population	652	Evenness	0.75		

Number	%	Code	ou	Designation	* : taxon IBD
114	17.48	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
108	16.56	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
106	16.26	NIIN	-	Nitzschia inconspicua Grunow	*
96	14.72	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
46	7.06	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
20	3.07	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
18	2.76	CYME	-	Cyclotella meneghiniana Kutzing	*
16	2.45	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
16	2.45	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
14	2.15	NACR	-	Navicula cryptocephala Kutzing	*
12	1.84	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
10	1.53	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
10	1.53	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
10	1.53	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
8	1.23	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
8	1.23	NIMI	-	Navicula imitans Mann	
6	0.92	NIHU	THUN	Nitzschia hungarica Grunow	*
6	0.92	AMVE	-	Amphora veneta Kutzing	*
4	0.61	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
4	0.61	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
4	0.61	NISC	-	Nitzschia scalaris (Ehr.)W.M.Smith	
2	0.31	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
2	0.31	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.31	NICO	-	Nitzschia communis Rabenhorst	
2	0.31	NAPU	SPUP	Navicula pupula Kutzing	*
2	0.31	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
2	0.31	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
2	0.31	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
2	0.31	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*

SLIDE NUMBER	**25**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG T5
STORET NUMBER	4985625
DATE	09/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
6.0	9.2	14.2	10.3	7.7	5.9	8.3	10.8	5.7
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
91.8	5.0	6.2	7.0	6.9	7.1	9.3	4.5	

QUALITY NOTES / 20

Number of species 23
Population 688

Diversity 2.86
Evenness 0.63

Genera number 11

Number	%	Code	ou	Designation	* : taxon IBD
310	45.06	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
100	14.53	NIIN	-	Nitzschia inconspicua Grunow	*
58	8.43	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
50	7.27	NIHU	THUN	Nitzschia hungarica Grunow	*
36	5.23	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
30	4.36	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
28	4.07	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
16	2.33	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
12	1.74	AMVE	-	Amphora veneta Kutzing	*
6	0.87	NIMI	-	Navicula imitans Mann	
6	0.87	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
4	0.58	NISP	-	Nitzschia species	
4	0.58	NICO	-	Nitzschia communis Rabenhorst	
4	0.58	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
4	0.58	NACU	CRCU	Navicula cuspidata Kutzing	*
4	0.58	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
4	0.58	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
2	0.29	NACR	-	Navicula cryptocephala Kutzing	*
2	0.29	FRCA	-	Fragilaria capucina Desmazieres	*
2	0.29	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.29	ANCO	-	Anomoeoneis costata (Kutzing) Grunow	
2	0.29	SUST	-	Surirella striatula Turpin sensu Schmidt	
2	0.29	SYDE	-	Synedra delicatissima W.Smith	*

SLIDE NUMBER	**26**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	PSG T6
STORET NUMBER	4985625
DATE	05/10/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
7.6	11.6	12.5	11.0	7.3	7.8	8.6	11.0	5.5
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
82.3	10.6	4.4	9.7	7.4	4.5	9.8	8.3	

QUALITY NOTES / 20

Number of species	17	Diversity	2.75	Genera number	10
Population	692	Evenness	0.67		

Number	%	Code	ou	Designation	* : taxon IBD
188	27.17	NIMI	-	Navicula imitans Mann	
176	25.43	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
144	20.81	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
72	10.40	NIIN	-	Nitzschia inconspicua Grunow	*
36	5.20	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
20	2.89	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
12	1.73	FRVI	-	Fragilaria virescens Ralfs	*
8	1.16	NART	NCTE	Navicula radiosa Kutzing var.tenella(Brebisson)Cleve & Möller	*
8	1.16	AMVE	-	Amphora veneta Kutzing	*
6	0.87	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
4	0.58	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
4	0.58	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.58	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
4	0.58	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
2	0.29	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	0.29	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
2	0.29	ACLI	ALIO	Achnanthes linearis (W.Sm.) Grunow	

SLIDE NUMBER **27**
PROJECT NAME Farmington Bay, GSL
SITE NAME PSG WID IN
STORET NUMBER 4985621
DATE 28/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
14.6	12.6	12.2	11.8	11.7	9.4	12.6	10.6	6.2
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
57.6	11.2	6.9	12.4	8.9	7.4	11.2	9.1	

QUALITY NOTES / 20

Number of species 29
Population 647
Diversity 3.77
Evenness 0.78
Genera number 15

Number	%	Code	ou	Designation	* : taxon IBD
128	19.78	NIMI	-	Navicula imitans Mann	
98	15.15	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
76	11.75	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
52	8.04	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
44	6.80	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
42	6.49	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
41	6.34	NIIN	-	Nitzschia inconspicua Grunow	*
40	6.18	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
24	3.71	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
14	2.16	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
14	2.16	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
10	1.55	GOAF	-	Gomphonema affine Kutzing	
10	1.55	SYUL	UULN	Synedra ulna (Nitzsch.)Ehr.	*
8	1.24	AMVE	-	Amphora veneta Kutzing	*
6	0.93	SYDE	-	Synedra delicatissima W.Smith	*
6	0.93	NACR	-	Navicula cryptocephala Kutzing	*
4	0.62	SYFT	-	Synedra fasciculata (Ag.)Kutzing var.truncata (Greville) Patrick	
4	0.62	NIHU	THUN	Nitzschia hungarica Grunow	*
4	0.62	SUST	-	Surirella striatula Turpin sensu Schmidt	
4	0.62	SUOV	-	Surirella ovalis Brebisson	*
2	0.31	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
2	0.31	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
2	0.31	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
2	0.31	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
2	0.31	ANCO	-	Anomoeoneis costata (Kutzing) Grunow	
2	0.31	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
2	0.31	NIAM	-	Nitzschia amphibia Grunow f.amphibia	*
2	0.31	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
2	0.31	NACU	CRCU	Navicula cuspidata Kutzing	*

SLIDE NUMBER **28**
PROJECT NAME Farmington Bay, GSL
SITE NAME PSG WIDGEON Out
STORET NUMBER 4985620
DATE 28/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
13.7	10.7	13.7	11.5	11.6	8.6	10.1	10.9	5.2
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
52.0	9.1	5.8	12.7	9.0	4.1	11.1	8.3	

QUALITY NOTES / 20

Number of species	26	Diversity	3.72	Genera number	15
Population	621	Evenness	0.79		

Number	%	Code	ou	Designation	* : taxon IBD
172	27.70	MAED	-	Mastogloia elliptica (Agardh) Cleve var.dansei(Thwaites) Cleve	
74	11.92	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
52	8.37	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
44	7.09	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
40	6.44	AMVE	-	Amphora veneta Kutzing	*
36	5.80	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
31	4.99	NIMI	-	Navicula imitans Mann	
24	3.86	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
22	3.54	CPEU	-	Cocconeis placentula Ehrenberg var.euglypta (Ehr.) Grunow	*
22	3.54	RHCU	RABB	Rhoicosphenia curvata (Kutzing) Grunow	*
22	3.54	FRVI	-	Fragilaria virescens Ralfs	*
10	1.61	NIIN	-	Nitzschia inconspicua Grunow	*
10	1.61	FCVE	SSVE	Fragilaria construens (Ehr.) Grunow f.venter (Ehr.) Hustedt	*
10	1.61	EPTU	-	Epithemia turgida (Ehr.) Kutzing var.turgida	
8	1.29	NIFR	-	Nitzschia frustulum(Kutzing)Grunow var.frustulum	*
8	1.29	GOAF	-	Gomphonema affine Kutzing	
6	0.97	BAPA	BPAX	Bacillaria paradoxa Gmelin	*
6	0.97	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
6	0.97	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
4	0.64	ACMI	PLMN	Achnantheiopsis minutissima (Krasske) Lange-Bertalot	
4	0.64	CYME	-	Cyclotella meneghiniana Kutzing	*
2	0.32	NICO	-	Nitzschia communis Rabenhorst	
2	0.32	NAHA	CHAL	Navicula halophila (Grunow) Cleve	*
2	0.32	NACU	CRCU	Navicula cuspidata Kutzing	*
2	0.32	GOPA	-	Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	*
2	0.32	SYRU	FCRP	Synedra rumpens Kutzing	*

SLIDE NUMBER	**29**
PROJECT NAME	Farmington Bay, GSL
SITE NAME	WGS5 A Pond
STORET NUMBER	4985440
DATE	28/09/2005

IPS	SLA	DESCY	LMA	GENRE	CEE	SHE	WAT	IDAP
7.0	7.2	12.8	9.8	11.0	5.8	8.4	10.3	6.6
TDI	IBD	DI-CH	EPI-D	IDP	LOBO	SID	TID	
78.7	5.6	10.1	6.6	6.3	5.5	7.7	3.5	

QUALITY NOTES / 20

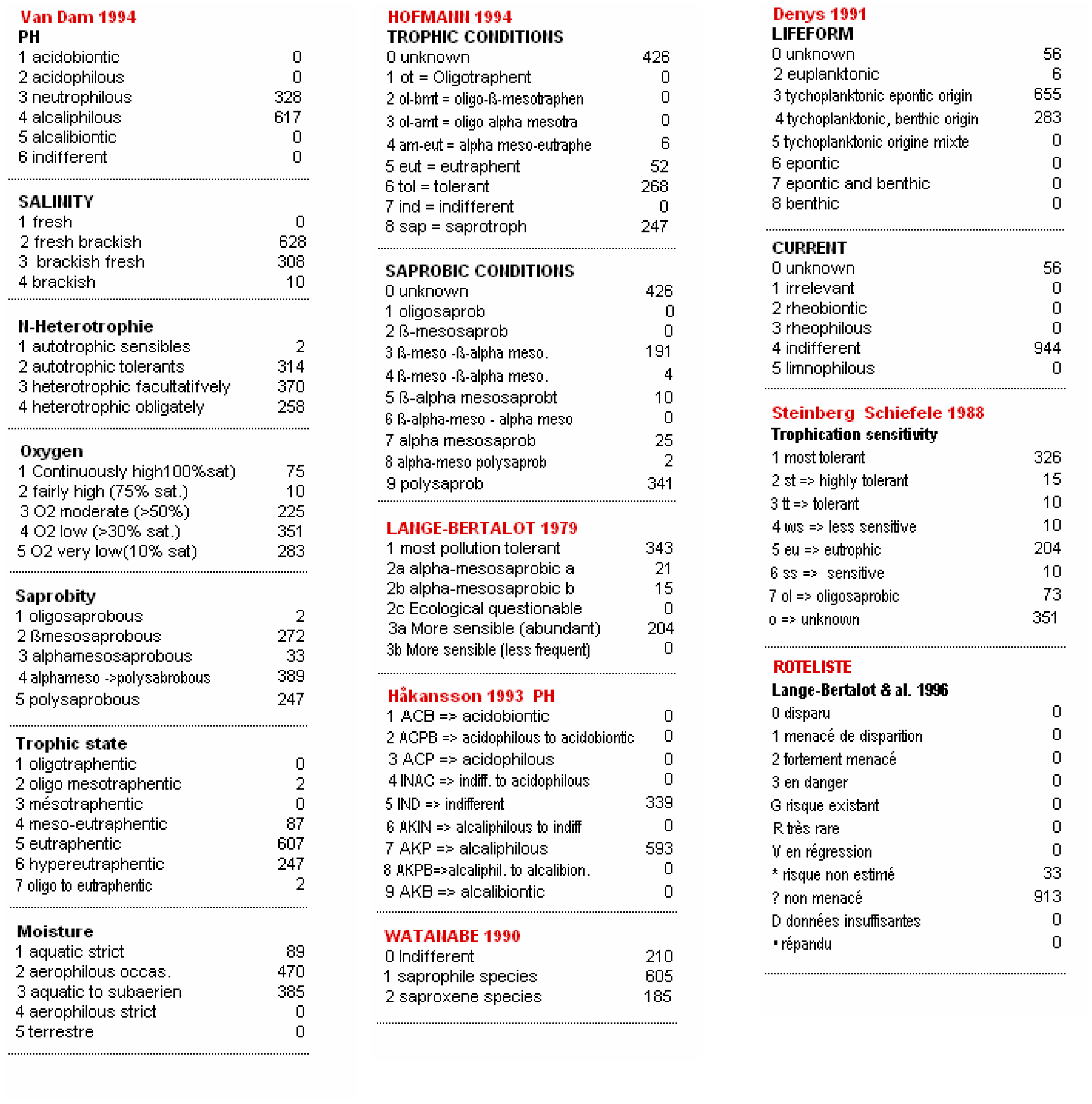
Number of species	21	Diversity	3.64	Genera number	11
Population	158	Evenness	0.83		

Number	%	Code	ou	Designation	* : taxon IBD
32	20.25	NATS	-	Navicula tripunctata var.schizomenoides (Van Heurck) Patrick	
32	20.25	NACV	-	Navicula cryptocephala Kutzing var.veneta (Kutz.) Rabenhorst	*
14	8.86	NIHU	THUN	Nitzschia hungarica Grunow	*
14	8.86	NACR	-	Navicula cryptocephala Kutzing	*
10	6.33	AMOV	-	Amphora ovalis (Kutzing) Kutzing	*
10	6.33	ANSP	-	Anomoeoneis sphaerophora (Ehr.) Pfitzer	
8	5.06	ANCO	-	Anomoeoneis costata (Kutzing) Grunow	
8	5.06	AMVE	-	Amphora veneta Kutzing	*
4	2.53	CYPU	-	Cymbella pusilla Grunow in A.Schmidt & al.	
4	2.53	SYFA	FTTU	Synedra fasciculata (Kutzing) Grunow	
2	1.27	SYPU	CTPU	Synedra pulchella (Ralfs ex Kutzing) Kutzing	*
2	1.27	RHGI	-	Rhopalodia gibba (Ehr.) O.Muller var.gibba	
2	1.27	NIPL	-	Nitzschia paleacea (Grunow) Grunow in van Heurck	*
2	1.27	NIIN	-	Nitzschia inconspicua Grunow	*
2	1.27	ACHA	PTHA	Achnantheiopsis hauckiana (Grunow) Lange-Bertalot	*
2	1.27	ACLD	PTDU	Achnanthes lanceolata(Breb.)Grunow ssp. dubia (Grunow) Lange-Bertalot	*
2	1.27	NAPU	SPUP	Navicula pupula Kutzing	*
2	1.27	NALA	-	Navicula lanceolata (Agardh) Ehrenberg	*
2	1.27	AMCO	-	Amphora coffeaeformis (Agardh) Kutzing var. coffeaeformis	
2	1.27	GYSP	-	Gyrosigma spencerii (Quekett) Griffith et Henfrey	
2	1.27	CYME	-	Cyclotella meneghiniana Kutzing	*

APPENDIX III

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site AMB W1 4985330
Date 22/08/2005
Slide No. 2



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	328
4 alcaliphilous	617
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	628
3 brackish fresh	308
4 brackish	10

N-Heterotrophie	
1 autotrophic sensibles	2
2 autotrophic tolerants	314
3 heterotrophic facultatifvely	370
4 heterotrophic obligately	258

Oxygen	
1 Continuously high100%sat)	75
2 fairly high (75% sat.)	10
3 O2 moderate (>50%)	225
4 O2 low (>30% sat.)	351
5 O2 very low(10% sat)	283

Saprobity	
1 oligosaprobous	2
2 ßmesosaprobous	272
3 alphamesosaprobous	33
4 alphameso ->polysabrobous	389
5 polysaprobous	247

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	2
3 mésotraphentic	0
4 meso-eutraphentic	87
5 eutraphentic	607
6 hypereutraphentic	247
7 oligo to eutraphentic	2

Moisture	
1 aquatic strict	89
2 aerophilous occas.	470
3 aquatic to subaerien	385
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	426
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	6
5 eut = eutraphent	52
6 tol = tolerant	268
7 ind = indifferent	0
8 sap = saprotroph	247

SAPROBIC CONDITIONS	
0 unknown	426
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	191
4 ß-meso -ß-alpha meso.	4
5 ß-alpha mesosaprobt	10
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	25
8 alpha-meso polysaprob	2
9 polysaprob	341

LANGE-BERTALOT 1979

1 most pollution tolerant	343
2a alpha-mesosaprobic a	21
2b alpha-mesosaprobic b	15
2c Ecological questionable	0
3a More sensible (abundant)	204
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	339
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	593
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	210
1 saprophile species	605
2 saproxene species	185

Denys 1991

LIFEFORM	
0 unknown	56
2 euplanktonic	6
3 tychoplanktonic epontic origin	655
4 tychoplanktonic, benthic origin	283
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

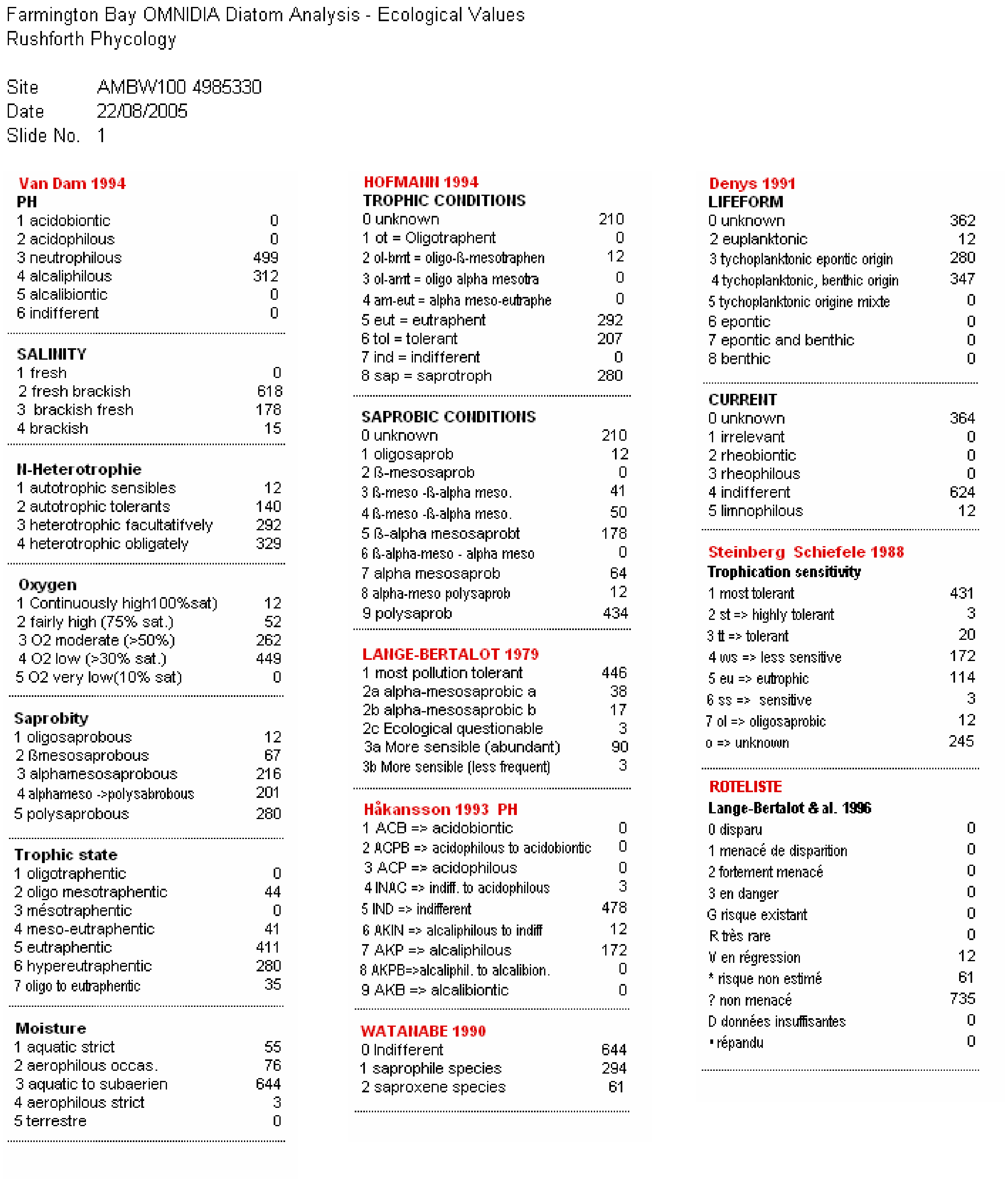
CURRENT	
0 unknown	56
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	944
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	326
2 st => highly tolerant	15
3 tt => tolerant	10
4 ws => less sensitive	10
5 eu => eutrophic	204
6 ss => sensitive	10
7 ol => oligosaprobic	73
o => unknown	351

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	33
? non menacé	913
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site AMBW100 4985330
Date 22/08/2005
Slide No. 1

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	499
4 alcaliphilous	312
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	618
3 brackish fresh	178
4 brackish	15

N-Heterotrophie	
1 autotrophic sensibles	12
2 autotrophic tolerants	140
3 heterotrophic facultatifvely	292
4 heterotrophic obligately	329

Oxygen	
1 Continuously high100%sat)	12
2 fairly high (75% sat.)	52
3 O2 moderate (>50%)	262
4 O2 low (>30% sat.)	449
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	12
2 ßmesosaprobous	67
3 alphamesosaprobous	216
4 alphameso ->polysabrobous	201
5 polysaprobous	280

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	44
3 mésotraphentic	0
4 meso-eutraphentic	41
5 eutraphentic	411
6 hypereutraphentic	280
7 oligo to eutraphentic	35

Moisture	
1 aquatic strict	55
2 aerophilous occas.	76
3 aquatic to subaerien	644
4 aerophilous strict	3
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	210
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	12
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	292
6 tol = tolerant	207
7 ind = indifferent	0
8 sap = saprotroph	280

SAPROBIC CONDITIONS	
0 unknown	210
1 oligosaprob	12
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	41
4 ß-meso -ß-alpha meso.	50
5 ß-alpha mesosaprobt	178
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	64
8 alpha-meso polysaprob	12
9 polysaprob	434

LANGE-BERTALOT 1979	
1 most pollution tolerant	446
2a alpha-mesosaprobic a	38
2b alpha-mesosaprobic b	17
2c Ecological questionable	3
3a More sensible (abundant)	90
3b More sensible (less frequent)	3

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	3
5 IND => indifferent	478
6 AKIN => alcaliphilous to indiff	12
7 AKP => alcaliphilous	172
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	644
1 saprophile species	294
2 saproxene species	61

Denys 1991

LIFEFORM	
0 unknown	362
2 euplanktonic	12
3 tychoplanktonic epontic origin	280
4 tychoplanktonic, benthic origin	347
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

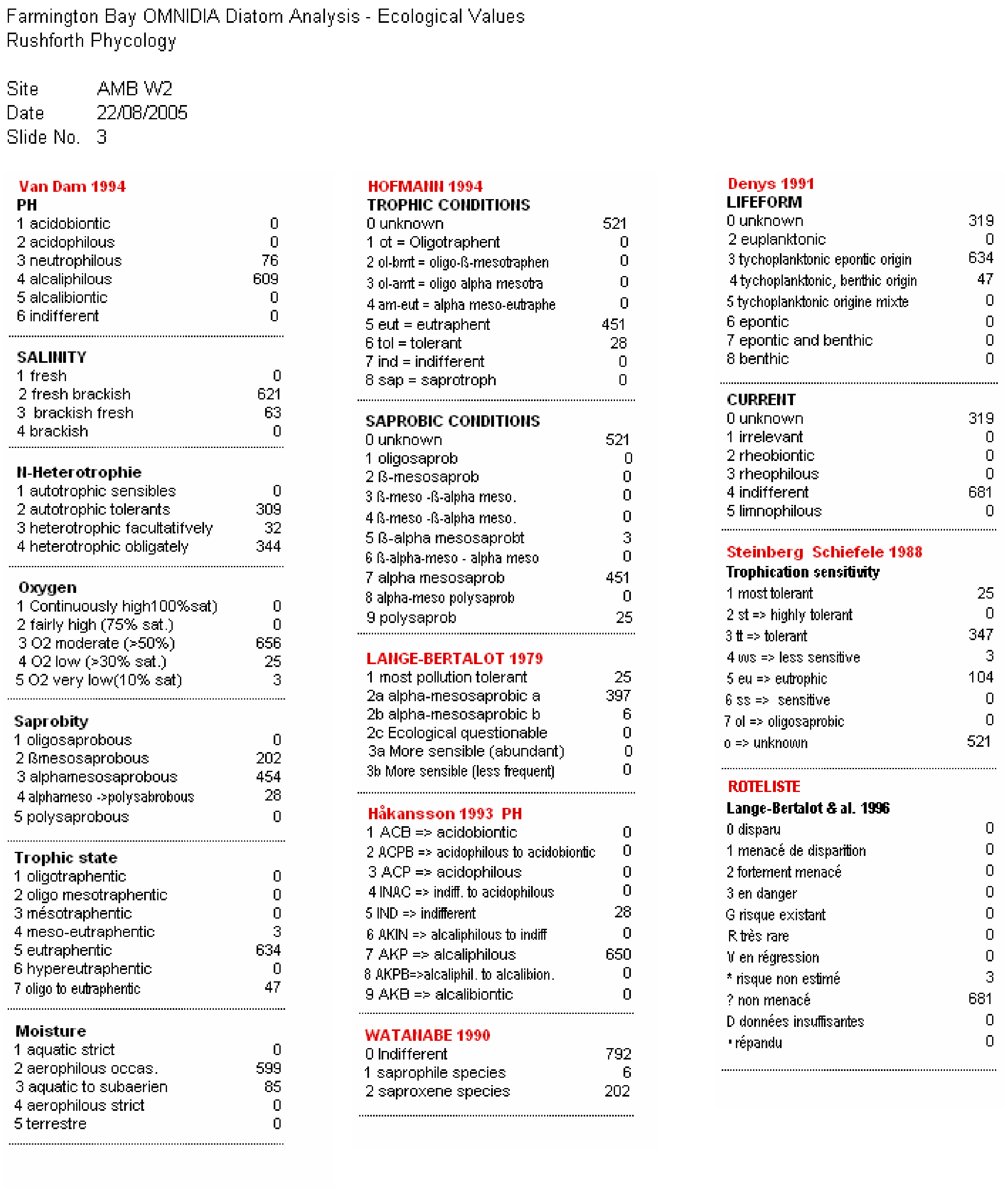
CURRENT	
0 unknown	364
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	624
5 limnophilous	12

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	431
2 st => highly tolerant	3
3 tt => tolerant	20
4 ws => less sensitive	172
5 eu => eutrophic	114
6 ss => sensitive	3
7 ol => oligosaprobic	12
o => unknown	245

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	12
* risque non estimé	61
? non menacé	735
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site AMB W2
Date 22/08/2005
Slide No. 3

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	76
4 alcaliphilous	609
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	621
3 brackish fresh	63
4 brackish	0

N-Heterotrophie	
1 autotrophic sensibles	0
2 autotrophic tolerants	309
3 heterotrophic facultatifvely	32
4 heterotrophic obligately	344

Oxygen	
1 Continuously high100%sat)	0
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	656
4 O2 low (>30% sat.)	25
5 O2 very low(10% sat)	3

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	202
3 alphamesosaprobous	454
4 alphameso ->polysabrobous	28
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	3
5 eutraphentic	634
6 hypereutraphentic	0
7 oligo to eutraphentic	47

Moisture	
1 aquatic strict	0
2 aerophilous occas.	599
3 aquatic to subaerien	85
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	521
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	451
6 tol = tolerant	28
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	521
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	3
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	451
8 alpha-meso polysaprob	0
9 polysaprob	25

LANGE-BERTALOT 1979	
1 most pollution tolerant	25
2a alpha-mesosaprobic a	397
2b alpha-mesosaprobic b	6
2c Ecological questionable	0
3a More sensible (abundant)	0
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	28
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	650
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	792
1 saprophile species	6
2 saproxene species	202

Denys 1991

LIFEFORM	
0 unknown	319
2 euplanktonic	0
3 tychoplanktonic epontic origin	634
4 tychoplanktonic, benthic origin	47
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

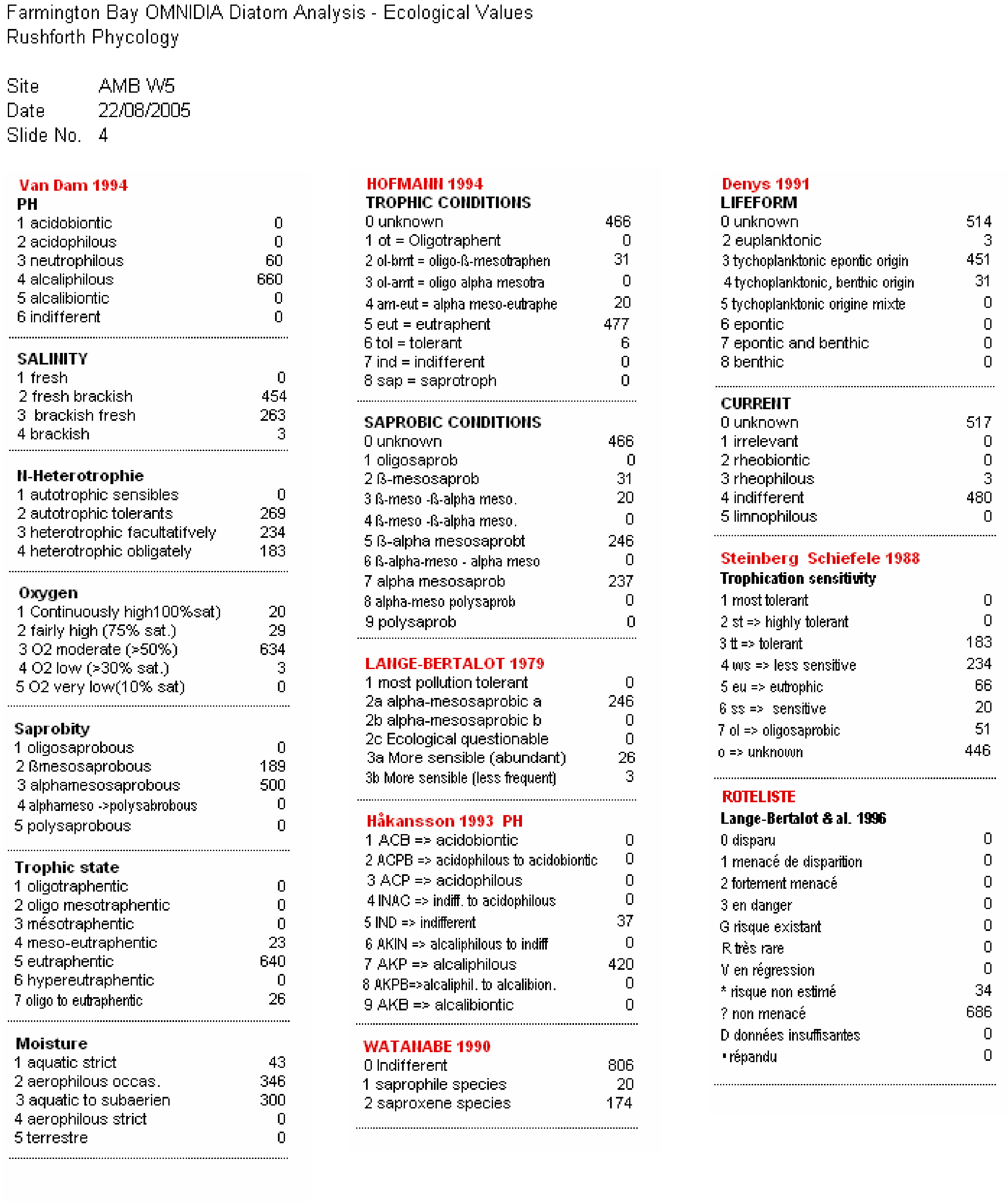
CURRENT	
0 unknown	319
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	681
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	25
2 st => highly tolerant	0
3 tt => tolerant	347
4 ws => less sensitive	3
5 eu => eutrophic	104
6 ss => sensitive	0
7 ol => oligosaprobic	0
o => unknown	521

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	3
? non menacé	681
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site	AMB W5
Date	22/08/2005
Slide No.	4

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	60
4 alcaliphilous	660
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	454
3 brackish fresh	263
4 brackish	3

N-Heterotrophie	
1 autotrophic sensibles	0
2 autotrophic tolerants	269
3 heterotrophic facultatifvely	234
4 heterotrophic obligately	183

Oxygen	
1 Continuously high100%sat)	20
2 fairly high (75% sat.)	29
3 O2 moderate (>50%)	634
4 O2 low (>30% sat.)	3
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	189
3 alphamesosaprobous	500
4 alphameso ->polysabrobous	0
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	23
5 eutraphentic	640
6 hypereutraphentic	0
7 oligo to eutraphentic	26

Moisture	
1 aquatic strict	43
2 aerophilous occas.	346
3 aquatic to subaerien	300
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	466
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	31
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	20
5 eut = eutraphent	477
6 tol = tolerant	6
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	466
1 oligosaprob	0
2 ß-mesosaprob	31
3 ß-meso -ß-alpha meso.	20
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	246
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	237
8 alpha-meso polysaprob	0
9 polysaprob	0

LANGE-BERTALOT 1979	
1 most pollution tolerant	0
2a alpha-mesosaprobic a	246
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	26
3b More sensible (less frequent)	3

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	37
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	420
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	806
1 saprophile species	20
2 saproxene species	174

Denys 1991

LIFEFORM	
0 unknown	514
2 euplanktonic	3
3 tychoplanktonic epontic origin	451
4 tychoplanktonic, benthic origin	31
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

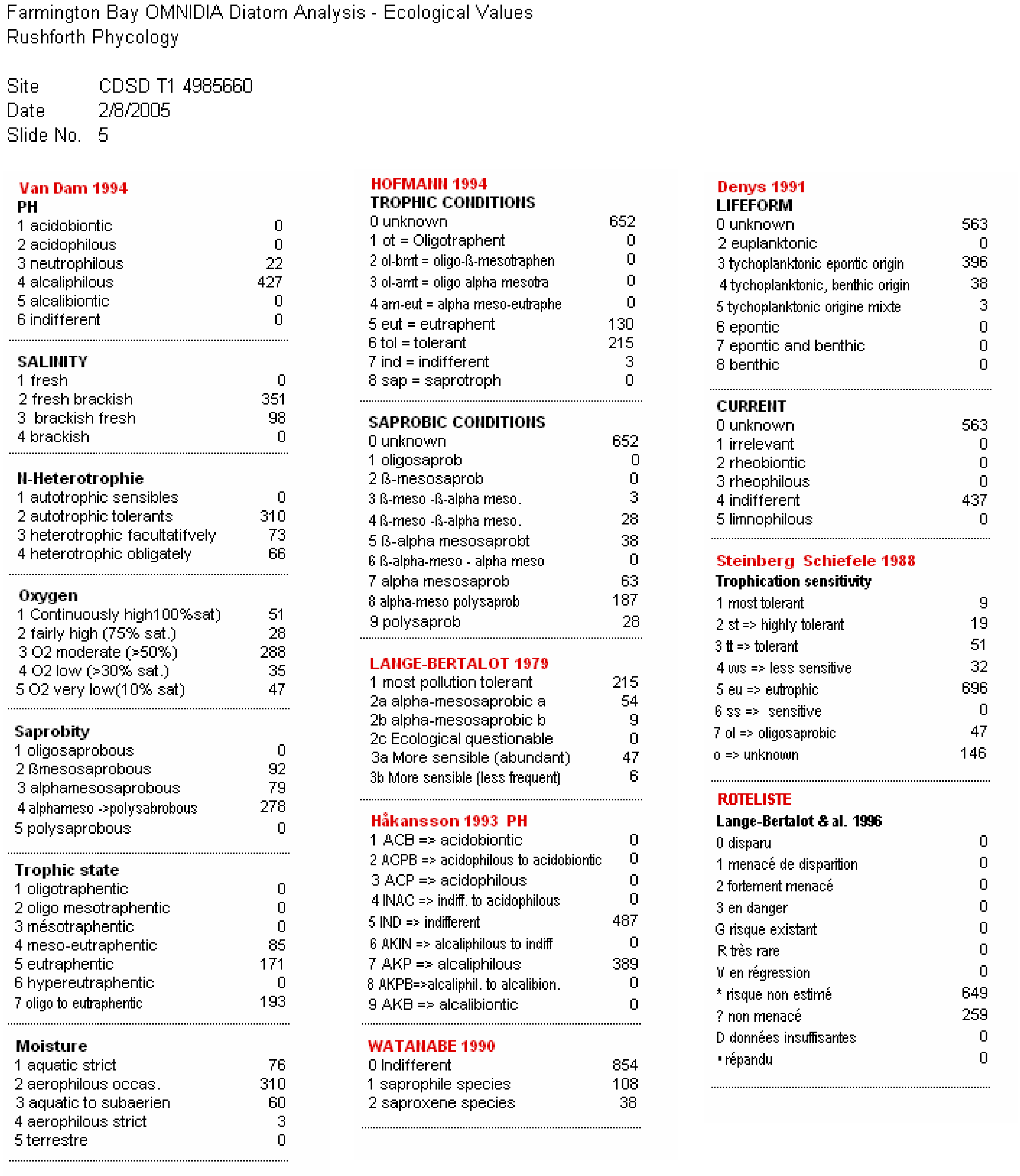
CURRENT	
0 unknown	517
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	3
4 indifferent	480
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	0
2 st => highly tolerant	0
3 tt => tolerant	183
4 ws => less sensitive	234
5 eu => eutrophic	66
6 ss => sensitive	20
7 ol => oligosaprobic	51
o => unknown	446

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	34
? non menacé	686
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site CDSD T1 4985660
Date 2/8/2005
Slide No. 5

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	22
4 alcaliphilous	427
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	351
3 brackish fresh	98
4 brackish	0

N-Heterotrophie	
1 autotrophic sensibles	0
2 autotrophic tolerants	310
3 heterotrophic facultatifvely	73
4 heterotrophic obligately	66

Oxygen	
1 Continuously high100%sat)	51
2 fairly high (75% sat.)	28
3 O2 moderate (>50%)	288
4 O2 low (>30% sat.)	35
5 O2 very low(10% sat)	47

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	92
3 alphamesosaprobous	79
4 alphameso ->polysabrobous	278
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	85
5 eutraphentic	171
6 hypereutraphentic	0
7 oligo to eutraphentic	193

Moisture	
1 aquatic strict	76
2 aerophilous occas.	310
3 aquatic to subaerien	60
4 aerophilous strict	3
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	652
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	130
6 tol = tolerant	215
7 ind = indifferent	3
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	652
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	28
5 ß-alpha mesosaprobt	38
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	63
8 alpha-meso polysaprob	187
9 polysaprob	28

LANGE-BERTALOT 1979	
1 most pollution tolerant	215
2a alpha-mesosaprobic a	54
2b alpha-mesosaprobic b	9
2c Ecological questionable	0
3a More sensible (abundant)	47
3b More sensible (less frequent)	6

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	487
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	389
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	854
1 saprophile species	108
2 saproxene species	38

Denys 1991

LIFEFORM	
0 unknown	563
2 euplanktonic	0
3 tychoplanktonic epontic origin	396
4 tychoplanktonic, benthic origin	38
5 tychoplanktonic origine mixte	3
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	563
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	437
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	9
2 st => highly tolerant	19
3 tt => tolerant	51
4 ws => less sensitive	32
5 eu => eutrophic	696
6 ss => sensitive	0
7 ol => oligosaprobic	47
o => unknown	146

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	649
? non menacé	259
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site CDSD T2 4985680
Date 2/8/2005
Slide No. 6

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	3
3 neutrophilous	40
4 alcaliphilous	415
5 alcalibiontic	3
6 indifferent	5

SALINITY	
1 fresh	8
2 fresh brackish	361
3 brackish fresh	92
4 brackish	5

N-Heterotrophie	
1 autotrophic sensibles	16
2 autotrophic tolerants	278
3 heterotrophic facultatifvely	102
4 heterotrophic obligately	59

Oxygen	
1 Continuously high100%sat)	199
2 fairly high (75% sat.)	19
3 O2 moderate (>50%)	164
4 O2 low (>30% sat.)	40
5 O2 very low(10% sat)	32

Saprobity	
1 oligosaprobous	8
2 ßmesosaprobous	237
3 alphamesosaprobous	92
4 alphameso ->polysabrobous	127
5 polysaprobous	0

Trophic state	
1 oligotraphentic	3
2 oligo mesotraphentic	3
3 mésotraphentic	0
4 meso-eutraphentic	205
5 eutraphentic	183
6 hypereutraphentic	0
7 oligo to eutraphentic	67

Moisture	
1 aquatic strict	197
2 aerophilous occas.	156
3 aquatic to subaerien	105
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	784
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	5
5 eut = eutraphent	111
6 tol = tolerant	100
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	784
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	19
4 ß-meso -ß-alpha meso.	5
5 ß-alpha mesosaprobt	67
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	46
8 alpha-meso polysaprob	46
9 polysaprob	30

LANGE-BERTALOT 1979

1 most pollution tolerant	75
2a alpha-mesosaprobic a	46
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	32
3b More sensible (less frequent)	5

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	5
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	412
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	358
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	747
1 saprophile species	229
2 saproxene species	24

Denys 1991

LIFEFORM	
0 unknown	582
2 euplanktonic	0
3 tychoplanktonic epontic origin	385
4 tychoplanktonic, benthic origin	30
5 tychoplanktonic origine mixte	3
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	582
1 irrelevant	3
2 rheobiontic	0
3 rheophilous	0
4 indifferent	415
5 limnophilous	0

Steinberg Schiefele 1988

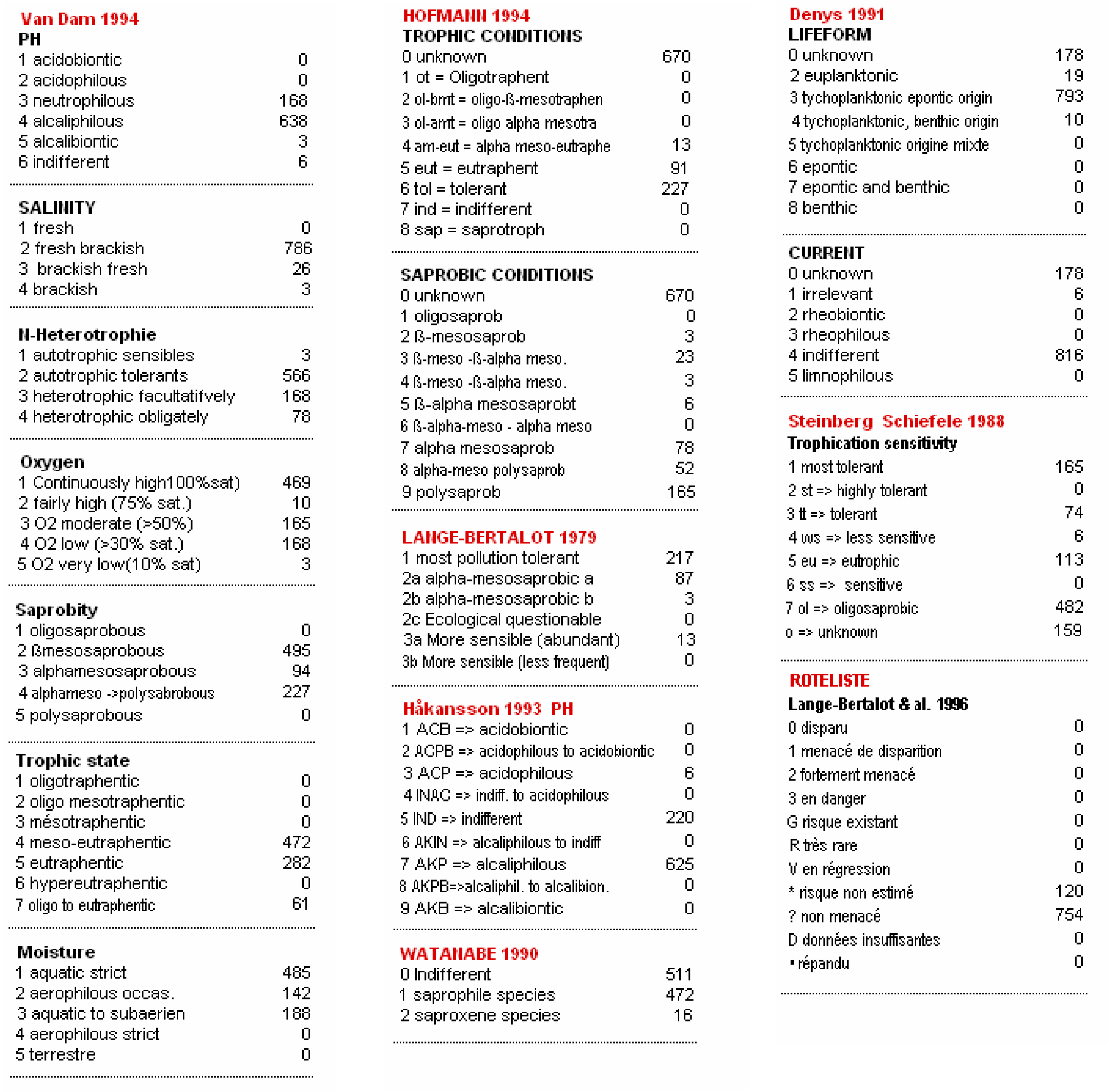
Trophication sensitivity	
1 most tolerant	30
2 st => highly tolerant	0
3 tt => tolerant	40
4 ws => less sensitive	59
5 eu => eutrophic	420
6 ss => sensitive	16
7 ol => oligosaprobic	191
o => unknown	243

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	8
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	412
? non menacé	402
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site CDSD T4 4985690
Date 31/08/2005
Slide No. 7



Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	168
4 alcaliphilous	638
5 alcalibiontic	3
6 indifferent	6

SALINITY

1 fresh	0
2 fresh brackish	786
3 brackish fresh	26
4 brackish	3

N-Heterotrophie

1 autotrophic sensibles	3
2 autotrophic tolerants	566
3 heterotrophic facultatifvely	168
4 heterotrophic obligately	78

Oxygen

1 Continuously high100%sat)	469
2 fairly high (75% sat.)	10
3 O2 moderate (>50%)	165
4 O2 low (>30% sat.)	168
5 O2 very low(10% sat)	3

Saprobity

1 oligosaprobous	0
2 ßmesosaprobous	495
3 alphamesosaprobous	94
4 alphameso ->polysabrobous	227
5 polysaprobous	0

Trophic state

1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	472
5 eutraphentic	282
6 hypereutraphentic	0
7 oligo to eutraphentic	61

Moisture

1 aquatic strict	485
2 aerophilous occas.	142
3 aquatic to subaerien	188
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	670
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	13
5 eut = eutraphent	91
6 tol = tolerant	227
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS

0 unknown	670
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	23
4 ß-meso -ß-alpha meso.	3
5 ß-alpha mesosaprobt	6
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	78
8 alpha-meso polysaprob	52
9 polysaprob	165

LANGE-BERTALOT 1979

1 most pollution tolerant	217
2a alpha-mesosaprobic a	87
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	13
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	6
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	220
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	625
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	511
1 saprophile species	472
2 saproxene species	16

Denys 1991

LIFEFORM

0 unknown	178
2 euplanktonic	19
3 tychoplanktonic epontic origin	793
4 tychoplanktonic, benthic origin	10
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	178
1 irrelevant	6
2 rheobiontic	0
3 rheophilous	0
4 indifferent	816
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity

1 most tolerant	165
2 st => highly tolerant	0
3 tt => tolerant	74
4 ws => less sensitive	6
5 eu => eutrophic	113
6 ss => sensitive	0
7 ol => oligosaprobic	482
o => unknown	159

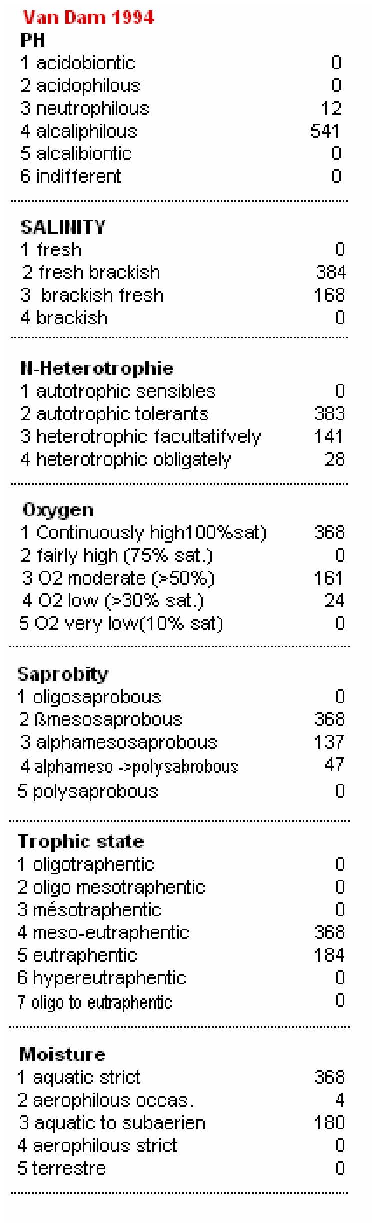
ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	120
? non menacé	754
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site CDSD T5 4985700
Date 31/08/2005
Slide No. 8



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	12
4 alcaliphilous	541
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	384
3 brackish fresh	168
4 brackish	0

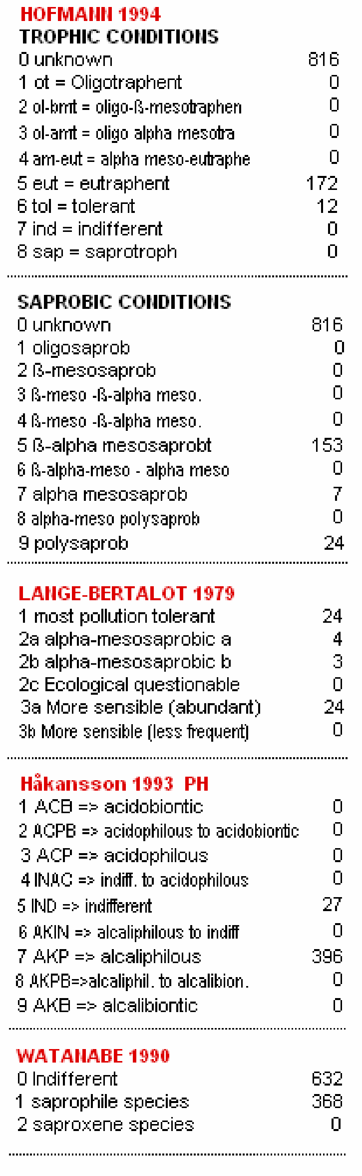
N-Heterotrophie	
1 autotrophic sensibles	0
2 autotrophic tolerants	383
3 heterotrophic facultatifvely	141
4 heterotrophic obligately	28

Oxygen	
1 Continuously high100%sat)	368
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	161
4 O2 low (>30% sat.)	24
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	368
3 alphamesosaprobous	137
4 alphameso ->polysabrobous	47
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	368
5 eutraphentic	184
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	368
2 aerophilous occas.	4
3 aquatic to subaerien	180
4 aerophilous strict	0
5 terrestre	0



HOFMANN 1994

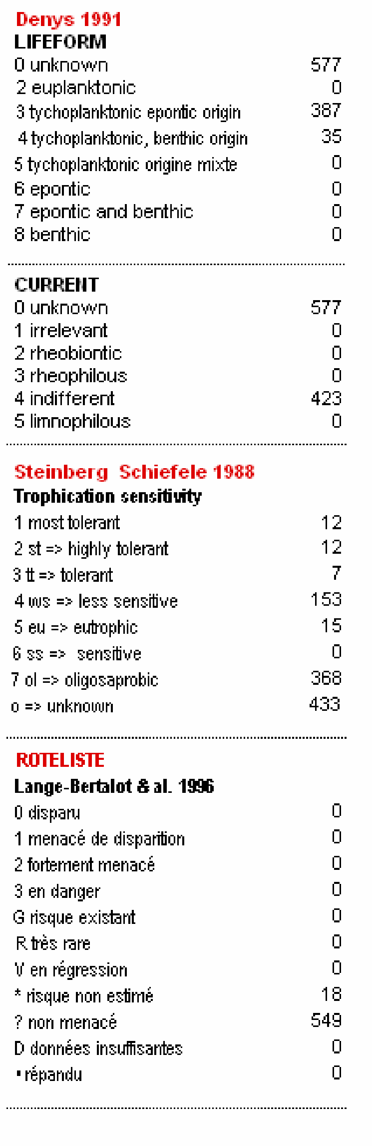
TROPHIC CONDITIONS	
0 unknown	816
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	172
6 tol = tolerant	12
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	816
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	153
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	7
8 alpha-meso polysaprob	0
9 polysaprob	24

LANGE-BERTALOT 1979	
1 most pollution tolerant	24
2a alpha-mesosaprobic a	4
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	24
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	27
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	396
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	632
1 saprophile species	368
2 saproxene species	0



Denys 1991

LIFEFORM	
0 unknown	577
2 euplanktonic	0
3 tychoplanktonic epontic origin	387
4 tychoplanktonic, benthic origin	35
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

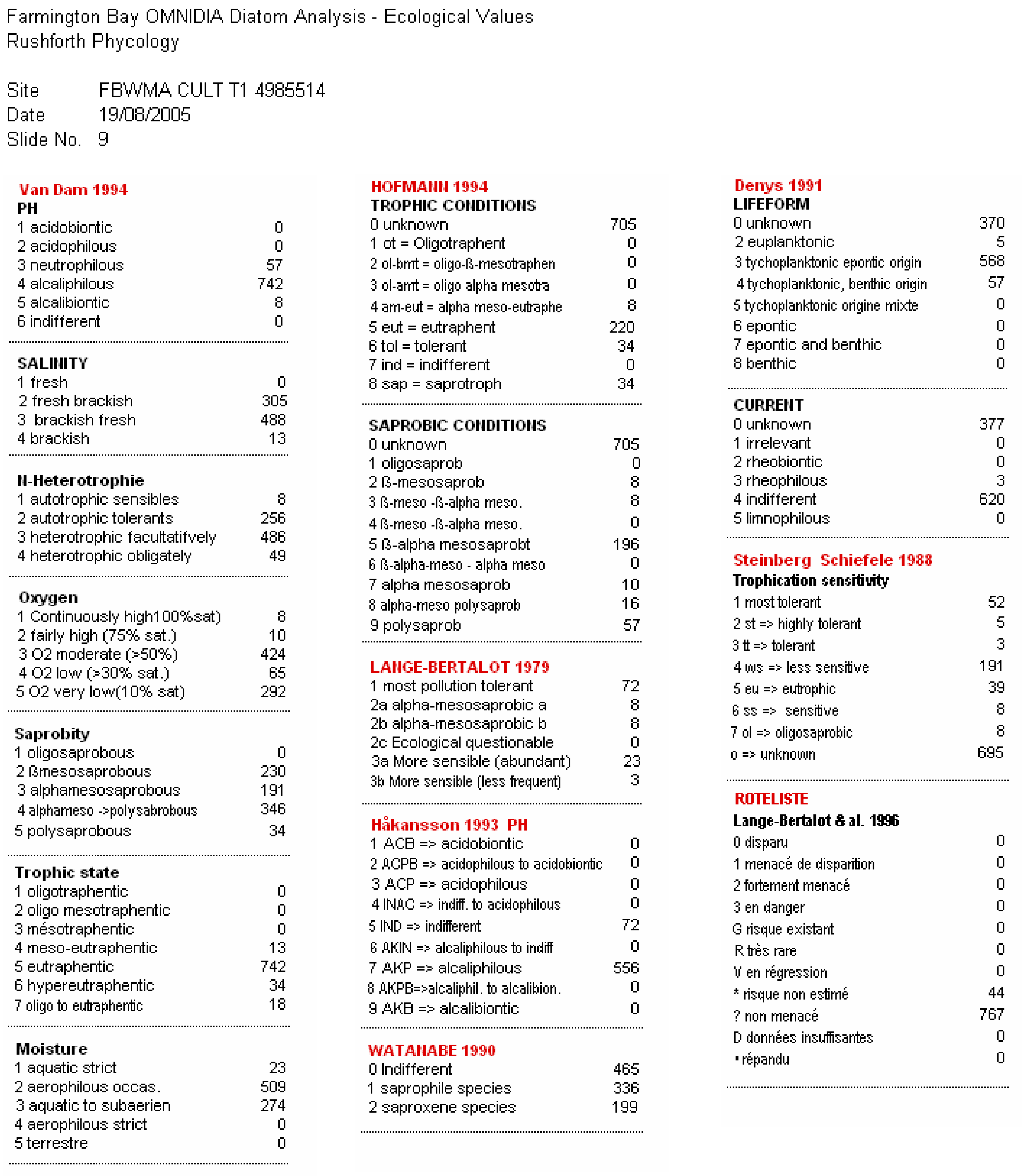
CURRENT	
0 unknown	577
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	423
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	12
2 st => highly tolerant	12
3 tt => tolerant	7
4 ws => less sensitive	153
5 eu => eutrophic	15
6 ss => sensitive	0
7 ol => oligosaprobic	368
o => unknown	433

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	18
? non menacé	549
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site	FBWMA CULT T1 4985514
Date	19/08/2005
Slide No.	9

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	57
4 alcaliphilous	742
5 alcalibiontic	8
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	305
3 brackish fresh	488
4 brackish	13

N-Heterotrophie	
1 autotrophic sensibles	8
2 autotrophic tolerants	256
3 heterotrophic facultatifvely	486
4 heterotrophic obligately	49

Oxygen	
1 Continuously high100%sat)	8
2 fairly high (75% sat.)	10
3 O2 moderate (>50%)	424
4 O2 low (>30% sat.)	65
5 O2 very low(10% sat)	292

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	230
3 alphamesosaprobous	191
4 alphameso ->polysabrobous	346
5 polysaprobous	34

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	13
5 eutraphentic	742
6 hypereutraphentic	34
7 oligo to eutraphentic	18

Moisture	
1 aquatic strict	23
2 aerophilous occas.	509
3 aquatic to subaerien	274
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	705
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	8
5 eut = eutraphent	220
6 tol = tolerant	34
7 ind = indifferent	0
8 sap = saprotroph	34

SAPROBIC CONDITIONS	
0 unknown	705
1 oligosaprob	0
2 ß-mesosaprob	8
3 ß-meso -ß-alpha meso.	8
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	196
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	10
8 alpha-meso polysaprob	16
9 polysaprob	57

LANGE-BERTALOT 1979

1 most pollution tolerant	72
2a alpha-mesosaprobic a	8
2b alpha-mesosaprobic b	8
2c Ecological questionable	0
3a More sensible (abundant)	23
3b More sensible (less frequent)	3

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	72
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	556
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	465
1 saprophile species	336
2 saproxene species	199

Denys 1991

LIFEFORM	
0 unknown	370
2 euplanktonic	5
3 tychoplanktonic epontic origin	568
4 tychoplanktonic, benthic origin	57
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

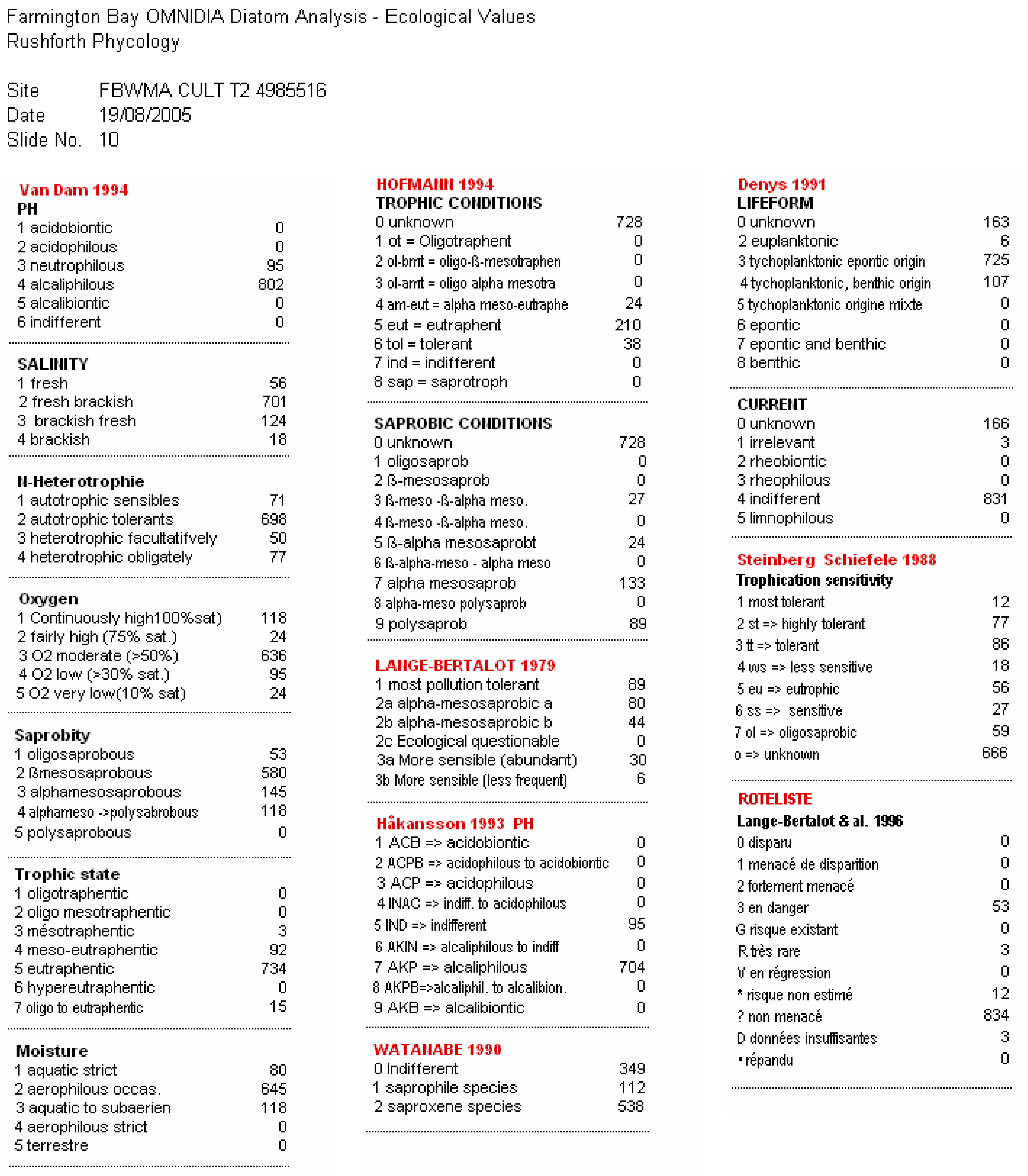
CURRENT	
0 unknown	377
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	3
4 indifferent	620
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	52
2 st => highly tolerant	5
3 tt => tolerant	3
4 ws => less sensitive	191
5 eu => eutrophic	39
6 ss => sensitive	8
7 ol => oligosaprobic	8
o => unknown	695

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	44
? non menacé	767
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site FBWMA CULT T2 4985516
Date 19/08/2005
Slide No. 10

Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	95
4 alcaliphilous	802
5 alcalibiontic	0
6 indifferent	0

SALINITY

1 fresh	56
2 fresh brackish	701
3 brackish fresh	124
4 brackish	18

N-Heterotrophie

1 autotrophic sensibles	71
2 autotrophic tolerants	698
3 heterotrophic facultatifvely	50
4 heterotrophic obligately	77

Oxygen

1 Continuously high100%sat)	118
2 fairly high (75% sat.)	24
3 O2 moderate (>50%)	636
4 O2 low (>30% sat.)	95
5 O2 very low(10% sat)	24

Saprobity

1 oligosaprobous	53
2 ßmesosaprobous	580
3 alphamesosaprobous	145
4 alphameso ->polysabrobous	118
5 polysaprobous	0

Trophic state

1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	3
4 meso-eutraphentic	92
5 eutraphentic	734
6 hypereutraphentic	0
7 oligo to eutraphentic	15

Moisture

1 aquatic strict	80
2 aerophilous occas.	645
3 aquatic to subaerien	118
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	728
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	24
5 eut = eutraphent	210
6 tol = tolerant	38
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS

0 unknown	728
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	27
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	24
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	133
8 alpha-meso polysaprob	0
9 polysaprob	89

LANGE-BERTALOT 1979

1 most pollution tolerant	89
2a alpha-mesosaprobic a	80
2b alpha-mesosaprobic b	44
2c Ecological questionable	0
3a More sensible (abundant)	30
3b More sensible (less frequent)	6

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	95
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	704
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	349
1 saprophile species	112
2 saproxene species	538

Denys 1991

LIFEFORM

0 unknown	163
2 euplanktonic	6
3 tychoplanktonic epontic origin	725
4 tychoplanktonic, benthic origin	107
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	166
1 irrelevant	3
2 rheobiontic	0
3 rheophilous	0
4 indifferent	831
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity

1 most tolerant	12
2 st => highly tolerant	77
3 tt => tolerant	86
4 ws => less sensitive	18
5 eu => eutrophic	56
6 ss => sensitive	27
7 ol => oligosaprobic	59
o => unknown	666

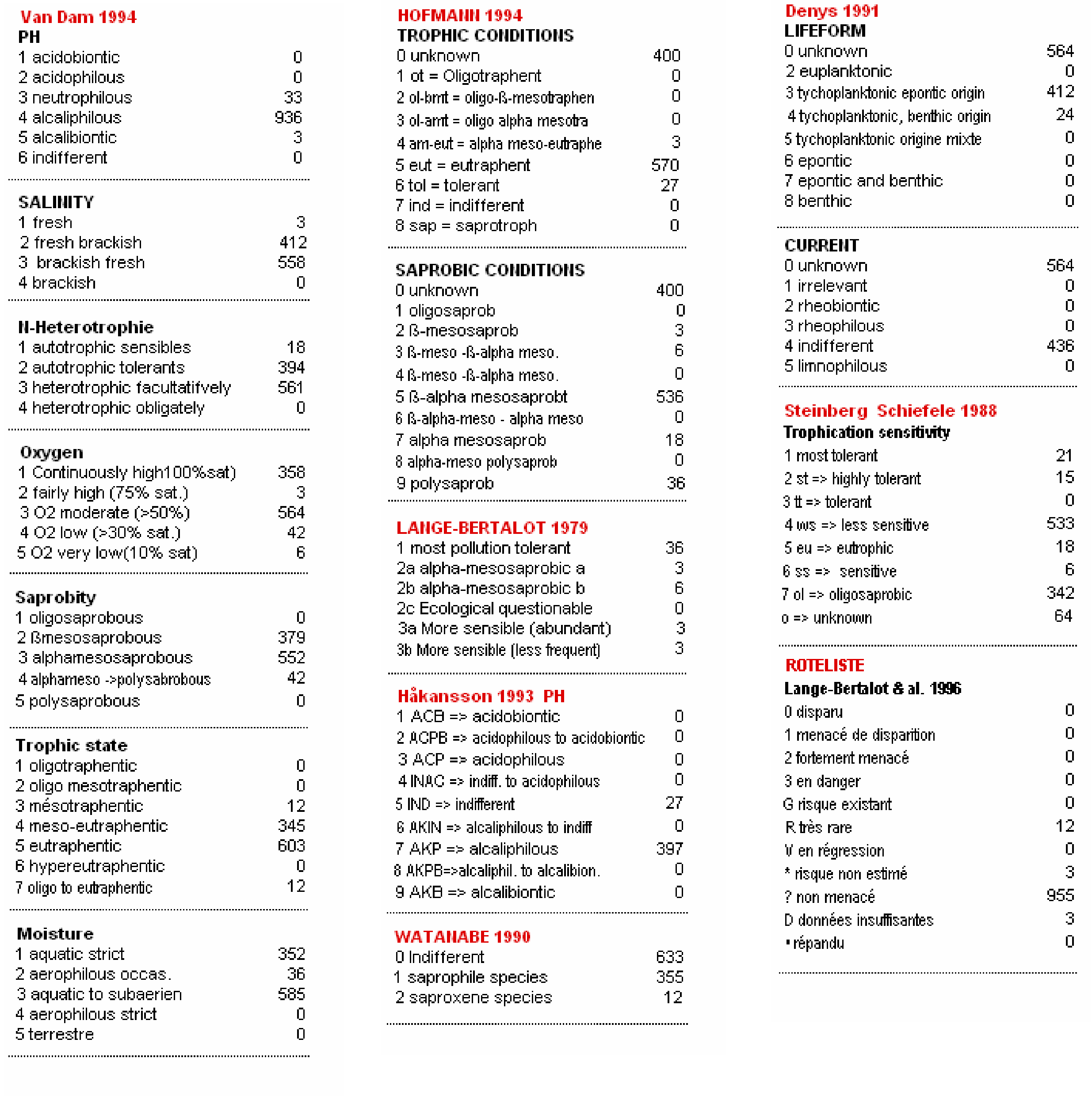
ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	53
G risque existant	0
R très rare	3
V en régression	0
* risque non estimé	12
? non menacé	834
D données insuffisantes	3
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site FBWMA CULT T3 4985517
Date 25/08/2005
Slide No. 11



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	33
4 alcaliphilous	936
5 alcalibiontic	3
6 indifferent	0

SALINITY	
1 fresh	3
2 fresh brackish	412
3 brackish fresh	558
4 brackish	0

N-Heterotrophie	
1 autotrophic sensibles	18
2 autotrophic tolerants	394
3 heterotrophic facultatifvely	561
4 heterotrophic obligately	0

Oxygen	
1 Continuously high100%sat)	358
2 fairly high (75% sat.)	3
3 O2 moderate (>50%)	564
4 O2 low (>30% sat.)	42
5 O2 very low(10% sat)	6

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	379
3 alphamesosaprobous	552
4 alphameso ->polysabrobous	42
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	12
4 meso-eutraphentic	345
5 eutraphentic	603
6 hypereutraphentic	0
7 oligo to eutraphentic	12

Moisture	
1 aquatic strict	352
2 aerophilous occas.	36
3 aquatic to subaerien	585
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	400
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	3
5 eut = eutraphent	570
6 tol = tolerant	27
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	400
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	6
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	536
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	18
8 alpha-meso polysaprob	0
9 polysaprob	36

LANGE-BERTALOT 1979	
1 most pollution tolerant	36
2a alpha-mesosaprobic a	3
2b alpha-mesosaprobic b	6
2c Ecological questionable	0
3a More sensible (abundant)	3
3b More sensible (less frequent)	3

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	27
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	397
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	633
1 saprophile species	355
2 saproxene species	12

Denys 1991

LIFEFORM	
0 unknown	564
2 euplanktonic	0
3 tychoplanktonic epontic origin	412
4 tychoplanktonic, benthic origin	24
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

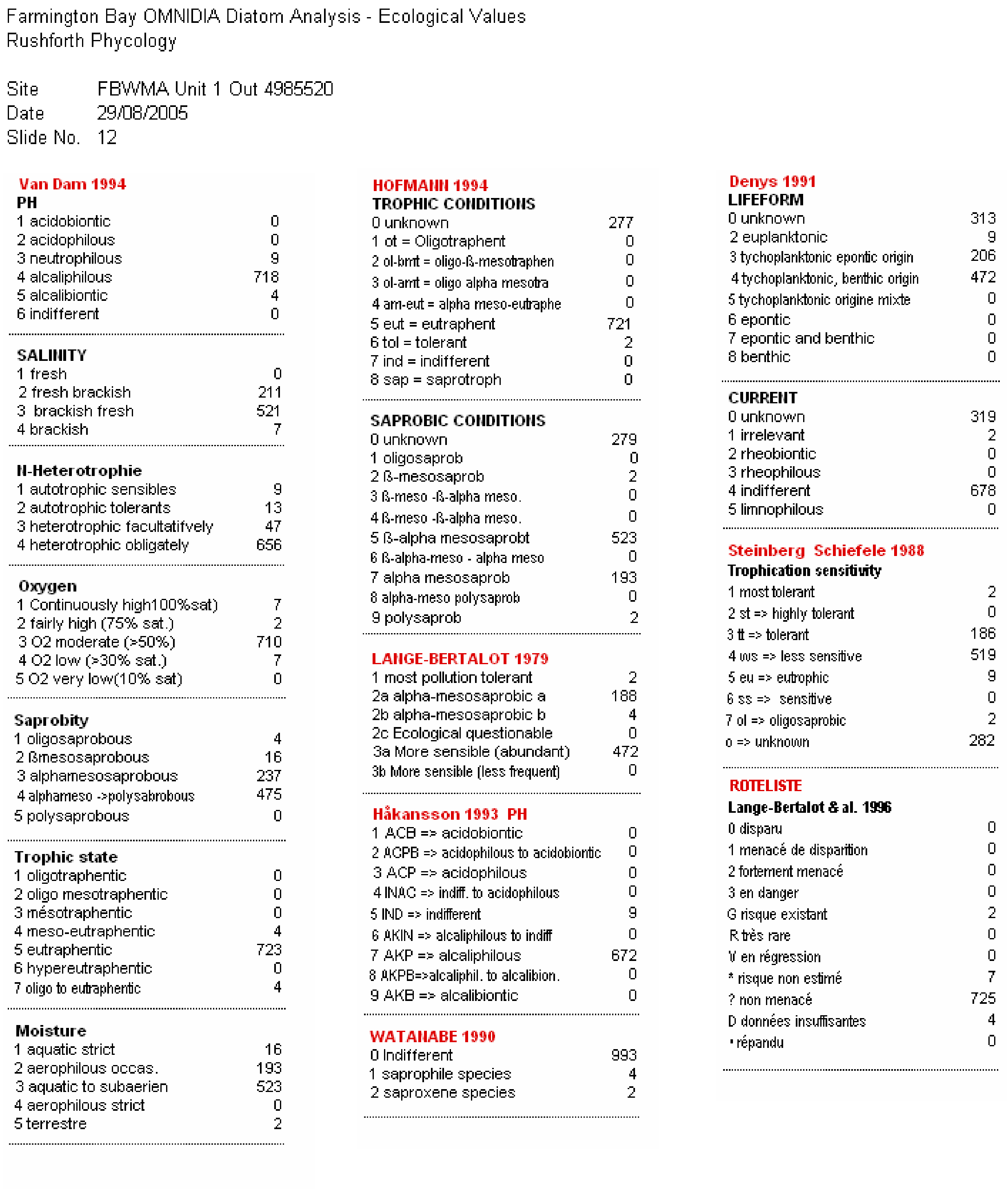
CURRENT	
0 unknown	564
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	436
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	21
2 st => highly tolerant	15
3 tt => tolerant	0
4 ws => less sensitive	533
5 eu => eutrophic	18
6 ss => sensitive	6
7 ol => oligosaprobic	342
o => unknown	64

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	12
V en régression	0
* risque non estimé	3
? non menacé	955
D données insuffisantes	3
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site FBWMA Unit 1 Out 4985520
Date 29/08/2005
Slide No. 12

Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	9
4 alcaliphilous	718
5 alcalibiontic	4
6 indifferent	0

SALINITY

1 fresh	0
2 fresh brackish	211
3 brackish fresh	521
4 brackish	7

N-Heterotrophie

1 autotrophic sensibles	9
2 autotrophic tolerants	13
3 heterotrophic facultatifvely	47
4 heterotrophic obligately	656

Oxygen

1 Continuously high100%sat)	7
2 fairly high (75% sat.)	2
3 O2 moderate (>50%)	710
4 O2 low (>30% sat.)	7
5 O2 very low(10% sat)	0

Saprobity

1 oligosaprobous	4
2 ßmesosaprobous	16
3 alphamesosaprobous	237
4 alphameso ->polysabrobous	475
5 polysaprobous	0

Trophic state

1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	4
5 eutraphentic	723
6 hypereutraphentic	0
7 oligo to eutraphentic	4

Moisture

1 aquatic strict	16
2 aerophilous occas.	193
3 aquatic to subaerien	523
4 aerophilous strict	0
5 terrestre	2

HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	277
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	721
6 tol = tolerant	2
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS

0 unknown	279
1 oligosaprob	0
2 ß-mesosaprob	2
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	523
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	193
8 alpha-meso polysaprob	0
9 polysaprob	2

LANGE-BERTALOT 1979

1 most pollution tolerant	2
2a alpha-mesosaprobic a	188
2b alpha-mesosaprobic b	4
2c Ecological questionable	0
3a More sensible (abundant)	472
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	9
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	672
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	993
1 saprophile species	4
2 saproxene species	2

Denys 1991

LIFEFORM

0 unknown	313
2 euplanktonic	9
3 tychoplanktonic epontic origin	206
4 tychoplanktonic, benthic origin	472
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	319
1 irrelevant	2
2 rheobiontic	0
3 rheophilous	0
4 indifferent	678
5 limnophilous	0

Steinberg Schiefele 1988

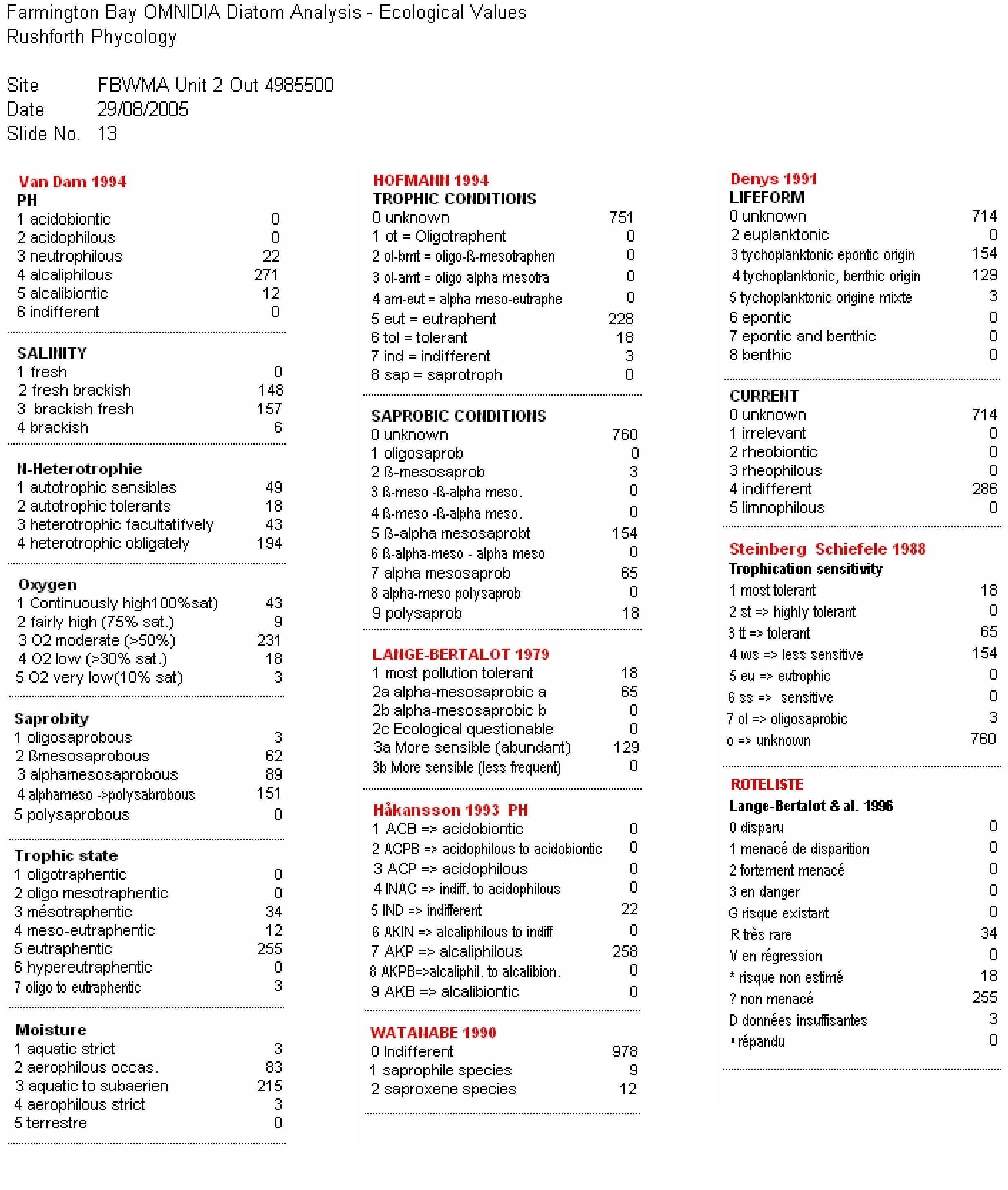
Trophication sensitivity

1 most tolerant	2
2 st => highly tolerant	0
3 tt => tolerant	186
4 ws => less sensitive	519
5 eu => eutrophic	9
6 ss => sensitive	0
7 ol => oligosaprobic	2
o => unknown	282

ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	2
R très rare	0
V en régression	0
* risque non estimé	7
? non menacé	725
D données insuffisantes	4
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site	FBWMA Unit 2 Out 4985500
Date	29/08/2005
Slide No.	13

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	22
4 alcaliphilous	271
5 alcalibiontic	12
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	148
3 brackish fresh	157
4 brackish	6

N-Heterotrophie	
1 autotrophic sensibles	49
2 autotrophic tolerants	18
3 heterotrophic facultatifvely	43
4 heterotrophic obligately	194

Oxygen	
1 Continuously high100%sat)	43
2 fairly high (75% sat.)	9
3 O2 moderate (>50%)	231
4 O2 low (>30% sat.)	18
5 O2 very low(10% sat)	3

Saprobity	
1 oligosaprobous	3
2 ßmesosaprobous	62
3 alphamesosaprobous	89
4 alphameso ->polysabrobous	151
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	34
4 meso-eutraphentic	12
5 eutraphentic	255
6 hypereutraphentic	0
7 oligo to eutraphentic	3

Moisture	
1 aquatic strict	3
2 aerophilous occas.	83
3 aquatic to subaerien	215
4 aerophilous strict	3
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	751
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	228
6 tol = tolerant	18
7 ind = indifferent	3
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	760
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	154
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	65
8 alpha-meso polysaprob	0
9 polysaprob	18

LANGE-BERTALOT 1979	
1 most pollution tolerant	18
2a alpha-mesosaprobic a	65
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	129
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	22
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	258
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	978
1 saprophile species	9
2 saproxene species	12

Denys 1991

LIFEFORM	
0 unknown	714
2 euplanktonic	0
3 tychoplanktonic epontic origin	154
4 tychoplanktonic, benthic origin	129
5 tychoplanktonic origine mixte	3
6 epontic	0
7 epontic and benthic	0
8 benthic	0

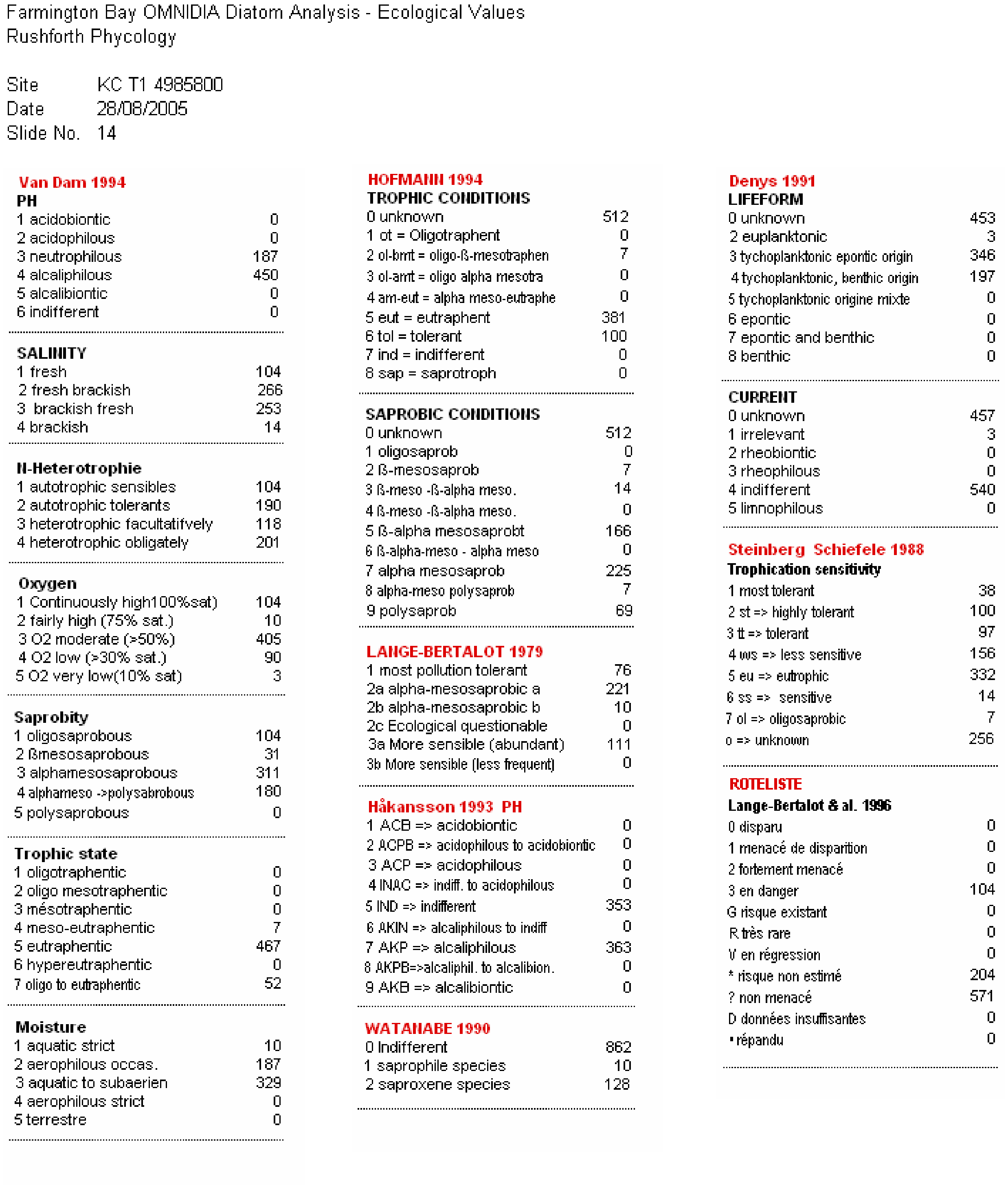
CURRENT	
0 unknown	714
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	286
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	18
2 st => highly tolerant	0
3 tt => tolerant	65
4 ws => less sensitive	154
5 eu => eutrophic	0
6 ss => sensitive	0
7 ol => oligosaprobic	3
o => unknown	760

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	34
V en régression	0
* risque non estimé	18
? non menacé	255
D données insuffisantes	3
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site KC T1 4985800
Date 28/08/2005
Slide No. 14

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	187
4 alcaliphilous	450
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	104
2 fresh brackish	266
3 brackish fresh	253
4 brackish	14

N-Heterotrophie	
1 autotrophic sensibles	104
2 autotrophic tolerants	190
3 heterotrophic facultatifvely	118
4 heterotrophic obligately	201

Oxygen	
1 Continuously high100%sat)	104
2 fairly high (75% sat.)	10
3 O2 moderate (>50%)	405
4 O2 low (>30% sat.)	90
5 O2 very low(10% sat)	3

Saprobity	
1 oligosaprobous	104
2 ßmesosaprobous	31
3 alphamesosaprobous	311
4 alphameso ->polysabrobous	180
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	7
5 eutraphentic	467
6 hypereutraphentic	0
7 oligo to eutraphentic	52

Moisture	
1 aquatic strict	10
2 aerophilous occas.	187
3 aquatic to subaerien	329
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	512
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	7
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	381
6 tol = tolerant	100
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	512
1 oligosaprob	0
2 ß-mesosaprob	7
3 ß-meso -ß-alpha meso.	14
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	166
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	225
8 alpha-meso polysaprob	7
9 polysaprob	69

LANGE-BERTALOT 1979	
1 most pollution tolerant	76
2a alpha-mesosaprobic a	221
2b alpha-mesosaprobic b	10
2c Ecological questionable	0
3a More sensible (abundant)	111
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	353
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	363
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	862
1 saprophile species	10
2 saproxene species	128

Denys 1991

LIFEFORM	
0 unknown	453
2 euplanktonic	3
3 tychoplanktonic epontic origin	346
4 tychoplanktonic, benthic origin	197
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

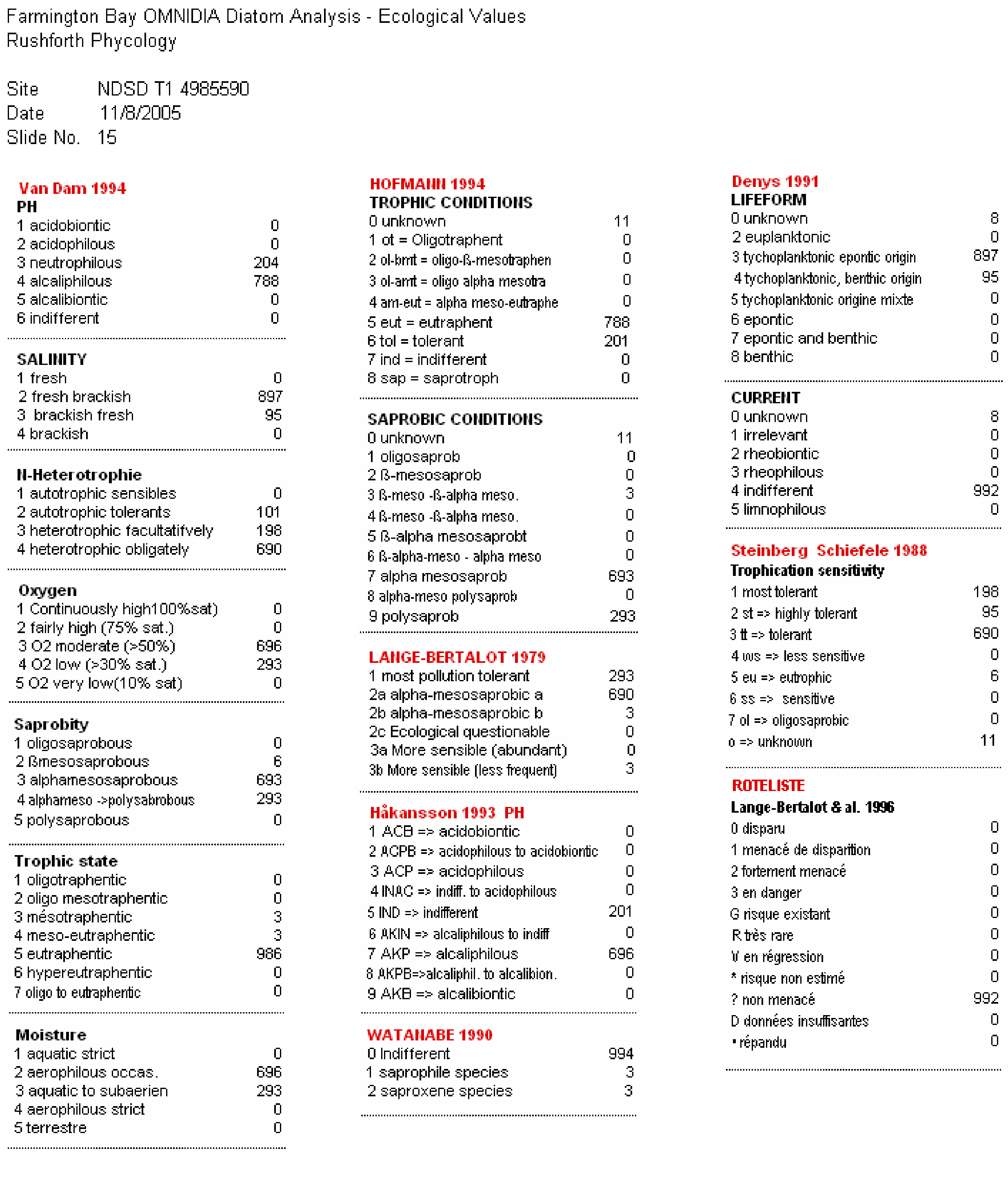
CURRENT	
0 unknown	457
1 irrelevant	3
2 rheobiontic	0
3 rheophilous	0
4 indifferent	540
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	38
2 st => highly tolerant	100
3 tt => tolerant	97
4 ws => less sensitive	156
5 eu => eutrophic	332
6 ss => sensitive	14
7 ol => oligosaprobic	7
o => unknown	256

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	104
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	204
? non menacé	571
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site NDSD T1 4985590
Date 11/8/2005
Slide No. 15

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	204
4 alcaliphilous	788
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	897
3 brackish fresh	95
4 brackish	0

N-Heterotrophie	
1 autotrophic sensibles	0
2 autotrophic tolerants	101
3 heterotrophic facultatifvely	198
4 heterotrophic obligately	690

Oxygen	
1 Continuously high100%sat)	0
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	696
4 O2 low (>30% sat.)	293
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	6
3 alphamesosaprobous	693
4 alphameso ->polysabrobous	293
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	3
4 meso-eutraphentic	3
5 eutraphentic	986
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	0
2 aerophilous occas.	696
3 aquatic to subaerien	293
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	11
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	788
6 tol = tolerant	201
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	11
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	0
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	693
8 alpha-meso polysaprob	0
9 polysaprob	293

LANGE-BERTALOT 1979	
1 most pollution tolerant	293
2a alpha-mesosaprobic a	690
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	0
3b More sensible (less frequent)	3

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	201
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	696
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	994
1 saprophile species	3
2 saproxene species	3

Denys 1991

LIFEFORM	
0 unknown	8
2 euplanktonic	0
3 tychoplanktonic epontic origin	897
4 tychoplanktonic, benthic origin	95
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

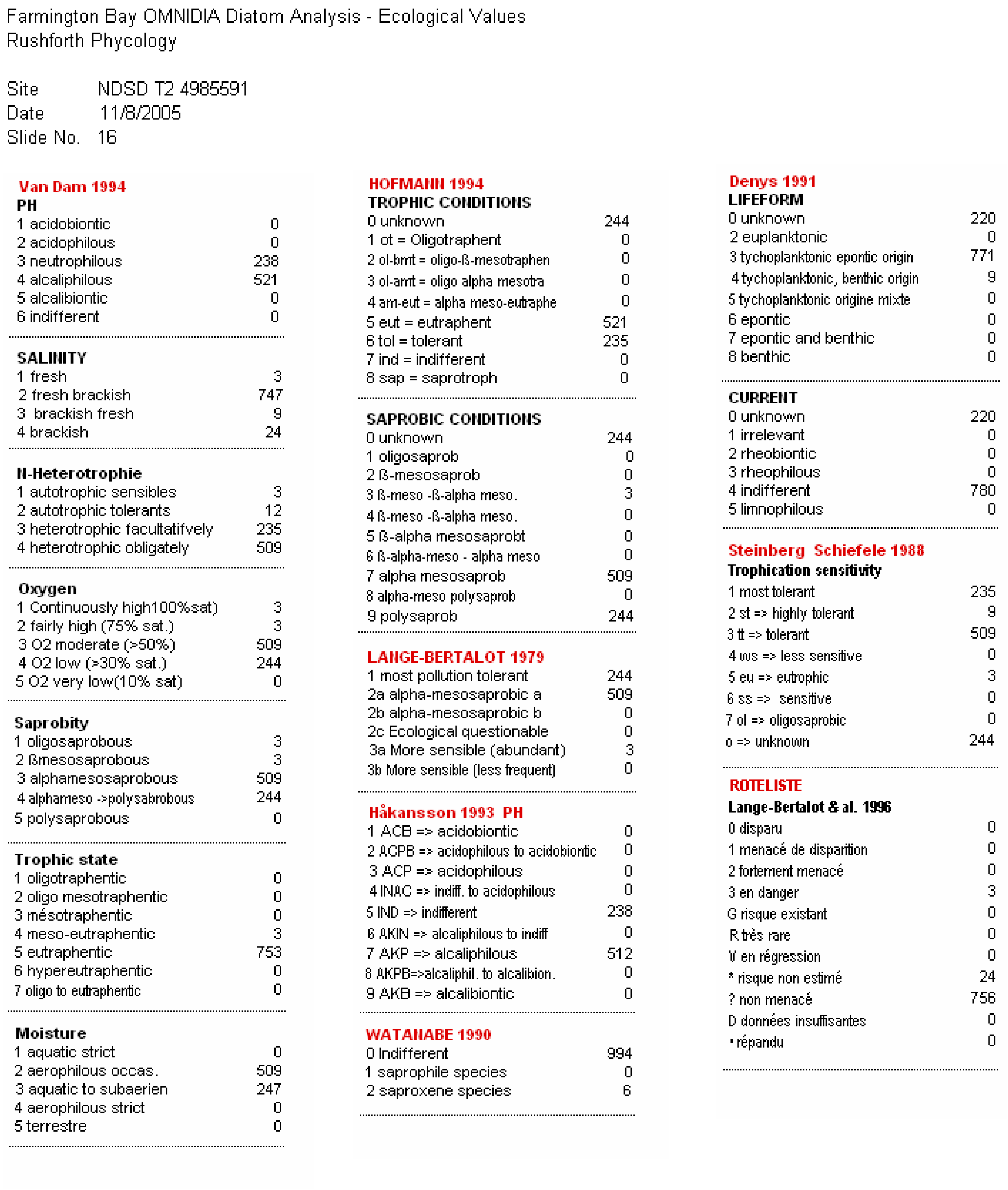
CURRENT	
0 unknown	8
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	992
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	198
2 st => highly tolerant	95
3 tt => tolerant	690
4 ws => less sensitive	0
5 eu => eutrophic	6
6 ss => sensitive	0
7 ol => oligosaprobic	0
o => unknown	11

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	0
? non menacé	992
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site NDSD T2 4985591
Date 11/8/2005
Slide No. 16

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	238
4 alcaliphilous	521
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	3
2 fresh brackish	747
3 brackish fresh	9
4 brackish	24

N-Heterotrophie	
1 autotrophic sensibles	3
2 autotrophic tolerants	12
3 heterotrophic facultatifvely	235
4 heterotrophic obligately	509

Oxygen	
1 Continuously high100%sat)	3
2 fairly high (75% sat.)	3
3 O2 moderate (>50%)	509
4 O2 low (>30% sat.)	244
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	3
2 ßmesosaprobous	3
3 alphamesosaprobous	509
4 alphameso ->polysabrobous	244
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	3
5 eutraphentic	753
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	0
2 aerophilous occas.	509
3 aquatic to subaerien	247
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	244
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	521
6 tol = tolerant	235
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	244
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	0
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	509
8 alpha-meso polysaprob	0
9 polysaprob	244

LANGE-BERTALOT 1979

1 most pollution tolerant	244
2a alpha-mesosaprobic a	509
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	3
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	238
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	512
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	994
1 saprophile species	0
2 saproxene species	6

Denys 1991

LIFEFORM	
0 unknown	220
2 euplanktonic	0
3 tychoplanktonic epontic origin	771
4 tychoplanktonic, benthic origin	9
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

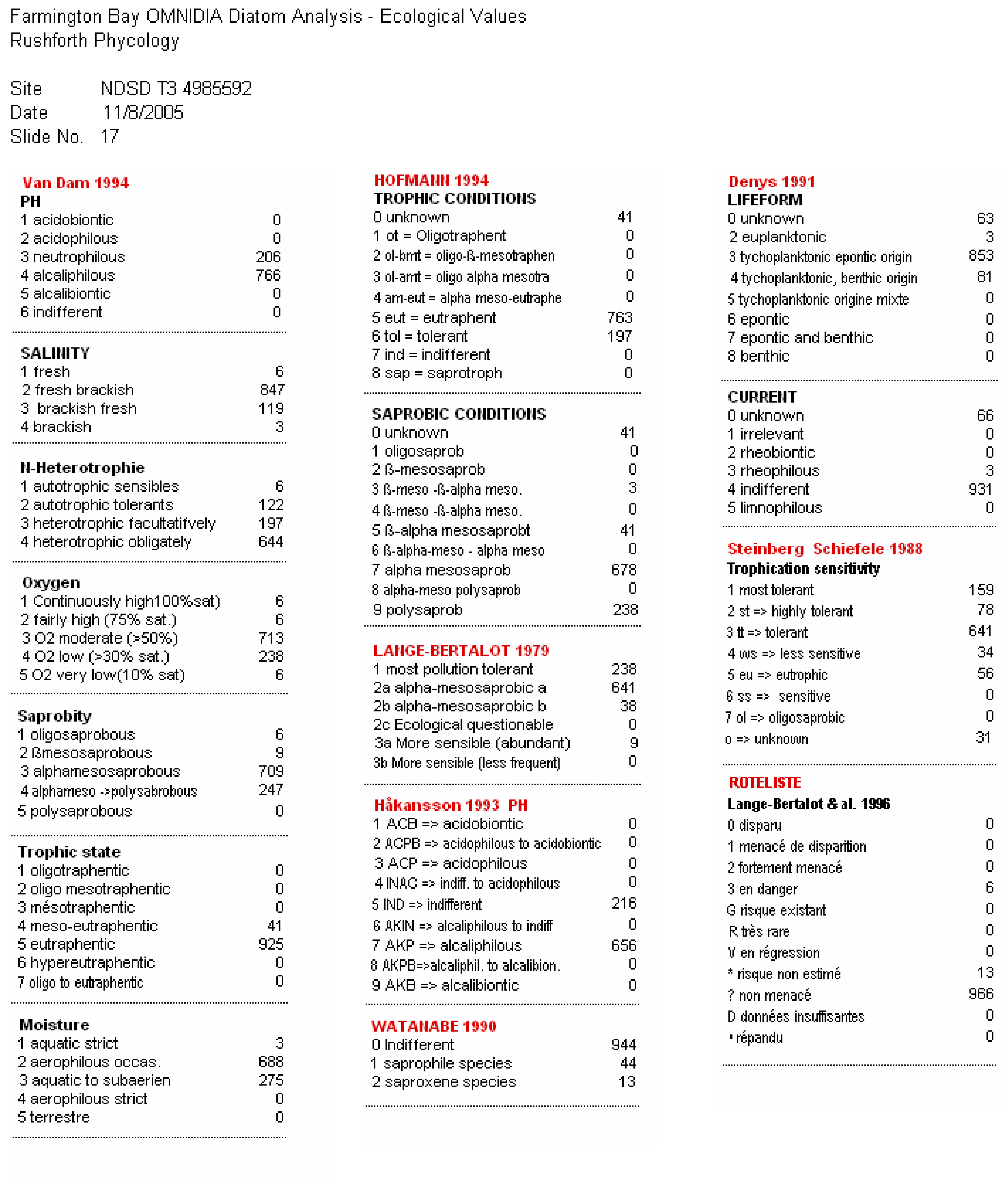
CURRENT	
0 unknown	220
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	780
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	235
2 st => highly tolerant	9
3 tt => tolerant	509
4 ws => less sensitive	0
5 eu => eutrophic	3
6 ss => sensitive	0
7 ol => oligosaprobic	0
o => unknown	244

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	3
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	24
? non menacé	756
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site NDSD T3 4985592
Date 11/8/2005
Slide No. 17

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	206
4 alcaliphilous	766
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	6
2 fresh brackish	847
3 brackish fresh	119
4 brackish	3

N-Heterotrophie	
1 autotrophic sensibles	6
2 autotrophic tolerants	122
3 heterotrophic facultatifvely	197
4 heterotrophic obligately	644

Oxygen	
1 Continuously high100%sat)	6
2 fairly high (75% sat.)	6
3 O2 moderate (>50%)	713
4 O2 low (>30% sat.)	238
5 O2 very low(10% sat)	6

Saprobity	
1 oligosaprobous	6
2 ßmesosaprobous	9
3 alphamesosaprobous	709
4 alphameso ->polysabrobous	247
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	41
5 eutraphentic	925
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	3
2 aerophilous occas.	688
3 aquatic to subaerien	275
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	41
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	763
6 tol = tolerant	197
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	41
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	41
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	678
8 alpha-meso polysaprob	0
9 polysaprob	238

LANGE-BERTALOT 1979

1 most pollution tolerant	238
2a alpha-mesosaprobic a	641
2b alpha-mesosaprobic b	38
2c Ecological questionable	0
3a More sensible (abundant)	9
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	216
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	656
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	944
1 saprophile species	44
2 saproxene species	13

Denys 1991

LIFEFORM	
0 unknown	63
2 euplanktonic	3
3 tychoplanktonic epontic origin	853
4 tychoplanktonic, benthic origin	81
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

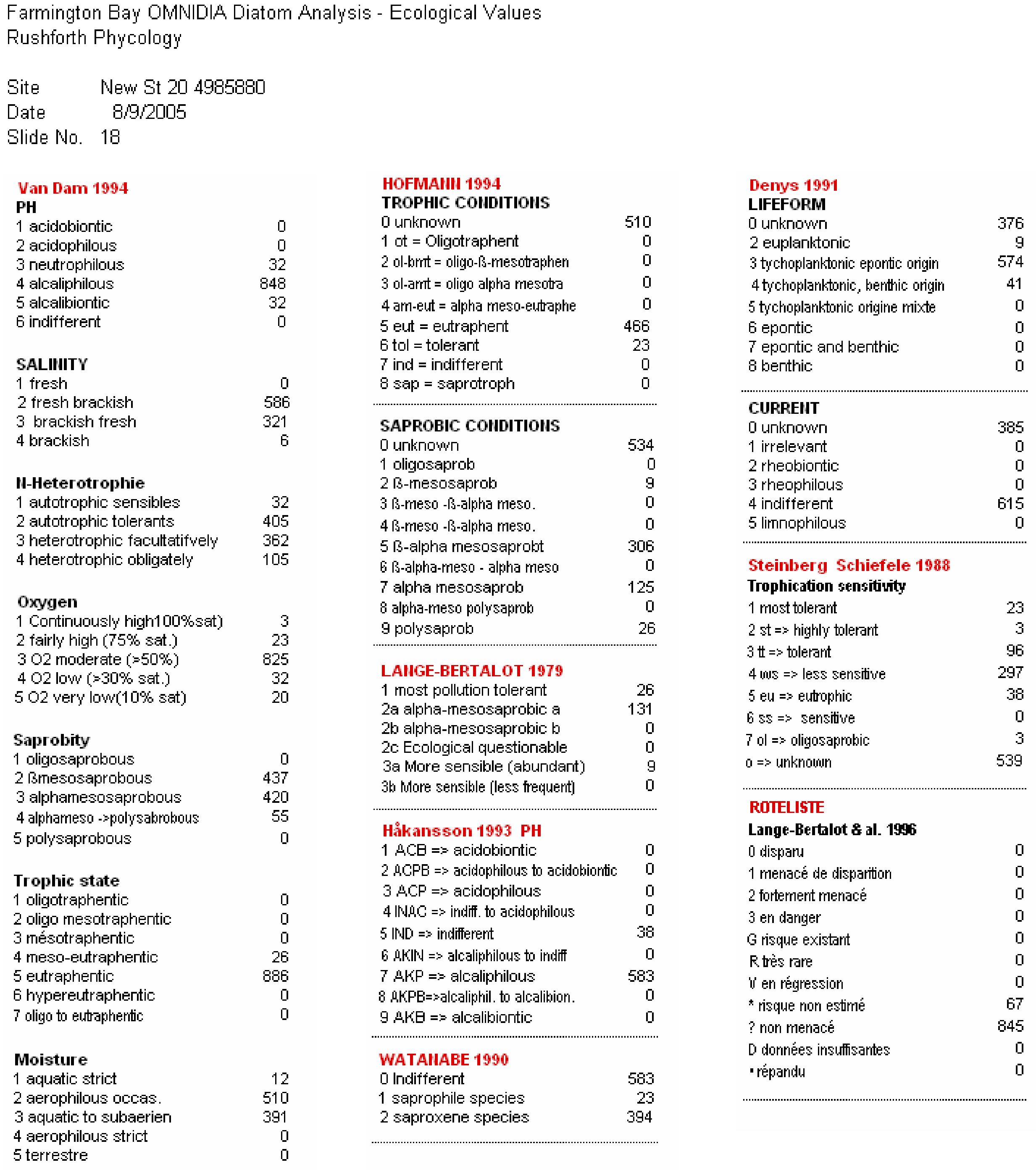
CURRENT	
0 unknown	66
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	3
4 indifferent	931
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	159
2 st => highly tolerant	78
3 tt => tolerant	641
4 ws => less sensitive	34
5 eu => eutrophic	56
6 ss => sensitive	0
7 ol => oligosaprobic	0
o => unknown	31

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	6
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	13
? non menacé	966
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site New St 20 4985880
Date 8/9/2005
Slide No. 18

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	32
4 alcaliphilous	848
5 alcalibiontic	32
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	586
3 brackish fresh	321
4 brackish	6

N-Heterotrophie	
1 autotrophic sensibles	32
2 autotrophic tolerants	405
3 heterotrophic facultatifvely	362
4 heterotrophic obligately	105

Oxygen	
1 Continuously high100%sat)	3
2 fairly high (75% sat.)	23
3 O2 moderate (>50%)	825
4 O2 low (>30% sat.)	32
5 O2 very low(10% sat)	20

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	437
3 alphamesosaprobous	420
4 alphameso ->polysabrobous	55
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	26
5 eutraphentic	886
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	12
2 aerophilous occas.	510
3 aquatic to subaerien	391
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	510
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	466
6 tol = tolerant	23
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	534
1 oligosaprob	0
2 ß-mesosaprob	9
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	306
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	125
8 alpha-meso polysaprob	0
9 polysaprob	26

LANGE-BERTALOT 1979	
1 most pollution tolerant	26
2a alpha-mesosaprobic a	131
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	9
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	38
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	583
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	583
1 saprophile species	23
2 saproxene species	394

Denys 1991

LIFEFORM	
0 unknown	376
2 euplanktonic	9
3 tychoplanktonic epontic origin	574
4 tychoplanktonic, benthic origin	41
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	385
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	615
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	23
2 st => highly tolerant	3
3 tt => tolerant	96
4 ws => less sensitive	297
5 eu => eutrophic	38
6 ss => sensitive	0
7 ol => oligosaprobic	3
o => unknown	539

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	67
? non menacé	845
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site New State 5-6 4985890
Date 6/11/2005
Slide No. 20

Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	84
4 alcaliphilous	860
5 alcalibiontic	0
6 indifferent	0

SALINITY

1 fresh	0
2 fresh brackish	779
3 brackish fresh	149
4 brackish	16

N-Heterotrophie

1 autotrophic sensibles	0
2 autotrophic tolerants	727
3 heterotrophic facultatifvely	130
4 heterotrophic obligately	78

Oxygen

1 Continuously high100%sat)	3
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	815
4 O2 low (>30% sat.)	110
5 O2 very low(10% sat)	6

Saprobity

1 oligosaprobous	0
2 ßmesosaprobous	688
3 alphamesosaprobous	133
4 alphameso ->polysabrobous	39
5 polysaprobous	75

Trophic state

1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	3
5 eutraphentic	860
6 hypereutraphentic	75
7 oligo to eutraphentic	6

Moisture

1 aquatic strict	3
2 aerophilous occas.	698
3 aquatic to subaerien	244
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	766
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	156
6 tol = tolerant	3
7 ind = indifferent	0
8 sap = saprotroph	75

SAPROBIC CONDITIONS

0 unknown	766
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	117
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	13
8 alpha-meso polysaprob	0
9 polysaprob	104

LANGE-BERTALOT 1979

1 most pollution tolerant	104
2a alpha-mesosaprobic a	13
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	3
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	84
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	711
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	231
1 saprophile species	84
2 saproxene species	685

Denys 1991

LIFEFORM

0 unknown	166
2 euplanktonic	0
3 tychoplanktonic epontic origin	718
4 tychoplanktonic, benthic origin	117
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	175
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	825
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity

1 most tolerant	78
2 st => highly tolerant	29
3 tt => tolerant	0
4 ws => less sensitive	117
5 eu => eutrophic	13
6 ss => sensitive	0
7 ol => oligosaprobic	3
o => unknown	760

ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	13
? non menacé	925
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site New St T1 4985870
Date 7/9/2005
Slide No. 19

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	15
4 alcaliphilous	337
5 alcalibiontic	0
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	293
3 brackish fresh	56
4 brackish	2

N-Heterotrophie	
1 autotrophic sensibles	2
2 autotrophic tolerants	180
3 heterotrophic facultatifvely	100
4 heterotrophic obligately	66

Oxygen	
1 Continuously high100%sat)	2
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	320
4 O2 low (>30% sat.)	17
5 O2 very low(10% sat)	10

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	171
3 alphamesosaprobous	149
4 alphameso ->polysabrobous	29
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	2
5 eutraphentic	349
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	2
2 aerophilous occas.	278
3 aquatic to subaerien	71
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	866
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	117
6 tol = tolerant	17
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	866
1 oligosaprob	0
2 ß-mesosaprob	0
3 ß-meso -ß-alpha meso.	2
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	37
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	78
8 alpha-meso polysaprob	0
9 polysaprob	17

LANGE-BERTALOT 1979

1 most pollution tolerant	17
2a alpha-mesosaprobic a	115
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	2
3b More sensible (less frequent)	2

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	15
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	298
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	820
1 saprophile species	10
2 saproxene species	171

Denys 1991

LIFEFORM	
0 unknown	63
2 euplanktonic	0
3 tychoplanktonic epontic origin	924
4 tychoplanktonic, benthic origin	12
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

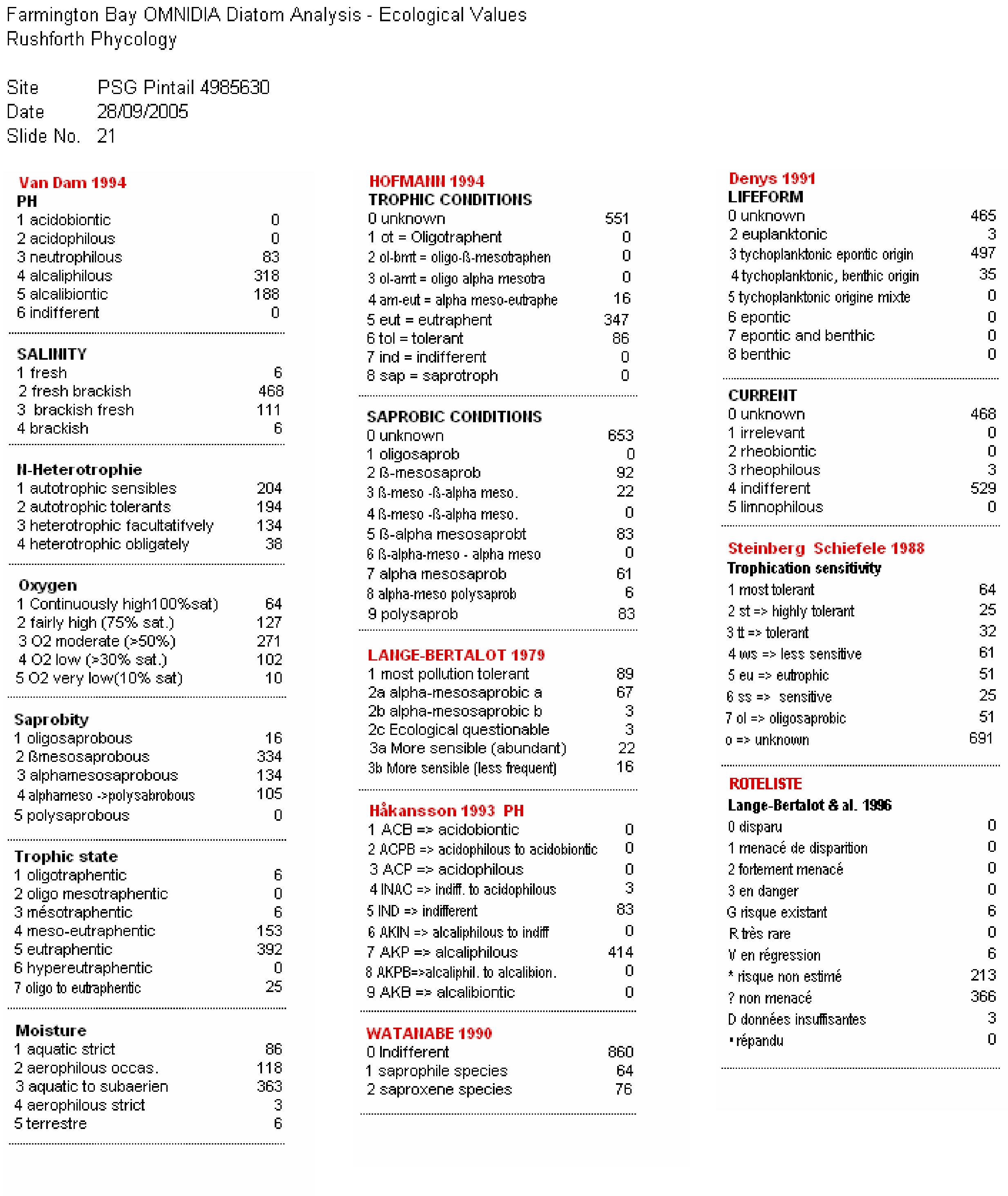
CURRENT	
0 unknown	66
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	934
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	15
2 st => highly tolerant	622
3 tt => tolerant	63
4 ws => less sensitive	37
5 eu => eutrophic	54
6 ss => sensitive	0
7 ol => oligosaprobic	0
o => unknown	210

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	5
? non menacé	963
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG Pintail 4985630
Date 28/09/2005
Slide No. 21

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	83
4 alcaliphilous	318
5 alcalibiontic	188
6 indifferent	0

SALINITY	
1 fresh	6
2 fresh brackish	468
3 brackish fresh	111
4 brackish	6

N-Heterotrophie	
1 autotrophic sensibles	204
2 autotrophic tolerants	194
3 heterotrophic facultatifvely	134
4 heterotrophic obligately	38

Oxygen	
1 Continuously high100%sat)	64
2 fairly high (75% sat.)	127
3 O2 moderate (>50%)	271
4 O2 low (>30% sat.)	102
5 O2 very low(10% sat)	10

Saprobity	
1 oligosaprobous	16
2 ßmesosaprobous	334
3 alphamesosaprobous	134
4 alphameso ->polysabrobous	105
5 polysaprobous	0

Trophic state	
1 oligotraphentic	6
2 oligo mesotraphentic	0
3 mésotraphentic	6
4 meso-eutraphentic	153
5 eutraphentic	392
6 hypereutraphentic	0
7 oligo to eutraphentic	25

Moisture	
1 aquatic strict	86
2 aerophilous occas.	118
3 aquatic to subaerien	363
4 aerophilous strict	3
5 terrestre	6

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	551
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	16
5 eut = eutraphent	347
6 tol = tolerant	86
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	653
1 oligosaprob	0
2 ß-mesosaprob	92
3 ß-meso -ß-alpha meso.	22
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	83
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	61
8 alpha-meso polysaprob	6
9 polysaprob	83

LANGE-BERTALOT 1979

1 most pollution tolerant	89
2a alpha-mesosaprobic a	67
2b alpha-mesosaprobic b	3
2c Ecological questionable	3
3a More sensible (abundant)	22
3b More sensible (less frequent)	16

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	3
5 IND => indifferent	83
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	414
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	860
1 saprophile species	64
2 saproxene species	76

Denys 1991

LIFEFORM	
0 unknown	465
2 euplanktonic	3
3 tychoplanktonic epontic origin	497
4 tychoplanktonic, benthic origin	35
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	468
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	3
4 indifferent	529
5 limnophilous	0

Steinberg Schiefele 1988

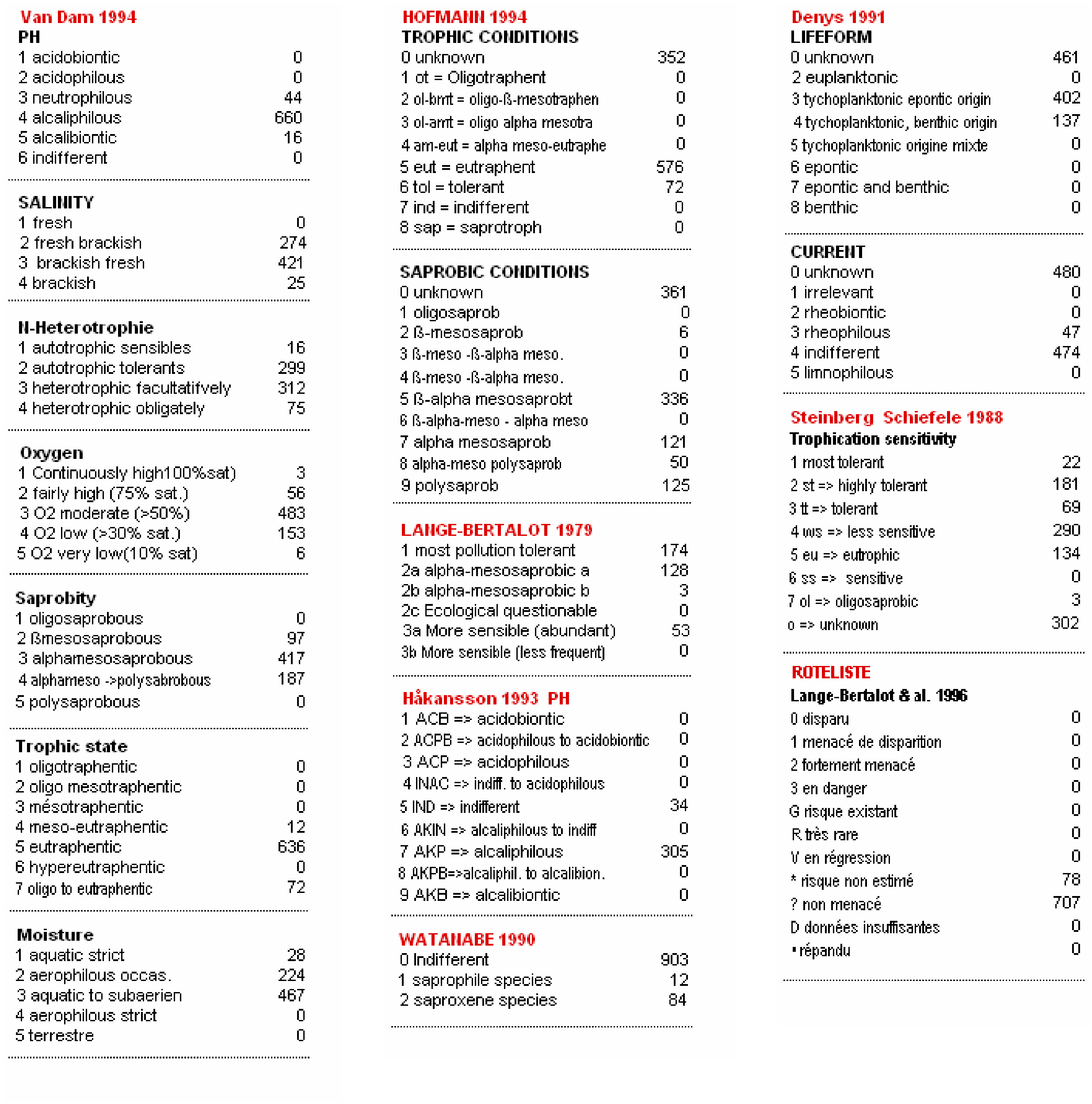
Trophication sensitivity	
1 most tolerant	64
2 st => highly tolerant	25
3 tt => tolerant	32
4 ws => less sensitive	61
5 eu => eutrophic	51
6 ss => sensitive	25
7 ol => oligosaprobic	51
o => unknown	691

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	6
R très rare	0
V en régression	6
* risque non estimé	213
? non menacé	366
D données insuffisantes	3
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG T1 4985623
Date 7/9/2005
Slide No. 22



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	44
4 alcaliphilous	660
5 alcalibiontic	16
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	274
3 brackish fresh	421
4 brackish	25

N-Heterotrophie	
1 autotrophic sensibles	16
2 autotrophic tolerants	299
3 heterotrophic facultatifvely	312
4 heterotrophic obligately	75

Oxygen	
1 Continuously high100%sat)	3
2 fairly high (75% sat.)	56
3 O2 moderate (>50%)	483
4 O2 low (>30% sat.)	153
5 O2 very low(10% sat)	6

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	97
3 alphamesosaprobous	417
4 alphameso ->polysabrobous	187
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	12
5 eutraphentic	636
6 hypereutraphentic	0
7 oligo to eutraphentic	72

Moisture	
1 aquatic strict	28
2 aerophilous occas.	224
3 aquatic to subaerien	467
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	352
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	576
6 tol = tolerant	72
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	361
1 oligosaprob	0
2 ß-mesosaprob	6
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	336
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	121
8 alpha-meso polysaprob	50
9 polysaprob	125

LANGE-BERTALOT 1979	
1 most pollution tolerant	174
2a alpha-mesosaprobic a	128
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	53
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	34
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	305
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	903
1 saprophile species	12
2 saproxene species	84

Denys 1991

LIFEFORM	
0 unknown	461
2 euplanktonic	0
3 tychoplanktonic epontic origin	402
4 tychoplanktonic, benthic origin	137
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

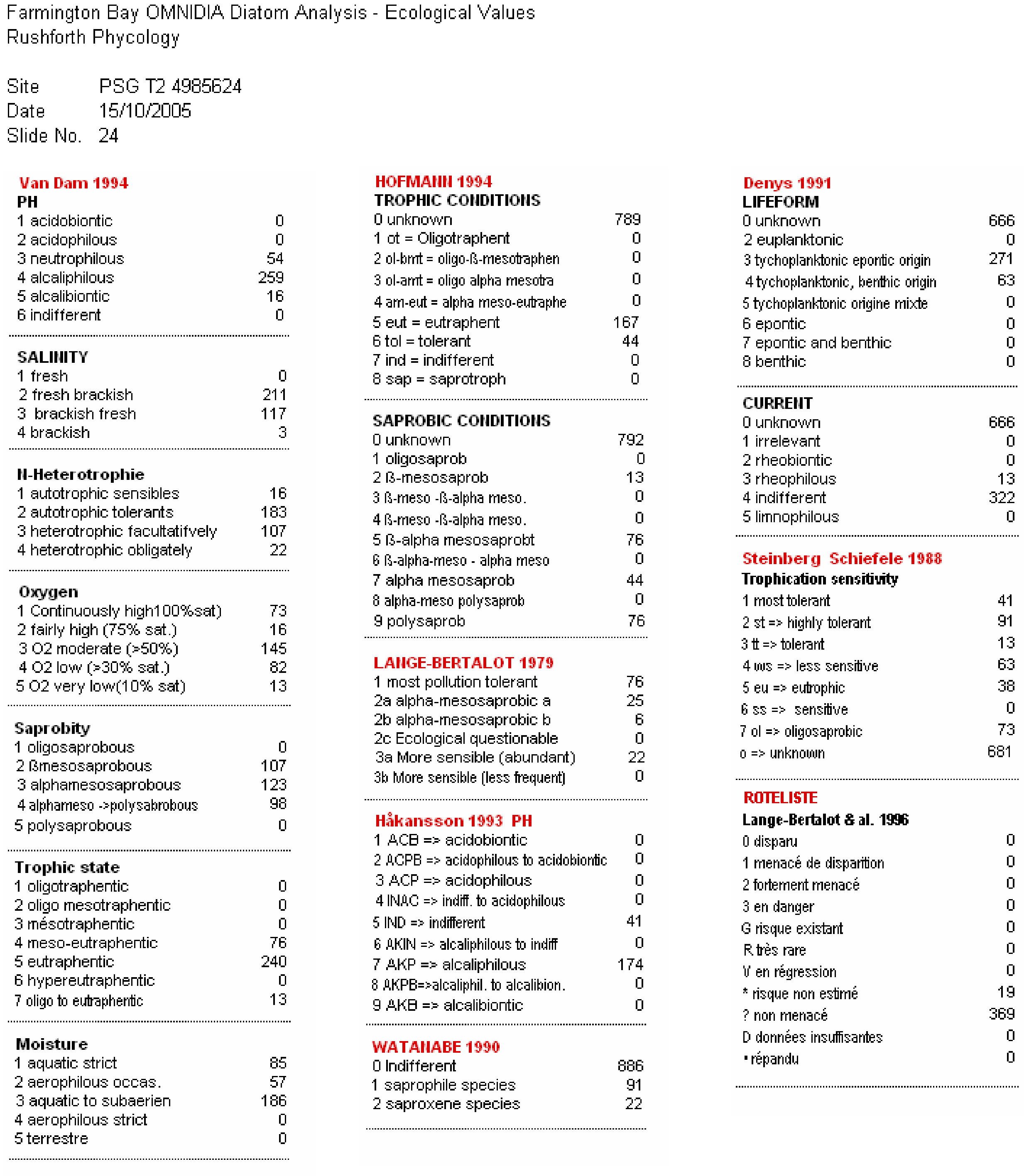
CURRENT	
0 unknown	480
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	47
4 indifferent	474
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	22
2 st => highly tolerant	181
3 tt => tolerant	69
4 ws => less sensitive	290
5 eu => eutrophic	134
6 ss => sensitive	0
7 ol => oligosaprobic	3
o => unknown	302

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	78
? non menacé	707
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG T2 4985624
Date 15/10/2005
Slide No. 24

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	54
4 alcaliphilous	259
5 alcalibiontic	16
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	211
3 brackish fresh	117
4 brackish	3

N-Heterotrophie	
1 autotrophic sensibles	16
2 autotrophic tolerants	183
3 heterotrophic facultatifvely	107
4 heterotrophic obligately	22

Oxygen	
1 Continuously high100%sat)	73
2 fairly high (75% sat.)	16
3 O2 moderate (>50%)	145
4 O2 low (>30% sat.)	82
5 O2 very low(10% sat)	13

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	107
3 alphamesosaprobous	123
4 alphameso ->polysabrobous	98
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	76
5 eutraphentic	240
6 hypereutraphentic	0
7 oligo to eutraphentic	13

Moisture	
1 aquatic strict	85
2 aerophilous occas.	57
3 aquatic to subaerien	186
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	789
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	167
6 tol = tolerant	44
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	792
1 oligosaprob	0
2 ß-mesosaprob	13
3 ß-meso -ß-alpha meso.	0
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	76
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	44
8 alpha-meso polysaprob	0
9 polysaprob	76

LANGE-BERTALOT 1979

1 most pollution tolerant	76
2a alpha-mesosaprobic a	25
2b alpha-mesosaprobic b	6
2c Ecological questionable	0
3a More sensible (abundant)	22
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	41
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	174
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	886
1 saprophile species	91
2 saproxene species	22

Denys 1991

LIFEFORM	
0 unknown	666
2 euplanktonic	0
3 tychoplanktonic epontic origin	271
4 tychoplanktonic, benthic origin	63
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	666
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	13
4 indifferent	322
5 limnophilous	0

Steinberg Schiefele 1988

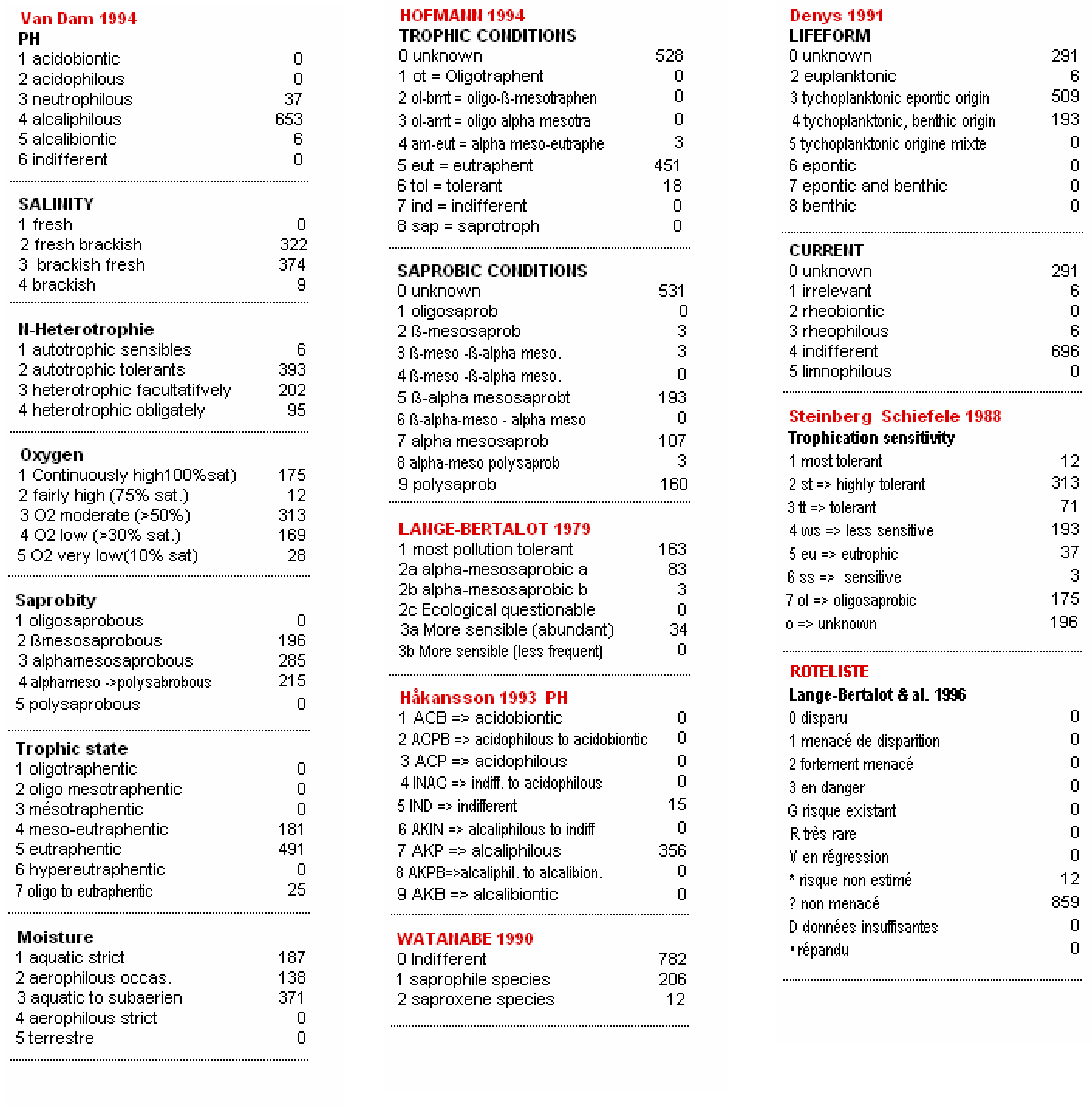
Trophication sensitivity	
1 most tolerant	41
2 st => highly tolerant	91
3 tt => tolerant	13
4 ws => less sensitive	63
5 eu => eutrophic	38
6 ss => sensitive	0
7 ol => oligosaprobic	73
o => unknown	681

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	19
? non menacé	369
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG T2 4985624
Date 7/9/2005
Slide No. 23



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	37
4 alcaliphilous	653
5 alcalibiontic	6
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	322
3 brackish fresh	374
4 brackish	9

N-Heterotrophie	
1 autotrophic sensibles	6
2 autotrophic tolerants	393
3 heterotrophic facultatifvely	202
4 heterotrophic obligately	95

Oxygen	
1 Continuously high100%sat)	175
2 fairly high (75% sat.)	12
3 O2 moderate (>50%)	313
4 O2 low (>30% sat.)	169
5 O2 very low(10% sat)	28

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	196
3 alphamesosaprobous	285
4 alphameso ->polysabrobous	215
5 polysaprobous	0

Trophic state	
1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	181
5 eutraphentic	491
6 hypereutraphentic	0
7 oligo to eutraphentic	25

Moisture	
1 aquatic strict	187
2 aerophilous occas.	138
3 aquatic to subaerien	371
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	528
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	3
5 eut = eutraphent	451
6 tol = tolerant	18
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	531
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	193
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	107
8 alpha-meso polysaprob	3
9 polysaprob	160

LANGE-BERTALOT 1979	
1 most pollution tolerant	163
2a alpha-mesosaprobic a	83
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	34
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	15
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	356
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	782
1 saprophile species	206
2 saproxene species	12

Denys 1991

LIFEFORM	
0 unknown	291
2 euplanktonic	6
3 tychoplanktonic epontic origin	509
4 tychoplanktonic, benthic origin	193
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	291
1 irrelevant	6
2 rheobiontic	0
3 rheophilous	6
4 indifferent	696
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	12
2 st => highly tolerant	313
3 tt => tolerant	71
4 ws => less sensitive	193
5 eu => eutrophic	37
6 ss => sensitive	3
7 ol => oligosaprobic	175
o => unknown	196

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	12
? non menacé	859
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG T5
Date 9/9/2005
Slide No. 25

Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	6
4 alcaliphilous	483
5 alcalibiontic	9
6 indifferent	0

SALINITY

1 fresh	0
2 fresh brackish	163
3 brackish fresh	328
4 brackish	12

N-Heterotrophie

1 autotrophic sensibles	9
2 autotrophic tolerants	265
3 heterotrophic facultatifvely	148
4 heterotrophic obligately	67

Oxygen

1 Continuously high100%sat)	0
2 fairly high (75% sat.)	6
3 O2 moderate (>50%)	323
4 O2 low (>30% sat.)	157
5 O2 very low(10% sat)	3

Saprobity

1 oligosaprobous	0
2 ßmesosaprobous	58
3 alphamesosaprobous	323
4 alphameso ->polysabrobous	110
5 polysaprobous	0

Trophic state

1 oligotraphentic	0
2 oligo mesotraphentic	0
3 mésotraphentic	3
4 meso-eutraphentic	0
5 eutraphentic	491
6 hypereutraphentic	0
7 oligo to eutraphentic	3

Moisture

1 aquatic strict	84
2 aerophilous occas.	90
3 aquatic to subaerien	320
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	605
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	6
5 eut = eutraphent	390
6 tol = tolerant	0
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS

0 unknown	605
1 oligosaprob	0
2 ß-mesosaprob	9
3 ß-meso -ß-alpha meso.	9
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	169
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	125
8 alpha-meso polysaprob	0
9 polysaprob	84

LANGE-BERTALOT 1979

1 most pollution tolerant	84
2a alpha-mesosaprobic a	116
2b alpha-mesosaprobic b	6
2c Ecological questionable	0
3a More sensible (abundant)	29
3b More sensible (less frequent)	3

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	0
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	209
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	951
1 saprophile species	9
2 saproxene species	41

Denys 1991

LIFEFORM

0 unknown	642
2 euplanktonic	0
3 tychoplanktonic epontic origin	247
4 tychoplanktonic, benthic origin	110
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	648
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	352
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity

1 most tolerant	0
2 st => highly tolerant	84
3 tt => tolerant	44
4 ws => less sensitive	169
5 eu => eutrophic	12
6 ss => sensitive	6
7 ol => oligosaprobic	0
o => unknown	686

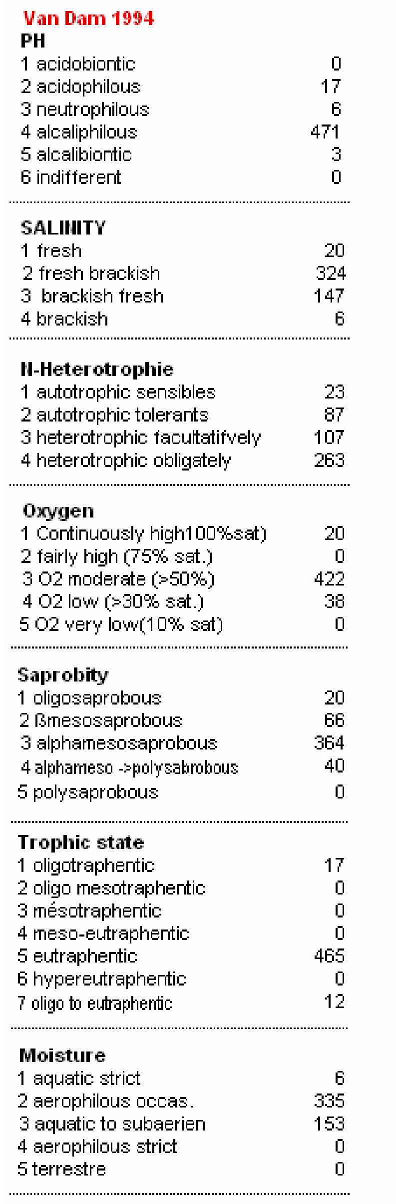
ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	15
? non menacé	483
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG T6 4985625
Date 5/10/2005
Slide No. 26



Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	17
3 neutrophilous	6
4 alcaliphilous	471
5 alcalibiontic	3
6 indifferent	0

SALINITY	
1 fresh	20
2 fresh brackish	324
3 brackish fresh	147
4 brackish	6

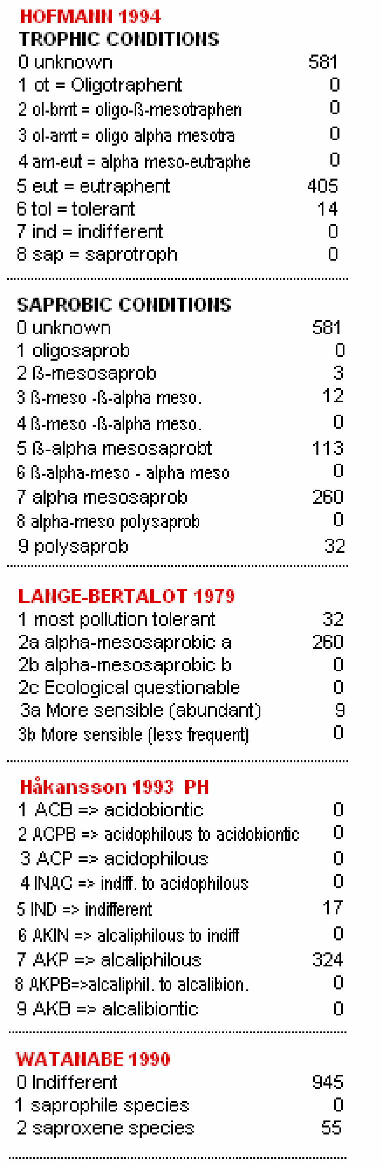
N-Heterotrophie	
1 autotrophic sensibles	23
2 autotrophic tolerants	87
3 heterotrophic facultatifvely	107
4 heterotrophic obligately	263

Oxygen	
1 Continuously high100%sat)	20
2 fairly high (75% sat.)	0
3 O2 moderate (>50%)	422
4 O2 low (>30% sat.)	38
5 O2 very low(10% sat)	0

Saprobity	
1 oligosaprobous	20
2 ßmesosaprobous	66
3 alphamesosaprobous	364
4 alphameso ->polysabrobous	40
5 polysaprobous	0

Trophic state	
1 oligotraphentic	17
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	0
5 eutraphentic	465
6 hypereutraphentic	0
7 oligo to eutraphentic	12

Moisture	
1 aquatic strict	6
2 aerophilous occas.	335
3 aquatic to subaerien	153
4 aerophilous strict	0
5 terrestre	0



HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	581
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	405
6 tol = tolerant	14
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	581
1 oligosaprob	0
2 ß-mesosaprob	3
3 ß-meso -ß-alpha meso.	12
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	113
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	260
8 alpha-meso polysaprob	0
9 polysaprob	32

LANGE-BERTALOT 1979

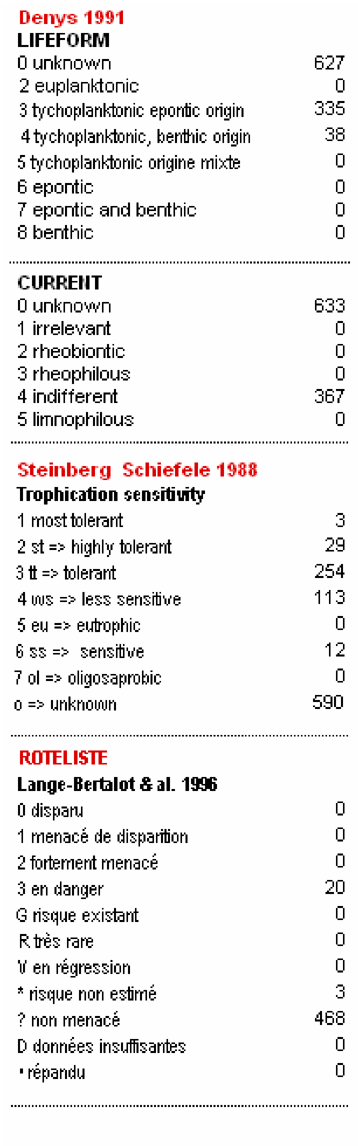
1 most pollution tolerant	32
2a alpha-mesosaprobic a	260
2b alpha-mesosaprobic b	0
2c Ecological questionable	0
3a More sensible (abundant)	9
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	17
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	324
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	945
1 saprophile species	0
2 saproxene species	55



Denys 1991

LIFEFORM	
0 unknown	627
2 euplanktonic	0
3 tychoplanktonic epontic origin	335
4 tychoplanktonic, benthic origin	38
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

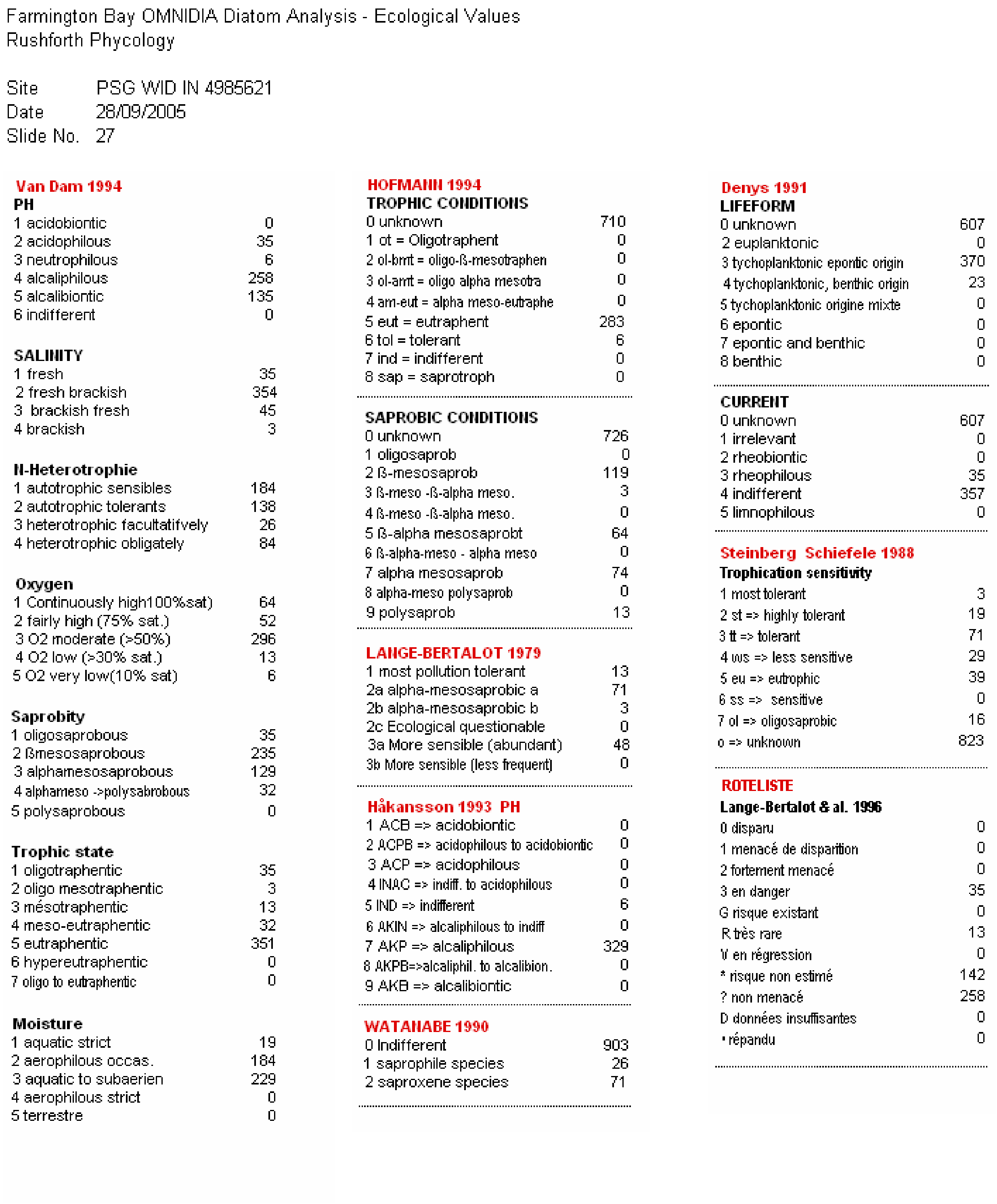
CURRENT	
0 unknown	633
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	0
4 indifferent	367
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	3
2 st => highly tolerant	29
3 tt => tolerant	254
4 ws => less sensitive	113
5 eu => eutrophic	0
6 ss => sensitive	12
7 ol => oligosaprobic	0
o => unknown	590

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	20
G risque existant	0
R très rare	0
V en régression	0
* risque non estimé	3
? non menacé	468
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG WID IN 4985621
Date 28/09/2005
Slide No. 27

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	35
3 neutrophilous	6
4 alcaliphilous	258
5 alcalibiontic	135
6 indifferent	0

SALINITY	
1 fresh	35
2 fresh brackish	354
3 brackish fresh	45
4 brackish	3

N-Heterotrophie	
1 autotrophic sensibles	184
2 autotrophic tolerants	138
3 heterotrophic facultatifvely	26
4 heterotrophic obligately	84

Oxygen	
1 Continuously high100%sat)	64
2 fairly high (75% sat.)	52
3 O2 moderate (>50%)	296
4 O2 low (>30% sat.)	13
5 O2 very low(10% sat)	6

Saprobity	
1 oligosaprobous	35
2 ßmesosaprobous	235
3 alphamesosaprobous	129
4 alphameso ->polysabrobous	32
5 polysaprobous	0

Trophic state	
1 oligotraphentic	35
2 oligo mesotraphentic	3
3 mésotraphentic	13
4 meso-eutraphentic	32
5 eutraphentic	351
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture	
1 aquatic strict	19
2 aerophilous occas.	184
3 aquatic to subaerien	229
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	710
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	283
6 tol = tolerant	6
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	726
1 oligosaprob	0
2 ß-mesosaprob	119
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	64
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	74
8 alpha-meso polysaprob	0
9 polysaprob	13

LANGE-BERTALOT 1979	
1 most pollution tolerant	13
2a alpha-mesosaprobic a	71
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	48
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	6
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	329
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	903
1 saprophile species	26
2 saproxene species	71

Denys 1991

LIFEFORM	
0 unknown	607
2 euplanktonic	0
3 tychoplanktonic epontic origin	370
4 tychoplanktonic, benthic origin	23
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	607
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	35
4 indifferent	357
5 limnophilous	0

Steinberg Schiefele 1988

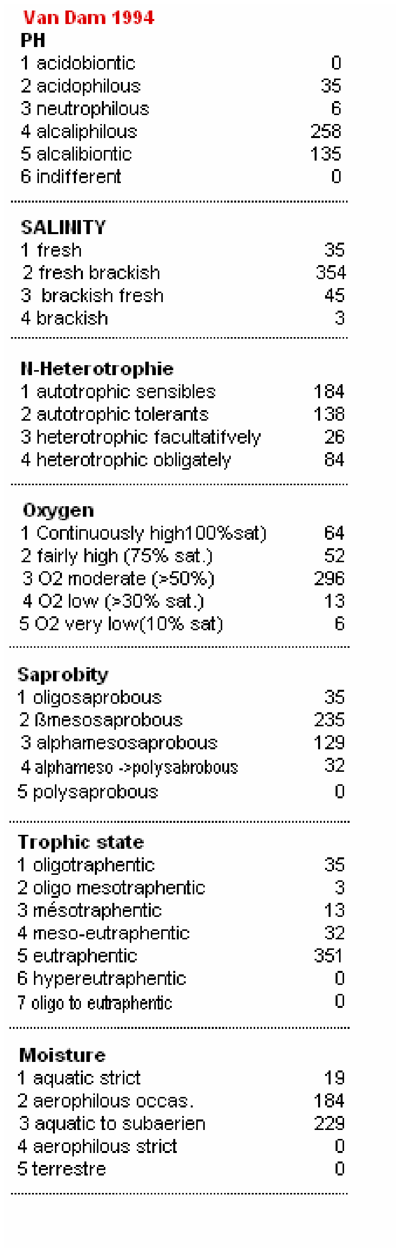
Trophication sensitivity	
1 most tolerant	3
2 st => highly tolerant	19
3 tt => tolerant	71
4 ws => less sensitive	29
5 eu => eutrophic	39
6 ss => sensitive	0
7 ol => oligosaprobic	16
o => unknown	823

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	35
G risque existant	0
R très rare	13
V en régression	0
* risque non estimé	142
? non menacé	258
D données insuffisantes	0
• répandu	0

Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site PSG WID OUT 4985620
Date 28/09/2005
Slide No. 28



Van Dam 1994

PH

1 acidobiontic	0
2 acidophilous	35
3 neutrophilous	6
4 alcaliphilous	258
5 alcalibiontic	135
6 indifferent	0

SALINITY

1 fresh	35
2 fresh brackish	354
3 brackish fresh	45
4 brackish	3

N-Heterotrophie

1 autotrophic sensibles	184
2 autotrophic tolerants	138
3 heterotrophic facultatifvely	26
4 heterotrophic obligately	84

Oxygen

1 Continuously high100%sat)	64
2 fairly high (75% sat.)	52
3 O2 moderate (>50%)	296
4 O2 low (>30% sat.)	13
5 O2 very low(10% sat)	6

Saprobity

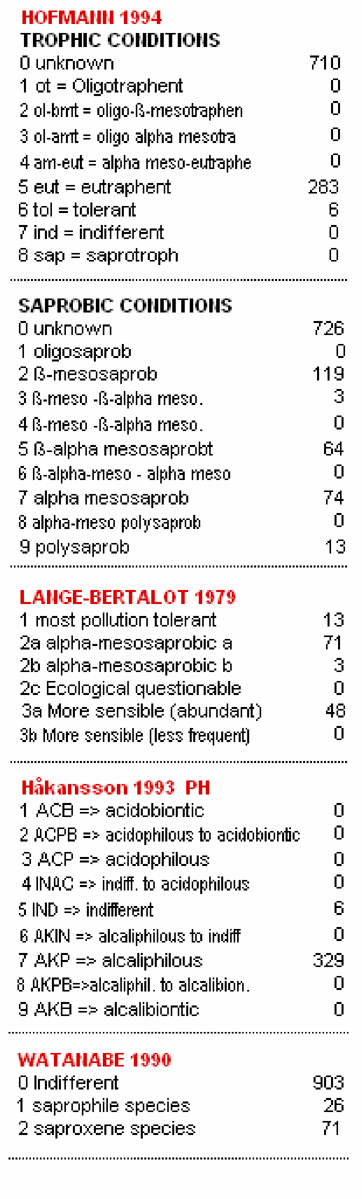
1 oligosaprobous	35
2 ßmesosaprobous	235
3 alphamesosaprobous	129
4 alphameso ->polysabrobous	32
5 polysaprobous	0

Trophic state

1 oligotraphentic	35
2 oligo mesotraphentic	3
3 mésotraphentic	13
4 meso-eutraphentic	32
5 eutraphentic	351
6 hypereutraphentic	0
7 oligo to eutraphentic	0

Moisture

1 aquatic strict	19
2 aerophilous occas.	184
3 aquatic to subaerien	229
4 aerophilous strict	0
5 terrestre	0



HOFMANN 1994

TROPHIC CONDITIONS

0 unknown	710
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	0
5 eut = eutraphent	283
6 tol = tolerant	6
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS

0 unknown	726
1 oligosaprob	0
2 ß-mesosaprob	119
3 ß-meso -ß-alpha meso.	3
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	64
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	74
8 alpha-meso polysaprob	0
9 polysaprob	13

LANGE-BERTALOT 1979

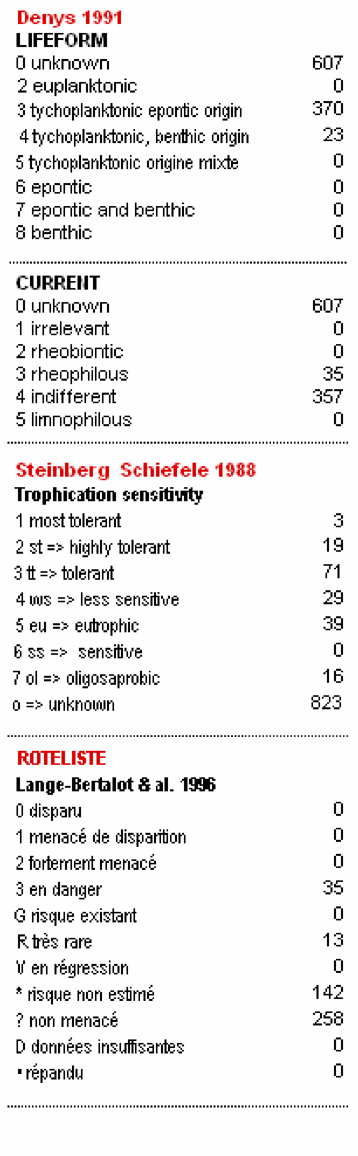
1 most pollution tolerant	13
2a alpha-mesosaprobic a	71
2b alpha-mesosaprobic b	3
2c Ecological questionable	0
3a More sensible (abundant)	48
3b More sensible (less frequent)	0

Håkansson 1993 PH

1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	6
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	329
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990

0 Indifferent	903
1 saprophile species	26
2 saproxene species	71



Denys 1991

LIFEFORM

0 unknown	607
2 euplanktonic	0
3 tychoplanktonic epontic origin	370
4 tychoplanktonic, benthic origin	23
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT

0 unknown	607
1 irrelevant	0
2 rheobiontic	0
3 rheophilous	35
4 indifferent	357
5 limnophilous	0

Steinberg Schiefele 1988

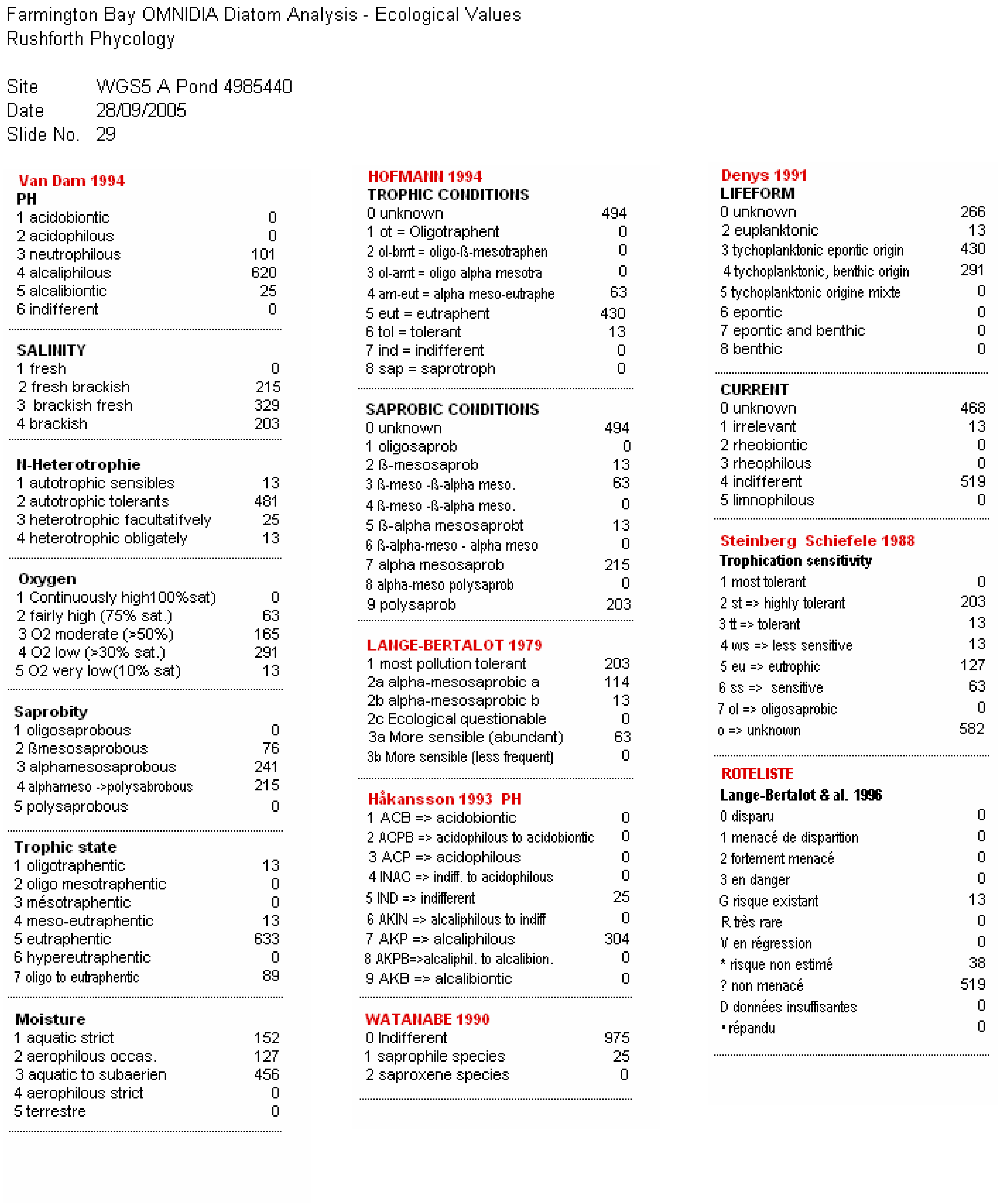
Trophication sensitivity

1 most tolerant	3
2 st => highly tolerant	19
3 tt => tolerant	71
4 ws => less sensitive	29
5 eu => eutrophic	39
6 ss => sensitive	0
7 ol => oligosaprobic	16
o => unknown	823

ROTELISTE

Lange-Bertalot & al. 1996

0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	35
G risque existant	0
R très rare	13
V en régression	0
* risque non estimé	142
? non menacé	258
D données insuffisantes	0
• répandu	0



Farmington Bay OMNIDIA Diatom Analysis - Ecological Values
Rushforth Phycology

Site WGS5 A Pond 4985440
Date 28/09/2005
Slide No. 29

Van Dam 1994

PH	
1 acidobiontic	0
2 acidophilous	0
3 neutrophilous	101
4 alcaliphilous	620
5 alcalibiontic	25
6 indifferent	0

SALINITY	
1 fresh	0
2 fresh brackish	215
3 brackish fresh	329
4 brackish	203

N-Heterotrophie	
1 autotrophic sensibles	13
2 autotrophic tolerants	481
3 heterotrophic facultatifvely	25
4 heterotrophic obligately	13

Oxygen	
1 Continuously high100%sat)	0
2 fairly high (75% sat.)	63
3 O2 moderate (>50%)	165
4 O2 low (>30% sat.)	291
5 O2 very low(10% sat)	13

Saprobity	
1 oligosaprobous	0
2 ßmesosaprobous	76
3 alphamesosaprobous	241
4 alphameso ->polysabrobous	215
5 polysaprobous	0

Trophic state	
1 oligotraphentic	13
2 oligo mesotraphentic	0
3 mésotraphentic	0
4 meso-eutraphentic	13
5 eutraphentic	633
6 hypereutraphentic	0
7 oligo to eutraphentic	89

Moisture	
1 aquatic strict	152
2 aerophilous occas.	127
3 aquatic to subaerien	456
4 aerophilous strict	0
5 terrestre	0

HOFMANN 1994

TROPHIC CONDITIONS	
0 unknown	494
1 ot = Oligotraphent	0
2 ol-bmt = oligo-ß-mesotraphen	0
3 ol-amt = oligo alpha mesotra	0
4 am-eut = alpha meso-eutraphe	63
5 eut = eutraphent	430
6 tol = tolerant	13
7 ind = indifferent	0
8 sap = saprotroph	0

SAPROBIC CONDITIONS	
0 unknown	494
1 oligosaprob	0
2 ß-mesosaprob	13
3 ß-meso -ß-alpha meso.	63
4 ß-meso -ß-alpha meso.	0
5 ß-alpha mesosaprobt	13
6 ß-alpha-meso - alpha meso	0
7 alpha mesosaprob	215
8 alpha-meso polysaprob	0
9 polysaprob	203

LANGE-BERTALOT 1979	
1 most pollution tolerant	203
2a alpha-mesosaprobic a	114
2b alpha-mesosaprobic b	13
2c Ecological questionable	0
3a More sensible (abundant)	63
3b More sensible (less frequent)	0

Håkansson 1993 PH	
1 ACB => acidobiontic	0
2 ACPB => acidophilous to acidobiontic	0
3 ACP => acidophilous	0
4 INAC => indiff. to acidophilous	0
5 IND => indifferent	25
6 AKIN => alcaliphilous to indiff	0
7 AKP => alcaliphilous	304
8 AKPB=>alcaliphil. to alcalibion.	0
9 AKB => alcalibiontic	0

WATANABE 1990	
0 Indifferent	975
1 saprophile species	25
2 saproxene species	0

Denys 1991

LIFEFORM	
0 unknown	266
2 euplanktonic	13
3 tychoplanktonic epontic origin	430
4 tychoplanktonic, benthic origin	291
5 tychoplanktonic origine mixte	0
6 epontic	0
7 epontic and benthic	0
8 benthic	0

CURRENT	
0 unknown	468
1 irrelevant	13
2 rheobiontic	0
3 rheophilous	0
4 indifferent	519
5 limnophilous	0

Steinberg Schiefele 1988

Trophication sensitivity	
1 most tolerant	0
2 st => highly tolerant	203
3 tt => tolerant	13
4 ws => less sensitive	13
5 eu => eutrophic	127
6 ss => sensitive	63
7 ol => oligosaprobic	0
o => unknown	582

ROTELISTE

Lange-Bertalot & al. 1996	
0 disparu	0
1 menacé de disparition	0
2 fortement menacé	0
3 en danger	0
G risque existant	13
R très rare	0
V en régression	0
* risque non estimé	38
? non menacé	519
D données insuffisantes	0
• répandu	0

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APENDIX E

EUTROPHICATION IN FARMINGTON BAY,
GREAT SALT LAKE, UTAH
2005 ANNUAL REPORT

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Department of Aquatic, Watershed and Earth Sciences
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Amy Marcarelli, Ph.D.
Department of Aquatic, Watershed and Earth Sciences
Utah State University

Report to
Central Davis Sewer District
2200 South Sunset Drive
Kaysville, Utah 84037
(801) 451-2190

Eutrophication in Farmington Bay, Great Salt Lake, Utah
2005 Annual Report

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March 1, 2006
Revisions May 30, 2006

Summary

Wurtsbaugh, W.A. and A.M. Marcarelli. 2006. Eutrophication in Farmington Bay, Great Salt Lake, Utah: 2005 Annual Report. Report to the Central Davis Sewer District, 90 pp.

Phytoplankton, zooplankton, and other related limnological parameters were sampled at three or more sites in Farmington Bay and at three similarly shallow sites in Gilbert Bay from May through November 2005 to assess eutrophication and beneficial use attainment in Farmington Bay. Salinities in Farmington Bay ranged from 0.6% during spring runoff (May) to 5% in September 2005, whereas salinities in Gilbert Bay ranged from 13% to 16% over this period.

In Farmington Bay, densities of toxic cyanobacteria and chlorophyll levels greatly exceeded the World Health Organization's criteria for moderate to high probabilities of public health risk. A massive bloom of the cyanobacterium *Nodularia spumigena* was present for most of the study period, as well as relatively high densities of non-toxic diatoms, pyrrophytes and chlorophytes. Surface scums of *Nodularia* were sometimes present. Very high nitrogen fixation rates by *Nodularia* in Farmington Bay during 2005 likely helped sustain phytoplankton growth in the bay. Chlorophyll levels averaged 263 µg L^{-1} and reached over 400 µg L^{-1} on three occasions – nearly double that found in 2003 when salinities were usually above 5%. A laboratory experiment demonstrated that *Nodularia* survived poorly and stopped fixing nitrogen at salinities above 5%. Preliminary analyses of the toxin nodularin that is produced by *Nodularia* indicated that it was present at extremely high concentrations. In August, samples were collected from three stations for pathogens and analyzed using molecular techniques. The preliminary analyses indicate that amoeba and taxa belonging to the Legionella group were present in all samples, but additional analyses will be necessary to determine if they could be the pathogenic *Legionaris pneumophila*. These preliminary findings raise human and wildlife health issues that merit further investigation.

Secchi disk readings averaged only 0.3 m, and mean total phosphorus concentrations were 673 µg L^{-1}. A mean Trophic state index calculated from these values was 87, indicating that Farmington Bay is hypereutrophic, and has the highest TSI of any water body in the state of Utah.

The high algal production and a shallow water column led to anoxia in Farmington Bay. Nighttime anoxia was frequent, and several boughts of prolonged anoxia for more than one day occurred at both the north and south ends of the bay. After July, a salt wedge protruded into the north end of Farmington from Gilbert Bay, and this layer was always anoxic and had high concentrations of hydrogen sulfide, thus making it uninhabitable for aquatic organisms other than bacteria.

From July through October, ammonia concentrations in Farmington Bay were usually greater than 150 µg N L^{-1} and they reached 400 µg N L^{-1} in May. The pH in Farmington Bay was usually above 9 and went above 9.5 frequently, indicating that a significant proportion of the

ammonia would be in the unionized, toxic form. At these pH levels, total ammonia concentrations from July-November greatly exceeded the EPA's suggested concentration for this pollutant (95 µg L^{-1} freshwater; 90 µg L^{-1} marine).

Zooplankton densities in Farmington Bay fluctuated greatly. In early May and during June and July total cladoceran and copepod densities were extremely high (> 400 L^{-1}) indicating that the high production in the bay is passed up the food web at certain times. After late August, however, nearly all the crustaceans disappeared, and an air-breathing insect predator, *Trichocorixa verticalis* (corixid) dominated the community. Brine shrimp were not abundant in Farmington Bay. Zooplankton biomass was approximately three times higher in Farmington than in Gilbert Bay, where brine shrimp were the only abundant organism. Both field and laboratory bioassays indicated that *Artemia* survived poorly in the Farmington Bay water, but it was not clear if this was due to poor water quality (anoxia, algal toxins, ammonia, etc.), or to some other factor associated with the low salinities in the bay. In addition to the poor survival in Farmington Bay water, two field mesocosm experiments demonstrated that densities of the predatory corixid in Farmington Bay during 2005 were sufficient to greatly limit *Artemia* densities there.

Artificial substrates deployed in Gilbert and Farmington Bays showed there were large differences in the bottom-dwelling (benthic) organisms in the two systems. In Gilbert Bay densities of the brine fly (*Ephydra cinerea*) larvae and pupae were each nearly 4,000 and 6,000 m^{-2} and no other invertebrates were abundant. In contrast, densities of a similar species of brine fly (*Ephydra hians*) in Farmington Bay were only 60 m^{-2}. Corixids were, however, abundant on the Farmington Bay substrates.

A large synoptic analysis of the Great Salt Lake during June indicated that chlorophyll and cyanobacterial pigments are far higher in Farmington Bay than in Gilbert Bay or in Bear River Bay. The high concentration of algae in Farmington Bay was associated with low salinity and high nutrient levels. However, nutrient levels are also high in Gilbert and Bear River Bays, so it is likely the interaction of salinity and nutrients that allow the extremely high algal populations in Farmington Bay. Satellite imagery demonstrated that a plume of high chlorophyll water extends approximately 10 miles from Farmington Bay out into Gilbert Bay. The laboratory bioassay described above showed that when the organic-rich water from Farmington Bay is diluted into Gilbert Bay with high salinity, the organic matter promotes the growth and survival of *Artemia.*

In summary, our analyses of Farmington Bay indicate it is hypereutrophic with poor water quality. Low oxygen and apparently high unionized ammonia concentrations do not meet either marine or freshwater criteria. Cyanobacterial blooms in 2005 also greatly exceeded levels considered to pose moderate or high probabilities of public health risk. Because of the unusual characteristics of Farmington Bay and the rest of the Great Salt Lake, the Utah Division of Water Quality has not, however, applied criteria for the bay established for other waters in the United States. The data presented here suggest that the state needs to move towards developing site-specific water quality standards for Farmington Bay that will protect its designated uses for contact recreation and the protection of aquatic wildlife.

Introduction

Farmington Bay, located in the southeast corner of the Great Salt Lake (Utah), receives the majority of municipal and industrial wastewater from the Salt Lake City metropolitan area, as well as non-point source pollution from agriculture and urban runoff. Nutrients from seven wastewater plants flow into Farmington Bay, either directly or via wetland complexes, and the bay also receives industrial effluents. Farmington Bay covers 100 mi^2 (260 km^2) with a mean depth of near 1 m, depending on cyclic changes in the elevation of this terminal lake. Nutrient and other pollutant loads are concentrated in Farmington Bay due to a causeway to Antelope Island. Consequently, natural mixing of contaminants with the the central part of the lake, Gilbert Bay, is substantially reduced and allows salinities in the bay to fluctuate between 0.5% and 10%, depending on inter-annual differences in runoff and seasonal fluctuations.

Monitoring to date indicates that Farmington Bay is hypereutrophic, with chlorophyll *a* concentrations >100 µg L^{-1}, Secchi depths <0.3 m and blooms of cyanobacteria (Carter 1971; Wurtsbaugh & Marcarelli 2004a). The trophic state indices are the highest of any water body in Utah. The filamentous cyanophyte (blue-green alga), *Nodularia spumigena* is sometimes abundant in Farmington Bay but is rarely seen at the higher salinities of the main lake. *Nodularia* can fix atmospheric nitrogen, and may thus contribute to the overall nutrient loading in Farmington Bay when low salinities allow it to persist. *Nodularia* and other cyanobacteria produce toxins, and are thus thought to be unpalatable to most zooplankton. A routine bioassay for cyanobacterial toxins utilizes brine shrimp nauplii as the test organism (e.g. Lahti et al. 1995), thus suggesting that these toxins may impact natural brine shrimp populations in the Great Salt Lake.

The automobile causeway across Farmington Bay not only impedes circulation with the main lake, but induces density-stratification in the bay. A high-density salt wedge (16%) from Gilbert Bay often underflows the less dense water in the northern portion of Farmington Bay. The hypereutrophic conditions are accentuated because the salt wedge traps organic matter, thus forming anoxic, reducing conditions that produce H_2S. Preliminary results suggest that when wind storms mix the H_2S trapped in the salt wedge into the overlying water, the entire bay may go anoxic for up to two days (Wurtsbaugh & Marcarelli 2004b). Water column anoxia related to wind mixing and the entrainment of H_2S–rich bottom water occurs in the hypereutrophic Salton Sea, and there it has been documented to kill phytoplankton, zooplankton and fish (Watts et al. 2001).

Preliminary sampling indicates that the densities of brine shrimp and brine flies in Farmington Bay are usually far lower than those in the remainder of the lake, despite the high algal production in the bay (Marcarelli et al. 2003; Wurtsbaugh and Marcarelli 2004a). Brine shrimp and brine flies are very important to the ecosystem, both as a primary food resource for migratory birds and for the commercial value of brine shrimp cysts. The poor water quality conditions in Farmington Bay may cause invertebrate abundances to be low, but it is also possible that densities are lower than in Gilbert Bay because low salinities in the bay may physiologically exclude certain species. At times, the lower salinities in Farmington Bay also provide acceptable conditions for air-breathing predatory insects (corixids) and a harpacticoid copepod, both of which may prey on brine shrimp. Consequently, it is possible that low brine shrimp densities, and possibly brine fly densities are due to predation by these invertebrates and not to water quality conditions.

Because of the unusual characteristics of Farmington Bay, a beneficial use assessment is not as straightforward as in freshwaters. Consequently, there were two primary goals for our 2005 research. First, we monitored water quality and plankton in the bay for the duration of the growing period to gain a better understanding, along with data collected in 2003, of how climatic and salinity changes influence limnological characteristics. Secondly we conducted field experiments to understand factors controlling the abundance of brine shrimp in the bay using two limnocorral experiments. Our goal was to understand whether the differences in brine shrimp abundance were due to salinity differences, eutrophication, or predation.

Methods

Routine monitoring – Three stations in Farmington Bay were sampled between May and November 2005. The GPS locations of these are shown in Table 1. We initially sampled stations 1, 2, and 4. However, shallow water conditions prevented sampling of Station 4 after 16 Aug 2005, at which point Station 3 replaced it as a routine sampling station. On seven dates we also sampled three stations (14, 15, and 18) in Gilbert Bay along a N-S transect west of Antelope Island, at depths comparable to those sampled in Farmington Bay.

To obtain high resolution measurements on some chemical parameters three TROLL 9000 multiparameter sonde were deployed from 27 May through 12 Nov 2005 stations 1 and 3/4. At station 1, two sondes were deployed, one 0.2 m below the surface and one 0.25 m above the lake bottom. The third sonde was deployed 0.2 m below the surface at station 4 until 15 Aug 2005, when it was moved north to station 3 because of lake shallowing. Temperature, dissolved oxygen, pH, oxidation-reduction potential (ORP), and conductivity were measured at 15 minute intervals by each sonde. Sondes were downloaded every 3-6 weeks and were re-calibrated at the time of each download. Weather data for comparison with the sonde data was obtained from the National Climactic Data Center (http://www.ncdc.noaa.gov) for the weather station at the Salt Lake City Airport (station code 24127, USAF code 725720).

Additional parameters were collected at 2-3 week intervals in Farmington Bay and 4-6 week intervals in Gilbert Bay. On each sampling date, routine limnological characteristics were measured. Vertical profiles of temperature, dissolved oxygen, pH, oxidation-reduction potential (ORP), and conductivity were measured using a TROLL 9000 multiparameter sonde. Secchi disk transparency and light transmission with a LiCor spherical sensor were measured to assess the depth of the photic zone in the bay. Water depth was determined with a weighted line or meter stick.

Water was collected at 0.4 m depth in both bays using a peristaltic pump and analyzed for a variety of chemical characteristics. Salinity was measured using a hand-held refractometer. In the laboratory, water was filtered through 0.8 µm GF/F filters and frozen for analysis of ammonium-N, nitrate-N, and phosphate-P. Internal spikes of these nutrients were done on a subset of split samples. Additionally, unfiltered water samples were frozen for total nitrogen and total phosphorus (TN/TP) analysis. Ammonium-N (detection limit 0.05 mg L^{-1}) and nitrate-N (detection limit 0.005 mg L^{-1}) were analyzed by the Utah State University Analysis Lab on a Lachat QuikChem 8000 Flow Injection Analyzer utilizing the cadmium reduction method for nitrate and the phenolate method for ammonia. Due to some methodological failure, nitrate-N concentrations were undetectable using their analysis technique and are not reported here. TN/TP samples were analyzed using a persulfate digestion followed by a second derivative analysis of N (detection limit 0.04 mg L^{-1}) (Crumpton et al. 1992). TP (after digestion) and phosphate-P samples were both analyzed using the malachite green method of Linge and Oldham (2001, 2002), which corrects for interference from arsenate, which is high in the Great Salt Lake (detection limit 0.006 mg L^{-1}).

Hydrogen sulfide (H_2S) measurements were made in Farmington Bay on each sampling date. Duplicate samples were collected from 3-4 depths in the mixed layer and 1-2 depths in the deep brine layer with a peristaltic pump into 300-mL BOD bottles. Bottles were filled using the “overflowing bottle” technique that insures that oxygen does not enter the bottle and change redox conditions. Samples were preserved using zinc acetate and the amount of hydrogen sulfide present was determined with the iodometric method (APHA 2000) within 48 hours (detection limit 0.31 mg L^{-1}).

Nitrogen fixation potential (acetylene reduction) was measured only at Station 1 in Farmington Bay on each sampling date. Water samples were collected at 0.2-m intervals from the entire water column using a peristaltic pump. Two 50-mL aliquots of water from each depth were placed in 62-mL glass serum vials and sealed with airtight septa. Samples were injected with 4-mL of acetylene gas generated from calcium carbide to achieve a headspace of approximately 20% ethylene gas and shaken for 30 seconds to ensure equal partitioning of gas between the liquid and vapor phases (Flett et al. 1976). All samples were then incubated for 2-hours minimum, suspended on an incubation line at the approximate depth of collection. Standards containing known concentrations of ethylene were also incubated with the samples. After the incubation, vials were shaken again to repartition the gas and final gas samples were collected into cleaned, re-evacuated 3-mL Vacutainers and returned to the lab. Ethylene and acetylene in each sample and standard were measured using a SRI 8610C gas chromatograph equipped with a Poropak T column, He carrier gas, and a flame ionization detector (Capone 1993). Concentrations of ethylene in the samples were compared to the known concentrations in the standards and then converted to the amount of N_2 fixed using an assumed 3:1 ethylene:N_2 conversion ratio (Capone 1993).

Phytoplankton were analyzed using both taxonomic identifications and measurements of chlorophyll *a* as a surrogate for overall algal biomass. Community samples were collected with an integrated tube sampler lowered to 10-cm above the bottom of the bay and preserved with 3% formalin. Phytoplankton cell density was determined by settling and counting samples in Utermohl chambers on an inverted microscope at 1000X (Wetzel and Likens 2000). Phytoplankton were identified to the lowest taxonomic group possible using Felix and Rushforth (1979)—usually genus or species. Because algal volumes can vary immensely between species, and because many ecological processes are more dependent on biovolumes than on densities, we also estimated the volume of each taxon. Length and width measurements were made on 10 individuals of each taxon and biovolumes were calculated using equations in Hillebrand et al. (1999). Two chlorophyll *a* samples were collected from 0.4 m for each station on each date—one with a peristaltic pump and one with an integrated tube sampler. In the laboratory, an aliquot (either 10 or 20-mL) of water was filtered through a 1.0-µm GF/F filter. The filter was wrapped in tin foil and immediately frozen until analysis within 1 month. The filters were extracted in 95% ethanol overnight and the chlorophyll *a* concentrations were measured with a Turner 10AU fluorometer using a non-acidification technique (Welschmeyer 1994).

Zooplankton were collected using vertical hauls with a 50-cm diameter net with 250-µm mesh from 10-cm above the bottom to the surface at each station. Zooplankton were preserved with 3% formalin and counted using a dissecting microscope at 10-30X. Entire samples were counted unless zooplankton were extremely abundant, in which case 5-50% of the sample was analyzed to give counts of 100-200 organisms. Zooplankton were identified to species and divided by sex and life stage (e.g. *Artemia* nauplii, juveniles, and adults).

Cement blocks covered with window mesh screening were deployed in May in both Farmington and Gilbert Bays to serve as artificial sampling substrates for brine fly larvae and pupae. Groups of these were retrieved at monthly intervals for analysis of chlorophyll levels and brine fly densities. Organisms on the substrates were preserved with 95% ethanol at the time of collection. Organisms were sorted and identified to species and divided by life stage. Identifications were made using a dissecting microscope at 10-30X when necessary. *E. cinerea* is distinctive with caudal tubules and *E. hians* has distinctive chevron-like dorsal pigment patches (D. Herbst, personal communication, Sierra Nevada Aquatic Research Laboratory, Univ. Calif.).

Synoptic sampling – Three large-scale synoptic samplings were undertaken to examine the horizontal variation in environmental factors in Farmington and Gilbert Bays. The first of these focused on both bays and was done in conjunction with Dr. David Naftz of the USGS, Salt Lake City, and Mr. Shane Bradt, a remote sensing specialist from the University of New Hampshire. The second two synoptics focused on Farmington Bay with limited sampling in Gilbert Bay and Ogden Bay. The dates and stations sampled were:

Date	Bay	Stations
31 May to 3 June	Farmington	11
(referred to as June)	Gilbert	30
	Bear River	1
8-9 August	Farmington	11
	Gilbert	3
	Bear River	0
21-22 October	Farmington	12
	Gilbert	3
	Bear River	0

Station locations are shown in Figure 1. At some stations a full set of parameters were measured, whereas at others a partial subset were measured. The parameters measured and methods used are given in Table 2. Not all of the results from the synoptic analyses are reported here.

To support the June synoptic we used satellite imagery to assess chlorophyll levels in order to give a better spatial coverage of the lake. We used the MODIS Aqua sensor which provided an image on June 2 at 13:05 local time (20:05 UTC). The imagery was analyzed by Mr. Shane Bradt using SeaDAS 4.8.3 (http://oceancolor.gsfc.nasa.gov/seadas/). The MODIS bands used were a subset of the 1 km bands, which were reprojected to 1.1 km pixels. To process the imagery, he used SeaDAS to apply the standard atmospheric algorithm and the most commonly used chlorophyll a algorithm (called OC4). A color gradient was added to the resultant chlorophyll data to produce a map. Chlorophyll concentrations in Farmington Bay could not be processed with this algorithm, as the process identified the high pigment levels there as "land". Additionally, a small cloud band obscured a portion of the lower part of Gilbert Bay precluding chlorophyll estimates there.

Pathogen and Toxin Analyses - On two dates, phytoplankton from Farmington Bay were collected for analysis of nodularin, a hepatotoxin produced by Nodularia. Integrated water column samples from Station 1 or 4 were filtered on GF/F filters, frozen at -20° C, freeze-dried and sent to the laboratory of Prof. Antonio Quesada, Biology Department, Universidad Autonoma de Madrid. The nodularin concentrations were analyzed there by high pressure liquid chromatography.

On August 8, 2005 samples were taken in Farmington Bay for analysis of pathogens at three sites: (1) slightly north of Farmington Bay Refuge were water was ca. 40-cm deep; (2) In front of Sewage Canal were water was 40-cm deep; (3) SW of Antelope Island Causeway breach where water was 35-40 cm deep. At each site three core samples were taken by inverting a 60-ml centrifuge tube and forcing it into the sediments. Each set of three was pooled for subsequent analyses. Three water surface water samples were collected at each site and pooled to yield approximately 500 mL. The water samples were transported to the lab and filtered through 90-mm GF/F filters until they clogged. The moist filters were frozen at -90° C and sent via overnight courier service packed between a layer of -90° C plastic ice to Dr. Rebecca Gast, Biology Department, Woods Hole Oceanographic Institution, MA. Sediments were analyzed for the presence of amoebas by culturing in five different media types that varied in salinity from full strength seawater to fresh water, and with a small amount of nutrient addition. *Legionella* bacteria were detected and identified using genus-specific amplification primers followed by DNA sequencing of the fragments.

Salinity controls of nitrogen fixation – To test the effect of phosphorus supply and salinity on phytoplankton populations and nitrogen fixation rates of the algal community in Farmington Bay, a bioassay experiment was conducted in May 2005. The Bay's salinity at this time was 1.5%, and the algal community was comprised of 85% *Nodularia spumegina*, a nitrogen-fixing cyanobacterium. Water was collected from Station 1 and transported back to the laboratory. Water was filtered through 153 µm Nitex netting to remove macrozooplankton and 500-mL aliquots were placed into 28, 900-mL glass jars. Jars were then randomly assigned to seven salinities: 2, 4, 5, 6, 7, 8, and 9%, for a final count of four jars of each salinity. The aliquots in the jars were then diluted to 800-mL using saline water (made with NaCl and $MgSO_4$ in a 7.8:1 ratio in deionized water) to reach the desired end salinity. Two jars within each salinity were then randomly assigned to either control or phosphorus-enriched treatments. Phosphorus was added to the jars as Na_2PO_4 at a final concentration of 200 µg P L^{-1}. After nutrient enrichments, jars were agitated and placed randomly in a temperature controlled incubation room at 20º C, with light intensities of approximately 150 µE m-^{2} sec-^{1} and an 18:6 light dark photoperiod for 6 days.

On days 1, 3, and 6, each jar was sampled to determine chlorophyll *a* concentrations and nitrogen fixation rates. Aliquots of 50-mL were collected from each sample jar, placed in a 62-mL glass serum vial, and sealed with a septum for N_2 fixation analysis as described above. After injection with acetylene, vials were incubated for 2 hours in the incubation chamber where the bioassay was conducted. Samples were collected and analyzed as described above. After termination of the acetylene reduction assay, a 10-mL aliquot was removed form the serum vial and filtered through a 25-mm Millipore AP 40 glass fiber filter with a nominal pore size of 0.7 µm. The filter was then stored and analyzed as described above for chlorophyll *a* analysis.

Mesocosm experiments – Three mesocosm experiments were run to assess the impact of corixid predation and salinity on brine shrimp survival. These experiments were conducted in 12 translucent fiberglass tubes that were 1.5-m long and 0.16 m in diameter and filled with 60 L each. Water depth in the tubes was 0.8 m, slightly higher than the mean depth of Farmington Bay. The tubes were suspended within wooden frames. The first experiment was deployed in the open water of Farmington Bay, but a wind storm destroyed the experiment and five tubes were lost. The two subsequent experiments were deployed in a boat birth in the Antelope Island Marina (Fig. 2).

The August experiment was conducted 7 – 23 August, to assess the impact of predacious corixids on *Artemia*. Surface water was collected in Farmington Bay 2 km south of the causeway on 7 August using large buckets. Salinity on this date was 3.6%. The water was filtered through 1-mm mesh to remove large *Artemia* and adult corixids, but most alternative zooplankton prey (cladoceran, copepods) passed through this mesh. Two days before the experiment adult and juvenile *Artemia* were collected from Gilbert Bay and juvenile *Artemia* nauplii were hatched from cysts in the laboratory. These were counted into plastic containers and added to the tubes at the start of the experiment. Corixids (3.5 - 5 mm) for the experiment were collected in the open water of Farmington Bay on 7 August and added with the prey. *Artemia* densities in the experiment were: Adults – 2 L^{-1}; juveniles – 2 L^{-1}; nauplii – 10 L^{-1}. These densities are common in Gilbert Bay (Wurtsbaugh and Gliwicz 2001). Densities of added corixids ranged from 0 to 1.2 L^{-1}, within the range observed in Farmington Bay (Fig. 20). Initial and final chlorophyll concentrations were measured as described above. After 16 days, the entire volume of the tube was filtered through 305-µm mesh and organisms were preserved using 3% formalin. Organisms were then identified and enumerated as described above.

The second experiment was conducted 10 – 26 September when temperatures were near 18° C. In this experiment, we tested both the effects of corixids and salinity on *Artemia* survival using a two-way factorial design (Table 3). Water was again collected from Farmington Bay on 10 September (ambient salinity 4%), filtered through 305-µm mesh to remove both small and large zooplankton, as well as some of the filamentous *Nodularia spumegina* that dominated the phytoplankton at this time. A 1:1 mixture of NaCl and Instant Oceans® was then added to half of the tubes to increase the salinity in those tubes to 8%, and the water was mixed until the salts were dissolved. This resulted in six high salinity tubes and six low salinity tubes. All of the tubes were then stocked with *Artemia* adults, juveniles, and nauplii at the same densities as described above. Approximately 30 adult brine flies were allowed to enter each tube before they were closed with the 1-mm mesh top. We anticipated that this would allow the brine flies to lay eggs and thus allow a measure of corixid predation in the different treatments. Corixids densities of 0, 0.6, and 1.2 L^{-1} were then randomly applied to two tubes of each salinity. After 16 days, the entire volume of the tube was filtered through 305-µm mesh and organisms were preserved using 3% formalin. Zooplankton and chlorophyll concentrations were estimated as described above.

Algal Suitability Bioassay Experiment – A single laboratory experiment was conducted to test the suitability of Farmington Bay water and Gilbert Bay water for the survival of *Artemia*. Water was collected from the two bays on August 8. *Nodularia* were at near peak densities in Farmington Bay at this time. Four water treatments were tested: (1) undiluted Farmington Bay (3% salinity); (2) undiluted Gilbert Bay water (15% salinity); (3) a mixture of 10% Farmington Bay and 90% Gilbert Bay water (13.8% salinity), and; (4) Gilbert Bay water diluted with deionized water (3% salinity). Water from Gilbert Bay was filtered through 150-µm mesh and water from Farmington Bay was filtered through 250-µm mesh to remove organisms but allow *Nodularia* to pass. Ten adult brine shrimp (5 mating pairs) were placed in 2-L buckets. Ten two-day old *Artemia* nauplii were placed in 900-ml jars of treatment water. Each treatment was duplicated. Survival of adult *Artemia* was assessed visually during the course of the 15-day experiment, but the initially small nauplii could not be seen by this method, and were preserved at the end of the experiment with 3% formalin for subsequent counting.

Results

Physical-chemical conditions – Water clarity in Farmington Bay was always lower than in Gilbert Bay in 2005, in contrast to 2003, when a water clearing event in May led to very deep Secchi depths in Farmington Bay (Fig. 3a). In Farmington, Secchi depths during 2005 were 0.14 - 0.75 m, compared to 0.60 – 2.90 m in Gilbert Bay. Not only were Secchi depths more variable through the entire sampling season in Gilbert Bay, but they were also more variable between sampling dates than in Farmington Bay (Fig. 3a). As observed in 2003, salinity was consistently higher in Gilbert Bay than in Farmington Bay for the duration of the 2005 monitoring, and ranged from 13.2% in June to 15.2% in November (Fig. 3b). In Farmington Bay, salinity ranged much more widely, from a low of 1.1% in early May to a peak of 5.1% in early October 2005. After this peak, salinity began to drop again, to a low of 2.8% in November (Fig. 3b). Water temperature was very similar between the two bays and strongly seasonally variable, ranging from a low of 7.5º C in November to 28.6º C in mid-July (Fig. 3c; Appendix 1).

Monitoring of water chemistry during 2005 showed that dissolved nutrient concentrations were very high in both bays, and total nutrient concentrations were more variable in Farmington Bay than in Gilbert Bay. In Gilbert Bay, ammonium-N concentrations were lowest in May, and increased to a steady concentration of around 400 µg N L^{-1} for the duration of the summer, then increasing again to 700 µg N L^{-1} in mid-November (Fig. 4a). Ammonium-N showed an opposite trend in Farmington Bay, where concentrations were greatest in early May at 400 µg N L^{-1}, and decreased by June to a stable level between 150 and 200 µg N L^{-1} (Fig. 4a; Appendix 2). Our ammonia results are consistent with those measured in Farmington Bay by the State DWQ, who found mean levels of 0.33 µg N L^{-1} (range 0.21-0.43) on five dates in 2004-2005. The pH in Farmington Bay was usually above 9 and went above 9.5 frequently (see below), indicating that >30% of the ammonia would be in the unionized, toxic form. At these pH levels, total ammonia concentrations from May-November exceeded the EPA's suggested chronic concentration for this pollutant (95 µg L^{-1} freshwater; 90 µg L^{-1} marine; EPA 1986, 1988).

Phosphate-P concentrations were stable between 26-78 µg P L^{-1} in Gilbert Bay during summer 2005. In Farmington Bay, phosphate concentrations were greatest in early May and late October at 119 and 105 µg P L^{-1}, respectively, while concentrations were <6 – 20 µg P L^{-1} on all other sampling dates (Fig. 4b). TN in Gilbert Bay was stable around 6000 µg N L^{-1}, and TP was stable around 350 µg P L^{-1} (Fig. 4c, d). In Farmington Bay, TN was around 6000 µg N L^{-1} in mid- May, then dipped to 2000 µg N L^{-1} in June, only to rise again by early July and range 5390 – 7440 µg N L^{-1} from July – Nov (Fig. 4c). TP in Farmington showed a very high peak of 2000 µg P L^{-1} in mid-May 2005, followed by a steep decline. TP ranged from 376 µg P L^{-1} on 29

July up to 818 µg P L^{-1} on 8 October (Fig. 4d). Mean TP concentrations in Farmington Bay were 673 µg P L^{-1} (with 1 outlier removed; Appendix 2).

The sondes deployed at Station 1 provide insight into the formation of the deep brine layer and mixing patterns of the surface and deep waters. The surface sonde shows very strong diel variations in dissolved oxygen (Fig. 5 middle). Conductivity rose through early October from approximately 18 mS cm^{-1} in late May to a high of 80 mS cm^{-1}in early October, followed by a decline to approximately 48 mS cm^{-1} in mid November (Fig. 5 middle), which matches the salinity pattern observed in the bay (Fig. 3b). The deep sonde at Station 1 showed highly variable conductivity measurements, likely due to two different phenomena. In the early part of the record (Late May and June), there was not a distinct deep brine layer at Station 1, so the bay frequently mixed to the bottom, resulting in alternating periods of anoxic and oxic conditions and large fluctuations in conductivity (Fig. 5 bottom). In August, prolonged periods of anoxia recorded by the deep sonde demonstrate the existence of a deep brine layer, and show that the bay mixed infrequently to the bottom during this period. However, in September, frequent deep mixing is again shown by the conductivity and oxygen record (Fig. 5 bottom). By this point, the water depth had decreased considerably, from 1.5 m in May to 0.9 m in September. Because our sonde was deployed on top of a 20-cm tall block, it's likely that the sonde here was moving into and out of the deep brine layer as wind mixing and seiche action resulted in vertical movement of the oxic-anoxic interface.

There was extreme diel variation in oxygen concentration in the overlying water layer, with frequent anoxia at night and supersaturation during the day. From August to November when the sondes were deployed, the Station 1 sonde at a depth of 0.2 m recorded anoxia (<0.5 mg/L) on 62% of the nights for which we have records. In addition to the frequent nighttime anoxia, there were also periods of sustained anoxia at Station 1. These occurred in late August, mid-September, and particularly from 27 – 31 October. On this latter date a peak in salinity was observed, indicating either: (1) mixing of surface water with the deep brine layer, or (2) high salinity water was pushed into Farmington Bay from Gilbert Bay. With this peak in conductivity, dissolved oxygen dropped to zero, and ORP remained negative until oxygen concentrations rose again on 31 October (Fig. 6 bottom). These near-anoxic or anoxic events usually occurred when wind velocities were high, but this correspondence was not as clear as we observed in 2003. In 2005 high wind velocities sometimes did not cause anoxia (Fig. 5 top; note early November). However, the wind gusts recorded on 27 October, immediately prior to the anoxic event, were the greatest winds in 2-3 weeks, and the water column was very shallow at this point, perhaps allowing the 30 mph winds (Fig. 6 top) to provide adequate mixing strength.

At Station 3/4 where water depth ranged from 0.7 to 1 m, conductivity and dissolved oxygen concentrations were much more variable than at Station 1. Conductivity rose from a low of 5 mS cm^{-1} (ca. 0.35% salinity) in May to a high of 80 mS cm^{-1} in October (Fig. 7 middle), but was highly variable on a daily-weekly scale. Station 3/4 was located in the south-central or central point (after 16 Aug) in the bay, and depending on the prevailing winds, may receive water from either the hypersaline north part of the bay, or the fresher south part of the bay. Frequent, prolonged periods of anoxia were also observed at this station, with 1-2 day events occurring throughout September and October (Fig. 7 middle). As this station lacked a deep brine layer, the anoxia at this station could be caused by wind suspension of the sediments and/or the associated hydrogen sulfide produced there.

The pH in Farmington Bay was very high, with values generally between 9.0 and 9.5 (Fig. 7 bottom). However, the plot of the data shows some marked changes in pH at the time the sondes were serviced, suggesting that the calibration was not held for the length of each deployment. When the sondes were redeployed pH was usually around 9.5. During the biweekly profiling with a fresh sonde, the average pH in the surface water (0–0.5 m) in Farmington Bay was 9.37, with a range 8.7–9.7. In Gilbert Bay profiles taken approximately monthly demonstrated a lower mean pH of 8.12, with a range of 7.8–8.5. The differences in pH are likely driven by the much higher rates of photosynthesis in Farmington Bay than in Gilbert Bay. Photosynthesis removes CO_2, an acid, thus allowing the pH to rise.

Hydrogen sulfide concentrations at Station 1 were very different between the mixed layer and the deep brine layer, and also showed seasonal variations. A sample vertical profile of sulfide, measured on 9 Aug, is shown in Fig. 8 (all profiles in Appendix 3). The mixed layer, above 1.0 m on this date as indicated by specific conductivity, was characterized by high concentrations of dissolved oxygen, likely due to active photosynthesis by phytoplankton, and very low concentrations of sulfide. In contrast, in the deep brine layer the oxygen concentration was zero by 1.2 m, and the sulfide concentration was 7.8 mg L^{-1} (Fig. 8). A seasonal examination of the deep brine layer and the mixed layer show that no hydrogen sulfide was stored in the bottom of Farmington Bay prior to June 1 in 2005, due to the lack of a deep brine layer (Fig. 9). Later in the season, concentrations peaked at 7.8 mg L^{-1}, but several decreases in sulfide to zero in early September and November suggest that mixing may have removed the sulfide from this layer. One such event was certainly the 4-day anoxic event observed beginning Oct 27 (Fig. 8). However, no such mixing event was recorded by the sondes at Station 1 in early September, suggesting some other mechanism resulted in the release of hydrogen sulfide from the deep brine layer on this date.

Phytoplankton and nitrogen fixation - Twenty-four different species or genera of algae were identified in Farmington Bay and Gilbert Bay, 23 of which occurred in Farmington Bay (Table 4). Only 14 of these taxa occurred in Gilbert Bay, and several, such as the cyanobacteria *Nodularia spumegina* and *Microcoleus* sp., were observed in only 1 or 2 samples from Gilbert (Table 4, Appendices 4 and 5). Although many of these species had been previously observed in the Great Salt Lake, several, such as *Scenedesmus* sp. and *Pediastrum* sp., had not been. These taxa were common in Farmington Bay when the salinity was less than 2%, and are very common freshwater genera. For convenience and clarity in these analyses, these species were grouped by division into four groups: green algae (division Chlorophyta), chrysophytes (division Pyrrophyta or Dinopyta), diatoms (division Bacillariophyta), and cyanobacteria (division Cyanophyta; Sze 1998).

Cell densities and biovolumes were all much greater in Farmington Bay than in Gilbert Bay for the duration of the 2005 sampling period and were comparable to the differences observed in 2003 (Fig. 10; Appendices 4 and 5). Densities in Farmington Bay ranged from 263,000 – 898,000 cells / mL, while they ranged from 14,000 – 74,000 in Gilbert Bay (Fig. 10a). The peak cell density in Farmington Bay was lower than the maximum of 1,900,000 cells / mL observed in 2003, but the means between the two years were similar (70,000 in 2003 vs. 60,000 in 2005). On all sampling dates in Farmington Bay, the phytoplankton biovolume was dominated by cyanobacteria, which averaged 61% and ranged from 19% – 92% of the total cell density (Fig. 11a). The dominant cyanobacterium in Farmington Bay was the nitrogen-fixing *Nodularia spumegina,* although *Microcoleus* sp. was also abundant on the 25 Aug and 13 Sep sampling dates. In Gilbert Bay in 2005, the algal community was routinely dominated by chlorophytes, particularly the green algae *Dunaliella viridis* and *Oocystus* sp. (Fig. 11b). In both bays an unidentified chrysophyte was observed on every sampling date, but in Farmington Bay the pyrrophytes *Glenodinium* sp. and *Chrysophyte* sp were also abundant on at least one sampling date, while they were never abundant in Gilbert Bay. Other moderately abundant taxa found only in Farmington Bay include the chlorophytes *Carteria* sp., *Scenedesmus* sp., *Pediastrum* sp., and the diatoms *Chaetocerous* sp, and *Synedra* sp. (Table 4). Biovolume showed very similar trends to density in both bays (Fig. 10b) and similar dominance by the different groups in each bay (Fig. 12).

Chlorophyll *a* concentrations, used as an indicator of algal biomass, were also much greater in Farmington Bay in 2005 than in Gilbert Bay, but were also greater than the concentrations observed in 2003. In both years there was an order of magnitude variation between the high and low observations, but in 2003, the mean chlorophyll concentration was 110 µg L^{-1}, compared to 262 µg L^{-1} in 2005 (Fig. 10c; Appendix 1). In contrast, 2005 Gilbert Bay concentrations ranged from 5.6 µg L^{-1} in early August to 27 µg L^{-1} on 15 May (Fig 10c). This increase in Farmington Bay from 2003 to 2005 is notable because a similar increase in cell density or biovolume (Fig. 10a, b) was not observed.

The high abundance and biovolume of nitrogen-fixing *Nodularia spumegina* in 2005 lead to very high rates of nitrogen fixation in the bay. A typical vertical profile for fixation is shown in Fig. 13 (all profiles are shown in Appendix 6). Note that fixation rates decline at a constant rate in the mixed layer of the hypolimnion, and drop to zero below the chemocline (Fig. 13). Temperature changes very little from the top to bottom of the water column on this sampling date, but light decreases dramatically in the short water column. A seasonal examination of nitrogen fixation within the entire mixed layer of Farmington Bay revealed that fixation rates were very closely related to abundance of *Nodularia* in the bay (Fig. 14). The one date where low fixation rates were observed despite high concentrations of *Nodularia* was May 17, when the weather was stormy, turbulent and cold, which may have depressed rates of nitrogen fixation. Interestingly, the decrease in nitrogen fixation and *Nodularia* biomass in late June was also correlated with a drop in total N concentrations, suggesting that nitrogen fixation was an important source of N to the bay (Fig. 14). A regression analysis comparing nitrogen fixation rates on the study dates to various environmental parameters showed that nitrogen fixation was negatively correlated with salinity and positively correlated with temperature, but these relationships were both weak and non-significant (r^2 approx. 0.10, $p > 0.25$; Fig. 15a, b). A positive, significant correlation was observed between nitrogen fixation rates and *Nodularia spumegina* biovolume ($r^2 = 0.41$, $p = 0.03$), but the scatter was high and the significant relationship was dependent on a single high value.

Pathogen and toxin analyses – Analysis of nodularin concentrations in Farmington Bay are incomplete. Initial analyses were difficult because the concentrations were higher than had ever been found by the analytical lab. The director of the lab reported: "I cannot estimate the concentration [of nodularin] because it is so high....but I have to tell you that it is terribly high."

All of the samples analyzed for pathogens were positive for the presence of species of the *Legionella* genus. Amoeba cultures were recovered from all three sediments types. The Causeway Breach site yielded 11 amoeba cultures, primarily on the full strength seawater media. Four of those amoeba cultures were also positive by amplification for *Legionella*. The

Sewage Canal site yielded 13 cultures, on all types of media. Only one of those cultures was positive for *Legionella*, and it was from a seawater medium isolate. The site near Farmington Bay refuge yielded 20 cultures, again on all types of media. Ten of these were positive for *Legionella* by amplification, and all of these were from amoebas isolated on either seawater medium or brackish water medium. None of the PCR fragments yielded sequences that were identical to *L. pneumophila*, the human pathogen. The *Legionella* sequences from the Great Salt Lake were distinct from ones Dr. Gast has recovered from Mt. Hope Bay, Massachusetts, and overall tended to cluster together in similarity analyses. This work confirms the unexpected diversity and distribution of *Legionella* species in saline environments that Dr. Gast's research group has recently discovered. The lack of *L. pneumophila* sequences does not mean that these organisms are not present, but rather that tests with pneumophila-specific primer sets still need to be accomplished.

Salinity controls of nitrogen fixation – The bioassay experiment conducted to examine the effects of phosphorus supply and salinity on nitrogen fixation rates showed that nitrogen fixation by *Nodularia spumegina* ceases at salinities greater than 5% (Fig. 16). In this experiment, there was no difference in chlorophyll *a* and nitrogen fixation rates between the control and phosphorus treatments. In contrast, salinity exerted a very clear effect on both chlorophyll *a* and nitrogen fixation (Fig. 16). Chlorophyll *a* concentrations decreased in the salinity treatments greater than 5% through the duration of the experiment, while increasing in salinity treatments less than 5% (Fig. 16a). Nitrogen fixation ceased at salinities greater than 6% on all days of the study, but continued at high rates at the 2 and 4% salinities for the entire experiment (Fig. 16b).

Zooplankton – Seven zooplankton taxa were identified in Farmington and Gilbert Bays (Table 5). Of these taxa, they dominant taxa in each bay varied. Farmington Bay was dominated by the calanoid copepod, *Diaptomus conexus*, and the cladoceran *Moina* sp., whereas Gilbert Bay was most always dominated by *Artemia franciscana.*

Zooplankton densities were extremely variable in Farmington Bay, reaching peaks of 200-600 crustaceans per liter in May and July, but declining to only less than 4% of these highs in late May and October. Zooplankton density was much greater in Farmington Bay than in Gilbert Bay on most sampling dates, but biomass differed little between the two bays (Fig. 17a, b; Appendices 7 and 8). This is because the dominant *Diaptomus* and *Moina* sp. were much smaller than *Artemia*, which were the dominant taxa in Gilbert Bay (Fig. 18). Although *Artemia* were rare in Farmington Bay, when they were present they made up a large part of the zooplankton biomass because of their large size (Fig. 19a). Only a small portion of the biomass in Gilbert Bay was made of up *Ephydra* sp. (brine fly larvae), which is to be expected given that they are a benthic species that only infrequently moves into the water column. Nevertheless, *Ephydra* were the next most abundant taxa after *Artemia*, although they were very rare.

Studies in 2003 showed that *Artemia* biomass was strongly negatively correlated in Farmington Bay with the abundance of two predacious zooplanktors, *Cletocampus albequrquensis* and *Trichocorixa verticalis* (Fig. 20). In 2005, high concentrations of *Cletocampus* were observed only on 3 May, but *Trichocorixa* was abundant from July – Oct, and reached peak densities of 1.3 L^{-1} in late September. Additionally, for much of the summer we found that any solid substrate (ropes, cement blocks) became covered with a 5-10 mm thick layer of corixid eggs, and corixids were abundant on benthic substrates, suggesting that our vertical zooplankton tows may underestimate the true population size of corixids in Farmington Bay.

A regression examination of how salinity may control phytoplankton and zooplankton biomass in Farmington Bay was conducted using seasonal data from 2003 and 2005 at the northernmost sampling station (Station 1; Fig. 21). Both *Nodularia* and cyanophyte biovolume was significantly related to salinity, but *Nodularia* was negatively related ($r^2 = 0.26$, $p = 0.01$; Fig. 21a), while chlorophytes were positively related ($r^2 = 0.40$, $p < 0.01$; Fig. 21b). Of the four zooplankton taxa observed (*Artemia, Moina, Trichocorixa* and *Diaptomus*), none showed a statistically significant relationship with salinity. *Artemia* were the only zooplankton taxa to show a positive relationship with increasing salinity, but this relationship was non-significant and explained almost none of the observed variation, because of the influence of three very large biomass values measured during a population explosion in May 2003 when salinity was near 4% (Fig. 21c).

Benthic substrates—Analysis of the invertebrate taxa on the benthic substrates on a single date in September showed that the overall invertebrate density per m^2 was ca. 3 times lower in Farmington Bay than in Gilbert Bay (Fig. 22). In Farmington Bay, the benthic community was dominated by adult corixids, and the invertebrate screens in the location were covered by a 0.5 – 1.5 cm thick layer of corixid eggs that were much too numerous to quantify. In Gilbert Bay, the main taxa found on the benthic substrates were *Ephydra* sp. (Fig. 22). *Ephydra* sp. were also observed in Farmington Bay, but in much lower densities than in Gilbert Bay, and the species found in each bay were different (*E. hians* in Farmington Bay, *E. cinerea* in Gilbert Bay, Appendix 9).

*Synoptic Analyses of Spatial Variations–*At the time of the June synoptic, the Bear River was discharging 4,000-5,000 cfs, thus contributing substantially to both water and nutrient loading to the northeast corner of the lake. The Surplus Canal was discharging over 1,000 cfs into the southeast corner of Gilbert Bay. The Jordan River was discharging less that 60 cfs during the study.

The June synoptic demonstrated that salinity (and ΔO^{18}–data not shown) varied significantly in the different bays. In Farmington Bay salinities ranged from 0.4 to 1.6% (Fig. 23a) with the lowest values in the southern end of the bay near inflows. In Gilbert Bay salinities were >13% in the south and in most of the north end except where influenced by flows from the Bear River, Farmington Bay, and perhaps the Weber and Ogden Rivers. Salinities in those areas ranged from 7-12% (Appendix 10).

There was a great deal of spatial variability in the plankton populations in the Great Salt Lake, with distinctive differences between Farmington Bay, Bear River Bay, and both the north and south parts of Gilbert Bay (Fig. 23, 24). Chlorophyll levels in Farmington Bay were greater than 150 µg L^{-1} at all stations, with extracted concentrations averaging 262 µg L^{-1}. At the single station sampled in the southern part of Bear River Bay the chlorophyll level was only 17 µg L^{-1}. Chlorophyll levels in Gilbert Bay differed from south to north. In the south where brine shrimp populations were high and nutrient loading presumably low, most chlorophyll measurements were low with mean levels of 1.1 µg L^{-1} (Fig. 23b; Appendix 10). In the north-east end of Gilbert and Ogden Bays, chlorophyll concentrations were 40-80 µg L^{-1} in areas influenced by Farmington Bay and Bear River outflows. Elsewhere chlorophyll concentrations ranged from 0.5-5 µg L^{-1} and averaged 2.7 µg L^{-1}. The MODIS satellite imagery (Fig. 24 B) showed a distinct chlorophyll plume of 10 to > 60 µg L^{-1} extending out of Farmington Bay and flowing WSW approximately 10 miles (16 km). The imagery also showed that the area west of Freemont Island had elevated chlorophyll levels, presumably under the influence of nutrients from the Bear River. Relative concentrations of phycocyanin, a pigment specific to cyanobacteria, were about 100 times higher in Farmington Bay than in the southern and northwestern parts of Gilbert Bay, and about 10 times higher than in the areas influenced by Farmington Bay and Bear River inflows (Fig. 23c; Appendix 10).

Nitrogen fixation also showed a north-south trend during the synoptic sampling. Nitrogen fixation rates on all three sampling dates were generally lowest at the south part of Farmington Bay, close to the Farmington Bay Refuge and the sewage canal inflow, and then increased to a peak in the middle section of the bay (Fig. 23d). This peak was greatest (21 µg N L^{-1} h^{-1}) in the early August sampling, but still peaked at ca. 10 μg L^{-1} h^{-1} in both June and October. Fixation then steadily decreased with increasing proximity to the causeway. Fixation rates were negligible north of the causeway in Gilbert and Ogden Bays where salinity was high (Fig. 23d).

Mesocosm experiments -

August – Initial temperatures in the August mesocosms were high (31° C) and remained high throughout the experiment. Initial chlorophyll levels were also high, averaging 212 ± 4 μg L^{-1} and they did not change significantly in any of the treatments during the experiment. In this experiment the corixids added to the mesocosms apparently reproduced, as there were large numbers of small (ca. 1 mm) corixids in the mesocosms at the end of the experiment, and their numbers were highly correlated with the numbers of adults added (Juveniles = 11.8 * Adults; $r^2 = 0.96$). We expect that the young juveniles may not have had a large impact on other zooplankton, as they likely hatched late in the experiment. Alternative prey other than *Artemia* were abundant in the experiment. Final mean densities of calanoid copepods and *Moina* in the tubes were 20 and 21 L^{-1}. Neither copepod nor cladoceran densities were significantly related to corixid abundances ($p > 0.11$, $p > 0.17$, respectively), although there was a tendency for *Moina* to be lower at the higher densities of corixids.

Despite the presence of high densities of alternative prey, corixid predation decreased juvenile *Artemia* densities significantly ($p = 0.003$) by the end of the 15 day experiment. (Fig. 25). Initial densities of nauplii in the experiment were 10 L^{-1}, and these would have grown into juveniles during the trial. Control treatments at the end of the experiment averaged 5 juveniles L^{-1}, suggesting a 50% survival of added nauplii. This estimate, however, is approximate, because there may have been some nauplii produced by the adult *Artemia* early in the experiment and these could have also grown to juvenile size. At corixid densities of 0.7 L^{-1} juvenile *Artemia* densities were only 0.6 L^{-1}, and with 1.2 corixids L^{-1} juvenile *Artemia* densities averaged 0.05 L^{-1} at the end of the experiment. Adult *Artemia* survival in the experiment was low (3%), but was not significantly influenced by corixid densities (Fig. 25).

September – In the September mesocosm experiment temperatures were near 18° C and initial chlorophyll levels in the tubes were 231 μg L^{-1}, despite considerable amounts of *Nodularia* being filtered out at the start of the experiment. Visual inspection indicated that Nodularia was far less abundant in the 8% salinity by the end of the experiment, a result consistent with the salinity – nitrogen fixation experiment described earlier.

Both salinity and corixid predation had a large impact on *Artemia* abundances (Fig. 26). In the 4% salinity treatment, juvenile survival was negligible, final densities were only 0.04 L^{-1}, and corixids did not significantly influence their densities. In contrast, at 8% salinity with corixids absent, densities of *Artemia* juveniles were 12.4 L^{-1}. In this salinity treatment corixids had a significant impact on juvenile survival. As corixid densities increased to 0.6 and 1.2 L^{-1}, juvenile *Artemia* densities decreased to 0.4 and 0.05 L^{-1}, respectively. Adult *Artemia* were not affected by salinity and corixids had a marginal impact on adult survival at the 8% salinity.

Algal Suitability Bioassay Experiment – The laboratory bioassay experiment showed that survival of adult *Artemia* in Farmington Bay water was poor, with less than 20% survival after 15 days (Fig. 27). Survival in 100% Gilbert Bay water was relatively high (66%), but it was even higher when 10% Farmington Bay water was mixed with 90% Gilbert Bay water. The lowest survival (8%) was in the Gilbert Bay water that had its salinity decreased from 15% to 3%. Results for the nauplii in the different waters were relatively similar. Survival and development to the adult stage was reduced 50% in the Farmington Bay water in relation to *Artemia* in Gilbert Bay water (Fig. 28). Survival and development was, however, highest in the treatment with a mix of 10% Farmington Bay water and 90% Gilbert Bay water with a salinity of 13.8%. Survival and development was lowest in the Gilbert Bay water with its salinity reduced to 3%.

Discussion

Plankton sampling in 2005 confirmed earlier reports that Farmington Bay is hypereutrophic (Carter 1971, Sorensen et al. 1988, Wurtsbaugh 1995, Wurtsbaugh et al. 2002, Wurtsbaugh and Marcarelli 2004a). Trophic state indices (TSI; Carlson 1977) provide a way of summarizing trophic data and comparing them with other lakes. The 2005 trophic data and TSI indices for Farmington Bay were:

Trophic State Indices

Parameter	Level	TSI
Total Phosphorus (µg/L)	673	98
Chlorophyll a (µg/L)	262	85
Secchi (m)	0.32	76
Average		87

The mean TSI is similar to that from 2001 (TSI = 91) that was reported from a preliminary analysis of Farmington Bay (Wurtsbaugh et al. 2002). The trophic state can be compared with other lakes that are considered threatened or impaired, and thus are on the state of Utah's 303d list (Fig. 29). Although Farmington Bay is not on this list, its mean TSI of 87 clearly indicates that it is the most eutrophic system in the state. Although this index is useful for comparing the trophic state in different water bodies, care is necessary when utilizing it to identify impairment, because not all waters have the same beneficial uses.

The plankton community in 2005 was dominated by a large bloom of *Nodularia spumegina* that lasted from May through November. This cyanobacteria has been observed previously in Farmington Bay (Carter 1971), but was not noted in our 2002-2003 survey. This bloom has the potential to profoundly change the biological community in Farmington Bay and influence beneficial uses. It is also quite likely that in high runoff years when salinities drop further in the Bay, that we will encounter blooms of other toxic cyanobacteria, as they are common in eutrophic brackish water (Gasiunaite et al. 2005).

The finding of *Legionaris* bacteria and amoebas in Farmington Bay and the presence of high densities of cyanobacteria raises concerns for the health of human and wildlife populations. Much more work will need to be done on the *Legionaris* and amoeba populations to determine if these are human pathogens or not, as non-pathogenic strains of these are common in natural waters. Likewise, additional work is needed on the toxins produced by *Nodularia* in Farmington Bay. Different species of cyanobacteria can produce both hepato- and neurotoxins that are lethal to mammals (including humans) and aquatic organisms such as brine shrimp (World Health Organization 2003; Beattie et al. 2003; Ibelings 2005; Ibelings and Havens, 2005). The hepatotoxin produced by *Nodularia* (nodularin) has not been studied as extensively as other cyanobacterial toxins, but its chemical structure is similar to that of the well-studied toxin microcystin. Nevertheless, the US Center for Disease Control (CDC) and Prevention indicates that nodularins can cause skin and eye irritation (http://www.cdc.gov/hab/cyanobacteria/facts.htm). A severe skin rash was was observed by one of us (WW) on a child catching brine shrimp in an area where Farmington Bay water overflowed along the north peninsula of Antelope Island (May 13, 2005). The CDC also notes that nodularins are tumor-promoters in mammals. Dried cyanobacteria (*Lyngbya* sp.) can also cause respiratory irritation (Abal et al. 2003; Queensland EPA 2005), but this effect has not been noted from *Nodularia*.

The World Health Organization (WHO 2003) indicates that there is a moderate probability of adverse health effects in recreational waters when cyanobacterial densities exceed 100,000 cells / mL or when chlorophyll levels dominated by cyanobacteria exceed 50 µg

L^{-1}. In Farmington Bay these levels were frequently exceeded by a factor of 10. When a moderate probability of health effects is suspected the WHO suggests that on-site risk advisory signs should be posted. When dense surface scums of cyanobacteria are present (see cover) there is the potential for acute poisoning, potential long-term illness and short-term adverse health outcomes. Under these conditions the WHO recommends prohibition of water contact activities and public health follow-up investigation. Since Farmington Bay and the outflow waters near Bridger Bay have designated uses for primary and secondary contact recreation, state and county agencies need to move towards addressing the public health concerns.

Cyanobacterial toxins have also been shown to cause flamingo and bald eagle mortalities (Alonso-Andicoberry et al. 2002; Wilde et al. 2005), and they have been associated with and suspected of causing mortalities and initiating botulism in other aquatic bird populations (Henrikson et al. 1997; Murphy et al. 2003). However, direct cause and effect has yet to be established. The predominant *Nodularia* in Farmington Bay produces only hepatoxins, but apparently in very high concentrations. Toxin production by cyanobacteria in Farmington Bay is an important water quality concern that could be affecting the survival and health of zooplankton and birds, and must be more closely examined to determine if Farmington Bay is meeting its beneficial uses for these species.

One important species of concern in relation to beneficial use is *Artemia franciscana.* Populations of *Artemia* were even lower in Farmington Bay in 2005 than 2003, but it is not clear what factors kept their populations low. The results of our algal suitability bioassay and the second mesocosm experiment indicated that Farmington Bay water was not suitable for *Artemia* survival, but it is not clear whether this is due to toxicity or to salinity. In the algal suitability assay low survival also occurred in 3% salinity water when Gilbert Bay water was diluted to this salinity. We do not think that salinity alone was responsible for the low survival, as several researchers have reported good survival of *Artemia* in 3.5% salinity (Vanhaecke et al. 1984; Triantaphyllidis et al. 1995; B. Marden, personal communication), and the highest *Artemia* densities we've observed in the bay were at the same low salinity used in the bioassay (4%).

Artemia survival was also very low in the September mesocosm experiment when Farmington Bay was at a salinity of 4%, but not when the salinity of this water was raised to 8%. It is possible that the low salinity, alone, was responsible for the mortalities, but as mentioned above, this does not seem likely. It is more likely that raising the salinity to 8% killed some other organism(s) that harm *Artemia*. Nodularia will not survive at 8% salinity, so their demise is one possibility for the increased *Artemia* survival. However, other parasites or microbes that were not monitored could have also been killed by the 8% salinity, so it is not clear exactly what the mechanism was that lead to increased *Artemia* survival.

The low survival in the diluted Gilbert Bay water may have been due to low food availability, as phytoplankton biomass was low in the diluted Gilbert Bay water lake water (initial chlorophyll near 3 µg L^{-1}), and it is likely that the phytoplankton adapted to the 15% salinity of that bay may not have survived when the salinity was reduced to 3%. In future experiments control treatments should utilize artificial brine shrimp food that is not affected by salinity in order to avoid this possible confounding factor. The addition of 10% Farmington Bay water to Gilbert Bay water did not cause mortalities, but in fact, increased survival of *Artemia*. It is likely that: (1) the *Nodularia* from the Farmington Bay water would have died immediately in the high salinity water (Fig. 16), and (2) the nutrients and/or organic matter from the Farmington Bay water promoted *Artemia* growth in the mixed water. This suggests that any released toxins from the *Nodularia* flowing into Gilbert Bay may not be toxic to *Artemia* there, and that the high production in Farmington Bay may contribute to *Artemia* production in Gilbert. More experiments will be necessary to test these hypotheses.

Another factor that may reduce *Artemia* and other zooplankton in Farmington Bay is anoxia. When the deep brine layer was present, there was complete anoxia and toxic levels of hydrogen sulfide, thus making this zone unsuitable for organisms dependent on dissolved oxygen. Furthermore, nighttime anoxia was very common, and this may have stressed the zooplankton. Finally, longer-term anoxic events were common in the south-central part of the bay and they also occurred in the north end of the bay. The more common nighttime and prolonged anoxia in the south end of the bay than in the north was unexpected because a shallow water column should be able to be reairated more easily than a deeper layer (north). Nutrient loading is, however, likely higher at the south end of the lake where the Sewage Canal enters, and a shallow water column contains less oxygen to meet the demands of respiration in the sediments. Whatever the reasons, the frequent anoxia through much of the bay indicates that it is a stressful environment for most organisms.

The prolonged anoxic events of several-day duration that were linked to wind events were less frequent in 2005 than in 2003 (Wurtsbaugh and Marcarelli 2004c), and consequently we were unable to sample immediately after storms. Analysis of plankton samples collected automatically at the causeway breach suggests that there were no marked mortalities associated with the one anoxic event at Station 1 in October. The lack of prolonged anoxic events in June-July 2005 was likely because a deep brine layer did not form at Station 1 until mid-July. We have argued previously that the deep brine layer is instrumental to causing anoxic events, because the anoxic deep brine layer acts as a storage zone for hydrogen sulfide produced in the water column (e.g. Watts et al. 2001) and for sulfide that is produced in the sediments and diffused into the overlying anoxic water (Ingvorsen et al. 1981). Releases of hydrogen sulfide from anoxic hypolimnia have been linked to multiple day anoxic events in the Salton Sea and to mass die-offs of phytoplankton, zooplankton, and fish (Watts et al. 2001). Interestingly, in 2003 all anoxic events were correlated with high wind events measured at the Salt Lake City airport, while the 2005 mixing event was not correlated with a similar event, indicating that either (1) mixing was caused by a localized wind event such as a microburst, or (2) some other factor cause water column destabilization and mixing in 2005. The high variability of total zooplankton densities in Farmington Bay suggests that there may be massive die-offs of organisms there, but if this is the case, the cause of these is not clear, as the rapid declines were not clearly linked with anoxic events or the wax and wane of *Nodularia* populations. Continued monitoring is necessary to determine the potential effects of multiple-day anoxic events in Farmington Bay.

The final reason that *Artemia* were likely low in Farmington Bay in 2005 was the high density of corixids. Our mesocosm experiments demonstrated that at corixid densities equal to, or above, 0.6 L^{-1} *Artemia* populations could not survive, and these predator densities were exceeded for a considerable portion of the summer. Corixid predation decreased *Artemia* abundance even when high densities of potential alternative prey are available. This may be due to the high escape capabilities of the calanoid copepod, and to the tough carapace of *Moina. Artemia*, although resistant to harsh conditions and capable of extraordinary feeding and population growth, is known to be highly vulnerable to predators (Williams 1998). Mellison (2000) and Belovsky (2005) have also suggested that corixids could control *Artemia* in Farmington Bay if densities of the predators were to reach high levels.

Although Moina and copepods were extremely abundant in Farmington Bay through mid-summer, they were nearly absent after August. The high densities in the spring and early summer suggest that the high productivity of the phytoplankton can be transferred up the food web. The near absence of macrozooplankton latter in the summer suggests either that the harsh water quality conditions (anoxia, ammonia, cyanobacteria and toxins) limit their abundance then, and/or that predation by corixids keeps them at very low levels.

The high densities of *Nodularia* in Farmington Bay were a major change from our earlier sampling. Previous work has suggested that *Nodularia spumegina* are intolerant of high salinities. Previous surveys have shown that *Nodularia* sp. abundance declines dramatically in Farmington Bay at salinities greater than 6% (data of Carter 1971, plotted in Wurtsbaugh and

Marcarelli 2004b). Stephens (1990) noted that *N. spumegina* appeared in Gilbert Bay when salinities decreased to 6% in the mid-1980's. This intolerance likely explains why *Nodularia* were absent from Farmington Bay in 2002-2003, when salinities were consistently greater than 5%, but very abundant in 2005 when salinities ranged from 0.5 – 5%. A mesocosm study in Mono Lake examined the community composition of benthic algal mats at five salinities between 5 and 15%. The filamentous cyanobacteria *Oscillatoria* sp. only occurred in salinity treatments between 5% and 10% and no other cyanobacteria was present at any salinity (Herbst and Blinn 1998). Other studies have shown that high salinities may cause stress on cyanobacteria species (Pickney et al. 1995) or affect their ability to osmoregulate (Bebout et al. 1993), thus affecting their survival at increased salinity. More work is needed to determine the specific mechanism affecting survival of *Nodularia spumegina* in the Great Salt Lake at high salinities.

The high *Nodularia* densities in Farmington Bay in 2005 allowed nitrogen fixation rates that are among the highest reported in any lake. A conservative seasonal estimate can be calculated by taking the mean hourly fixation rate observed in this study, assuming 10 h / day of fixation, and then multiplying by the number of days in this study and the mean depth of Farmington Bay (0.5 m), resulting in a fixation rate in g N / m^2 / season. The 10 h / day of fixation is certainly conservative, but is comparable to assumed duration of fixation in a review of fixation rates in oceans, estuaries, and lakes by Howarth et al. (1988). Using these assumptions, we estimate a *seasonal* fixation rate of 5.0 g N / m^2 / season, which is lower than only one *annual* estimate in Howarth et al. (1988), and the only higher value was 9.2 g N m^{-2} yr^{-1} in a hypereutrophic reservoir in South Africa. This source of nitrogen is likely to be an important part of the nitrogen cycle in Farmington Bay. Horne and Galat (1985) found that nitrogen fixation by *Nodularia spumegina* provided 99.5% of the alga's needs and 81% of the total annual N input to Pyramid Lake in Nevada. However, this lake had very low hydrologic input of N, in contrast to Farmington Bay, which has excessively high dissolved nutrient loading from the sewage canal and sewage treatment plants along its shoreline (Wurtsbaugh et al. 2002).

Considerable amounts of nutrients from hydrologic sources in Farmington Bay are likely removed if the discharges flow through wetlands (Theron Miller, Utah Div. Water Quality; personal communication). The discharges into the Jordan River always pass through wetlands before entering the lake. During low water years that expose extensive mud flats, wetlands also develop along the wastewater outfalls of the Davis County sewage treatment plants, and these also remove nutrients. However, the loading from the Salt Lake Sewage Canal alone is adequate to cause hypereutrophic conditions in Farmington Bay, and this canal does not pass through a wetland. The estimates of loading from all of the domestic and industrial sources need to be analyzed and combined with estimates of nitrogen fixation to help understand eutrophication processes in Farmington Bay.

The high fixation rates may also explain why the usually nitrogen-limited waters were able to support far higher algal populations (as indicated by chlorophyll *a*) in 2005 than in 2003 when higher salinities precluded *Nodularia* from growing. When cyanobacteria die, a large portion of the nitrogen they fixed is released to the rest of the ecosystem via decomposition and mineralization, and recent research indicates that as much as 25% of the nitrogen fixed by pelagic cyanobacteria is released as dissolved organic nitrogen (Mulholland et al. 2004). Nitrogen fixation thus could potentially make Farmington Bay a net source of fixed nitrogen for the lake. However, it is unclear how much nitrogen is consumed by microbial reactions in Farmington Bay. The major counterbalancing forces to nitrogen fixation in the nitrogen budget are denitrification ($2NO_3 \rightarrow \rightarrow N_2$) and the recently discovered anammox reaction ($NO_2 + NH_3 \rightarrow N_2$; Dalsgaard et al. 2005). Both bacterially-driven reactions occur in anoxic or hypoxic environments when nitrate and nitrite are present. Farmington Bay is an ideal site for these reactions as there is an abundance of biological activity to generate ammonium, considerable oxygen during the daytime so that the ammonia can be oxidized to nitrite and nitrate via nitrification, and nighttime anoxia when bacteria can utilize the nitrate produced during the day and produce N_2. Additionally, these processes can occur at the sediment-water interface where anoxic and oxic conditions occur within millimeters of each other in the presence of high concentrations of nitrogen reactants. It is possible that denitrification and anammox more than counterbalance nitrogen fixation in the bay, with the system thus acting as a treatment pond to remove nitrogen before it can reach Gilbert Bay. Detailed studies on nitrogen fixation and nitrogen loss mechanisms are needed to test this hypothesis.

Our analyses of Farmington Bay indicate that water quality there is poor. Low oxygen and high unionized ammonia concentrations do not meet either marine or freshwater criteria. Cyanobacterial blooms in 2005 also greatly exceeded levels considered to pose moderate or high probabilities of public health risk. Because of the unusual characteristics of Farmington Bay and the rest of the Great Salt Lake, the Utah Division of Water Quality has not, however, applied criteria established for other waters in the United States. The data presented here suggest that the state needs to move towards either adopting the existing standards or to develop site-specific water quality standards for Farmington Bay.

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Table 1: Station numbers and GPS coordinates of sampling stations in Farmington and Gilbert Bays used in this study.

Station Name	GPS Coordinates (lat long)	Location and notes
1	N 41 02.985 W 112 11.321	N end of Farmington Bay, 3 km from causeway
2	N 41 01.823 W 112 09.547	SSE of Station 1
3	N 40 59.803 W 112 08.442	SSE of Station 2
4	N 40 57.849 W 112 06.548	SSE of Station 3; too shallow to sample after Aug 2005
14	N 41 00.829 W 112 15.397	West side of Antelope Island, North Site
15	N 40 55.518 W 112 15.387	West side of Antelope Island, South Site
18	N 40 57.572 W 112 15.832	West side of Antelope Island, between Stations 14 and 15

Table 2: Parameters and methods used in the synoptic surveys of Farmington, Bear River & Gilbert Bays.

Parameters	Method	Dates	All Sta.	Subset
Physical				
Temperature/conductivity profile	InSitu sonde	All		x
Light penetration	LiCor Radiometer	All		x
Current Profile	Acoustic doppler profiler (USGS)	June		x
Satellite imagery	MODIS satellite, NASA	June	lake	
Spectral reflectance signature		June		x
Surface skin temperature	Infarred gun	June	x	
Secchi depth	25-cm disk	All	x	
Biological				
Chlorophyll *a*(extracted)	Turner 10AU fluorometer (Welschmeyer method)	All	x	
Chlorophyll: in vivo fluorescence	Turner Aqua flour field fluorometer	June	x	
Phycocyanin (Lab fluorometer)*	Turner Trilogy fluorometer; Ex 600 nm; Em 640 nm	June	x	
Phycocyanin (Field Fluorometer*	Turner Aquaflour fluorometer Ex: 595 nm; Em 670 nm	June	x	
Phycoerythrin (Lab fluorometer)*	Turner Trilogy fluorometer. Ex 550 nm; Em 610 nm			x
Nitrogen Fixation	Acetylene reduction, laboratory incubation	All		x
Phytoplankton taxonomic sample	3% formalin preservation, inverted microscope	All		x
Zooplankton taxonomic sample	3% formalin preservation, dissecting scope	All		x
Zooplankton isotopic content 15N	Mass spectrometer (Ehlringer Laboratory, U of U)	June		x
Seston isotopic composition 15N, 13C	Mass spectrometer (Ehlringer Laboratory, U of U)	June		x
Chemical				
Salinity	Field refractometer	All	x	
Total N, Total P, Ammonium	Colorimetric analyses	All		x
H2O isotopic analysis ; ^{18}O, D	Mass spectrometer (Ehlringer Laboratory, U of U)	All	x	
Colored Dissolved Organic Matter	Absorbance at 440 nm	All		x

* cyanobacterial pigment

Table 3: Outline of predator and salinity treatments used in the Mesocosm experiment #2.

	PREDATOR DENSITY		
SALINITY	4%, 0 corixids L^{-1}	4%, 0.6 corixids L^{-1}	4%, 0.8 corixids L^{-1}
	8%, 0 corixids L^{-1}	8%, 0.6 corixids L^{-1}	8%, 0.8 corixids L^{-1}

Table 4. Phytoplankton observed in Farmington and Gilbert Bays during the 2005 sampling period. Divisions are shown in bold.

Name	**Farmington Bay**	**Gilbert Bay**
CHLOROPHYTA		
Carteria sp.	X	
Dunaliella viridis	X	X
Dunaliella salina	X	X
Oocystis sp.	X	X
Pediastrum sp.	X	
Spermatozopsis sp.	X	X
Scenedesmus sp.	X	
PYRROPHYTA		
Cryptomonas sp.	X	X
Glenodinium sp.	X	
Unidentified chrysophyte	X	X
BACILLARIOPHYTA		
Amphora sp.*	X	X
Amphora coffeaeformis	X	X
Chaetocerous sp.	X	
Cyclotella sp.	X	X
Nitzschia palea	X	
Navicula graciloides	X	X
Navicula lanceolata		X
Navicula tripuctata	X	
Navicula sp. (45 – 100 µm)	X	X
Synedra sp.	X	
CYANOPHYTA		
Microcoleus sp.	X	X
Nodularia spumegina.	X	X
Pseudanabaena sp.	X	
Spirulina sp.	X	

Table 5. Names and occurrence of zooplankton taxa observed in Farmington and Gilbert Bays during the 2002-2003 sampling period. X indicates that a taxa was found in that bay during the study period.

Name	Stage	Farmington Bay	Gilbert Bay
Artemia franciscana	Adult	X	X
	Juvenile	X	X
	Nauplii	X	X
Trichocorixa verticalis		X	X
Ephydra sp.	Adult	X	X
	Pupae	X	X
	Larvae	X	X
Cletocampus albuquerquensis		X	
Diaptomus conexus		X	X
Moina sp.		X	X
Cyclopoid copepod (very rare)		X	X

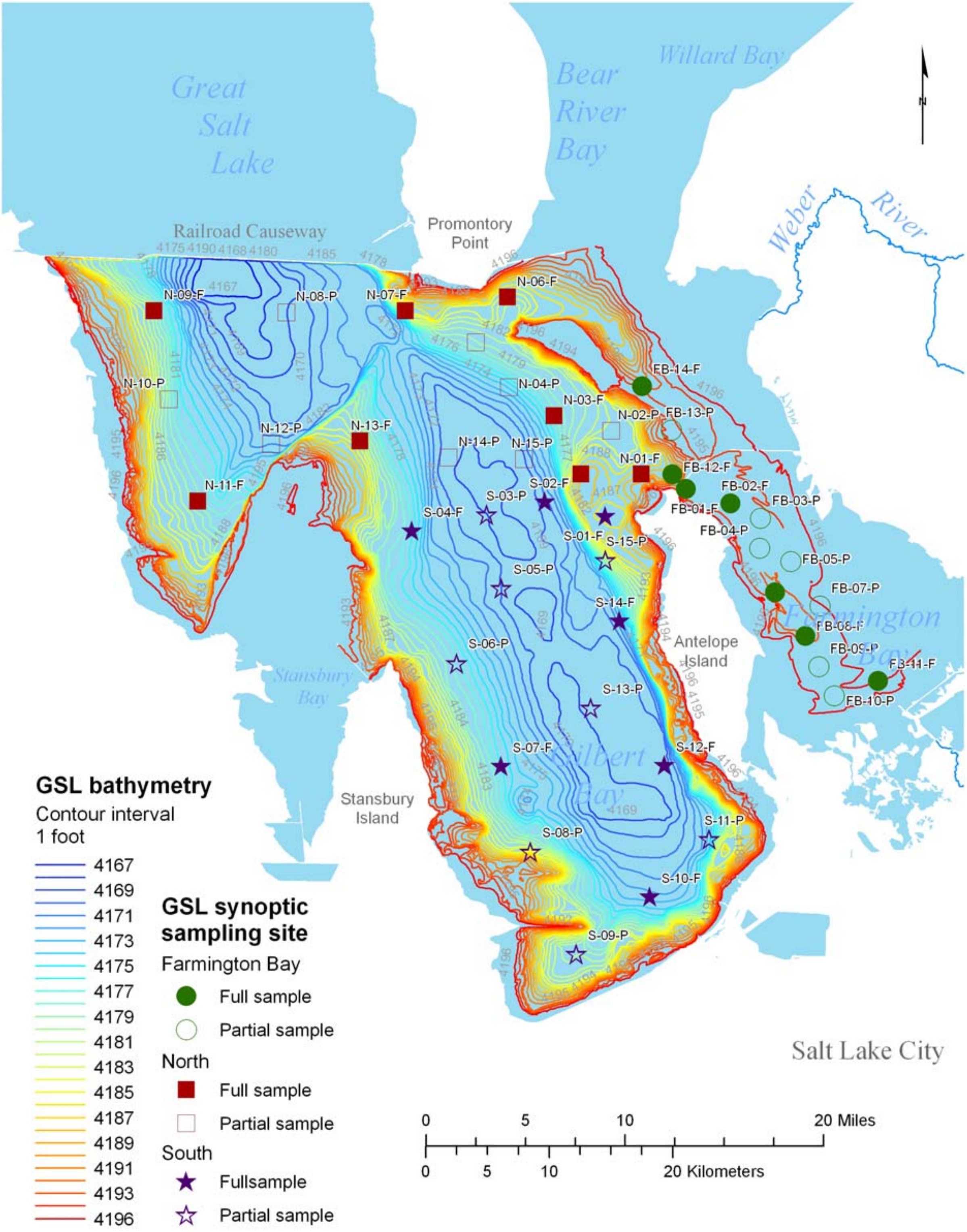

Figure 1. Location of the synoptic sampling sites used in this study. Note that Stations FB 12, 13 and 14 were collected north of the automobile causeway in Ogden Bay.

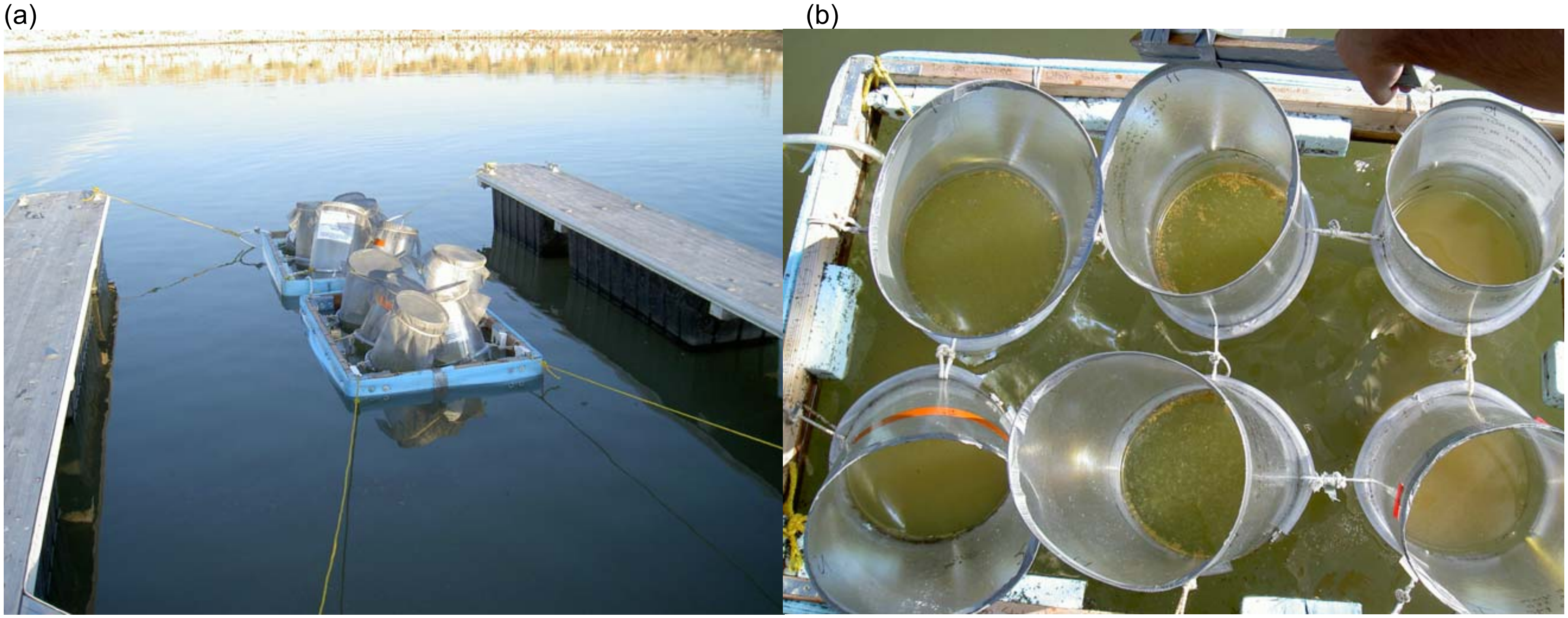

Figure 2. Fiberglass cylinders used in the mesocosm experiments (a) located in Antelope Island Marina, and (b) close up of one set. Photos by J. Armegol Diaz.

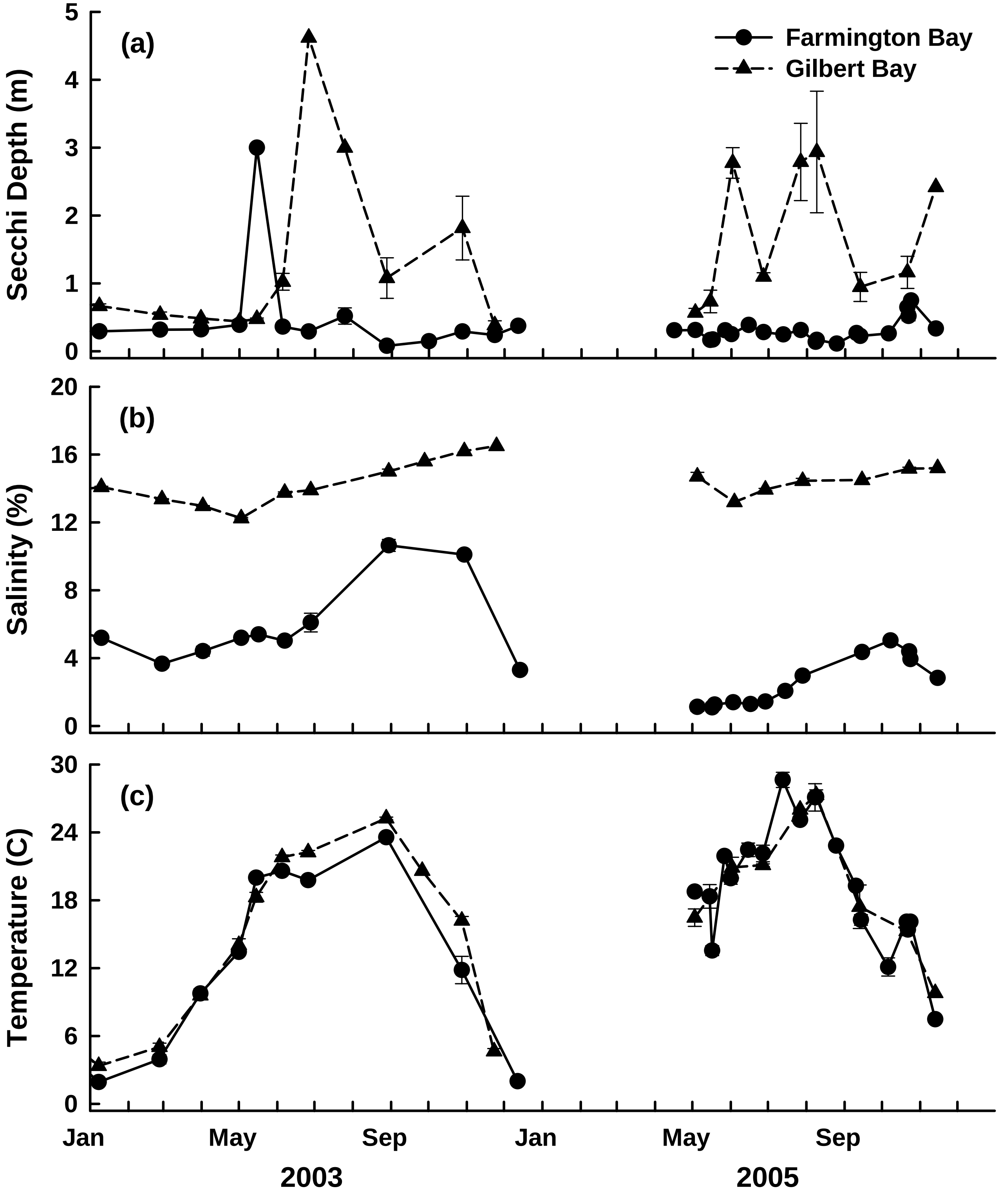

Figure 3. Trend in (a) Secchi depth (index of water clarity), (b) salinity, and (c) temperature in the mixed layer in Farmington and Gilbert bays during 2003 and 2005. Error bars are ± 1 S. E.

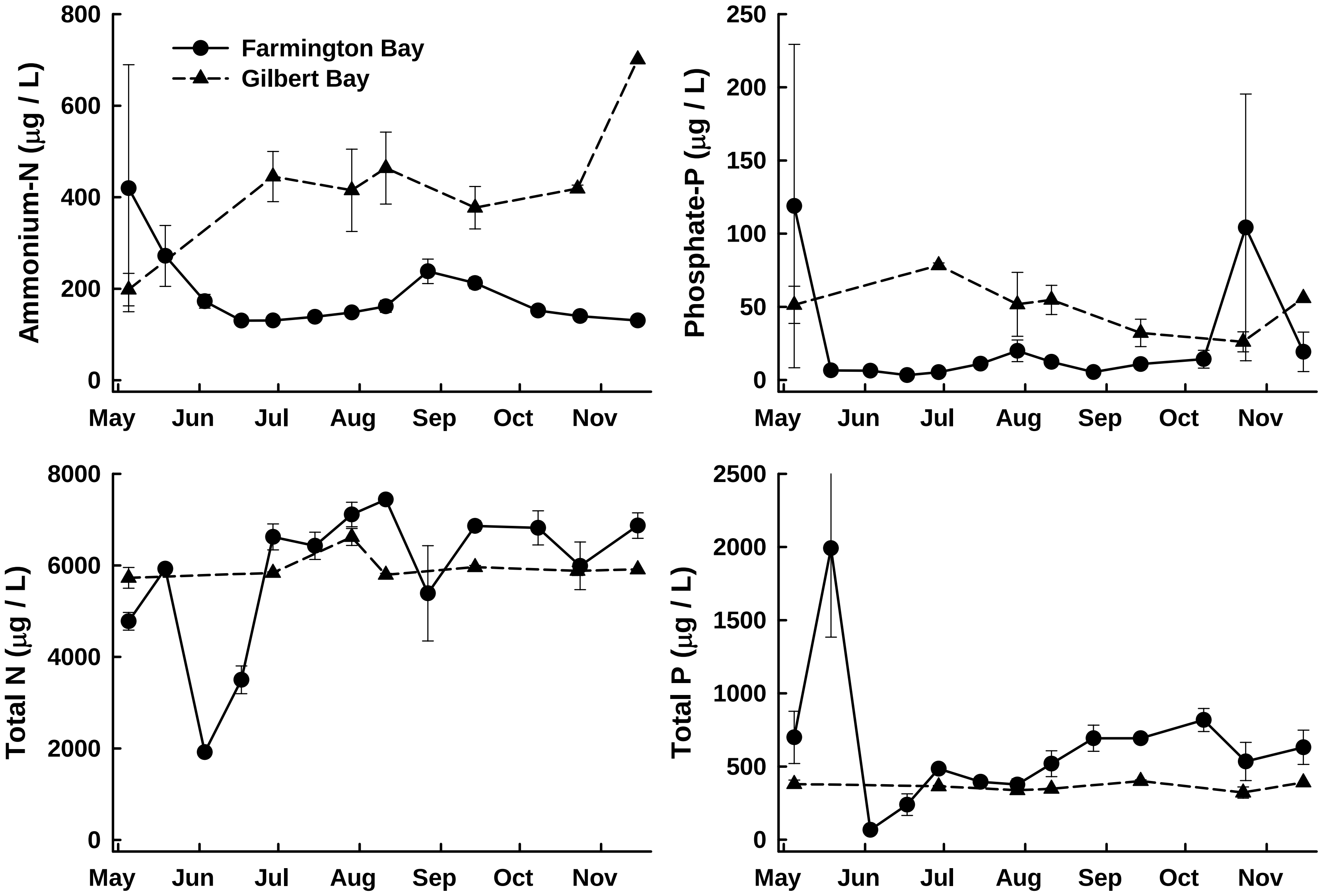

Figure 4. Trends in chemical species measured in Farmington and Gilbert Bays during the 2005 study. Error bars are ± 1 S. E.

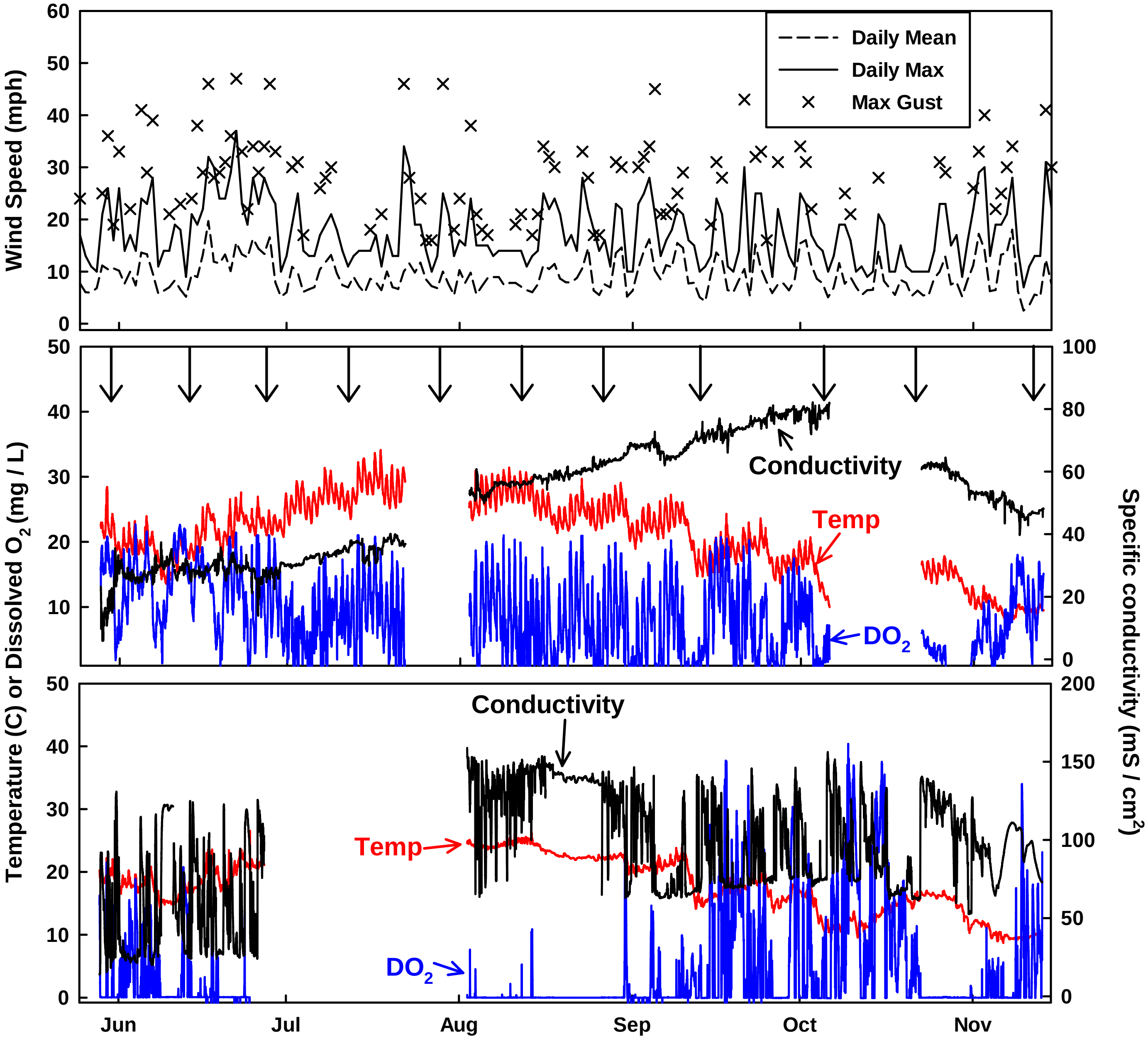

Figure 5. Weather data (top pane) collected at SLC international airport, compared to water quality data measured *in situ* at 0.2m (middle pane) and the bottom of the water column (bottom pane) at Station 1 in Farmington Bay in 2005. Arrows represent 2005 project sampling dates on Farmington Bay. Daily weather means and maximums determined from hourly observations from the National Climate Data Center (http://www.ncdc.noaa.gov). "Speed" indicates that the observation is 2-minute average of the conditions just prior to the observation; "gust" is the maximum 5 second wind speed measured in the 5 minutes prior to the observation.

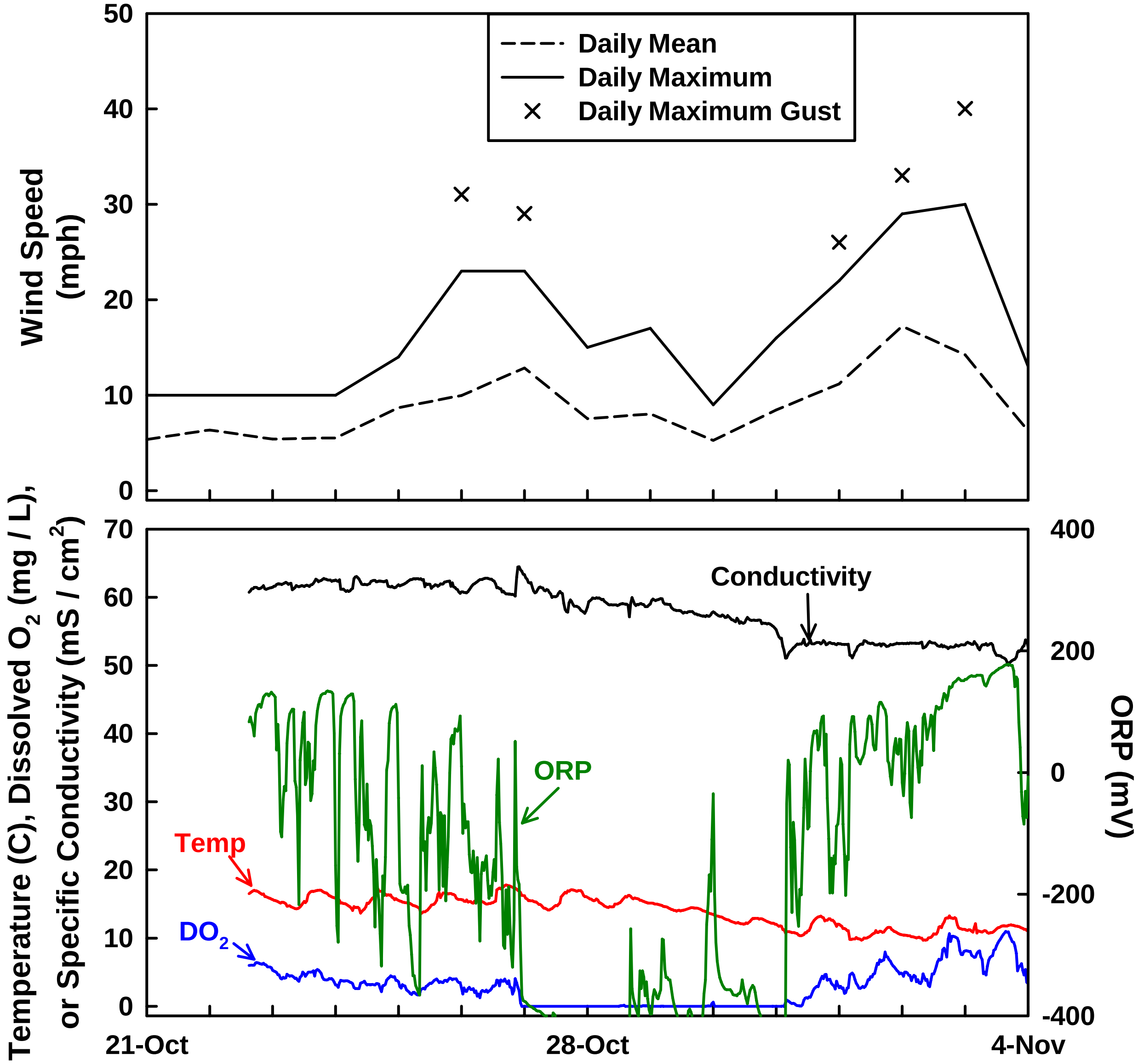

Figure 6. An expanded view of (a) wind data, collected at the Salt Lake airport, and (b) water quality record at Station P1, showing in detail the single period of anoxia documented in 2005, from 27-Oct to 31-Oct. Note that when oxygen concentrations drop to zero, ORP is negative. This event was not correlated with a large wind event at the salt lake airport, but there was a peak in salinity indicating mixing with the deep brine layer or that high-salinity water was pushed into Farmington Bay from Gilbert Bay.

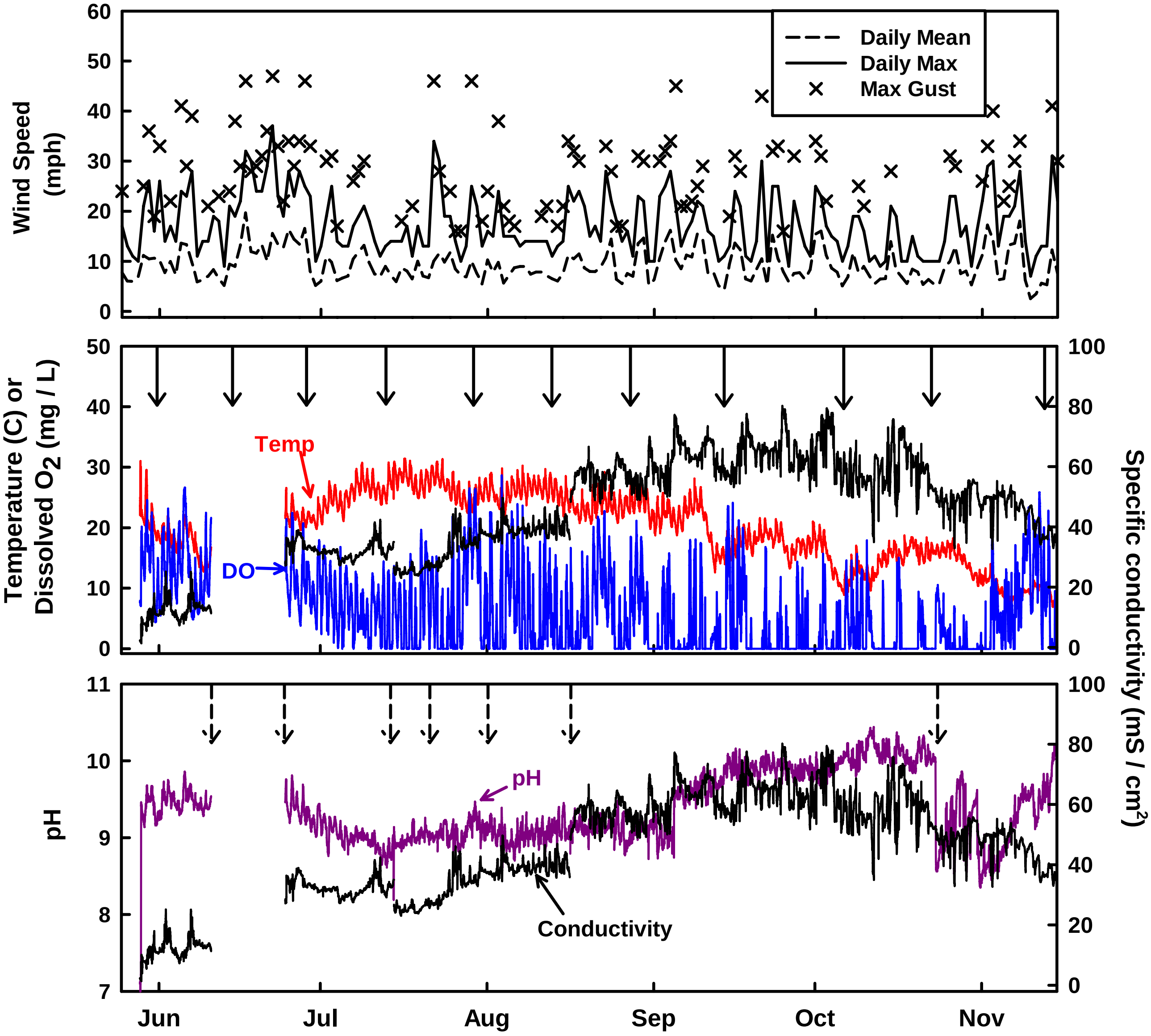

Figure 7. Weather data (top pane) collected at SLC international airport, compared to water quality data (bottom and middle panes) measured *in situ* at Station 3 in 2005. Solid arrows on the middle pane represent 2005 project sampling dates on Farmington Bay. Dashed arrows on the bottom pane represent days that the sondes were downloaded and calibrated. Daily weather means and maximums determined from hourly observations from the National Climate Data Center (http://www.ncdc.noaa.gov). “Speed” indicates that the observation is 2-minute average of the conditions just prior to the observation; “gust” is the maximum 5 second wind speed measured in the 5 minutes prior to the observation.

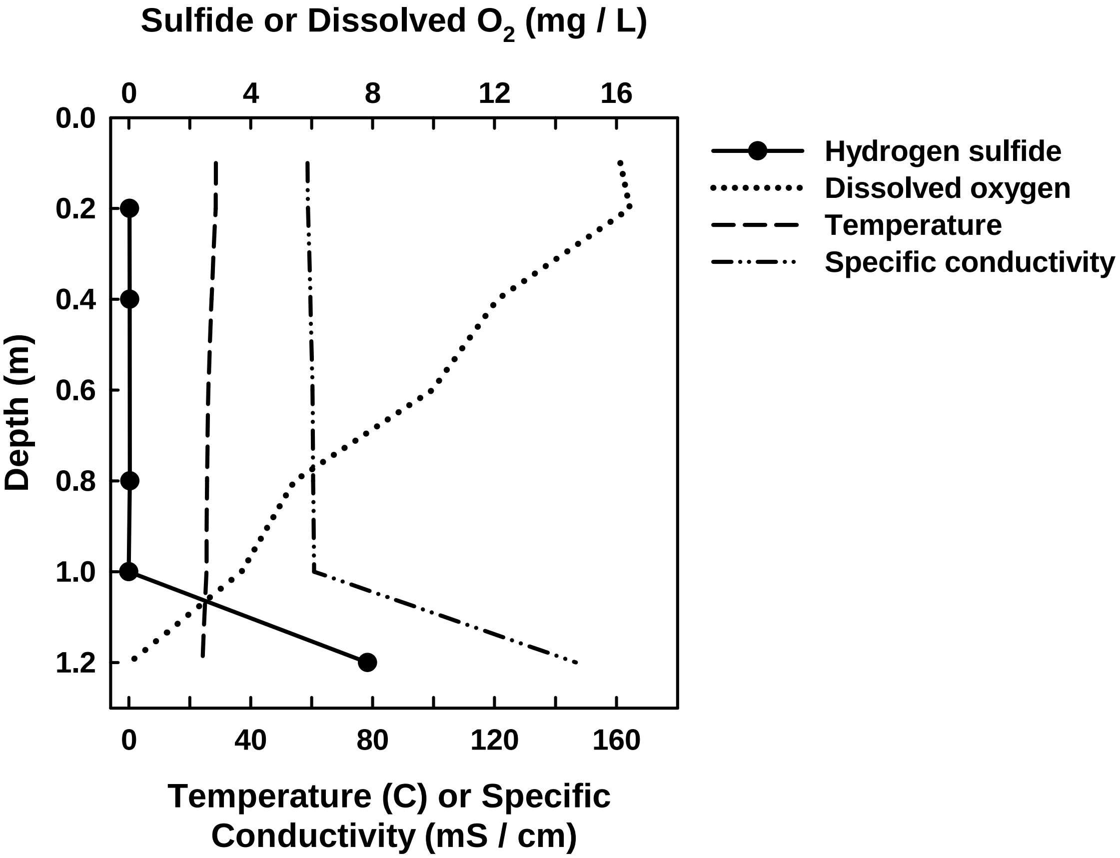

Figure 8. Typical vertical profile for hydrogen sulfide concentrations observed in Farmington Bay in the 2005 study. This profile was measured at 15:00, 9 Aug 2005. n=1 for each measurement.

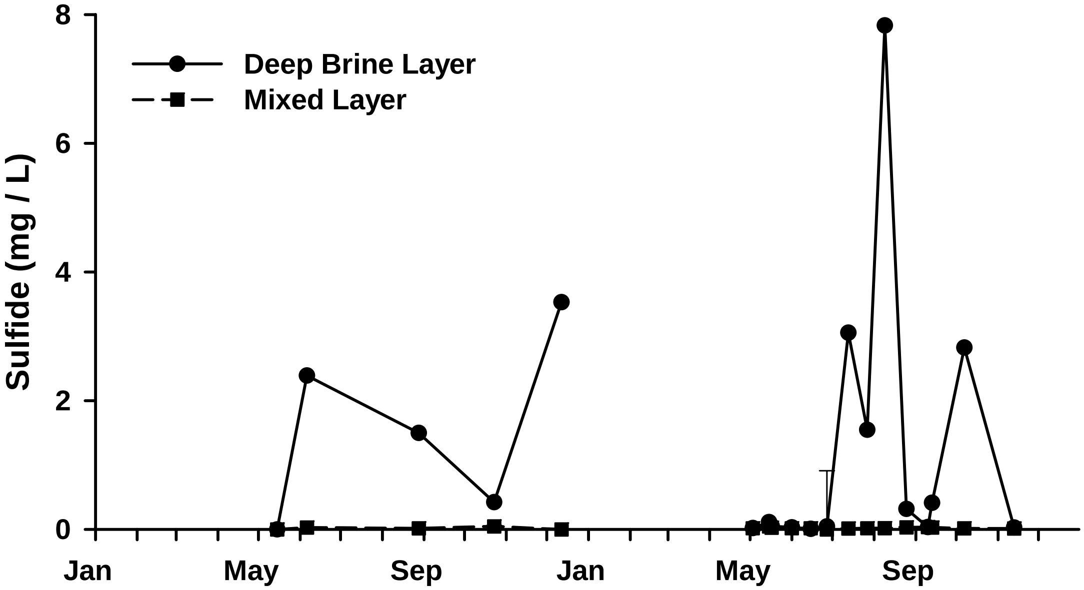

Figure 9. Seasonal pattern of hydrogen sulfide concentrations in the mixed and deep brine layers at Station P1 in Farmington Bay. Error bars are ± 1 S. E, n varies between sampling dates. In 2005, a deep brine layer did not form until early July, while it was present for the entire sampling period in 2003.

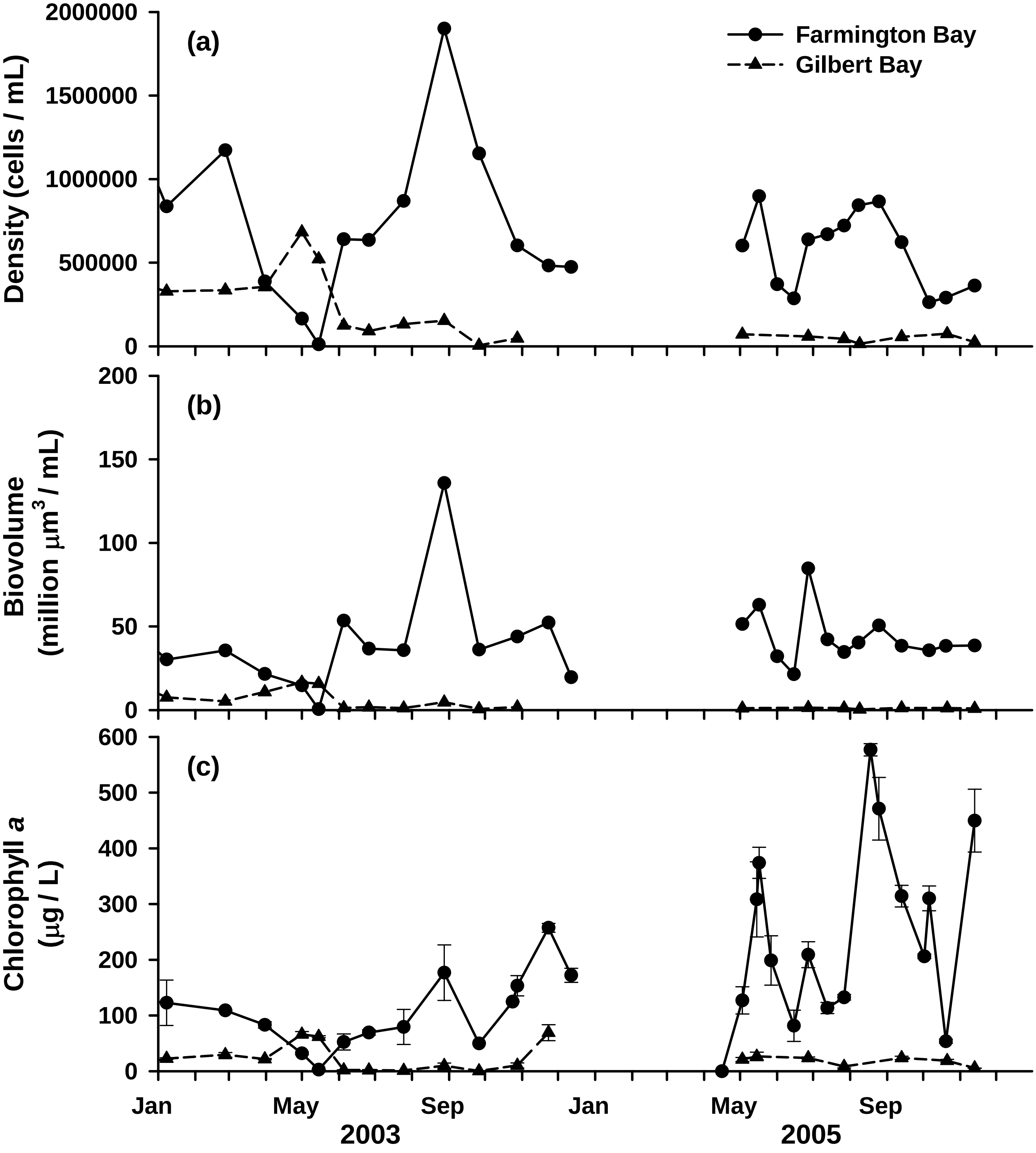

Figure 10. (a) Total phytoplankton density, (b) biomass, and (c) chlorophyll *a* in Farmington and Gilbert Bays during 2003 and 2005. Error bars are ± 1 S. E.

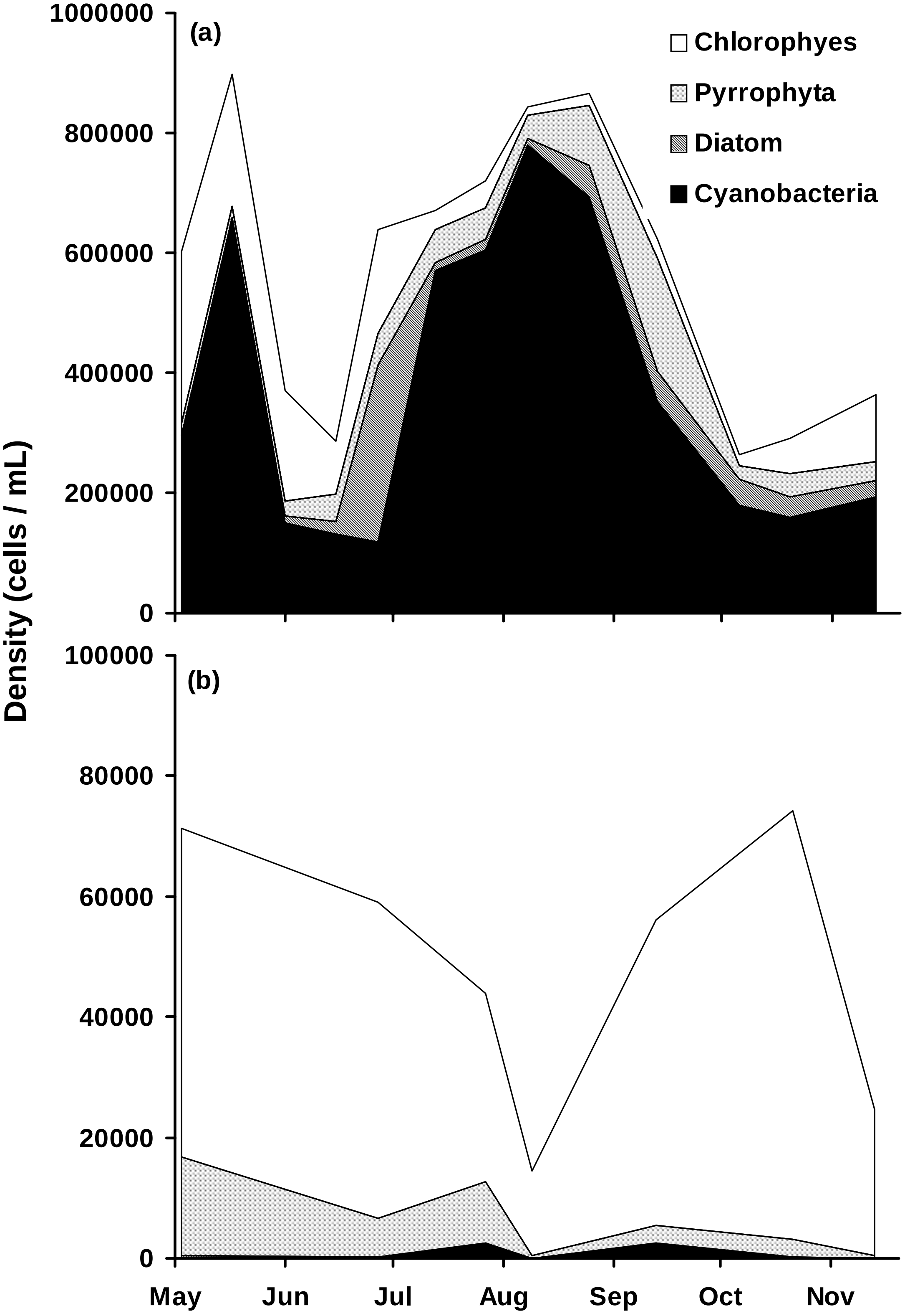

Figure 11. Phytoplankton densities in (a) Farmington and (b) Gilbert Bays during the 2005 study. Note x-axis on (a) is 10X greater than on (b).

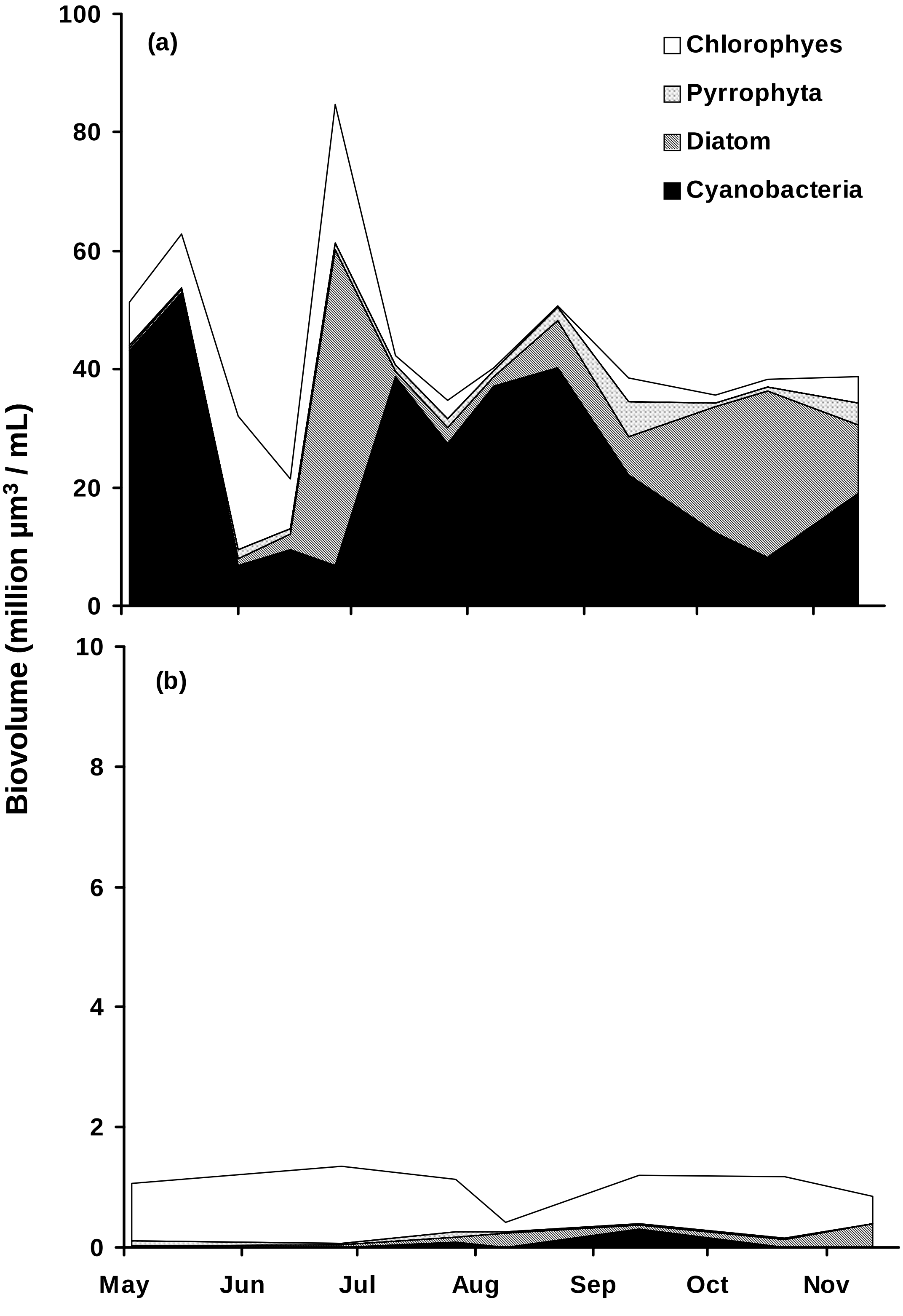

Figure 12. Phytoplankton biovolumes in (a) Farmington and (b) Gilbert Bays during 2005. Note x-axis on (a) is 10X greater than on (b). Biovolume is expressed at 1 million µm^3 / mL of ease of presentation; 1 million µm^3 / mL = 10^{-6} µm^3 / mL.

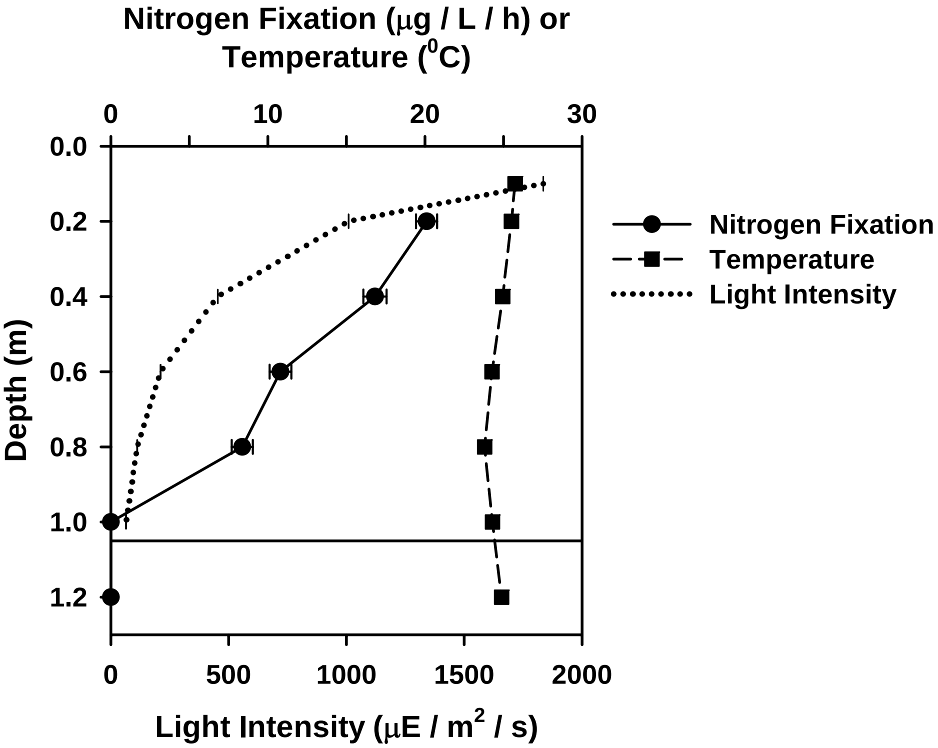

Figure 13. Typical vertical profile for nitrogen fixation observed in Farmington Bay in the 2005 study. This profile was measured on 25 Jul 2005. The horizontal line indicates the approximate depth of the deep brine layer on the study date. Error bars are ± 1 S. E, n=2.

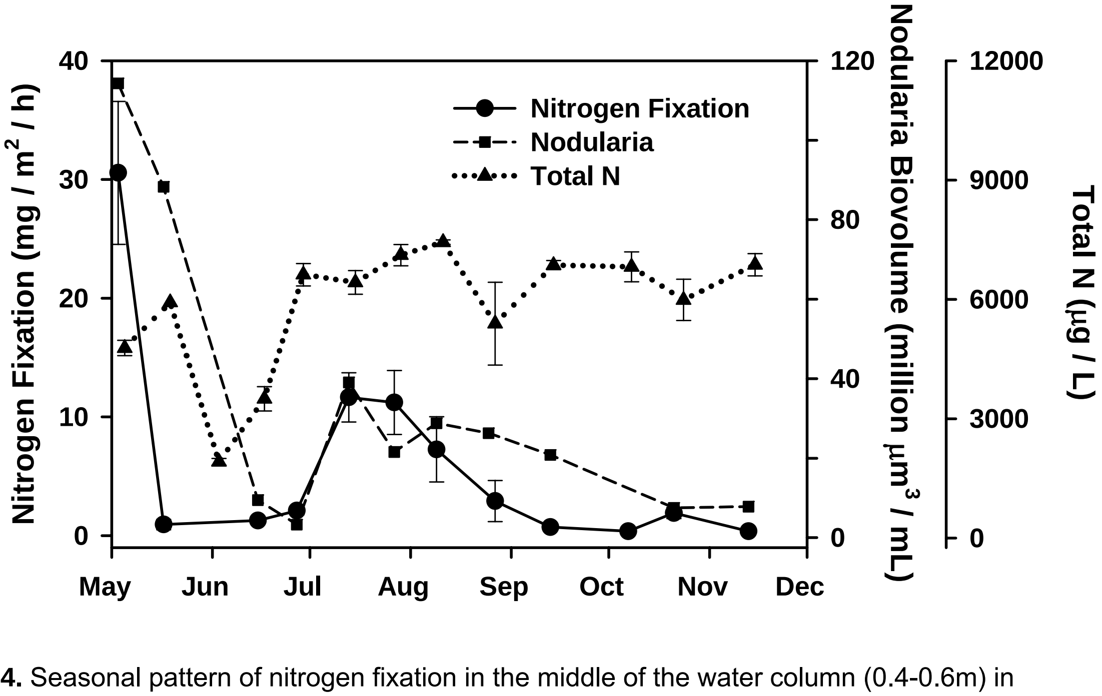

Figure 14. Seasonal pattern of nitrogen fixation in the middle of the water column (0.4-0.6m) in Farmington Bay at the northernmost sampling station in 2005. For comparison, Nodularia biovolume is also plotted. For nitrogen fixation, error bars are ± 1 S. E, n=2.

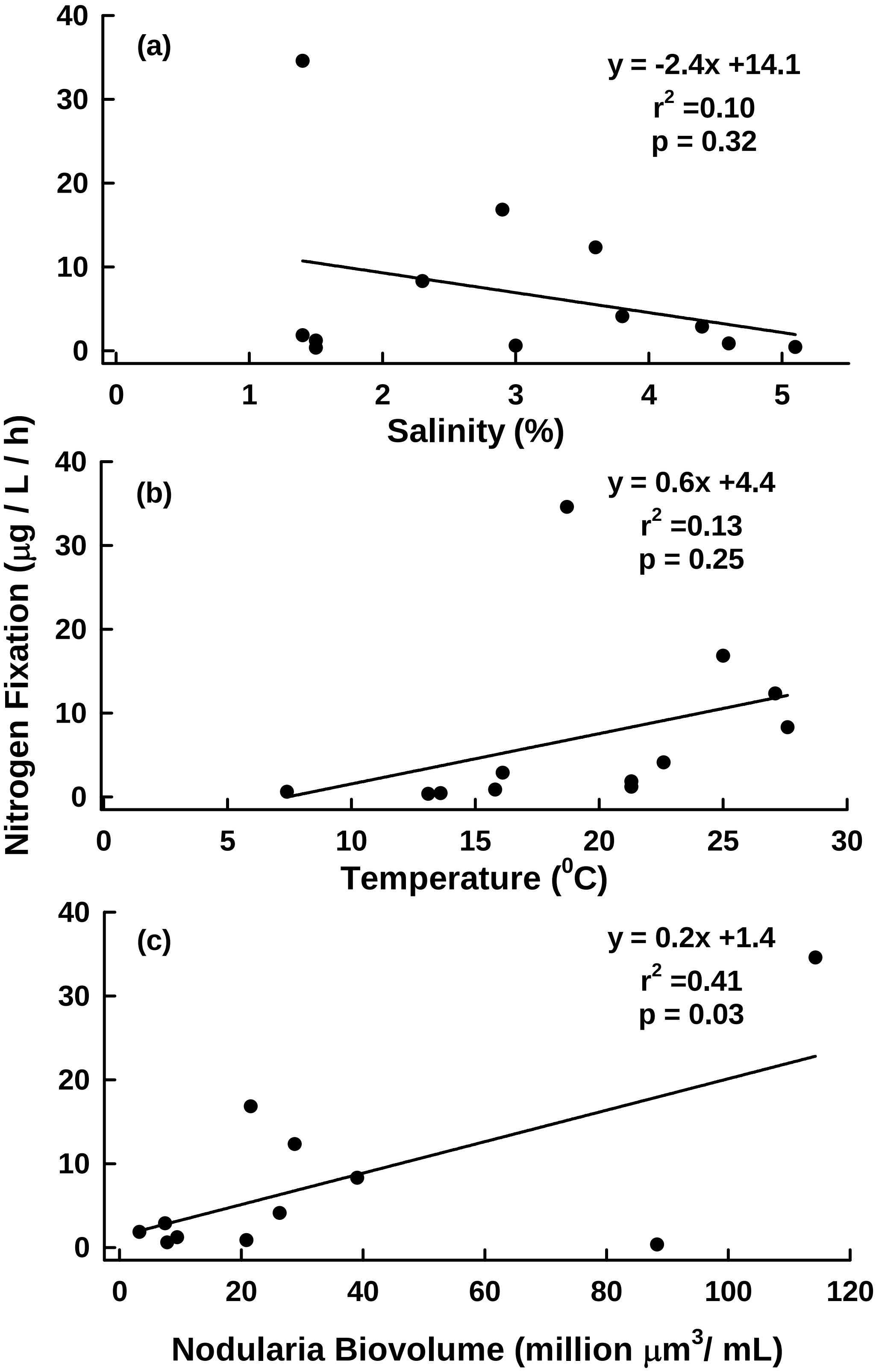

Figure 15. Nitrogen fixation rates, measured in the middle of the water column at Station 1, vs. (a) salinity, (b), temperature, and (c) Nodularia biovolume.

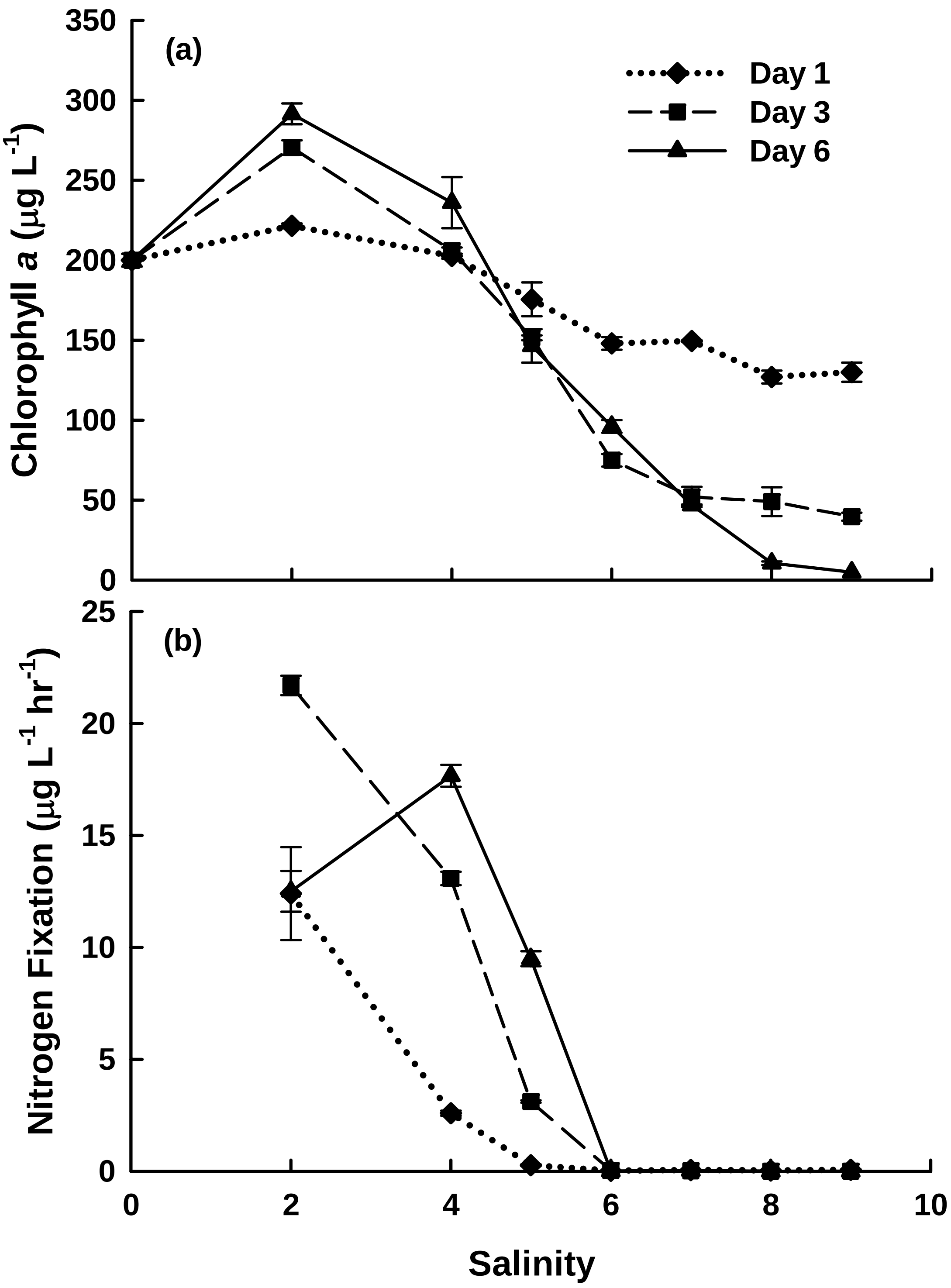

Figure 16. (A) Chlorophyll *a* and (b) nitrogen fixation results from the salinity-bioassay on the three days of the experiment. Note (1) how nitrogen fixation peaks later at higher salinities and (2) how nitrogen fixation ceases on all days at greater than 6% salinity. Error bars are ± 1 S.E. Results from the control and phosphorus treatments were not significantly different (Two—way ANOVA on each sample day, $p > 0.40$) and are combined for this figure.

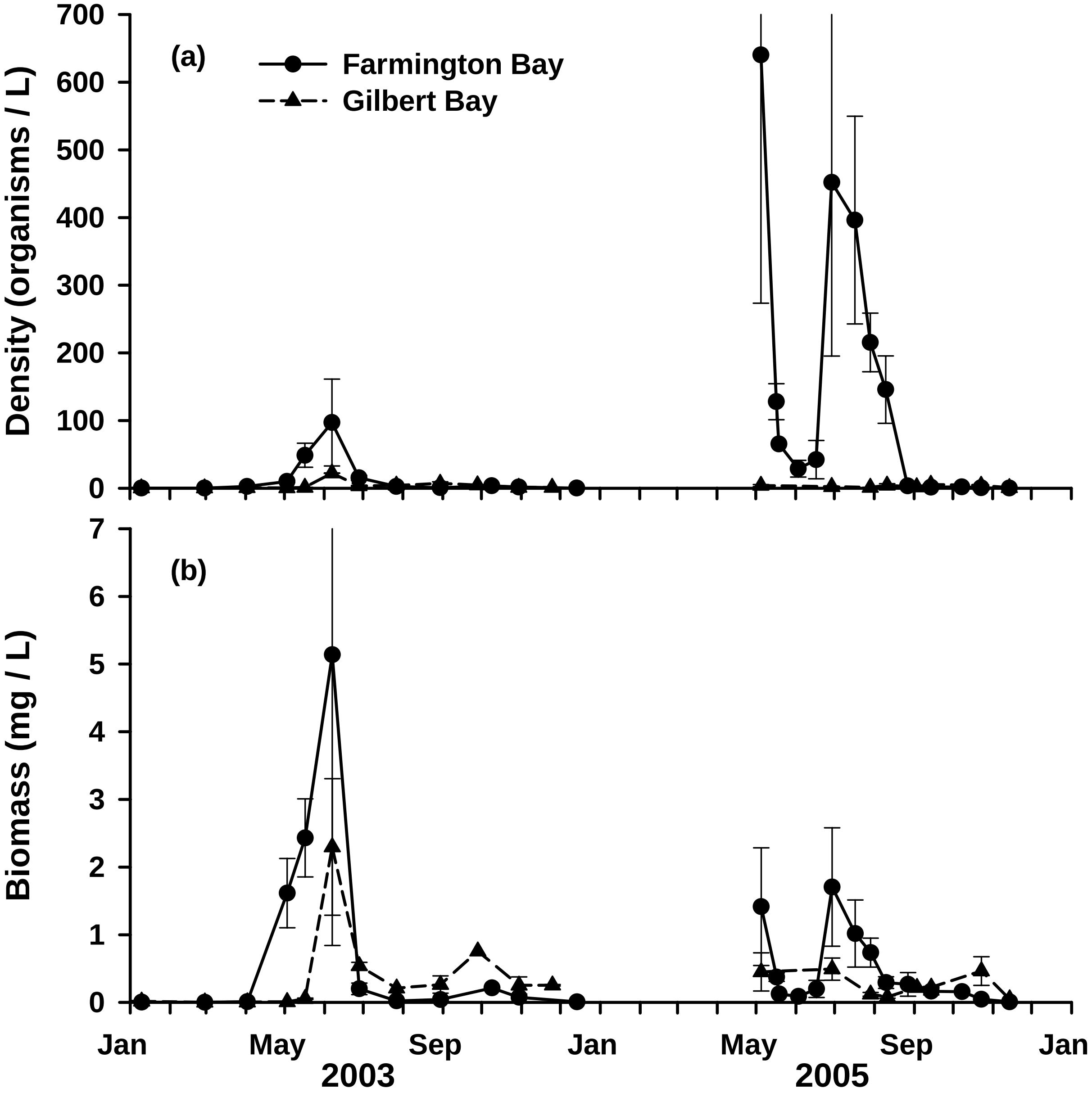

Figure 17. (a) Total zooplankton density and (b) biomass in Farmington and Gilbert Bays during 2003 and 2005. Error bars are ± 1 S. E.

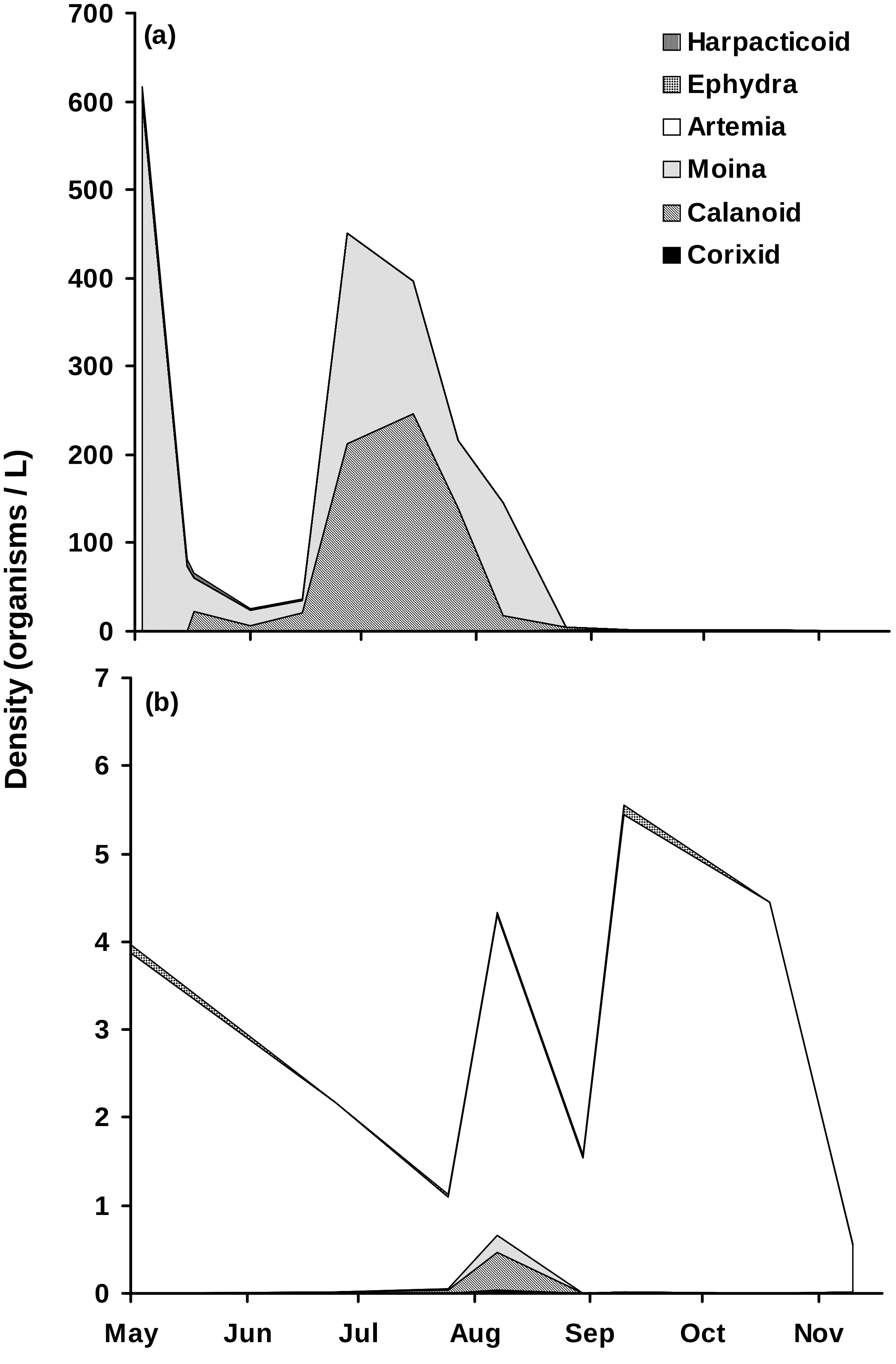

Figure 18. Zooplankton densities in (a) Farmington and (b) Gilbert Bays during the 2005 study. Note x-axis on (a) is 40X greater than on (b).

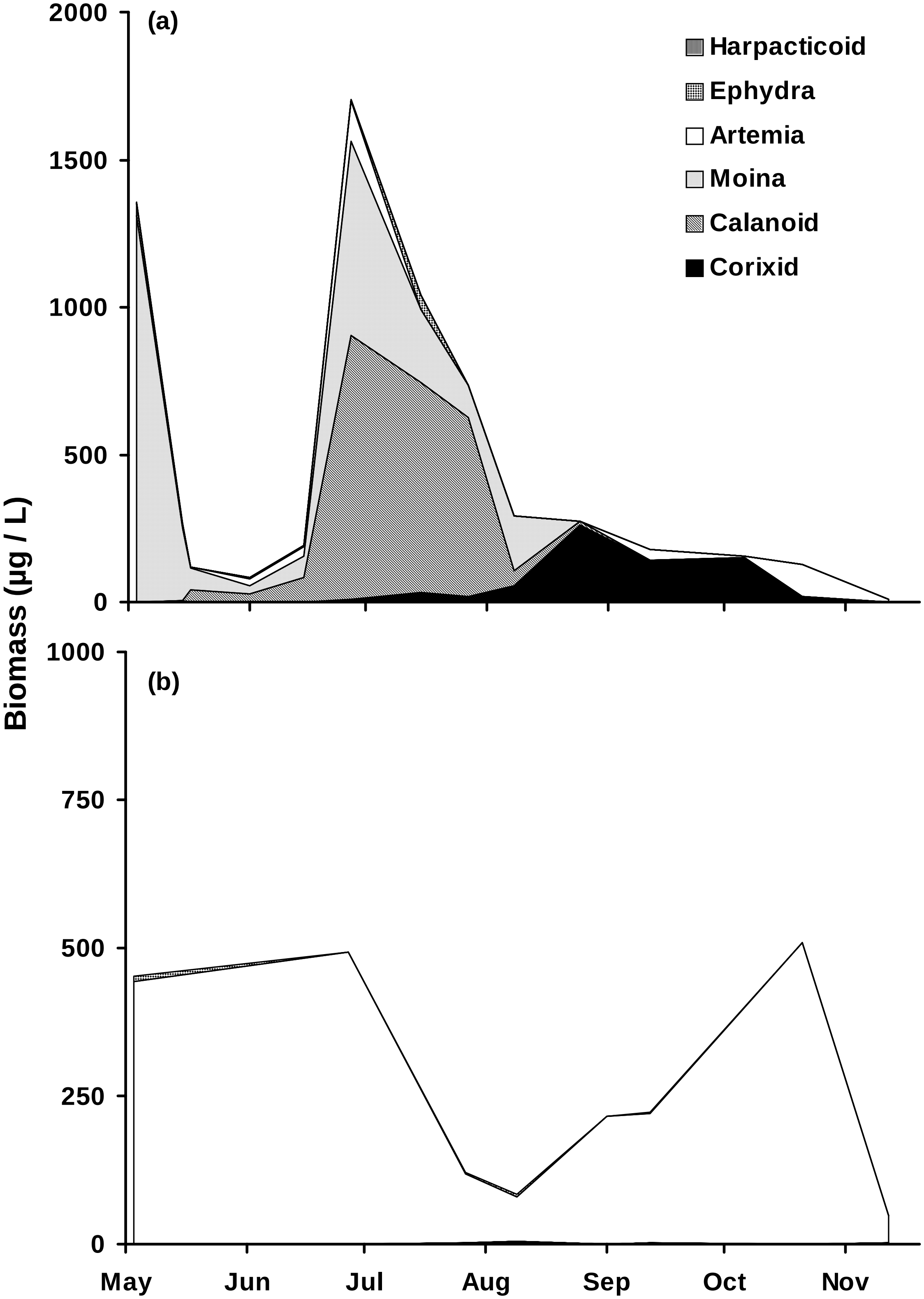

Figure 19. Zooplankton biomass in (a) Farmington and (b) Gilbert Bays during 2005.

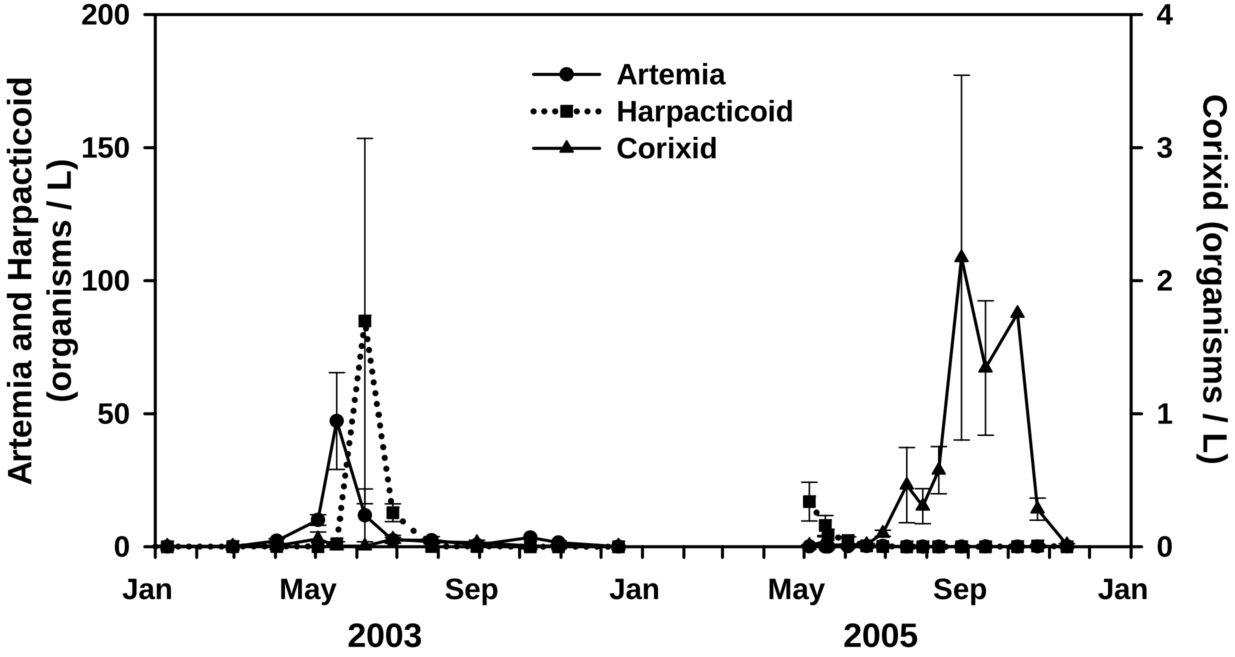

Figure 20. Relationship between brine shrimp and the predacious corixids and harpacticoids in Farmington Bay during 2003 and 2005. Note that densities of corixids are much lower than the other species (right scale). Error bars are ± 1 S. E.

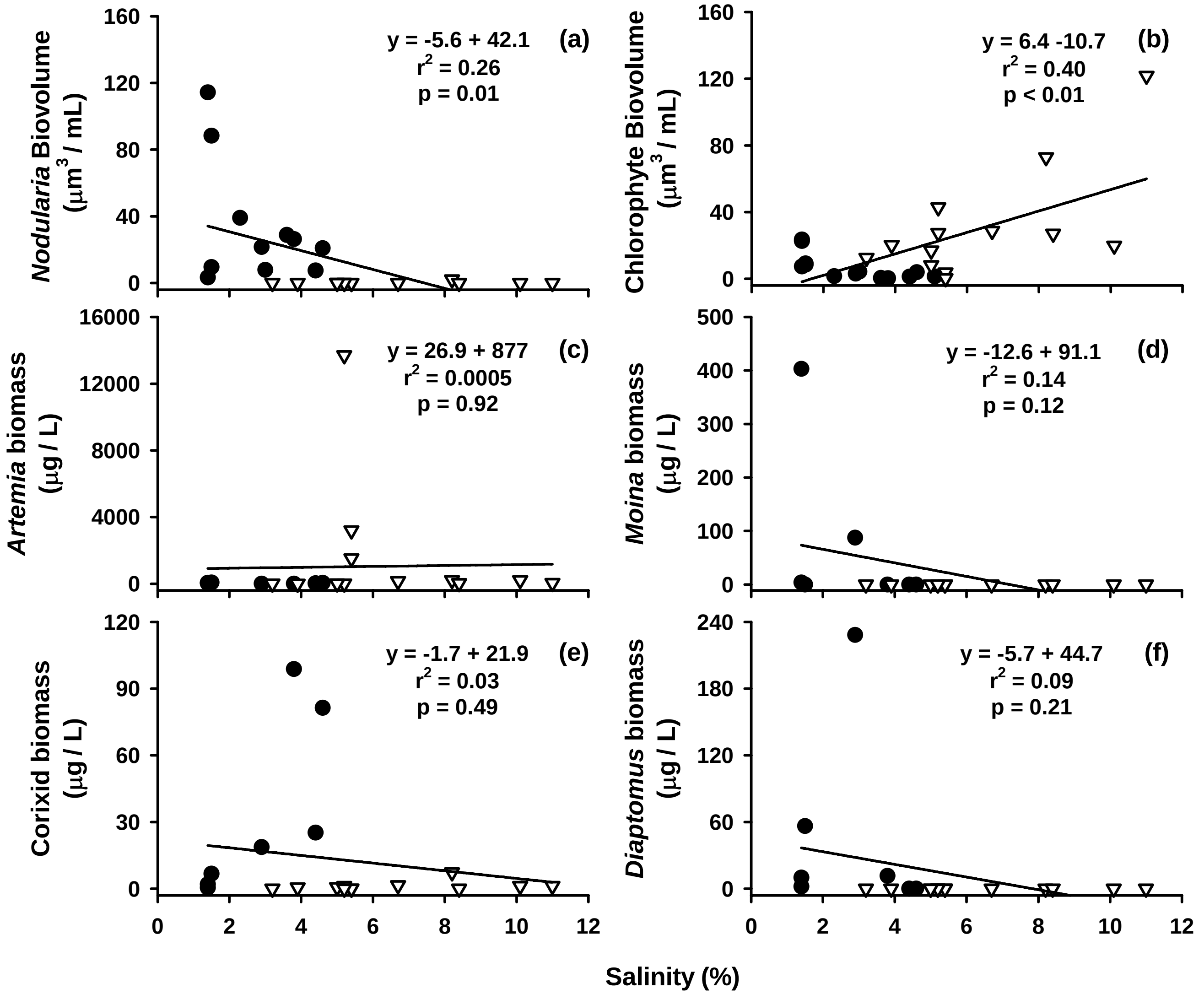

Figure 21. Salinity vs. the abundance of important phytoplankton and zooplankton taxa in 2003 (open triangles) and 2005 (closed circles), including (a) *Nodularia spumegina,* (b) green algae, (c) *Artemia franciscana*, (d) *Moina* sp., (e) *Trichocorixa verticalis*, and (f) *Diaptomus conexus*.

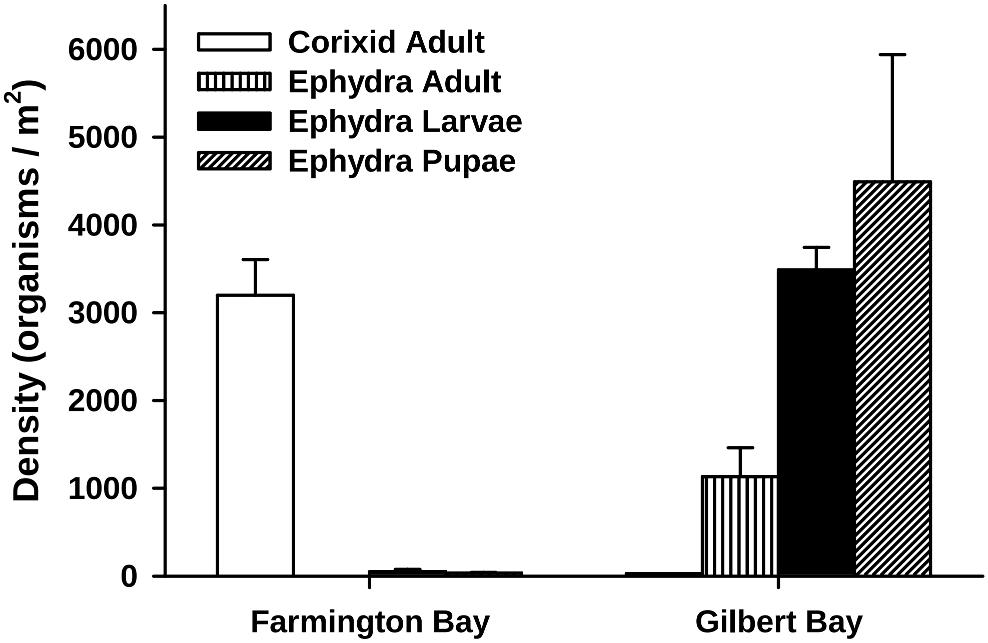

Figure 22. Density of organisms on benthic substrates on September 7, 2006 in Farmington and Gilbert bays. Ephydra species were different between the two bays, but are grouped here for ease of presentation. Error bars are ± 1 S. E.

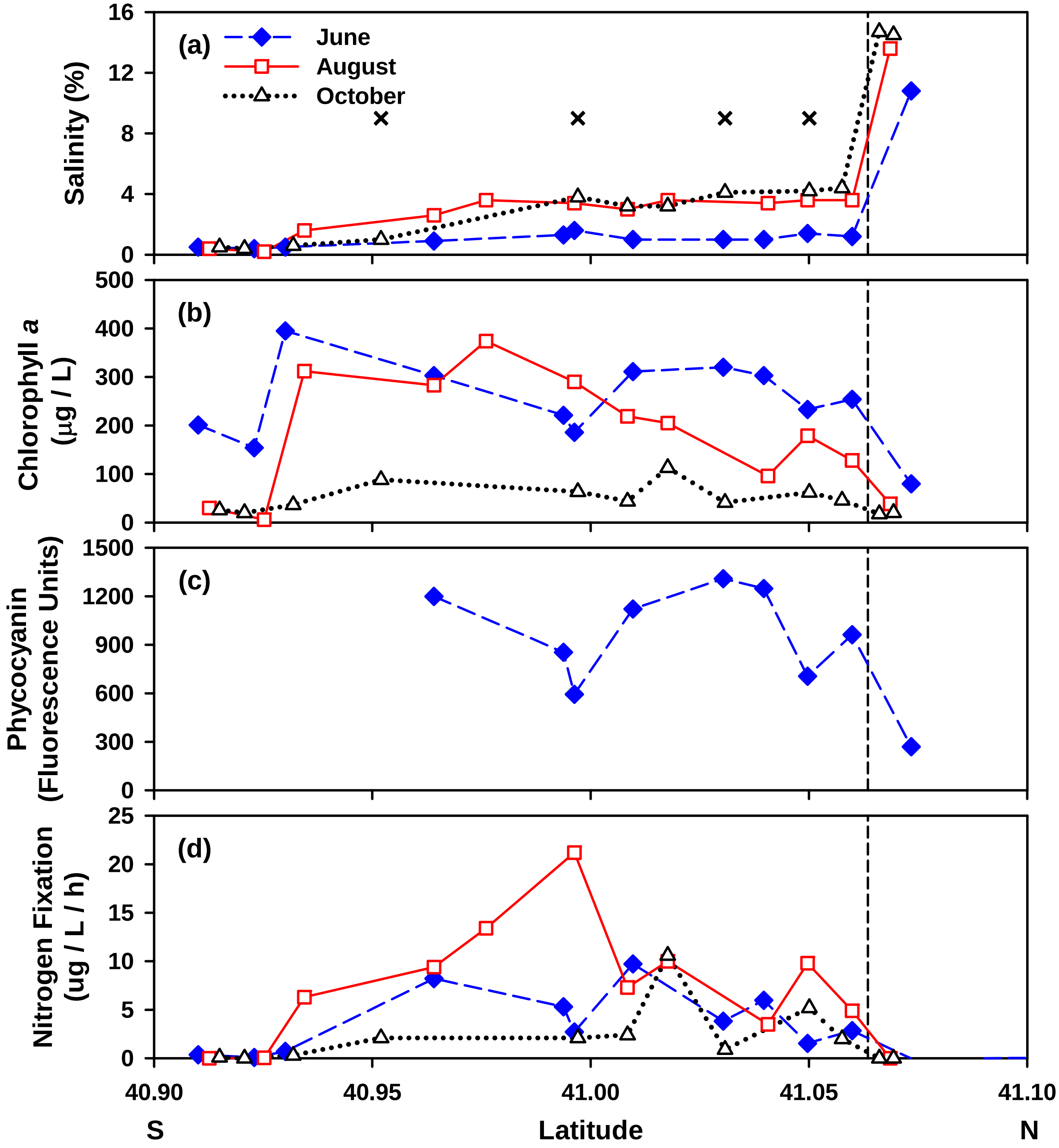

Figure 23. South to North variation in plankton in Farmington Bay and north of the Antelope Island Causeway during the June, August and October synoptic analyses. The southernmost stations were near the Farmington Bay Migratory Bird Refuge and the discharge point of the Sewage Canal. The position of the 4 routine sampling stations (Table 1) are shown as X's in the top frame. The dotted line shows the position of the Antelope Island causeway. (a) Salinity. (b) Chlorophyll *a*. (c) Concentrations of the cyanobacterial pigment phycocyanin during the June synoptic . This pigment was not measured at the three southernmost stations. (d) Nitrogen fixation rates.

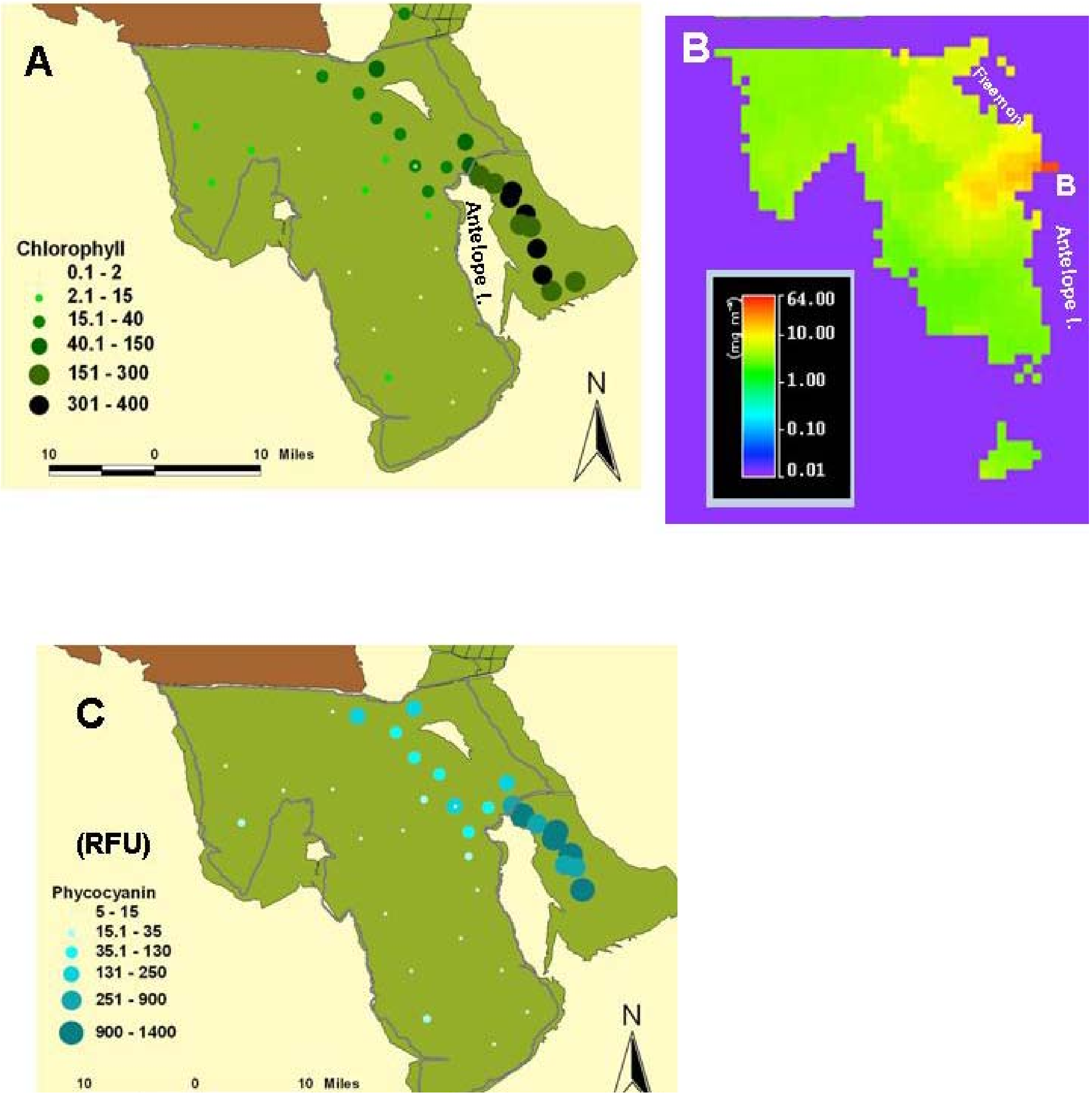

Figure 24. Spatial variation on plankton pigments during the June, 2005 synoptic of Farmington Bay, Bear River Bay (1 sta.), and Gilbert Bay. A. Chlorophyll *a* (extracted concentrations). B. Chlorophyll estimates in Gilbert Bay derived from MODIS satellite imagery (Terra) on June 2, 2005. A cloud covered parts of the southern part of Gilbert Bay, precluding measurements there. Spectra in Farmington and Ogden Bays could not be analyzed with the software C. Relative fluorescence units (RFU) of the cyanobacterial pigment, phycocyanin, at the synoptic stations.

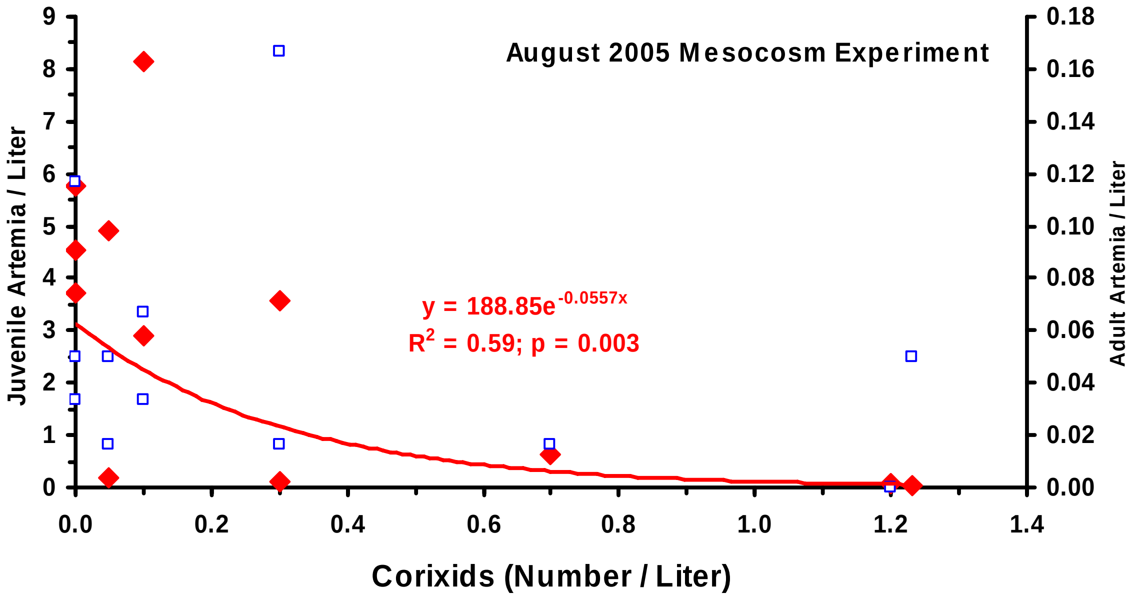

Figure 25. Densities of juvenile (solid dimonds) and adult *Artemia* at the end of a 15-day mesocosm experiment in August with different densities of corixid predators. Final adult densities were not significantly affected by corixids. Initial densities of *Artemia* nauplii in the experiment were 10/L, and these would have grown into the juvenile size class by the end of the experiment.

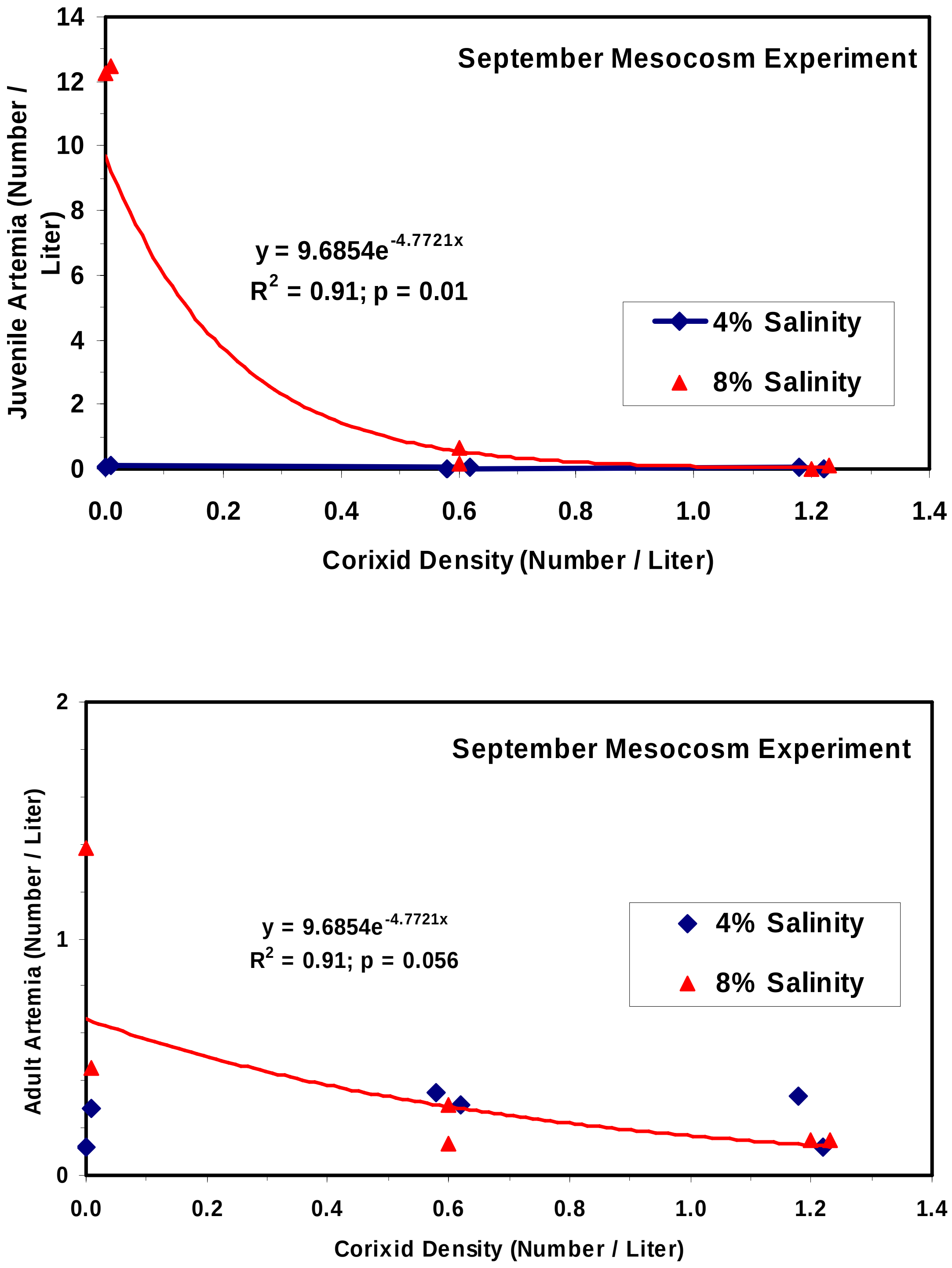

Figure 26. Final densities of juvenile (above) and adult (below) *Artemia* at three densities of corixid predators and two salinities (4%, 8"%) in the 16 day-long September mesocosm experiment. Initial nauplii densities were 10/L, and these would have grown to juvenile size during the experiment. Initial adult densities were 10/L.

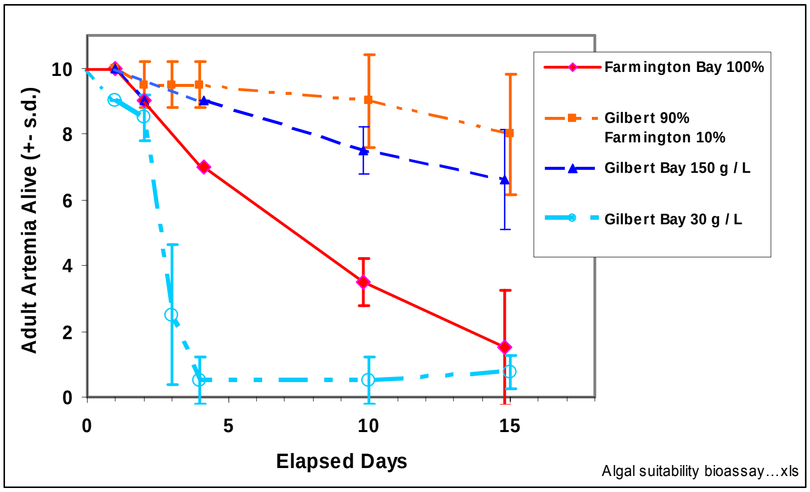

Figure 27. Influence of Farmington Bay and Gilbert Bay on adult *Artemia* survival in the Algal Suitability Bioassay Experiment. Treatments consisted of pure Farmington Bay water (Farmington 100%), 90% Gilbert Bay water mixed with 10% Farmington Bay water; 100% Gilbert Bay water, and Gilbert Bay water with its salinity reduced to 3% with deionized water.

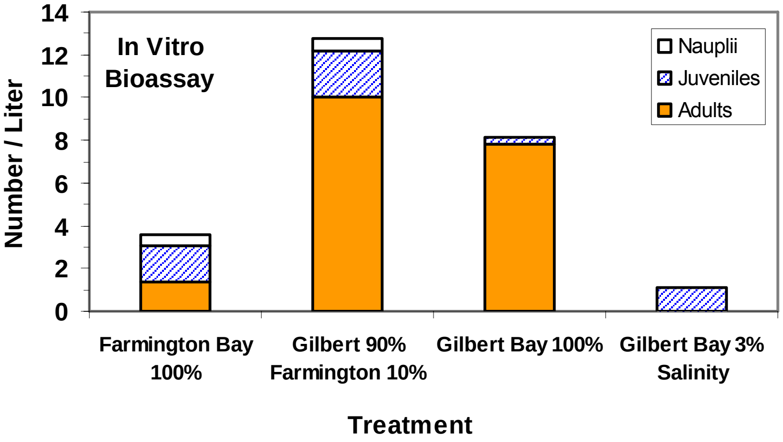

Figure 28. Influence of Farmington Bay and Gilbert Bay water on the survival and development of *Artemia* nauplii after a 15-day exposure. Treatments are as in Figure 27. Ten nauplii per liter were placed in the containers at the start of the experiment.

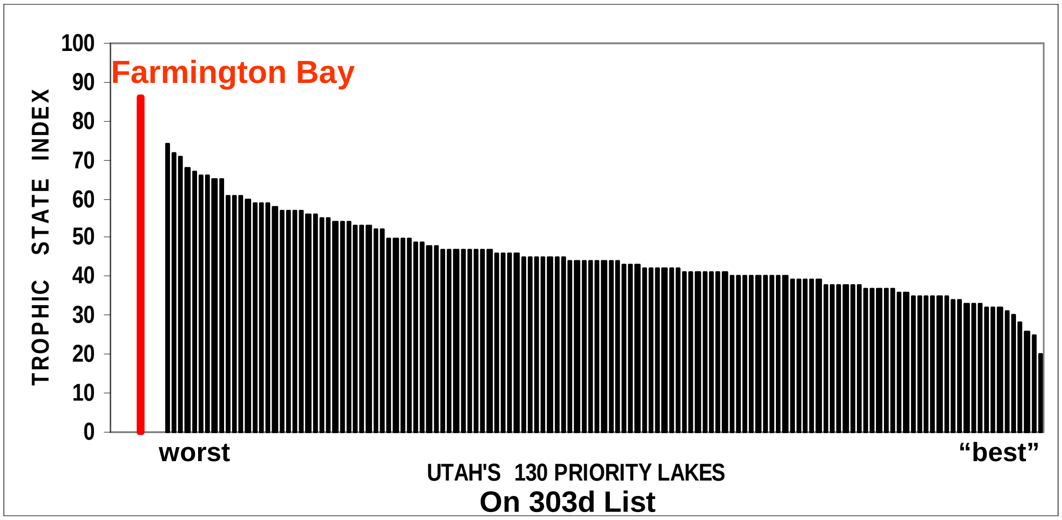

Figure 29. Trophic State Indices (Carlson 1977) from 130 lakes on the state of Utah's list of threatened or impaired waters (303d List). The higher the TSI, the more eutrophic the system. Although Farmington Bay is not on the list, it is clearly the most eutrophic water body in Utah with a TSI of 87 in 2005.

Appendix 1: Environmental characteristics collected during routine sampling. Measurements of temp, salinity, and chlorophyll *a* were made at 0.4m deep on all dates. Dashes indicate missing data.

Region	Date Sampled	Station	Temperature ºC	Salinity (%)	Secchi Depth (m)	Chlorophyll *a* (µg L^{-1})
Farmington	3-May-05	P1	18.7	1.4	0.33	178.75
Farmington	3-May-05	P2	18.9	1.4	0.33	150
Farmington	3-May-05	P4	18.7	0.6	0.28	52.5
Farmington	15-May-05	P1	15.2	1.1	0.23	263
Farmington	15-May-05	P2	19.7	–	0.09	511.5
Farmington	15-May-05	P4	19.4	–	0.25	151
Farmington	17-May-05	P1	13.1	1.5	0.15	433.5
Farmington	17-May-05	P2	13.1	1.0	0.19	288.5
Farmington	17-May-05	P3	14.4	1.3	0.18	400
Farmington	27-May-05	P1	21.8	–	0.35	122
Farmington	27-May-05	P4	22.0	–	0.27	275.5
Farmington	1-Jun-05	P1	18.9	1.4	0.25	233.0
Farmington	1-Jun-05	P3	20.7	–	0.27	186.0
Farmington	1-Jun-05	P4	20.2	–	0.24	303.0
Farmington	15-Jun-05	P1	21.3	1.5	0.39	37.3
Farmington	15-Jun-05	P2	23.4	1.5	0.475	37.75
Farmington	15-Jun-05	P4	22.7	0.9	0.3	169.5
Farmington	27-Jun-05	P1	21.3	1.4	0.25	176
Farmington	27-Jun-05	P2	23.6	–	0.29	169.5
Farmington	27-Jun-05	P4	21.5	1.5	0.31	282
Farmington	13-Jul-05	P1	27.6	2.3	0.195	132.5
Farmington	13-Jul-05	P2	28.4	2.1	0.33	82.8
Farmington	13-Jul-05	P4	29.9	1.8	0.22	125
Farmington	27-Jul-05	P1	25.0	2.9	0.31	119
Farmington	27-Jul-05	P2	25.3	3.4	0.24	135.5
Farmington	27-Jul-05	P4	25.0	2.6	0.39	143.5
Farmington	8-Aug-05	P3	28.3	–	0.12	290.0
Farmington	8-Aug-05	P4	25.9	–	0.16	283.0
Farmington	9-Aug-05	P1	27.1	–	0.17	179.0
Farmington	25-Aug-05	P1	22.6	–	0.16	327
Farmington	25-Aug-05	P2	23.1	–	0.08	600
Farmington	25-Aug-05	P3	22.8	–	0.1	486.5
Farmington	13-Sep-05	P1	15.8	4.6	0.22	274
Farmington	13-Sep-05	P2	15.8	4.5	0.23	295.5
Farmington	13-Sep-05	P3	17.2	4.0	0.23	373.5
Farmington	6-Oct-05	P1	12.9	5.1	0.27	283
Farmington	6-Oct-05	P2	11.3	5.0	0.26	337.5
Farmington	21-Oct-05	P1	16.1	4.4	0.65	54.05
Farmington	22-Oct-05	P2	15.1	4.1	0.59	41.2
Farmington	22-Oct-05	P3	15.7	3.8	0.45	59.8
Farmington	24-Oct-05	P4	16.1	1.0	0.75	88.1
Farmington	13-Nov-05	P1	7.4	3.0	0.34	356.5
Farmington	13-Nov-05	P2	7.2	2.7	0.33	379.5
Farmington	13-Nov-05	P3	7.8	2.8	–	613.5

Appendix 1 (con't)

Region	Date Sampled	Station	Temperature ºC	Salinity (%)	Secchi Depth (m)	Chlorophyll *a* (µg L^{-1})
Gilbert	3-May-05	P14	15.6	14.4	0.6	16.4
Gilbert	3-May-05	P15	18.0	15.2	0.45	32.175
Gilbert	3-May-05	P18	15.8	14.5	0.66	15.075
Gilbert	2-Jun-05	SW of P15	20.0	13.2	3	5.4
Gilbert	2-Jun-05	W of P18	21.8	–	2.55	3.3
Gilbert	27-Jun-05	P14	21.3	14.0	1	29.475
Gilbert	27-Jun-05	P15	20.9	13.8	1.2	19.825
Gilbert	27-Jun-05	P18	21.1	14.0	1.1	22.075
Gilbert	27-Jul-05	P14	26.0	14.6	1.66	15.9
Gilbert	27-Jul-05	P15	26.1	14.3	3.48	3.69
Gilbert	27-Jul-05	P18	25.9	–	3.23	5.38
Gilbert	8-Aug-05	P14	28.0	–	1.63	5.6
Gilbert	8-Aug-05	P15	26.4	–	4.65	1.5
Gilbert	8-Aug-05	P18	27.4	–	2.53	2.5
Gilbert	13-Sep-05	P14	15.5	14.5	0.66	26.6
Gilbert	13-Sep-05	P15	–	–	1.37	30.25
Gilbert	13-Sep-05	P18	19.4	–	0.82	14.6
Gilbert	21-Oct-05	P14	15.7	15.3	0.69	27.075
Gilbert	21-Oct-05	P15	14.9	15.0	1.4	12.35
Gilbert	21-Oct-05	P18	15.2	15.2	1.4	16.55
Gilbert	13-Nov-05	P18	9.8	15.2	2.42	5.6

Appendix 2: Water chemistry samples collected during the routine sampling. Dashes indicate missing data. Detection limit for nitrate-N was 0.005 mg L^{-1}.

Region	Date	Station	Ammonium-N (mg/L)	Nitrate-N (mg/L)	Phosphate-P (mg/L)	TN (mg/L)	TP (mg/L)
Farmington	3-May-05	P2	0.150	–	0.009	4.422	0.487
Farmington	3-May-05	P3	0.959	–	–	–	–
Farmington	3-May-05	P4	–	–	0.340	5.09	1.053
Farmington	17-May-05	P2	0.186	–	0.006	–	2.587
Farmington	17-May-05	P3	0.227	–	0.006	–	2.612
Farmington	1-Jun-05	P1	0.172	–	0.007	2.024	0.074
Farmington	1-Jun-05	P3	0.147	–	0.006	1.977	0.071
Farmington	1-Jun-05	P4	0.199	–	0.006	1.752	0.056
Farmington	15-Jun-05	P1	0.132	–	<0.006	3.295	0.151
Farmington	15-Jun-05	P2	0.137	–	<0.006	3.107	0.181
Farmington	15-Jun-05	P4	0.122	–	<0.006	4.097	0.386
Farmington	27-Jun-05	P1	0.135	<0.005	0.007	6.978	0.436
Farmington	27-Jun-05	P2	0.130	<0.005	–	6.063	0.484
Farmington	27-Jun-05	P4	0.127	<0.005	0.009	6.824	0.535
Farmington	13-Jul-05	P1	0.141	<0.005	0.013	6.525	0.385
Farmington	13-Jul-05	P2	0.140	<0.005	0.009	5.870	0.343
Farmington	13-Jul-05	P4	0.135	<0.005	0.011	6.886	0.460
Farmington	27-Jul-05	P1	0.153	<0.005	0.014	6.576	0.334
Farmington	27-Jul-05	P2	0.136	<0.005	0.011	7.395	0.341
Farmington	27-Jul-05	P4	0.154	<0.005	0.035	7.364	0.455
Farmington	8-Aug-05	P3	0.163	<0.005	0.012	7.454	0.473
Farmington	8-Aug-05	P4	0.184	<0.005	0.016	7.331	0.690
Farmington	9-Aug-05	P1	0.138	<0.005	0.009	7.529	0.395
Farmington	25-Aug-05	P1	0.193	<0.005	<0.006	7.385	0.518
Farmington	25-Aug-05	P2	0.235	<0.005	0.007	3.874	0.812
Farmington	25-Aug-05	P3	0.286	<0.005	0.006	4.913	0.750
Farmington	25-Aug-05	P4	–	–	<0.006	–	–
Farmington	12-Sep-05	P1	0.237	<0.005	0.009	6.634	0.674
Farmington	12-Sep-05	P2	0.198	<0.005	0.011	6.967	0.663
Farmington	12-Sep-05	P3	0.203	<0.005	0.013	6.987	0.742
Farmington	6-Oct-05	P1	0.141	<0.005	0.020	7.192	0.739
Farmington	6-Oct-05	P2	0.163	<0.005	0.008	6.446	0.897
Farmington	21-Oct-05	P1	0.130	–	0.012	6.602	0.368
Farmington	22-Oct-05	P2	0.129	<0.005	0.012	6.402	0.438
Farmington	22-Oct-05	P3	0.128	<0.005	0.016	6.517	0.409
Farmington	24-Oct-05	P4	0.173	<0.005	0.378	4.431	0.925
Farmington	13-Nov-05	P1	0.126	<0.005	0.006	6.780	0.525
Farmington	13-Nov-05	P2	0.135	<0.005	<0.006	6.438	0.504
Farmington	13-Nov-05	P3	0.130	<0.005	0.046	7.394	0.866

Appendix 2 (con't)

Region	Date	Station	Ammonium-N (mg/L)	Nitrate-N (mg/L)	Phosphate-P (mg/L)	TN (mg/L)	TP (mg/L)
Gilbert	3-May-05	P14	0.164	–	0.045	5.829	0.368
Gilbert	3-May-05	P15	0.269	–	0.076	6.057	0.432
Gilbert	3-May-05	P18	0.161	–	0.033	5.292	0.340
Gilbert	27-Jun-05	P14	0.336	<0.005	0.075	5.787	0.353
Gilbert	27-Jun-05	P15	0.513	<0.005	0.079	5.845	0.368
Gilbert	27-Jun-05	P18	0.486	<0.005	0.081	5.873	0.373
Gilbert	27-Jul-05	P14	0.242	<0.005	0.008	6.85	0.329
Gilbert	27-Jul-05	P15	0.545	<0.005	0.078	6.255	0.341
Gilbert	27-Jul-05	P18	0.458	<0.005	0.068	6.754	0.346
Gilbert	9-Aug-05	P14	0.320	<0.005	0.037	5.750	0.335
Gilbert	9-Aug-05	P15	0.591	<0.005	0.071	5.855	0.358
Gilbert	9-Aug-05	P18	0.480	<0.005	0.056	5.777	0.348
Gilbert	12-Sep-05	P14	0.318	<0.005	0.023	6.034	0.413
Gilbert	12-Sep-05	P15	0.469	<0.005	0.051	5.904	0.385
Gilbert	12-Sep-05	P18	0.344	<0.005	0.023	5.946	0.404
Gilbert	21-Oct-05	P14	0.427	–	0.019	6.044	0.247
Gilbert	21-Oct-05	P15	0.403	–	0.040	5.696	0.375
Gilbert	21-Oct-05	P18	0.426	–	0.019	5.896	0.343
Gilbert	13-Nov-05	P18	0.701	<0.005	0.056	5.913	0.391

Appendix 3: Hydrogen sulfide, oxygen, and salinity vertical profiles collected during routine sampling. Dashes indicate missing data

Bay	Date	Station	Depth (m)	Sulfide (mg L^{-1})	Temperature (C)	DO (mg L^{-1})	Salinity (%)
Farmington	3-May-05	P1	0.25	0.01	18.8	16	–
Farmington	3-May-05	P1	0.5	0.02	18.6	16	1.4
Farmington	3-May-05	P1	1	0.02	18.1	15.8	1.5
Farmington	3-May-05	P2	0.5	0.02	18.9	13.6	1.4
Farmington	3-May-05	P4	0.5	0.03	18.7	2.3	0.6
Farmington	15-May-05	P1	0.2	0.08	15.3	17.0	1.1
Farmington	15-May-05	P1	1.2	0.01	14.9	16.2	1.4
Farmington	15-May-05	P1	1.4	0.11	12.3	3.2	5.6
Farmington	15-May-05	P4	0.2	0.02	20.4	17.3	0.4
Farmington	15-May-05	P4	1.2	0.00	14.4	13.8	0.9
Farmington	17-May-05	P1	0.2	0.02	13.1	6.3	1.5
Farmington	17-May-05	P1	1.2	0.03	13.1	6.4	1.5
Farmington	17-May-05	P1	1.4	0.05	–	–	–
Farmington	17-May-05	P2	0.2	0.03	8.6	8.6	1
Farmington	17-May-05	P2	1.2	0.01	8.0	8.0	1.1
Farmington	17-May-05	P3	0.4	0.02	14.4	9.3	1.3
Farmington	1-Jun-05	P1	0.2	0.01	19.0	12.4	1.4
Farmington	1-Jun-05	P1	1.2	0.02	18.0	9.9	1.6
Farmington	1-Jun-05	P1	1.4	0.03	17.9	9.3	–
Farmington	1-Jun-05	P3	0.4	0.03	20.7	12.8	1.6
Farmington	1-Jun-05	P4	0.4	0.02	20.2	17.7	0.9
Farmington	15-Jun-05	P1	0.2	0.02	21.5	16.1	1.5
Farmington	15-Jun-05	P1	0.8	0.02	21.3	16.7	1.5
Farmington	15-Jun-05	P1	1.4	0.01	20.3	16.0	1.5
Farmington	15-Jun-05	P2	0.4	-0.08	23.4	17.7	1.5
Farmington	15-Jun-05	P4	0.4	0.01	22.7	22.2	0.9
Farmington	27-Jun-05	P1	0.2	0.01	22.5	12.7	1.4
Farmington	27-Jun-05	P1	0.8	0.01	20.6	9.5	1.4
Farmington	27-Jun-05	P1	1.2	-0.06	20.5	8.5	1.4
Farmington	27-Jun-05	P1	1.4	0.04	20.4	7.2	1.7
Farmington	27-Jun-05	P2	0.4	0.01	23.6	13.5	2
Farmington	27-Jun-05	P4	0.4	0.01	21.5	12.0	1.5
Farmington	13-Jul-05	P1	0.2	0.01	27.8	13.7	2.3
Farmington	13-Jul-05	P1	0.6	0.01	27.5	13.7	2.3
Farmington	13-Jul-05	P1	1	0.02	26.8	10.5	2.4
Farmington	13-Jul-05	P1	1.2	3.92	25.0	0.7	7.1
Farmington	13-Jul-05	P1	1.4	2.19	23.5	0.3	12
Farmington	13-Jul-05	P2	0.2	0.02	29.1	15.2	–
Farmington	13-Jul-05	P2	0.6	0.02	28.0	14.4	2.1
Farmington	13-Jul-05	P2	1	0.36	25.3	1.5	–
Farmington	13-Jul-05	P4	0.2	0.02	29.9	18.0	–
Farmington	13-Jul-05	P4	0.4	0.14	29.9	18.1	1.8
Farmington	13-Jul-05	P4	1	0.04	29.2	14.6	–

Appendix 3 (con't)

Bay	Date	Station	Depth (m)	Sulfide (mg L^{-1})	Temperature (C)	DO (mg L^{-1})	Salinity (%)
Farmington	27-Jul-05	P1	0.2	0.02	25.5	17.6	–
Farmington	27-Jul-05	P1	0.4	0.01	25.0	17.6	2.9
Farmington	27-Jul-05	P1	0.6	0.01	24.3	17.3	–
Farmington	27-Jul-05	P1	0.8	0.01	23.8	16.1	–
Farmington	27-Jul-05	P1	1	0.02	24.3	0.8	–
Farmington	27-Jul-05	P1	1.2	1.55	24.9	0.3	–
Farmington	27-Jul-05	P2	0.4	0.01	25.3	22.4	3.4
Farmington	27-Jul-05	P4	0.4	0.01	25.0	22.8	2.6
Farmington	8-Aug-05	P3	0.4	0.02	28.3	28.3	3.4
Farmington	8-Aug-05	P4	0.4	0.02	25.9	20.3	2.6
Farmington	9-Aug-05	P1	0.2	0.02	28.5	16.4	3.6
Farmington	9-Aug-05	P1	0.4	0.03	27.1	12.1	–
Farmington	9-Aug-05	P1	0.8	0.03	25.7	5.4	–
Farmington	9-Aug-05	P1	1	0.00	25.5	3.7	–
Farmington	9-Aug-05	P1	1.2	7.83	24.2	0.0	11.7
Farmington	25-Aug-05	P1	0.2	0.02	22.6	8.3	–
Farmington	25-Aug-05	P1	0.6	0.03	22.1	4.5	–
Farmington	25-Aug-05	P1	0.8	0.04	21.1	0.6	–
Farmington	25-Aug-05	P1	1	0.32	21.8	0.0	–
Farmington	25-Aug-05	P2	0.2	0.05	23.1	4.9	–
Farmington	25-Aug-05	P2	0.4	0.13	23.1	4.4	–
Farmington	25-Aug-05	P2	0.8	0.05	22.3	1.1	–
Farmington	25-Aug-05	P3	0.4	0.03	22.8	5.3	–
Farmington	10-Sep-05	P1	0.2	0.05	19.2	4.6	–
Farmington	10-Sep-05	P1	0.4	0.02	19.3	4.5	–
Farmington	10-Sep-05	P1	0.6	0.03	19.3	4.5	–
Farmington	10-Sep-05	P1	0.9	0.03	19.2	4.1	–
Farmington	13-Sep-05	P1	0.2	0.04	16.0	13.0	4.6
Farmington	13-Sep-05	P1	0.6	0.03	15.3	12.8	4.8
Farmington	13-Sep-05	P1	0.8	0.02	14.9	12.1	4.9
Farmington	13-Sep-05	P1	1	0.41	16.4	0.4	11.4
Farmington	13-Sep-05	P2	0.4	0.00	15.8	17.9	4.5
Farmington	13-Sep-05	P2	0.8	-0.02	15.2	0.7	–
Farmington	13-Sep-05	P3	0.4	0.07	17.2	20.0	4.0
Farmington	6-Oct-05	P1	0.2	0.01	13.6	18.7	–
Farmington	6-Oct-05	P1	0.6	0.02	9.9	17.6	5.1
Farmington	6-Oct-05	P1	1	2.82	11.3	0.2	11.5
Farmington	21-Oct-05	P1	0.2	0.00	16.1	9.7	–
Farmington	21-Oct-05	P1	0.6	0.00	16.1	9.7	4.4
Farmington	21-Oct-05	P1	1	7.66	17.0	3.7	–
Farmington	13-Nov-05	P1	0.2	0.01	7.4	19.4	–
Farmington	13-Nov-05	P1	0.6	0.01	7.4	21.6	3.0
Farmington	13-Nov-05	P1	1	0.03	7.4	22.0	–

Appendix 3 (con't)

Bay	Date	Station	Depth (m)	Sulfide (mg L^{-1})	Temperature (C)	DO (mg L^{-1})	Salinity (%)
Gilbert	3-May-05	P14A	0.5	-0.01	15.6	8.9	14.4
Gilbert	3-May-05	P15A	0.5	0.00	18.0	11.6	15.2
Gilbert	3-May-05	P18A	0.5	0.01	15.8	10.1	14.5
Gilbert	27-Jun-05	P14A	0.4	-0.01	21.3	11.2	14.0
Gilbert	27-Jun-05	P15A	0.4	0.00	20.9	8.8	13.8
Gilbert	27-Jun-05	P18A	0.4	0.00	21.1	8.9	14.0
Gilbert	27-Jul-05	P14A	0.4	0.02	26.0	13.3	14.6
Gilbert	27-Jul-05	P15A	0.4	0.01	26.1	3.4	14.3
Gilbert	27-Jul-05	P18A	0.4	0.00	25.9	5.3	–
Gilbert	9-Aug-05	P14A	0.4	0.01	28.0	10.7	14.2
Gilbert	9-Aug-05	P15A	0.4	0.00	26.4	3.7	14.2
Gilbert	9-Aug-05	P18A	0.4	0.00	27.5	5.5	14.1
Gilbert	13-Sep-05	P14A	0.4	-0.01	15.5	7.0	14.5
Gilbert	13-Sep-05	P15A	0.4	-0.01	19.9	4.1	14.8
Gilbert	13-Sep-05	P18A	0.4	0.00	18.8	7.5	14.8
Gilbert	21-Oct-05	P14A	0.4	-0.01	15.7	11.3	15.3
Gilbert	21-Oct-05	P15A	0.4	0.00	14.9	8.2	15.0
Gilbert	21-Oct-05	P18A	0.4	-0.01	15.2	9.8	15.2

Appendix 4: Algal Densities (cells/ml) collected during routine sampling. All data are results of single samples so variance estimates were not possible.

Date Sampled	**Region**	**Station**	***Carteria* sp.**	***Dunaliella salina***	***Dunaliella viridis***	***Oocystis* sp.**	***Pediastrum* sp.**	***Scenedesmus* sp.**	***Spermatozopsis* sp.**	**Chlorophyta Totals**
3-May-05	Farmington	1	4682	0	0	7491	0	22472	191945	226589
3-May-05	Farmington	2	0	0	0	7210	0	73407	392598	473214
3-May-05	Farmington	4	0	0	5012	1928	11759	109687	27759	156145
17-May-05	Farmington	1	6554	0	3745	16854	28090	58052	60861	174155
17-May-05	Farmington	2	0	0	0	4369	7282	83020	198083	292755
17-May-05	Farmington	3	4682	0	0	31835	0	159174	0	195690
1-Jun-05	Farmington	1	0	0	2979	103080	0	33069	28004	167133
1-Jun-05	Farmington	3	0	728	3277	97585	0	21847	37869	161307
1-Jun-05	Farmington	4	0	0	5098	167861	10924	11652	29494	225028
15-Jun-05	Farmington	1	0	205	1843	28265	0	1639	7783	39735
15-Jun-05	Farmington	2	0	0	0	76466	0	1456	0	77922
15-Jun-05	Farmington	4	0	0	4096	117976	0	2048	27036	151157
27-Jun-05	Farmington	1	0	0	2185	111422	0	4369	1639	119614
27-Jun-05	Farmington	2	0	0	1639	113606	0	6008	8739	129992
27-Jun-05	Farmington	4	0	0	0	208278	21119	26945	10924	267266
13-Jul-05	Farmington	1	0	0	4588	2622	0	0	0	7210
13-Jul-05	Farmington	2	0	0	4369	3641	0	1456	8011	17478
13-Jul-05	Farmington	4	0	0	21301	39325	0	3277	8193	72096
27-Jul-05	Farmington	1	0	0	3025	14117	0	0	0	17142
27-Jul-05	Farmington	2	0	0	0	40145	0	0	0	40145
27-Jul-05	Farmington	4	0	0	0	59807	0	19663	3277	82747
8-Aug-05	Farmington	3	0	0	6554	7491	0	0	1873	15917
8-Aug-05	Farmington	4	0	0	11470	7373	0	0	1639	20482
9-Aug-05	Farmington	1	0	0	1788	596	0	0	0	2383
25-Aug-05	Farmington	1	0	596	5958	1192	0	0	0	7746
25-Aug-05	Farmington	2	0	0	20482	3277	0	0	0	23759
25-Aug-05	Farmington	3	0	936	27153	0	0	0	0	28090
10-Sep-05	Farmington	1	0	1192	5958	7150	0	0	3575	17875
12-Sep-05	Farmington	2	0	3745	3745	6554	0	0	936	14981
13-Sep-05	Farmington	1	0	1788	0	14300	0	0	596	16683
13-Sep-05	Farmington	3	0	0	0	68000	0	7373	2458	77831
6-Oct-05	Farmington	2	0	6554	15293	3277	0	0	0	25124
20-Oct-05	Farmington	1	0	728	16750	8011	0	0	3641	29130
21-Oct-05	Farmington	1	0	0	1542	0	0	0	0	1542
22-Oct-05	Farmington	2	0	0	150419	2949	0	0	26545	179913
22-Oct-05	Farmington	3	0	262	2884	5506	0	0	11011	19663
13-Nov-05	Farmington	1	0	0	10768	3745	0	0	0	14513
13-Nov-05	Farmington	2	0	596	13704	5363	0	0	0	19663
13-Nov-05	Farmington	3	0	0	15293	224482	0	10924	43695	294394

Appendix 4 (con't)

Date Sampled	Region	Station	*Microcoleus* sp.	*Nodularia heterocyst*	*Nodularia* veg	*Pseudoanabaena* sp.	*Spirulina* sp.	Cyanophyta Totals	*Amphora coffeaeformis*	*Chaetocerous* sp.
3-May-05	Farmington	1	0	57115	651676	0	0	708792	0	0
3-May-05	Farmington	2	0	13108	161889	0	0	174998	0	0
3-May-05	Farmington	4	0	0	0	193	0	193	0	2120
17-May-05	Farmington	1	0	51497	831449	0	0	882947	0	0
17-May-05	Farmington	2	0	34956	433307	0	0	468262	0	0
17-May-05	Farmington	3	0	37453	585198	0	0	622651	0	0
1-Jun-05	Farmington	1	0	5958	109634	0	0	115593	0	16088
1-Jun-05	Farmington	3	0	10195	165676	0	0	175871	0	3277
1-Jun-05	Farmington	4	0	12380	144193	0	0	156573	0	4369
15-Jun-05	Farmington	1	0	10651	129036	0	0	139687	0	4711
15-Jun-05	Farmington	2	0	7100	78286	0	0	85387	0	0
15-Jun-05	Farmington	4	0	13108	155663	0	0	168771	0	9422
27-Jun-05	Farmington	1	0	4916	72096	0	0	77012	0	2731
27-Jun-05	Farmington	2	819	16386	238137	0	0	255341	0	1092
27-Jun-05	Farmington	4	1639	1456	21847	0	728	25671	0	0
13-Jul-05	Farmington	1	0	40636	559730	0	0	600366	0	7210
13-Jul-05	Farmington	2	0	47336	619009	0	0	666345	0	7282
13-Jul-05	Farmington	4	0	36048	406908	0	0	442956	0	5462
27-Jul-05	Farmington	1	0	34788	357457	0	504	392749	0	10083
27-Jul-05	Farmington	2	0	64723	728337	0	0	793060	0	6554
27-Jul-05	Farmington	4	0	44241	575952	1639	819	622651	0	0
8-Aug-05	Farmington	3	0	70224	896991	0	0	967215	0	10299
8-Aug-05	Farmington	4	0	54892	688193	0	0	743084	0	11470
9-Aug-05	Farmington	1	0	43496	582134	0	0	625630	0	2383
25-Aug-05	Farmington	1	32771	35154	409341	0	0	477266	596	17875
25-Aug-05	Farmington	2	9831	56530	734072	0	0	800434	0	18024
25-Aug-05	Farmington	3	8427	63670	730327	0	0	802423	936	29962
10-Sep-05	Farmington	1	2979	14896	246081	0	596	264552	0	59584
12-Sep-05	Farmington	2	11236	6086	154492	936	0	172750	468	48688
13-Sep-05	Farmington	1	11917	5958	359290	0	0	377165	0	10725
13-Sep-05	Farmington	3	7373	24578	559566	0	0	591518	0	1639
6-Oct-05	Farmington	2	0	13108	177510	0	273	190892	0	4369
20-Oct-05	Farmington	1	0	15293	184246	364	364	200268	0	9467
21-Oct-05	Farmington	1	0	10795	146506	0	0	157301	0	3470
22-Oct-05	Farmington	2	0	6554	91104	0	655	98313	0	655
22-Oct-05	Farmington	3	0	11535	170934	0	1049	183518	0	12846
13-Nov-05	Farmington	1	0	11236	146534	0	0	157769	0	31835
13-Nov-05	Farmington	2	0	11321	171005	0	0	182326	0	34559
13-Nov-05	Farmington	3	0	15293	224482	0	1639	241414	0	0

Appendix 4 (con’t)

Date Sampled	**Region**	**Station**	**"Clear oval diatom"**	***Cyclotella* sp.**	***Nitzschia palea***	***Navicula graciloides***	***Navicula tripuctata***	**Large *Navicula***	***Synedra* sp.**	**Diatom Totals**
3-May-05	Farmington	1	0	936	0	0	0	0	0	936
3-May-05	Farmington	2	0	655	0	655	0	0	0	1311
3-May-05	Farmington	4	193	0	0	0	0	0	0	2313
17-May-05	Farmington	1	0	936	0	0	0	0	0	936
17-May-05	Farmington	2	0	0	0	728	0	0	0	728
17-May-05	Farmington	3	0	0	0	0	0	0	0	0
1-Jun-05	Farmington	1	298	298	0	2681	0	0	596	19961
1-Jun-05	Farmington	3	728	364	0	2913	0	0	364	7647
1-Jun-05	Farmington	4	0	1092	0	1821	0	0	1456	8739
15-Jun-05	Farmington	1	0	0	0	0	0	0	5735	10446
15-Jun-05	Farmington	2	0	0	0	182	0	0	22029	22212
15-Jun-05	Farmington	4	0	819	0	5735	0	0	11470	27446
27-Jun-05	Farmington	1	0	2185	0	546	0	0	353382	358843
27-Jun-05	Farmington	2	2185	0	0	546	0	0	128900	132723
27-Jun-05	Farmington	4	728	2185	0	2185	0	0	388884	393981
13-Jul-05	Farmington	1	0	0	0	655	0	0	655	8520
13-Jul-05	Farmington	2	728	0	0	0	0	0	728	8739
13-Jul-05	Farmington	4	1639	1639	0	13655	0	546	0	22940
27-Jul-05	Farmington	1	0	1008	0	2521	0	1513	19663	34788
27-Jul-05	Farmington	2	0	819	0	819	0	0	2458	10651
27-Jul-05	Farmington	4	0	0	0	819	0	0	10651	11470
8-Aug-05	Farmington	3	936	0	0	1873	0	0	2809	15917
8-Aug-05	Farmington	4	1639	0	0	2458	0	0	819	16386
9-Aug-05	Farmington	1	1192	0	0	1192	0	0	1788	6554
25-Aug-05	Farmington	1	1788	596	0	10129	0	0	41709	72692
25-Aug-05	Farmington	2	0	0	0	1639	0	0	20482	40145
25-Aug-05	Farmington	3	0	936	0	2809	0	0	10299	44943
10-Sep-05	Farmington	1	1192	596	0	2383	0	0	9533	73288
12-Sep-05	Farmington	2	0	2341	468	2809	0	0	26217	80991
13-Sep-05	Farmington	1	596	0	0	1788	0	0	0	13108
13-Sep-05	Farmington	3	0	0	0	3277	0	0	33590	38506
2-Oct-05	Farmington	Causeway	0	252	0	1513	0	252	31259	39829
6-Oct-05	Farmington	2	0	15839	0	0	0	0	24032	44241
20-Oct-05	Farmington	1	0	21483	0	0	0	0	44059	75009
21-Oct-05	Farmington	1	0	1542	0	0	0	0	12337	17349
22-Oct-05	Farmington	2	0	1639	0	0	328	1311	17041	20973
22-Oct-05	Farmington	3	0	1311	0	524	262	0	9438	24382
13-Nov-05	Farmington	1	0	468	0	0	0	0	468	32771
13-Nov-05	Farmington	2	0	9235	0	0	0	0	298	44092
13-Nov-05	Farmington	3	0	0	0	546	0	0	0	546

Appendix 4 (con't)

Date Sampled	Region	Station	*Euplotes* sp.	Unknown ciliates	Protozoa Totals	"Chrysophytes"	*Cryptomonas* sp.	*Glenodinium* sp.	Pyrrophyta Totals	ALL TAXA
3-May-05	Farmington	1	0	0	0	0	0	0	0	936317
3-May-05	Farmington	2	0	0	0	3933	0	0	3933	653456
3-May-05	Farmington	4	193	0	193	27373	8482	1542	37398	196242
17-May-05	Farmington	1	936	0	936	11236	0	0	11236	1070210
17-May-05	Farmington	2	728	0	728	30586	0	728	31315	793788
17-May-05	Farmington	3	2809	0	2809	12172	0	0	12172	833322
1-Jun-05	Farmington	1	0	0	0	16683	0	12513	29196	331883
1-Jun-05	Farmington	3	0	0	0	9467	12380	3641	25489	370314
1-Jun-05	Farmington	4	364	0	364	17478	0	4005	21483	412187
15-Jun-05	Farmington	1	0	0	0	11470	19048	2867	33386	223254
15-Jun-05	Farmington	2	0	0	0	2913	0	0	2913	188434
15-Jun-05	Farmington	4	0	0	0	57759	37277	4916	99952	447326
27-Jun-05	Farmington	1	546	0	546	18570	10378	1639	30586	586601
27-Jun-05	Farmington	2	0	0	0	36048	5462	12016	53526	571582
27-Jun-05	Farmington	4	0	0	0	74281	0	0	74281	761199
13-Jul-05	Farmington	1	0	0	0	12453	28183	1311	41947	658043
13-Jul-05	Farmington	2	0	0	0	40782	27673	728	69183	761745
13-Jul-05	Farmington	4	0	0	0	26217	22940	3277	52434	590426
27-Jul-05	Farmington	1	0	1008	1008	0	39829	4538	44367	490054
27-Jul-05	Farmington	2	0	0	0	2458	0	0	2458	846314
27-Jul-05	Farmington	4	0	0	0	24578	85205	0	109783	826651
8-Aug-05	Farmington	3	936	0	936	5618	39325	936	45880	1045865
8-Aug-05	Farmington	4	1639	819	2458	4916	47518	3277	55711	838121
9-Aug-05	Farmington	1	0	0	0	2383	10725	1788	14896	649463
25-Aug-05	Farmington	1	1192	0	1192	4171	70905	1788	76863	635759
25-Aug-05	Farmington	2	819	0	819	13928	72916	819	87663	952820
25-Aug-05	Farmington	3	1873	0	1873	15917	119849	936	136702	1014031
10-Sep-05	Farmington	1	1192	0	1192	15492	237143	1192	253827	610734
12-Sep-05	Farmington	2	468	0	468	2341	193818	1873	198031	467221
13-Sep-05	Farmington	1	596	0	596	0	150747	0	150747	558299
13-Sep-05	Farmington	3	1639	0	1639	0	149108	0	149108	858602
2-Oct-05	Farmington	Causeway	0	10588	10588	0	25713	252	25965	254858
6-Oct-05	Farmington	2	0	0	0	3277	18024	273	21574	281831
20-Oct-05	Farmington	1	364	0	364	35320	38597	364	74281	379052
21-Oct-05	Farmington	1	0	3470	3470	3470	13880	0	17349	197011
22-Oct-05	Farmington	2	0	0	0	28183	0	1966	30149	329348
22-Oct-05	Farmington	3	0	0	0	17827	12322	1835	31985	259548
13-Nov-05	Farmington	1	0	0	0	0	49157	3745	52902	257955
13-Nov-05	Farmington	2	0	0	0	3575	36346	596	40517	286598
13-Nov-05	Farmington	3	0	0	0	3823	3277	0	7100	543454

Appendix 4 (con’t)

Date Sampled	**Region**	**Station**	***Carteria* sp.**	***Dunaliella salina***	***Dunaliella viridis***	***Oocystis* sp.**	***Pediastrum* sp.**	***Scenedesmus* sp.**	***Spermatozopsis* sp..**	**Chlorophyta Totals**
3-May-05	Gilbert	14	0	0	43845	4960	0	0	0	48805
3-May-05	Gilbert	15	0	66	53897	5753	0	0	0	59716
3-May-05	Gilbert	18	0	0	55380	113	0	0	0	55494
27-Jun-05	Gilbert	14	0	0	45971	1701	0	0	0	47671
27-Jun-05	Gilbert	15	0	0	55720	2324	0	0	0	58044
27-Jun-05	Gilbert	18	0	99	49102	2182	0	0	0	51384
27-Jul-05	Gilbert	14	0	0	51186	680	0	0	0	51866
27-Jul-05	Gilbert	15	0	13	9932	77	0	0	691	10713
9-Aug-05	Gilbert	14	0	0	15781	667	0	0	0	16449
9-Aug-05	Gilbert	18	0	0	10639	794	0	0	0	11432
13-Sep-05	Gilbert	14	0	159	71342	2778	0	0	0	74279
13-Sep-05	Gilbert	15	0	0	43696	1637	0	0	0	45333
13-Sep-05	Gilbert	18	0	0	30275	2579	0	0	0	32854
21-Oct-05	Gilbert	14	0	0	98701	2976	0	0	0	101677
21-Oct-05	Gilbert	15	0	0	52829	1360	0	0	0	54190
21-Oct-05	Gilbert	18	0	113	55494	1304	0	0	0	56911
13-Nov-05	Gilbert	18	0	25	23559	670	0	0	0	24254

Date Sampled	**Region**	**Station**	***Microcoleus* sp.**	***Nodularia* heterocyst**	***Nodularia* veg**	***Pseudoanabaena* sp.**	***Spirulina* sp.**	**Cyanophyta Totals**	***Amphora coffeaeformis***	***Chaetocerous* sp.**
3-May-05	Gilbert	14	0	0	0	0	0	0	0	0
3-May-05	Gilbert	15	0	0	0	0	0	0	0	0
3-May-05	Gilbert	18	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	14	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	15	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	18	0	0	0	0	0	0	0	0
27-Jul-05	Gilbert	14	0	0	0	0	0	0	57	0
27-Jul-05	Gilbert	15	0	230	1933	0	0	2163	0	0
9-Aug-05	Gilbert	14	0	0	0	0	0	0	0	0
9-Aug-05	Gilbert	18	0	0	0	0	0	0	0	0
13-Sep-05	Gilbert	14	238	159	2222	0	0	2619	79	0
13-Sep-05	Gilbert	15	0	99	694	0	0	794	0	0
13-Sep-05	Gilbert	18	0	317	3214	0	0	3531	0	0
21-Oct-05	Gilbert	14	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	15	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	18	0	0	0	0	0	0	0	0
13-Nov-05	Gilbert	18	0	0	0	0	0	0	0	0

Appendix 4 (con’t)

Date Sampled	Region	Station	"Clear oval diatom"	*Cyclotella* sp.	*Nitzschia palea*	*Navicula graciloides*	*Navicula tripuctata*	Large *Navicula*	*Synedra* sp.	Diatom Totals
3-May-05	Gilbert	14	66	0	0	0	727	0	0	794
3-May-05	Gilbert	15	0	0	0	0	132	0	0	132
3-May-05	Gilbert	18	113	0	0	0	0	0	0	113
27-Jun-05	Gilbert	14	113	0	0	0	113	0	0	227
27-Jun-05	Gilbert	15	0	0	0	0	113	0	0	113
27-Jun-05	Gilbert	18	50	99	0	0	248	0	0	397
27-Jul-05	Gilbert	14	57	0	0	0	113	0	0	227
27-Jul-05	Gilbert	15	0	0	0	0	0	0	0	0
9-Aug-05	Gilbert	14	36	0	0	36	18	0	0	90
9-Aug-05	Gilbert	18	12	0	0	0	25	0	0	37
13-Sep-05	Gilbert	14	317	0	0	0	79	0	0	476
13-Sep-05	Gilbert	15	0	99	0	0	50	0	0	149
13-Sep-05	Gilbert	18	0	0	0	0	40	0	0	40
21-Oct-05	Gilbert	14	0	99	0	0	198	0	0	298
21-Oct-05	Gilbert	15	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	18	57	0	0	0	0	0	0	57
13-Nov-05	Gilbert	18	0	0	0	0	0	0	0	0

Date Sampled	Region	Station	*Euplotes* sp.	Unknown ciliates	Protozoa Totals	"Chrysophytes"	*Cryptomonas* sp.	*Glenodinium* sp.	Pyrrophyta Totals	ALL TAXA
3-May-05	Gilbert	14	0	0	0	18847	198	0	19046	68645
3-May-05	Gilbert	15	0	0	0	20170	529	0	20699	80547
3-May-05	Gilbert	18	0	0	0	9183	113	0	9296	64903
27-Jun-05	Gilbert	14	0	0	0	13094	1077	0	14171	62069
27-Jun-05	Gilbert	15	0	0	0	1077	340	0	1417	59574
27-Jun-05	Gilbert	18	0	0	0	3521	149	0	3670	55451
27-Jul-05	Gilbert	14	0	0	0	10146	170	0	10316	62409
27-Jul-05	Gilbert	15	0	0	0	0	0	0	0	12876
9-Aug-05	Gilbert	14	0	0	0	433	126	0	559	17098
9-Aug-05	Gilbert	18	0	0	0	298	0	0	298	11767
13-Sep-05	Gilbert	14	0	0	0	0	397	0	397	77771
13-Sep-05	Gilbert	15	0	0	0	2778	248	0	3026	49302
13-Sep-05	Gilbert	18	0	0	0	4801	238	0	5039	41464
21-Oct-05	Gilbert	14	0	0	0	4960	2083	0	7043	109018
21-Oct-05	Gilbert	15	0	0	0	510	453	0	964	55154
21-Oct-05	Gilbert	18	0	0	0	737	283	0	1020	57988
13-Nov-05	Gilbert	18	0	0	0	198	99	0	298	24552

Appendix 5: Algal Biovolumes (µm^3 mL^{-1}) collected during routine sampling. All data are results of single samples so variance estimates were not possible.

Date Sampled	Region	Station	*Carteria* sp.	*Dunaliella salina*	*Dunaliella viridis*	*Oocystis* sp.	*Pediastrum* sp.	*Scene-desmus* sp.	*Spermato-zopsis* sp.	Chlorophyta Totals
3-May-05	Farmington	1	5144747	0	0	546039	0	1731283	397413	7819482
3-May-05	Farmington	2	0	0	0	1061491	0	3630133	1320889	6012514
3-May-05	Farmington	4	0	0	59070	652107	1018341	6524795	48632	8302945
17-May-05	Farmington	1	1565549	0	29685	966318	2516452	3124284	124624	8326912
17-May-05	Farmington	2	0	0	0	0	3299581	4400364	410122	8110067
17-May-05	Farmington	3	2241857	0	0	1379902	0	7568646	0	11190404
1-Jun-05	Farmington	1	0	0	18220	14570174	0	2457258	55752	17101403
1-Jun-05	Farmington	3	0	326207	20942	17395317	0	2004214	66343	19813023
1-Jun-05	Farmington	4	0	0	35196	29350256	675535	868827	56369	30986183
15-Jun-05	Farmington	1	0	0	7442	3690216	0	144497	13016	3855171
15-Jun-05	Farmington	2	0	0	0	6293752	0	65241	0	6358993
15-Jun-05	Farmington	4	0	0	17902	14670057	0	201400	47365	14936724
27-Jun-05	Farmington	1	0	0	22617	15595686	0	319683	2610	15940596
27-Jun-05	Farmington	2	0	0	17398	17188922	0	607959	16006	17830285
27-Jun-05	Farmington	4	0	0	0	33464394	1565734	1837621	21747	36889497
13-Jul-05	Farmington	1	0	0	45930	71765	0	0	0	117695
13-Jul-05	Farmington	2	0	0	44074	454033	0	148460	13396	659964
13-Jul-05	Farmington	4	0	0	208201	3506984	0	140921	15658	3871764
27-Jul-05	Farmington	1	0	0	32119	1107005	0	0	0	1139124
27-Jul-05	Farmington	2	0	0	0	2249261	0	0	0	2249261
27-Jul-05	Farmington	4	0	0	0	3330237	0	2455180	6524	5791941
8-Aug-05	Farmington	3	0	0	65614	629969	0	0	2982	698566
8-Aug-05	Farmington	4	0	0	82862	521931	0	0	2610	607402
9-Aug-05	Farmington	1	0	0	20877	45550	0	0	0	66428
25-Aug-05	Farmington	1	0	0	58418	91101	0	0	0	149519
25-Aug-05	Farmington	2	0	0	194305	208772	0	0	0	403077
25-Aug-05	Farmington	3	0	0	265399	0	0	0	0	265399
10-Sep-05	Farmington	1	0	0	49194	456393	0	0	5694	511281
12-Sep-05	Farmington	2	0	2625964	13980	467809	0	0	1491	3109245
13-Sep-05	Farmington	1	0	5205390	83701	772852	0	0	949	6062892
13-Sep-05	Farmington	3	0	0	160755	5576378	0	463939	5219	6206291
6-Oct-05	Farmington	2	0	2232653	160755	293093	0	0	0	2686500
20-Oct-05	Farmington	1	0	312579	181400	487776	0	0	5799	987553
21-Oct-05	Farmington	1	0	0	15965	139429	0	0	0	155394
22-Oct-05	Farmington	2	0	0	1073257	420885	0	0	46504	1540646
22-Oct-05	Farmington	3	0	2526145	38581	377042	0	0	20167	2961936
13-Nov-05	Farmington	1	0	0	137193	555735	0	0	0	692928
13-Nov-05	Farmington	2	0	513865	141827	10334390	0	0	0	10990081
13-Nov-05	Farmington	3	0	0	175369	503582	0	561180	129124	1369254

Appendix 5 (con't)

Date Sampled	Region	Station	*Microcoleus* sp.	*Nodularia* heterocyst	*Nodularia* veg	*Pseudoanabaena* sp.	*Spirulina* sp.	Cyanophyta Totals	*Amphora coffeaeformis*	*Chaetocerous* sp.
3-May-05	Farmington	1	0	3476686	111000000	0	0	114000000	0	0
3-May-05	Farmington	2	0	2170564	12969299	0	0	15139864	0	0
3-May-05	Farmington	4	0	0	0	20724	0	20724	0	17311
17-May-05	Farmington	1	0	9616555	78658257	0	0	88274812	0	0
17-May-05	Farmington	2	0	5895898	29053397	0	0	34949295	0	0
17-May-05	Farmington	3	0	4960833	30581885	0	0	35542718	0	0
1-Jun-05	Farmington	1	0	429169	4827606	0	0	5256775	0	345898
1-Jun-05	Farmington	3	0	789159	6513244	0	0	7302404	0	55866
1-Jun-05	Farmington	4	0	1844394	6195716	0	0	8040110	0	89250
15-Jun-05	Farmington	1	0	1007826	8458802	0	0	9466628	0	50995
15-Jun-05	Farmington	2	0	610659	5385485	0	0	5996144	0	0
15-Jun-05	Farmington	4	0	1186495	12048773	0	0	13235268	0	133947
27-Jun-05	Farmington	1	0	302043	2976258	0	0	3278302	0	16963
27-Jun-05	Farmington	2	0	1215446	14495689	0	0	15711136	0	31679
27-Jun-05	Farmington	4	0	86119	1315266	0	8699	1410083	0	0
13-Jul-05	Farmington	1	0	3405196	35644051	0	0	39049247	0	266429
13-Jul-05	Farmington	2	0	3937168	40578382	0	0	44515550	0	211191
13-Jul-05	Farmington	4	0	2596475	29893901	0	0	32490377	0	200040
27-Jul-05	Farmington	1	0	2247890	19298622	0	156579	21703092	0	0
27-Jul-05	Farmington	2	548027	3031210	28274787	0	0	31854024	0	190072
27-Jul-05	Farmington	4	1417042	3665364	23218990	132114	63610	28497120	0	0
8-Aug-05	Farmington	3	0	5662017	42188321	0	0	47850339	0	337381
8-Aug-05	Farmington	4	0	3835702	31161932	0	0	34997635	0	312951
9-Aug-05	Farmington	1	0	3564586	25206590	0	0	28771176	0	71417
25-Aug-05	Farmington	1	2916289	2532100	23767090	0	0	29215479	1793544	432372
25-Aug-05	Farmington	2	893089	4010973	32881642	0	0	37785704	0	522699
25-Aug-05	Farmington	3	715791	5451463	47875671	0	0	54042925	279606	854972
10-Sep-05	Farmington	1	178643	1196942	14518381	0	93948	15987913	0	1569351
12-Sep-05	Farmington	2	743528	363284	9847230	44737	0	10998778	369918	1411966
13-Sep-05	Farmington	1	4611971	262448	20573098	0	0	25447516	0	340620
13-Sep-05	Farmington	3	2086418	1221135	33133809	0	0	36441362	0	35230
6-Oct-05	Farmington	2	0	958265	10820115	0	260965	12039346	0	126715
20-Oct-05	Farmington	1	0	1404405	10414225	28271	215296	12062197	0	279158
21-Oct-05	Farmington	1	0	823975	6652813	0	0	7476788	0	100618
22-Oct-05	Farmington	2	0	575429	3338894	0	81421	3995744	0	4697
22-Oct-05	Farmington	3	0	873945	8281514	0	134560	9290020	0	234591
13-Nov-05	Farmington	1	0	962023	6862703	0	0	7824726	0	749139
13-Nov-05	Farmington	2	0	1514548	10729619	0	0	12244167	0	1163064
13-Nov-05	Farmington	3	0	3929559	32820576	0	412325	37162461	0	0

Appendix 5 (con’t)

Date Sampled	**Region**	**Station**	**"Clear oval diatom"**	***Cyclotella* sp.**	***Nitzschia palea***	***Navicula graciloides***	***Navicula tripuctata***	**Large Navicula**	***Synedra* sp.**	**Diatom Totals**
3-May-05	Farmington	1	0	407665	0	0	0	0	0	407665
3-May-05	Farmington	2	0	391448	0	0	0	146793	0	538241
3-May-05	Farmington	4	62056	0	0	0	0	0	0	79367
17-May-05	Farmington	1	0	559212	0	0	0	0	0	559212
17-May-05	Farmington	2	0	0	0	0	0	852487	0	852487
17-May-05	Farmington	3	0	0	0	0	0	0	0	0
1-Jun-05	Farmington	1	130779	1037693	0	0	0	65819	95150	1675340
1-Jun-05	Farmington	3	192951	217471	0	0	0	52423	15229	533940
1-Jun-05	Farmington	4	0	949721	0	0	0	46104	265817	1350892
15-Jun-05	Farmington	1	0	0	0	0	0	0	941990	992985
15-Jun-05	Farmington	2	0	0	0	0	0	1087	4174604	4175691
15-Jun-05	Farmington	4	0	744180	0	0	0	123306	1901424	2902856
27-Jun-05	Farmington	1	0	2398619	0	0	0	244655	62881548	65541785
27-Jun-05	Farmington	2	409838	0	0	0	0	281843	22740660	23464020
27-Jun-05	Farmington	4	361872	1060873	0	0	0	432961	69198860	71054565
13-Jul-05	Farmington	1	0	0	0	0	0	14092	109650	390171
13-Jul-05	Farmington	2	493225	0	0	0	0	0	110757	815173
13-Jul-05	Farmington	4	287642	883984	0	0	244655	224593	0	1840914
27-Jul-05	Farmington	1	0	439024	0	0	1084010	57814	3696188	5277036
27-Jul-05	Farmington	2	0	250527	0	0	0	101777	431122	973498
27-Jul-05	Farmington	4	0	0	0	0	0	244655	1846599	2091254
8-Aug-05	Farmington	3	111842	0	0	0	0	838817	469927	1757968
8-Aug-05	Farmington	4	89911	0	0	0	0	1382682	149522	1935065
9-Aug-05	Farmington	1	69749	0	0	0	0	533793	317168	992127
25-Aug-05	Farmington	1	303669	259423	0	0	0	4657603	8119507	15566119
25-Aug-05	Farmington	2	0	0	0	0	0	227774	3146196	3896668
25-Aug-05	Farmington	3	0	286316	0	0	0	1096055	1738729	4255679
10-Sep-05	Farmington	1	144124	355862	0	0	0	1270249	1754393	5093980
12-Sep-05	Farmington	2	0	4718348	753841	0	0	1119588	4752811	13126472
13-Sep-05	Farmington	1	39857	0	0	0	0	344474	0	724951
13-Sep-05	Farmington	3	0	0	0	0	0	733231	5915845	6684306
2-Oct-05	Farmington	Causeway	0	77085	0	0	327612	51595	5582599	6228964
6-Oct-05	Farmington	2	0	31927487	0	0	0	0	4188614	36242817
20-Oct-05	Farmington	1	0	73061678	0	0	0	0	8148183	81489019
21-Oct-05	Farmington	1	0	4367301	0	0	0	0	2397984	6865903
22-Oct-05	Farmington	2	0	4160632	0	146793	8028332	0	3077665	15418119
22-Oct-05	Farmington	3	0	5541252	0	230171	0	135284	2052640	8193939
13-Nov-05	Farmington	1	0	1145265	0	0	0	0	89001	1983406
13-Nov-05	Farmington	2	0	31108082	0	0	0	0	45310	32316455
13-Nov-05	Farmington	3	0	0	0	0	0	114825	0	114825

Appendix 5 (con’t)

Date Sampled	Region	Station	*Euplotes* sp.	Unknown ciliates	Protozoa Totals	"Chrysophytes"	*Cryptomonas* sp.	*Glenodinium* sp.	Pyrrophyta Totals	ALL TAXA
3-May-05	Farmington	1	0	546039	0	1731283	397413	7819482	0	122530187
3-May-05	Farmington	2	0	1061491	0	3630133	1320889	6012514	0	21715672
3-May-05	Farmington	4	59070	652107	1018341	6524795	48632	8302945	0	9990588
17-May-05	Farmington	1	29685	966318	2516452	3124284	124624	8326912	0	104415142
17-May-05	Farmington	2	0	0	3299581	4400364	410122	8110067	0	51455489
17-May-05	Farmington	3	0	1379902	0	7568646	0	11190404	0	70695215
1-Jun-05	Farmington	1	18220	14570174	0	2457258	55752	17101403	0	26956265
1-Jun-05	Farmington	3	20942	17395317	0	2004214	66343	19813023	0	28585038
1-Jun-05	Farmington	4	35196	29350256	675535	868827	56369	30986183	0	42938695
15-Jun-05	Farmington	1	7442	3690216	0	144497	13016	3855171	0	14963518
15-Jun-05	Farmington	2	0	6293752	0	65241	0	6358993	0	16546739
15-Jun-05	Farmington	4	17902	14670057	0	201400	47365	14936724	0	32764309
27-Jun-05	Farmington	1	22617	15595686	0	319683	2610	15940596	0	91072657
27-Jun-05	Farmington	2	17398	17188922	0	607959	16006	17830285	0	59229706
27-Jun-05	Farmington	4	0	33464394	1565734	1837621	21747	36889497	0	109699120
13-Jul-05	Farmington	1	45930	71765	0	0	0	117695	0	39903737
13-Jul-05	Farmington	2	44074	454033	0	148460	13396	659964	0	47129459
13-Jul-05	Farmington	4	208201	3506984	0	140921	15658	3871764	0	39506896
27-Jul-05	Farmington	1	32119	1107005	0	0	0	1139124	0	30880547
27-Jul-05	Farmington	2	0	2249261	0	0	0	2249261	548027	35173268
27-Jul-05	Farmington	4	0	3330237	0	2455180	6524	5791941	1417042	39300416
8-Aug-05	Farmington	3	65614	629969	0	0	2982	698566	0	56873583
8-Aug-05	Farmington	4	82862	521931	0	0	2610	607402	0	43508311
9-Aug-05	Farmington	1	20877	45550	0	0	0	66428	0	30333448
25-Aug-05	Farmington	1	58418	91101	0	0	0	149519	2916289	48219174
25-Aug-05	Farmington	2	194305	208772	0	0	0	403077	893089	45331488
25-Aug-05	Farmington	3	265399	0	0	0	0	265399	715791	63432528
10-Sep-05	Farmington	1	49194	456393	0	0	5694	511281	178643	27869210
12-Sep-05	Farmington	2	13980	467809	0	0	1491	3109245	743528	36084443
13-Sep-05	Farmington	1	83701	772852	0	0	949	6062892	4611971	39735311
13-Sep-05	Farmington	3	160755	5576378	0	463939	5219	6206291	2086418	61069596
2-Oct-05	Farmington	Causeway	83701	32520	0	0	0	116221	15959	31421681
6-Oct-05	Farmington	2	160755	293093	0	0	0	2686500	0	51565373
20-Oct-05	Farmington	1	181400	487776	0	0	5799	987553	0	98088252
21-Oct-05	Farmington	1	15965	139429	0	0	0	155394	0	20592362
22-Oct-05	Farmington	2	1073257	420885	0	0	46504	1540646	0	21627096
22-Oct-05	Farmington	3	38581	377042	0	0	20167	2961936	0	21098446
13-Nov-05	Farmington	1	137193	555735	0	0	0	692928	0	20455268
13-Nov-05	Farmington	2	141827	10334390	0	0	0	10990081	0	56313236
13-Nov-05	Farmington	3	175369	503582	0	561180	129124	1369254	0	39180076

Appendix 5 (con't)

Date Sampled	Region	Station	*Carteria* sp.	*Dunaliella salina*	*Dunaliella viridis*	*Oocystis* sp.	*Pediastrum* sp.	*Scenedesmus* sp.	*Spermatozopsis* sp.	Chlorophyta Totals
3-May-05	Gilbert	14	0	0	466360	275011	0	0	0	741371
3-May-05	Gilbert	15	0	0	486709	2539	0	0	0	489248
3-May-05	Gilbert	18	0	0	1168494	45259	0	0	0	1213754
27-Jun-05	Gilbert	14	0	0	832752	71622	0	0	0	904374
27-Jun-05	Gilbert	15	0	0	1811427	106399	0	0	0	1917826
27-Jun-05	Gilbert	18	0	0	965185	0	0	0	0	965185
27-Jul-05	Gilbert	14	0	0	1565855	47667	0	0	0	1613522
27-Jul-05	Gilbert	15	0	0	128490	0	0	0	1321	129811
9-Aug-05	Gilbert	14	0	0	175939	0	0	0	0	175939
9-Aug-05	Gilbert	18	0	0	128775	0	0	0	0	128775
13-Sep-05	Gilbert	14	0	0	773097	146187	0	0	0	919283
13-Sep-05	Gilbert	15	0	0	846738	49268	0	0	0	896006
13-Sep-05	Gilbert	18	0	0	510334	81147	0	0	0	591481
21-Oct-05	Gilbert	14	0	0	1509086	67283	0	0	0	1576369
21-Oct-05	Gilbert	15	0	0	490699	0	0	0	0	490699
21-Oct-05	Gilbert	18	0	0	935436	24564	0	0	0	960000
13-Nov-05	Gilbert	18	0	0	444933	13997	0	0	0	458930

Date Sampled	Region	Station	*Microcoleus* sp.	*Nodularia* heterocyst	*Nodularia* veg	*Pseudoanabaena* sp.	*Spirulina* sp.	Cyanophyta Totals	*Amphora coffeaeformis*	*Chaetocerous* sp.
3-May-05	Gilbert	14	0	0	0	0	0	0	0	0
3-May-05	Gilbert	15	0	0	0	0	0	0	0	0
3-May-05	Gilbert	18	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	14	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	15	0	0	0	0	0	0	0	0
27-Jun-05	Gilbert	18	0	0	0	0	0	0	0	0
27-Jul-05	Gilbert	14	0	0	0	0	0	0	82875	0
27-Jul-05	Gilbert	15	0	15781	66489	0	0	82270	0	0
9-Aug-05	Gilbert	14	0	0	0	0	0	0	0	0
9-Aug-05	Gilbert	18	0	0	0	0	0	0	0	0
13-Sep-05	Gilbert	14	0	24954	184093	0	0	209047	66354	0
13-Sep-05	Gilbert	15	62183	15596	59947	0	0	137727	0	0
13-Sep-05	Gilbert	18	0	58802	497973	0	0	556775	0	0
21-Oct-05	Gilbert	14	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	15	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	18	0	0	0	0	0	0	0	0
13-Nov-05	Gilbert	18	0	0	0	0	0	0	0	0

Appendix 5 (con't)

Date Sampled	**Region**	**Station**	**"Clear oval diatom"**	***Cyclotella* sp.**	***Nitzschia palea***	***Navicula graciloides***	***Navicula tripuctata***	**Large *Navicula***	***Synedra* sp.**	**Diatom Totals**
3-May-05	Gilbert	14	32901	0	0	0	0	23461	0	56362
3-May-05	Gilbert	15	0	0	0	0	0	2844	0	2844
3-May-05	Gilbert	18	30037	0	0	0	0	0	0	30037
27-Jun-05	Gilbert	14	26051	0	0	0	0	7406	0	33456
27-Jun-05	Gilbert	15	0	0	0	0	0	14083	0	14083
27-Jun-05	Gilbert	18	9627	50795	0	0	0	21916	0	82338
27-Jul-05	Gilbert	14	12188	0	0	0	0	4604	0	99667
27-Jul-05	Gilbert	15	0	0	0	0	0	0	0	0
9-Aug-05	Gilbert	14	3926	0	0	0	397479	1357	0	402763
9-Aug-05	Gilbert	18	3703	0	0	0	0	93192	0	96895
13-Sep-05	Gilbert	14	112826	0	0	0	0	1138	0	180318
13-Sep-05	Gilbert	15	0	36384	0	0	0	1185	0	37569
13-Sep-05	Gilbert	18	0	0	0	0	0	17916	0	17916
21-Oct-05	Gilbert	14	0	43190	0	0	0	25594	0	68783
21-Oct-05	Gilbert	15	0	0	0	0	0	0	0	0
21-Oct-05	Gilbert	18	190430	0	0	0	0	0	0	190430
13-Nov-05	Gilbert	18	0	0	0	0	0	0	0	0

Date Sampled	**Region**	**Station**	***Euplotes* sp.**	**Unknown ciliates**	**Protozoa Totals**	**"Chrysophytes"**	***Cryptomonas* sp.**	***Glenodinium* sp.**	**Pyrrophyta Totals**	**ALL TAXA**
3-May-05	Gilbert	14	0	0	0	73738	8777	0	82515	82529
3-May-05	Gilbert	15	0	0	0	78912	8614	0	87527	87542
3-May-05	Gilbert	18	0	0	0	29952	10055	0	40007	40025
27-Jun-05	Gilbert	14	0	0	0	35191	23133	0	58325	58339
27-Jun-05	Gilbert	15	0	0	0	6861	7383	0	14244	14259
27-Jun-05	Gilbert	18	0	0	0	11486	2365	0	13852	13870
27-Jul-05	Gilbert	14	0	0	0	64639	13000	0	77639	77653
27-Jul-05	Gilbert	15	0	0	0	0	0	0	0	15
9-Aug-05	Gilbert	14	0	0	0	946	1149	0	2095	2109
9-Aug-05	Gilbert	18	0	0	0	1896	0	0	1896	1914
13-Sep-05	Gilbert	14	0	0	0	0	14184	0	14184	14198
13-Sep-05	Gilbert	15	0	0	0	9060	10045	0	19104	19119
13-Sep-05	Gilbert	18	0	0	0	10491	7921	0	18412	18430
21-Oct-05	Gilbert	14	0	0	0	23034	57199	0	80233	80247
21-Oct-05	Gilbert	15	0	0	0	2738	3792	0	6530	6545
21-Oct-05	Gilbert	18	0	0	0	2883	7719	0	10602	10620
13-Nov-05	Gilbert	18	0	0	0	847	2098	0	2945	2963

Appendix 6: Nitrogen (N_2) fixation vertical profiles at station P1 measured during 2005. Top values are the mean rate at each date, followed in parentheses by the standard error and number of replicates.

Date	Depth (m)	N_2 Fixation (µg L^{-1} h^{-1})	Date	Depth (m)	N_2Fixation (µg L^{-1} h^{-1})	Date	Depth (m)	N_2Fixation (µg L^{-1} h^{-1})
3-May-05	0.25	45.5 (2.5, 2)	27-Jul-05	0.2	20.1 (0.6, 2)	21-Oct-05	0.2	3.4 (0.4, 2)
3-May-05	0.5	34.6 (1.3, 2)	27-Jul-05	0.4	16.8 (0.7, 2)	21-Oct-05	0.4	2.9 (0.4, 2)
3-May-05	0.75	23.9 (0.2, 2)	27-Jul-05	0.6	10.8 (0.6, 2)	21-Oct-05	0.6	2.1 (0.2, 2)
3-May-05	1	18.3 (0.2, 2)	27-Jul-05	0.8	8.4 (0.6, 2)	21-Oct-05	0.8	1.2 (0.1, 2)
17-May-05	0.2	2.0 (0.6, 2)	27-Jul-05	1	0.0 (0.0, 2)	21-Oct-05	1	0.0 (0.0, 2)
17-May-05	0.6	0.4 (0.0, 2)	27-Jul-05	1.2	0.0 (0.0, 2)	13-Nov-05	0.2	0.7 (0.1, 2)
17-May-05	1	0.2 (0.0, 2)	9-Aug-05	0.2	12.8 (0.8, 2)	13-Nov-05	0.6	0.6 (0.0, 2)
17-May-05	1.4	0.2 (0.0, 2)	9-Aug-05	0.4	12.3 (–, 1)	13-Nov-05	1	0.2 (0.0, 2)
15-Jun-05	0.2	1.7 (0.0, 2)	9-Aug-05	0.6	10.1 (0.2, 2)			
15-Jun-05	0.4	1.2 (0.0, 2)	9-Aug-05	0.8	1.0 (0.0, 2)			
15-Jun-05	0.6	1.1 (0.0, 2)	9-Aug-05	1	0.4 (0.1, 2)			
15-Jun-05	0.8	1.0 (0.0, 2)	9-Aug-05	1.2	0.1 (0.0, 2)			
15-Jun-05	1.2	0.3 (0.0, 2)	27-Aug-05	0.2	8.3 (0.2, 2)			
15-Jun-05	1.4	0.3 (0.0, 2)	27-Aug-05	0.4	4.1 (0.1, 2)			
27-Jun-05	0.2	3.0 (0.2, 2)	27-Aug-05	0.6	1.5 (0.1, 2)			
27-Jun-05	0.4	1.8 (0.1, 2)	27-Aug-05	0.8	0.6 (0.0, 2)			
27-Jun-05	0.6	2.1 (0.1, 2)	27-Aug-05	1	0.2 (0.0, 2)			
27-Jun-05	0.8	1.7 (0.1, 2)	13-Sep-05	0.2	1.4 (0.0, 2)			
27-Jun-05	1	1.1 (0.0, 2)	13-Sep-05	0.4	0.9 (0.0, 2)			
27-Jun-05	1.2	0.6 (0.0, 2)	13-Sep-05	0.6	0.9 (0.1, 2)			
27-Jun-05	1.4	0.3 (0.0, 2)	13-Sep-05	0.8	0.5 (0.0, 2)			
13-Jul-05	0.2	17.2 (1.2, 2)	13-Sep-05	1	0.0 (–, 1)			
13-Jul-05	0.4	14.6 (–, 1)	7-Oct-05	0.2	0.8 (0.0, 2)			
13-Jul-05	0.6	12.0 (0.2, 2)	7-Oct-05	0.4	0.4 (0.0, 2)			
13-Jul-05	0.8	9.0 (0.5, 2)	7-Oct-05	0.6	0.4 (0.0, 2)			
13-Jul-05	1	5.4 (0.1, 2)	7-Oct-05	0.8	0.3 (0.0, 2)			
13-Jul-05	1.2	0.0 (0.0, 2)	7-Oct-05	1	0.4 (–, 1)			
13-Jul-05	1.4	0.0 (0.0, 2)	7-Oct-05	0.6	0.4 (0.0, 2)			

Appendix 7: Zooplankton density (organisms L^{-1}) by taxa for each sampling date at each station.

Date Sampled	Region	Station	***Artemia franciscana* male**	***Artemia franciscana* female**	***Artemia franciscana* juvenile**	***Artemia franciscana* nauplii**	***Trichocorixa verticalis***	***Ephydra sp.* adult**	***Ephydra sp.* pupae**	***Ephdra sp.* larvae**
16-Apr	Farmington	Causeway	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1
3-May	Farmington	1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Farmington	2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Farmington	4	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0
15-May	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-May	Farmington	2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
15-May	Farmington	4	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0
17-May	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Jun	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1-Jun	Farmington	3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1-Jun	Farmington	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
15-Jun	Farmington	1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
15-Jun	Farmington	2	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
15-Jun	Farmington	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Farmington	1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
27-Jun	Farmington	2	0.3	0.3	0.0	0.0	0.1	0.0	0.0	0.0
27-Jun	Farmington	4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
15-Jul	Farmington	1	0.0	0.0	0.0	0.0	0.7	0.0	0.2	0.0
15-Jul	Farmington	2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
27-Jul	Farmington	1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
27-Jul	Farmington	2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
27-Jul	Farmington	4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
8-Aug	Farmington	3	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
8-Aug	Farmington	4	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
9-Aug	Farmington	1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
25-Aug	Farmington	1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
25-Aug	Farmington	2	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0
25-Aug	Farmington	3	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
12-Sep	Farmington	1	0.1	0.1	0.0	0.0	1.4	0.0	0.0	0.0
12-Sep	Farmington	2	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
12-Sep	Farmington	3	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0
6-Oct	Farmington	2	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
21-Oct	Farmington	1	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0
21-Oct	Farmington	2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
21-Oct	Farmington	3	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
12-Nov	Farmington	1	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0
12-Nov	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 7 (con’t)

Date Sampled	Region	Station	*Diaptomus conexus*	Cyclopoid copepod	*Cletocampus albuquerquensis*	UNID Dipteran adult	UNID Dipteran pupae	UNID Dipteran larvae	*Moina* sp.
16-Apr	Farmington	Causeway	0.0	14.5	0.4	0.0	0.0	0.0	0.1
3-May	Farmington	1	0.3	0.0	24.1	0.0	0.0	0.0	163.6
3-May	Farmington	2	0.0	19.2	24.3	0.0	0.0	0.0	322.3
3-May	Farmington	4	0.0	50.5	2.4	0.0	0.0	0.0	1314.0
15-May	Farmington	1	0.0	26.0	9.5	0.0	0.0	0.0	74.7
15-May	Farmington	2	0.0	38.2	13.6	0.0	0.0	0.0	41.2
15-May	Farmington	4	0.0	77.1	0.8	0.0	0.0	0.0	102.1
17-May	Farmington	2	22.3	0.0	4.5	0.0	0.0	0.0	38.5
1-Jun	Farmington	1	9.4	3.5	4.9	0.0	0.0	0.0	32.3
1-Jun	Farmington	3	3.9	0.0	0.0	0.0	0.0	0.0	2.7
1-Jun	Farmington	4	7.1	4.3	2.0	0.0	0.0	0.0	15.7
15-Jun	Farmington	1	14.1	0.0	0.0	0.0	0.0	0.0	0.9
15-Jun	Farmington	2	9.7	0.8	0.0	0.0	0.0	0.0	1.5
15-Jun	Farmington	4	37.1	18.3	1.0	0.0	0.0	0.0	42.1
27-Jun	Farmington	1	178.0	0.2	0.0	0.0	0.0	0.0	12.9
27-Jun	Farmington	2	296.4	0.0	0.0	0.0	0.0	0.0	667.9
27-Jun	Farmington	4	164.9	2.7	0.3	0.0	0.0	0.0	31.2
15-Jul	Farmington	1	167.4	0.0	0.0	0.0	0.0	0.0	74.3
15-Jul	Farmington	2	323.9	0.0	0.0	0.0	0.0	0.0	225.5
27-Jul	Farmington	1	95.8	0.0	0.0	0.0	0.0	0.0	33.7
27-Jul	Farmington	2	188.5	0.0	0.0	0.0	0.0	0.0	83.3
27-Jul	Farmington	4	130.7	0.0	0.0	0.0	0.0	0.0	112.8
8-Aug	Farmington	3	9.8	0.0	0.0	0.0	0.0	0.0	228.6
8-Aug	Farmington	4	11.9	0.0	0.0	0.0	0.0	0.0	116.0
9-Aug	Farmington	1	28.0	0.0	0.0	0.0	0.0	0.0	40.8
25-Aug	Farmington	1	3.1	0.0	0.0	0.0	0.0	0.0	0.0
25-Aug	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Aug	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-Oct	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Farmington	2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
21-Oct	Farmington	3	0.0	0.1	0.6	0.0	0.0	0.0	0.0
12-Nov	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 7 (con't)

Date Sampled	Region	Station	*Artemia franciscana* male	*Artemia franciscana* female	*Artemia franciscana* juvenile	*Artemia franciscana* nauplii	*Trichocorixa verticalis*	*Ephydra sp.* adult	*Ephydra sp.* pupae	*Ephydra sp.* larvae
3-May	Gilbert	14	0.0	0.2	0.8	0.5	0.0	0.0	0.1	0.1
3-May	Gilbert	15	0.3	0.3	1.7	0.9	0.0	0.0	0.0	0.0
3-May	Gilbert	18	1.3	3.8	1.7	0.2	0.0	0.0	0.0	0.0
27-Jun	Gilbert	14	0.4	0.4	0.1	0.3	0.0	0.0	0.0	0.0
27-Jun	Gilbert	15	0.9	0.8	0.0	0.1	0.0	0.0	0.0	0.0
27-Jun	Gilbert	18	1.8	1.5	0.0	0.1	0.0	0.0	0.0	0.0
27-Jul	Gilbert	15	0.3	0.4	0.1	0.1	0.0	0.0	0.0	0.0
27-Jul	Gilbert	18	0.2	0.1	0.3	0.7	0.0	0.0	0.0	0.0
9-Aug	Gilbert	14	0.2	0.1	0.1	8.4	0.0	0.0	0.0	0.0
9-Aug	Gilbert	15	0.4	0.4	0.0	0.3	0.0	0.0	0.0	0.0
9-Aug	Gilbert	18	0.2	0.1	0.1	0.5	0.0	0.0	0.0	0.0
12-Sep	Gilbert	14	0.4	0.2	1.4	2.8	0.0	0.0	0.0	0.0
12-Sep	Gilbert	18	0.5	0.2	1.3	4.0	0.0	0.0	0.0	0.2
21-Oct	Gilbert	14	1.1	0.6	1.2	0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	15	1.6	2.4	1.0	0.8	0.0	0.0	0.0	0.0
21-Oct	Gilbert	18	0.3	0.3	2.4	0.1	0.0	0.0	0.0	0.0
12-Nov	Gilbert	18	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0

Date Sampled	Region	Station	*Diaptomus conexus*	Cyclopoid copepod	*Cletocampus albuquerquensis*	UNID Dipteran adult	UNID Dipteran pupae	UNID Dipteran larvae	*Moina sp.*
3-May	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jul	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jul	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-Aug	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-Aug	Gilbert	15	0.9	0.0	0.0	0.0	0.0	0.0	0.4
9-Aug	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 8: Zooplankton biomass (μg L^{-1}) by taxa for each sampling date at each location.

Date Sampled	Region	Station	*Artemia franciscana* male	*Artemia franciscana* female	*Artemia franciscana* juvenile	*Artemia franciscana* nauplii	*Trichocorixa verticalis*	*Ephydra sp.* adult	*Ephydra sp.* pupae	*Ephydra sp.* larvae
16-Apr	Farmington	Causeway	0.0	2.7	0.6	0.2	0.0	0.0	0.0	28.4
3-May	Farmington	1	16.4	10.0	0.0	0.0	0.4	0.0	1.1	0.0
3-May	Farmington	2	13.1	44.3	0.0	0.0	0.9	0.0	0.0	0.0
3-May	Farmington	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-May	Farmington	1	5.6	6.7	0.0	0.0	0.9	0.0	0.0	2.3
15-May	Farmington	2	3.3	6.1	0.0	0.0	4.3	0.0	0.0	5.0
15-May	Farmington	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
17-May	Farmington	2	0.0	3.4	0.0	0.0	0.5	0.0	0.0	0.8
1-Jun	Farmington	1	2.9	5.2	0.0	0.0	0.5	0.0	0.0	0.0
1-Jun	Farmington	3	22.4	27.4	1.8	0.1	1.9	0.0	0.0	0.0
1-Jun	Farmington	4	3.1	3.0	0.0	0.0	2.2	0.0	0.0	2.4
15-Jun	Farmington	1	32.8	16.5	0.0	1.5	4.8	0.2	0.5	0.0
15-Jun	Farmington	2	5.4	7.8	0.0	0.0	0.2	0.0	0	2.4
15-Jun	Farmington	4	0.0	0.0	0.0	0.0	0.4	0.0	3.6	3.7
27-Jun	Farmington	1	14.6	16.6	0.0	0.0	9.9	0.0	0.2	0.0
27-Jun	Farmington	2	146.3	203.2	0.0	0.0	9.0	0.0	0.0	1.9
27-Jun	Farmington	4	10.4	17.6	0.0	0.0	10.2	0.0	0.0	0.0
15-Jul	Farmington	1	0.7	0.0	0.0	0.0	57.9	0.0	47.5	0.0
15-Jul	Farmington	2	0.0	0.0	0.0	0.0	6.0	0.2	0.0	0.0
27-Jul	Farmington	1	0.0	0.0	0.0	0.0	18.7	0.0	0.0	0.0
27-Jul	Farmington	2	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0
27-Jul	Farmington	4	0.0	0.0	0.0	0.0	31.8	0.0	0.0	0.0
8-Aug	Farmington	3	0.0	0.0	0.0	0.0	91.8	0.0	0.0	0.0
8-Aug	Farmington	4	0.0	0.0	0.0	0.0	57.6	0.0	0.0	0.2
9-Aug	Farmington	1	0.0	0.0	0.0	0.0	16.4	0.1	1.9	0.0
25-Aug	Farmington	1	0.7	0.4	0.0	0.0	98.8	0.3	0.0	0.0
25-Aug	Farmington	2	0.0	0.0	0.0	0.0	614.4	0.0	0.0	0.0
25-Aug	Farmington	3	0.0	0.0	0.0	0.0	71.0	0.0	0.0	0.0
12-Sep	Farmington	1	31.9	20.8	0.0	0.0	81.4	0.0	0.6	0.0
12-Sep	Farmington	2	9.4	6.8	0.0	0.0	74.8	0.0	0.0	0.0
12-Sep	Farmington	3	0.0	0.0	0.0	0.0	269.1	0.0	0.0	0.0
6-Oct	Farmington	2	0.0	5.2	0.0	0.0	151.9	0.0	0.0	0.0
21-Oct	Farmington	1	18.7	3.2	0.0	0.0	25.2	0.0	0.1	0.0
21-Oct	Farmington	2	8.0	6.0	0.0	0.0	12.8	0.0	0.0	0.0
21-Oct	Farmington	3	11.9	13.9	0.0	0.0	35.8	0.0	0.0	0.0
12-Nov	Farmington	1	5.9	4.2	0.0	0.4	0.1	0.0	0.0	0.4
12-Nov	Farmington	2	3.5	3.8	0.1	0.0	2.5	0.0	0.0	0.0
12-Nov	Farmington	3	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0

Appendix 8 (con't)

Date Sampled	Region	Station	*Diaptomus conexus*	Cyclopoid copepod	*Cletocampus albuquerquensis*	UNID Dipteran adult	UNID Dipteran pupae	UNID Dipteran larvae	*Moina* sp.
16-Apr	Farmington	Causeway	0.0	20.7	0.6	0.0	0.0	0.0	0.5
3-May	Farmington	1	1.8	0.0	61.0	0.0	0.0	0.0	403.1
3-May	Farmington	2	0.1	28.2	44.0	0.0	0.0	0.0	463.3
3-May	Farmington	4	0.0	97.3	3.8	0.0	0.0	0.0	3054.8
15-May	Farmington	1	0.0	45.7	12.5	0.4	0.2	0.0	300.4
15-May	Farmington	2	0.0	73.5	23.8	0.4	0.3	0.0	148.6
15-May	Farmington	4	0.2	180.1	1.5	0.0	0.0	0.0	299.3
17-May	Farmington	2	39.8	0.0	6.5	0.0	0.0	0.0	73.1
1-Jun	Farmington	1	39.1	5.8	9.2	0.0	0.0	0.0	47.7
1-Jun	Farmington	3	9.9	0.0	0.0	0.0	0.0	0.0	3.6
1-Jun	Farmington	4	24.3	7.8	3.6	0.3	0.0	0.0	38.8
15-Jun	Farmington	1	40.2	0.0	0.0	0.0	0.0	0.0	2.0
15-Jun	Farmington	2	27.0	2.2	0.0	0.6	0.0	0.0	3.7
15-Jun	Farmington	4	175.8	50.8	2.2	1.2	0.0	0.0	209.9
27-Jun	Farmington	1	540.2	0.4	0.0	0.0	0.0	0.0	49.4
27-Jun	Farmington	2	1231.6	0.0	0.0	3.0	0.0	0.0	1841.8
27-Jun	Farmington	4	914.5	6.5	0.4	1.1	2.4	0.8	81.7
15-Jul	Farmington	1	285.2	0.0	0.0	0.0	0.0	0.0	129.6
15-Jul	Farmington	2	1137.1	0.0	0.0	0.0	0.0	0.0	368.8
27-Jul	Farmington	1	228.2	0.0	0.0	0.0	0.0	0.0	87.6
27-Jul	Farmington	2	953.1	0.0	0.0	0.0	0.0	0.0	107.5
27-Jul	Farmington	4	634.7	0.0	0.0	0.0	0.0	0.0	139.9
8-Aug	Farmington	3	20.5	0.0	0.0	0.0	0.0	0.0	346.2
8-Aug	Farmington	4	45.0	0.0	0.0	0.0	0.0	0.0	140.2
9-Aug	Farmington	1	81.7	0.0	0.0	0.0	0.0	0.0	74.0
25-Aug	Farmington	1	11.5	0.0	0.0	0.0	0.0	0.0	0.0
25-Aug	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-Aug	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.1
12-Sep	Farmington	1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-Oct	Farmington	2	0.0	0.0	0.1	0.0	0.0	0.0	0.0
21-Oct	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Farmington	2	0.0	0.0	0.4	0.0	0.0	0.0	0.0
21-Oct	Farmington	3	0.0	0.2	1.6	0.0	0.0	0.0	0.0
12-Nov	Farmington	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Farmington	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Farmington	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 8 (con't)

Date Sampled	Region	Station	*Artemia franciscana* Male	*Artemia franciscana* Female	*Artemia franciscana* Juvenile	*Artemia franciscana* Nauplii	*Trichocorixa verticalis*	*Ephydra sp.* Adult	*Ephydra sp.* Pupae	*Ephydra sp.* Larvae
3-May	Gilbert	14	9.3	15.3	5.0	1.5	0.0	0.1	10.5	4.9
3-May	Gilbert	15	143.5	144.3	18.2	3.2	0.0	0.0	1.2	0.1
3-May	Gilbert	18	373.5	425.1	192.8	0.6	0.0	0.0	0.0	0.0
27-Jun	Gilbert	14	96.7	108.6	0.4	0.7	0.0	0.1	0.0	0.2
27-Jun	Gilbert	15	225.4	269.0	0.1	0.4	0.0	0.0	0.0	0.0
27-Jun	Gilbert	18	387.2	387.1	0.0	0.3	0.0	0.0	0.0	0.0
27-Jul	Gilbert	15	78.4	66.7	0.1	0.2	0.0	0.1	0.0	0.0
27-Jul	Gilbert	18	36.3	29.9	20.7	1.9	1.3	0.1	0.8	0.2
9-Aug	Gilbert	14	22.8	34.0	0.5	20.5	0.0	0.0	0.0	0.0
9-Aug	Gilbert	15	58.4	48.7	0.0	0.8	1.4	0.2	0.0	0.0
9-Aug	Gilbert	18	19.7	14.7	0.9	1.1	5.9	0.3	5.5	0.0
12-Sep	Gilbert	14	98.9	97.4	6.5	6.5	1.4	0.0	0.0	0.3
12-Sep	Gilbert	18	157.2	47.0	12.8	10.1	2.2	0.0	0.0	6.2
21-Oct	Gilbert	14	245.8	116.2	10.3	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	15	404.7	440.7	19.1	2.1	0.0	0.0	0.0	0.0
21-Oct	Gilbert	18	59.7	67.7	24.0	0.3	0.0	0.0	0.0	0.0
12-Nov	Gilbert	18	18.3	19.8	8.1	0.2	1.5	0.0	0.0	0.6

Date Sampled	Region	Station	*Diaptomus conexus*	Cyclopoid copepod	*Cletocampus albuquerquensis*	UNID Dipteran adult	UNID Dipteran pupae	UNID Dipteran larvae	*Moina* sp.
3-May	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-May	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	14	0.1	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	15	0.1	0.0	0.0	0.0	0.0	0.0	0.0
27-Jun	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jul	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27-Jul	Gilbert	18	0.1	0.0	0.0	0.0	0.0	0.0	0.0
9-Aug	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-Aug	Gilbert	15	1.4	0.0	0.0	0.0	0.0	0.0	0.5
9-Aug	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Sep	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Oct	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12-Nov	Gilbert	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 9: Macroinvertebrate densities on benthic brine fly substrates in Gilbert and Farmington Bays. Densities are the top number and are reported as organisms / m^2. Followed in parentheses are (1) the standard error of the station replicates and (2) the number of samples collected at each station.

Region	**Date**	**Station**	**Depth**	***Trichocorixa verticalis***	***Ephydra cinera* larvae**	***Ephydra cinera* pupae**	***Ephydra hians* larvae**	***Ephydra hians* pupae**	***Ephydra* Adult (both species)**
Gilbert	7-Sep-05	P14A	0.5M	18.5 (9.2, 3)	6325 (1463.7, 3)	8993.5 (370.4, 3)	0 (0, 3)	0 (0, 3)	2373 (231.4, 3)
Gilbert	7-Sep-05	P14A	1.0M	0 (0, 3)	1071.1 (374.8, 3)	249.3 (112, 3)	0 (0, 3)	0 (0, 3)	129.3 (75.6, 3)
Gilbert	7-Sep-05	P15A	0.5M	18.5 (9.2, 3)	4533.7 (1403.6, 3)	1071.1 (136, 3)	0 (0, 3)	0 (0, 3)	2197.6 (841.6, 3)
Gilbert	7-Sep-05	P15A	1.0M	0 (0, 3)	3037.9 (345, 3)	2760.8 (134.1, 3)	0 (0, 3)	0 (0, 3)	1071.1 (420.8, 3)
Gilbert	7-Sep-05	P18A	0.5M	9.2 (9.2, 3)	2613.1 (412.5, 3)	6546.6 (517.1, 3)	0 (0, 3)	0 (0, 3)	720.2 (27.7, 3)
Gilbert	7-Sep-05	P18A	1.0M	0 (0, 3)	3351.8 (983.4, 3)	7322.3 (1535.4, 3)	0 (0, 3)	0 (0, 3)	304.7 (99.9, 3)
Farmington	7-Sep-05	P1A	0.5M	5300 (1,281.7, 3)	0 (0, 3)	0 (0, 3)	46.2 (33.3, 3)	18.5 (18.5, 3)	0 (0, 3)
Farmington	7-Sep-05	P1A	1.0M	1911.4 (523.6, 3)	9.2 (9.2, 3)	0 (0, 3)	9.2 (9.2, 3)	9.2 (9.2, 3)	0 (0, 3)
Farmington	7-Sep-05	P2A	0.5M	3361 (1463.8, 3)	0 (0, 3)	0 (0, 3)	0 (0, 3)	0 (0, 3)	0 (0, 3)
Farmington	7-Sep-05	P2A	1.0M	2225.3 (501.3, 3)	0 (0, 3)	0 (0, 3)	18.5 (9.2, 3)	9.2 (9.2, 3)	9.2 (9.2, 3)

Appendix 10: Data collected during the 2005 synoptic surveys

Synoptic	Station Identity Code	Date Collected	LAT	LONG	Salinity %	Skin Temp	Temp at 0.2 m	Secchi (m)	Station Depth (m)	Chl a Field (ug/L)	Chllorphyll Extracted (ug/L)	CDOM (absorb./cm)	Phycocyanin (Fluoresence units)	Phycoerythrin (fluoresence units)	N_fixation (ug N/L/hr)
Farmington Bay															
June	FB-10	3-Jun-05	40.910	-112.082	0.5	–	–	0.25	0.9	–	201	0.012	–	17.6	0.4
June	FB-11	3-Jun-05	40.923	-112.039	0.4	–	15.5	0.17	0.4	–	154	0.012	–	14.9	0.1
June	FB-9	1-Jun-05	40.930	-112.099	0.5	–	–	0.25	–		395	0.150	–	26.3	0.7
June	FB-8-F	1-Jun-05	40.964	-112.109	0.9	20.4	21.5	0.24	1.3	223	303	0.095	1199	18.4	8.2
June	FB-7-P	1-Jun-05	40.994	-112.122	1.3	19.6	20.9	0.28	0.8	220	221	0.008	853	20.7	5.3
June	FB-6-F	1-Jun-05	40.996	-112.140	1.6	18.9	20.5	0.27	0.9	157	186	0.008	594	16.5	2.7
June	FB-5-P	1-Jun-05	41.010	-112.130	1.0	21.2	22.6	0.22	0.8	241	311	0.010	1121	25.8	9.7
June	FB-4-P	1-Jun-05	41.030	-112.159	1.0	19.4	21.6	0.24	1.5	204	320	0.011	1309	18.6	3.8
June	FB-3-P	1-Jun-05	41.040	-112.155	1.0	20.8	23.2	0.24	1.3	220	303	0.012	1247	18.6	6.0
June	FB-2-F	1-Jun-05	41.050	-112.188	1.4	15.2	19.0	0.25	1.5	113	233	0.025	705	14.2	1.5
June	FB-1-F	1-Jun-05	41.060	-112.215	1.2	17.6	18.3	0.26	1.9	238	254	0.011	962	16.3	2.8
Bear River Bay															
June	BRB	3-Jun-05	41.271	-112.355	0.2	–	18.3	–	–		17	0.004	–	39.8	0.0
Gilbert Bay (with Ogden Bay--Sta FB12, 13)															
June	S-10-F	2-Jun-05	40.762	-112.258	13.2	19.2	20.5	2.30	7.4	0.1	0.4	0.004	6.2	–	–
June	S-8-P	2-Jun-05	40.793	-112.374	14.0	18.2	–	1.30	3.4	3.4	2.7	0.007	16.1	1.0	–
June	S-11-P	2-Jun-05	40.804	-112.202	13.6	19.2	–	2.40	7.2	-0.7	0.4	0.004	6.7	–	–
June	S-7-F	2-Jun-05	40.856	-112.403	14.0	19.3	19.7	2.70	6.3	1.2	0.5	0.006	7.7	-0.7	–
June	S-12-F	2-Jun-05	40.858	-112.246	13.8	18.8	20.0	3.00	8.5	0.4	0.4	0.004	5.9	0.7	–
June	S-13-P	2-Jun-05	40.899	-112.318	14.0	17.8	–	3.05	8.7	0.9	0.5	0.005	7.3	0.6	–
June	S-6-P	2-Jun-05	40.930	-112.448	13.6	18.2	–	2.90	6.0	-0.1	0.5	0.008	6.3	0.7	–
June	S-14-F	2-Jun-05	40.963	-112.291	13.2	19.8	21.8	2.55	7.7	2.5	1.1	0.004	12.2	0.4	–
June	S-15-P	2-Jun-05	41.007	-112.306	12.6	20.2	–	0.85	5.5	4.3	5.7	0.005	29.3	1.8	–
June	S-4-F	2-Jun-05	41.028	-112.494	13.8	18.0	19.4	2.55	6.0	1.8	1.5	0.005	10.7		–
June	S-1-F	2-Jun-05	41.038	-112.308	12.0	17.0	17.9	0.60	3.5	14.4	19.9	0.007	91.9	5.6	–
June	S-3-P	2-Jun-05	41.039	-112.421	13.1	17.8	–	2.00	8.9	1.0	2.9	0.005	15.0	0.9	–
June	N-11-F	31-May-05	41.046	-112.700	13.6	19.8	21.0	1.55	4.7	4.2	4.4	0.004	27.2	–	0.1
June	N-1-F	31-May-05	41.071	-112.274	13.6	18.8	19.7	0.75	2.3	4.4	3.0	0.004	18.1	–	0.1
June	N-2-P	31-May-05	41.071	-112.274	13.2	19.4	20.0	0.65	3.6	10.6	29.1	0.007	111.0		0.1
June	N-16-F	31-May-05	41.071	-112.331	13.7	20.2	20.4	2.10	2.5	1.9	0.4	0.007	7.0	–	0.1
June	N-15-P	31-May-05	41.072	-112.332	13.6	19.2	19.6	1.05	7.6	12.2	25.0	0.004	141.6	–	0.1
June	FB-12-F	1-Jun-05	41.073	-112.233	10.8	17.6	18.5	0.35	2.0	108.2	79.7	0.007	270.0	13.2	0.0
June	FB-13-P	1-Jun-05	41.104	-112.242	11.8	19.2	18.6	0.33	0.6	39.4	45.8	0.005	171.7	16.9	0.0
June	N-14-F	31-May-05	41.080	-112.384	13.8	19.2	19.8	1.65	7.8	6.1	5.4	0.007	34.1	–	0.1
June	N-12-P	31-May-05	41.089	-112.629	13.6	19.2	21.5	1.75	7.1	2.2	3.3	0.006	9.9	–	
June	N-13-F	31-May-05	41.092	-112.544	13.8	19.6	20.3	1.95	4.0	2.9	1.1	0.005	10.2	–	0.1
June	N-3-F	31-May-05	41.113	-112.359	13.6	17.6	19.2	0.93	5.3	10.1	28.0	0.006	84.0	-0.8	0.1
June	N-10-P	31-May-05	41.119	-112.729	13.6	20.4	21.0	2.05	4.6	1.1	2.2	0.004	12.8	–	
June	N-4-P	31-May-05	41.134	-112.403	13.6	18.4	19.2	0.69	5.6	11.1	29.7	0.004	100.5	–	0.1
June	N-5-P	31-May-05	41.166	-112.436	13.0	18.8	20.1	0.68	5.6	11.8	28.8	0.004	94.1	–	
June	N-9-F	31-May-05	41.167	-112.746	13.7	19.4	20.1	1.55	4.8	5.5	4.9	0.004	21.7	–	0.1
June	N-7-F	31-May-05	41.187	-112.503	11.4	19.8	20.3	0.38	4.0	27.5	40.0	0.005	190.5	–	0.1
June	N-8-P	31-May-05	41.193	-112.545	13.9	19.2	20.1	1.90	8.0	0.2	1.6	0.004	11.0	–	
June	N-6-F	31-May-05	41.199	-112.404	7.0	18.8	18.8	0.20	4.0	35.4	53.0	0.011	201.8	–	0.2

Appendix 10 (con't)

Synoptic	Station Identity Code	Date Collected	LAT	LONG	Salinity %	Skin Temp	Temp at 0.2 m	Secchi (m)	Station Depth (m)	Chl a Field (ug/L)	Chllorophyll Extracted (ug/L)	CDOM (absorb./cm)	Phycocyanin (Fluoresence units)	Phycoerythrin (fluoresence units)	N_fixation (ug N/L/hr)
Farmington Bay															
August	FB-10-P	8-Aug-05	40.913	-112.045	0.4	–	24.4	> depth	0.3	–	30	0.010	–	–	0
August	FB-11-F	8-Aug-05	40.925	-112.022	0.2	–	25.6	> depth	0.2	–	6	0.013	–	–	0.05
August	FB-9-P	8-Aug-05	40.934	-112.083	1.6	–	27.9	0.26	0.4	–	312	0.018	–	–	6.3
August	FB-8-F	8-Aug-05	40.964	-112.109	2.6	–	27.7	0.16	1.1	–	283	0.018	–	–	9.4
August	FB-7-P	8-Aug-05	40.976	-112.110	3.6	–	27.4	0.15	0.6	–	374	0.013	–	–	13.4
August	FB-6-F	8-Aug-05	40.996	-112.140	3.4	–	28.6	0.12	1.0	–	290	0.013	–	–	21.2
August	FB-5-P	8-Aug-05	41.008	-112.125	3.0	–	27.5	0.19	0.7	–	219	0.012	–	–	7.3
August	FB-4-P	8-Aug-05	41.018	-112.157	3.6	–	28.5	0.20	1.1	–	205	0.011	–	–	10
August	FB-3-P	8-Aug-05	41.041	-112.156	3.4	–	27.9	0.39	1.0	–	96	0.013	–	–	3.5
August	FB-2-F	9-Aug-05	41.050	-112.188	3.6	–	28.5	0.17	1.3	–	179	0.011	–	–	9.8
August	FB-1-F	8-Aug-05	41.060	-112.229	3.6	–	27.2	0.26	1.5	–	128	0.016	–	–	4.9
Gilbert Bay (with Ogden Bay--Sta FB12F)															
August	P14	9-Aug-05	41.014	-112.257	14.2	–	28.0	1.63	1.5	–	5.6	0.004	–	–	0
August	P15	9-Aug-05	40.926	-112.257	14.2	–	26.5	4.65	1.6	–	1.5	0.004	–	–	0
August	P18	9-Aug-05	40.976	-112.261	14.1	–	27.5	2.53	1.5	–	2.5	0.004	–	–	0
August	FB-12-F	8-Aug-05	41.069	-112.241	13.6	–	29.9	0.85	2.4	–	38.3	0.004	–	–	0
Farmington Bay															
October	FB-10-P	24-Oct-05	40.915	-112.050	0.5	–	11.3	> depth	0.2	–	26	0.009	–	–	0.1
October	FB-11-F	24-Oct-05	40.921	-112.030	0.4	–	14.4	> depth	0.1	–	20	0.007	–	–	0
October	FB-9-P	24-Oct-05	40.932	-112.088	0.6	–	15.0	> depth	0.5	–	36	0.011	–	–	0.3
October	FB-8-F	24-Oct-05	40.952	-112.104	1.0	–	15.2	0.75	0.9	–	88	0.011	–	–	2.1
October	FB-5-P	22-Oct-05	41.008	-112.131	3.2	–	14.8	0.59	0.5	–	44	0.012	–	–	2.4
October	FB-4-P	22-Oct-05	41.018	-112.157	3.2	–	10.3	0.60	0.8	–	113	0.010	–	–	10.6
October	FB-3-P	22-Oct-05	41.031	-112.160	4.1	–	11.5	0.59	1.0	–	41	0.010	–	–	0.9
October	FB-2-F	22-Oct-05	41.050	-112.189	4.2	–	15.8	0.50	1.1	–	62	0.012	–	–	5.2
October	FB-1-F	22-Oct-05	41.058	-112.222	4.4	–	16.0	0.60	1.3	–	46	0.011	–	–	2
October	FB-6-F	22-Oct-05	41.997	-112.141	3.8	–	12.0	0.45	0.7	–	63	0.014	–	–	2.1
Gilbert Bay (with Ogden Bay--Sta FB12F)															
October	P15	21-Oct-05	40.925	-112.257	15.0	–	15.0	1.40	1.5	–	12	0.003	–	–	–
October	P18	21-Oct-05	40.976	-112.260	15.2	–	15.2	1.40	0.9	–	17	0.003	–	–	–
October	P14	21-Oct-05	41.014	-112.258	15.3	–	15.6	0.69	1.2	–	27	0.005	–	–	–
October	FB-15-P	22-Oct-05	41.066	-112.293	14.7	–	16.9	0.80	2.0	–	18	0.004	–	–	0
October	FB-12-F	22-Oct-05	41.069	-112.240	14.5	–	17.3	0.80	1.8	–	20	0.005	–	–	0

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APENDIX F

GREAT SALT LAKE, FARMINGTON BAY SEDIMENT PHOSPHORUS STUDY

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Sediment Phosphorus Study

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February, 2006

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Report Title

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Sediment Phosphorus Study

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Abstract

Water quality concerns for Farmington Bay include issues associated with the health and vitality of the wetlands and the open waters. Some concerns center around the high concentration of nutrients that enter the lake from natural and man-made sources. Nutrients allow and promote microorganism and algae growth in the Bay. This study evaluated the historic loading of phosphorus to Farmington Bay and the interaction of phosphorus between the sediment and the liquid phases under mixing conditions. Sediment cores were used to evaluate the historic phosphorus loading to the Bay. From the cores it appears that historic loadings are similar to the current loadings. In addition to the sediment phosphorus evaluation, the study tested to see what happens when water and sediment interact under mixing conditions. The average depth of Farmington Bay is currently about one meter. At this depth, the shallow areas of the Bay and the sheet flow environments exhibit complete mixing with the sediments during wind events. Experiments were conducted using lake sediment and various waters with varying phosphorus concentrations which enter the Bay to determine what occurs when mixing takes place. It appears that the sediment has the ability to either absorb or release phosphorus depending on the initial water phosphorus concentration and the oxygen state of the sediment Once the effect of sediment - liquid P interaction was identified, sorption isotherms were constructed to graphically depict the effect of P as it transfers between the liquid and sediment phases.

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Chapter 1

Great Salt Lake, Farmington Bay Phosphorus Study

Introduction

Often times the Great Salt Lake (GSL) is a study in contrast. "Water, water everywhere, and not a drop to drink," is a conflict we all understand very well. A beautiful lake whose blue waters are not fit for drinking by man or animal. When people recreate at the GSL they quickly find a playground they must share with brine flies, gnats and lake stink. Birds find the GSL and its surrounding wetlands an inviting habitat for nesting or for resting during migration. According to the Utah Department of Wildlife Resources, water bird survey, during an average year there are over 87,000,000 bird use days at the GSL (a bird use day is one bird for one day). The lake is visited by over 450,000 ducks each year. Between 600,000 and 1.5 million Eared Grebes stay about 90 days at the GSL during the fall staging period. During 2001, Wilson Phalaropes peaked at the lake at about 566,000. This represents 30% of the U.S. Wilson Phalaropes population. 50% of the North American Avocet population are also at the lake at the same time. With such significance, as part of the Western Hemisphere Shorebird Reserve, keeping the lake inviting to birds is of great importance.

Recently some individuals and organizations have expressed concern for the GSL and for man-made pollutants that enter the lake in increasing quantities. The State of Utah, Division of Water Quality has heard these concerns and has established a program to evaluate whether pollutants of concern need to be controlled more stringently than in the past. Water quality concerns for Farmington Bay include issues associated with the health and vitality of the wetlands and the open waters. Some concerns center around the high concentration of nutrients that enter the lake from natural and man-made sources. Nutrients allow and promote microorganism and algae growth in the Bay. Studies done by Wayne Wurtsbaugh of Utah State University indicate that Farmington Bay is highly eutrophic. During periods of high water inflows to the Bay, salinity can range from one-half to three percent salt. At salt concentrations of less than 6% cyanobacter is usually abundant because of the sufficient concentration of phosphorus(P) in the bay. Standard approaches to reducing cyanobacter in a lake would be to reduce the availability of P. Recent estimates from Wurtsbaugh, et. al. suggest that about half the amount of P reaching Farmington Bay are from anthropogenic sources. While this was a rather superficial estimate, there is a lot of P that comes from wastewater treatment plant that enters the Bay. As such, there is a need to research P inputs and the fate and effect of it in the Bay. Wurtsbaugh is currently conducting synoptic studies of the Bay to determine the impact of the high concentrations of cyanobacter on the lake. Additional studies are proposed to determine more accurately the sources of P to the Bay.

The proposed studies by CDSD will evaluate the historic loading of phosphorus to Farmington Bay and the interaction of P between the sediment and the liquid phases under mixing conditions. Sediment cores will be used to evaluate the historic P loading to the Bay. Two studies by USGS indicate that a sediment deposition of about 0.4 cm/year exists in Farmington Bay(Naftz). Based on this information, the study will evaluate two feet deep sediment cores to determine historic sediment P concentrations. Total P values will be determined for each two inch segment of the core. The assumption in this analysis is that sediment P values are primarily influenced by current sediment deposition. Further, EPA land treatment design manuals biosolids land application testing conducted by the District assume that P does not migrate through the sediment column, but usually binds with the surface sediments. These assumptions seem to be correct based on District Biosolids application field studies, although this assumption requires further validation. In these studies (annual CDSD Biosolids Report to EPA) excess P application remains in the top 0-12-inch sample even when significant surface water percolates through the site. While nitrates can be seen migrating downward, lower soil samples for P remain unchanged. In addition, there does not appear to be significant hydraulic transport through the sediment to drive soluble P lower in the sediment. These assumptions deserve further investigation at a later time.

In addition to the sediment P evaluation, CDSD will also test to see what happens when water and sediment interact under mixing conditions. The average depth of Farmington Bay is currently about one meter. At this depth, the shallow areas of the Bay and the sheet flow environments exhibit complete mixing with the sediments during wind events. The mixing may allow P to become soluble again. This sediment supply of P is well documented in the literature and can be a major source of P to the lake environment. Experiments will be conducted using lake sediment and various sources of water inflow to the Bay to determine what occurs when mixing takes place. Some of the treated effluent sources of water will contain significant P while some of the stream sources of water will be low in P. Ortho-P will be tested for in this evaluation using a Hach colormetric method. Since most of the water sources to the Bay enter through wetlands and sheet flow environments, this appears to be a fair representation of the water P values reaching the lake. The release or deposition of P to the sediment will be evaluated over time. Liquid samples will be centrifuged to eliminate most particulate P from the testing. Once the effect of sediment - liquid P interaction had been identified, sorption isotherms will be constructed to graphically depict the effect of P as it transfers between the liquid and sediment phases.

This research will begin to assess the sediment P impact on Farmington Bay. The ability to control P inputs to the lake through treatment or containment and the ability to control sediment P release is critical to understand whether P control can be used to reduce the quantities of cyanobacter that occur in the Bay. Further studies will be needed to determine if cyanobacter in Farmington Bay is an impairment.

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Chapter 2

Literature Review

Sediment and water phosphorus (P) interaction has been evaluated in many water bodies around the world. Many technical articles have published which report on this body of research. A review of this information was conducted to determine areas where research emphasis should be placed. This section reports on the available research reviewed. Since the Great Salt Lake Farmington Bay sediment-water interface is assumed to be complex, review of other research may help in evaluation of this specific water body.

Generally accepted sediment-water interaction findings state that under aerobic conditions aerobic sediments usually have the potential to bind P from the water, while anaerobic sediments tend to release P to the overlying water (Appan and Wang, 2000; Garcia and De Iorio, 2003; Kelton et al, 2004; de Montigny and Prairie, 1993). Generally this release mechanism is thought to be a chemical reaction although in some research the driving mechanism for the release to occur appeared to be of bacterial origin. In saline systems and salt marsh sediments, P is usually available. Only in low salinity areas has P limitations been reported (Stribling and Cornwall, 2001). Stribling showed that P increased in the later part of the summer due to temperature increases and rising sediment anoxia. This study further showed that during senescence maximum porewater P was observed. The impact of plant originated P has also been shown to be a significant P source in water bodies with more than half the P in a system coming from such humic substances(Qlu and McComb, 2000). Qlu also evaluated the fractionation of P with loosely bound P associated with Fe and Al and tightly bound P associated with Ca. The root zones of submerged macrophytes has also been shown to be a P-sink with P release occurring at the end of the growing season when reductive conditions exist (Hupfer and Dollan, 2003). Sediment P has also been shown to correlate well with macrophyte growth rates, much better than water P. A sediment P concentration above 400 ppm was shown to be needed to produce maximum plant tissue P (Carr and Chambers, 1998). When P reduction is evaluated for a water body, experimentation showed that the a phytoplankton dominated lake lost two to three times more P under anoxic conditions to the water than under oxic conditions. In a macrophyte dominated lake the P lost under varying oxygen conditions was about the same. P losses in the macrophyte dominated lake was about equal to the anoxic state in the phytoplankton dominated lake ((Kisand and Noges, 2003).

The sorption of P by a sediment has been shown to occur quickly, usually within 11 - 14 minutes after mixing (Appan and Wang, 2000). At fish farms where P is added to the overlying water, 90% of the Ortho-P is absorbed into the sediment within 4 days (Bhakta and Jana, 2002).

The microbial community has also been evaluated as factor in P interaction between sediment and the overlying water. In an evaluation below a point source discharge of P, research was conducted to determine the effect of organic P mineralization. The research evaluated the effect of the microbial community on the release rate of P compared to the "classical" view that the release is based on redox. In the redox theory, when the redox potentials drop below +120 mV (-80 mV ag-agcl) Fe^{+3} is reduced to Fe^{+2} and phosphate is released from the sediment. This research evaluated the additional P released from mineralization of organic phosphorus (OP). The study originated because P in the water remained quite high even though there has been a tremendous reduction in influent P. Soluble Ortho-P release rates correlated with the overlying water P. Some of the sample sites supported substantial waterfowl populations and this was identified as a P enrichment source. The conclusion was that the microbial community acts as a large source or sink for P (Kelton et al, 2004). Research in a Potomic river estuary also reported the same benthic regeneration of P. This regeneration can supply a large fraction of the total P need. Regeneration is controlled by physical, biological and chemical factors. In situ flux chambers were used to evaluate P - H2O interaction. In situ benthic fluxes were generally 5 - 10 times higher than calculated diffusive fluxes. It was noted that tidal river sediments (oxic) retained 80-90% of their phosphorus while seasonally anoxic estuary sediments retained only 10% of their sediment P input. The paper also reported on several studies where the benthic flux of phosphate provided between 50% and 330% of all the needed P. In this study all the needed P was supplied in some locations The impact of benthic P was greater in the transition and saline environments than in the fresh water segments. "Sensitivity analysis, whereby the parameters describing water column regeneration are evaluated, suggests that diffusive benthic fluxes of phosphate are nearly as important as water column dissolved phosphorus concentration in the transition zone between freshwater and brackish water. In situ fluxes, which are enhanced relative to diffusive fluxes by the effects of bioturbation could support a large proportion of these water-column concentrations of dissolved phosphorus." (Callendar, 1982) A final study reviewed showed that microorganisms may release or bind P through various metabolic reactions, extra-cellular release and cell lysis. Microorganisms may also alter the chemical or physical conditions which would stimulate chemical and biological processes which enhance P cycling. The lake being researched is highly eutrophic even though over 90% of the P inputs were reduced in 1970. The surface sediment has a high organic content and total P in the sediment averages about 1600 mg/kg. Large concentrations of loosely bound P are in the sediment. Cyanobacteria Microcystis was noted in abundance in the sediment. There appears to be a relationship between the biomass of Microcystis and chemical parameters in the sediment. The data strongly indicates that microbial processes play an important roll in the release of P from the sediment. It is postulated that the presence of Microcystis in the sediment stimulates mineralization by either the decaying of the cells which serve as a substrate for the bacteria or that they excrete products that create a favorable environment. In this lake it may be that the highly P saturated sediments cause P to recycle frequently between sediment and water. The net effect has been a significant delay in P reduction.

The research appears to be conflicted over the more important release mechanism for P between sediment and water. The difference could be because of the differences in sediment organic concentrations and the salinity of the overlying water system. One such study for the Wadden Sea concluded that the primary source for bio-available P was from the metal associated P pool, while the next highest source was the organic P pool. The study also found that the bio-available P was generally higher in fine grained sediments than from coarse grained sediments. Pore water was shown to have a higher P concentration than the overlying water. Experiments found that anoxic conditions led to a rather rapid increase in water P. Availability of P from sediments was four times greater for anoxic vs. oxic conditions (de Jonge et al, 1993).

Mixing of the sediment with the water is important in the release or absorption of P. Wind has been observed as a major driver of such mixing (Strebling and Cornwall, 2001). Shallow water bodies have an increased tendency to resuspend sediments. In a shallow Florida day, sediment P behaved like a buffer for the water system P (Zhang, 2002). Other forms of mixing have also been observed to drive P from the sediment to the water column. In a Danish Fjord increased water column P and attendant increased eutrophication occurred when mussel dredging took place. Anaerobic conditions contributed to high organic matter oxidation which increased sulfate reduction which sulfate competed with P for iron binding sites (Holmer et al, 2003).

Natural runoff and agricultural sources have been shown to be a significant source of P to water systems. Evaluation of sediment cores for an Australian river indicated that P deposition has not changed much for over the past 200 years (Olley and Caitcheon, 2000). Agricultural losses also occur when excess soil P is available (Tunny et al, 2000). One question that becomes apparent about Farmington Bay is does surface run-off carry excess P from home and open space fertilizer to the Bay during storm events?

The ability and time for a water body to recover from a eutrophic state may depend on the ability of the lake to move the P “down stream” once inputs have been reduced. In some water bodies this has been approximated to take years while in others it may take centuries. One such paper reported that shallow lakes are more resistant to recovery that deep lakes. The P concentration in a sea being studied fluctuated annually due to changes in the internal P release. The study indicated that the P release from the sea's sediments was strongly associated with microbial activity. Climactic, hydrologic, and hydro-chemical factors are all factors that have to be evaluated to identify why the "vast difference" in P release occurs. After reduction of input P, the recycling of P from and then back to the sediment is still significant. Time delays in reducing sediment P could be greater than 66 years (KleeBerg and Kozerski, 1997). A second paper reviewed confirmed this finding on the resistance of shallow lakes to recovery. Further, this research indicated that Without grazing fish, bioturbation can increased due to larger numbers of organisms present. The highest sediment P release occurred when the total Fe:P ration was the highest. P release varied throughout the season and from site to site. After twelve years, summer P levels were high and still driven by internal recycle of P (Ramm and Scheps, 1997).

Finally some literature supports the position that P control cannot be effective in salt water systems. One such study study discussed the difference in fresh and salt water P release under oxic conditions. In discussing P immobilization, a comparison was drawn between the amount of organic P expected to be released and the amount of the actual release. Where P released actual is less than the expected organic P release, the difference is assumed to be immobilized in the sediment. P release in salt water systems is significantly greater than P release in fresh water. The relative P release in salt water systems has been significantly greater than in fresh water systems. The reason given for this difference is that there is greater P immobilization in the fresh water systems. In oxic, fresh water lake sediments are thought to be sediment traps, while in salt water systems the demonstrated net absorption is much lower. This abundance of P is probably why P control is not implemented as an effective nutrient control mechanism in salt waters (Caraco, et al, 1990).

The literature reviewed suggests many more areas of study for Farmington Bay than are being proposed for investigation at this time. All of the possible impacts may need to be investigated over time to insure that a thorough understanding of the Great Salt Lake is developed so that effective, justifiable, protective standards can be developed.

Chapter 3

GSL Sediment Cores and Surface Sampling

This section reports on the sampling methods and results for sediment samples taken from Farmington Bay in the Great Salt Lake. Samples were taken in 2004 and 2005 and results were evaluated and compared. All samples were tested for total P and percent solids and some samples were also tested for mercury and total volatile solids. A map showing sampling locations is shown in Appendix 4. One sample underwent a detailed organic and inorganic analysis by the U. S. Geological Survey Laboratory in Denver, Co.

SAMPLING METHODS

Samples were collected from Farmington Bay by District Staff in PVC or polyethylene containers. Deep samples were collected in 2-inch diameter tubes in the field and then split into 2-inch segments in the District laboratory. Sample locations were identified by latitude and longitude from a hand-held GPS unit. Samples were labeled and then sent to a commercial, NELAP certified laboratory for analysis. All samples were refrigerated at 4^{o}C between sampling and transport to the laboratory. Total solids were evaluated in the laboratory using EPA method 160.3 and total volatile solids, when tested, was done using EPA method 160.4. Total phosphorus concentrations in the samples was evaluated by ICP method EPA 6010A. Mercury, when tested, was identified using EPA method 7471A. Methods used by the USGS are not reported here but can be seen in the tabular results of the testing complied by them. All containers were prepared by thorough rinsing with de-ionized water. Sample handling methods were deemed to be appropriate based on the levels of P anticipated in the samples.

RESULTS AND DISCUSSION

deep samples were evaluated for P in 2-inch increments. Sample increment values were graphed with the X-axis being sediment P concentration on a dry basis and the Y-axis being the depth of the sample from the surface. Sample graphs fell into two general patterns. Figure 1 shows the first general pattern for sample results.

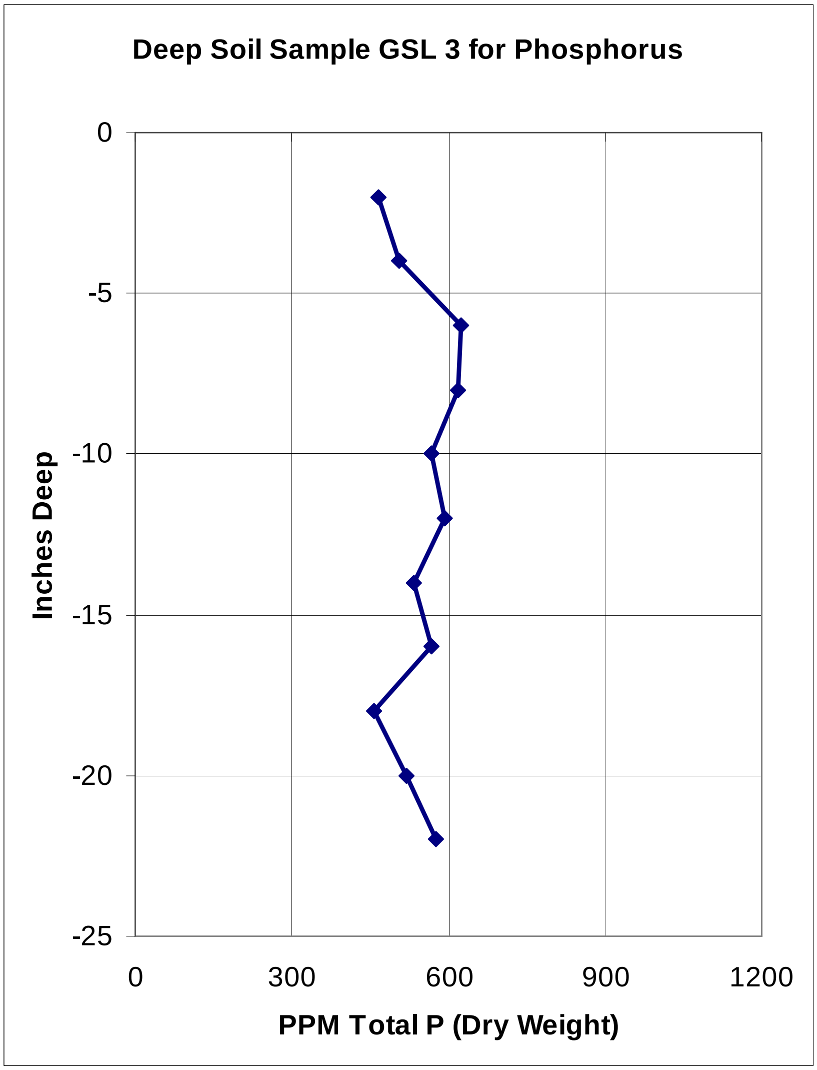

Figure 1 - Farmington Bay Sample GSL-03

In general, Figure 1 demonstrates a P concentration that is consistent throughout the entire sample. While there are concentration variations between sample depths, the overall trend for the sample is a constant value. This would indicate that the P deposition rate has not changed over the deposition time period. Evaluations by USGS of the soil cores indicates a sediment deposition rate of about 0.4 cm per year. Assuming this deposition rate is uniform throughout the core, a 24-inch sample length would be about a 150 year sediment history. Thus, the bottom of the sediment core would be about the time the pioneers entered the Salt Lake Valley.

The second general pattern for sample results is illustrated by Figure 2.

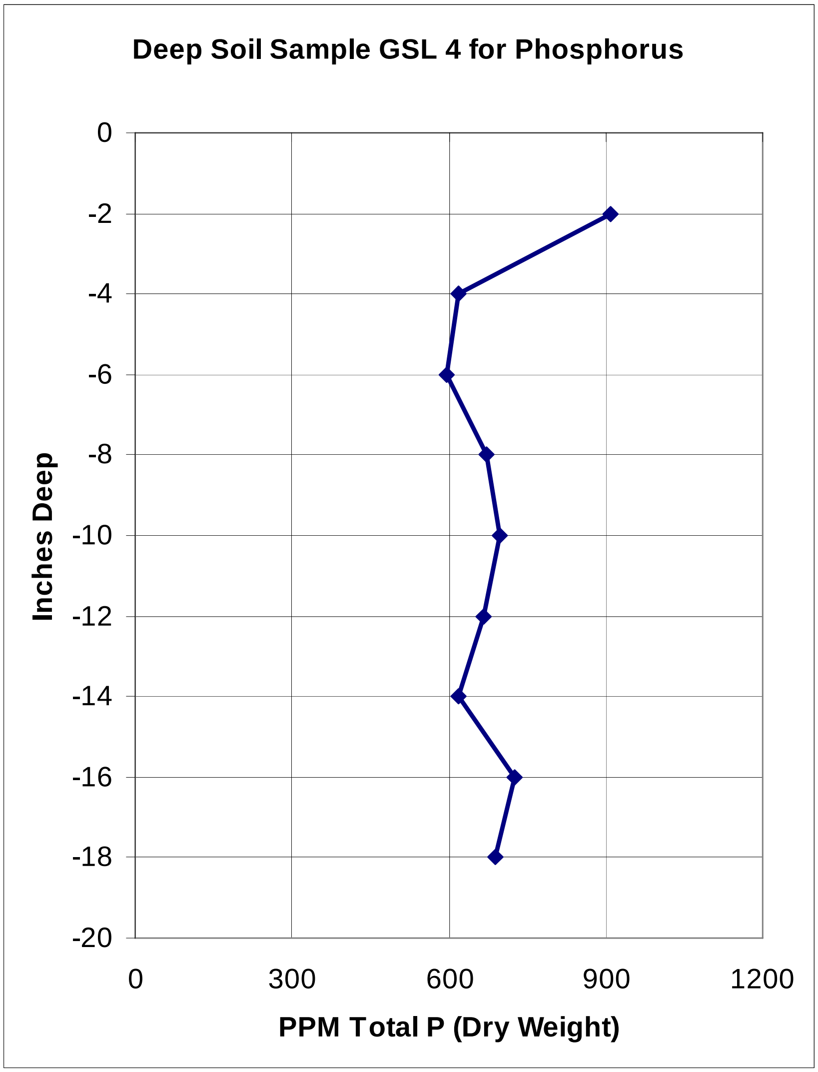

Figure 2 Farmington Bay Sample GSL-04

In Figure 2, the P concentration appears uniform in all but the top sample of the core. The top most sample has a increasing spike in concentration. A review of the sampling locations for those samples which display the surface spike shows all these samples were taken from areas where rooted macrophytes were present. The spike in concentration appears to parallel the literature information which indicates that organic P pools exist around the wetland areas. Thus the samples appear consistent with other researcher findings. An alternative conclusion that these areas have a greater anthropogenic impact to the surface could be drawn, however the lack of a spike in the other samples makes this theory seem less acceptable.

Assuming that the explanation of the surface spike values is accurate, all deep samples would indicate that the deposition rate of P in the sediment is relatively constant. Variation of sample P could be explained by the impact and deposition of organic sediment resulting from varying lake surface levels. As the lake surface elevation rises and falls, the wetland surrounding the lake may move back and forth. Thus, areas where organic matter deposits may also move. This is one theory of how varying P concentrations could occur, however, additional testing for organic content of the sediment would be needed to verify or nullify the assumption. Table 1, below is a summary of the deep sampling results.

In addition to the deep soil profiles, a synoptic sampling of the surface sediment, 0 - 2-inch intervals, was also conducted. Samples were obtained over a several week period and were analyzed in the same manner as the deep samples. The synoptic samples were taken to see if P variation occurred across Farmington Bay. The samples were plotted on a lake map to see if any trends could be observed. Figure 3 is the map with the plotted values displayed.

Depth Inches	GSL USGS	GSL 01	GSL 02	GSL 03	GSL 04	GSL 05
2	1600	452	657	465	908	960
4	1100	486	696	506	619	677
6	N/A	551	592	624	596	719
8	980	541	617	618	672	659
10	1000	547	644	566	698	652
12	1100	566	668	592	667	697
14	N/A	589	654	533	618	656
16	1100	642	656	567	726	607
18	N/A	554	718	457	689	638
20	N/A	556	791	519		628
22	1200	577	703	576		611
24						646
26						628
28						686

Depth Inches	GSL 07	GSL 08	GSL 09	GSL 40	GSL 41
2	571	1030	289	613	889
4	308	546	261	607	534
6	299	574	218	680	471
8	481	701	238	635	634
10	446	603	231	571	664
12	551	600	208	579	629
14	640	740	208	703	512
16	638	689	257	682	302
18	679	720	230	683	346
20	545	581	280	641	1067
22	780	615	400	902	881
24	638	399		963	
26		330		644	
28				720	

Note: All values are Total P on a dry weight basis in ppm or mg/Kg

Table 1 - Deep Soil Sampling Results

A review of the information presented on the map shows that a P gradient exists with higher values near the shore and lowest values next to Antelope Island. Along the shore, the surface sediment P values ranged from about 900 to 1,800 mg/Kg. Further out in the lake bed, generally beyond the wetland zone, the sediment P decreases to a range of 400 to 800 mg/Kg. Along the East shore of Antelope Island the P sediment concentration ranges from about 200 to 400 mg/Kg. The variation of sediment P decreasing from the eastern shore westward could be the results of the impact of wetlands on the sediment with the presence of surface organic P pools. However, the gradient could also be the result of reducing sediment deposition as lake inflows expand across the lake bottom. Finally the reducing P concentrations could be a product of the deposition of anthropogenic generated P attaching to the surface Fe and Al as it flows

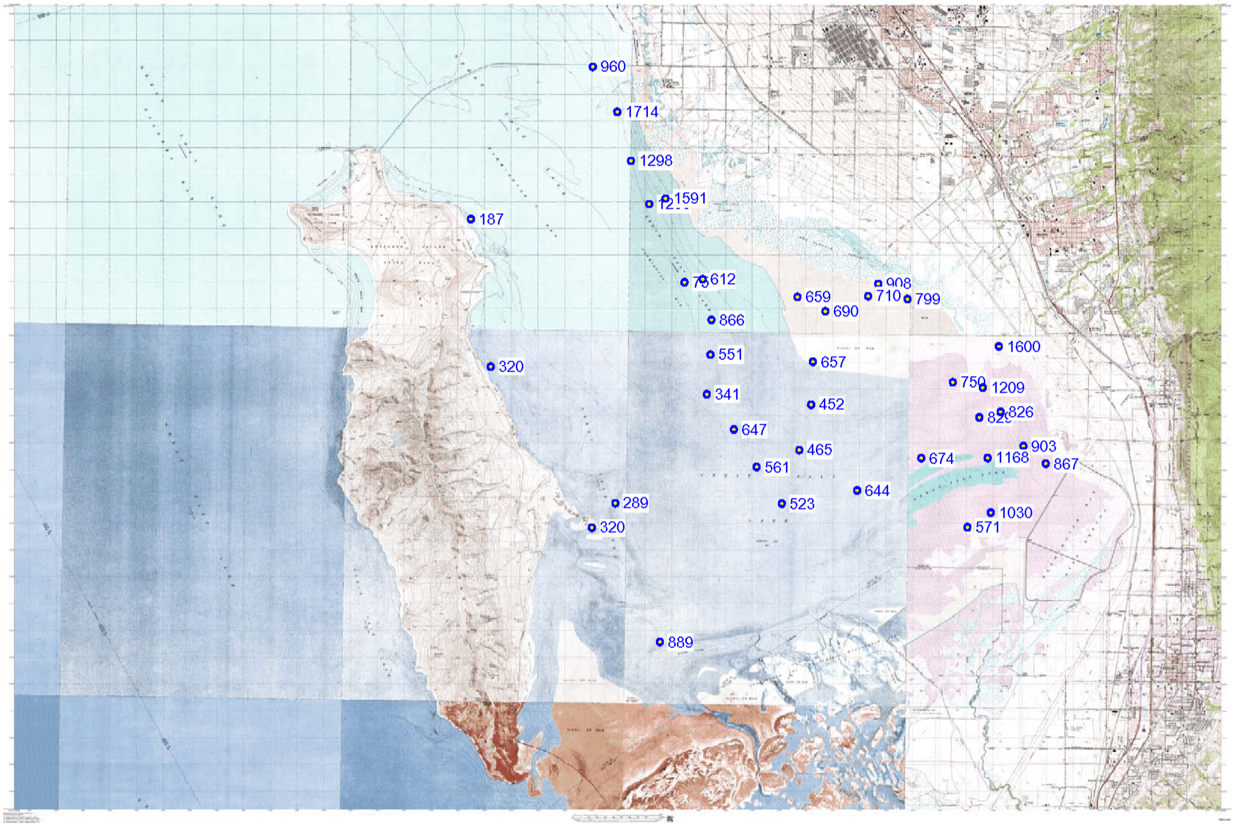

Figure 3 - Synoptic Sampling Results - Surface Samples

'Test Lake2.IT3'; Scale: 1" = 1.348Mi 2,169Mt 7,115Ft, 1 Mi = 0.742" , 1 cm = 854Mt out into the lake. Additional research will be needed to identify the most likely causes of the surface sediment P gradient.

CONCLUSIONS

Sediment sampling has shown that P deposition may have been constant for over 150 years. Sediment P deposition may be impacted by organic matter deposits in the wetland areas. Finally, sediment P concentrations display a gradient from the eastern shore westward. Additional P sediment research should be conducted to determine the specific fate and disposition of the P as it interacts with the sediment. Fe, Al or Ca binding should be quantified as should the amount of organic P in the sediment. The anoxic or oxic state of the sediment should be evaluated and release mechanisms identified. The effect of sediment biota on the release of P should also be quantified. Finally, the potential reasons for the sediment P gradient should be evaluated, and science developed to answer which causes are most likely. The literature review also poses additional questions which should be addressed on a priority basis.

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Chapter 4

Sediment-Water Interface Effect Testing

This section discusses the impact to water phosphorus concentration as Great Salt Lake Farmington Bay sediment and fresh water sources are mixed. Farmington Bay and the associated wetlands are very shallow and subject to mixing when wind events occur. The impact sediment conditions have on the water P concentration needs to be identified. In this section only the ortho-phosphorus concentration was measured in the water samples as this is the portion that is bio-available. This research has limited the evaluation to the mixing of water and sediment and changes to P over time and has not looked at other potentially significant variable physical conditions which may be changing also.

SAMPLING METHODS

District Staff collected surface sediment from Farmington Bay in plastic containers. Sample containers were prepared by thorough rinsing with laboratory water. A clean, small hand shovel was used to collect a three-inch deep by three-inch diameter soil sample. Sample locations were identified by latitude and longitude from a hand -held GPS unit. Samples were labeled at the sample site, transported to the District laboratory, and refrigerated until testing.

Sediment samples were mixed and quartered until a representative sample was obtained. A small amount of the quartered sediment sample was then placed into centrifuge tubes. Generally, the ratio of water to sediment was about four parts water to one part sediment. Between twenty-four and thirty tubes were used to ensure an adequate amount of water sample was available for ortho-P testing. The tubes were separated into two groups; one group was mixed with water having a relatively low ortho-P concentration while the other was mixed with water having a higher ortho-P concentration. Tubes were then shaken until soil and liquid was mixed. The tubes were left in the laboratory at the room ambient conditions for the remainder of the study. Tubes were mixed at various times throughout the study period. After a final mixing, two to three tubes were removed from the larger group and centrifuged. The water was removed from the centrifuge tubes and tested for orthophosphates as specified in the HACH DR-4000 spectrophotometer Handbook, Method 8048, pp. 579-585.

RESULTS AND DISCUSSION

The sediment –water mixing was used to simulate the sediment and overlying water mixing in Farmington Bay during wind events. The change in ortho-P caused by mixing as a function of time was looked at. Two general conditions existed after mixing sediment with various source waters. Each appears to be a result of the condition of the sediment and the initial ortho-P concentration in the water. The two different results are discussed below.

Aerobic Sediment Interaction

Sediment samples, which appeared to be aerobic based on the lack of any sediment H_2S odors observed during collection usually, responded as shown in Figure 4.

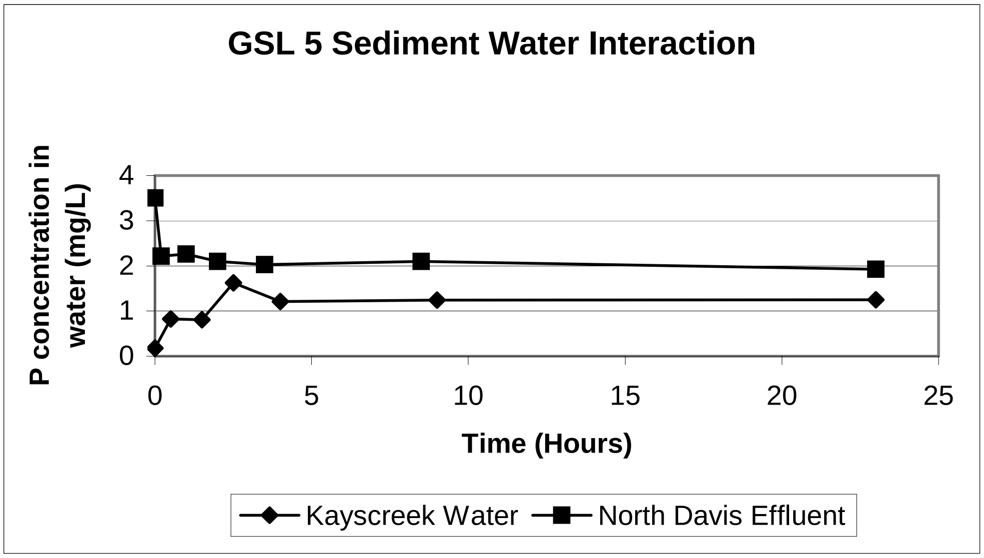

Figure 4 – Aerobic Sediment Sample

As can be seen, the sediment responded to a low and high ortho-P concentration in the water differently. When mixed with Kays Creek water that had an initial water concentration of about 0.2 mg/L ortho-P, the sediment released soil ortho-P to the water after mixing. The release appeared to occur within the first hour and then gradually increased as time continued. The second water source was North Davis Sewer District effluent. When the sediment was mixed with this water at an ortho-P concentration of about 3.5 mg/L, the soil rapidly absorbed water column ortho-P. The absorption was rapid initially with only minor changes after about two hours. While the final values for the low and high initial P waters tended to approach each other after equilibrium was reached, there still was a noticeable difference in the final concentrations.

Some aerobic sediment samples exhibited a different response when mixed with a water source containing low ortho-P concentrations. Sample GSL 16 demonstrates this alternative response as shown in Figure 5.

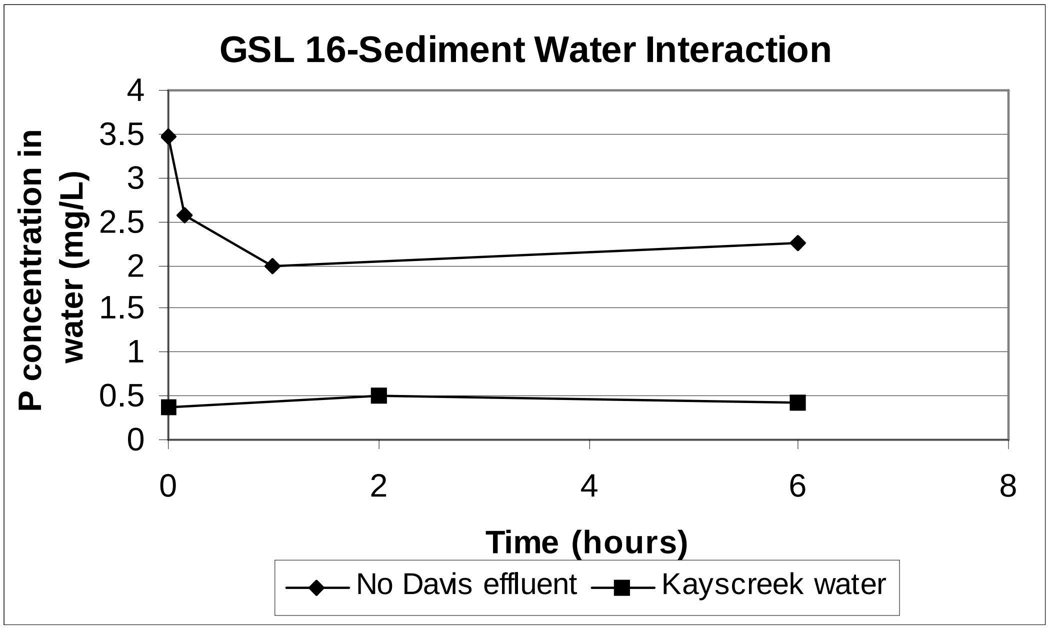

Figure 5 - Aerobic Sediment Sample Alternative

Water taken from Kays Creek had an ortho-P concentration of 0.4 mg/L, which stayed constant with little change after mixing with this sediment. The water taken from the effluent of the North Davis Sewer plant had an ortho-P concentration of 3.5mg/L and, similar to other tests, the water column ortho-P was absorbed into the sediment. This drop of 1.5 mg/L ortho-P in the water column occurred within the first hour and then appeared to taper off over the next six hours.

Anaerobic Sediment Interaction

Sediment samples, which appeared to be anaerobic based on the presence of significant H_2S odors observed during collection and in the laboratory usually, responded as shown in Figure 6.

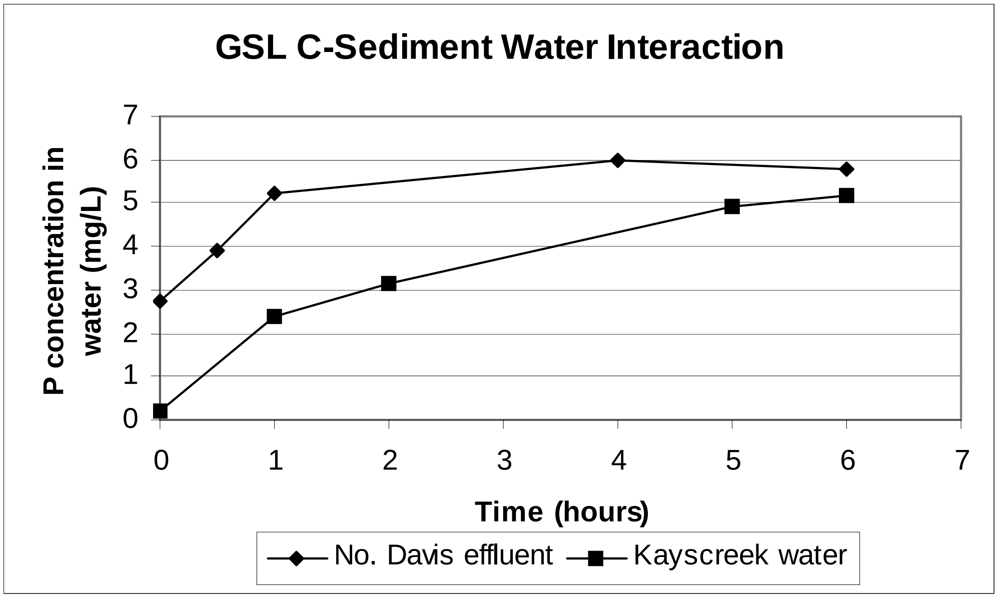

Figure 6 – Anaerobic Sediment Sample

Keys Creek water started with 0.2 mg/L ortho-P. After mixing with the sediment, ortho-P was released into the water column. Although the most rapid release of ortho-P occurred in the first two hours, the release continued for the duration of the test, six hours. Similar results were obtained with the water from Central Davis effluent that started off with 2.4 mg/L ortho-P. The sediment released ortho-P rapidly in the first hour and then more slowly for the next few hours slightly dropping at the last test which was 6 hours after initial mixing. It appears as though the two waters approach the same end point. The release of ortho-P from anaerobic sediment is consistent with the literature which suggests that P associated with iron or aluminum may be released as sulfur compounds tend be absorbed on the surface of iron and aluminum minerals.

CONCLUSION

Several conclusions can be drawn from the experiments mixing water and Bay sediment. First, it is certain that the sediment has an impact on the overlying water ortho-P concentration. As mixing occurs, the sediment may uptake or release ortho-P into the water column. This would mean that the sediment is probably a sink for P. Secondly, depending on the sediment oxidative state it can either accept or release P. This interaction is a function of the soil condition and the water ortho-P concentration. While it is possible that some of the P changes in the water may be due to either high or low porewater concentrations, this factor would only explain a part of the change. In many of the soil samples there was no free water in the soil and in all samples the volume of water to soil was about 4:1 which would require a very high porewater P value to affect the final water concentration. This study served to illustrate the potential for significant impact of sediment P. More studies are needed to determine soil characteristic such as DO and pH to validate assumptions on aerobic and anaerobic sediment interactions. The interaction between the water and soil needs to be studied in more depth, the use of a flow through cell with varying levels of agitation to mimic flow and wave actions that occur in Farmington Bay would be beneficial. Finally, many other physical parameters should be also be monitored to be certain that any other mitigating factors have been identified.

Chapter 5

Sorption Isotherms

After having determined that Great Salt Lake sediment may acts as a sink for ortho-P, the development of a relationship, at constant temperature, concerning the transfer of ortho-P between sediment and water was undertaken. A series of dilutions of wastewater treatment effluent with DI water was prepared. These dilutions were measured for ortho-P and then mixed with a predetermined amount of sediment. Sediment samples were gathered using the same procedures as was done for the sediment water interaction testing. Water samples were mixed with sediment and after mixing were allowed to sit in the lab for at least eight hours. The water was then centrifuged and/or filtered and then re-measured for water concentration ortho=P. The results of all the sorption isotherms were charted with the water concentration on the X-axis in mg/L and the amount absorbed or released from the sediment was calculated. This value was plotted on the Y-axis in mg/Kg. Figure 7 is a graph of the collective curves. The results suggest that a correlation between the initial P concentration and the final P in the water can be drawn. As such, the value of the initial water P concentration in mg/L was plotted on the X-axis with the final P concentration, in mg/L, plotted on the Y-axis for several of the sorption isotherms. This relationship exhibited two types of graphs. Figures 8 and 9 show the relationship between initial and final water concentration when the sediment readily absorbs ortho-P. This graph is for GSL 11.

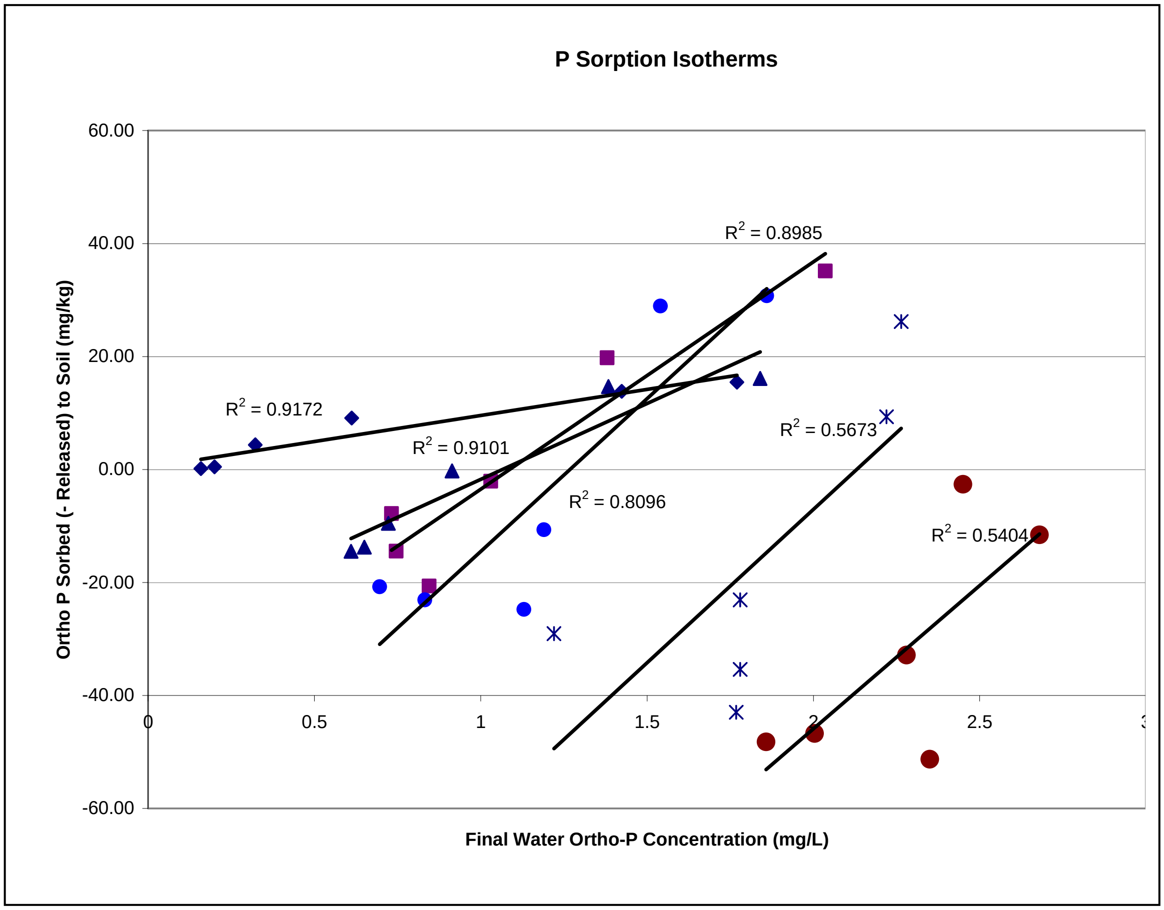

Figure 7 Ortho-P Sorption Isotherms Graph

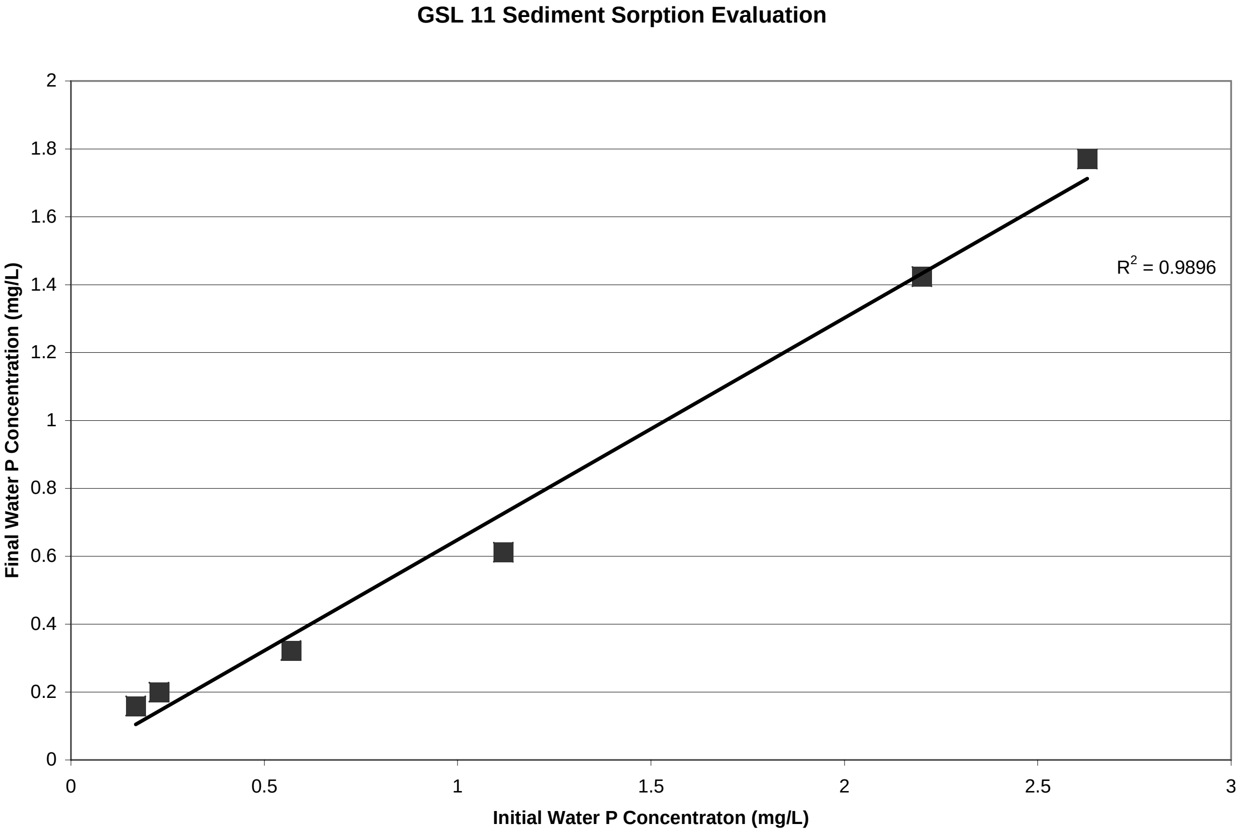

Figure 8 – Initial vs. Final Ortho-P concentration GSL 11

As can be seen, the sediment acted as a sink for P from the water. As the water concentration increased, the amount of P transferred per unit of sediment increased. The correlation coefficient of 0.99 is extremely good, indicating the graph can be used to project the final concentration from the initial water concentration for this sediment at the same physical conditions that existed in this experiment. Below is a bar chart showing the rate of sediment transfer rate in mg/Kg for each water concentration, starting with the low ortho-P water. Obviously the amount of P available for transfer increases as the concentration increases thus acting as a partial driver for the process.

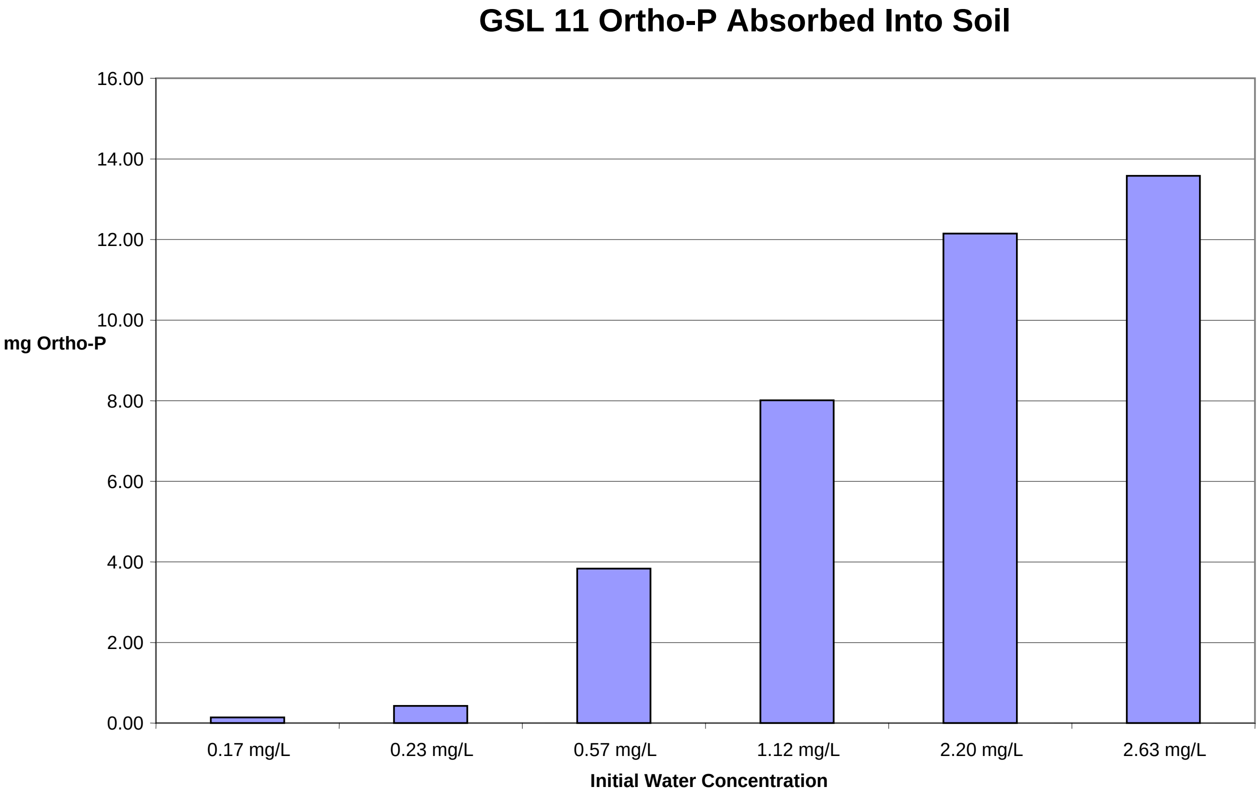

Figure 9 – Sediment ortho-P transfer in mg/Kg GSL 11

The first bar indicates that at an initial water ortho-P concentration of about 0.17 mg/L only a very little amount of P is transferred to the sediment. The fourth bar is for an initial water concentration of about 1.12 mg/L. At this concentration in the water, the sediment accepts about 8.1 mg/Kg. At a water concentration of about 2.63 mg/L, the last bar, almost 14 mg/Kg of ortho-P is partitioned to the sediment.

Another sample, GSL 22 demonstrated the condition when the sediment both donated and then accepted water ortho-P. In this scenario the sediment responded differently when mixed with a varying ortho-P concentration in the water. The results are shown in Figure 10.

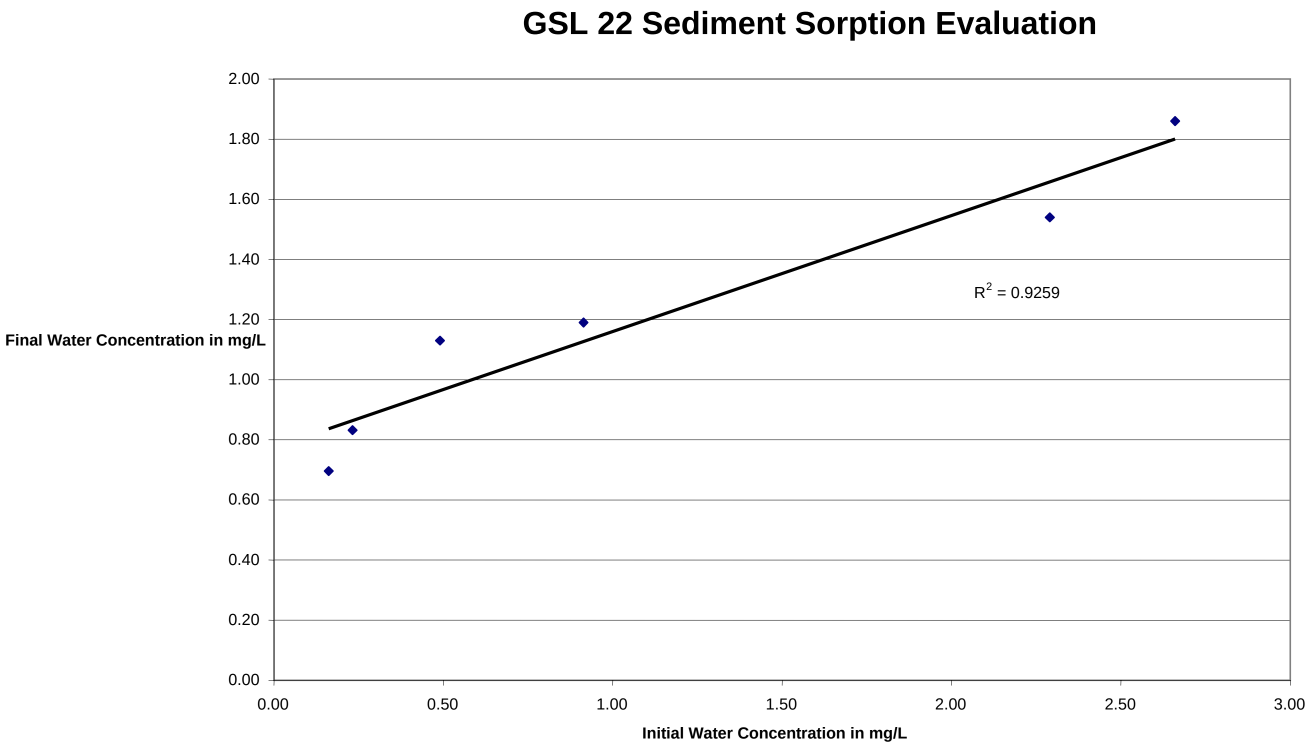

Figure 10 – Initial vs. Final ortho-P Concentration GSL 22

Up to a concentration of about 1.3 mg/L in the water ortho-P is transferred from the sediment to the water. Above 1.3 mg/L, the sediment accepts P from the water. Figure 11 shows the net amount transferred to or from the sediment as the water ortho-P increases. Reiterating the effect of varying ortho-P water concentrations when mixed with sediment, if the water is low in P the sediment releases Ortho-P to the water. When water with high P is mixed with the same sediment, ortho-P is transferred from the water to the sediment.

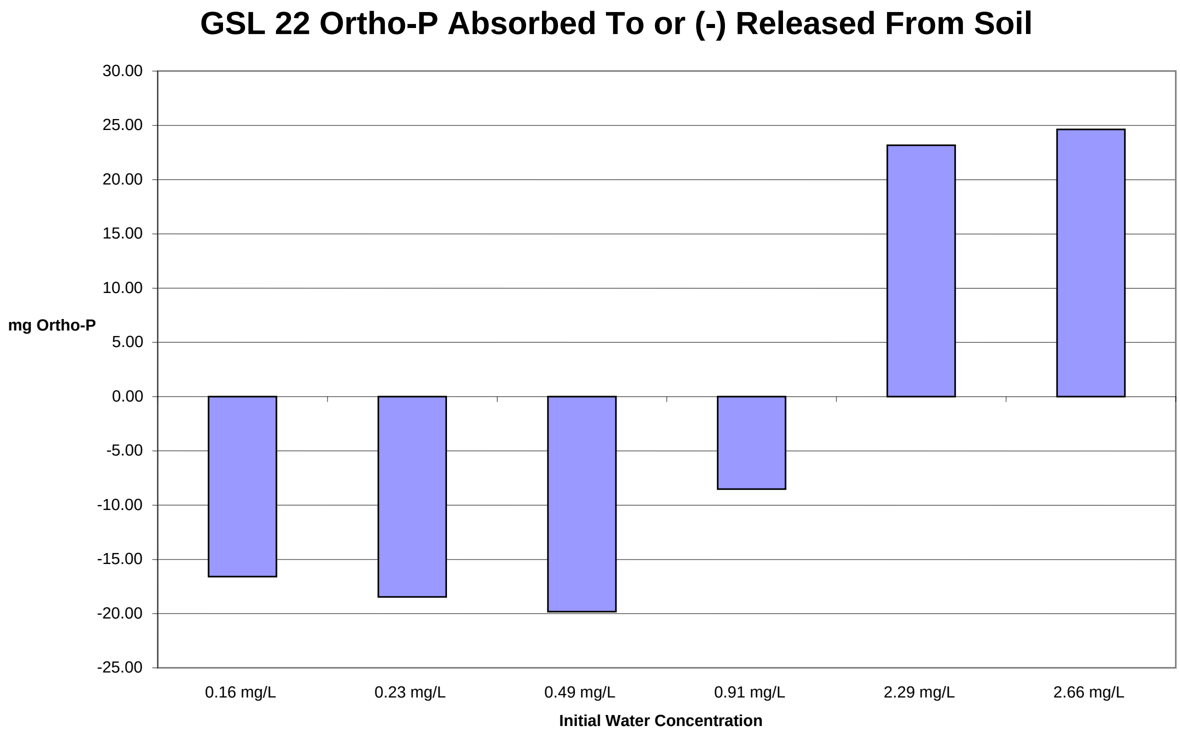

Figure 11 – Sediment ortho-P transfer in mg/Kg GSL 22

GSL 22, when mixed with water at an initial concentration of about 0.16 mg/L, releases P so that the final water ortho-P ends up at about 0.7 mg/L. At the other end of the spectrum, when an initial water concentration of about 2.7 is mixed with the same sediment, the sediment accepts ortho-P and the final water ortho-P concentration is only about 1.9 mg/L.

CONCLUSION

An apparent correlation exists between the initial and the final concentration of ortho-P in water when mixed with Great Salt Lake Farmington Bay sediment. The response of the sediment to the water varies depending on the condition of the sediment, although the exact relationship has not been determined as too few physical parameters were measured during the experiment. Sediment can act as a sink for excess P in the water as well as a source of P when water has low initial ortho-P concentrations. The actual cycling mechanisms between water and sediment should be investigated further.

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Chapter 6

General Conclusions

Each section of this report contains specific conclusions based on the type of testing being conducted. Each section also contains recommendations for additional study. In general the testing and evaluation to date had demonstrated the interrelationship of phosphorus between the Farmington Bay waters and sediments. Too few physical parameters, such as pH were measured for the results to be conclusive. The oxic or anoxic condition of the sediment plays an important role in the release or uptake of phosphorus to the overlying water. In order for sediment interaction to take place, a mixing event must occur. A phosphorus balance to Farmington Bay is needed for further determine if phosphorus control to the Bay is viable. Even if phosphorus control can reduce sufficiently the amount of incoming phosphorus, the reduction of water column P may take a long time to be seen. Either encapsulation of the exiting sediment must occur from new deposits, or a washout of the existing sediment must take place. Significant additional research must take place to determine if the concentration of phosphorus is, or contributes to an impairment of Farmington Bay and if such an impairment exists, can any control mechanisms on anthropogenic sources sufficiently reduce phosphorus to achieve an improvement.

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Appendix 1

Sediment Sampling Results

CDSD Deep Sediment Sample
GSL- 2004-1 9/17/2004

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.44	520	-2	1182
4	0.44	480	-4	1091
6	0.6	740	-6	1233
8	0.77	840	-8	1091
10	0.78	700	-10	897
12	0.77	710	-12	922

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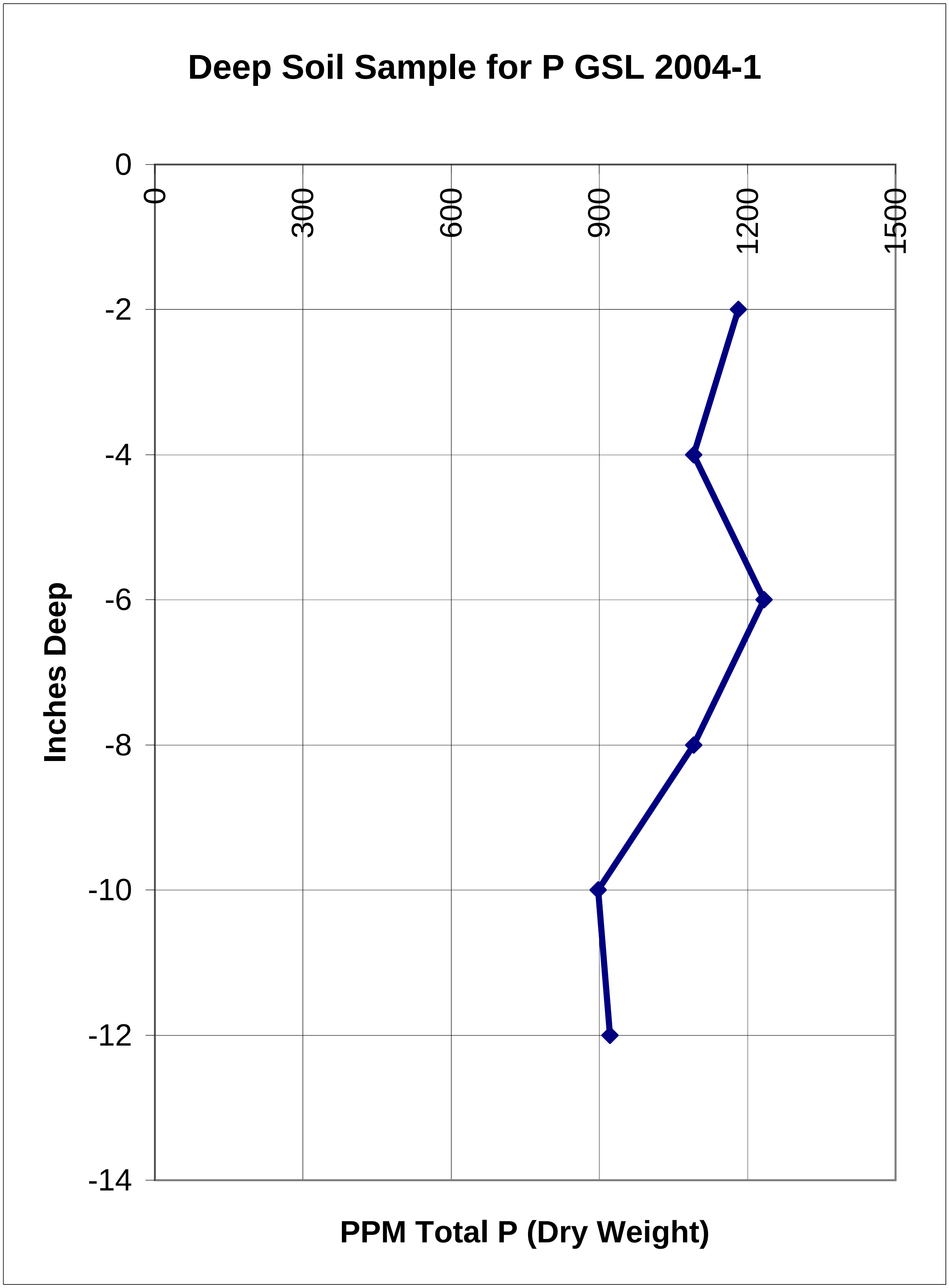

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CDSD Deep Sediment Sample
GSL- 2004-2 9/17/2004

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.61	510	-2	836
4	0.56	560	-4	1000
6	0.69	490	-6	710
8	0.7	530	-8	757
10	0.77	470	-10	610
12	0.79	460	-12	582

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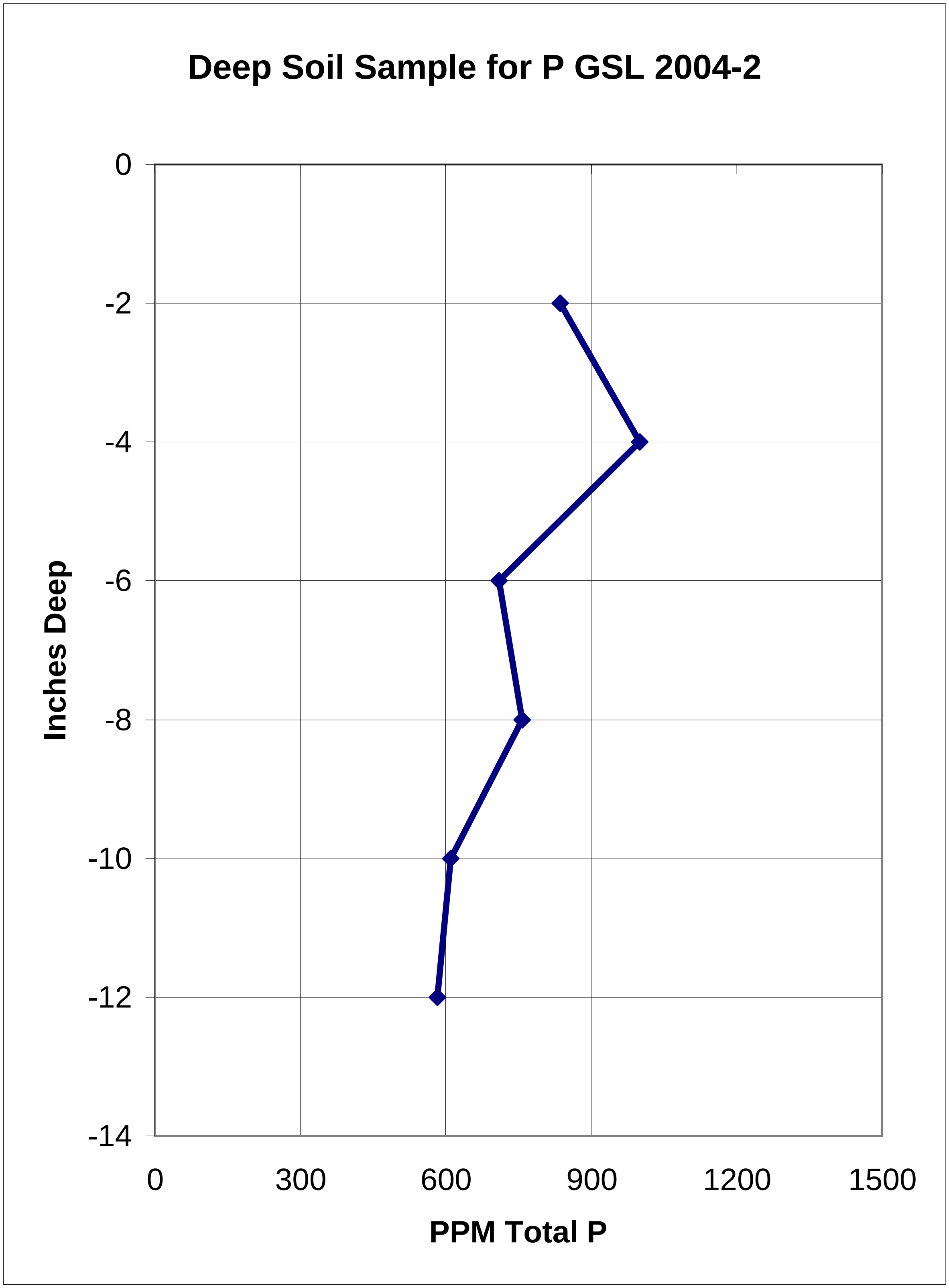

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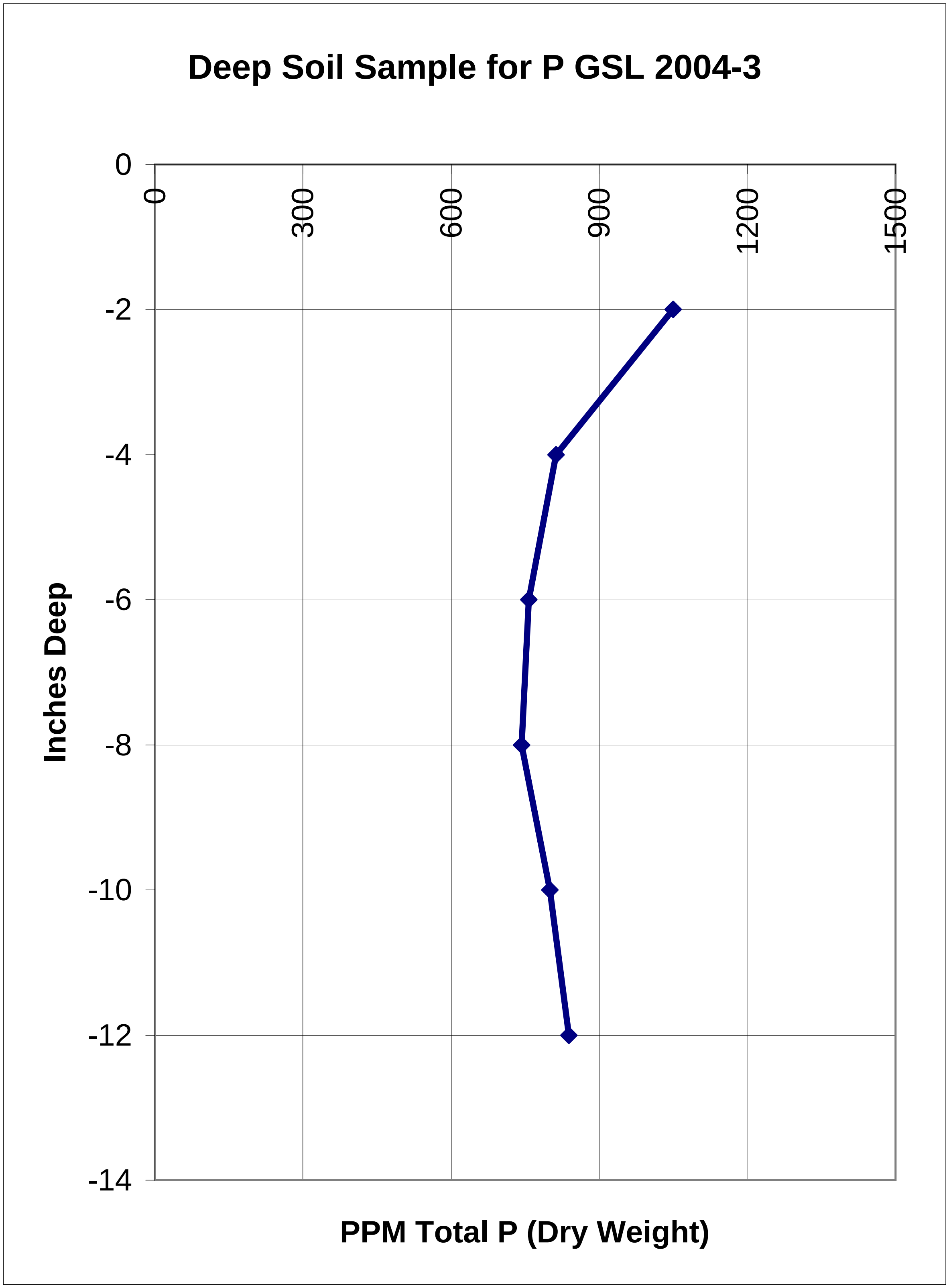
CDSD Deep Sediment Sample
GSL- 2004-3 9/17/2004

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.6	630	-2	1050
4	0.64	520	-4	813
6	0.66	500	-6	758
8	0.66	490	-8	742
10	0.7	560	-10	800
12	0.68	570	-12	838

CDCSD Deep Sediment Sample
GSL - 2004-03



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CDSD Deep Sediment Sample
GSL- 2004-4 9/17/2004

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.6	580	-2	967
4	0.63	410	-4	651
6	0.63	430	-6	683
8	0.63	440	-8	698
10	0.62	420	-10	677
12	0.61	420	-12	689

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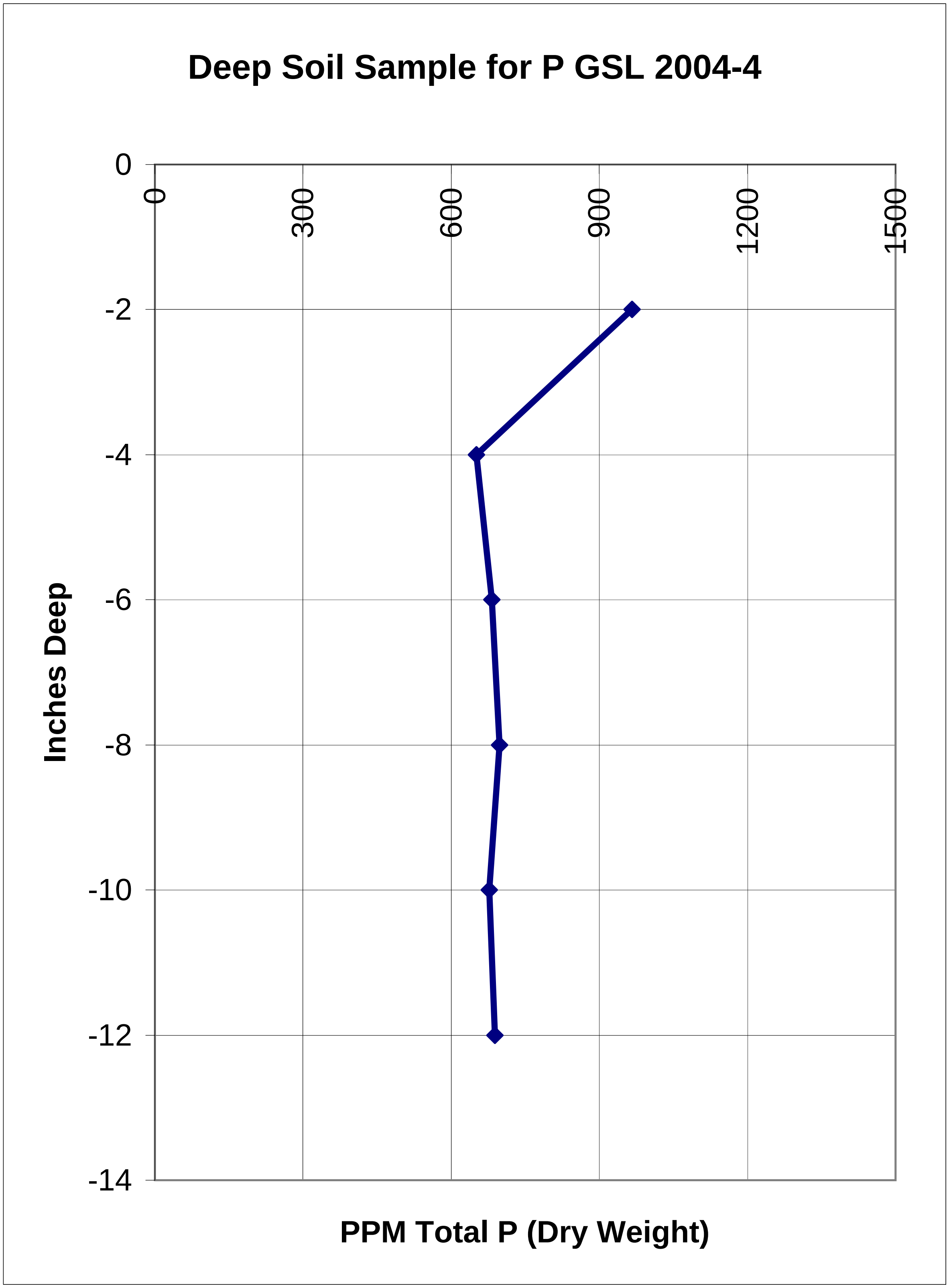

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GSL- 2004-5 9/17/2004

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.69	370	-2	536
4	0.7	350	-4	500
6	0.73	350	-6	479
8	0.74	420	-8	568
10	0.8	410	-10	513
12	0.7	410	-12	586

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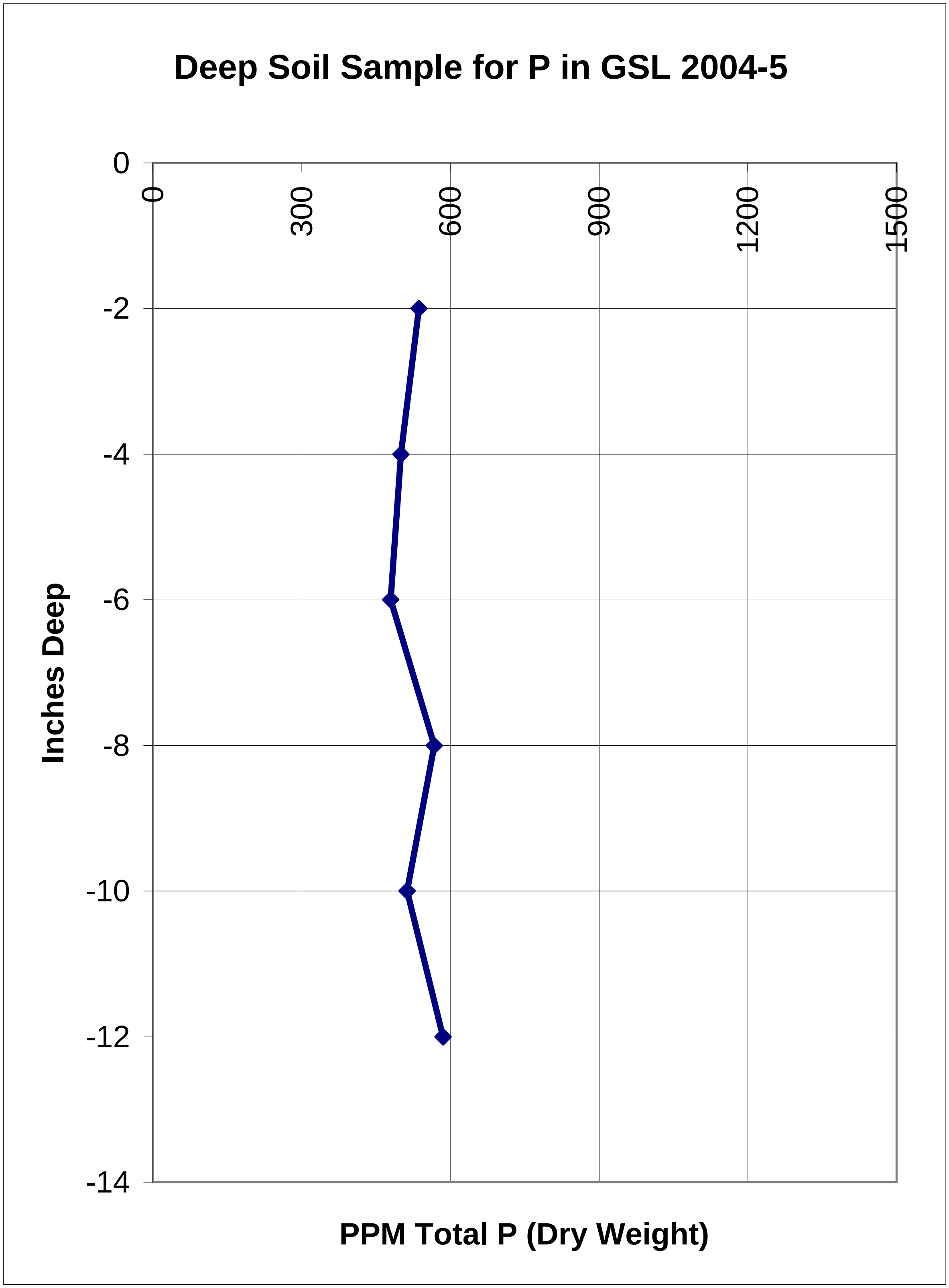

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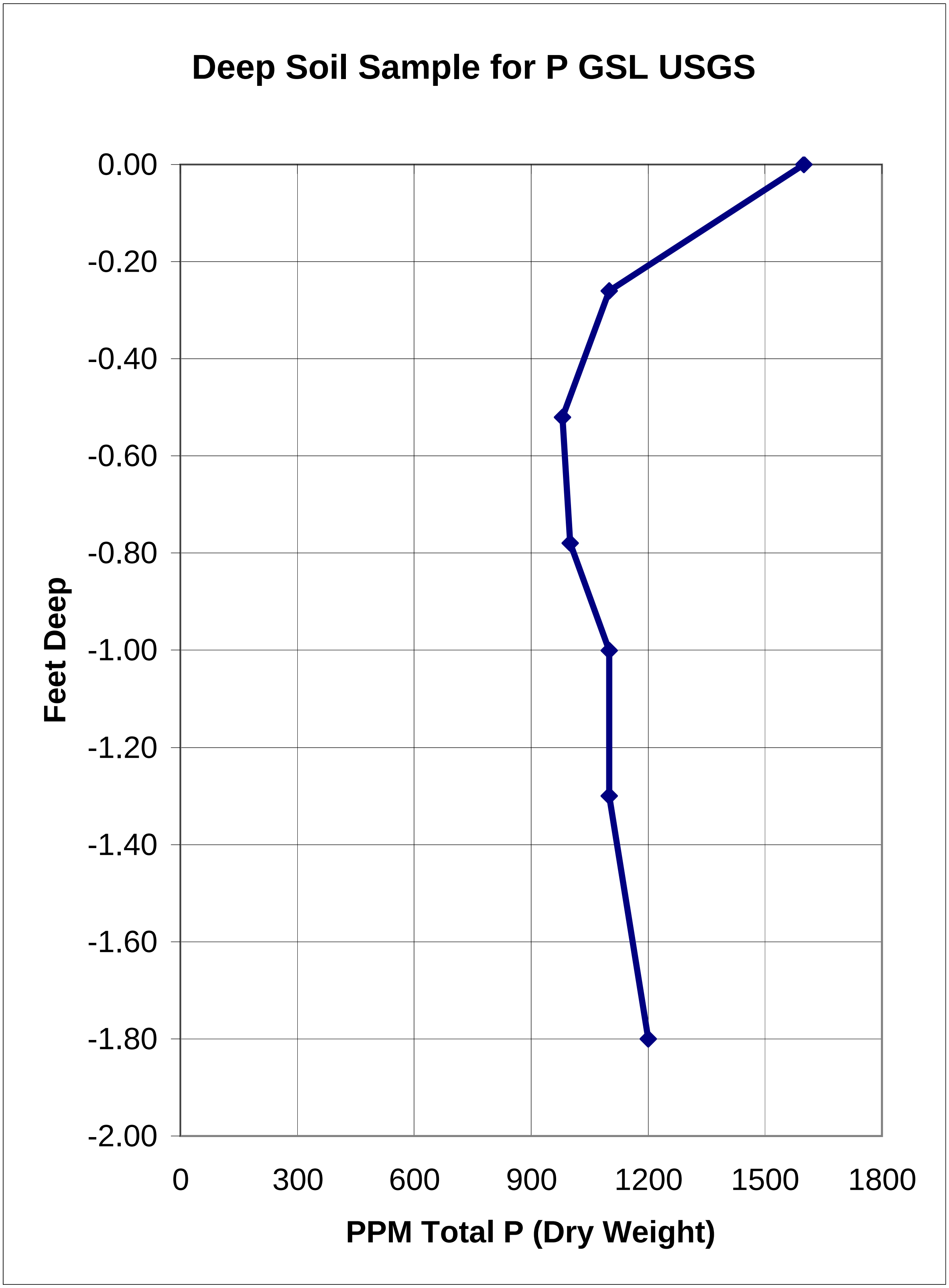
CDSD Deep Sediment Sample
GSL- 2004 USGS 9/29/2004

Depth Feet	**Hg ppm - Dry**		**P ppm Dry**	
0.00	0.250	0.00	1600	0.00
0.26	0.720	-0.26	1100	-0.26
0.52	0.16	-0.52	980	-0.52
0.78	0.06	-0.78	1000	-0.78
1.00	0.06	-1.00	1100	-1.00
1.30	0.02	-1.30	1100	-1.30
1.80	0.02	-1.80	1200	-1.80

CDSD Deep Sediment Sample
GSL - 2004 USGS



CDSD Deep Sediment Sample
GSL- 01 5/25/2005

Depth Inches	% Solids	Hg ppm	P ppm	Hg ppm - Dry		P ppm Dry
2	0.73	0.25	330	0.342	-2	452
4	0.74	0.05	360	0.068	-4	486
6	0.69	0.034	380	0.034	-6	551
8	0.74	0.037	400	0.037	-8	541
10	0.75	0.037	410	0.037	-10	547
12	0.76	0.038	430	0.038	-12	566
14	0.73	0.036	430	0.036	-14	589
16	0.67	0.033	430	0.033	-16	642
18	0.74	0.037	410	0.037	-18	554
20	0.72	0.036	400	0.036	-20	556
22	0.71	0.036	410	0.036	-22	577
24	0.69	0.034	420	0.034	-24	609

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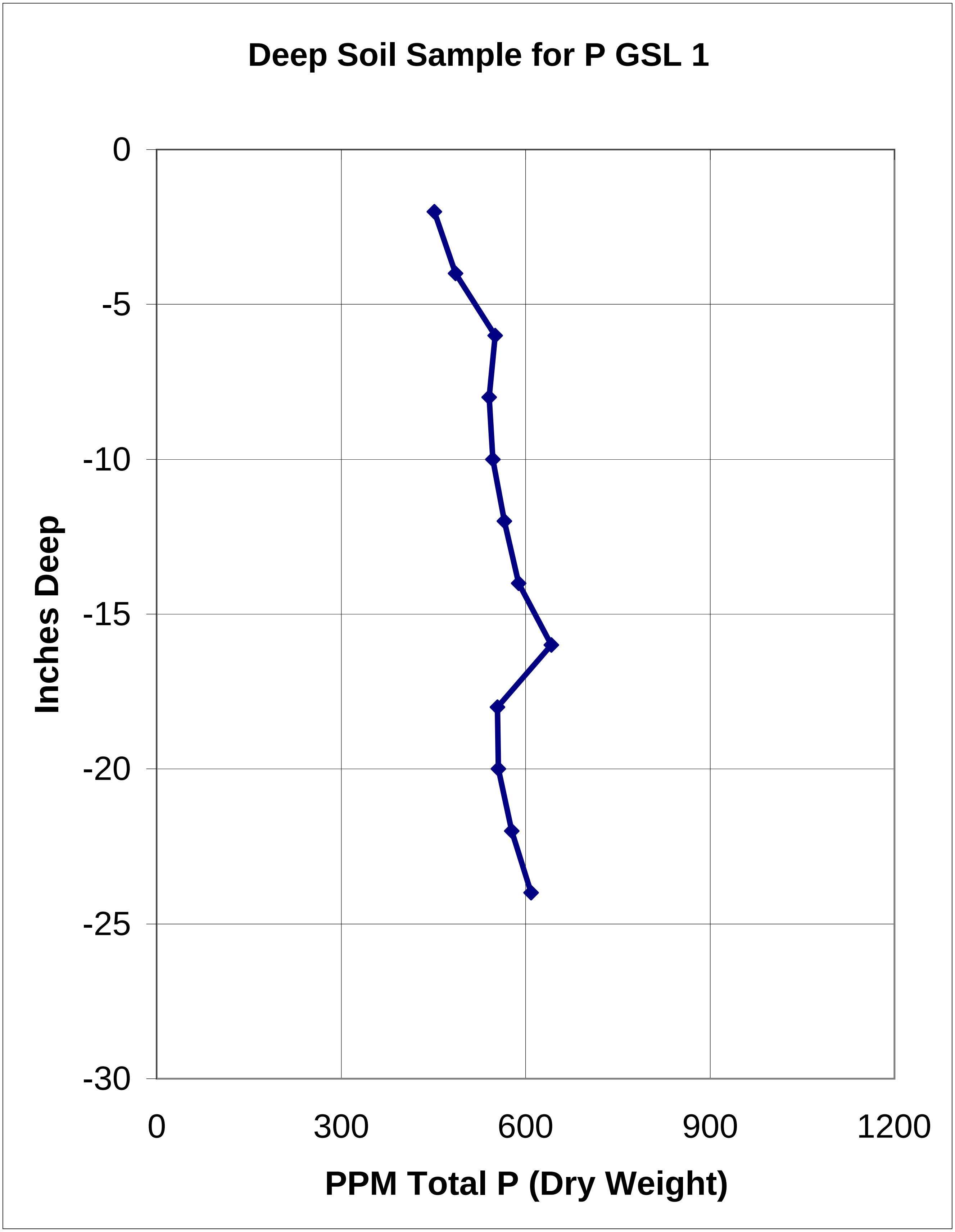
Deep Soil Sample
GSL - 01



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CDSD Deep Sediment Sample
GSL- 02 6/15/2005

Depth Inches	% Solids	% VS	Hg ppm	P ppm	Hg ppm - Dry		P ppm Dry
2	0.769	9.89	0.211	505	0.274	-2	657
4	0.757	10.6	0.096	527	0.127	-4	696
6	0.706	9.27	0.0358	418	0.0358	-6	592
8	0.744	10.3	0.0925	459	0.0925	-8	617
10	0.769	8.06	0.192	495	0.192	-10	644
12	0.733	9.31		490		-12	668
14	0.735	8.3		481		-14	654
16	0.709	10.6		465		-16	656
18	0.756	8.79		543		-18	718
20	0.719	10.5		569		-20	791
22	0.72	6.49		506		-22	703

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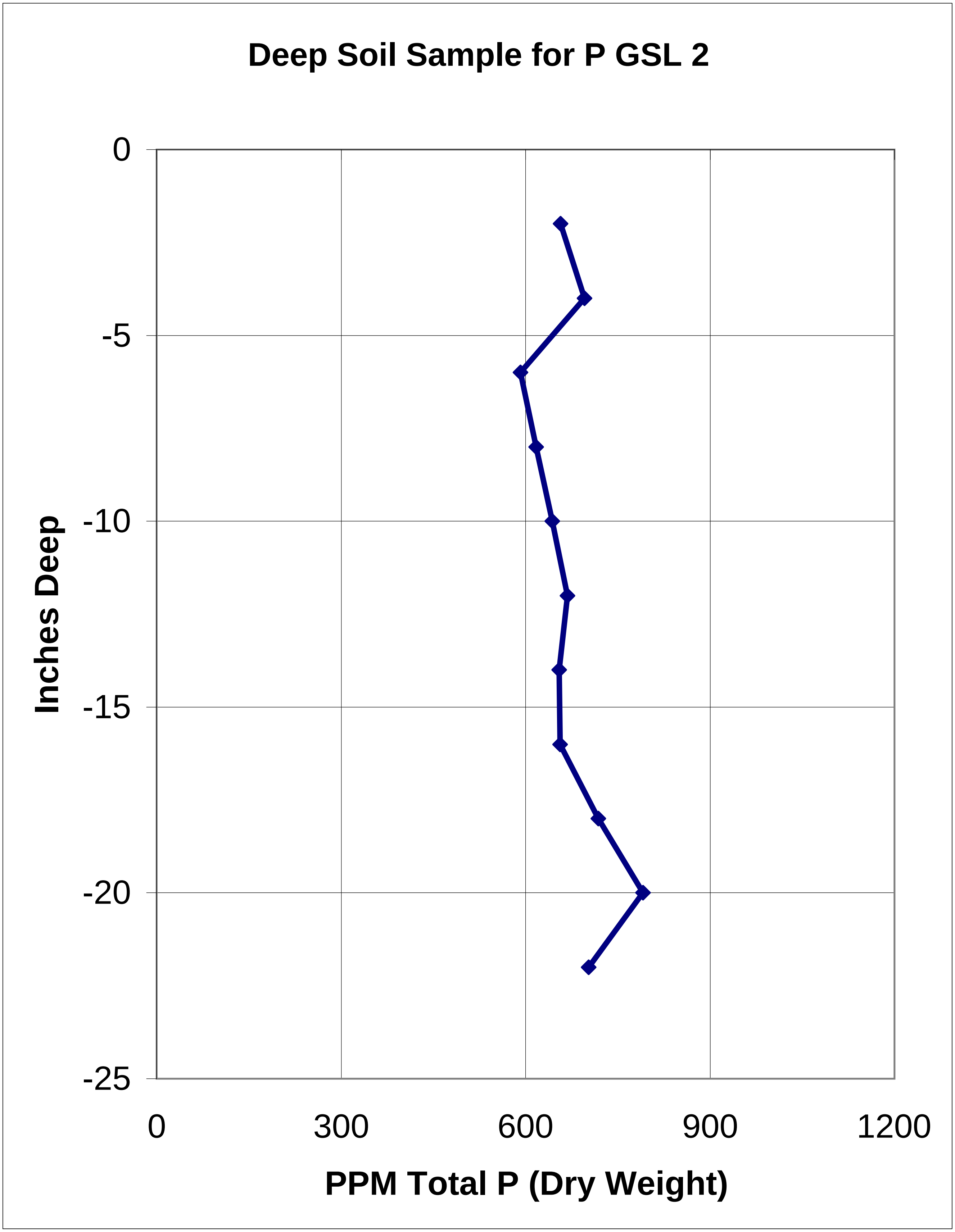
GSL - 02



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11/29/2005

CDSD Deep Sediment Sample
GSL- 03 6/15/2005

Depth Inches	% Solids	% VS	Hg ppm	P ppm	Hg ppm - Dry		P ppm Dry
2	0.725	8.14	0.0358	337	0.049	-2	465
4	0.712	15.5	0.0358	360	0.050	-4	506
6	0.623	18.4	0.0358	389	0.0358	-6	624
8	0.685	15	0.0516	423	0.0516	-8	618
10	0.68	13.3	0.0516	385	0.0516	-10	566
12	0.682	0.134		404		-12	592
14	0.724	10.6		386		-14	533
16	0.704	13.2		399		-16	567
18	0.669	0.16		306		-18	457
20	0.699	0.149		363		-20	519
22	0.682	0.147		393		-22	576

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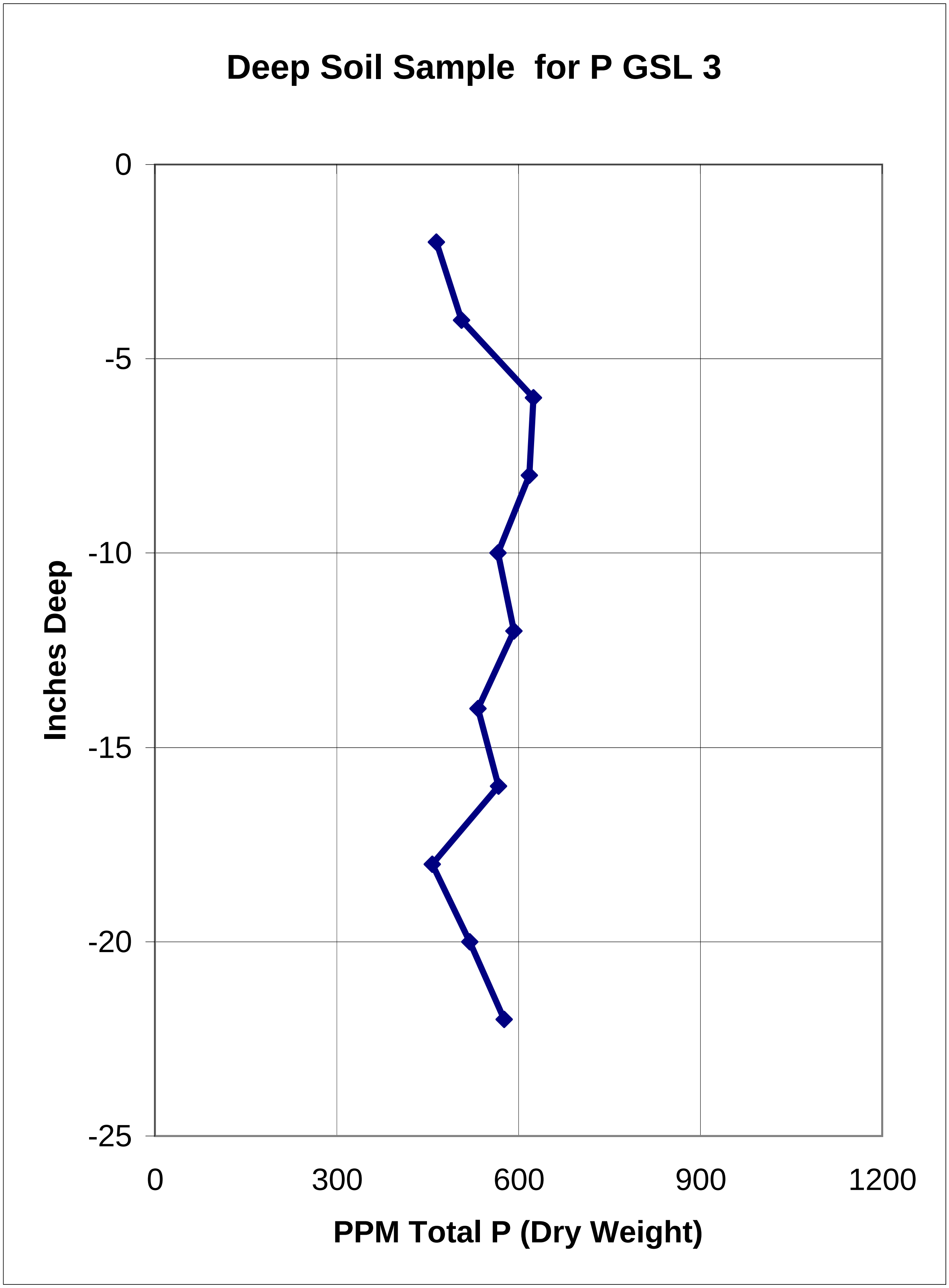
CDCSD Deep Sediment Sample
GSL - 03



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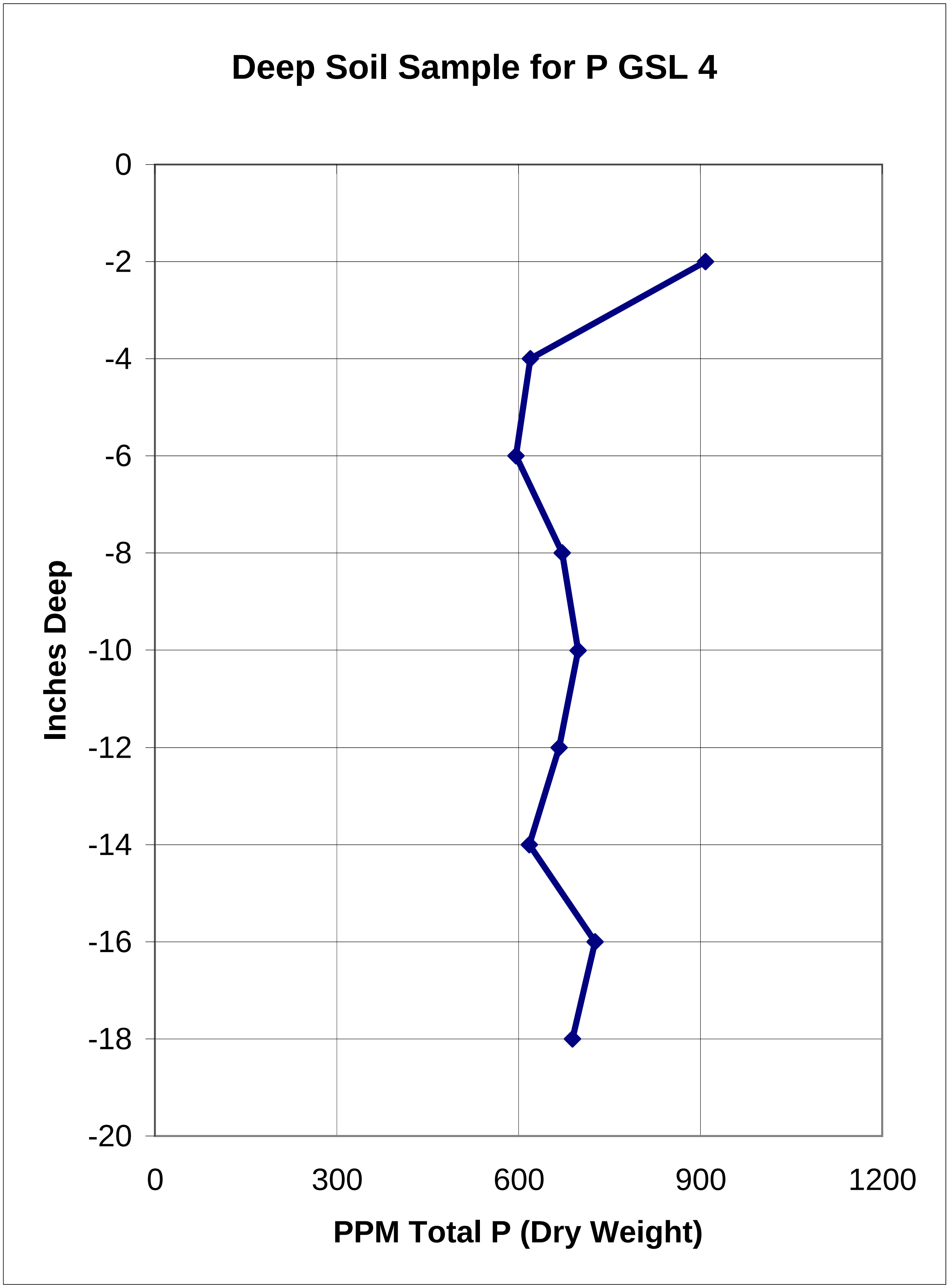
11/29/2005

CDSD Deep Sediment Sample
GSL- 04 6/24/2005

Depth Inches	% Solids	% VS	Hg ppm	P ppm	Hg ppm - Dry		P ppm Dry
2	0.721	12.4	0.079	655	0.110	-2	908
4	0.691		0.09	428	0.130	-4	619
6	0.695		0.04	414	0.04	-6	596
8	0.698		0.04	469	0.04	-8	672
10	0.682		0.04	476	0.04	-10	698
12	0.693			462		-12	667
14	0.683			422		-14	618
16	0.664			482		-16	726
18	0.711			490		-18	689

CDCSD Deep Sediment Sample
GSL - 04

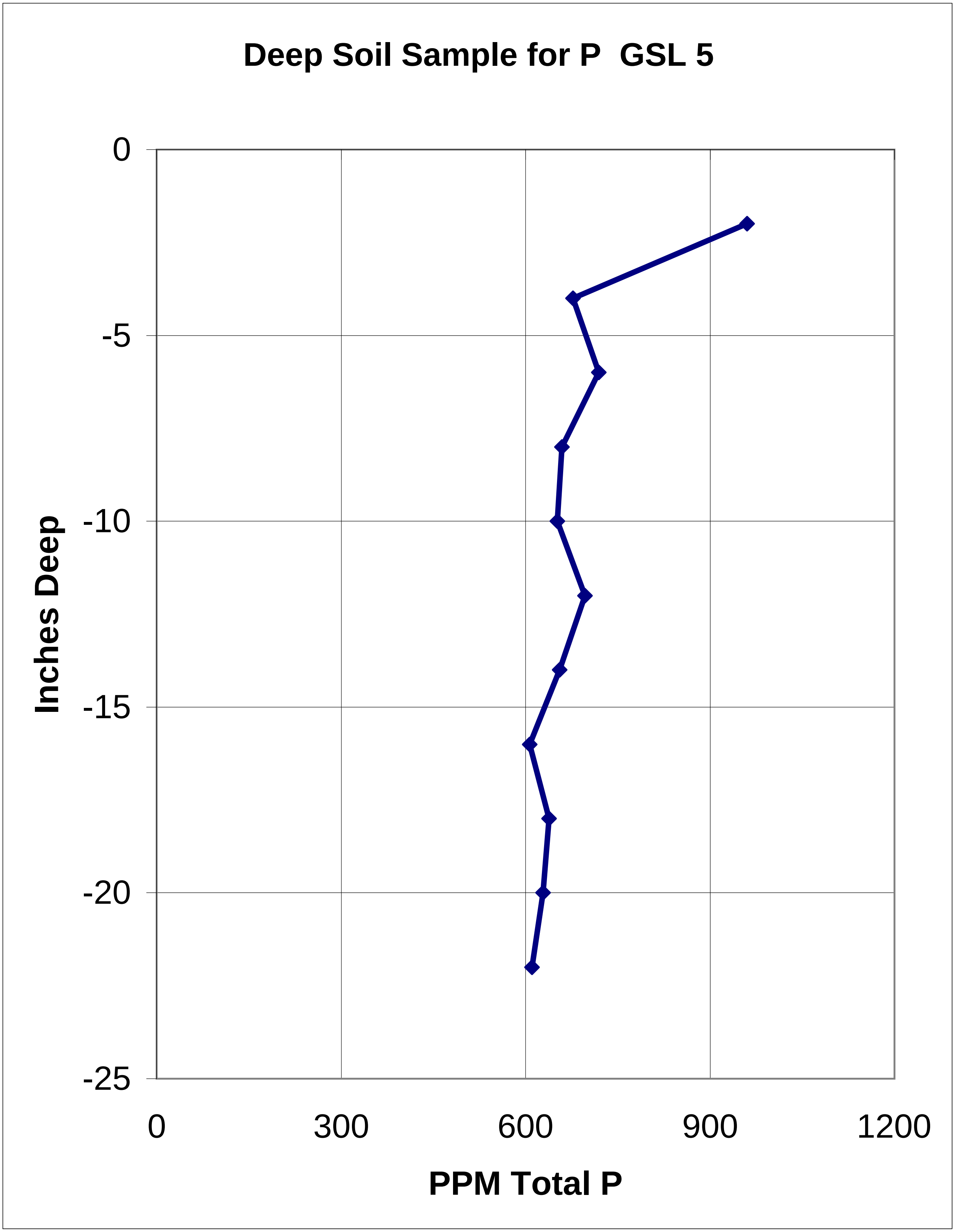


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P-Hg Sample GSL-04 6-24P Graph
11/29/2005

CDSD Deep Sediment Sample
GSL- 05 7/7/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.75	720	-2	960
4	0.731	495	-4	677
6	0.73	525	-6	719
8	0.786	518	-8	659
10	0.772	503	-10	652
12	0.792	552	-12	697
14	0.778	510	-14	656
16	0.791	480	-16	607
18	0.777	496	-18	638
20	0.74	465	-20	628
22	0.75	458	-22	611
24	0.756	495	-24	655

CDSD Deep Soil Sample
GSL - 05

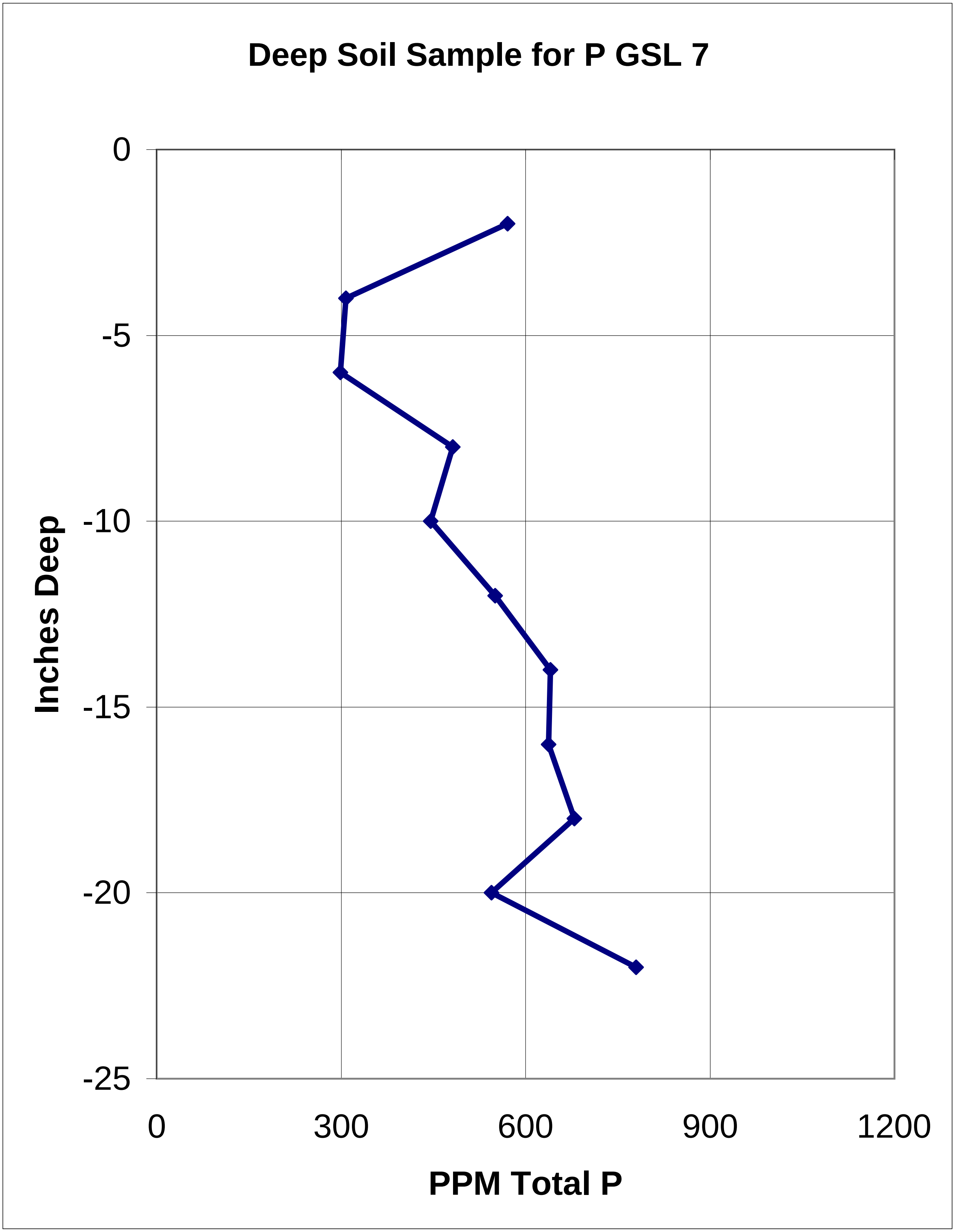


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P-Hg Sample GSL-05 7-7P Graph Chart 1
11/29/2005

CDSD Deep Sediment Sample
GSL- 07 7/18/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.85	485	-2	571
4	0.813	250	-4	308
6	0.936	280	-6	299
8	0.81	390	-8	481
10	0.897	400	-10	446
12	0.69	380	-12	551
14	0.617	395	-14	640
16	0.596	380	-16	638
18	0.67	455	-18	679
20	0.716	390	-20	545
22	0.641	500	-22	780
24	0.805	520	-24	646
26	0.733	460	-26	628
28	0.743	510	-28	686

CDSD Deep Soil Sample
GSL - 07

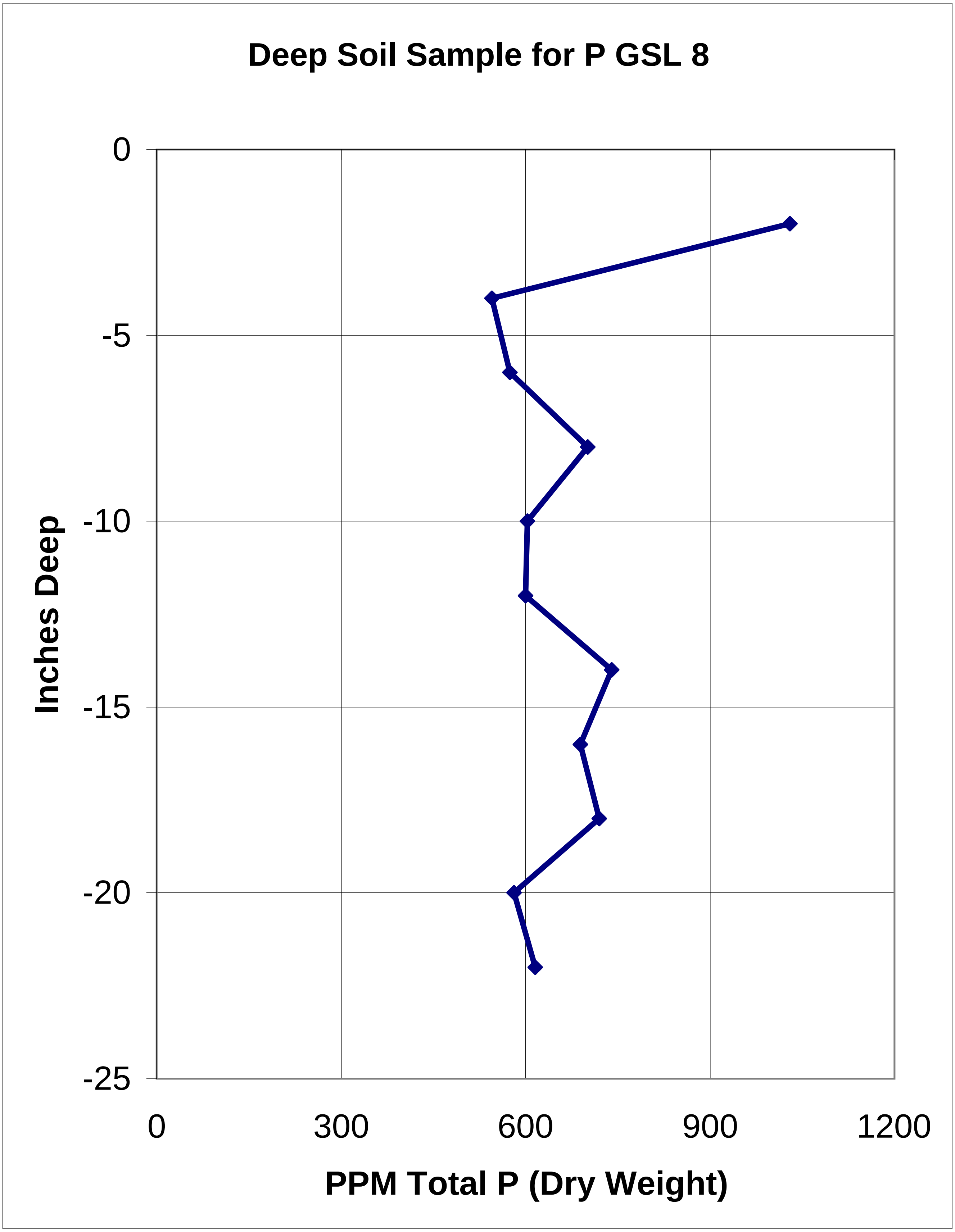


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P-Hg Sample GSL-07 7-18P Graph Chart 1
11/29/2005

CDSD Deep Sediment Sample
GSL- 08 7/18/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.6	618	-2	1030
4	0.625	341	-4	546
6	0.606	348	-6	574
8	0.599	420	-8	701
10	0.688	415	-10	603
12	0.71	426	-12	600
14	0.67	496	-14	740
16	0.66	455	-16	689
18	0.66	475	-18	720
20	0.709	412	-20	581
22	0.715	440	-22	615
24	0.712	454	-24	638

CDSD Deep Soil Sample
GSL - 08

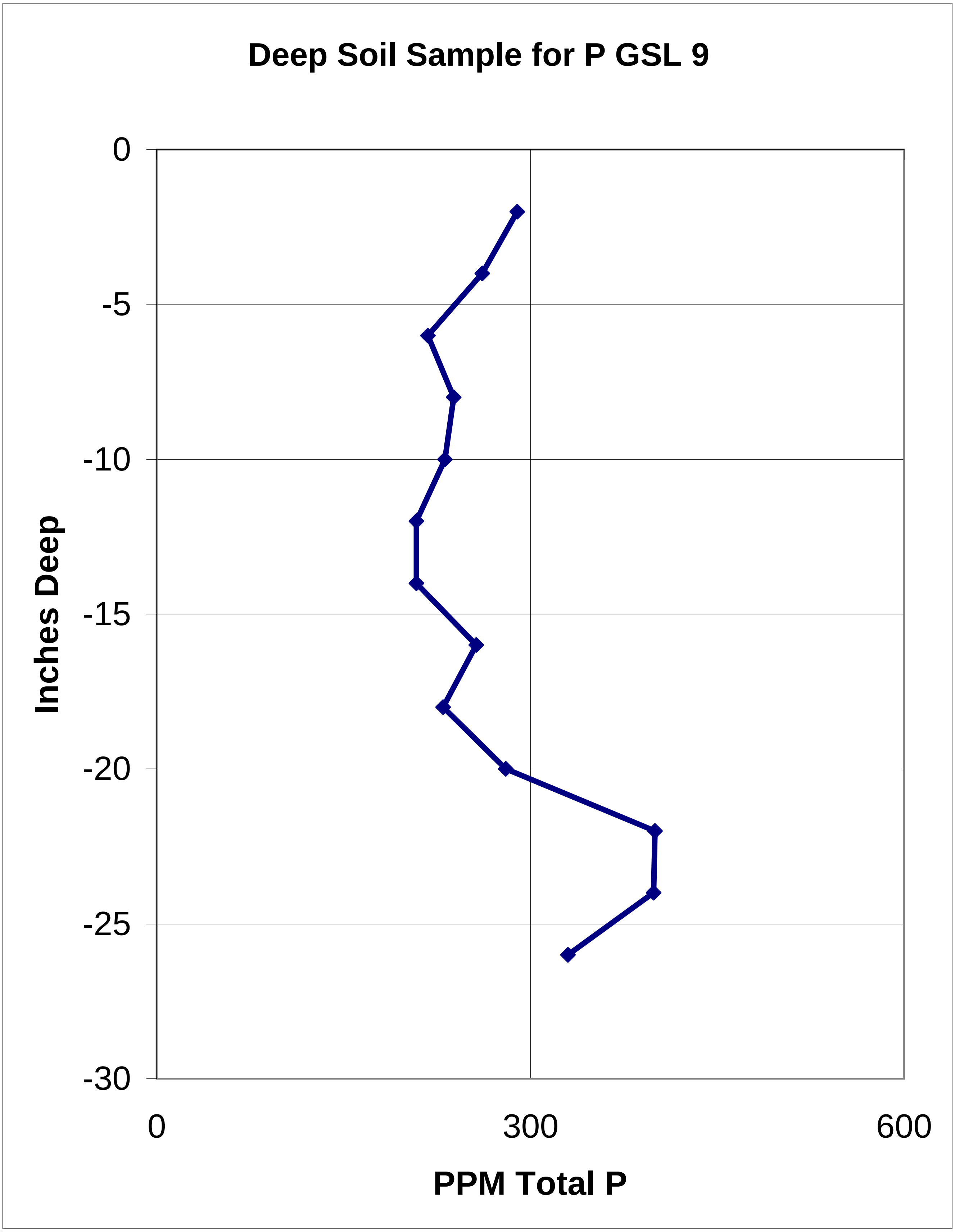


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P-Hg Sample GSL-08 7-18P Graph Chart 1
11/29/2005

CDSD Deep Sediment Sample
GSL- 09 8/2/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.864	250	-2	289
4	0.846	221	-4	261
6	0.84	183	-6	218
8	0.826	197	-8	238
10	0.817	189	-10	231
12	0.825	172	-12	208
14	0.825	172	-14	208
16	0.799	205	-16	257
18	0.791	182	-18	230
20	0.778	218	-20	280
22	0.79	316	-22	400
24	0.772	308	-24	399
26	0.751	248	-26	330

CDSD Deep Soil Sample
GSL - 09

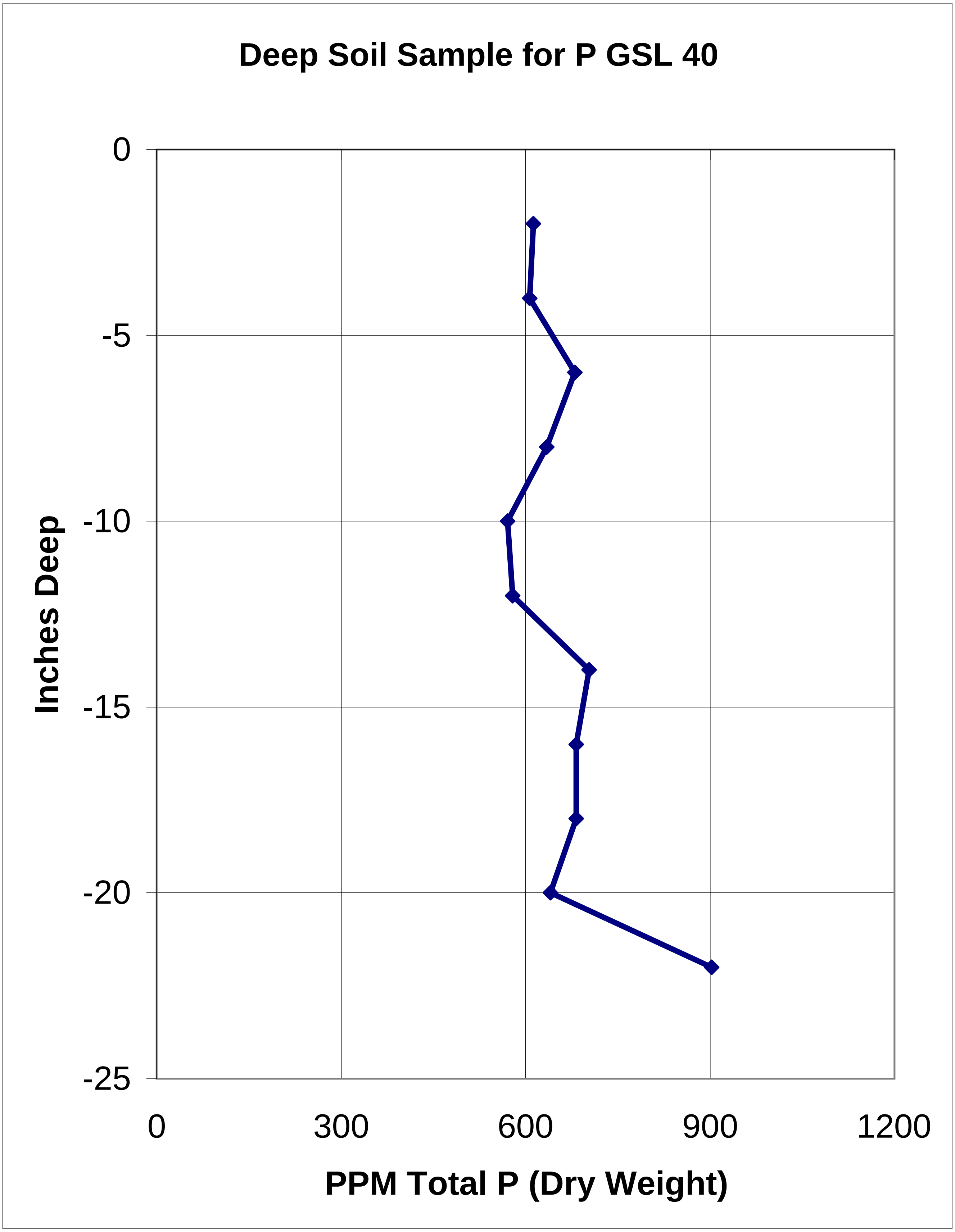


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P Sample GSL-9 8-2P Graph Chart 1
11/29/2005

CDSD Deep Sediment Sample
GSL- 40 8/17/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.739	453	-2	613
4	0.694	421	-4	607
6	0.71	483	-6	680
8	0.764	485	-8	635
10	0.788	450	-10	571
12	0.751	435	-12	579
14	0.627	441	-14	703
16	0.677	462	-16	682
18	0.687	469	-18	683
20	0.779	499	-20	641
22	0.778	702	-22	902

CDSD Deep Soil Sample
GSL - 40

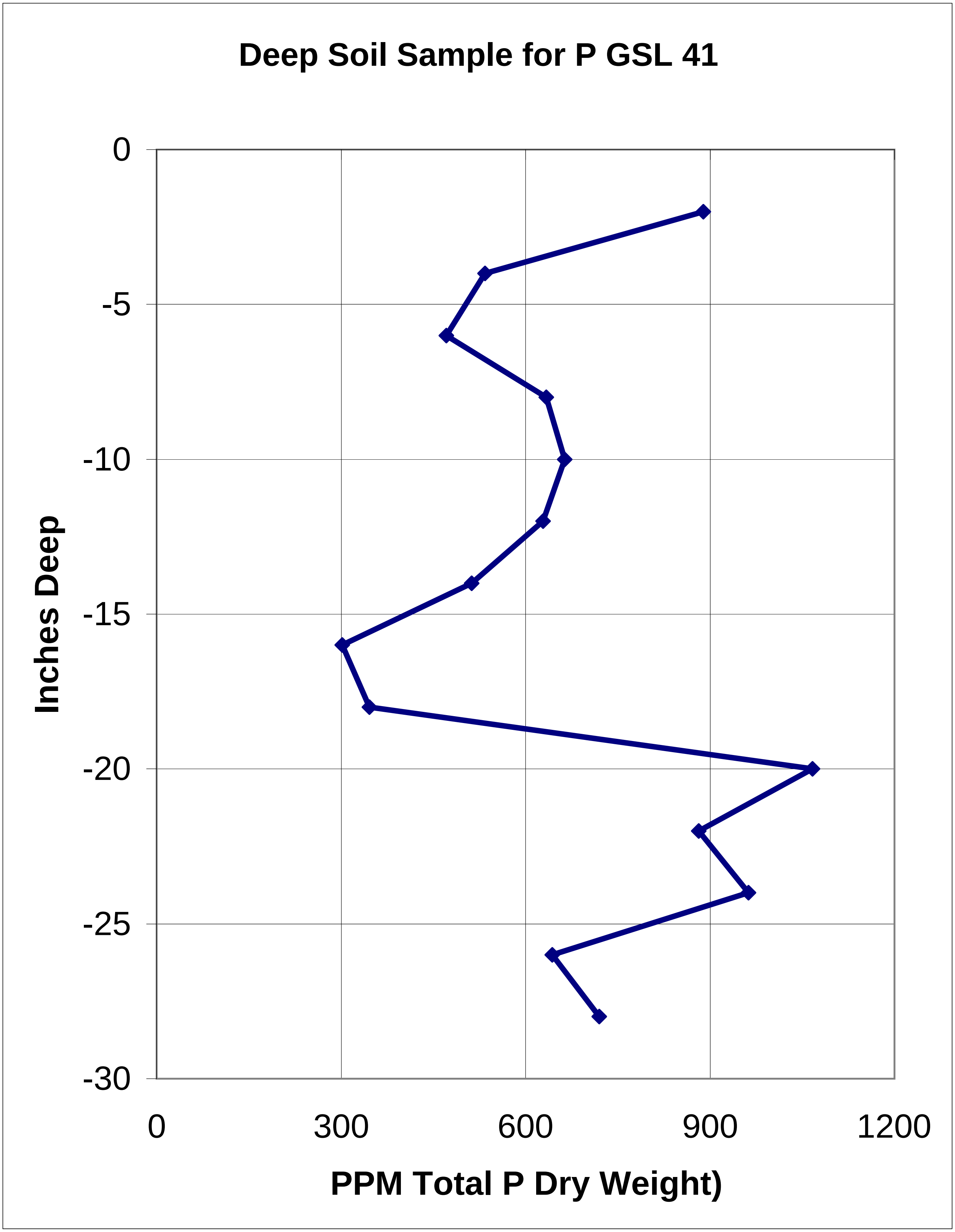


C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P Sample GSL-40 8-17P Graph Chart 1
11/29/2005

CDSD Deep Sediment Sample
GSL- 41 9/1/2005

Depth Inches	% Solids	P ppm		P ppm Dry
2	0.751	668	-2	889
4	0.745	398	-4	534
6	0.758	357	-6	471
8	0.625	396	-8	634
10	0.717	476	-10	664
12	0.571	359	-12	629
14	0.607	311	-14	512
16	0.567	171	-16	302
18	0.523	181	-18	346
20	0.421	449	-20	1067
22	0.565	498	-22	881
24	0.615	592	-24	963
26	0.547	352	-26	644
28	0.542	390	-28	720

CDSD Deep Soil Sample
GSL - 41



C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Deep P Sample GSL-41 9-1P Graph Chart 1
11/29/2005

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Appendix 2

Sediment Water Interface Testing Results

Note: All values reported in this appendix as P are ortho-phosphorus (reactive phosphorus).

CDSD Sediment Water Interaction

GSL A

6/22/2005 40°58'32"N 111°58'10"W

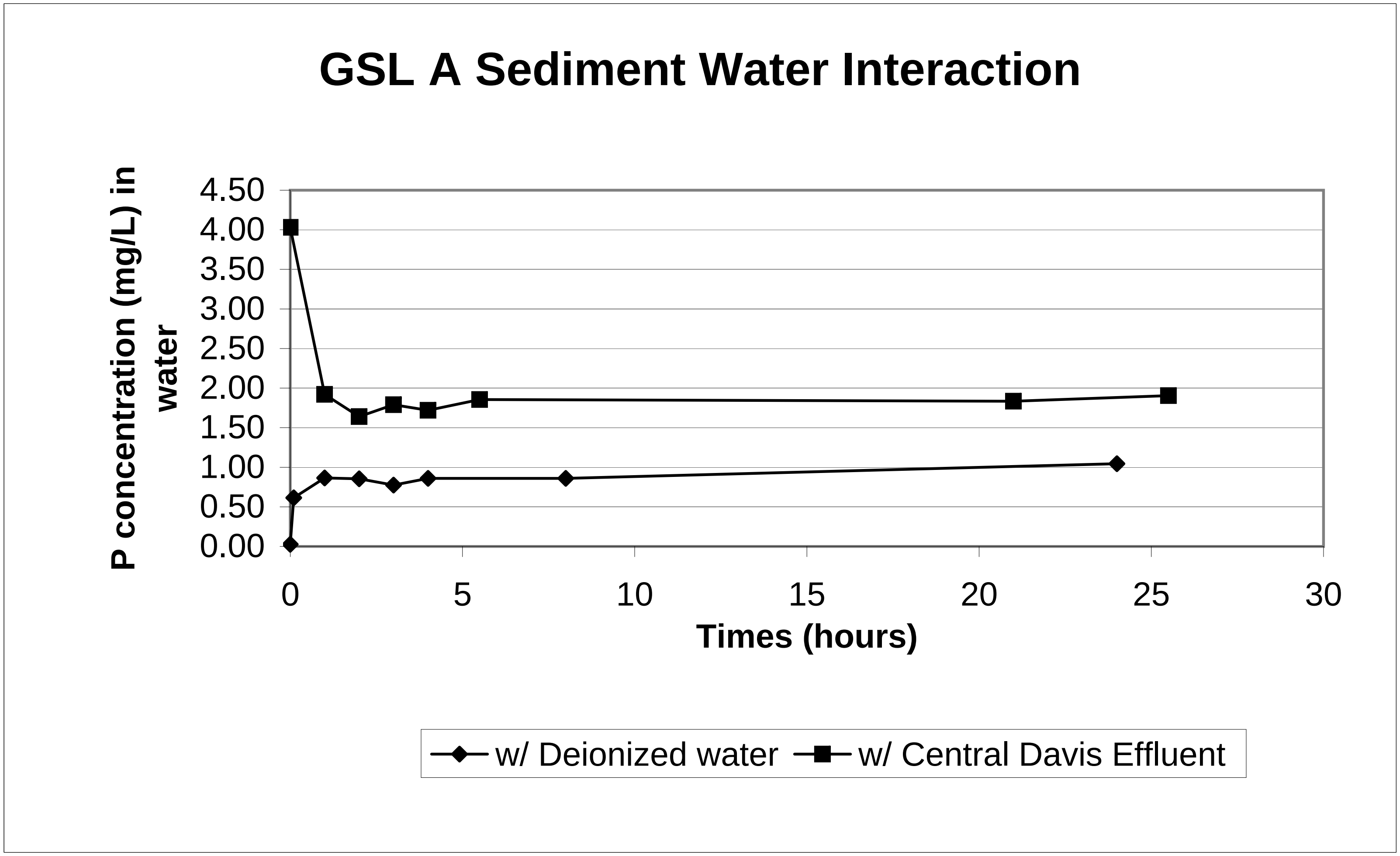
w/ Deionized water

Date	Time	Hours	P (mg/L)
6/22/2005		0	0.03
	8:00am	0.1	0.62
	9:00am	1	0.87
	10:00	2	0.86
	11:00	3	0.78
	12:00	4	0.86
	4:00	8	0.86
6/23/2005	8:00am	24	1.05

w/ Central Davis Effluent

Date	Time	Hours	P (mg/L)
6/21/2005	10:30am	0	4.03
	11:30	1	1.92
	12:30	2	1.64
	1:30	3	1.79
	2:30	4	1.72
	4:00	5.5	1.86
6/22/2005	7:00am	21	1.84
	12:00	25.5	1.91

CDSD Sediment Water Interaction



CDSD Sediment Water Interaction

GSL B

6/22/2005 40^{o}56'53"N 111^{o}57'56"W

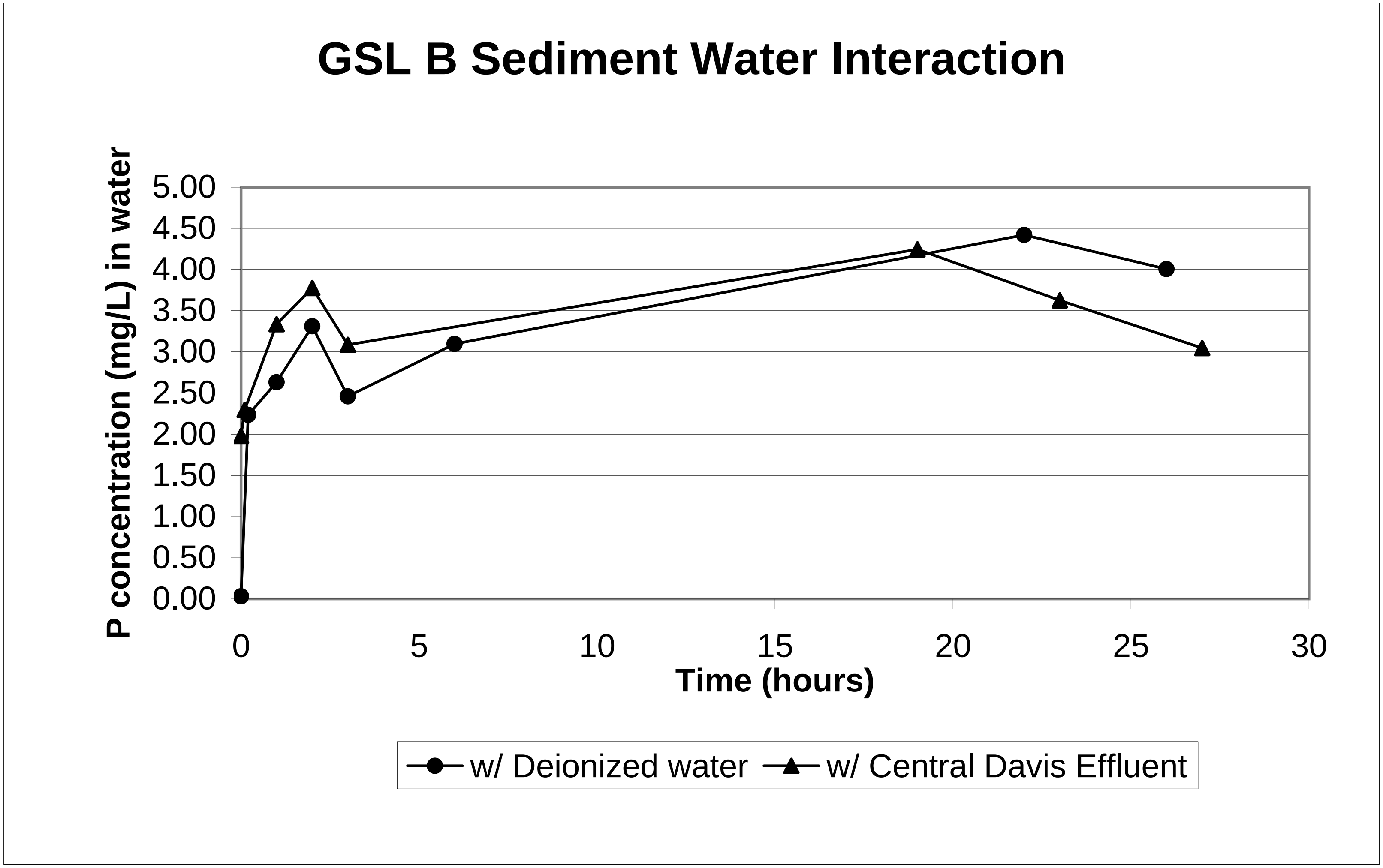
w/ Deionized water

Date	Time	Hours	P (mg/L)
6/22/2005	9:50	0	0.03
	10	0.2	2.24
	11:00	1	2.63
	12:00	2	3.31
	1:00	3	2.46
	4:00	6	3.10
6/23/2005	8:00am	22	4.42
	12:00	26	4.01

w/ Central Davis Effluent

Date	Time	Hours	P (mg/L)
6/22/2005	12:50	0	1.98
	1:00	0.1	2.30
	2:00	1	3.34
	3:00	2	3.78
	4:00	3	3.09
6/23/2005	8:00am	19	4.25
	12:00	23	3.63
	4:00	27	3.05

CDSD Sediment Water Interaction



CDSD Sediment Water Interaction

GSL 04

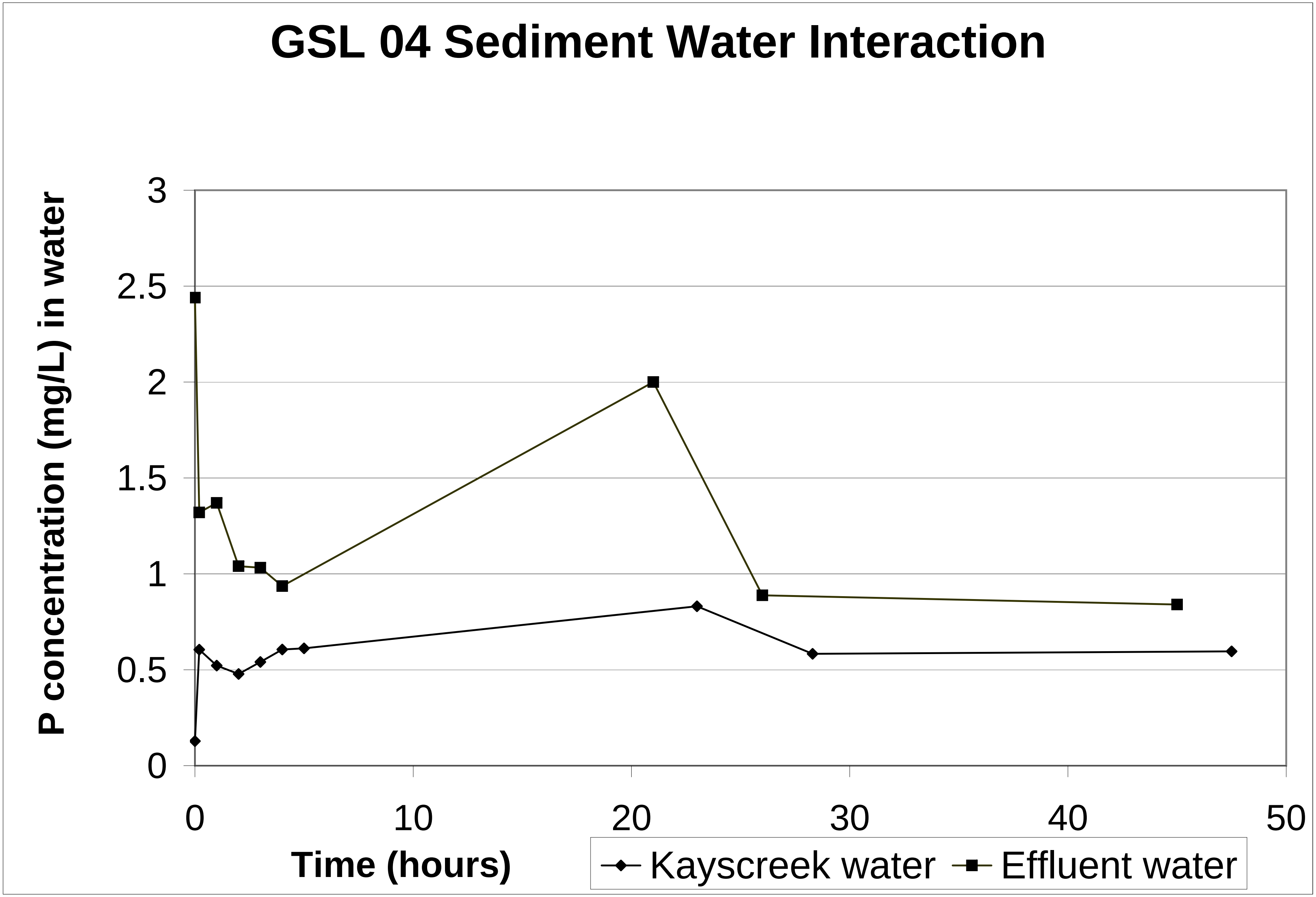
41°01'01"N 112°00'51"W

w/KaysCreek water

Date	Time	Hours	P (mg/L)
6/28/2005	7:00	0	0.13
	7:10	0.2	0.61
	8:10	1	0.52
	9:10	2	0.48
	10:10	3	0.54
	11:05	4	0.61
	12:05	5	0.61
6/29/2005	6:20	23	0.83
	11:30	28.3	0.58
6/30/2005	6:30	47.5	0.60

w/ Central Davis Sewer Effluent

Date	Time	Hours	P (mg/L)
6/28/2005	9:50	0	2.44
	10:00	0.2	1.32
	10:55	1	1.37
	11:55	2	1.04
	1:00	3	1.03
	2:05	4	0.94
6/29/2005	6:30	21	2.00
	11:45	26	0.89
6/30/2005	6:40	45	0.84


GSL 04 Sediment Water Interaction
P concentration (mg/L) in water
3
2.5
2
1.5
1
0.5
0
0
10
20
30
40
50
Time (hours)
Kayscreek water
Effluent water

CDSD Sediment Water Interaction

GSL 5

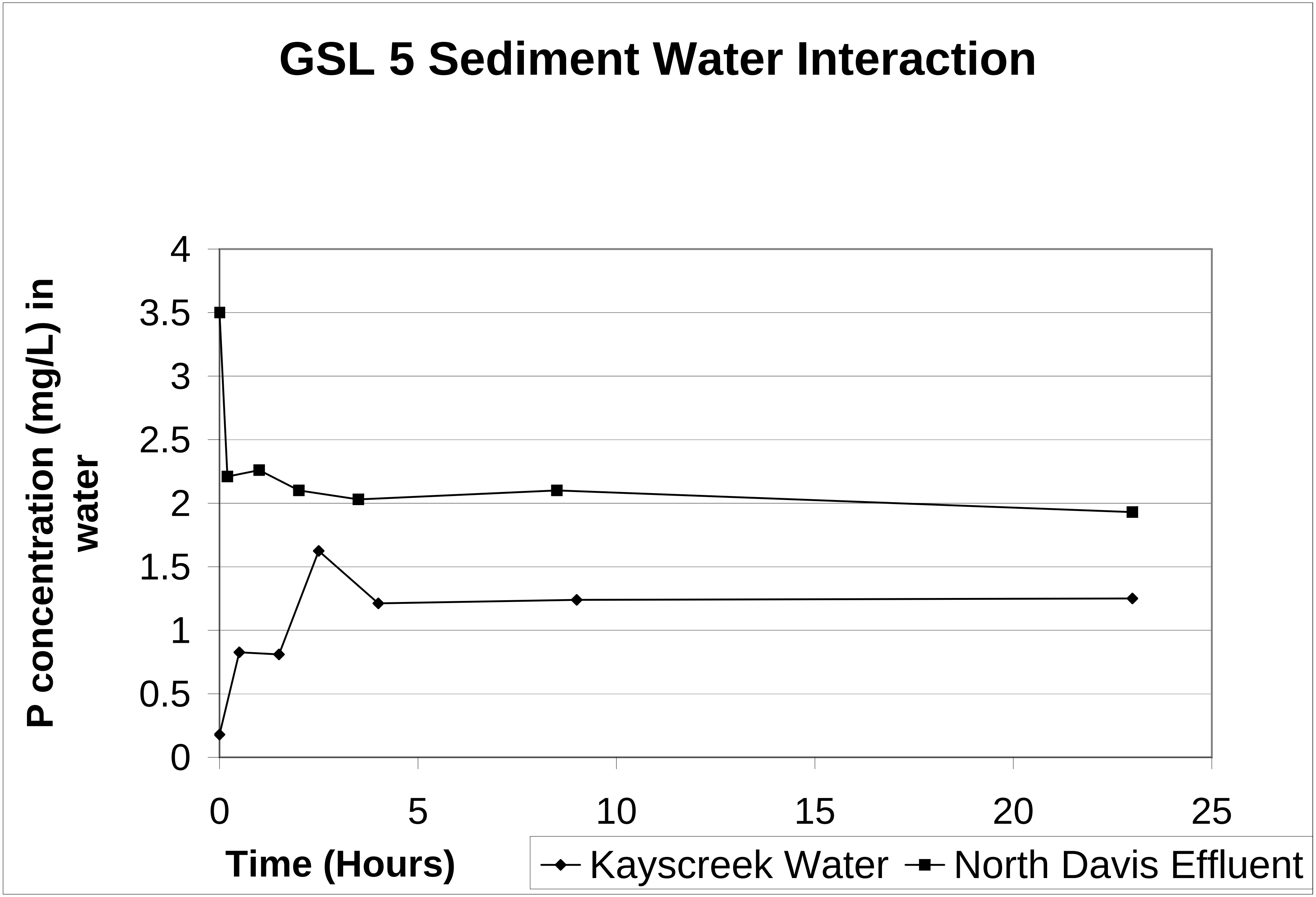
41^{o}5'19"N 112o8'32"W

w/North Davis Sewer Effluent

Date	**Time**	**Hours**	**P (mg/L)**
7/12/2005	7:40am	0	3.50
	7:55	0.2	2.21
	8:50	1	2.26
	10:00	2	2.10
	11:30	3.5	2.03
	4:30	8.5	2.10
7/13/2005	6:30 AM	23	1.93

w/Kayscreek Water

Date	**Time**	**Hours**	**P (mg/L)**
7/12/2005	7:25am	0	0.18
	7:50	0.5	0.83
	8:50	1.5	0.81
	10:00	2.5	1.62
	11:30	4	1.21
	4:20	9	1.24
7/13/2005	6:30	23	1.25


GSL 5 Sediment Water Interaction
P concentration (mg/L) in water
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
Time (Hours)
Kayscreek Water
North Davis Effluent

CDSD Sediment Water Interaction

GSL 7

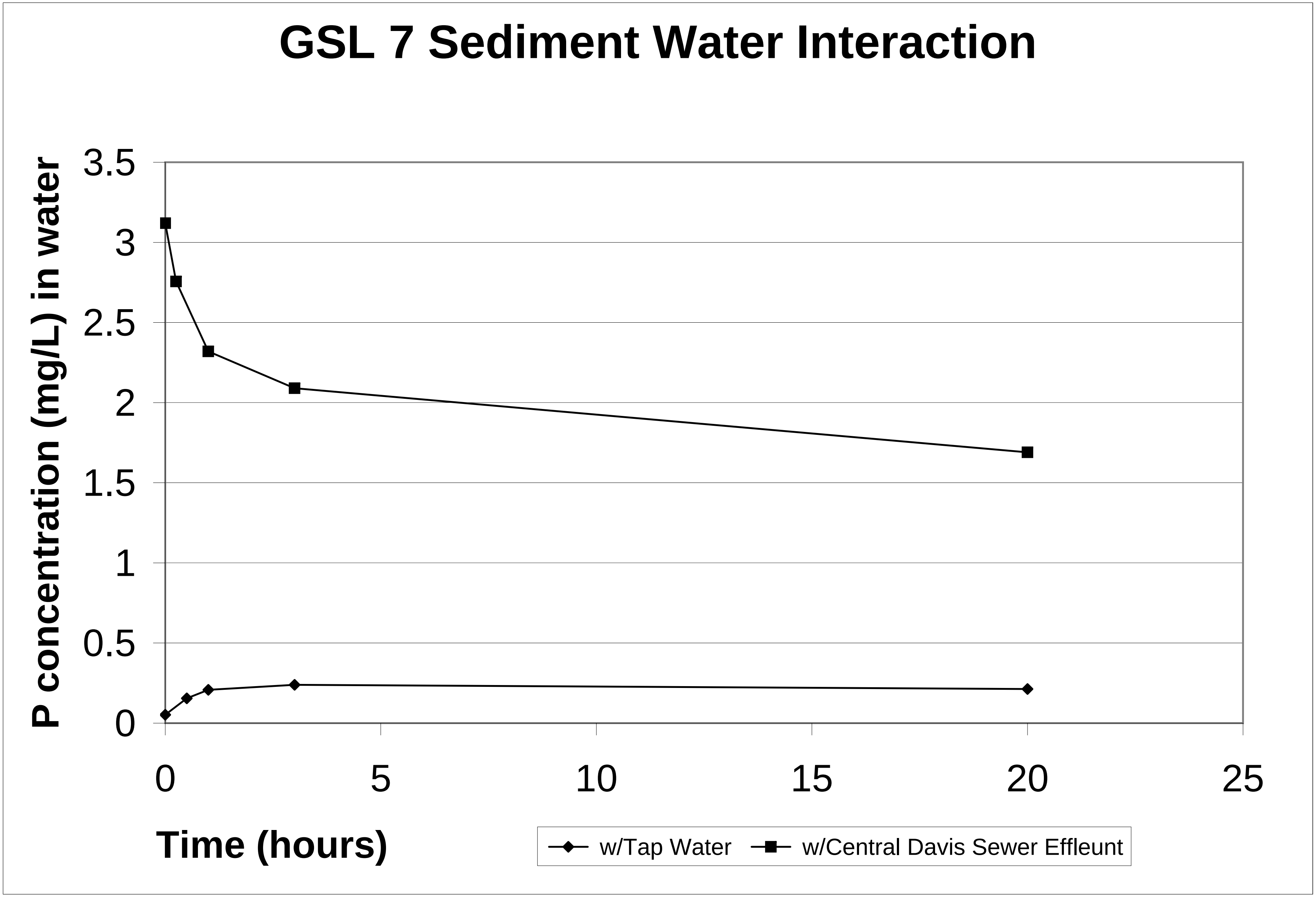
7/18/2005 9:40 AM $40^{o}56'08''N$ $111^{o}58'24''W$

w/Tap Water

	Time	Hours	P (mg/L)
initial water	11:30	0	0.05
	11:55	0.5	0.16
	12:25	1	0.21
	2:40	3	0.24
7/19/2005	7:25 AM	20	0.21

w/Central Davis Sewer Effleunt

	Time	Hours	P (mg/L)
initail water	11:30	0	3.12
	11:50	0.25	2.76
	12:20	1	2.32
	2:30	3	2.09
7/19/2005	7:20 AM	20	1.69


GSL 7 Sediment Water Interaction
P concentration (mg/L) in water
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
Time (hours)
w/Tap Water
w/Central Davis Sewer Effleunt

CDSD Sediment Water Interaction

GSL 8

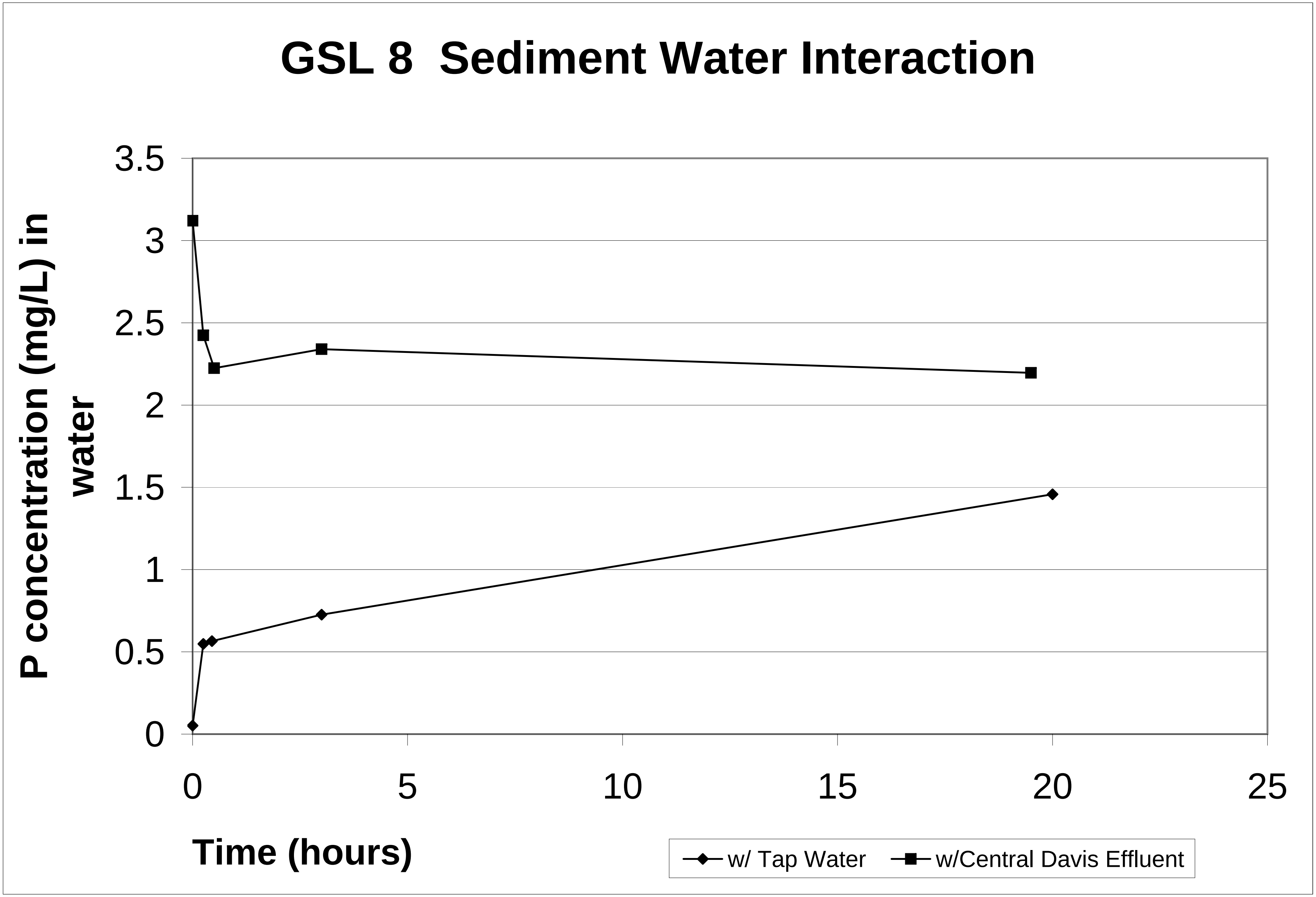
7/18/2005 9:30 AM 40°56'26"N 111°57'47"W

w/ Tap Water

	Time	Hours	P (mg/L)
initial water	11:30	0	0.05
	11:45	0.25	0.55
	12:10	0.45	0.57
	2:25	3	0.73
7/19/2005	7:10 AM	20	1.46

w/Central Davis Sewer Effluent

	Time	Hours	P (mg/L)
initial water	11:30	0	3.12
	11:40	0.25	2.42
	12:00	0.5	2.22
	2:15	3	2.34
7/19/2005	7:00 AM	19.5	2.20


GSL 8 Sediment Water Interaction
P concentration (mg/L) in water
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
Time (hours)
w/ Tap Water
w/Central Davis Effluent

CDSD Sediment Water Interaction

GSL D

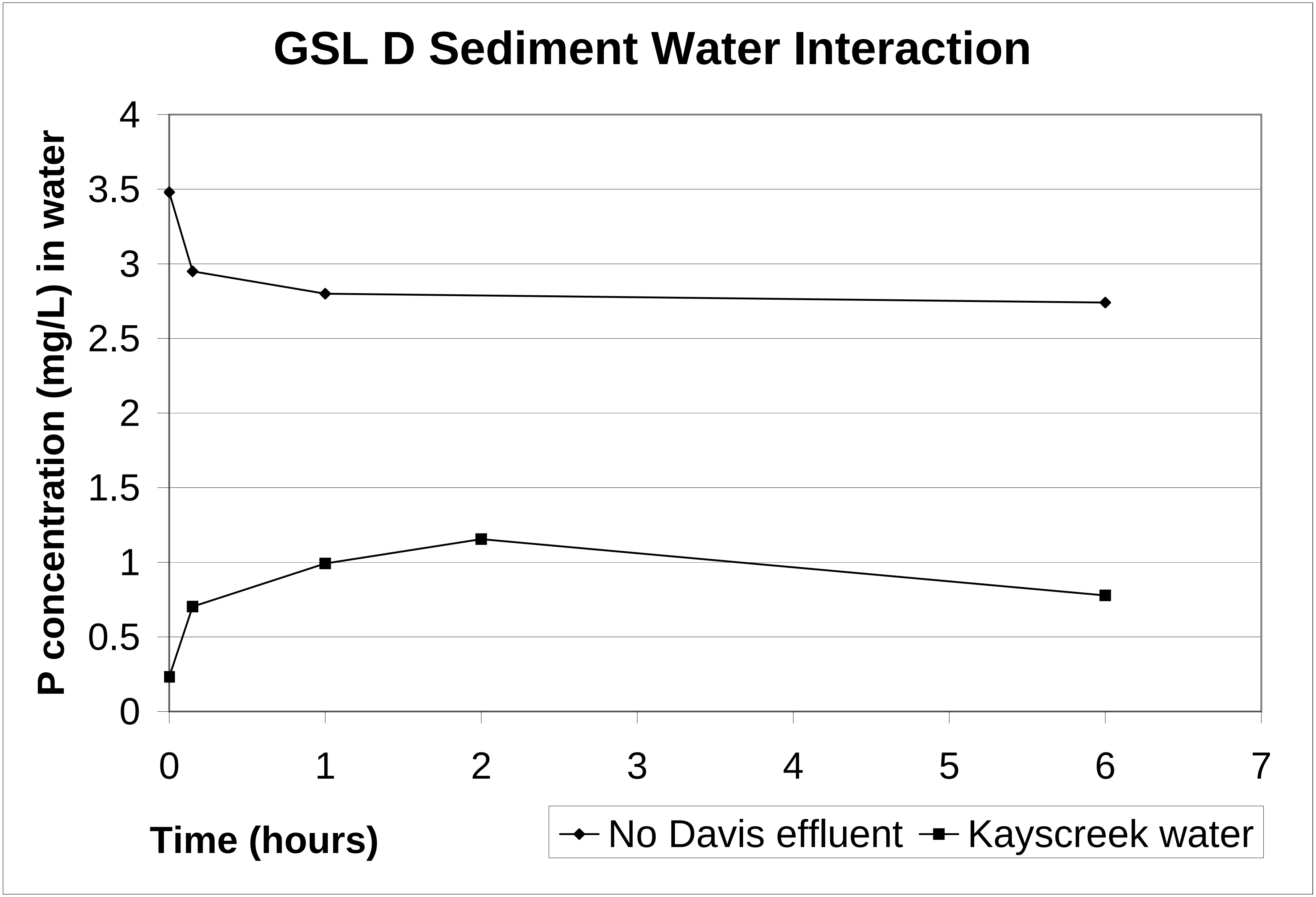
7/19/2005 12:01 PM 41^{o}02'13"N 112^{o}11'46"W

w/North Davis Sewer effluent

	Time	**Hours**	**P (mg/L)**
initial water	8:35	0	3.48
	8:45	0.15	2.95
	9:45	1	2.80
	2:40	6	2.74

w/ Kayscreek water

	Time	**Hours**	**P (mg/L)**
initial water	8:10	0	0.23
	8:30	0.15	0.70
	9:00	1	0.99
	10:00	2	1.16
	2:30	6	0.78


GSL D Sediment Water Interaction
P concentration (mg/L) in water
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
Time (hours)
No Davis effluent
Kayscreek water

CDSD Sediment Water Interaction

GSL16

7/19/2005 12:12 PM 40°59'15"N 112°11'09"W

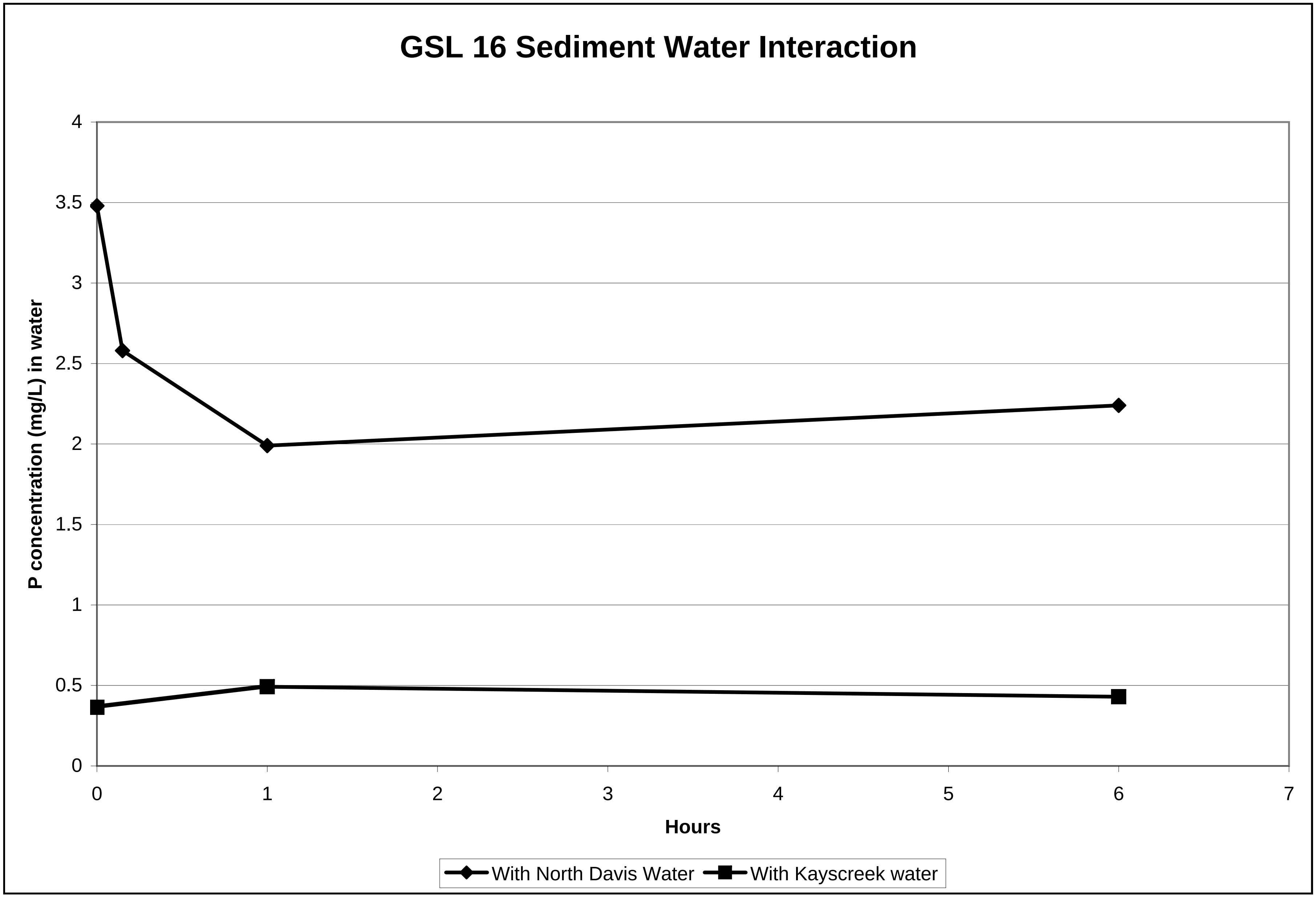
w/ North Davis Sewer effluent

	Time	Hours	P (mg/L)
initial water	8:35	0	3.48
	8:45	0.15	2.58
	9:45	1	1.99
	2:45	6	2.24

w/ Kayscreek water

	Time	Hours	P (mg/L)
initial water	8:15	0	0.36
	10:00	2	0.49
	2:30	6	0.43

CDSD Sediment Water Interaction



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11/30/2005 9:03 PM

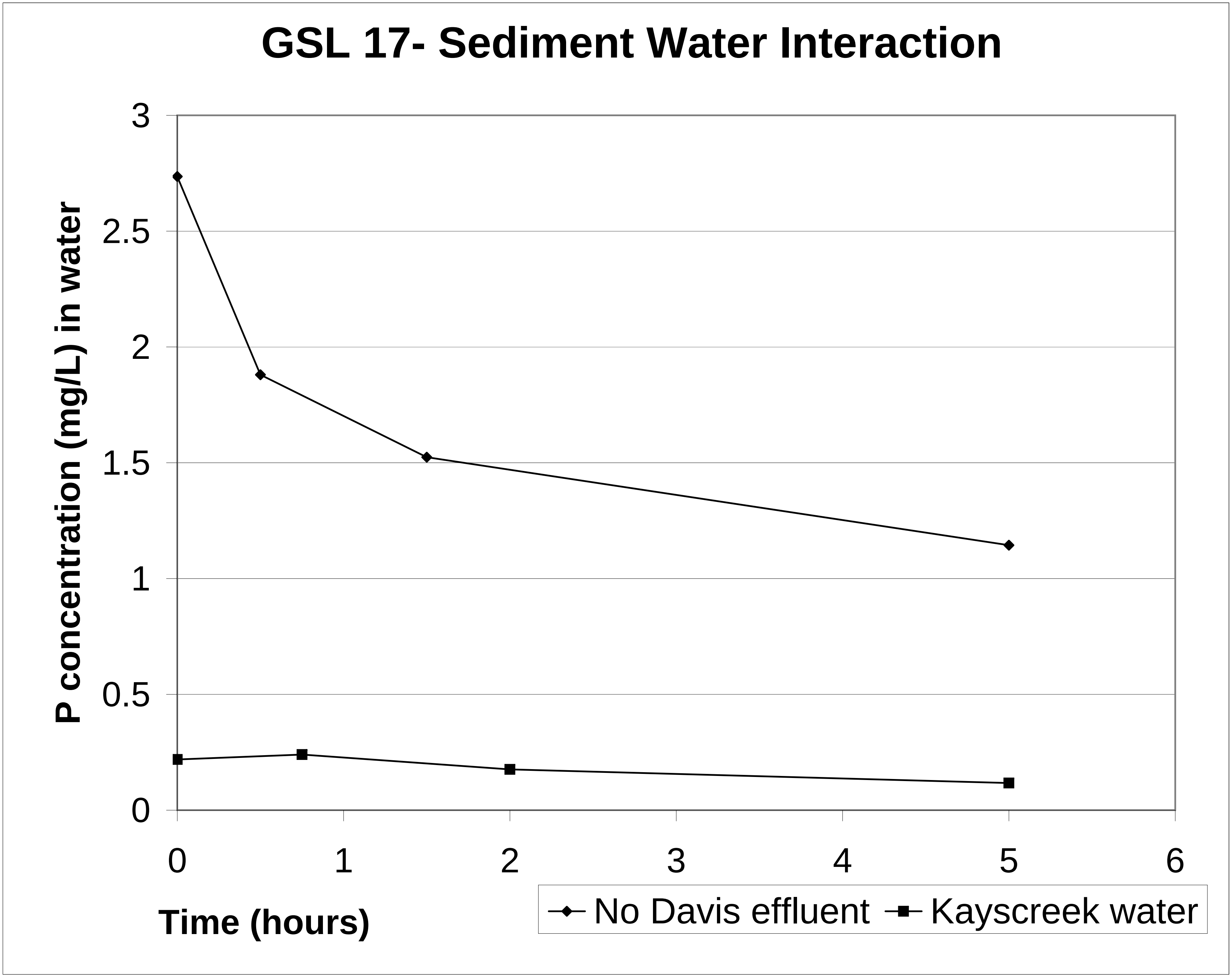
CDSD Sediment Water Interaction

GSL17

7/19/2005 12:30 PM $40^o56'02"N$ $112^o08'24"W$

w/ North Davis Sewer effluent	Time	Hours	P (mg/L)
initial water	10:30	0	2.74
	10:55	0.5	1.88
	11:55	1.5	1.52
	3:35	5	1.14

w/ Kayscreek water	Time	Hours	P (mg/L)
initial water	10:40	0	0.22
	11:20	0.75	0.24
	12:30	2	0.18
	3:45	5	0.12


GSL 17- Sediment Water Interaction
P concentration (mg/L) in water
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Time (hours)
No Davis effluent
Kayscreek water

CDSD Sediment Water Interaction

GSL C

7/19/2005 12:57 PM 41°04'25"N 112°07'52"W

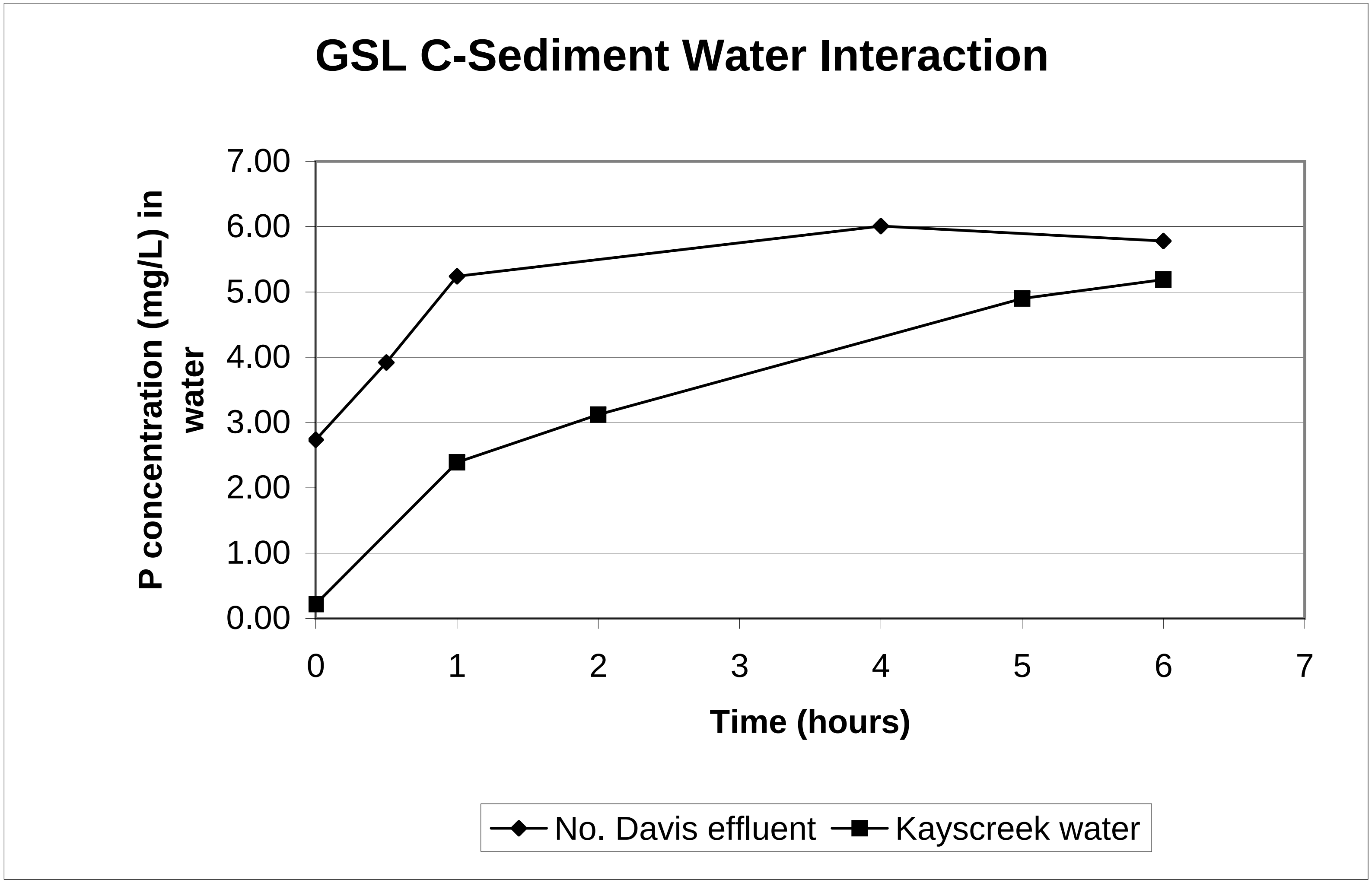
w/ North Davis Sewer effluent

	Time	**Hours**	**P (mg/L)**
initial water	10:30	0	2.74
	11:10	0.5	3.92
	11:40	1	5.24
	2:45	4	6.01
	4:55	6	5.78

w/ Kayscreek water

	Time	**Hours**	**P (mg/L)**
initial water	10:40	0	0.22
	11:30	1	2.39
	12:35	2	3.12
	3:50	5	4.90
	4:50	6	5.19

CDSD Sediment Water Interaction



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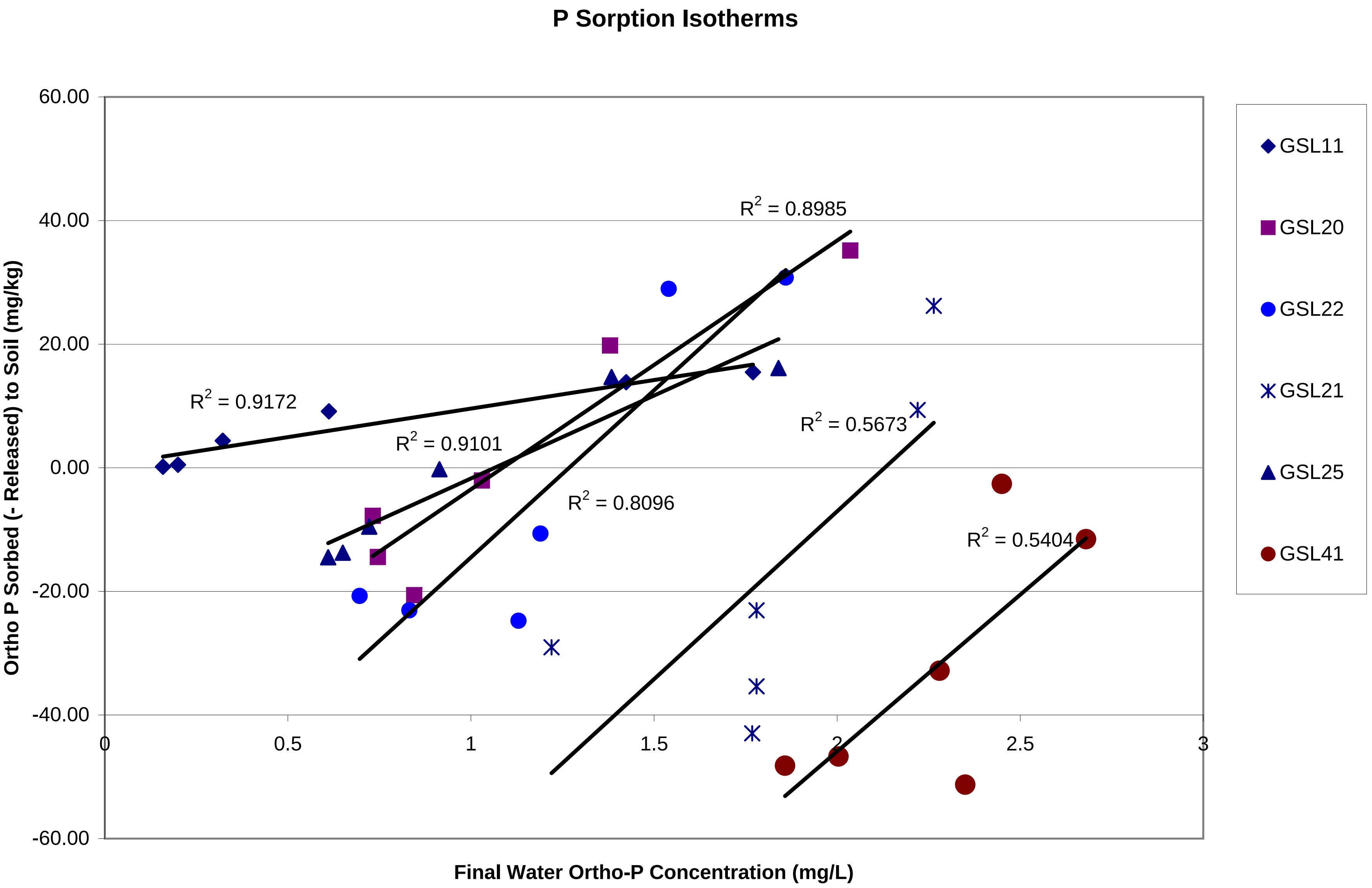
Appendix 3

Sorption Isotherm Results

Note: All values reported in this appendix as P are ortho-phosphorus (reactive phosphorus).

CDSD Sediment - Water Ortho-P Sorption Isotherms



C:\Data Files\Great Salt Lake Info\Sediment Sampling Study\Appendix 3\Appendix 3 Rev 1\sorbed data Corrected
12/22/2005 9:22 PM

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 11

10-Aug-05
Added Central Davis effluent to soil 1:00pm
Tested water August 11, 2005 6:30am

P (mg/L) liquid	P (mg) soil	P (mg/L) liquid w/soil	P sorbed (mg/kg)
0.17	115.97	0.159	0.162
0.23	157.38	0.200	0.486
0.57	392.77	0.322	4.367
1.12	771.73	0.612	9.124
2.20	1518.61	1.424	13.835
2.63	1814.05	1.770	15.471

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 20

6-Sep-05
Added Central Davis effluent to soil 2:00pm
Tested water 9-7-05 11:00am

P (mg/L) liquid	P (mg) soil	P (mg/L) liquid w/soil	P sorbed (mg/kg)
0.151	7.019	0.845	-20.616
0.269	6.889	0.746	-14.438
0.47	7.017	0.732	-7.785
0.964	6.633	1.030	-2.075
2.064	7.211	1.380	19.778
3.252	7.213	2.036	35.148

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 21

6-Sep-05

Added Central Davis effluent to soil 3:15pm

Tested water 9-8-05 2:00pm

P (mg/L) liquid	P (mg) soil	P (mg/L) liquid w/soil	P sorbed (mg/kg)
0.115	8.259	1.220	-29.043
0.184	8.002	1.768	-42.972
0.394	8.505	1.780	-35.375
0.888	8.396	1.780	-23.062
2.572	8.171	2.220	9.351
3.252	8.186	2.264	26.201

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 25

16-Sep-05

Added Central Davis effluent 9-15-05 7:15 am

Tested on 9-16-05

P (mg/L) liquid	P (mg) soil	P (mg/L) liquid w/soil	P sorbed (mg/kg)
0.111	0.610	P (mg/L) liquid w/so	P sorbed (mg/kg)
0.203	0.650	2.857	-14.485
0.441	0.722	2.696	-13.749
0.906	0.914	2.447	-9.522
1.856	1.384	2.753	-0.241
2.352	1.840	2.664	14.691
		2.632	16.130

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 22

10-Aug-05

August 11, 2005 added Central Davis effluent 8:00am

Tested water 4:00pm

P (mg/L) liquid	P (mg) soil	P (mg/L) liquid w/soil	P sorbed (mg/kg)
0.162	0.696	3.007	-20.737
0.232	0.832	3.036	-23.075
0.490	1.130	3.019	-24.757
0.914	1.190	3.024	-10.656
2.290	1.540	3.024	28.956
2.660	1.860	3.036	30.767

CDSD Sediment - Water Ortho-P Sorption Isotherm

GSL 41

15-Sep-05

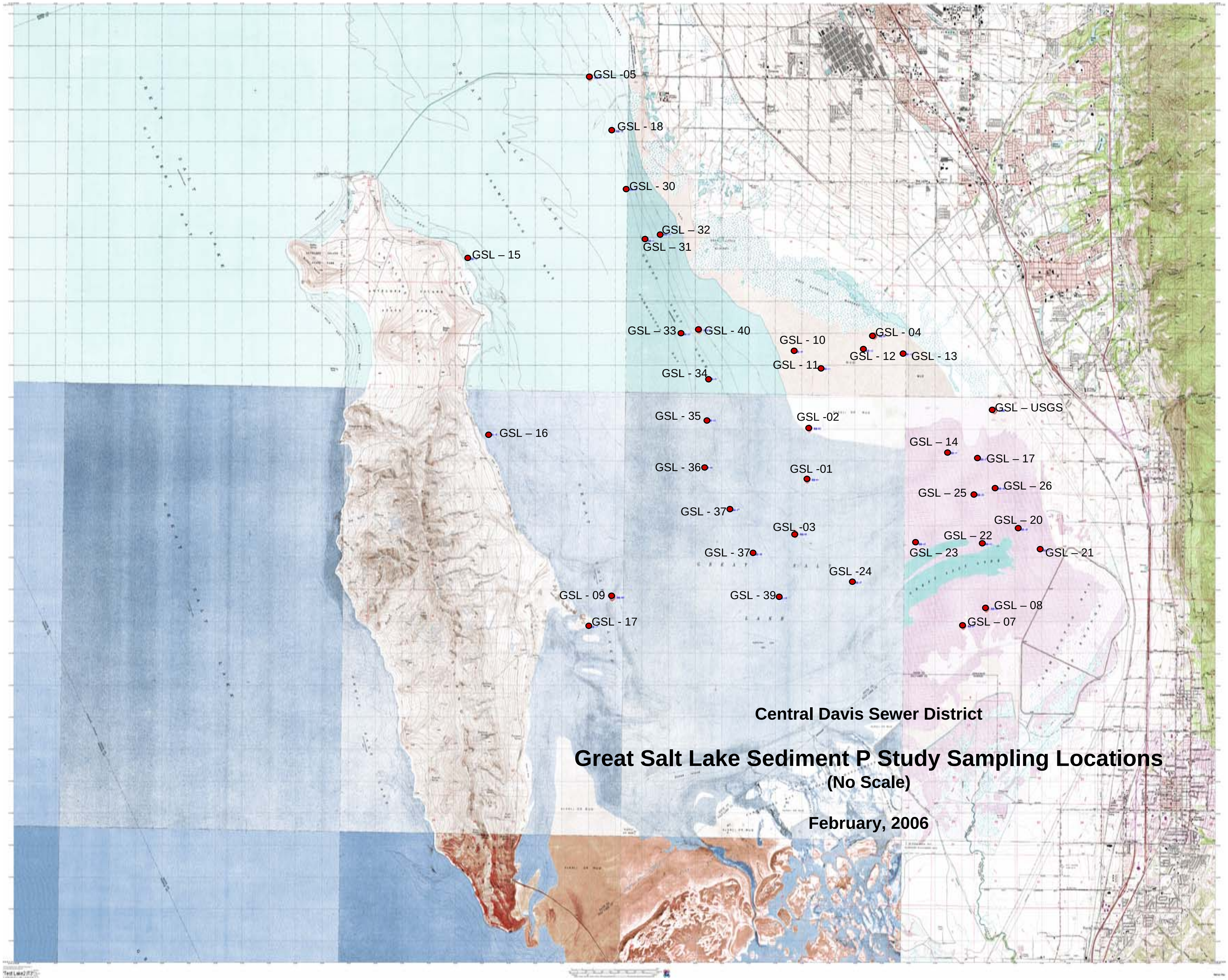
Added Central Davis Effluent 9/15/2005 @ 7:15 am

Tested on 9/16/2005 at 8:00 am

initial reading m	final reading (mg/l	initial mg P in soil	Psorbed (mg/kg)
0.114	1.858	5.706	-48.199
0.194	2.004	6.109	-46.726
0.462	2.350	5.807	-51.273
1.082	2.280	5.754	-32.837
2.244	2.680	5.947	-11.561
2.352	2.450	5.935	-2.604

Appendix 4

Sampling Location Map

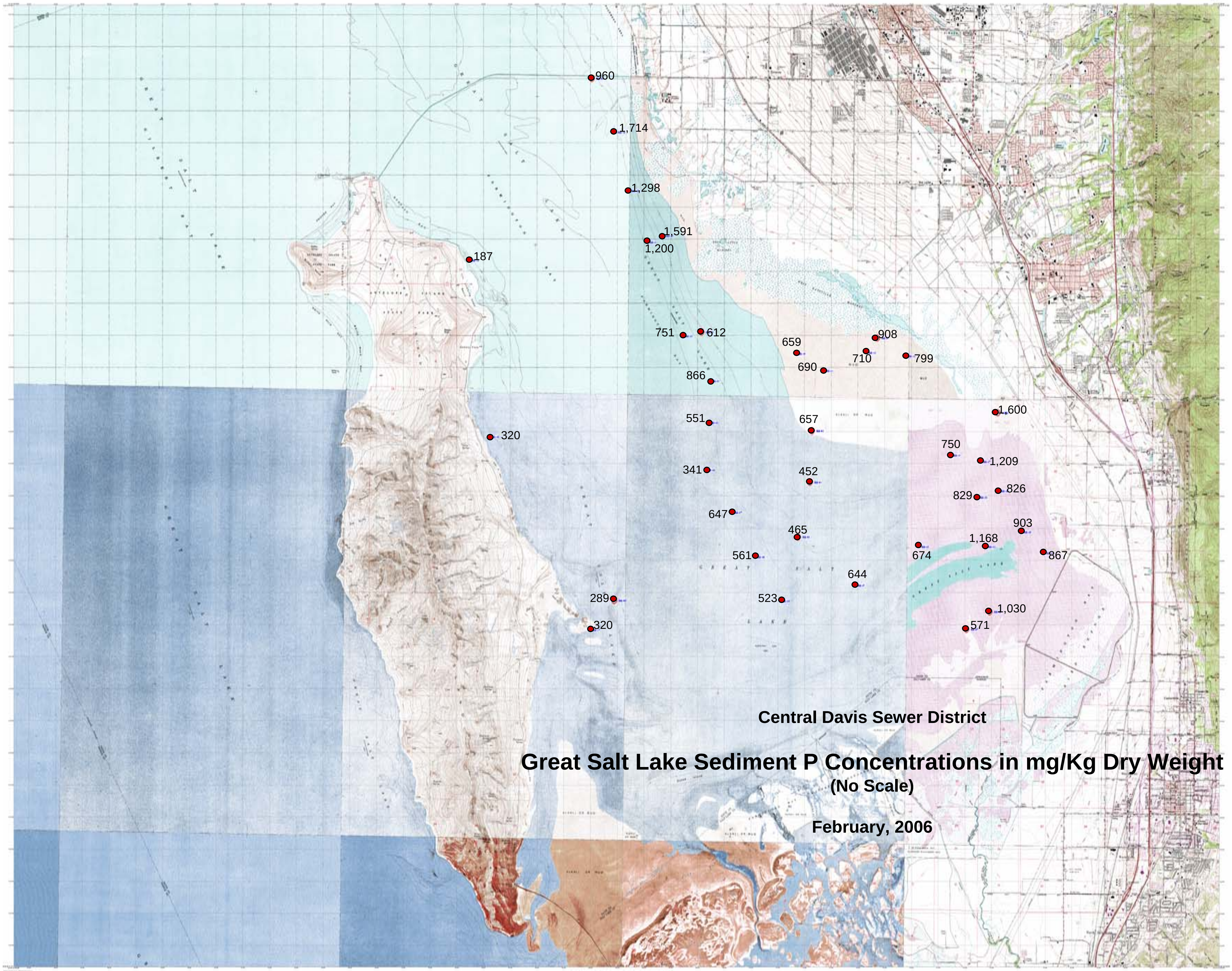


Central Davis Sewer District

Great Salt Lake Sediment P Study Sampling Locations

(No Scale)

February, 2006



Central Davis Sewer District

Great Salt Lake Sediment P Concentrations in mg/Kg Dry Weight

(No Scale)

February, 2006