REPORT ON THE NINE COASTAL LAKES IN MONMOUTH COUNTY

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MONMOUTH COUNTY HEALTH DEPARTMENT

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INTRODUCTION

This is an addendum to the 1989 Interim Report on the Nine Coastal Lakes in Monmouth County; included are the data for the sampling during the spring and summer of 1989. Maps for each lake are included from the previous report; Site one is nearest the inlet, Site two is nearest the outlet, and Site three is an additional inlet (for Deal Lake and Wreck Pond only).

Nineteen eighty-eight, when the fall sampling began, was a year of drought, while there was record rainfall during the spring and summer of 1989. Nonpoint sources of nutrients, such as lawn fertilizers and animal droppings, are washed into the lakes during rain; but lack of rain causes a drop in current flow, inhibits mixing, and allows the lake to stagnate -most visible during algae blooms. In other words, although there were less pollutants washed into the lakes in 1988, there was less mixing within the lakes; conversely, there were more nonpoint pollutants draining into the lakes in 1990, but there was also more mixing and dilution because of the increase in current flow.

The EPA index for relating the water quality in a lake to national averages are included at the end of this report. The coastal lakes generally have parameters that indicate poor water quality. In the absence of point source pollution, such as factory or sewer plant discharges, the eutrophication is due to nonpoint sources of pollution associated with population density.

These lakes are the discharge points for their watersheds into the ocean; any efforts to reduce nutrient inputs in these lakes will directly affect the quality of ocean bathing beaches.

TAKANASSEE LAKE

PHYSICAL PARAMETERS

As noted in the previous report, Takanassee Lake has a substantial macrophyte growth near Site 2; this affects the chemistry of the lake, including dissolved oxygen and suspended solids.

The increase in pH in the fall at Site 2 may be because this is when most macrophytes were at this site. Macrophytes, as well as algae, release carbon dioxide, causing shifts in the bicarbonate carbonate buffering system, and resulting in a decrease in the concentration of hydrogen ions - and therefore a rise in pH.

Dissolved oxygen, however, is highest in the spring (9.7mg/l-10.3mg/l). This may be related to the increase in water volume due to spring runoff as well as the increased solubility of oxygen at cooler temperatures, 10.3C, compared to fall and summer temperatures of 16-21C. In addition there is less oxygen consumption by respiring bacteria, and lower photosynthetic activity as indicated by chlorophyll a measurements of 2mg/m3 and 1mg/m3 at sites 1 and 2 respectively.

NUTRIENTS

Nitrate levels were comparable in the fall and summer; ammonia is highest in the spring, indicating runoff and decomposition of organic debris during winter. Fall, with the lowest ammonia levels, reflects maximum uptake by phytoplankton and in fact has the most algae cells present at either site during the year. Phosphate is typically below detection limits.

BACTERIA

Fecal coliform were low throughout the lake; the highest reading (110 colonies in the spring at Site 1) is still below the 200 fecal coliform standard for ocean bathing beaches. Note however, those enterococci are above the EPA standard of 35 colonies for this same site. The resident waterfowl population may also be determining the extreme difference between these levels and the coliform. Animals excrete proportionally more enterococci than coliform as compared to humans. This lake had the lowest bacteria levels of all nine lakes.

ALGAE

Green algae comprises over 91% of the total cell count at both in lake sites during the spring. The prevalent genera Nannochloris dominates all year at both sites though the green algae group drops to 80% in summer and fall. The flagellate group is second highest in total numbers and are commonly found in organically enriched areas. During summer the pollutant tolerant diatom Nitzchia acicularis appears in low numbers at Site 2 (58/ml) and is less than .76% of the total number of cells found? However with increased nutrient input the water quality may support an increase in such species. Chlorophyll a is highest in summer as expected with conditions conducive to photosynthetic activity. The decrease in the number of cells per ml is not directly proportional to the chlorophyll readings because of the differences in size of algae cells. Although less numbers of

cells may be counted; their larger size allows them to produce more chlorophyll than more of the smaller size species. This lake had the lowest chlorophyll a levels of all nine lakes.

STORM DRAINS

Thirty-six storm drains have been mapped around Takanassee Lake. Three were flowing in dry weather in fall of 1988, #17, #20, #21.As reported previously, initial high fecal counts were due to rainfall with additional dry weather sampling showing a significant decrease in coliform. These three drains were again sampled in summer of 1989. Elevated nitrate and ammonia levels were found in # 17 and #20; however, coliform levels were low in these pipes. This tends to indicate nonpoint runoff originating from adjacent well maintained lawns. Storm drain #8 was flowing in spring and sampled. Parameter results were representative of most storm drains with fecal counts reading 500 and ammonia and nitrates reading between .2mg/l and 2.0mg/l; the pH was 6.1.

INLETS, OUTLET, AND UPSTREAM SURVEY

The most striking trend is the elevated enterococci in the inlet in the spring (701 colonies) compared to coliform (13 colonies). Enterococci are comparatively more numerous in the feces of animals than in humans. The nutrient levels do not appear to reflect a major impact from the well kept lawns around upstream sites such as Monmouth College, but this may be due to the unique formation of this lake, as discussed below.

CONCLUSION

The eutrophication of Takanassee Lake is primarily being caused by nonpoint sources such as runoff from well maintained lawns, both residential and commercial, in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. The waterfowl on the lake are also adding nutrients that promote algal proliferation. Fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash.

Note that this lake has low levels of fecal coliform in the inlet as well as the outlet. This may be because there are two lakes that precede the main section of the lake, and upstream pollution is settling out before it reaches the main body of the lake. Note also that this lake has one of the highest macrophyte populations of all the lakes, possibly because this lake is not treated. Some macrophytes of the Elodea species, which is present in this lake (see previous report), are used in sewer plants to “polish” the effluent of total suspended solids and Biological Oxygen Demand. Fecal coliform adsorb to suspended solids, and are provided with nutrients by the components that are measured by BOD.

DEAL LAKE

PHYSICAL PARAMETERS

The parameters tested in spring and summer of 1989 for Deal Lake again showed only slight variations between sites. The depth of the water increased at least .3 meters during spring runoff, and salinity concentrations decreased to zero at Sites 1 and 3. The salinity reading of 8 parts per thousand (o/too) during the summer at Site 2 indicates salt water movement from the outfall (also 8 o/too) and can account for the high pH of 9.0 at that time. During the summer, pH was highest throughout the lake due to increased photosynthetic activity - indicated at each site by an increase in chlorophyll a. Photosynthetic activity initiates the CO_2 fixation process which decreases hydrogen ion concentration thus increasing pH. Photosynthesis can also cause a Rise in dissolved oxygen (DO) to as high as 13.0 mg/l due to Large amounts of phytoplankton releasing oxygen into the water Column. This may contribute to the fall reading of 12.2 mg/l at Site 3. DO was highest at Site 2 throughout the year (9.0 - 13.0 mg/l) due to the intermixing of tidal waters and exposure to off Shore winds. The secchi disk readings at Site 2 reflect the Fluctuating water level and a lower algal presence with Chlorophyll a measuring only 13-41 mg/m3.

NUTRIENTS

Ammonia (NH_3) concentrations in Deal Lake ranged from 1.2 mg/l to 1.9 mg/l in the spring season compared to only .05 mg/l to .08 mg/l in fall and summer seasons. The decomposition of dead plant and animal tissue after the winter season could account for the spring increase. NH_3 concentrations of <1.0 mg/l are considered low, and are associated with healthy fresh water systems.

The significant increase of nitrates (NO_3) at all three sites from below detection limits in the summer and fall to .35mg/l to .41 mg/l in the spring is due to the absence of significant numbers of algae and macrophytes during the spring. Phosphate (PO_4), remained below detectable limits through out the year.

BACTERIA

Fecal coliform counts for spring dropped from the previous fall of 300, to 23 and 60 at Site 1 and 3 respectively. Site 2 re-mained low at 23. This reflects both a dilution process from spring runoff in the tributary confluent sites combined with natural winter die-off of bacteria. Bacteria counts remained low during the summer except at Site 1 with greater than 1600 colonies. Enterococcus levels also increased at Site 1 to 140.

Enterococcus is a sub group of streptococci and its normal habitat is the intestine of animals and humans. An increase could be caused by waterfowl or road runoff. Site 1 has flowing storm drains on either side compared to Sites 2 and 3 where area storm drains flow only intermittently.

ALGAE

In the spring season, each Deal Lake site has approximately the same total number of algae cells /ml present. This represents only half that amount seen at Site 2 and 3 the previous fall, and one third that seen at Site 1. This is expected after winter die off, prior to the onset of algal reproduction. At this time, green alga comprises over 90% of the total composition at Site 1 and 2, and 72% at Site 3.

Two other major algal groups represented at all three sites throughout the year are the blue-green - characterizing eutrophic conditions - and the diatoms. Generally an increase is seen in both groups during the summer, at varying percentages, depending upon their competitiveness with a variety of less significant species.

Among the green algae, Nannochloris sp. monopolizes the number of cells/ml not only at each site but during all three sampling seasons. Scenedesmus quadricauda is considered a pollutant tolerant species and is the second most common throughout the lake although found in much lower numbers. The exception here is in the early fall when Dictyosphaerium pulchellum far out numbers S. quadricauda at all three sites. D. pulchellum is a common coastal plain species that often proliferates during the summer.

Among the diatoms, Nitzschia acicularis, Navicula sp. and Melosi ra sp. dominate at all three sites during the summer. When con sidered individually they do not necessarily indicate organic pollution, but when found as a group, become known as “Pollution Algae” that are commonly present in organically enriched areas.

STORM DRAINS

In September of 1988 a total of 151 storm drains were located that directly empty into Deal Lake. Two additional storm drains were located due to the lower level of Deal Lake in early spring, bringing the total to 153. At the end of the fall sampling season five storm drains in Deal, Interlaken, and Asbury Park with fluctuating or consistently high fecal coliform levels were designated for investigative follow up.

Although these storm drains were routinely inspected, sampling in the summer season was performed on 7-12-89 for Asbury Park storm drain #59, #60 #75. Deal #113, and Interlaken #132 were sampled on 8-2-89. Additional parameters tested included enterococcus, ortho-phosphate (PO4), nitrate (NO3), ammonia(NH3), TKN, and pH.

Fecal coliform levels were less than 300 for all five storm drains with Enterococcus ranging 8 to 81. PO4 was less than detectable at all five drains as was NO3 for two in Asbury Park. Otherwise NO3 measured .22mg/l to .5mg/l. NH3 levels ranged .15mg/l to .34mg/l. TKN, measuring organic nitrogen and free ammonia, ranged from 1.0mg/l to 2.62mg/l. Combined, the impact of storm drain collection into Deal Lake significantly increases available nitrogen for phytoplankton.

Given the proper conditions this can accelerate algal blooms. Deal Lake has the most number of storm drains of all nine lakes.

INLETS, OUTLET, AND UPSTREAM SURVEY

Six main tributaries to Deal Lake were sampled in the spring and summer of 1989 for a variety of parameters to collect a represen tative idea of impacts to Deal Lake. The most striking results are the elevated ammonia levels at Hollow Brook (inlet #1) and Deal Lake Brook (inlet #2) ranging from 3.6mg/l to 8.3 mg/l (spring).Surveys done by the Monmouth County Health Department confirm this to be influenced by leachate from the M & T De Lisa Landfill (Seaview Square) and the Neptune Township Landfill.

Inlet #4, Interlaken, had the highest enterococcus levels of 369-390 with fecal coliform levels of >1600 in both spring and summer. Of all the inlets, this sampling spot is closet in proximity to an upstream duck pond and though other inlets have similar fecal counts, the enterococcus is not as elevated. Enterococcus is associated more closely with animal feces than human and is evident where waterfowl congregate. Deal Lake Brook had the lowest fecal levels during both sampling seasons of 22 and 50 with an enterococcus count of 0 in the summer. The prevalent fecal counts of 900 to >1600 can be due to the fact that sampling data was collected within 24 hours of rainfall. Generally, an increase is seen in wet weather after accumulated waste is washed into the storm drain system.

Nitrate (NO3) readings were highest at inlet #6 during both spring and summer, probably influenced by the collection of fertilizer runoff from the golf course on which it borders.

PH ranged from 5.8 to 6.8 in the spring and increased in the summer to 6.1 to 7.1. This is considerably lower than the in lake pH of 8 -9, and the outlet pH of 9 seen in the summer, probably due to tidal influence.

CONCLUSIONS

Deal Lake with its 153 storm drains and six main tributaries becomes a recipient of a large collection system delivering nutrients and road pollutants to the lake on a continual basis. The accessible waterway makes for mishaps such as accidental sewage overflows and oil spills to easily make their way to Deal Lake proper. Although Deal Lake can still support a variety of wildlife more attention must be given to the nonpoint sources.

WESLEY LAKE

PHYSICAL PARAMETERS

Chlorophyll a levels were extremely high during the fall (100mg/m3) indicating excessive photosynthetic activity, accounting for the higher dissolved oxygen (DO) levels seen at both sites at this time (8-11 mg/l). Cooler water temperatures allow for more oxygen produced by algae to be dissolved into the water column. As temperatures gradually increase through spring and summer in Wesley Lake, DO gradually decreases. Chlorophyll a measurements indicate a similar decrease (22-24mg/m3) in photo synthetic activity accounting for this drop in DO (2-3mg/l). The high number of algae cells present however at both sites in the summer, 122-148,000 cells/ml, are respiring during the night consuming oxygen. The oxygen pool is not being replaced during the day due to the depletion of nutrients often seen in the eutrophication of lakes. The secchi disk readings reflect this eutrophication process, never reading greater than .6m at any time. pH ranged from 5.7 to 6.8 at either site throughout the year. With excessive productivity pHs are generally higher, 7-8, but decomposing humic substances will counteract the rise and in fact can lower the pH to 5. Also there are acidic springs discharging into the lake from the underlying Kirkwood formation.

NUTRIENTS

Ortho-phosphate (PO4), non detectable throughout the year. Nitrate nitrogen (NO3), the available form of nitrogen for plants is extremely low, at .1mg/l to .3mg/l.

The nitrate and ammonia levels found in Wesley Lake are more likely due to decomposing algae and zooplankton unable to be sustained in the eutrophying lake. Ammonia is a by-product of decomposition of organic matter. The lake is only 1.0m to 1.7m deep and is anaerobic in the bottom sediment; during the summer, gases (nitrogen, etc.) can be observed bubbling bottom muck to the surface by the inlet.

BACTERIA

Fecal coliform were highest during the fall and summer: 1600 - >2400 colonies. This reflects runoff and warmer temperatures during these seasons. Enterococcus was highest in the summer;

90 colonies at Site one. In addition to rain and warm temperatures, dog droppings along the grassy area around the lake may be a factor. Because the lake is so shallow, wind will resuspend and redistribute the sediments, which will increase the number of bacteria present throughout the water column.

ALGAE

Chlorophyll a levels were extremely high during the fall (100) versus spring and summer (22-51). The phytoplankton was not quantified during the fall sampling; during the spring and summer, green algae were the dominant species. Total cell count was highest in the summer at 148,132 cells at Site 1. The green algae species Nanno chloris sp. dominates the lake at both sites during the year.

This is common in several coastal lakes. However, the high diversity of species found in significant numbers clearly implies the lake is dominated by pollutant tolerant algae.

STORM DRAINS AND UPSTREAM SURVEY

Thirty-one storm drains have been mapped around Wesley Lake, and one runs parallel to it before mixing with the lake water east of the dam and discharging into the ocean. This storm drains was repaired in the fall after a sewer interconnection was identified by this department. Storm drain water quality decreased during the summer; for example, the ratio of enterococcus to fecal coliform increased from the spring; enterococci persist longer in the environment than fecal coliform. At storm drain 1, the nitrate increased to 2.29 mg/l; this is probably due to the release of nitrogen from the anaerobic sediments deposited in the lake by this pipe. These sediments are also contaminated with oil from a site identified upstream of the lake.

CONCLUSIONS

The accelerated eutrophication of Wesley Lake is mainly caused by nonpoint sources such as runoff from well maintained lawns, both residential and commercial, in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. Fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash.

FLETCHER LAKE

PHYSICAL PARAMETERS

There is tidal influence in Fletcher Lake; there was zero salinity at sites as well as the inlet and outlet throughout the year. Site 1 is representative of the west end of the lake which is dammed by a wooden barrier across the lake. The depth of the water in the fall was .3m and contains another .3m of detritus covering the sediment. Site 2, representing the major body of the lake had a depth of 1.15m in the fall. Both sites see a slight increase in depth during the spring probably due to runoff. However in the summer depths return to .25m (Site 1) and 1.2m at Site 2.

The secchi disk readings were <.3m for both sites in fall indicative of excessive proliferation of phytoplankton. Due to the shallowness of Site #1 the secchi remained consistent with the water depth in both spring and summer. At Site #2 however, the suspected increase the spring is seen due to lower algal cell counts as indicated by the low chlorophyll a measurements of 25mg/m3.

An increase in dissolved oxygen (DO) is common in the spring with solubility of oxygen increasing in colder waters and bacterial respiration declining after winter.

Although this is reflected at both sites in the spring, DO at Site 1 drops to 3.0 mg/l in the following summer months. Extensive accumulation of detritus at Site 1 supports bacteria that consume O2 during decomposition. In fact, the strong sulfur dioxide odor present implies anaerobic decomposition in the lower layers of detritus, where oxygen has been depleted. In contrast to this stagnating characteristics of Site 1,DO measures 9-11mg/l at Site 2, an area of greater mixing and circulation. In addition, the high photosynthetic activity with chlorophyll a measuring 60.6mg/m3 contributes to this increase as well as to the rise in pH to 8.6 and 9.3 during the productive seasons.

PH at Site 1 averaged 6.3 during each season. This is attributed to the decomposition of organic debris present which can typically lower the pH to 5.

NUTRIENTS

Ortho-phosphate (PO4) is not detectable at any sampling site throughout the year. Nitrate (NO3) and ammonia (NH3) levels were higher in the spring than summer throughout the lake due to less uptake by algal cells. Nitrate levels were higher at Site 1 and the inlet than at Site 2 and the outlet throughout the year probably because of road runoff and the concentrated bird droppings in shallow stagnating waters of Site 1.

BACTERIA

The abundance of residential waterfowl present at Site 1 can account for the high bacteria counts of >1600 especially during warmer weather which enhances bacterial growth. Spring readings were only 30 at the inlet and 300 at Site 1. Bacteria counts at Site 2 ranged from 50 in the spring, again in cooler waters, to 300 in late summer. Fecal coliform at the outlet was constant at 170. There is more dilution and fewer birds at Site 2. The enterococcus counts, which are more concentrated in animal feces than humans, read only 1 during spring at Site #2 and the outlet, and increase to only 3

and 11 respectively in the summer. In comparison, both Sites 1 and the inlet ranged from 35 in spring to 223 in the summer.

ALGAE

There is a wide variety of algae types in Fletcher Lake but green algae comprises the highest percentage at each site throughout the year. Within this group Nannochloris sp. comprises most of the cells/ml at any given time. There is no significance to this particular genera except that it is not presently overrun by other pollutant tolerant species known to be in the lake. However, if the constant input of nutrients and pollutants from non point sources continues the "polluted" species, Nitchia acicular is and Scenedesmus quadricauda may be able to proliferate and out compete the thriving cleaner water species. The blue-green algae group, usually associated with eutrophication is very limited in Fletcher Lake and is found in low numbers. In the summer Oscillatoria minima experiences a growth spurt but is not present in the fall or spring. Oscillatoria is known to be slime producing and may be undesirable.

STORM DRAINS

There are twenty-two storm drains that discharge into Fletcher Lake. None of these pipes were observed flowing, except after rainfall, in the fall of 1988. Two storm drains #11, and #19 were flowing in dry weather in the spring season due to increase of runoff. These were sampled for nutrients and bacteria.

Fecal coliform was >1600 for both with enterococcus level of 610 and 419. Ammonia levels were higher than the in-lake readings at .48mg/l. Nitrates were similar to the inlet readings at 1.1mg/l and 1.2mg/l. This is a prime example of runoff discharging street debris and animal waste into the lake. Several sewer interconnections in the inlet storm drain to Fletcher Lake were abated west of Memorial Drive in 1986-87.

CONCLUSION

Fletcher Lake is widely used as a recreational area with an access bridge at the west end and a playground - park bordering its northeast corner. It collects water from storm drain systems of residences and businesses including numerous service stations. The small dam at the west end that slows water movement and allows settling of nutrients and pollutants, illustrates the accelerated effect of nonpoint source pollution. This area of the lake acts as a detention basin and slows the flow of road run off to the ocean. This may be temporarily positive for the impact on coastal waters but the lake itself is losing its aesthetic value and in extreme hot temperatures smells of hydrogen sulfide.

SYLVAN LAKE

PHYSICAL PARAMETERS

Salinity at all sites is zero, or just above detection limits, indicating the lack of tidal influence.

The decrease in pH during the spring may be due to bacterial decomposition of organic matter. The extensive macrophytes Vallisneria americana or tape grass present in the fall would provide such a source. Increases in the pH in the fall and summer may also be affected by fertilizer runoff from the well maintained lawns that surround the lake, as well as photosynthetic activity.

The dissolved oxygen is also the highest during the spring, (9.4mg/l to 10mg/l) which is common throughout the coastal lakes. The decrease of oxygen consumption by bacteria and algae along with increased volume of colder water can account for this trend. The secchi disk readings remained at .3m at both sites during the sampling seasons indicating extensive plant and algae growth within the lake.

NUTRIENTS

Nitrate levels were highest in the spring (1.5mg/l at site 2), which reflects the comparative lack of algae not utilizing the nutrients, and storm runoff. Ammonia is also highest in the spring (.38mg/l), again related to the runoff and decomposition of dead plant material. Phosphate is typically below detection limits.

BACTERIA

Fecal coliform were generally quite low, except for one marginally high reading in the fall (920 colonies); enterococci did not rise above 6 colonies. This could be directly related to the limited impact of storm drains noted to have little or no flow most of the year.

ALGAE

Chlorophyll a levels were highest in the summer (35.46mg/m3 and 37.78 mg/m3 versus 20mg/m3 and 16mg/m3) in the spring reflecting an increase in photosynthetic activity. A decrease in the total # of cells resulted during the summer, but blue- green algae proliferated, accounting for the rise in chlorophyll a .Green algae comprised 61% of the total cells compared to the previous 94% , and blue-green inversely were 33% from a previous .4%. At this time the ever prevalent genera Nannochloris dropped in total cell numbers from 92,000 to 4,000/ml. It seems without treatment that these dominant green algae are limiting species diversity throughout the nine coastal lakes.

STORM DRAINS

Thirty storm drains have been mapped around Sylvan Lake; none of these were noted with significant flows during dry weather.

OUTLET SAMPLING

The outlet at the east end of the lake was sampled in all three periods; the highest enterococci levels were during the spring (25 colonies), which is consistent with the findings in the in-lake stations. Enterococci are comparatively more numerous in the feces of animals than in humans; and Sylvan Lake supports a resident waterfowl population.

CONCLUSIONS

The obvious eutrophication of Sylvan Lake is probably caused by nonpoint sources such as runoff from well maintained lawns in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. The fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash; it is evident that many residents use this grassy area for walking their dogs.

SILVER LAKE

PHYSICAL PARAMETERS

The uniformity of saline readings at Silver Lake throughout the year implies salt water intrusion via groundwater, as well as flowing in during high tide. Salinity at both in lake stations was highest in the fall at 14 parts per thousand (0/00). The overall drop to 6 0/00 throughout the lake in both spring and summer strengthen this implication. The timing of the fall sampling was nearest high tide and water depth was 2m compared to spring and summer depths of 1.6m. Having a lower water depth in the spring when other coastal lakes are experiencing an increase due to spring runoff, also indicates tidal influences at Silver Lake.

A pH of 8.0 at all four sampling sites in the spring is representative of uniform salt water intrusion. PH remains at 8.0 during the summer at all sites except the inlet where the slight drop to 7.2 can be due to an increase of nitrates and ammonia-nitrogen (see nutrients). Fall readings of pH were slightly more acidic ranging from 5 to 8 at Site 1 to 6.9 at both inlet and outlet. This could be due to the accumulation of humic substances found in large quantity at the inlet as well as the perimeter of the lake.

An increase in dissolved oxygen (DO) to 12 mg/l at each site in the spring can be accounted for in part by decreased O2 consumption by respiring bacteria. Chlorophyll a measures only 11 mg/m3 from a previous 151 mg/m3 in the fall. This decrease of photosynthetic activity is caused by an annual program of algacide application to Silver Lake. As a result, secchi disk readings gradually improved to 1 meter in the summer as the total number of cells/ml decreased to 15,000 from a previous 70-93,000.

Consequently, DO drops during the summer at Sites 1 and 2, (6.5 & 8.1 respectively). Warmer water temperatures and increased hours of sunlight contribute to the minimal increase of chlorophyll a to 13 mg/m during the summer.

NUTRIENTS

Nitrate-nitrogen (NO3) and ortho-phosphate (PO4) were below detectable limits at all four sampling sites during the fall and spring except at the inlet when NO3 was .056mg/l in the fall. The low concentration of nutrients is usually seen in eutrophic water bodies due to the utilization and uptake by algae. In the summer NO3 increases at each site ranging from .07 mg/l to .15 mg/l. With algacide applications limiting algae growth an increase in nutrients is expected. However, PO4 did not increase.

Ammonia nitrogen (NH3) concentrations ranged from .053 mg/l at the inlet to .12 mg/l at the outlet. NH3 is a metabolic by product of decomposition of organic material. Subsequently, in the spring an increase in NH3 is seen throughout the lake (.1mg/l to.14mg/l) except at Site 2 (.06mg/l), an area of greater mixing and not conducive to collection of organic debris. A consistent drop is seen at each site in the summer to .06mg/l except at the inlet which remained .11mg/l. This is probably due to concentrated bird droppings seen near the inlet (see bacteria).

BACTERIA

In the fall both in lake sites had fecal coliform counts of 130, indicative of fair water quality. The highest count was at the inlet, 900, with the outlet reading 500.

Winter bacterial die-off and a decrease in migrating bird population could contribute to fecal coliform levels dropping to <50 at all four sites in the spring. Enterococcus, however, varied between sites with #2 having the lowest count of 3 and the inlet and site #1 having >100. The outlet was 25.

Fecal coliform counts increased to 900 at site #1 and >1600 at the three remaining sites during the summer. Each of these three sites had a corresponding enterococcus elevation with a high of 613 at the inlet. This most likely is associated with nonpoint runoff and water sediment turbulence, as the sampling was per-formed immediately following rain. Another source is the enormous number of birds congregating at either end of the lake at this time, but especially by Ferruggiano Park where frequent feeding of ducks and geese was observed. Bacteria will multiply in the warmer water more rapidly and can survive and reproduce among the accumulation of leaves and debris present at Silver Lake inlet. The trash floatables also increase during the summer along the park.

ALGAE

Silver Lake is treated annually with the algacides copper sulfate and aquazine. As a result phytoplankton diversity is limited to those resistant to the algacides.

In the spring the lake is comprised totally of green algae with one genera Nannochloris sp. monopolizing the total # cells/ml at both sites. Summer conditions allow blue-green and brownish algae to proliferate, but green algae still comprises over 91% of the total # cells/ml at both sites. However, due to treatment, these totals drop to 15,000 cells/ml from a previous 70-90,000 cells/ml.

The blue-green algae Oscillatoria guttulata is known to be toler ant to organic enrichment and is found at Site #1 at .38% during the summer. Chlorophyll a measurements were highest in the fall at 151 mg/m3 compared to spring and summer of 11-13mg/m3. This is due to the degradation of algacide applications coupled with unseasonably warm temperatures.

STORM DRAINS

Twenty-two storm drains were located and numbered on Silver Lake. In the spring, storm drain #8 and #9 were flowing compared to the previous fall when no storm drains were flowing. This is attributed to spring runoff. Both storm drains were checked on June 13 after rain and found flowing.

On August 2, both storm drains were sampled during dry weather. Fecal coliform levels read 240 and 900 respectively with comparable Enterococcus levels of 201 and 204. Nitrate and ammonia levels (.18mg/l-1.1mg/l) were higher than in- lake nutrient levels and pH was slightly above 7.0. It should be noted that the flow was greater at storm drain #9 than #8 when comparing bacteria and

nutrient impacts within storm drains. Storm drain #9 was consistently higher for each parameter measured.

CONCLUSION

While the algacide program for Silver Lake is limiting excessive plant growth and enhancing the aesthetic value of the lake, the perimeter of the lake is routinely used for dog walking. Ferruggiaro Park borders the southwest end of the lake where picnicking is common as evidenced by the increased floatables and food trash seen on fair weather days. The organic element of both food and feces can only add to the acceleration of eutrophication by adding nutrients to the lake for bacterial and algal growth. Additional impacts from storm drains must also be addressed if Silver Lake is to continue to be a source of recreation and enjoyment for people and of shelter and residence for wildlife.

LAKE COMO

PHYSICAL PARAMETERS

As noted in the previous report, Lake Como is the only tea-colored coastal lake, due to humic acids from decaying vegetation upstream in the Polypod Brook watershed. This affects the chemistry of the water and the sediments.

The increase in pH in the summer is probably because algae release carbon dioxide during photosynthetic activity which increases with warmer weather and more daylight. This causes a shift in the bicarbonate-carbonate buffering system and results in a decrease in the concentration of hydrogen ions - and therefore a rise in pH. There was less rain in the fall of 1988 than in the spring and summer of 1989; the 6.6 pH in the fall probably reflects the proportionally higher amount of acidic groundwater discharging into the lake. Site 2, by the outlet, is subject to some tidal flows, as indicated by salinity readings of .1 -1.0 parts per thousand throughout the year.

Dissolved oxygen is highest in the fall (10.31mg/l to 11.21mg/l). This may be related to photosynthesis as the highest number of algae cells at each site occurs at this time.

NUTRIENTS

Nitrate levels were some of the lowest in all the coastal lakes, with it being nondetectable at both sites in the summer. This is indicative of excessive phytoplankton uptake as confirmed by chlorophyll a measurements of 68 mg/m3 and 72mg/m3 at Sites 1 & 2 respectively. Ammonia levels were consistent with other lake parameters as lower numbers were seen during proliferation of algae in fall and summer and increases were seen in the spring with decomposition of plant material and runoff.

BACTERIA

Fecal coliform were low throughout the lake; the highest reading (220 colonies in the spring at Site 1) is barely above the 200 fecal coliform standard for ocean bathing beaches. Enterococci are also below the recommended EPA standard of 35 colonies for swimming beaches.

ALGAE

Blue-green algae proliferates during the summer in Lake Como as in most of the coastal lakes, changing the percentage of green algae to 68%-80% from a previous 94% in the spring. The genera most prevalent in the nine coastal lakes, Nannochloris, comprises about 50% of the total cell count at each site throughout the year, even as the total number of cells continually increases. Fall shows the highest number of cells with flagellates increasing to 25% of the total and green algae dropping to only 56% of the total. Flagellates are known to survive in organically enriched environments. However, the green algae Ankistrodesmus falcatus, generally associated with clean water, appears at both sites but in low numbers.

STORM DRAINS

Thirty-seven storm drains have been mapped around Lake Como. Elevated enterococci levels were found in # 22 and #23 in the summer (156 and 173); however, coliform levels were low in these pipes (500 and 220). Enterococci are more prevalent in animal feces than in human indicating these levels probably originate from collection of bird and dog droppings. Other sampling data of the same pipes show very low enterococci levels of 1 and 10 with corresponding fecal counts of 60 and 30 respectively, confirming this assumption. The storm drains #2, #3 and #5 were sampled in June of 1989. Results are indicative of road runoff and rain-water collection. Fecal coliform colonies were 500 -1600 and ammonia and nitrate nutrients were considerably higher than the in lake levels ranging from .31 mg/l to 1.62 mg/l. The common pH of 5.8 for each storm drain is indicative of the acidic rain water.

INLETS, OUTLET, AND UPSTREAM SURVEY

The most striking trend is the elevated enterococci compared to coliform at both the inlet and the outlet. For example, at the inlet in the summer, there are almost 1000 enterococci. Enterococci are comparatively more numerous in the feces of animals than in humans. Polypod Brook (the inlet) was walked by health department personnel in the fall and no point sources of these bacteria are evident. These levels reflect impacts from nonpoint sources, such as animal feces from road runoff, lawns etc.

CONCLUSIONS

The eutrophication of Lake Como is primarily being caused by non point sources such as runoff from well maintained lawns, both residential and commercial, in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. The waterfowl on the lake are also adding nutrients that promote algae proliferation. Fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash.

SPRING LAKE

PHYSICAL PARAMETERS

Salinity at all sites is zero, indicating the lack of tidal flow. The increase in pH during the spring may be due to an algae bloom before the lake was treated, as indicated by the high chlorophyll a levels. Carbon dioxide is fixed by algae during blooms which cause a shift in the bicarbonate-carbonate buffering system and results in a decrease in the concentration of hydrogen ions - and therefore a rise in pH. Since it rained the day before the sampling took place, it may also represent the effects of fertilizer runoff from the well maintained lawns that surround the lake.

Algae metabolism also accounts for the increase in dissolved oxygen during the spring (12.4 and 11.5). The secchi disk readings in the spring and summer are also significantly lower than in the fall (.4 and .5m versus 1.45).

NUTRIENTS

Nitrate levels were highest in the summer, which may reflect the lack of uptake by algae following treatment of the lake during the summer (.71 mg/l versus .08 mg/l). Ammonia is highest in the spring, which is typically seen because of decomposition of plant materials and the return of migrating waterfowl. Phosphate is typically below detection limits.

BACTERIA

Fecal coliform were generally quite low, with a range from 2 to 170 colonies; enterococci did not rise above 33. The minimal number of storm drains at Spring Lake in conjunction with the low flow rate of these storm drains can account for the comparatively low bacteria counts in relation to the other coastal lakes. This is fortunate, as Spring Lake discharges directly into the ocean at Essex Av. (there is a second outfall at Ocean Av. by Wreck Pond).

ALGAE

Chlorophyll a levels were highest in the spring (82 and 51 mg/m3 versus 40.77 and 43.18 mg/m3) probably reflecting conditions before the lake was treated for algae. Green algae were the dominant species in the spring and summer (75 - 93%); blue- green was also significant in the summer only (21%). Blue-green algae are generally associated with eutrophic conditions and proliferate in summer with warmer water temperatures and increase sun light. Even with algacide applications species diversity and total # of cells present at each site are comparatively high.

Algacide is controlling certain species present in the spring, but these are quickly being replaced by other dormant species within Spring Lake.

STORM DRAINS

Sixteen storm drains have been mapped around Spring Lake; none of these were noted flowing in dry weather.

OUTLET SAMPLING

The outlet at the southeast end of the lake was sampled in all three periods; the highest enterococci levels were during the spring (38 colonies) , which is consistent with the findings in the in-lake stations. Enterococci are comparatively more numerous in the feces of animals than in humans; and Spring Lake supports a resident waterfowl population.

CONCLUSIONS

The gradual eutrophication of Spring Lake is probably caused by nonpoint sources such as runoff from well maintained lawns in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. The fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash.

At this time, algae blooms are being controlled by the use of aquazine. The public must become more aware of the significance of nonpoint pollution: that runoff and seepage from many small discharges are the most significant sources of the deterioration of Spring Lake.

WRECK POND

PHYSICAL PARAMETERS

What is striking about the Wreck Pond data are the differences between Site 1, the fresh water inlet, and the other two sites, which are tidal.

Sites 2 and 3 are consistently tidal; the average ocean pH ranges from 7 to 8; and of course, the salinities are higher than Site 1. Site 1 is only saline in the fall of 1988, possibly because the lack of rain that year decreased the flow of fresh water into the lake and allowed the tide to push further upstream in the lake.

The increase in pH at Site 2 (8.6) and Site 3 (9) could also be due to the fixation of carbon dioxide by algae during blooms. This causes a shift in the bicarbonate-carbonate buffering system and results in a decrease in the concentration of hydrogen ions - and therefore a rise in pH. Fall has the highest pH because of algae blooms; spring has the lowest because of the large volume of fresh water discharging into the lake during the record rain of 1989.

Algae metabolism at Site 3 also accounts for the increase of dissolved oxygen at this site in the fall (13.5mg/l); while algae decay may account for the low DO at Site 2, the shallow inlet known as Black Creek (4.5 mg/l). The lake was treated to control algae in the summer of 1989; and because of that, and the rain keeping the currents moving, DO stayed around 8.5 through the summer as well as the spring. This was also reflected in the secchi disk readings, where spring and summer had the highest readings.

NUTRIENTS

Nitrate levels were highest in the spring, during the time when there is the most runoff and a minimal phytoplankton population;

Site 1, at the inlet, consistently has the highest nitrate levels, .79 mg/l in the spring. Fall, with the lowest nitrate levels, reflects maximum nitrate uptake by phytoplankton. Ammonia follows the same pattern; phosphate is typically below detection limits.

BACTERIA

Fecal coliform were highest at Site 1 during the spring and summer: 900 - 1600 colonies. This reflects runoff and warmer temperatures during these seasons. Enterococcus were highest in the summer, with Sites 2 (973) and 3 (1118) having the highest levels; in addition to rain and warm temperatures, the resident waterfowl population may also be determining the extreme difference between these levels and the coliform.

ALGAE

Chlorophyll a levels were highest in the summer at Sites 2 and 3 ranging from 62-72mg/m3. This is a direct response to the 10 fold increase in the number of cells of algae present from the previous spring season. Ninety-six percent of the total at either site are of the green algae group. The

predominance is shared in each season by two different species. The commonly predominant genera Nannochloris sp., seen increasing in most coastal lakes during the summer, decreases and is over taken by Chodatella quadriseta in the summer. This monopolizing affect is indicative of an algal bloom. It is interesting that in the fall green algae drops below 40% in volume at all three sites and golden-browns begin to increase along with flagellates which are known to be found in organically enriched areas. Pithophora blooms are commonly observed in this lake.

STORM DRAINS

Thirty-six storm drains have been mapped around Wreck Pond; five of these flow in dry as well as wet weather, depending on the time of the year. Storm drains were sampled in the spring for a variety of parameters; it rained the day of the sampling, 5/24/89, as well as the day before. This is reflected in the elevated coliform and enterococci in two of the storm drains; the third, (#1), is primarily an overflow drain for Spring Lake, as well as the discharge for storm drains along the southern end of Ocean Av. Number 11 has the largest drainage basin, located near the Spring Lake Department of Public Works.

INLETS, OUTLET, AND UPSTREAM SURVEY

The most striking trend is the large amount of enterococci in the outlet in the summer (1111) compared to coliform (500). This site is higher than the levels found in the inlets or storm drains. Enterococci are comparatively more numerous in the feces of animals than in humans; and Wreck Pond is known for its large resident waterfowl population, that congregate in the main body of the lake above the inlet. Black Creek, the smaller inlet downstream of the Spring Lake Golf Course, has somewhat higher nutrient levels, especially nitrate in the summer- Black Creek 1.15 mg/l; Old Mill Creek: .84 mg/l. Old Mill may still be a more significant nutrient source because of its larger flow.

CONCLUSIONS

The accelerated eutrophication of Wreck Pond is being caused by nonpoint sources such as runoff from well maintained lawns, both residential and commercial, in the watershed. Street runoff, especially during the increased traffic in the summer, is also a major nutrient source. The waterfowl on the lake are also adding nutrients that promote algae proliferation. Fringe areas around the lake should not be used for dog walking unless the droppings are removed and placed by the owner in his trash. At this time, Pithophora blooms are being controlled by the use of an algacide application in the early spring.

RECOMMENDATIONS

Of the nine lakes, Takanassee Lake had the lowest overall levels of bacteria and chlorophyll a. This may be because the lake is really a series of four lakes; three impoundments immediately precede the largest pond that is located east of Ocean Avenue. These may be acting as detention basins which remove settling solids and adsorbed nutrients. This lake also has most of its macrophytes growing in the main current of the lake, rather that just along the banks. One of these macrophytes, Elodea sp., is used in sewer plants to remove Biological Oxygen Demand and Total Suspended Solids. These are parameters which measure nutrients and adsorption sites for bacterial growth and algae.

The new Sewage Infrastructure Act will eventually address the abatement of nonpoint pollution from storm drains, lawns, traffic, etc. over time. At this point, however, the public must become more aware of the significance of nonpoint pollution: that runoff and seepage from many small discharges are the most significant sources of the deterioration of these lakes. The Monmouth County Health Department encourages local citizens to form Water Watch groups, under the NJDEP sponsored program.

By forming a Water Watch group, residents can become directly involved with prioritizing solutions, and will become more aware to notify the health department of violations as they are happening. For more information on this program, call the Monmouth County Health Department at 431-7456; or the Water Watch program at the NJDEP, at 609-633-7021. To report spills at any time, call the DEP at 609-292-7172, or call the Monmouth County Health Department.

Appendix
Sediment Sampling

Bulk sediments in the nine (9) lakes were sampled for Total Petroleum Hydrocarbons, (TPH), Heavy Metals, PCB's and Pesticides – in the same sites as the aqueous samples.

The two most impacted lakes, Fletcher and Wesley, are located in an older, somewhat urban area of the coastal zone. However, all lakes contain these contaminants to some extent (see table). Site one, which is closest to the feeder streams of the lake, almost always contains higher levels of pollutants than site two, which is nearest to the lake outlet.

Lakes act as sinks for sediments moved by storm events in the feeder streams, or in storm drains discharging into the lake, or in direct overland flow.

Small elongated finger lakes, with more shoreline, tend to accumulate more sediment; slow-flowing lakes also have higher rates of sediment settling.

Pollutants will absorb to mucky, fine organic sediments more than to coarse sand. Storm events will also re-suspend and re-distribute sediment contaminants already in the lake, as well as bioturbation – the movement of benthic organism that live in the sediments. The amount of contaminant that is released from the sediment into the water also depends on the re-dox potential, which measures, among other parameters, how oxygenated the sediments are.

There are no definitive federal guidelines relating the total amount of pollutants in aquatic sediments to impact on the environment and public health. The Army Corps of Engineers, when reviewing an application for dredge disposal, generally requires only a limited analysis of sediment, which exposes test organisms to the sediment and then times how long it takes for half of them to die. Chronic bioassays can also be required, which measure damage in addition to death. Included in this appendix is a preliminary classification of aquatic sediments compiled by the EPA for the Great Lakes Commission in 1977. Most of the coastal lakes sediments fall into the moderate and heavily polluted categories. The sources of the contamination, all non- point, are both specific and ubiquitous.

TPH & Heavy Metals

Total Petroleum Hydrocarbons includes straight-chain, cyclic, and ploy cyclic hydro-carbons. Natural sources of these elements, such as from decomposition of leaves, probably represent a small amount of the analysis; the bulk is from petroleum compounds found in oil and gasoline. Heavy metals are also naturally present in soil, a table has been prepared from seven sources to provide baseline for comparing the metals found in the lake sediments. Almost all levels are above background. The sources of the metals are variable; for example, Mercury was used in pesticides and thermometers; Selenium is used in photo-electric cells. However, they all are commonly found in oil; a table is included that lists the various amounts of metals found in used and virgin oil. Many metals are also trace elements in various alloys and pigments.

The “upstream survey” section of the main reports list some of the specific sources, now abated and no longer in litigation that had previously discharged petroleum products into some of the lakes or their tributaries. That Fletcher and Wesley Lake sediments generally contain higher levels of TPH and metals than the other seven (7) lakes, points to the importance of specific non point sources – such as spills, or dumping used oil into catch basins, or leaking underground storage tanks etc. However, the fact that all the lake sediments contain these contaminants points to non specific sources-classic non point pollution – an impact created by the cumulative effect of the sheer number of ubiquitous, chronic releases. A short review of the effects of storm runoff and atmospheric deposition ranges from nearby sources, such as traffic, and precipitation scavenging of the finer particulates and gases from distant sources.

Storm Runoff & Atmospheric Deposition Continued

The metals accumulated in the lakes represent past sources in addition to present. The atmospheric input of lead to water is probably less now than in the recent past. This can be inferred from the measurements of lead in blood. A recent “Innovation” program on PBS noted that the average blood lead in America is down 38% since the reduction of lead in gasoline, thereby removing it from the exhaust and the ambient air (Innovation 1989) Air Pollution can not be considered distinct from water pollution.

The 1980 census estimated about 5000,000 people live in Monmouth County; 189800 households were estimated in 1985 based on the 1980 census (somewhat less than three people per household). For illustrative purposes, assume three cars are owned for every two households; this is about 285,000 cars. This surely under estimates the total vehicles in Monmouth County- it does not include fleets of cars operated by business and government, or buses, trucks etc. It also does not take into account commuter traffic or summer tourism. For instance the Garden State Parkway reports the annual average daily volume of cars for 1988 at the North bound lane of the Asbury Park toll Plaza is 57,030 vehicles. In July of 1988, 74,520 vehicles per day passed through this toll plaza.

This interim report is a presentation of data and a preliminary acknowledgement of areas of concern. Site specific sources of contamination will continue to be located and abated through existing or recent regulations.

Public education programs, like the Water Watch Program (adopt-a-stream), must be encouraged. So should government sponsored events, like special days that residents can turn in their old pesticides and other hazardous wastes to the Health Department for proper disposal (two were sponsored by the Monmouth County Health Department and the NJDEP in 1988; more are proposed for 1989).

Improving local use of mass transportation and encouraging car pooling is evidently warranted.

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GLOSSARY

Ammonia - NH3: Another of the five common forms of nitrogen, it is a metabolic by-product of the decomposition of organic material. Naturally present in surface and groundwater at low concentrations.

Chlorophyte: Green algae, (division Chlorophyta).

Chlorophyll: Photosynthetic pigment found in most plants, generally proportional in quantity to the plant biomass.

Chrysophyte: Golden or yellow-green (division Chrysophyta)

Cryptophyte: Algae of variable pigment (division Cryptophyta)

Cyanophyte: Bluegreen algae (division Cyanophyta)

Diatom: A specific chrysophyte, having a siliceous shell, commonly found in great variety in fresh or saltwaters (sub-division Bacillariophyta)

Dinoflagellate: Unicellular algae, usually motile, having pigments similar to diatoms. More commonly found in saltwater (division Pyrrhophyta)

Dissolved Oxygen: The amount of the gas which is held in solution in water measured in parts per million or milligrams per liter. This will vary with respect to certain physical, chemical and biochemical activities in the body of water.

Enterococcus: A subgroup of Fecal Stretococcus bacteria normally present in the intestine of warm blooded animals; it persists longer in the environment than fecal coliform bacteria.

Euglenoid: Algae similar to green algae in pigment, but with unique food storage and cell wall structures (division Euglenophyta)

Eutrophic: High nutrient, high productivity trophic state generally associated with poor water quality.

Eutrophication: As a body of water ages, it passes from a low nutrient concentration, low productivity stage to a high nutrient concentration, high productivity stage. Eutrophication is a long-term natural process, greatly accelerated by man's activities.

Fecal Coliform: A group of non-pathogenic bacteria abundant in the colon of warm blooded animals. Their presence or absence is used as a bacteriologic index of water pollution since they longer lived in water and more resistant to chlorination than the common human pathogenic bacteria.

Heavy Metals: Found in nature, includes mercury, lead, cadium, chromium, etc. Various metals are found as trace elements in most alloys.

Leachate: Water and dissolved or particulate substances discharging from a landfill.

Limiting Nutrient: That nutrient of which there is the least quantity, in a system, but which will cause cessation of productivity when it is taken out of a system.

Macrophyte: A plant of higher taxonomic position than algae, usually a vascular plant completely or partially in water.

Nitrate NO3: One of the five common forms of nitrogen and an essential nutrient for plants. The preferred form for uptake by algae and higher plants, its concentration can reveal much information on the productivity and trophic states of a lake, especially when measured over a prolonged scale.

Non-point Source: A diffuse source of loading, including runoff from all land types.

Pesticides: Used for termite control, lawn and ornamental care, etc. Most of the pesticides found in these lake sediments have been banned for at least a decade.

pH: The term used to describe acidity or alkalinity, it is the concentration of free hydrogen ions. Based on an arbitrary scale of zero to fourteen with (7) being neutral, lower then seven(7) acidic, higher than seven(7) alkaline.

Phosphate - PO4: The form in which phosphorous usually occurs in natural and wastewaters. Essential to growth of organisms, it is usually the limiting nutrient since it is the one in naturally short supply. Added to a lake via discharge of raw or treated wastewater, agricultural drainage or certain industrial waste, it may stimulate growth of aquatic algae and higher plants to nuisance quantities (blooms).

Phytoplankton: Algae suspended, floating or moving only slightly under their own power in the water column.

Point Source: A specific source of loading, including effluents or channeled discharges that enter natural waters at a specific point.

Salinity: The ionic composition of water; reported as grams per milograms or parts per thousand (0/00).

Secchi Disk: A round, 20 cm. in diameter, white and red metal dish used to provide an approximate evaluation of water transparency by measuring the mean depth at which it disappears and re-appears when lowered from a boat.

Sedimentation: The deposition of various solids on the bottom of a lake.

Sanitary Sewer: A pipe constructed to contain the flow of domestic and industrial wastewater.

Storm Drain: A pipe constructed to allow groundwater and storm water to discharge into a surface water body.

Total Petroleum Hydrocarbons: Includes straight chain, cyclic and polycyclic forms of petroleum.

Watershed: Drainage basin, the area from which an aquatic system receives water.

Trophic State: The biological, chemical and physical condition of aquatic system.