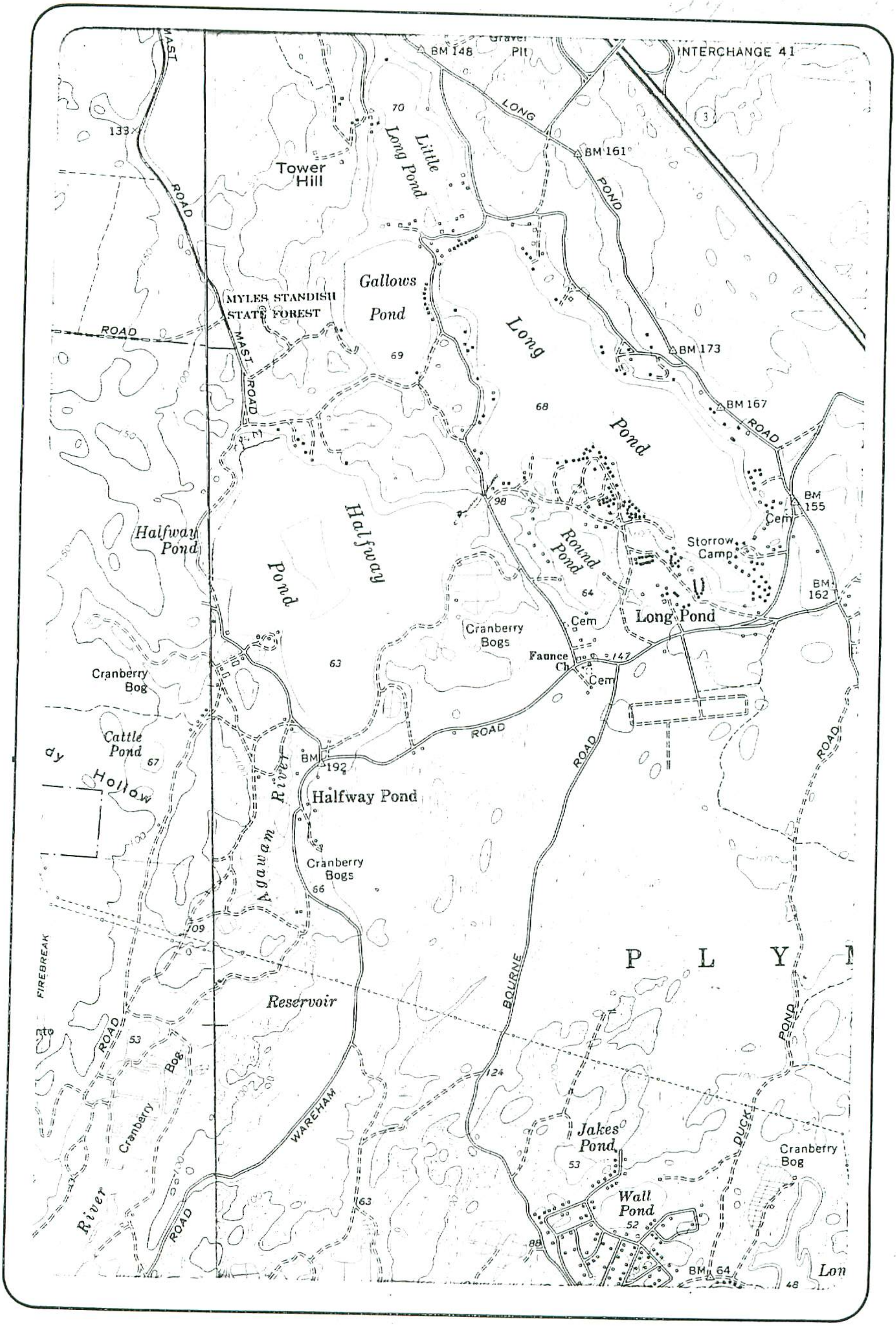
MAST
ROAD
BM 148
Gravel Pit
INTERCHANGE 41
LONG
POND
ROAD
3
70
Little Long Pond
133
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Gallows Pond
69
MYLES STANDISH STATE FOREST
ROAD
MAST ROAD
Long Pond
68
BM 173
BM 167
ROAD
BM 155
Cem
Halfway Pond
Halfway Pond
98
Round Pond
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Lyons-Skwarto did a previous base line survey and a modified eutrophication index for forty-one ponds in Plymouth and Little Long ranked thirty-first (31). It ranked high on the plant trophic index, it was thirtieth (30). Both the phosphate and nitrate readings were high and the pond was ranked as ultra eutrophic (hypereutrophic). Further studies were recommended mainly for its impact on Long Pond, which is oligotrphic. The outfall of Little Long contributes the only tributary to Long Pond and its volume per day is substantial. The nutrient loading from this known point might be substantial enough to change the trophic state of Long Pond from oligotrophic to eutrophic. Thus it was, the program was started and completed, always keeping in mind the updated guidelines of federal and state programing; most expecially the guidelines of the Federal Clean Lakes Program.

Another problem that was always present: would restorative remedies affect Long Pond? It was paramount that remedies should not endanger the trophic state of Long Pond.

# CLASSIFICATION DEFINITION

The trophic state of a lake is determined by a large number of factors including latitude, altitude, climate, watershed characteristics, soil types, human activities and lake morphometry. Three factors are found to be most important. They are climate, nutrient supply and lake depth.

OLIGOTROPHIC: Aquatic plant production is low; aquatic animal production is low; aquatic plant nutrient flux is low. Oxygen is present in the hypolimnion. Depth tends to be deeper. Water quality for most domestic and industrial use is good, total salts or conductance is usually lower Number of plant and animal species is varied and diverse. Oligotrophic waters have only a small supply of available nutrients, hence, they support little organic production.

EUTROPHIC: Aquatic plant production is high; aquatic animal production is high; aquatic plant nutrient flux is high. Oxygen in hypolimnion is absent. Depth tends to be more shallow. Water quality for most domestic and industrial uses is generally poor. Total salts or conductance is mostly higher. Number of plant and animal species is fewer. Eutrophic waters are waters with a good supply of nutrients, they may support rich organic production, such as algal blooms.

MESOTROPHIC: Lakes exhibit conditions between eutrophic and oligotrophic, their water is less transparent than oligotrophic waters, but more transparent than eutrophic waters. Supplies of dissolved oxygen decrease during the summer months in deep water, but do not disappear entirely as in eutrophic waters. Less all-around production than eutrophic waters.

The term ultraoligotrophic is sometimes used for lakes on the lowest extreme scale while the term hypereutrophic is used for this other extreme.

The above is a brief description of classification, and the trophic index was developed along these qualifications. The following parameters were considered in rating.

1. oxygen depletion
2. transparency
3. phytoplankton
4. nitrogen
5. total phosphorous
6. biological

A previous report rated Little Long Pond as a highly eutrophic pond and with the various parameters examined in this report this was brought into a sharper focus.

Plant production was very high throughout the growing season, there was an abundance of both macrophytes and microphytes. The elodea population was dense out to the seven foot contour line which included 90% of the pond bottom. Blue-green filamentous algae was found in the deepest points.

Phosphorus is usually the most important nutrient controlling lake productivity, therefore, total phosphorus is an important measure of a lake's trophic state. An average figure would generally be taken as between .015 .02 ppm as the lowest dividing line between eutrophic and oligrotrophic lakes, with a .04 ppm being a critical reading. Readings taken during non-productive season. The March, April and early May readings were well over the accepted critical. If the pond was nitrogen limited the above would not be so critical and the emphasis would be on the nitrogen readings. Little Long Pond is a phosphorus limited pond.

Nitrogen is an important plant nutrient, but limmologists have done little to develop quantitative trophic criteria for nitrogen concentrations .25 ppm of nitrate is generally taken as a critical point, above which algae and plant growth are greatly accelerated. The March readings are all high with station 2 and outfall very high, so high as to indicate nutrient pollution.

Little Long is a shallow non-stratified pond. Most eutrophic lakes tend to be shallow with a relatively extensive littoral zone.

# LITTLE LONG POND - A Problem Lake

Eutrophication = A natural enrichment process or a lake, which may be accelerated by man's activities. Usually manifested by one or more of the following general characteristics.

1. Excessive biomass accumulations of primary producers.
2. Rapid organic and inorganic sedimentation and shallowing.
3. Seasonal and dissolved oxygen deficiencies.

Indices of eutrophication

Biological parameters

Macrophyte identification and coverage

Submersed aquatic plant vegetation population was dense, with 95% of the benthos covered. Dominant species was Elodea. Heavy Elodea count out to 3 foot contour line.

Macrophytes - Phytoplankton

**Algal Generic** identification - algal pigment - chlorophylla.

Average summertime count of chlorophylla on trophic scale

.005 ppm oligotrophic .01 ppm eutrophic

Water color in July and August had a heavy green tint, with green unicellular alge predominant.

**Physical indicators - species pediastrum duplex at $10^4$/ml count $10^4$/ml oxygen depletion.**

This is a non-stratified pond and being so it exhibits standard fluctuations of oxygen common in shallow bodies of water. Readings are often high but oxygen depletion results when plant and animal respiration and and decay of organic material remove the dissolved oxygen from the water faster than it is replaced by or photosynthesis. Below 4.0 mg/l is considered critical.

Transparency

In oligotrophic lakes the secchi disc reading is 3 meters plus and the eutrophic reading ranges from 1 foot to 2.0 meters. Little Pond readings ranged from 5 feet (1.5 M) to 7 feet (2.13 M).

Depth - Shallow--Mean depth 05' 1.52 M most eutrophic
Maximum depth 08' 2.44 M

Lakes tend to be shallow with a relatively extensive littoral zone.

Chemical Parameters

Heavy metals - none to indicate industrial feeding.

Total phosphorus (i.e. the phosphorus present in both inorganic and organic, dissolved and suspended forms)

The dividing line between oligotrophic and mesotrophic lakes is usually regarded as about .01 ppm for oligotrophic and .02 for mesotrophic and .03 for eutrophic. Total phosphorus readings in Little Long were continually .03 or higher.

Indices of Eutrophication

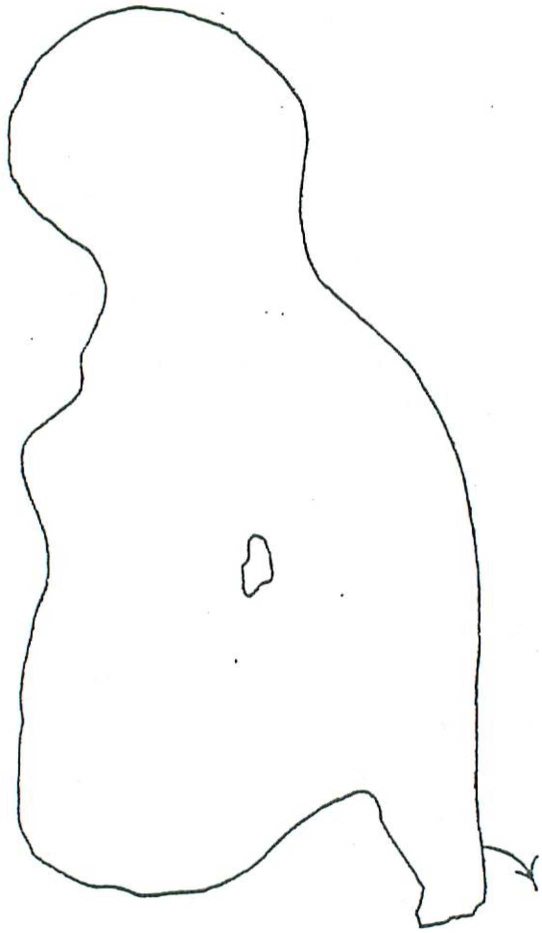
Chemical Parameters

Nitrogen. Eutrophic Lakes: Nitrates plus ammonia nitrogen. The lowest acceptable limit for eutrophic classification. In Long Pond the nitrate and ammonia nitrogen were usually above the bare minimum of .3 mg/l

Conclusion: Little Long Pond is a highly eutrophic Pond with a prospect of generally worsening conditions unless strong counter measures are instituted. The following includes testing in-lake and outlet; monitoring all parameters, conclusions and solutions, and funding, are all with the idea in mind to offer methods of reducing the effects and rate of eutrophication of Little Long Pond.

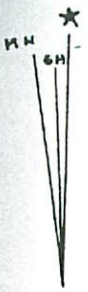
LITTLE LONG POND

Planimetric Map

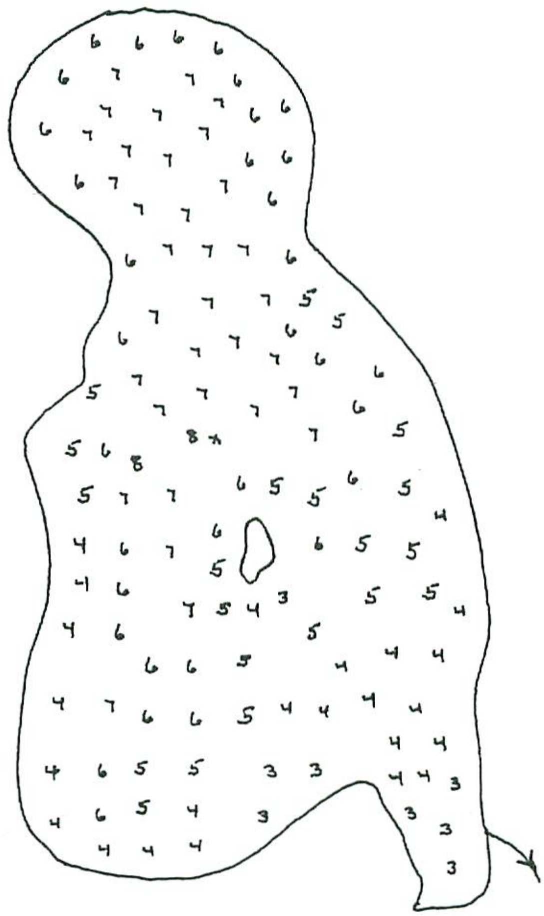
ittle Long Pond
lymouth, Mass.
atershed type: coastal
cres: 45 = 18.23 Hectares
ltitude: 068'
ater type: warm
ond type: natural
tratified: no
ond use: recreation, esthetic
opo sheet: USGS 1:24000 Sagamore
osition Topo sheet: up 21.6 right 1.6
horeline distance: 1.25 miles 6600'

Scale 1:520'



LITTLE LONG POND

(Bathymetric Map)

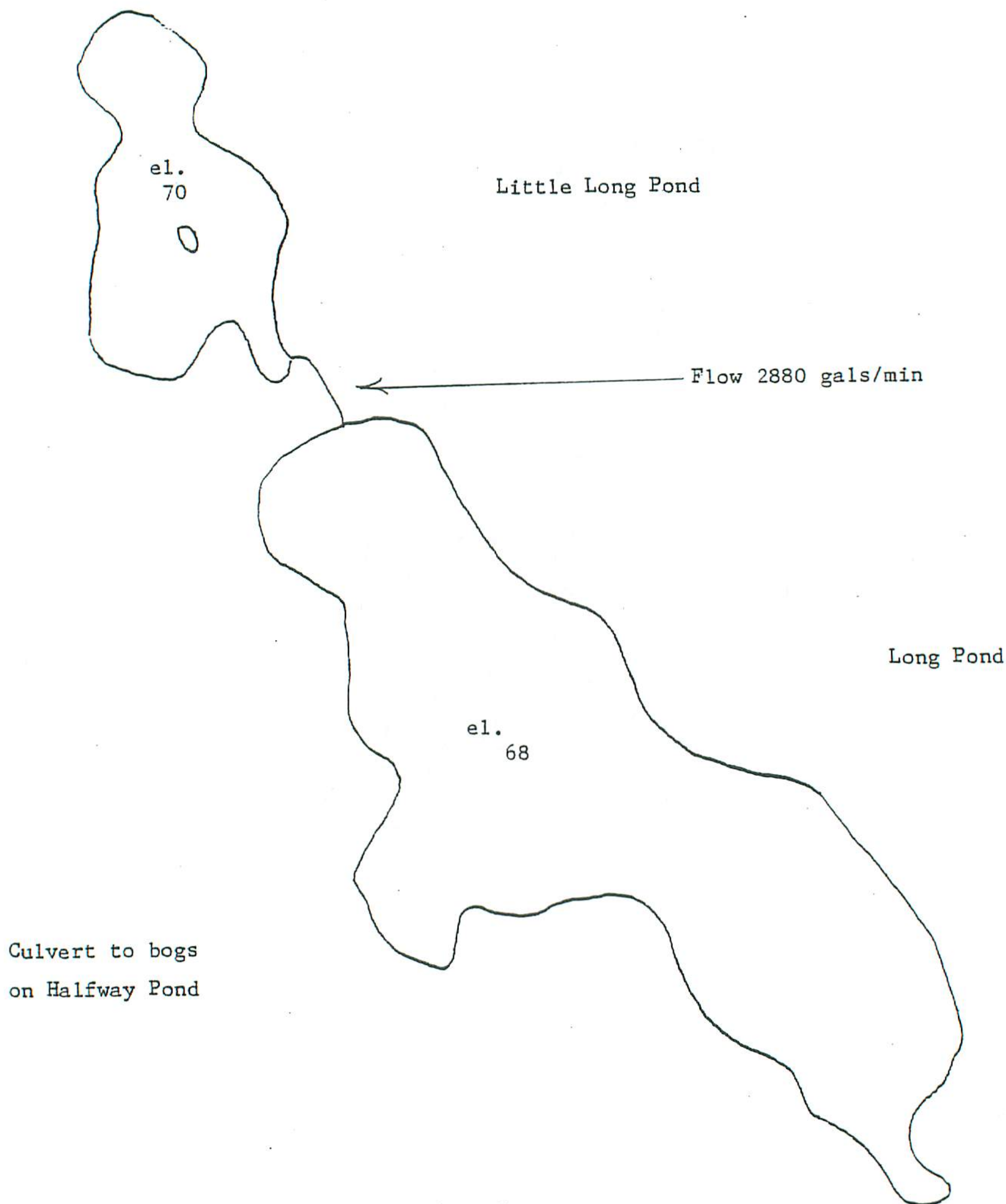


Maximum depth 8' 2.44 M
Mean depth 05' 1.52 M
Surface area 45 acres 18.2 H
Acre feet 225
Total gals. 73,316,475

Scale 1:520'

LITTLE LONG POND

Impoundment Map

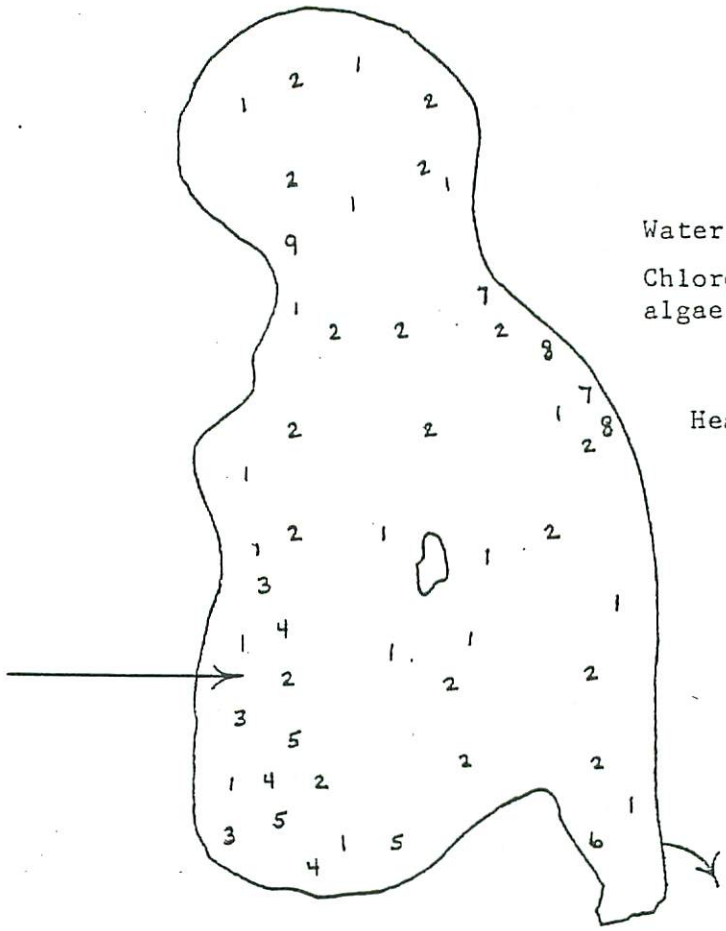



There are no commercial agricultural enterprises affecting the surface flow of this impoundment.

Scale 1:1030'

LITTLE LONG POND

Submersed Aquatic Plant Map with Key



Water has green tint.

Chlorophyceae
algae unicellular

Heavy elodea count out to
7 foot contour line.

Heavy infestation
Potamogeton Sap.

Najas

with large clumps
of elodea.

Scale 1:520'

## SUBMERSED AQUATIC PLANTS

| LATIN | COMMON | MAP NUMBER |
|---|---|---|
| Potamogeton | Pondweed | |
| Potamogeton Americanus | | |
| Potamogeton Ampl. Folius | Large Leaf Pondweed | |
| Potamogeton Crispus | Curly Leaf Pondweed | |
| Potamogeton Diversifolius | Waterthread Pondweed | 3 |
| Potamogeton Filiformus | | |
| Potamogeton Filiosus | Leafy Pondweed | |
| Potamogeton Gramineus | Variable Pondweed | |
| Potamogeton Natans | Floating Brown Leaf | |
| Potamogeton Nodosus | American Pondweed | |
| Potamogeton Pectinatus | Sago Pondweed | 4 |
| Potamogeton Praelongus | White Stem Pondweed | |
| Potamogeton Richardsonii | Richardson Pondweed | |
| Potamogeton Robinsii | | |
| Potamogeton Vaginatus | Giant Pondweed | |
| Najas | Bushy Pondweed | 5 |
| Zannichellia | Horned Pondweed | |
| Elodea | Waterweed | 1 |
| Ranunculus | Water Buttercup | |
| Ceratophyllum D. | Coontail | |
| Myriophyllum | Water Milfoil | |
| Alisma | Waterplantain | |
| Heteranthera D. | Water Star Grass; Mud Plantain | 6 |
| Nasturtium | Water, Cress | |
| Utricularia | Bladderwort | |
| Vallisneria | Wild Celery | |

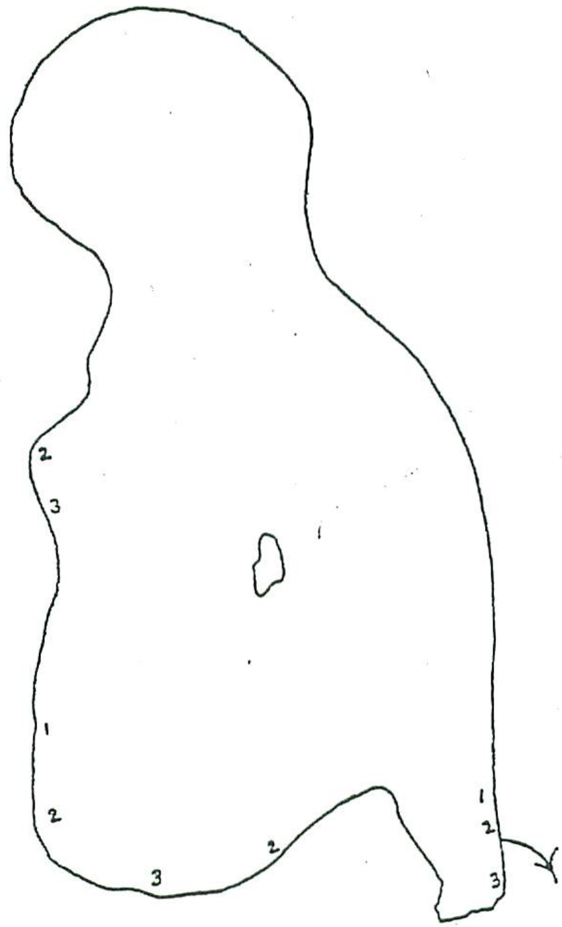
Addenda

Algae

| | | |
|---|---|---|
| Chlorophyceae | green | |
| unicellular | | 2 |
| filamentous | | 7 |
| Cyanophyceae | blue-green | |
| filamentous | | 8 |
| Sphagnum | moss | 9 |

LITTLE LONG POND

Emersed Aquatic Plant Map with Key



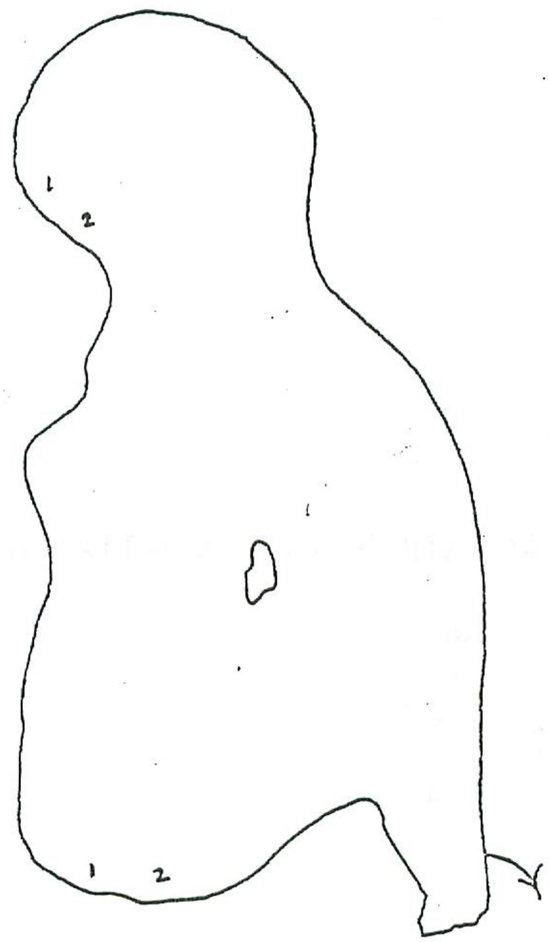

Scale 1:520'

# EMERSED AQUATIC PLANTS

| LATIN | COMMON | MAP NUMBER |
| --- | --- | --- |
| Peltandra | Arrow Arum | |
| Pontederia | Pickerel Weed | |
| Sagittaria | Arrowhead; Duck Potatoe | |
| Polygonum | Watersmart Weed | |
| Typha | Cattail | |
| Eleocharis | Spike Rush Sedge | 1 |
| Scirpus | Bulrush Sedge | 2 |
| Juncaceae | Juncus Rush | 3 |
| | Addenda | |


LITTLE LONG POND

Floating Aquatic Plant Map with Key




Scale 1:520'

## FLOATING AQUATIC PLANTS ATTACHED

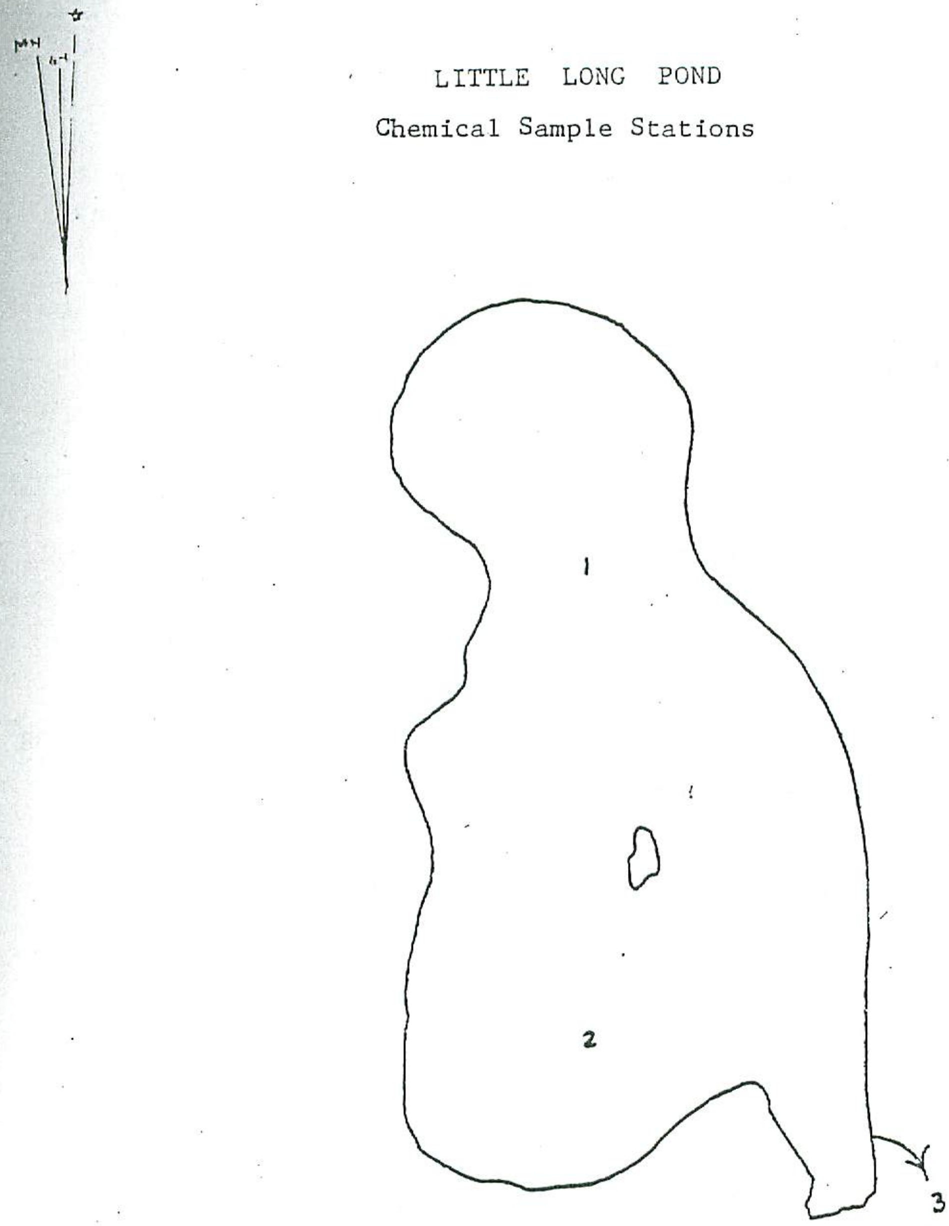
| LATIN | COMMON | MAP NUMBER |
|---|---|---|
| Nuphar | Cow Lily, Yellow Water Lily, Spatterdock | |
| Nymphaea | Water Lily, White Water Lily | 1 |
| Brasenia | Watershield | 2 |
| | Addenda | |

## FLOATING AQUATIC PLANTS - UNATTACHED

| LATIN | COMMON | MAP NUMBER |
|---|---|---|
| Lemna | Duckweed | |
| Spirodelia | Big Duckweed | |
| Wolffia | Watermeal | |
| | Addenda | |

LITTLE LONG POND

Chemical Sample Stations

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# P H O S P H O R U S

The discharge of phosphorus-containing wastewaters into the surface waters of the United States has contributed to their over fertilization and eutrophication.

Phosphorus is found in wastewater in these principal forms orthophosphat polyphosphates or condensed phosphates and organic phosphorus compounds.

The quantity of phosphorus resulting from human excretions reportedly ranges from .5 to 2.3 lb. per capita per year. The mean annual excretion is estimated to be 1.2 lb. per capita. The mean annual contribution of phosphorus from synthetic detergents with phosphate builders is estimated to be about 2.3 lb. per capita at present. Thus exclusive of industrial wastes and other phosphorus sources, such as water softening or sequestering agents, the domestic phosphorus contribution to wastewater is about 3.5 lb. per capita per year. The Cornell findings being "human activities are responsible for 75 - 80% of the dissolved phosphorus reaching the lakes in central New York."

Phosphorus is considered a key element in the eutrophication of surface waters in the New England Region.

Sawyer and Curry and Wilson suggest a concentration of .01 mg/1 of inorganic phosphorus as a maximum permissible without the danger of supporting undersirable growths. If the assets of inorganic nitrogen and phosphorus exceed .3 and .01 - .015 mg/1 respectively at start of the growing season, nuisance blooms of algae may occur.

If orthophosphate levels of .01 mg/1 or greater occur, then the lake is susceptible to algae blooms and macrophyte growth (Sawyer, Vollenweider).

The so-called Cornell Study "Lakes and Phosphorus Imputs"(see Addenda) to this report reached the important basic conclusion that dissolved phosphorus (organic and inorganic) has a far more important influence on algal growth.

Residential runoff - 6%

Atmospheric fall-out - 6%

Studies have shown that approximately 50% of the phosphorous present in domestic waste water is derived from the phosphorous that is used in various cleaning compounds such as detergents.

Phosphate is usually strongly sorbed by aquifer materials except in sandy areas. Quartz and other sands that have low iron, carbonates, aluminum, clay mineral and organic content will readily transport phosphate in ground water.

In sandy soil such as those contacted in southern Massachusetts, it is found that the sorption capacity of the sandy soil is exceedingly small with the results that septic tank disposal systems located in the watershed area with sandy soil, rarely have problems with plugging. Those systems readily transmit the nutrients from the household to a nearby water course via ground water. High phosphorous readings in aquifer and springs feeding Little Long Pond are evidence of this phenomenon.

According to a Cornell study, the phosphorous content of domestic sewage ranges from 1 - 2 kilograms (2.2 - 4.4 lbs.) per capita per year depending primarily on whether laundry detergents containing phosphates are being used by households.

Various researchers have recorded the annual per capita contribution of phosphorous in pounds from domestic sewage as 2-4 (Bush - Mulford 1954); 2.3 (Metzler et al 1958); 1.9 (Owen 1953); and 3.5 (Sawyer 1965).

The eutrophication of a lake can be controlled or its effects on water minimized by reducing the nutrient input into the lake, increasing nutrient output from the lake, immobilizing nutrients within the lake and controlling excessive growths of algae and macrophytes within the lake.

This has the phosphorus attached to the soil particles (particulated). The benthic transfer of nutrients is complex and the transfer to and from the water column is still open to reserve.

The EPA guidelines in it's "clear lakes program" states "phosphorus is usually the most important nutrient controlling lake productivity, therefore, total phosphorus (i.e. the phosphorus present in both inorganic and organic, dissolved and suspended forms) is an important measure of trophic state. The dividing line between oligotrophic lakes is usually regarded as 10ug/l (.01 mg/l) and between mesotrophic and eutrophic lakes as about .02 mg/l." Best reading times are in winter months, the most non-productive season.

Concentrations of total more than .01 mg/l in the groundwater are not considered normal and when this value is attained, a source of contamination is suspect. Soluble phosphorus concentrations in groundwater are virtually non-existent because of chemical fixation and precipitation as insoluble compounds of calcium, magnesium, iron and aluminum; this is in contrast to nitrates which have greater mobility. In The Carver Soil Series, however, fixation is virtually non-existent.

# N I T R O G E N

According to Sawyer, the critical concentration of nitrogen, below which algal growths were not troublesome, was .3 mg/1, provided that phosphorus was kept below .015 mg/1.

For some algae, the optimum nitrogen: phosphorus ration appears to be about 30:1, for other algae rations 15.18: 1

The presence of .01 mg/1 of phosphorus and .30 mg/1 of inorganic nitrogen in ponds or lakes at the time of spring overturn will probably foster the production of algae bloom.

Gerloff and Skoog suggest that in many instances nitrogen rather than phosphorus may be the limiting element in the growth of algae.

Imhoff and Mueller point out that enormous growth of plants in streams, lakes and ponds, does not occur if the nitrate as N is kept below .3 mg/1 and the total nitrogen as N is below .6 mg/1.

According to Lavfer, a generally accepted limit for free ammonia for sanitary purity of water supplies is between .05 and .10 mg/1. Although free ammonia is often of vegatable origin and without hygienic significance, it's concentration of plus .10 mg/1 renders water suspect of recent pollution.

Nitrites in water are generally formed by the action of bacteria upon ammonia and organic nitrogen. Owing to the fact that they are quickly oxidized to nitrates, they are seldom present in surface water in significant concentrations. In conjuction with ammonia and nitrates, nitrates in water are often indicative of pollution.

As a very important nutrient and a common constituant in septic tank effluent, nitrogen has a much greater mobility then phosphorus and hence as an indicator would be first to make it's appearance.

The nitrogen cycle in surface waters and lake sediments. A modified representation of the nitrogen cycle applicable to the surface water environment is presented in figure 4. Nitrogen can be added by precipitation, dustfall, surface runoff, subsurface groundwater entry and direct discharge of wastewater effluent. In addition, nitrogen from these can be fixed by certain photosynthetic blue-green algae and some bacterial species.

Within the aquatic environment, ammonification, nitrification, assimilation and denitricication can occur as shown in figure 5. Ammonification of organic matter is carried out by microorganisms. The ammonia thus formed, along with nitrates, can be assimilated by algae and aquatic plants, such growths may create water quality problems.

The nitrogen cycle in soil and groundwater. Figure 5, shows the major aspects of the nitrogen cycle associated with the soil/groundwater environment. Nitrogen can enter the soil from waste water or waste water effluent, artificial fertilizers, plant and animal matter, precipitation and dustfall. In addition, nitrogen fixing bacteria convert nitrogen gas into forms available to plant life. Usually more than 90% of the nitrogen present in soil is organic.

The nitrate content is generally low due to assimilation by plant roots and leaching by water percolating through the soil. Nitrate pollution is the principal groundwater quality problem in many locations.

The problem in Plymouth is the Carver soil series and it's inability to filter or bind any polluting plumes and nitrates are readily transported into the groundwater.

## GENERAL GUIDELINES

| | | Permissible Levels | Critical |
|---|---|---|---|
| Total phosphorous mg/l | | .025 | .04 |
| Orthophosphorous mg/l | | .004 | .01 |
| Organic Nitrogen mg/l | | .20 | .40 |
| Ammonia mg/l | | .02 | .05 |
| Nitrate mg/l | | .10 | .25 |
| Nitrite mg/l | Less than | .001 | .002 |
| Inorganic Nitrogen mg/l | | .12 | .30 |

Little Long Pond has no tributary feed, under normal conditions. The only contributions to volume are rainfall, aquifer action and some surface runoff. All factors point to in-lake nutrient loading.

Station 1 = All P readings in the Bellweather months, March, April and October were critical or above. The nitrate readings were exceedingly high except in August and September, see nutrient utilization. Total nitrogen readings are so high as to suspect bad septic leakage somewhere in the area of station 1. Such high nutrient loading in time will show up in changing of trophic state of Long Pond.

Station 2 = The loading here, though high, is not as high as station 1. All nitrate readings were lower. The March and October readings were high, in fact, critical. The phosphate readings were critical from March to June.

The outfall phosphate readings were very high March through June. The high phosphate reading makes suspect a pollution infiltration along outlet stream. (see locating faulty septic systems.).

## Little Long

### Chemical Parameters

Station No. 1

| | Total Phosphorus Mg/L | Nitrate N Mg/L | Nitrite N Mg/L | Kjeldahl N Mg/L |
|---|---|---|---|---|
| ugust 15 | .04 | 1.5 | .005 | .70 |
| ugust 30 | .04 | 1.5 | " | |
| eptember | .04 | 1.3 | " | .50 |
| ctober | .05 | 1.2 | " | .30 |
| arch | .05 | 1.7 | " | .40 |
| pril | .04 | 1.3 | " | .45 |
| ay 15 | .05 | .40 | " | .75 |
| ay 30 | .05 | .40 | " | .70 |
| une 15 | .05 | .30 | " | .70 |
| une 30 | .05 | .35 | " | .70 |
| uly 15 | .04 | .45 | " | .50 |
| uly 30 | .04 | .35 | " | .50 |
| ugust 15 | .03 | .25 | " | .45 |
| ugust 30 | .03 | .20 | " | .45 |
| eptember | .02 | .15 | " | .40 |
| ctober | .04 | .35 | " | .35 |

Little Long

Chemical Parameters

Station No. 2

| | Total Phosphorus Mg/L | Nitrate N Mg/L | Nitrite N Mg/L | Kjeldahl N Mg/L |
|---|---|---|---|---|
| August 15 | .03 | .15 | .005 | .60 |
| August 30 | .03 | .20 | " | .55 |
| September | .03 | .22 | " | .45 |
| October | .03 | .22 | " | .35 |
| March | .04 | .30 | " | .50 |
| April | .04 | .15 | " | .65 |
| May 15 | .04 | .25 | " | .85 |
| May 30 | .04 | .25 | " | .85 |
| June 15 | .04 | .25 | " | .90 |
| June 30 | .04 | .30 | " | .90 |
| July 15 | .03 | .30 | " | .65 |
| July 30 | .03 | .30 | " | .55 |
| August 15 | .02 | .20 | " | .52 |
| August 30 | .02 | .20 | " | .50 |
| September | .02 | .15 | " | .35 |
| October | .04 | .40 | " | .35 |

Little Long

Chemical Parameters

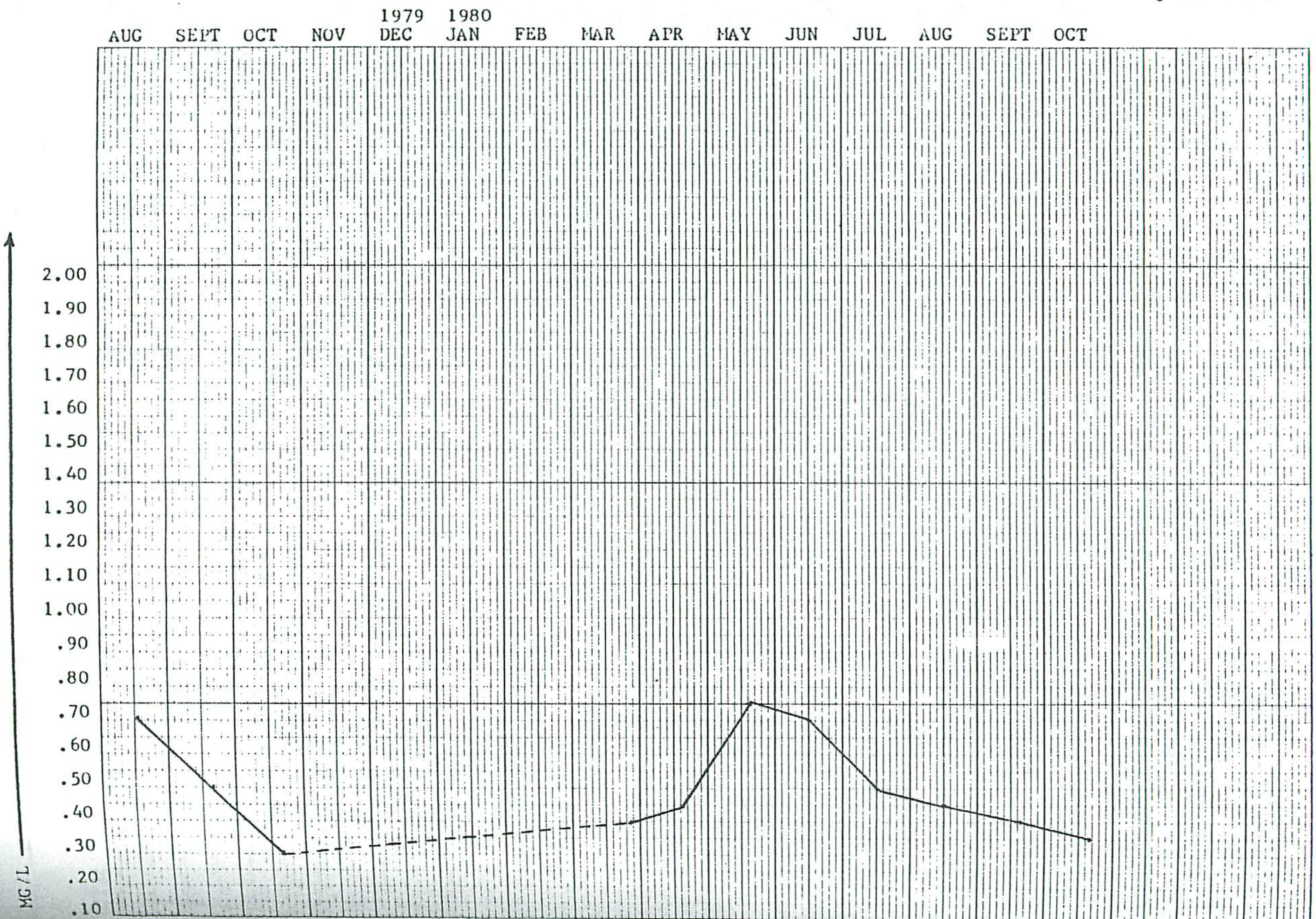
Station No. Outlet

| | Total Phosphorus Mg/L | Nitrate N Mg/L | Nitrite N Mg/L | Kjeldahl N Mg/L |
|---|---|---|---|---|
| ugust 15 | .04 | .90 | .005 | .50 |
| ugust 30 | .04 | .80 | " | .70 |
| eptember | .04 | .70 | " | .60 |
| tober | .03 | .70 | " | .40 |
| rch | .06 | 1.13 | " | .40 |
| ril | .08 | .50 | " | .50 |
| y 15 | .08 | .40 | " | .70 |
| y 30 | .07 | .30 | " | .70 |
| ne 15 | .07 | .30 | " | .60 |
| ne 30 | .07 | .20 | " | .60 |
| ly 15 | .05 | .20 | " | .5 |
| ly 30 | .04 | .15 | " | .45 |
| gust 15 | .03 | .10 | " | .45 |
| gust 30 | .02 | .06 | " | .35 |
| ptember | .02 | .20 | " | .30 |
| tober | .03 | .14 | " | .30 |

46 3010

LITTLE LONG POND - Station 1

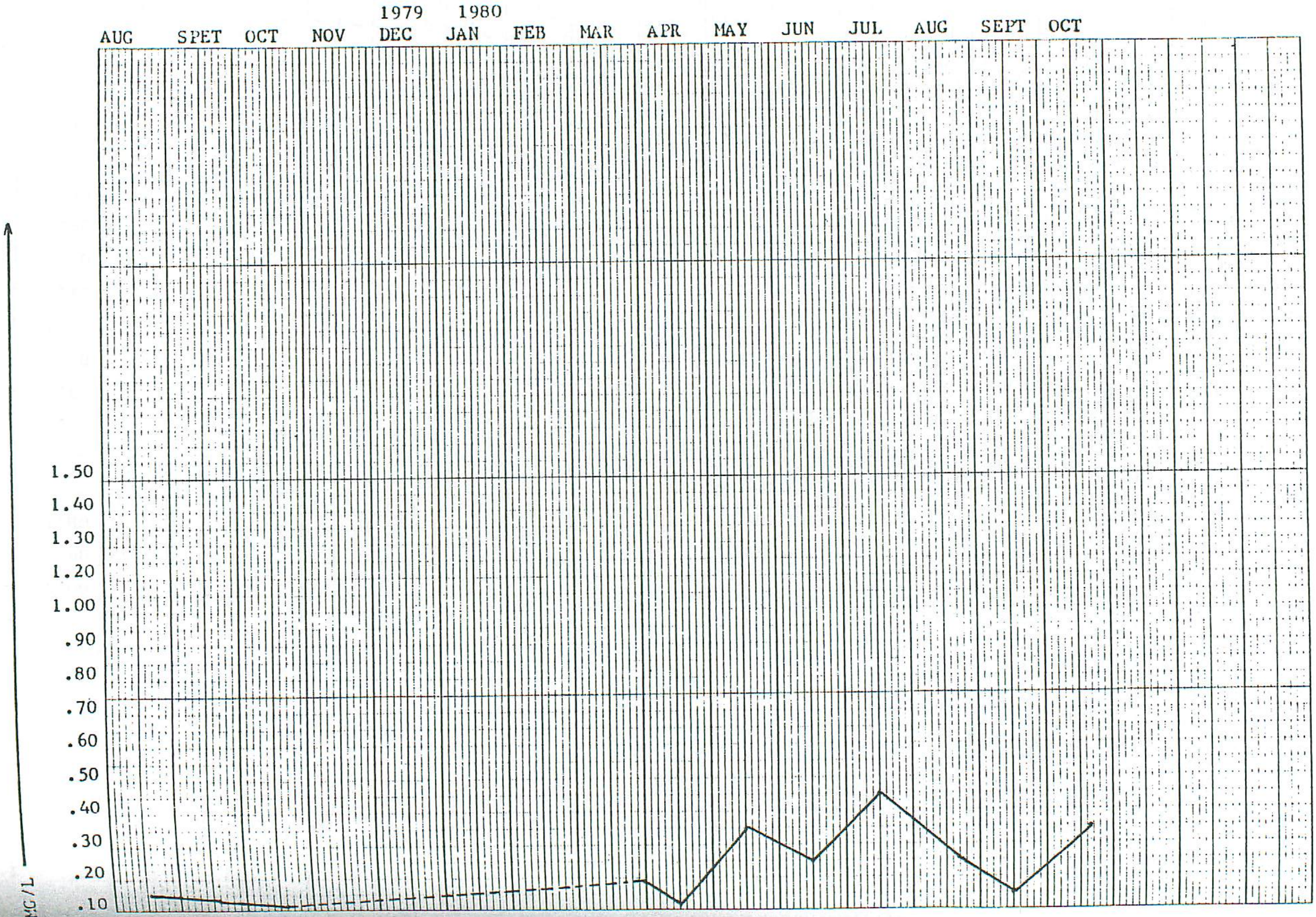
Kjeldahl (N)



46 3010

LITTLE LONG POND - Station 1

Nitrate (N)

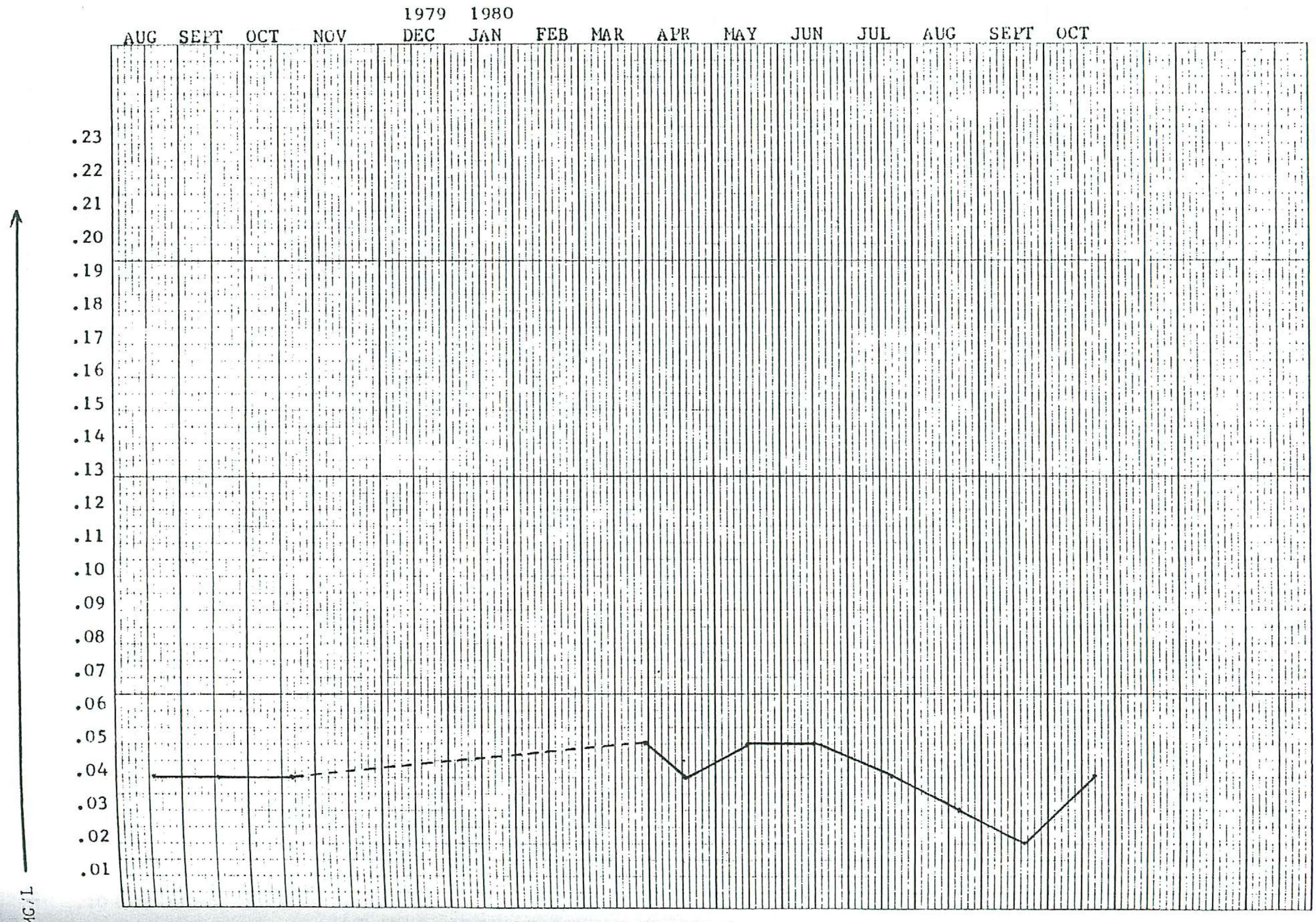


K+E 1 YEAR BY WEEKS X 180 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 3010

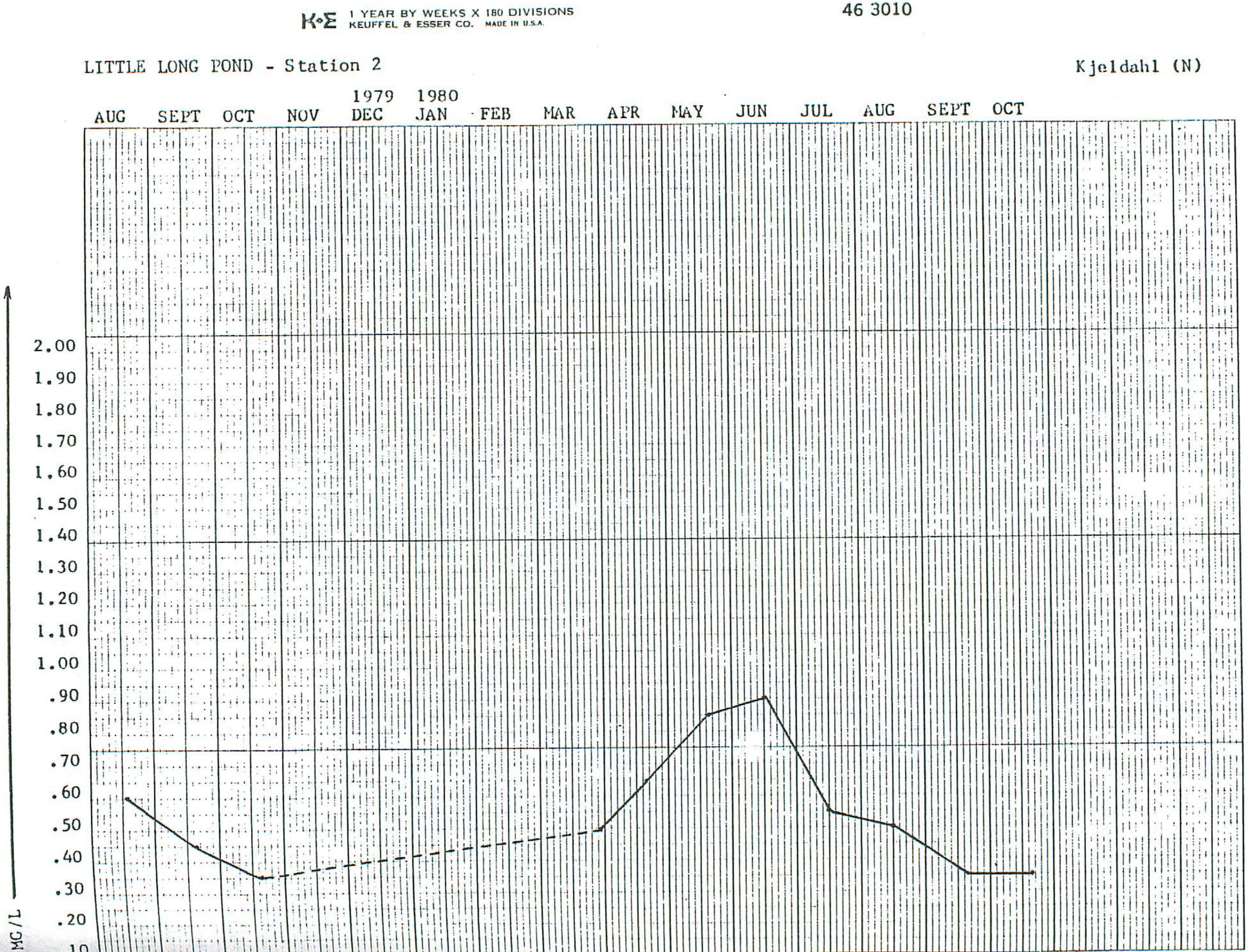
LITTLE LONG POND - Station 1

Total Phosphorous (P)

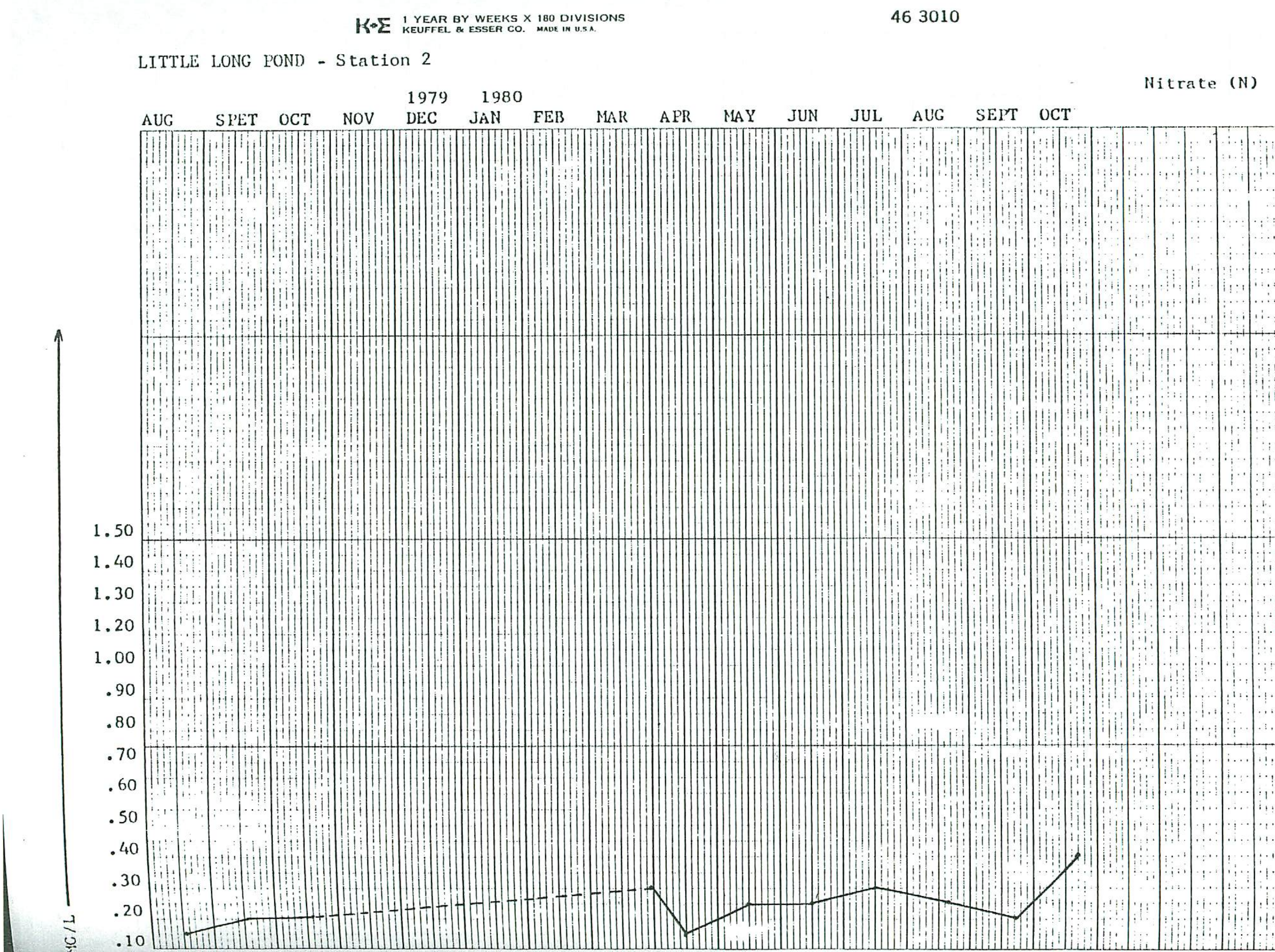


LITTLE LONG POND - Station 2

Kjeldahl (N)

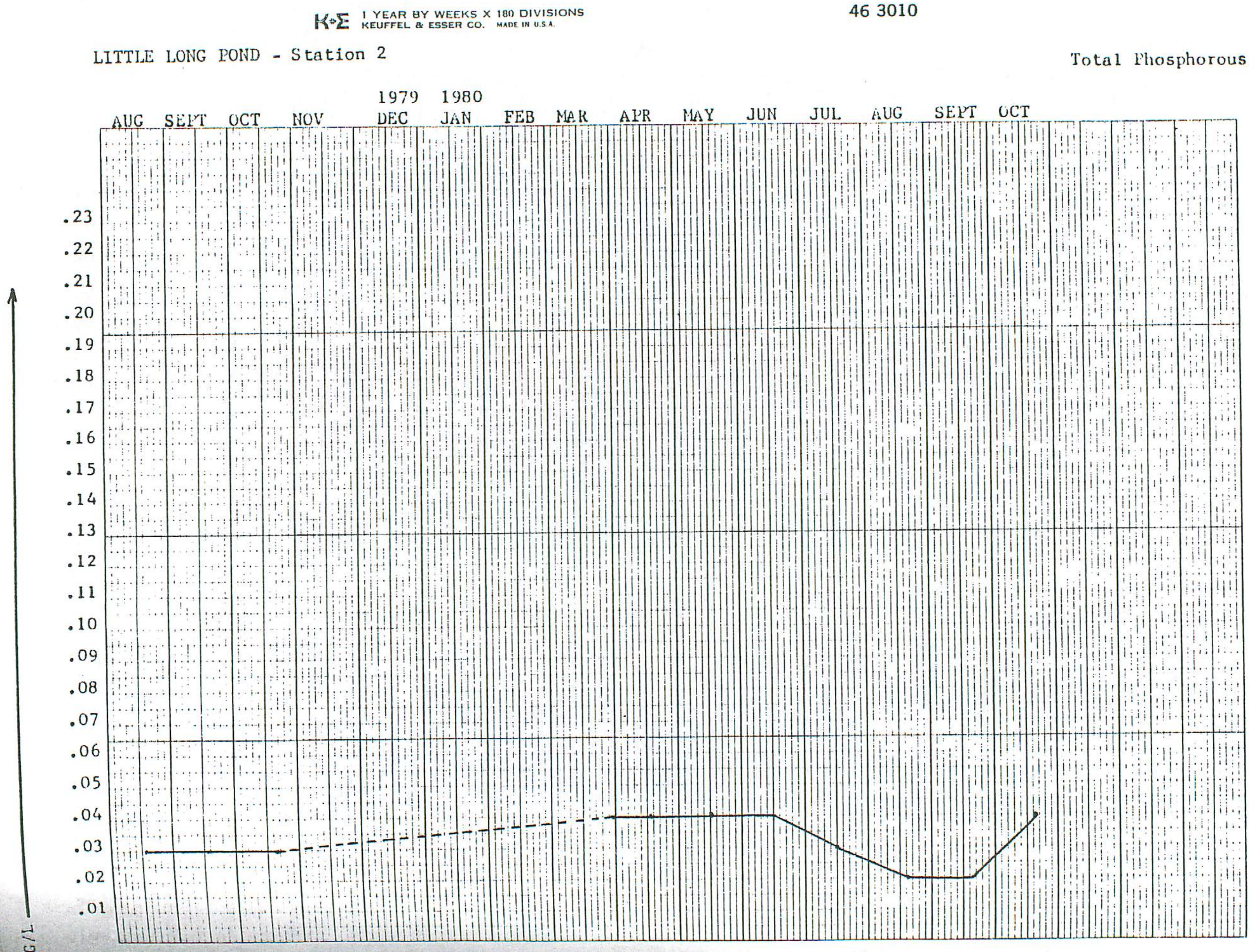


LITTLE LONG POND - Station 2



LITTLE LONG POND - Station 2

Total Phosphorous (P)

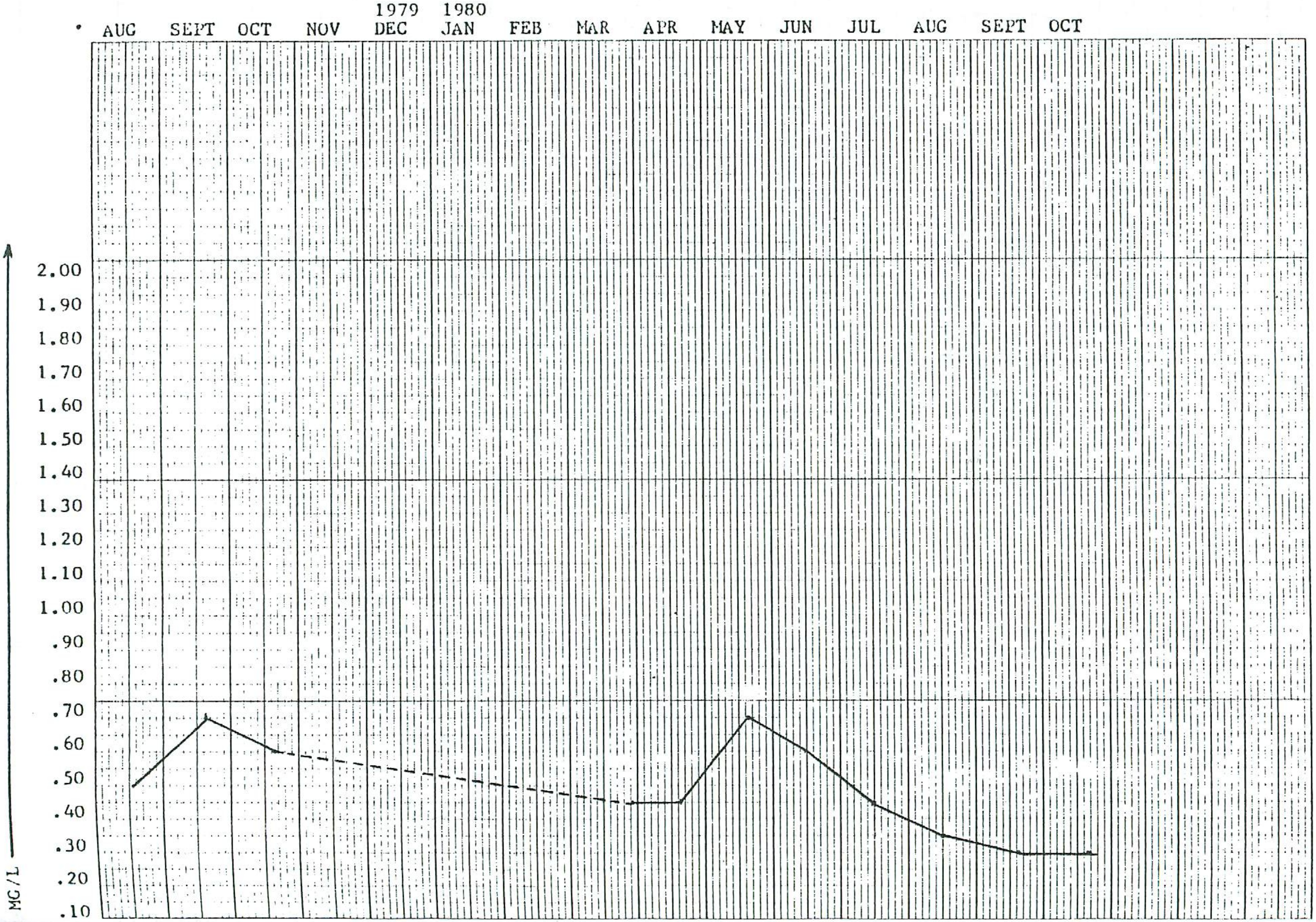


K+E 1 YEAR BY WEEKS X 180 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 3010

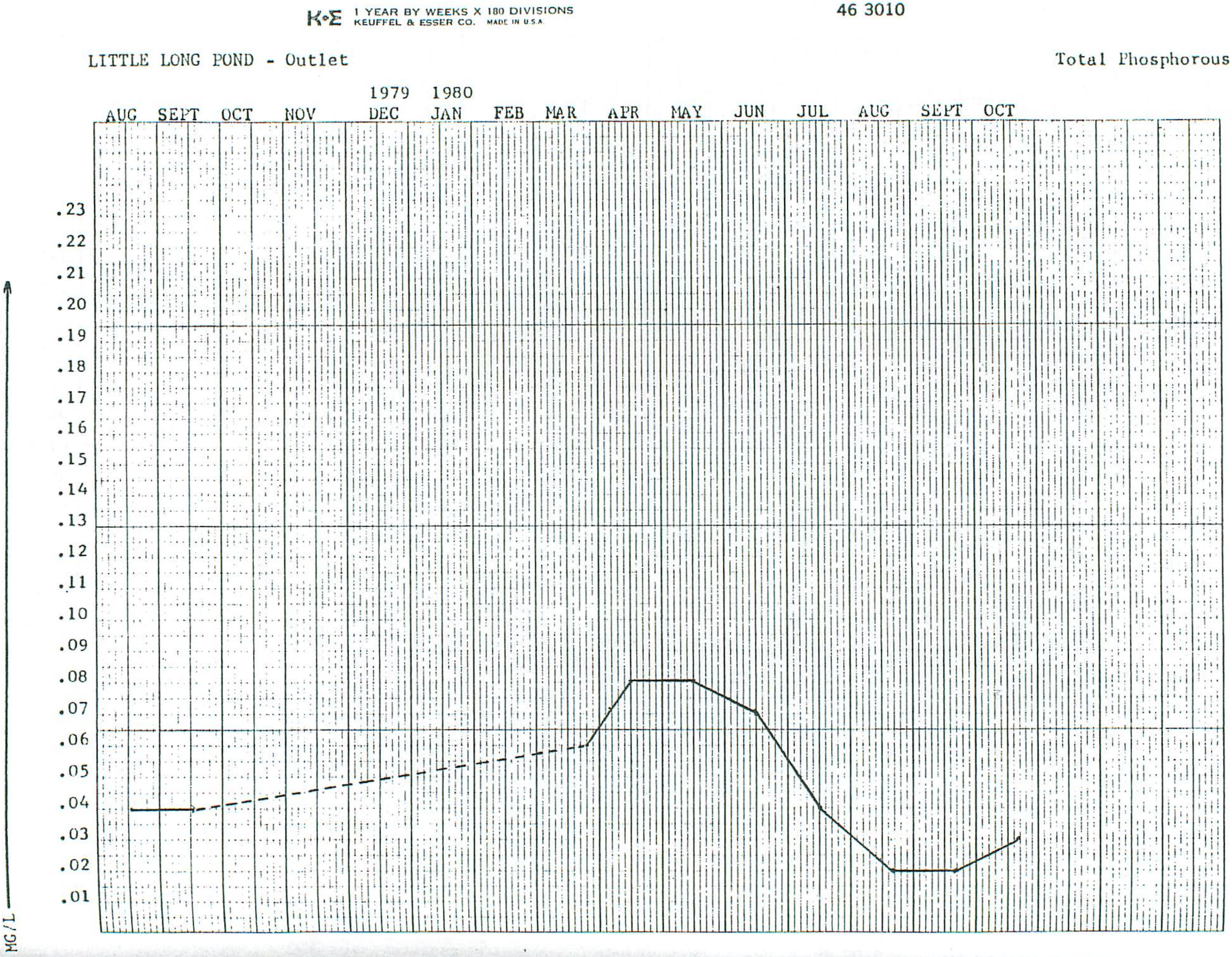
LITTLE LONG POND - Outlet

Kjeldahl (N)



LITTLE LONG POND - Outlet

Total Phosphorous (P)

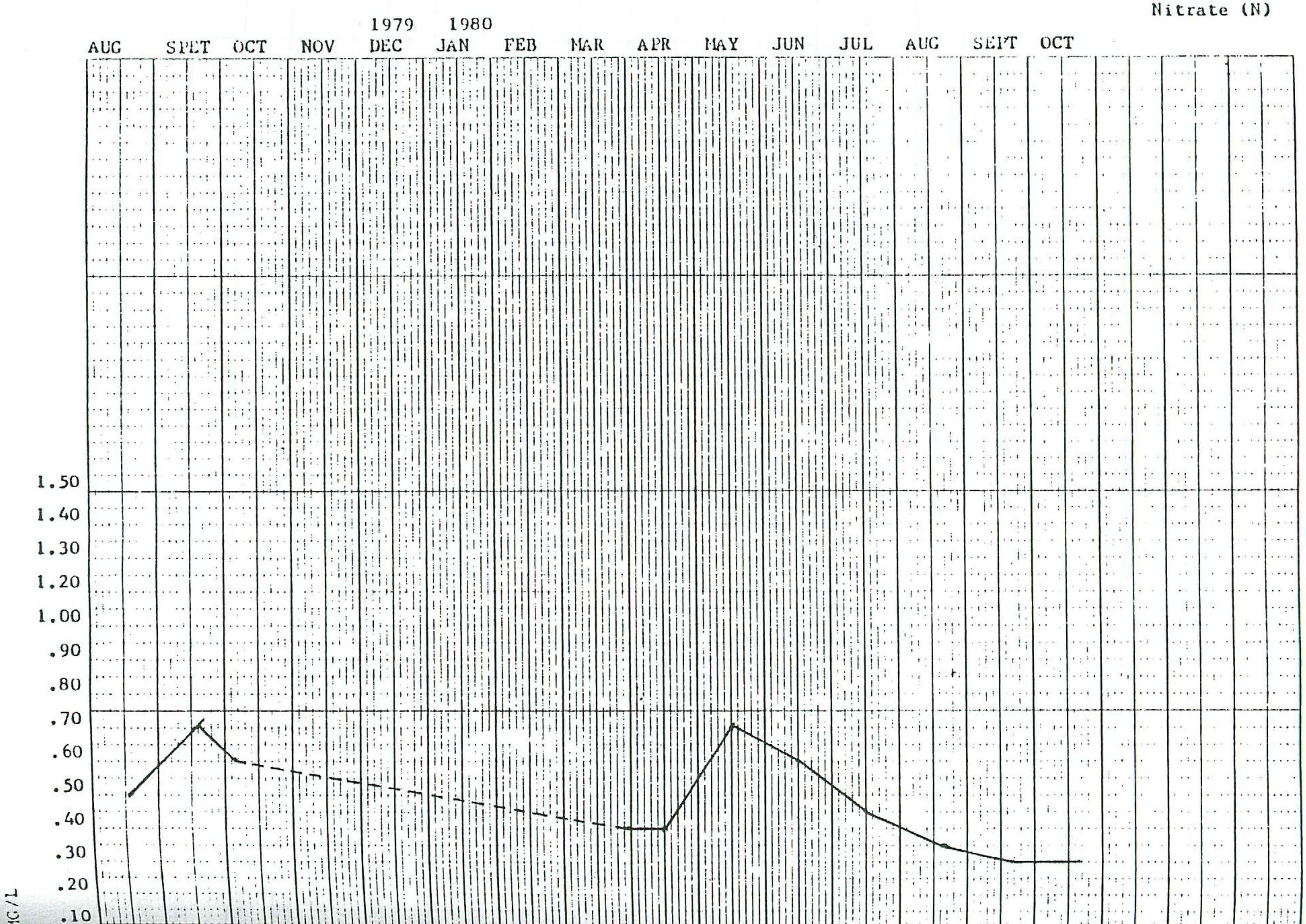


K•E 1 YEAR BY WEEKS X 180 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 3010

LITTLE LONG POND - Outlet

Nitrate (N)



Chemical and Physical Paramenters

Station 1

| | Temp. F° C° | Secchi Feet M | Conductivity Mhos/cm | Ph Standard Units | Do | Total Hardness | Total Alkalinity |
|---|---|---|---|---|---|---|---|
| August 30 | 62 | 6.5 | 280 | 7.1 | 6.2 | 17 | |
| September | 60 | 7.0 | 275 | 7.0 | 7.0 | 18 | |
| October | 57 | 7.0 | 275 | 7.0 | 7.0 | 18 | |
| March | 54 | 7.0 | 300 | 7.0 | 7.5 | 17 | |
| April | 57 | 7.0 | 325 | 7.2 | 7.5 | 17 | |
| May 15 | 59 | 7.0 | 330 | 7.0 | 7.3 | 19 | LESS THAN 10 |
| May 30 | 61 | 6.5 | 330 | 7.0 | 7.2 | 19 | |
| June 15 | 63 | 6.0 | 335 | 7.0 | 7.2 | 18 | |
| June 30 | 63 | 5.0 | 340 | 7.0 | 7.0 | 18 | |
| July 15 | 64 | 5.0 | 350 | 7.0 | 7.0 | 18 | |
| July 30 | 65 | 5.0 | 345 | 7.0 | 6.5 | 17 | |
| August 15 | 65 | 5.0 | 340 | 6.9 | 6.4 | 18 | |
| August 30 | 64 | 5.0 | 310 | 7.0 | 6.5 | 19 | |
| September | 62 | 6.5 | 285 | 7.0 | 7.0 | 18 | |
| October | 58 | 7.0 | 260 | 7.0 | 7.0 | 18 | |
| | | | | | | | |

Chemical and Physical Paramenters

Station 2

| | Temp. F° | Temp. C° | Secchi Feet | Secchi M | Conductivity Mhos/cm | Ph Standard Units | Do | Total Hardness | Total Alkalinity |
|---|---|---|---|---|---|---|---|---|---|
| August 30 | 64 | | 6.5 | | 250 | 6.4 | 6.1 | 18 | |
| September | 61 | | 7.0 | | 230 | 6.4 | 6.7 | 18 | |
| October | 58 | | 7.0 | | 210 | 6.4 | 6.8 | 18 | |
| March | 54 | | 7.0 | | 250 | 6.3 | 7.2 | 17 | |
| April | 57 | | 7.0 | | 260 | 6.3 | 7.2 | 18 | |
| May 15 | 59 | | 7.0 | | 280 | 6.4 | 7.2 | 19 | |
| May 30 | 61 | | 6.5 | | 280 | 6.4 | 7.1 | 19 | |
| June 15 | 62 | | 6.0 | | 280 | 6.4 | 7.0 | 19 | LESS THAN 10 |
| June 30 | 65 | | 5.0 | | 285 | 6.4 | 6.8 | 20 | |
| July 15 | 65 | | 5.0 | | 285 | 6.4 | 6.7 | 19 | |
| July 30 | 66 | | 5.0 | | 285 | 6.3 | 6.5 | 18 | |
| August 15 | 68 | | 5.0 | | 280 | 6.3 | 6.4 | 18 | |
| August 30 | 68 | | 5.0 | | 260 | 6.4 | 6.0 | 18 | |
| September | 64 | | 6.5 | | 240 | 6.4 | 6.5 | 17 | |
| October | 58 | | 7.0 | | 250 | 6.4 | 6.8 | 17 | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## Chemical and Physical Paramenters

Station 3

| | Temp. F° C° | Secchi Feet M | Conductivity Mhos/cm | Ph Standard Units | Do | Total Hardness | Total Alkalinity |
|---|---|---|---|---|---|---|---|
| ugust 30 | 68 | | 170 | 6.0 | 6.0 | 19 | |
| eptember | 65 | | 160 | 6.0 | 6.2 | 19 | |
| ctober | 60 | | 160 | 6.0 | 6.8 | 20 | |
| larch | 54 | | 180 | 5.9 | 7.2 | 19 | |
| pril | 59 | | 200 | 5.9 | 7.0 | 19 | |
| lay 15 | 64 | | 200 | 5.9 | 7.0 | 18 | |
| lay 30 | 66 | | 210 | 6.0 | 6.9 | 18 | |
| June 15 | 69 | | 210 | 6.0 | 6.9 | 19 | |
| June 30 | 72 | | 210 | 6.0 | 6.7 | 19 | |
| July 15 | 72 | | 220 | 6.0 | 6.6 | 20 | |
| luly 30 | 73 | | 200 | 6.0 | 6.3 | 19 | |
| ugust 15 | 73 | | 190 | 6.0 | 6.1 | 19 | |
| ugust 30 | 72 | | 190 | 6.0 | 6.1 | 18 | |
| September | 67 | | 180 | 6.0 | 6.5 | 19 | |
| October | 60 | | 180 | 6.0 | 6.7 | 18 | |
| | | | | | | | |

## Heavy Metals

Natural waters may contain elements other than those considered by EPA standards. Manganese is commonly found. Aluminum, zinc, and copper are usually found in natural waters in varying quantities. Traces of molybdenum, gallium, and nickel have been occasionally found.

A new test was run on Hexavalent Chromium, for this is a carcinogen. All the analyses checked by the Texas Instrument Company Lab show all metals well within the range commonly found in natural waters. It can be concluded that industrial wastes do not present a problem in Little Long either by ground water or by rain.

| Metal | EPA 1976 Drinking Water Standards | N.Y. State Ground Water Regulations | Proposed EPA Ground Water Classification | Little Long Pond |
|---|---|---|---|---|
| Zinc | - | .6 | 5.0 | .004 |
| Cadmium | .01 | .02 | .01 | .001 |
| Selenium | .01 | .02 | .01 | .007 |
| Gold | - | - | - | |
| Iron | - | .06 | .3 | .021 |
| Palladium | - | - | - | .005 |
| Aluminum | - | - | - | .006 |
| Copper | .1 | .4 | - | .006 |
| Nickel | - | - | - | .005 |
| Lead | .05 | .1 | .05 | .001 |
| Chromium | .05 | .1 | .05 | .001 |
| Boron | - | .01 | - | .008 |
| Chromium (Hexavalent)* | .05 | .1 | .05 | .000 |

* noted carcinogen

\- = not considered to date

Heavy metal readings were so low as to conclude that industrial pollution was not to be considered in this report.

# HEAVY CHEMICALS, HEAVY METALS AND AQUIFER POLLUTION

The Carver soil series and all sand and gravel soil series have a potential aquifer pollution problem with heavy metal and chemical compounds as they have with nutrient compounds, along with the added problems of density. Many industrial land-fill and household contaminants have a much greater density range than with the nutrient chemicals. Thus, along with solubility and aquifer flow you have the added factors of gravity and density to consider in the diffusion of contaminants.

The effect of densities of various pollutants on the migration in an unconfined aquifer is shown in figure 6.

Products of greater densities fall to the base of the aquifer and flow generally in the direction of, from greater to lesser slopes of the confining bed, with some small amounts following the direction of groundwater flow, the quantity depending on the solubility and the amount.

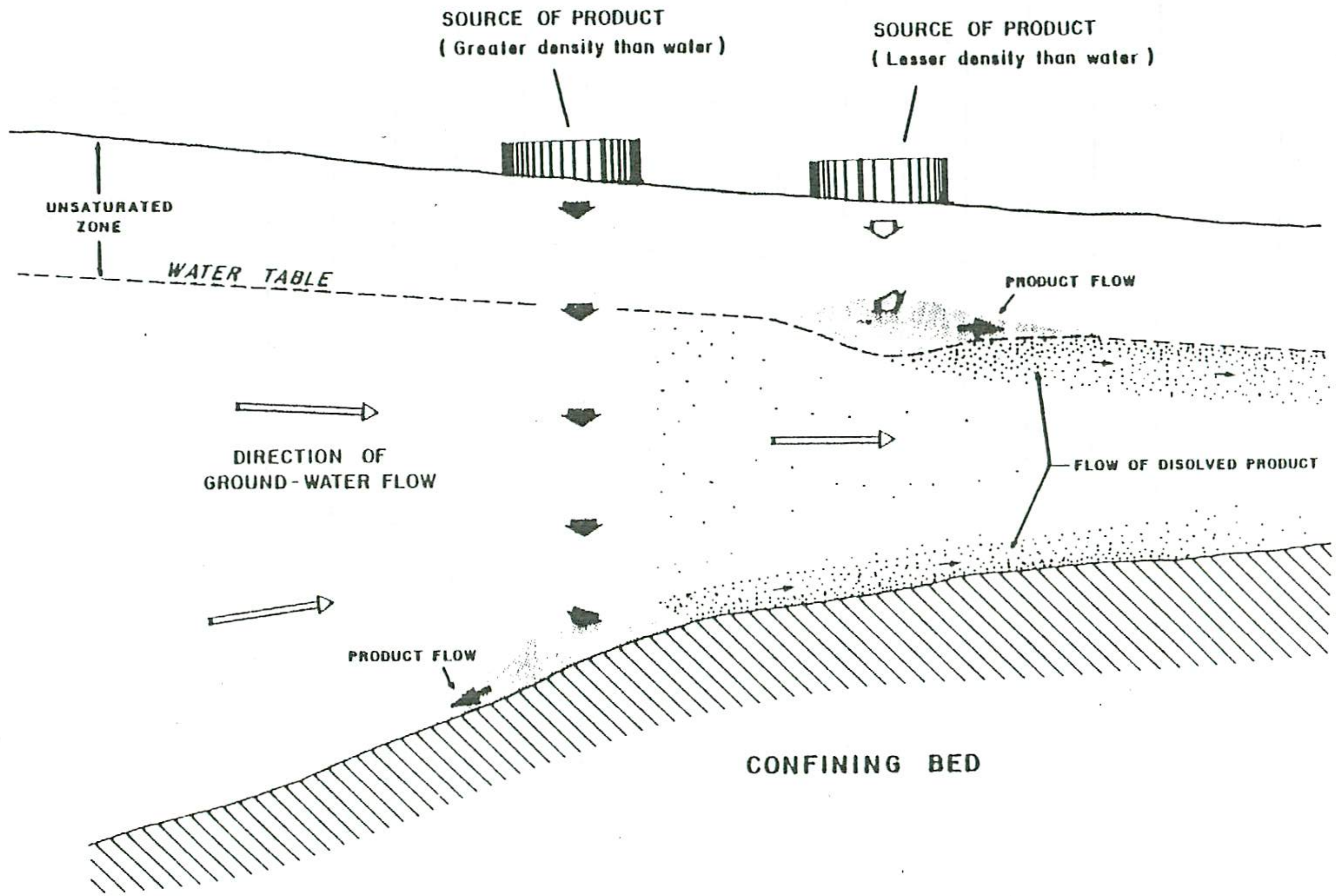
Materials of lesser densities generally follow the direction of the flow of the aquifer.

In the landfill area of Plymouth, the density and solubility parameter become important factors, as the landfill is located on the Ellisville Moraine, situated between the Manomet outwash plain and Manfields and the Wareham outwash plain.

Periodic monitoring of lakes, ponds, kettleholes and stratigically situated wells for heavy metals, industrial wastes and household contaminants is strongly suggested so as to pick up at once aquifer damage and any upward trends in quantities would give first warning signs.

Little Long's heavy metals readings are all well within the known standards. However, future periodic testings should include phemolic compound, chlorides, fluorides, sulfates, cyanides, magnesium and manganese. As new standards and testings are continually being added to this parameter, close touch should be maintained with the most recent developments.

Figure 6




Effects of density on migration of contaminants.

Biological Measurements

Pigment, Gemera Volume

| | Diatoms | Cyanophyta Blue Green Algae Unicellular | Cyanophyta Blue Green Algae Filamentous | Chlorophyta Green Unicellular | Chlorophyta Green Filamentous | Flagellates | Chlorophylla $Mg/M^3$ |
|---|---|---|---|---|---|---|---|
| | Cells/Ml | Cells/Ml | Cells/Ml | Cells/Ml | Cells/Ml | Cells/Ml | $MG/M^3$ |
| January | | | | | | | |
| February | | | | | | | |
| March | 10 | | | | | 110 | 210 |
| April | | 10 | | | | | 43 |
| May 15 | | | | | | | |
| May 30 | 20 | 10 | 10 | 15 | | | |
| June 15 | | 10 | 10 | 40 | | 140 | 60 |
| June 30 | | | 10 | | | 190 | 200 |
| July 15 | 30 | 20 | 10 | 80 | | 220 | 2 |
| July 30 | | | 20 | | | | 210 |
| August 15 | 140 | 40 | 30 | 240 | | 350 | 100 |
| August 30 | 160 | 70 | 40 | 240 | | | |
| September | | | | 250 | | 225 | |
| October | | | | 140 | | | |
| November | | | | | | 220 | |
| December | | | | | | | |

Little Long

Benthos

| Paramenter | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| Total Phosphorus Mg/L | 166 | 190 | 185 | |
| Total Nitrogen Mg/L | 2.6 | 3.0 | 2.8 | |
| Solids | 4.8 | 4.9 | 4.4 | |
| Total volatile solids | .68 | .65 | .71 | |

Nutrient Budget

August 1979

| Tributary | Total Flow G. | Total P PPM*2 | lbs./Month | Total N PPM*3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 128,563,200 | .04 | 42.7 | 1.4 | 1501.9 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 5,303,176 | 0 | 0 | 2.44 | 107.9 |
| In lake | Total Gallons | Total PPM*2 | lbs/Month | Total PPM*3 | lbs/Month |
| | 73,316,475 | .035 | 21.4 | 1.47 | 899.3 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget
September 1979

| Tributary | Total Flow G. | Total P PPM*2 | lbs./Month | Total N PPM*3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 128,360,100 | .04 | 42.8 | 1.4 | 1499.5 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 4,007,930 | | | 2.44 | 81.6 |
| In lake | Total Gallons | Total PPM*2 | lbs/Month | Total PPM*3 | lbs/Month |
| | 73,316,478 | .035 | 21.4 | 1.12 | 685.2 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget
October 1979

| ributary | Total Flow G. | Total P PPM*2 | lbs./Month | Total N PPM*3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| utfall | | | | | |
| 1 | 127,963,200 | .03 | 32.2 | 1.3 | 1388.1 |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| ainfall *1 | 4,337,852 | | | 2.44 | 88.3 |
| n lake | Total Gallons | Total PPM*2 | lbs/Month | Total PPM*3 | lbs/Month |
| | 73,316,475 | .03 | 18.35 | 1.04 | 636.3 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

# Nutrient Budget

## March 1980

| | Total Flow G. | Total P PPM *2 | lbs./Month | Total N PPM *3 | lbs/Month |
|---|---|---|---|---|---|
| Tributary | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 150,347,520 | .06 | 67.2 | 1.43 | 1794.0 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 6,561,764 | | | 2.44 | 119.3 |
| In lake | Total Gallons | Total PPM *2 | lbs/Month | Total PPM *3 | lbs/Month |
| | 73,316,475 | .05 | 30.6 | 1.45 | 887.5 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget

April 1980

| | Total Flow G. | Total P PPM[*2] | lbs./Month | Total N PPM[*3] | lbs/Month |
|---|---|---|---|---|---|
| ributary | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| utfall | | | | | |
| 1 | 150,347,520 | .08 | 89.6 | .90 | 1129.1 |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| ainfall [*1] | 5,327,614 | | | 2.44 | 96.8 |
| n lake | Total Gallons | Total PPM[*2] | lbs/Month | Total PPM[*3] | lbs/Month |
| | 73,316,475 | .04 | 24.5 | 1.28 | 783.1 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget

May 1980

| Tributary | Total Flow G. | Total P PPM*2 | lbs./Month | Total N PPM*3 | lbs/Month |
|---|---|---|---|---|---|
| | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 148,428,000 | .08 | 88.4 | 1.1 | 1362.4 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 2,810,439 | | | 2.44 | 51.1 |
| In lake | Total Gallons | Total PPM*2 | lbs/Month | Total PPM*3 | lbs/Month |
| | 73,316,475 | .05 | 30.6 | 1.13 | 691.3 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget

June 1980

| Tributary | Total Flow G. | Total P PPM *2 | lbs./Month | Total N PPM *3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 146,196,000 | .07 | 762 | .8 | 975.9 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 3,726,887 | | | 2.44 | 67.7 |
| In lake | Total Gallons | Total PPM *2 | lbs/Month | Total PPM *3 | lbs/Month |
| | 73,316,475 | .05 | 30.6 | 1.08 | 660.7 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Nutrient Budget

July 1980

| Tributary | Total Flow G. | Total P PPM *2 | lbs./Month | Total N PPM *3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Outfall | | | | | |
| 1 | 135,616,320 | .04 | 45.3 | .65 | 735.6 |
| 2 | | | | | |
| 3 | | | | | |
| Total | | | | | |
| Rainfall *1 | 2,688,246 | 0 | 0 | 2.44 | 54.7 |
| in lake | Total Gallons | Total PPM *2 | lbs/Month | Total PPM *3 | lbs/Month |
| | 73,316,475 | .04 | 24.5 | .9 | 550.6 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

Little Long

Nutrient Budget

August 1980

| ributary | Total Flow G. | Total P PPM*2 | lbs./Month | Total N PPM*3 | lbs/Month |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| utfall | | | | | |
| 1 | 129,326,080 | .02 ppm | 21.6 | .41 | 442.46 |
| 2 | | | | | |
| 3 | | | | | |
| otal | | | | | |
| ainfall *1 | 1,893,992 | 0 | 0 | 2.44 | 38.6 |
| in lake | Total Gallons | Total PPM*2 | lbs/Month | Total PPM*3 | lbs/Month |
| | 73,316,475 | .03 | 18.4 | .70 | 428.3 |

*1 Rainfall - Phosphorus data not available $NH_4$ .48 PPM $No_3$ 1.96 PPM.

*2 Total P. = All orthophosphates, condensed, organic and inorganic species.

*3 Kjeldahl Nitrates, Nitrites.

## Macrophyte, Microphytes and Nutrient Utilization

The period of greatest biological activity occurs in a lake or pond ecosystem during the months of July and August. This is the period of maximum utilization of nutrients by both plants and algae. The long periods of daylight, coupled with high water temperatures, provide the physical thrust for this utilization. So it is at this period the limiting nutrient, as well as others, are shown in many cases to be the lowest of the readings during the yearly cycle.

A phosphate reading in March might be .08ppm, and in the same system read as low as .01 - .02 ppm in July and August. Thus, it is that nutrient reading at the season of maximum activity in the biomass could well be below the accepted eutrophication level in a high eutrophic lake, and might even approach oligotrophic levels.

It is for this reason that nutrient readings taken in the spring and fall overturn, in stratified lakes, are the real indicators of the trophic condition of the lake. The late fall, winter, and early spring readings for non-stratified bodies of water are the indicators of the actual trophic condition of these lakes and ponds.

# HYDROLOGY, GROUNDWATER GEOLOGY

Nearly all of Plymouth and parts of Carver, Wareham, and Bourne lie over an unconsolidated aquifer, "The Plymouth Aquifer". This aquifer is located primarily in the soil series called "The Carver Series."

This series is exceedingly well drained and the water moves rapidly through the soil profile to the ground water, with little or no purification action. The surface run-off is very low, and infiltration capacity is very high in the Carver soils. This combination of physical factors endangers the water table. The general flow of the aquifer is from northwest to the **southeast.**

There are two types of aquifers: the water table (unconfined aquifer)(see fig. 2) and the artesian (confined aquifer). The type that concerns this report is the unconfined and not the artesian classification, although the protection of the upper (unconfined) would lead generally to the protection of the other.

In an unconfined aquifer the water is under atmospheric pressure and the upper saturated surface is known as the water table. The water table is responsible to changes in the amount of stored water and fluctuates seasonally in response to the variations in the rate of natural recharge. The principal source of natural recharge to a water table aquifer is precipitation.

An example of this is the lowering of the water table in many kettleholes in Plymouth, i.e. Island Pond, Sandy Pond, and Clear Pond. Also, the various ponds (natural) spring fed, i.e. Little Herring into Great Herring Sea, (flow data in Great Herring report), reflect a corresponding raising and lowering of flow volume due to atmospheric recharge.

The rainfall in 1980 being 29.4 inches, as against 42.5 normal, a deficit of 13.1 inches. The deficit is reflected in general lowering of the water level in the various kettleholes. Thus reflecting a variation of precipitation in a corresponding lowering or raising of the water table.

Streams can be areas of recharge to or discharge from the water table aquifer. Groundwater in an aquifer is constantly moving from points of recharge towards points of discharge. The movement of ground water is from regions of high hydrostatic head towards those of lower hydrostatic head. See figure 2, for these interalations.

Discharge locations for aquifers can be springs, pumped wells, gaining streams and swamps, ponds, lakes and the sea.

Confined or artesian aquifers are bound above and below by geologic formations of lower permeability. The aquifers can receive recharge from leakage out of confining beds or from precipitation and surface water bodies in the outcrop area of the aquifer. See figure 1, ground water discussion.

The velocity of flow of ground water may in any aquifer be as low as 10 feet per year and only in coarse material or fissures does the velocity exceed 1 mile per year. Coupled with minimum rates of lateral and vertical diffussion, the low velocities of flow cause two significant conditions to develop in ground water basins or streams. First, pollution that is being added to the ground at one point may not affect the quality of water supplies or water quality in surface waters at nearby points for many years, or at distant points for decades, consequently, no complaints are registered and no one may be aware of the damage being done. Second, when pollution is finally discovered or when the quality of water is degraded, the damanged cannot be repaired or otherwise rectified merely by stopping the pollution, for purification by leaching and dilution will require a longer time than the period of original pollution. Thus the speed of groundwater pollution depends on many things but the primary self-evident conclusion is that soil types govern a great deal the speed of contamination.

Well drained soils, Geology, and potential Aquifer Pollution

Investigations of Childs 1972a, Childs 1972b, Dudley, and Stephenson 1973 show the soil problem areas.

1. Where coarse sands and gravels are principle sub-soil materials
2. Very impermeable materials where the effluant may become ponded above horizons at short distances from the point of release.
3. In poorly drained soils with high water tables.

Soils that percolate water very quickly are most often inadequate in terms of removing waste water impurities, such as bacteria, phosphorus and nitrogen. These impurities can cause potential ground and surface water pollution problems. See figure 3.

Lot sizes and set backs, type of sewage system should be determined by soil type, along with the soils hydraulic capabilities, purification capabilities, and physical constraints. The slope problem should be part of the consideration.

The present methodology in regards to percolation rates should be upgraded so as to accurately assess the soils ability to remove pollutants at potential leach field sites.

The characteristics of the Carver soils makes the whole ecosystem susceptable to groundwater contamination. May of the lakes, ponds, and kettleholes in

Plymouth are fed by aquifers and any nutrients transferred by this means aids in the eutrophication of these systems. Long-range safe guards must be implemented to protect this valuable natural resource.

Figure 1

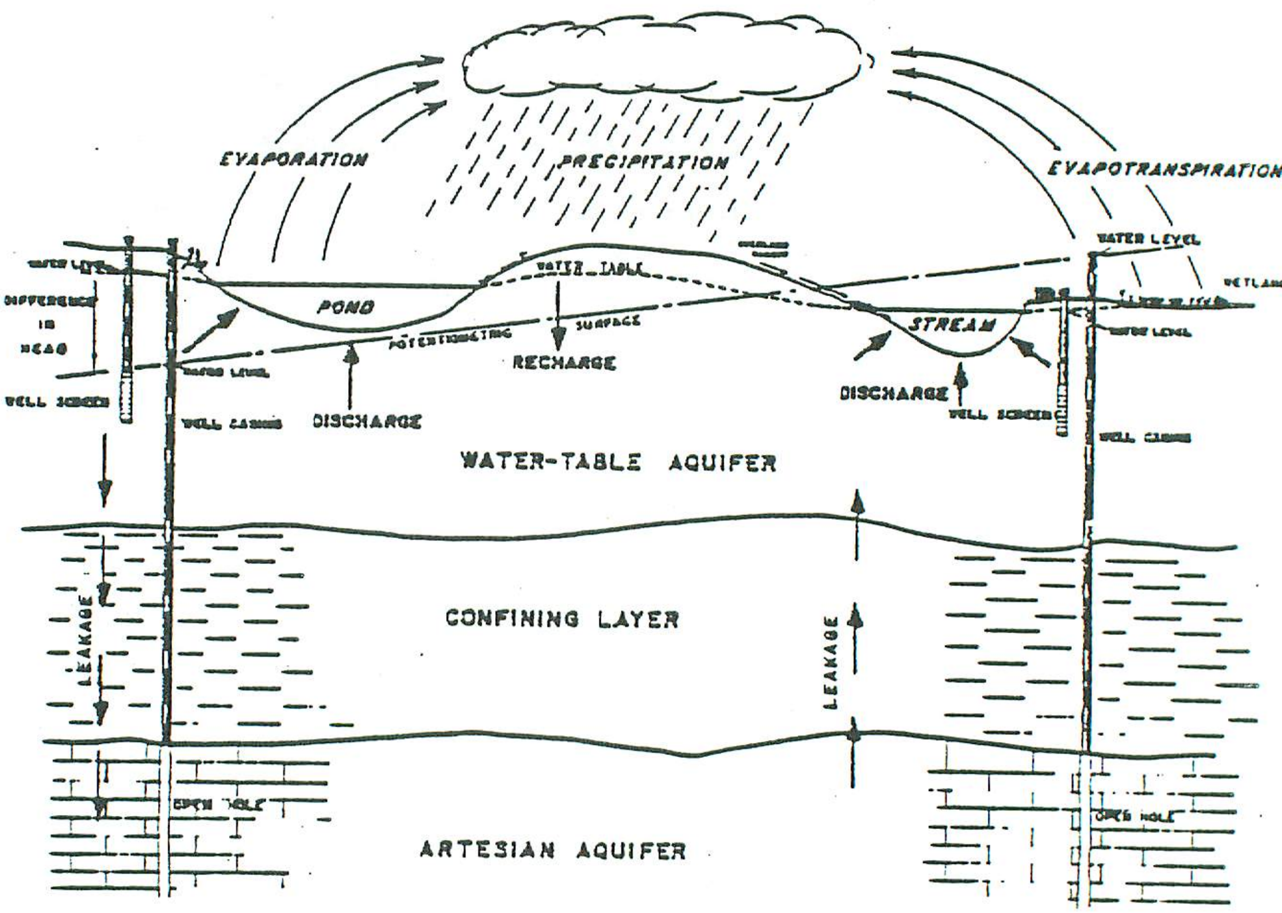



Illustration of relationships within the hydrologic system.

Figure 2

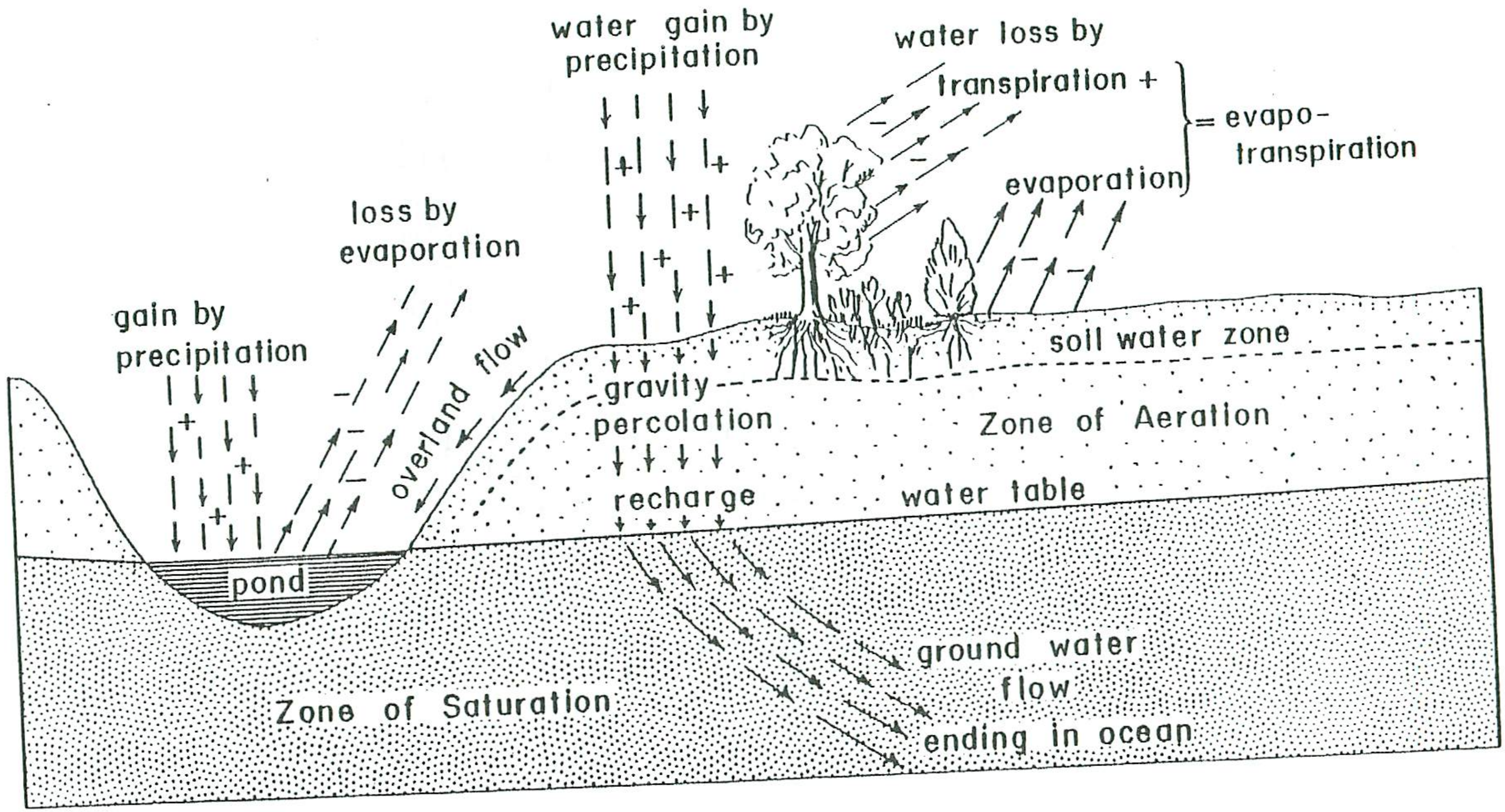
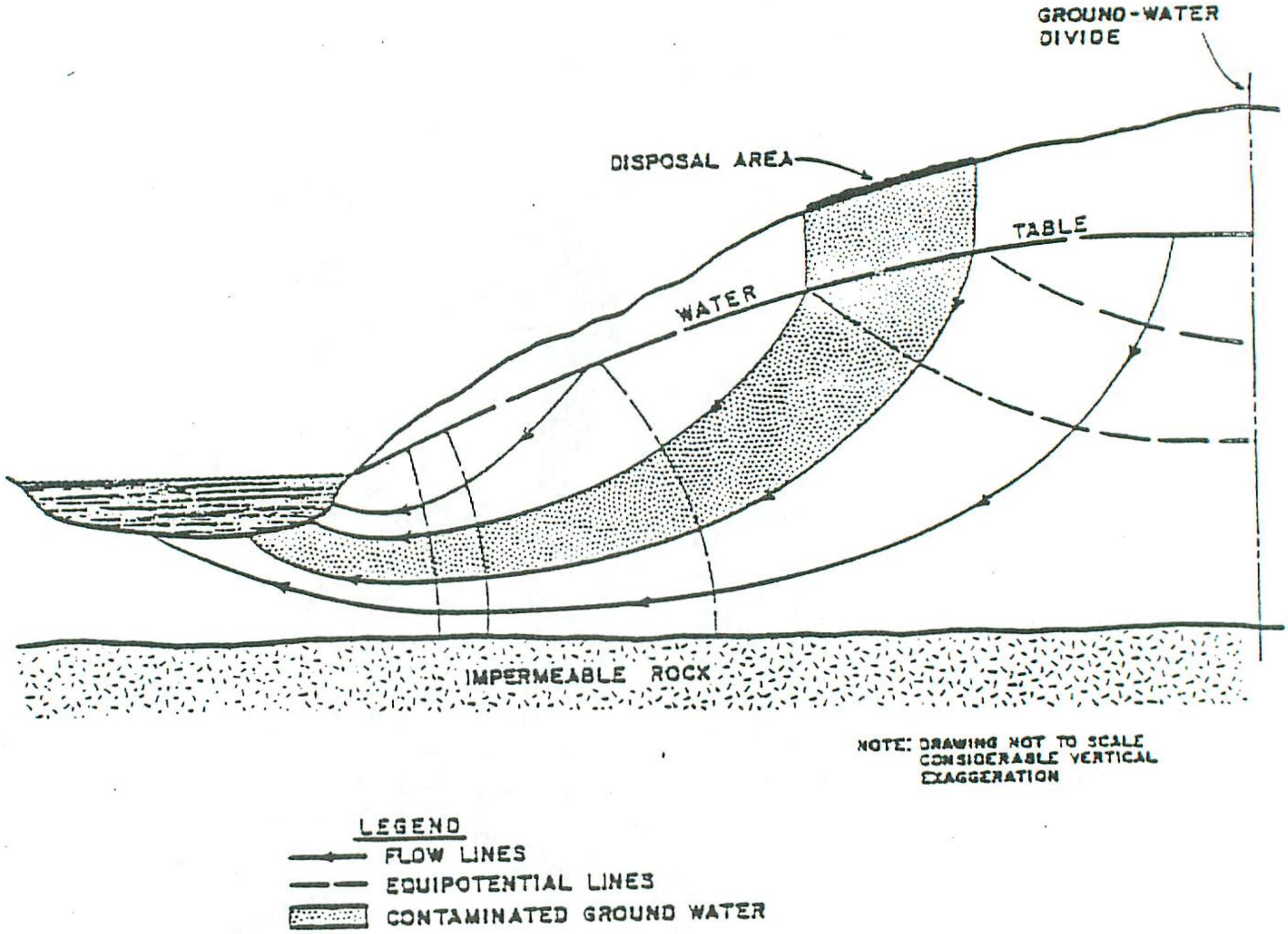

water gain by
precipitation
water loss by
transpiration +
evaporation
= evapo-
transpiration
loss by
evaporation
gain by
precipitation
overland flow
soil water zone
gravity
percolation
Zone of Aeration
recharge
water table
pond
ground water
flow
ending in ocean
Zone of Saturation

Figure 3



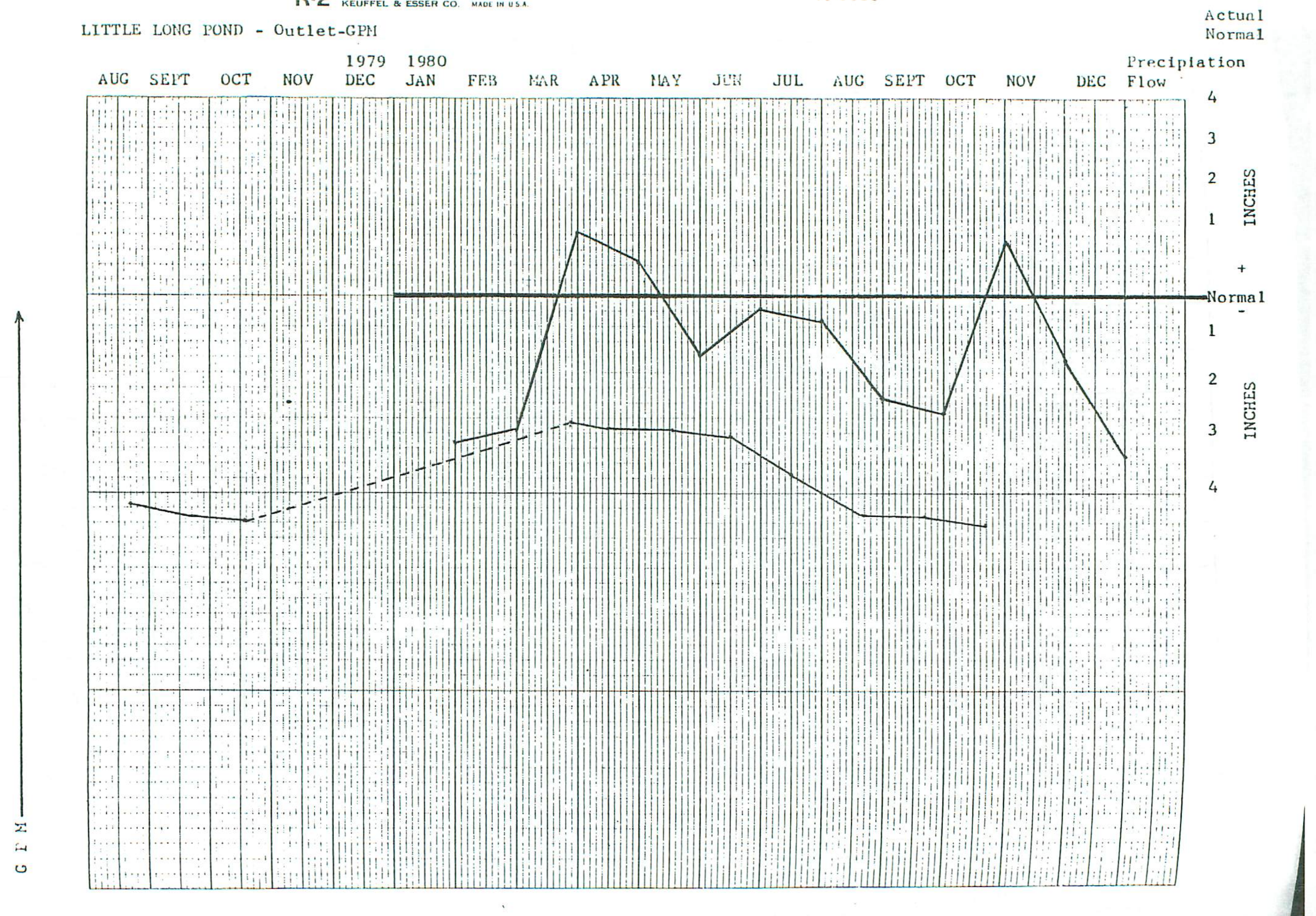

Flow in a water-table aquifer (humid region).

# HYDRAULIC PARAMETERS MONTHLY

| | Trib. 1 | Trib. 2 | Aquifer Inflow | Rainfall | Rainfall | Outfall | Outfall | Evap. | Evap. | Lake Bottom Loss | T. Gain | T. Loss |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gallons | Gallons | Gallons | Inches | Gallons | Gallons | Gallons | Inches | Gallons | | | |
| August | | | 127.1 mg | 4.34 | 5.3 mg | 128.6 mg | | 3.15 | 3.8 mg | | 128.6 mg | |
| September | | | 126.8 | 3.28 | 4.0 | 128.4 | | 2.01 | 2.5 | | 128.4 | |
| October | | | 125.4 | 3.55 | 4.3 | 128.0 | | 1.47 | 1.8 | | 128.1 | |
| November | | | 124.1 | 4.87 | 5.95 | 130.1 | | .6 | .7 | | 130.1 | |
| December | | | 127.3 | 4.34 | 5.3 | 132.6 | | 0 | 0 | | 132.6 | |
| January | | | 139.3 | .74 | .9 | 140.2 | | 0 | 0 | | 140.2 | |
| February | | | 144.0 | .88 | 1.1 | 145.1 | | 0 | 0 | | 145.1 | |
| March | | | 144.6 | 5.37 | 6.6 | 150.3 | | .7 | .85 | | 150.3 | |
| April | | | 148.4 | 4.36 | 5.3 | 150.3 | | 2.78 | 3.4 | | 150.3 | |
| May | | | 150.1 | 2.30 | 2.8 | 148.4 | | 3.63 | 4.4 | | 148.4 | |
| June | | | 147.0 | 3.05 | 3.7 | 146.2 | | 3.73 | 4.6 | | 146.2 | |
| July | | | 138.3 | 2.20 | 2.7 | 135.6 | | 4.36 | 5.3 | | 135.6 | |
| August | | | 131.4 | 1.55 | 1.9 | 129.3 | | 3.23 | 3.9 | | 129.3 | |
| September | | | 130.3 | .82 | 1.0 | 128.5 | | 2.33 | 2.8 | | 128.5 | |
| October | | | 126.8 | 4.14 | 5.1 | 129.9 | | 1.57 | 1.9 | | 129.9 | |
| November | | | 128.8 | 3.01 | 3.7 | 121.7 | | .6 | .73 | | 131.7 | |
| December | | | 134.7 | .97 | 1.2 | 135.9 | | 0 | 0 | | 135.9 | |

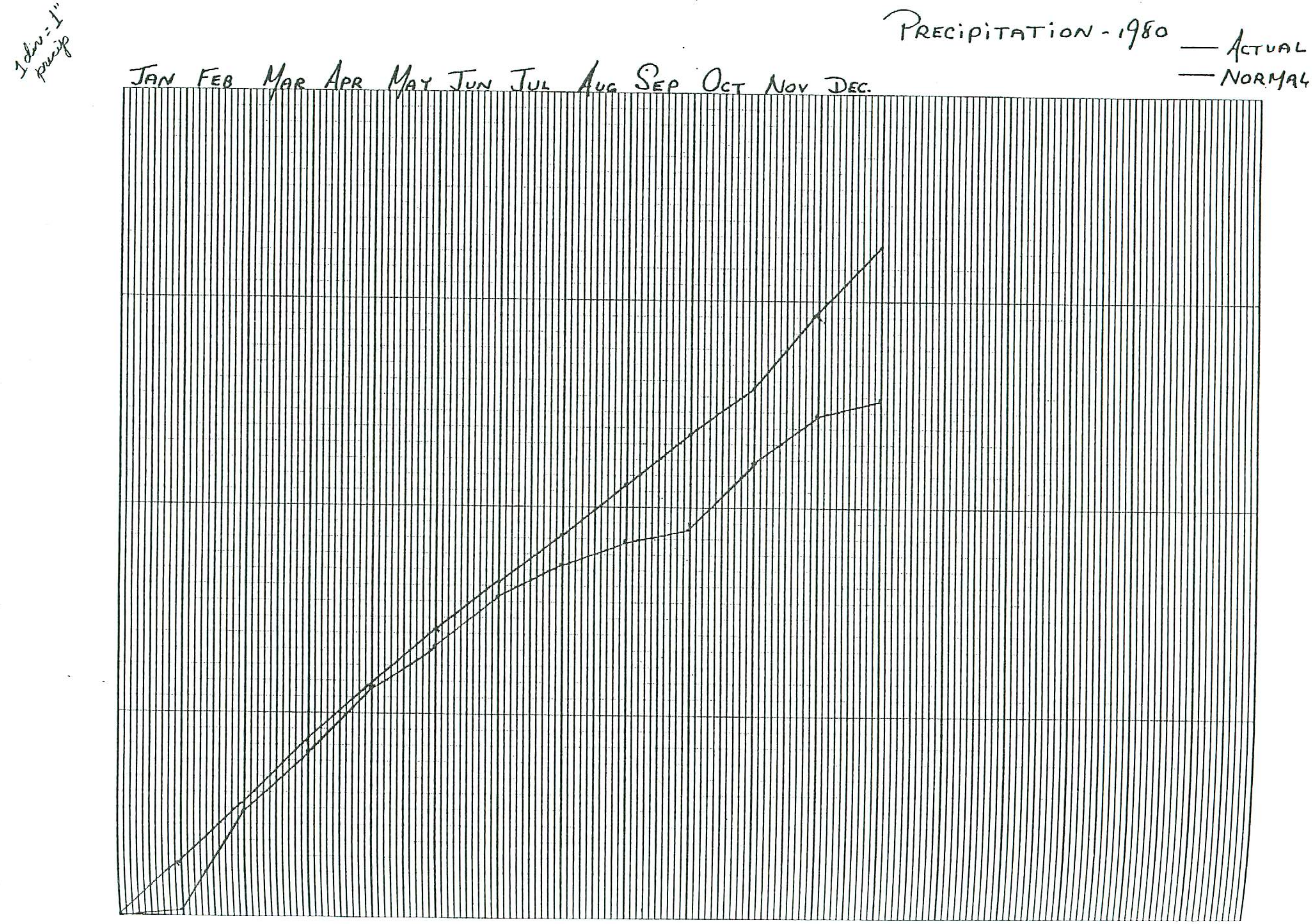
mg = million gallon   * Used Government data (see Addenda)   *Normal 42.52 inches

LITTLE LONG POND - Outlet-GPM



K•E 1 YEAR BY WEEKS X 100 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 3010



# LITTLE LONG GEOLOGY

## Soil Series Discussion

Carver soil series consist of excessively drained, nearly level to steep sandy soils that formed in thick deposits of coarse, pebbly quartz sand. In most places, Carver soils are coarse sand, but in some places the surface layer and the upper part of the subsoil are loamy coarse sand. Water moves rapidly downward through the solum and underlying substratum. These soils do not retain sufficient moisture for good plant growth and are extremely acid.

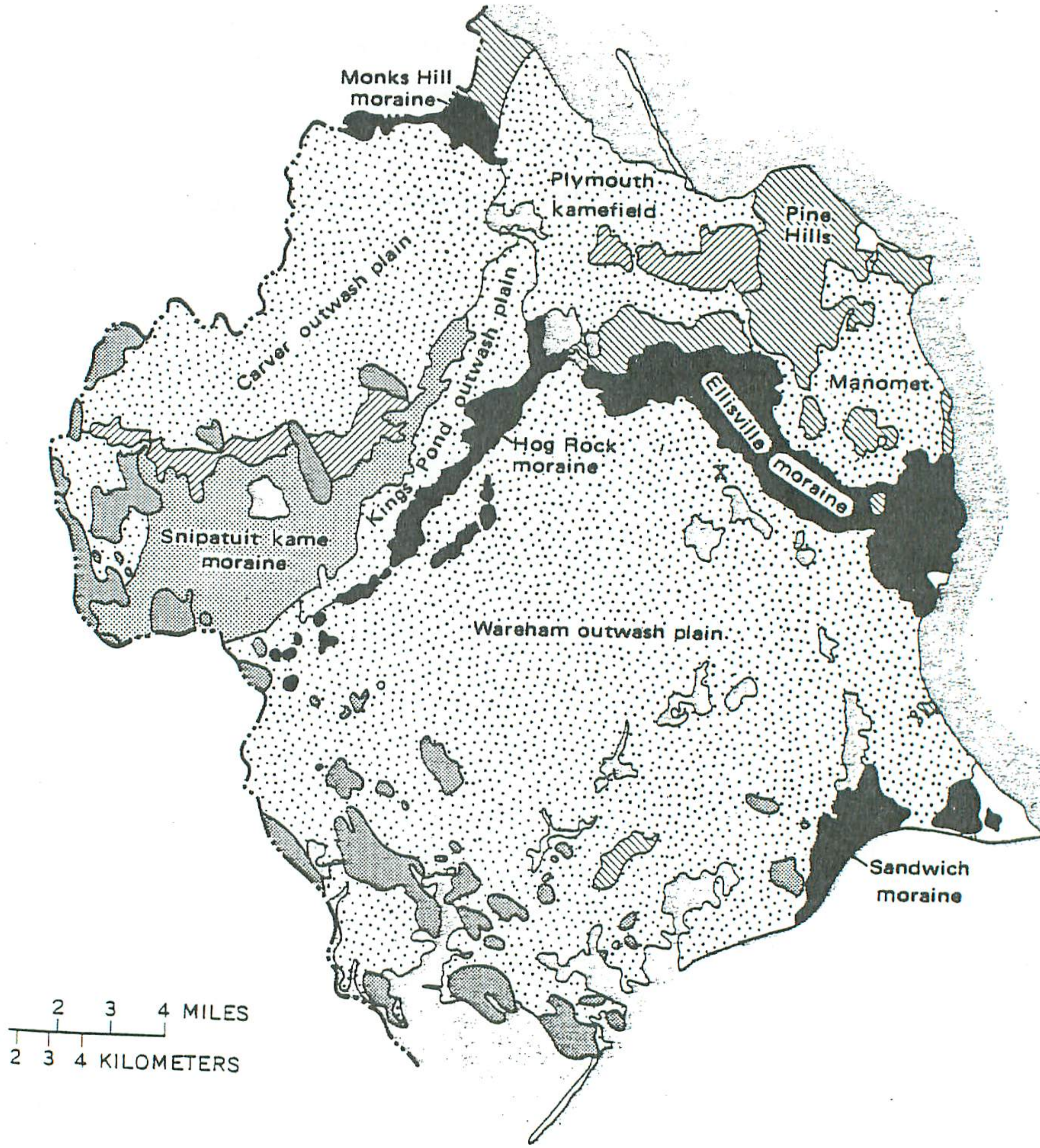
Carver soils are excessively drained. The permeability of Carver soils is a rapid 6.3 inches per hour. This was the most rapid ecosystem susceptible to groundwater contamination. Many of the lakes, ponds and kettleholes in Plymouth County are fed by aquifers and Little Long is one such example (see hydrologic information), and any nutrients transferred by this means aids in the eutrophication of these systems. Long range safe guards must be implemented to protect this valuable natural resource.

CcD - Carver and Gloucester soils - 8-35% slopes
These soils occupy moraines in the southeastern parts of the county. Sandy Carver soils make up about two-thirds of this unit, and extremely stony Gloucester soils make up the rest.

Gloucester series soils are nearly level to steep, well drained, and somewhat excessively drained soils that formed in glacial till, derived chiefly from granite.

Gloucester soils are extremely stony except where they have been cleared for tillage.

Unmarked areas: No danger to aquifers with normal use.




X = Little Long Pond location.

Little Long Pond

Soil Survey Map with

Soil Legend

## SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, or E, shows the slope. Symbols without a slope letter are those of nearly level soils or land types.

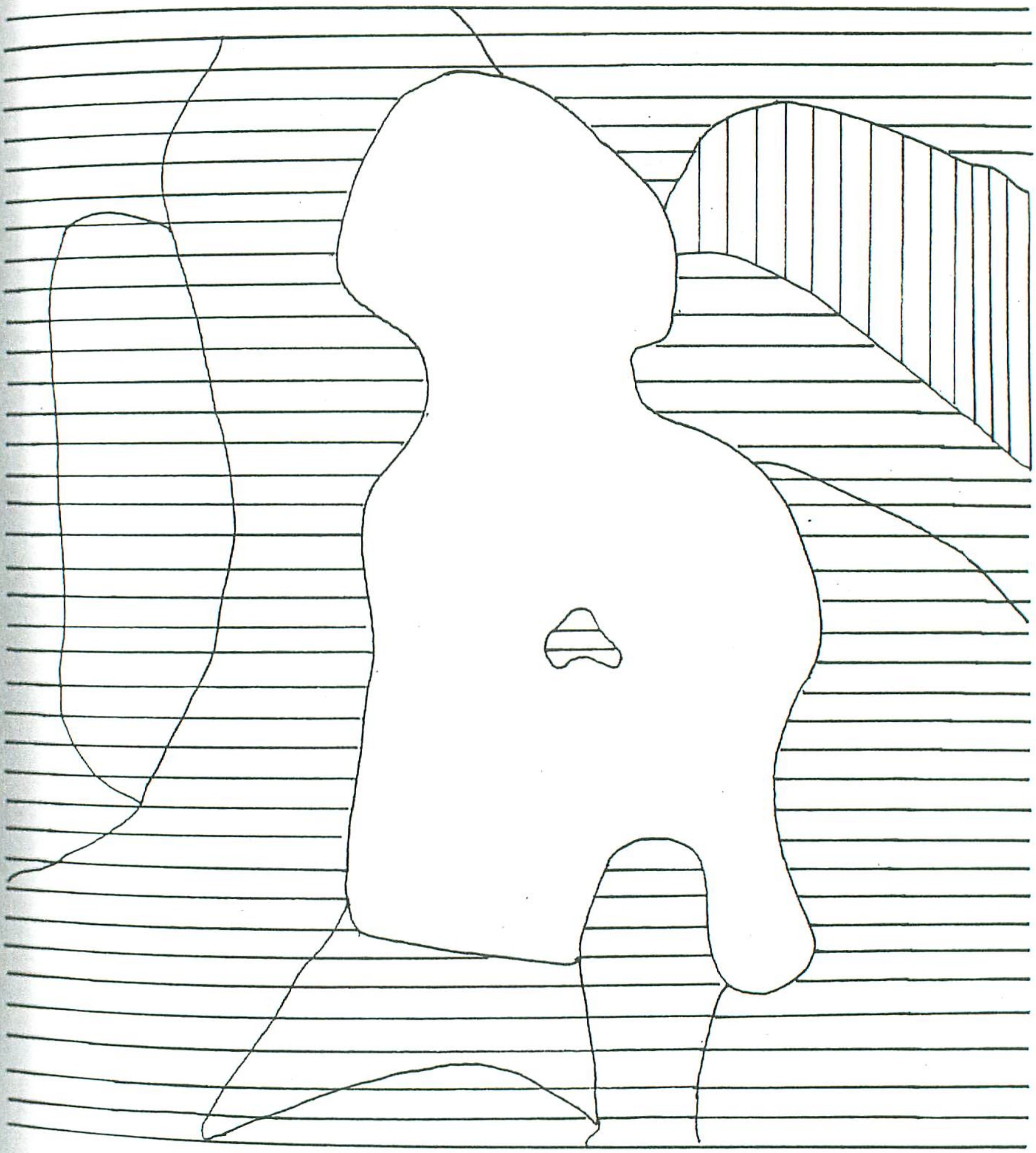
| SYMBOL | NAME |
|---|---|
| AfA | Agawam fine sandy loam, 0 to 3 percent slopes |
| AfB | Agawam fine sandy loam, 3 to 8 percent slopes |
| AgA | Agawam fine sandy loam, silty subsoil variant, 0 to 3 percent slopes |
| AgB | Agawam fine sandy loam, silty subsoil variant, 3 to 8 percent slopes |
| AuA | Au Gres and Wareham loamy sands, 0 to 3 percent slopes |
| AuB | Au Gres and Wareham loamy sands, 3 to 8 percent slopes |
| BaA | Belgrade silt loam, 0 to 3 percent slopes |
| BaB | Belgrade silt loam, 3 to 8 percent slopes |
| BbB | Bernardston silt loam, 3 to 8 percent slopes |
| BbC | Bernardston silt loam, 8 to 15 percent slopes |
| BcB | Bernardston very stony silt loam, 3 to 8 percent slopes |
| BcD | Bernardston very stony silt loam, 8 to 25 percent slopes |
| BdA | Birdsall silt loam, 0 to 3 percent slopes |
| Bo | Borrow land, loamy material |
| Br | Borrow land, sandy and gravelly materials |
| BsA | Brockton loam, 0 to 3 percent slopes |
| BtA | Brockton extremely stony loam, 0 to 3 percent slopes |
| CaA | Carver coarse sand, 0 to 3 percent slopes |
| CaB | Carver coarse sand, 3 to 8 percent slopes |
| CaC | Carver coarse sand, 8 to 15 percent slopes |
| CaE | Carver coarse sand, 15 to 35 percent slopes |
| CbA | Carver loamy coarse sand, 0 to 3 percent slopes |
| CbB | Carver loamy coarse sand, 3 to 8 percent slopes |
| CbC | Carver loamy coarse sand, 8 to 15 percent slopes |
| CcD | Carver and Gloucester soils, 8 to 35 percent slopes |
| DeA | Deerfield sandy loam, 0 to 3 percent slopes |
| DeB | Deerfield sandy loam, 3 to 8 percent slopes |
| Du | Dune land and Coastal beach |
| EnA | Enfield very fine sandy loam, 0 to 3 percent slopes |
| EnB | Enfield very fine sandy loam, 3 to 8 percent slopes |
| EnC | Enfield very fine sandy loam, 8 to 15 percent slopes |
| EsA | Essex coarse sandy loam, 0 to 3 percent slopes |
| EsB | Essex coarse sandy loam, 3 to 8 percent slopes |
| EsC | Essex coarse sandy loam, 8 to 15 percent slopes |
| EtB | Essex very stony coarse sandy loam, 3 to 8 percent slopes |
| EtC | Essex very stony coarse sandy loam, 8 to 15 percent slopes |
| EtD | Essex very stony coarse sandy loam, 15 to 25 percent slopes |
| EuB | Essex extremely stony coarse sandy loam, 3 to 8 percent slopes |
| EuC | Essex extremely stony coarse sandy loam, 8 to 25 percent slopes |
| Fr | Fresh water marsh |
| GaA | Gloucester fine sandy loam, firm substratum, 0 to 3 percent slopes |
| GaB | Gloucester fine sandy loam, firm substratum, 3 to 8 percent slopes |
| GaC | Gloucester fine sandy loam, firm substratum, 8 to 15 percent slopes |
| GbA | Gloucester loamy sand, 0 to 3 percent slopes |
| GbB | Gloucester loamy sand, 3 to 8 percent slopes |
| GbC | Gloucester loamy sand, 8 to 15 percent slopes |
| GcB | Gloucester very stony fine sandy loam, firm substratum, 3 to 8 percent slopes |
| GcC | Gloucester very stony fine sandy loam, firm substratum, 8 to 15 percent slopes |
| GcD | Gloucester very stony fine sandy loam, firm substratum, 15 to 25 percent slopes |
| GdB | Gloucester very stony loamy sand, 3 to 8 percent slopes |
| GdC | Gloucester very stony loamy sand, 8 to 15 percent slopes |
| GeB | Gloucester extremely stony loamy sand, 3 to 15 percent slopes |
| GeD | Gloucester extremely stony loamy sand, 15 to 35 percent slopes |
| HaA | Hinckley gravelly loamy sand, 0 to 3 percent slopes |
| HaB | Hinckley gravelly loamy sand, 3 to 8 percent slopes |
| HaC | Hinckley gravelly loamy sand, 8 to 15 percent slopes |
| HaE | Hinckley gravelly loamy sand, 15 to 35 percent slopes |
| HoB | Hollis–Charlton fine sandy loams, 3 to 8 percent slopes |
| HpC | Hollis–Charlton very rocky fine sandy loams, 3 to 15 percent slopes |
| HrC | Hollis–Charlton extremely rocky fine sandy loams, 3 to 15 percent slopes |
| HrD | Hollis–Charlton extremely rocky fine sandy loams, 15 to 25 percent slopes |
| Ma | Made land |
| MeA | Merrimac fine sandy loam, 0 to 3 percent slopes |
| MeB | Merrimac fine sandy loam, 3 to 8 percent slopes |
| MeC | Merrimac fine sandy loam, 8 to 15 percent slopes |
| MfA | Merrimac sandy loam, 0 to 3 percent slopes |
| MfB | Merrimac sandy loam, 3 to 8 percent slopes |
| MfC | Merrimac sandy loam, 8 to 15 percent slopes |
| MfE | Merrimac sandy loam, 15 to 35 percent slopes |
| Mu | Muck, shallow |
| Mv | Muck, deep |
| NnA | Ninigret sandy loam, silty subsoil variant, 0 to 3 percent slopes |
| NnB | Ninigret sandy loam, silty subsoil variant, 3 to 8 percent slopes |
| NoA | Norwell sandy loam, 0 to 3 percent slopes |
| NoB | Norwell sandy loam, 3 to 8 percent slopes |
| NpA | Norwell extremely stony sandy loam, 0 to 3 percent slopes |
| NpB | Norwell extremely stony sandy loam, 3 to 8 percent slopes |
| Pe | Peat |
| PtA | Pittstown silt loam, 0 to 8 percent slopes |
| PuB | Pittstown very stony silt loam, 3 to 15 percent slopes |
| QuA | Quonset sandy loam, 0 to 3 percent slopes |
| QuB | Quonset sandy loam, 3 to 8 percent slopes |
| QuC | Quonset sandy loam, 8 to 15 percent slopes |
| QuE | Quonset sandy loam, 15 to 35 percent slopes |
| RaA | Raynham silt loam, 0 to 3 percent slopes |
| Sa | Saco very fine sandy loam |
| Sb | Sanded muck |
| ScA | Scarboro sandy loam, 0 to 3 percent slopes |
| SdA | Scarboro fine sandy loam, silty subsoil variant, 0 to 3 percent slopes |
| SeA | Scituate sandy loam, 0 to 3 percent slopes |
| SeB | Scituate sandy loam, 3 to 8 percent slopes |
| SfA | Scituate very stony sandy loam, 0 to 3 percent slopes |
| SfB | Scituate very stony sandy loam, 3 to 8 percent slopes |
| SgA | Scituate extremely stony sandy loam, 0 to 3 percent slopes |
| SgB | Scituate extremely stony sandy loam, 3 to 8 percent slopes |
| Td | Tidal marsh |
| TsA | Tisbury very fine sandy loam, 0 to 8 percent slopes |
| WaA | Walpole fine sandy loam, silty subsoil variant, 0 to 3 percent slopes |
| WbA | Warwick fine sandy loam, 0 to 3 percent slopes |
| WbB | Warwick fine sandy loam, 3 to 8 percent slopes |
| WbC | Warwick fine sandy loam, 8 to 15 percent slopes |
| WcC | Warwick very rocky fine sandy loam, 3 to 15 percent slopes |
| WnA | Windsor loamy sand, 0 to 3 percent slopes |
| WnB | Windsor loamy sand, 3 to 8 percent slopes |
| WnC | Windsor loamy sand, 8 to 15 percent slopes |
| WnE | Windsor loamy sand, 15 to 35 percent slopes |

Little Long

Geologic Data

| | | |
|---|---|---|
| CaB | Carver coarse sand | 3 - 8 percent slopes |
| CaC | " " " | 8 - 15 percent slopes |
| CaE | " " " | 15 - 35 percent slopes |
| CaD | " " " | 8 - 35 percent slopes |

LITTLE LONG



- Soil series very sensitive to groundwater pollution
- Soil series sensitive to groundwater pollution

SCALE 1:400

# GUIDELINES FOR REHABILITATION

# OF

# L I T T L E   L O N G   P O N D

## LONG RANGE CONTROL TECHNIQUES

## IN-LAKE MANAGEMENT METHODS

# LONG RANGE CONTROL TECHNIQUES

1. Controlling Nutrient and Sediment Influx

2. Watershed Management

   A. Non-Structural

   B. Structural

# NON-STRUCTURAL CONTROL TECHNIQUES

1. ZONING REGULATION

   A. MINIMUM LOT SIZES

   B. BUILDING SET BACKS

   C. DISCOURAGE DEVELOPMENT OF PORTIONS OF SHORELINE

   D. RESTRICT HIGH POLLUTION GENERATING SOURCES

      1. NEAR SHORE

      2. NEAR TRIBUTARIES

      3. IN FLOOD PLAINS

2. DEVELOPMENT CONTROL

   A. RESTRICT DIVISION OF LAND FOR BUILDING OR SETTLING

   B. LIMIT DEVELOPMENT IN EROSION AREAS

   C. LIMIT DEVELOPMENT IN AREAS WHERE SOIL CHARACTERISTICS PREVENT ADEQUATE ON-SITE WASTE DISPOSAL.

   D. ENCOURAGE FORMS OF DEVELOPMENT WHICH FACILITATE EFFECTIVE AND ECONOMIC WASTE DISPOSAL PRACTICES AND PRESERVATION OF NATURAL SPACES.

3. PHOSPHATE BAN

# ZONING REGULATION

Lot sizes should depend on:

1. Soil conditions

   The state of Maine uses an in-depth soil percolation method called site evaluation for subsurface waste water disposal - it includes guidelines for monitoring high ground water levels.

2. Environmental conditions

   Such considerations include size of developments, if ground water water can become contaminated with large numbers of dwellings and/or businesses.

Building set-backs:

State of Maine has established a minimum distance of 100 feet from leaching field to any river, stream, lake, pond, ocean or drinking-water supply.

Discourage development of shoreline:

Use these areas as non-polluting recreation areas.

Restrict high pollution generating sources:

Especially in areas that could possibly contaminate groundwater.

It is possible that one of the best methods to control nutrient in-flux for a given lake is to control land use within the watershed.

## NON-STRUCTURAL DEVELOPMENT CONTROL

## DEVELOPMENT CONTROL

Lot size should be determined by actual soil type with particular interest devoted to:

1. The soil's hydraulic capabilities
2. The soil's purification capabilities
3. Any physical constraints

Some soils like the Carver series pecolate water rapidly but such soils are inadequate in terms of removing wastewater impurities such as bacteria, phosphorous and nitrogen. It is these impurities that can cause ground and surface water pollution.

To best determine the above 3 factors a soil evaluation program should be established (the state of Maine guidelines are recommended). The site evaluation would determine whether a specific parcel of land would be considered suitable for the proposed disposal system.

Slope should be another limiting factor on lot sizes; the difficulty of designing and building adequate absorption fields on steep slopes, as well as erosion problems associated with steep slopes call for further adjustment of lot sizes according to the capability of the natural slope.

Other factors to be considered are ground water flow, watersheds, nearby wells and streams, topography, vegetation and ground cover.

Where soil characteristics prevent adequate on-site waste disposal or if an area is heavily developed, closed system sewage disposal is recommended. Included in closed systems are:

1. recirculating toilets
2. gas incinerating toilets
3. electric incinerating toilets
4. composting toilets
5. chemical toilets
6. low water flush toilets
7. vacuum toilets
8. sewerless toilets

A list of manufacturers is included in the Addenda.

Investigations (Childs 1972A, Childs 1972B, Dudley and Stephensen, 1973) indicate that problem areas occur:

1. Where coarse sands and gravel are the principal subsoil materials.
2. Very impermeable materials where effluent may become ponded above horizons at short distances from point of release.
3. In poorly drained soils with high water table.

# VOLUNTARY PHOSPHATE BAN

Though few studies have been made in depth, reports by Sawyer (32) and Vollenweider (17) pertaining to Wisconsin and Swiss lakes respectively indicate that when inorganic nitrogen (ammonia plus nitrate nitrgen) is equal to or greater than .3 mg/l and the orthophosphate is equal to or greater than .01 mg/l, then the lake is likely to have excessive crops of algae and other aquatic plants.

A recent study make in Vermont showed that all the lakes so tested were found to be phosphorous limited.

A Cornell research team conducted a study of 13 lakes in central New York - this study led to a quantitative expression of the relation between phosphorous loading and concentrations of algae.

Phosphorous in runoff occurs in 3 general forms:

1. Dissolved organic
2. Dissolved inorganic
3. Particulated

The dissolved phosphorous in both forms has a far more important influence on algal growth than has phosphorous which is attached to soil particles.

Sources of Dissolved Phosphorous:

Sewage - 55%

Agricultural runoff - 18%

Forest runoff - 15%

Most lakes so studies are phosphorous limited, any reduction in their phosphorous loading may slow their eutrophication. One sure method of reducing phosphorous loading is to reduce the amount of phosphorous entering water treatment facilities and domestic waste water facilities (septic systems as phosphate detergents may contribute over 50% of the phosphorous in domestic wastewaters,. eliminating this source can have a significant impact. The solution is simple: stop using detergents with phosphates and use phosphate-free detergents.

A voluntary local ban or even a state wide ban of household laundry detergents and cleaning fluids containing more than .5% phosphorous.

Advantages:

1. Better water quality
2. Algae free lakes and ponds
3. No cost to state or town

Disadvantages:

1. There may be a slight added cost to consumer
2. Ring around the collar

How:

1. Newspaper articles
2. Local radio
3. Town government

This is classified as a long-range control technique but an immediate execution will initiate an in-lake comeback.

# STRUCTURAL CONTROL TECHNIQUES

A. DIVERSION

B. CONTROLLING NUTRIENT AND SEDIMENT INFLUX

a. Locating faulty septic systems

b. Flow reducing devices

c. Controlling nutrient and sediment influx

C. SOIL EROSION CONTROL

D. SANITARY LANDFILL LEACHATE

E. SEWERING

# D I V E R S I O N

The most frequently used method to reduce lake eutrophication is to divert waste waters around or away from the lake.

Diversion of nutrient-rich water away from eutrophying lakes and ponds will be encouraged by the state when:

1. Sewage treatment plant effluent or storm sewer outflow enters a lake or pond by its tributaries or direct outfall.

2. Rerouting of the inflow does not have a significant negative impact on the biota or hydrologic cycle of the system, adjacent wetlands or any other riparian habitats within the course of diversion.

3. Further treatment of waste water or storm water cannot render it nutrient-impoverished, or is not cost-effective.

Little Long Pond is aquifer fed with no tributaries, hence diversion is a structural control technique that cannot be used in restoration of Little Pond.

## LONG RANGE CONTROL TECHNIQUES

### FLOW REDUCING DEVICES

Most conventional homes are presently not equipped with water-saving devices. These devices vary in design, but all basically accomplish the same results - reduce the amount of water consumption. These devices range from specially designed attachments that replace existing fistures, such as faucets or shower heads; to special in-line devices that adapt to existing fixtures.

Widespread utilization of such devices by homeowners and industrial complexes will affect a substantial water savings program, reduce loads on leach fields and reduce the potential for depletion and contamination of groundwater.

The twofold benefits, water saving and protection of the groundwater, coupled with low cost, shouldmake this attractive to every homeowner occupying home sites on the Carver soil series, expecially those in the watershed areas.

## LOCATING FAULTY SEPTIC SYSTEMS AROUND LITTLE LONG POND

### DYE METHOD

The often used dye test is a poor indication, defining only blatant problems because the dye may:

1. Have a long travel time.
2. React in the soil and lose its fluorescent characteristics (fluorescent dye when introduced into an acidic septic tank can lose its fluorescent character)
3. The dye may be bound in soils, especially clays. Consequently, pollution may be occurring even though the dye is not detected and the septic tank is allowed to continue polluting.
4. Access problem
5. High cost
6. Many other small but complex problems.

### SEPTIC SNOOPER

A. Minimal time

B. No access problem

C. Very simple in application

D. Low cost

E. Data is more special and discriminating.

   1. This factor allows for far superior planning techniques and can represent substantial savings.

This is a very useful tool in pinpointing nutrient influx by tracing septic leachate. Gives exact location of septic plumes by surveying perimeter of lake where homes are located.

Estimated cost for 1 mile of shoreline on Little Long Pond about

Time: 1 day.

Due to high nutrient readings on outfall, septic snooper should be used along tributary between Little Long and Long Pond, roughly 750 feet in length, to locate any possible plumes.

## Controlling Nutrient and Sediment Influx

Storm water, in picking up of pollutants from the land surface, becomes the transporter of degradation. The storm water run-off can discharge directly into the lake or pond or storm water can discharge sediments and nutrients into the lake or pond tributaries.

Strom water run-off has the potential of picking up and carrying high level of pollutants into lakes and streams. This is expecially true where a long period without rain is followed by intensive rainfall, under these circumstances, the initial surge of run-off carries oils, fertilizers, organic matter, eroded soil as well as other forms of pollution to the aquatic ecosystem. At times, this initial surge can be more highly pollute than the effluent at the municipal treatment plant.

The two basic control measures that are used are: Surface pollution should be reduced and the storm water can be treated to remove the transported matter.

The structures that are used to control this sediment influx are: catch basins, sediment basins, recharge basins and settling ponds.

A sediment basin is a small impoundment which retains storm water run-off long enough to allow heavier sediment particles to settle to the bottom of the basin. They can be constructed in various ways such as a dam forming a basin with run-off provided by a perforated vertical riser pipe ringed by a collar to collect trash. Periodically the basins must be attended as they fill with sediments. Construction of basins of this type would be an effective means of capturing sediments eroded from developed areas and unpaved roads. On paved areas they are aimed at catching run-off contaminat with oils and heavy metals.

Basins should be located in natural depressions to reduce construction cost and diversion methods should be applied to direct run-off to these basins. (The water table at Little Long Pond will not be affected by any diversion methods as it's water budget is supplied by underground aquifers.)

Sediment basins will not have a great effect on phosphorous loading, however, following major storms and thaws they will substantially affect lake visibility, turbidity and prevent sediment and oil residues. Their relatively low cost and easy maintenance (most town D.P.W.'s have equipment that can easily do this type of work) make them a very useful tool in watershed management.

The reduction of surface pollution: A significant reduction in the nutrient load of storm water, can be accomplished by regulatory control measures or by other structural means such as street cleaning in the watershed area.

Parking

The area between Long and Little Long Pond is an area where such structural control measures can be used along with the preventative measure such as road cleaning the parking areas.

## SOIL EROSION CONTROL

At present, this is not a problem however, as population increases the town must guard against the ever present danger of erosion. The town can do this by:

1. Controlling land use.
2. Develop programs that minimuze loss of soil and fertilizer on building sites, expecially where slope is a problem.

The Carver soil series have low to very low water holding capacity and a rapid intake rate. Water moves rapidly through soil profile. All these factors lead to national erosion control. Extensive lawn and agricultural practices should be discouraged because of low moisture retention and nutrient holding capacity. Ground cover native to area should be encouraged.

## SANITARY LANDFILL LEACHATE

Little Long Pond is not affected by sanitary landfill leachate.

1. Landfill is located on eastern shed of Ellisville Moraine.

2. Low metallic readings.

3. About 12,000 feet from landfill.

# SEWERING

The ultimate aim of the Town of Plymouth or in fact any town should be a sewage system. The Cornell study recommends; firstly, a ban on phosphate detergents, then tertiary treatment of sewage plant effluent; however, sewage systems beyond tertiary are being used for mineral stripping with the end result being nearly pure water. This report deals with phosphorous removal, hence this position is only secondary, however, with all factors being considered sewering should be considered as an ultimate goal.

The State of Massachusetts would encourage sewering:

1. If septic system leachate is or will become a significant contributor to the overall nutrient flux of the lake or pond.
2. If alternate methods of waste disposal (i.e. no-discharge waste disposal methods) are not available.
3. If the construction of a sewer system does not encourage growth in the watershed which could lead to a significant degradation of the environmental quality of the watershed and lake ecosystem.

The physical characteristics of the Plymouth soils; the number of ponds, lakes and kettleholes being fed by deep aquifers and ground water, lead to the conclusion that the ultimate goal should be a sewage system encompassing the whole town with a tertiary treatment system that would eliminate any future danger of contamination. Eastern Massachusetts is presently plagued with outbreaks of even artesian well contamination. Human waste and industrial contamination must be contained. The cost of such systems is great - but the destruction and pollution of clean water systems will be of far greater cost to everyone. To clean contaminated water is costly and perhaps some waters will not be able to be cleaned. Preventative methods are tantamount.

ALTERNATIVE SEPTIC WASTE SYSTEMS

In areas where soil characteristics prevent adequate on-site waste disposal, the following alternatives should be considered:

Non water-using toilets

The single most important non-point source of pollution in surface waters may well be nutrient loading from shoreline subsurface sewage disposal systems. The results of the Billington Sea groundwater sampling point directly to this conclusion The prevalence of the Carver - Gloucester soil association makes not only the shoreline a target of non-point source nutrient loading, but possibly the entire watershed.

Eliminating toilet discharge as a contributing factor to subsurface disposal systems would significantly reduce both the problem of malfunctioning systems and the problem of nutrient migration into ground and surface waters.

It is recommended that non water using toilets be used in the following geographic areas:

1. Islands
2. Existing development adjacent to surface waters.
3. On marginal soils where groundwater pollution would be a danger.

Two recommended systems are: composting toilets and incinerating toilets; there are many other types such as vacuum toilets, chemical toilets, etc. but composting and incinerating toilets are the most popular.

Composting Toilets

There are a number of composting toilets on the market (see Addenda) but most consist of a tough plastic container in which compostable wastes are placed, in some units the decomposition of the waste is accelerated by a heating coil at the base of the unit and aeration from a fan, which draws air through the compost and out a vent pipe. The fan runs continuously and removes all odors whereas the heating coil functions intermittently depending on room temperature.

Buildings using a self-contained sewage disposal system, instead of a sub-surface disposal system could reduce the amount of nutrient pollution 30-50% depending on the nutrient loading of the gray water discharge. (Uttormark et al 1974)

A system for a family of 5-6, can be purchased for about $700 and has an operating cost of $6.00 - $7.00 per month.

Incinerating Toilets

These toilets consist of a cabinet similar to a conventional toilet which uses propane or natural gas to incinerate the waste and an exhaust fan blows the gases out the exhaust vent. The incinerating cycle is controlled by a preset timer and lasts 15 - 20 minutes. Periodically the mineral ash in the firebox must be cleaned by a vacuum cleaner. One unit can service up to 12 people on a full-time basis. The unit is easily installed, requiring only gas and electrical connections and the attachment of a vent pipe to the outside.

The price for an incinerating toilet is about $600.00 plus delivery and installation charges. Operating costs using bottled gas would be about 6 cents per incineration cycle or about $45.00 a month for a family of 5.

Another system which uses air instead of water for the transport of sewage from the toilet is recommended for further study. The vacuum system uses only 3 pints of water per flush rather than the conventional 4-6 gallons per flush. Because of the reduced volume of liquid, the sewage is collected in a holding tank and transported to an existing treatment plant.

# IN-LAKE MANAGEMENT METHODS

A. CONTROL OF MACROPHYTES AND MICROPHYTES BY HARVESTING

B. REDUCTION OF MOTOR BOAT USE

C. CHEMICAL INACTIVATION OF NUTRIENTS

D. CHEMICAL CONTROL VIA ALGICIDES AND HERBICIDES

E. LAKE BOTTOM SEALING

F. DRAWDOWN

G. BIOLOGICAL METHODS
   a. Herbivorous fish
   b. Biomanipulation

H. DILUTION

I. AERATION AND MIXING OF WATER

J. DREDGING

# MACROPHYTE HARVESTING

Aquatic plant harvesting is a widely used technique for in-lake management in lakes or bays with excessive local plant growths. It involves three stages to be at maximum efficiency.

1. Cutting
2. Collecting
   A. Harvesting machines effective out to the 5 foot contour line both harvest and collect plants together with a portion of the rooted mass.
3. Disposal
   A. Front-end loader and dump truck handle the disposal process. Disposal can become difficult, however, when submersed aquatic plants approach 7 tons/acre wet weight and contain 3.2 lbs./acre phosphorous. (MacKenthun and Ingram) Large areas are needed for disposal and Plymouth has ample sand dunes and sand bank erosion areas which could benefit from spreading of the harvested material.

## ADVANTAGES

1. The primary advantage is that it is an ecologically elegent solution to nuisance plant control. Nutrients are removed from the aquatic ecosystem and are not recycled through bacterial decomposition of dead matter. Further growth may become impaired or even limited by the removal of macro-nutrients (phosphates, nitrates, carbon, etc.)
2. No chemicals are added to the aquatic environment.
3. No"closing" of the lake.
   A. Intervals of up to 2 weeks are necessary with chemical application.
4. No lowering of dissolved oxygen.
5. Controls all species
   A. Chemicals have resistant species problem.
6. No build-up of detritus.

## DISADVANTAGES

1. Cost: $300 per acre was average cost in State '79 program. Towns must also assume cost of disposal.

2. Effective only to depth of 5 feet.

3. Does not harvest all roots.
   A. Many aquatic plants reproduce by rhizome as well as seed and root.

The aquatic plant harvesting program is recommended for Little Long Pond, not only for the above advantages but also because most disadvantages are overcome by the physical characteristics of Little Long Pond itself:

Short flush time

A. Suspended material would be flushed out of the aquatic system.

Depth

A. With a 5.0 foot average depth, much of the lake area is available to the harvester.

Relatively smooth bottom

A. There are no stumps or debris such as is prevalent in an artificial system.

Elodea

A. The target species is susceptible to efficient harvesting.

Disposal

A. Dune stabilization
B. Erosion control

Recreation

A. Lake is immediately available for recreation.

Rental Cost:

1980 state bid average cost $250/acre.

A. Town attends to disposal.

DEQE Eutrophication and Aquatic Vegetation Control Program

Machine Purchase:

| | | |
|---|---|---|
| Small Chub | - | $12,900 |
| Trailer | | 1,250 |

Capable of 1 - 2 acres/day, 2 man crew, manual operation

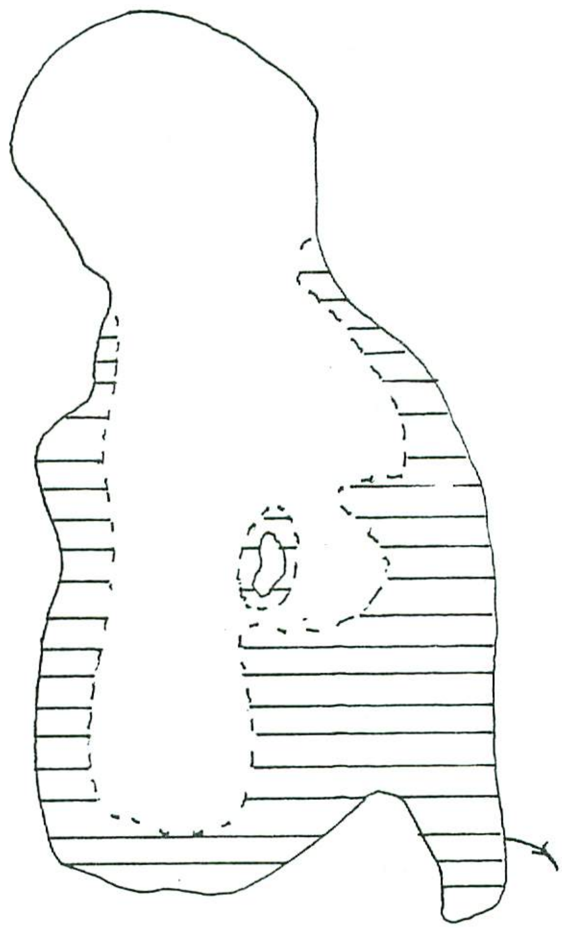
H-400 $28,000

2 - 4 acres per day, 1 man crew, hydraulic operation

Aquamarine Corp. Waukeska, Wisc.


LITTLE LOND POND

Macrophyte Harvesting Map



Area to be harvested

Total acreage 19A. App.

Scale 1:520'

## Restriction of Motor Boat Use

The Environmental Protection Agency and Massachusetts Resources Commission have conducted recent investigations focusing on biological effects of oil and gasoline discharges specifically; raw fuel, phenols, lead, volatile and non-volatile oil discharged by two-stroke outboard motors.

A. Since 1972 outboard manufacturers have included a recycling device to reduce discharge or unused gasoline and oil.

B. Older engines manufactured before 1972 release as high as 50% unburned fuel mixtures.

However, results of the E.P.A. and state studies conclude:

1. There is no significant adverse aquatic life impact.
2. Most volatile aromatic constituents of gasoline and oil evaporate.
3. Some non-volatiles persist but are decomposed by bacteria.

Most of the data gather by these studies indicates no firm support for either complete restriction, or size restriction. Little Long is a recreational lake and hence, widely used for fishing and boating - to use restrictive measures might put an unnecessary burden on both the Town and lake inhabitants. New engine designs coupled with looming petroleum shortages might solve the problem without added procedures. As new data becomes available, perhaps then, a new approach may precipitate; other eutrophic causes are major, this at present is minor.

# NUTRIENT INACTIVATION

This method can be used to remove nutrients that are essential for plant or algae growth by addition of chemical activators which are added to the lake. There are many activators that are used for a variety of reasons, such as, aluminum, alum, iron, ion exchange resins, polyelectrolytes, fly-ash, etc.

Aluminum and iron salts can be added directly to the lake to remove phosphorous from the lake water and carry it to the sediments.

The state will encourage the chemical inactivation of essential nutrients in the water column if:

1. Only a small watershed is involved.
2. The lake has a relatively long retention time (over .3 year)
3. Total phosphorous in water exceeds .03 mg/l
4. Sediments regenerate enough nutrients to promote moderate to excessive algal growth.
5. When nutrient loading from the watershed is not sufficient to promote eutrophic conditions in the pond without the contribution of internal nutrient loading.

Little Long Pond has an average retention time of 18 days, and most phosphorous comes from in-lake sources, not from sediment release. The end result of this technique would not solve the basic problem. Long-term effectiveness would be limited by continual nutrient input.

Little Long's outfall is the major tributary to Long Pond and any such treatment would have a direct impact on Long Pond. Therefore, any in-lake procedures attempted on Little Long Pond would directly affect Long Pond. It is therefore deemed more

Little Long's outfall is the major tributary to Long Pond and any such treatment would have a direct impact on Long Pond. Therefore, any in-lake procedures attempted on Little Long Pond would directly affect Long Pond. It is therefore deemed more prudent to stay with long term watershed management techniques.

In activation of phosphorus release from sediments with aluminum salts appears to be a successful technique for lowering phosphorus concentration to levels limiting to algal growth when used in conjunction with a program to manage phosphorus income from the watershed. The technique has a longevity of at least 5 - 6 years and there are no known deleterious side effects to biota if proper procedures for dose determination and application are followed.

Examples of EPA grants using this method:

EPA 625/2 80 27 Lake restoration in Cabbossee watershed plain

EPA 625/2 80 25 Restoration of Medical Lake - Washington

# CHEMICAL CONTROL BY ALGICIDES AND HERBICIDES

Herbicide control should NOT be used.

Chemical control of algae might have to be used until suggested programs are implemented, particularly if algae blooms render Little Long Pond undesirable for recreation purposes. State aid can be applied for through the Department of Environmental Quality Engineering.

Three necessary conditions are:

1. Midday water temperatures do not exceed 27°c (80°F)
2. Dissolved oxygen within 2 meters of surface is above 4.0 mg/1.
3. Copper in sediments does not exceed 150-300 mg/kg (dry weight).

# LAKE BOTTOM SEALING

Significant amounts of exchangeable nutrients are usually found in the benthos of a lake or pond and in some instances removal by dredging is recommended (ex. Morse's Pond, Wellesley) to reduce the nutrient contact. However, at a greatly reduced cost, bottom sealing has been used instead. Several covering materials are showing promist of surpressing the transport of nutrients from the sediments into the overlaying waters by either physically retarding exchange, or by increasing the capacity of surface sediments to hold nutrients.

Lake bottom sealing covers can have additional advantages such as:

1. Elimination of suitable substrates.
2. Erosion control by bottom stabilization.
3. Minimization of water loss by infiltration.

A recent effort has been in Thirty-Acre Pond, Brockton, Massachusetts, where this technique has been applied as a corrective measure. The short-term effect of this technique seems to be desirable, however, long-range effects have still to be evaluated.

Large amount of groundwater present in Little Long Pond would in all liklihoo preclude the possibility of state participation in such a project. The state would consider sealing if the following conditions prevailed:

1. If drawdown is possible.
2. If dealing with a limited area (generally less than 1 hectare)
3. If shallow area is being considered (littoral zone - less than 5 feet.)
4. If considerable groundwater seepage does not occur.

Generally, the state prefers chemical sealants over physical.

Physical sealants:

A. Plastic Sheeting

1. perforated
2. non-perforated

B. Rubber liners

Chemical sealants:

A. Clays

B. Zeolites

C. Flyash

In summary, sediment covering retards rooted plant growth, but only screen and sheeting materials have been shown to be both effective and ecologically safe. Because both of those materials are very expensive, it is generally recommended that they be used selectively -- around docks, beaches or boating areas, for example --- rather than in the entire shallow area of the pond, unless silation is rapid, one installation may last several years before plant growth can begin on top of the sheeting.

Little Long Pond has too much groudwater influence to consider sealing methods. The high flush rate is one of Little Long Pond's greatest assets and should be maintained at any cost.

Note: See E.P.A. policy statement for funding practices.

# D R A W D O W N

In lakes and ponds where water level can be contolled, drawdowns have been used to consolidate sediments, reduce their release of nutrients and kill aquatic plants. While exposed to air, sediments lose much of their water content and they may no longer release nutrients into lake water when the lake is refilled (DUNSET ETAL 1974). Beds of aquatic plants may dry out during drawdown and if their roots are exposed, some species may die or not be able to reproduce (BEARD 1973).

Drawdown is not possible in Little Long at present, water-level control technology would have to be applied before drawdown could be effectively used as a short-range control measure. This and other shortcomings have the decision not to consider this technique.

Responses of some common nuisance aquatic plants to lake level drawdown:

Alligator weed, naiads and potamogeton spp. increase in abundance after drawdown.

Chara, hyacinths and white lilies decrease in abundance after drawdown.

Cabomba, elodea, milfoil and bladderwort exhibit no change or clear response after lake level drawdown.

# Lake Level Drawdown

Lake level drawdown is a multipurposed lake improvement technique. It has been used to attempt control of nuisance rooted plants, to menaga fish, to consolidate flocculent sediments by dewatering, to provide access to dams, docks and shoreline stabilizing structures for needed repairs, to permit dredging using conventional earthmoving equipment and to facilitate application of sediment covers. The procedure is often an inexpensive one which can be effective in aquatic plant control where susceptible species are present and where rigorous conditions or dry, cold or heat can be achieved for 1 to 2 months.

Certain species of aquatic plants are susceptible to drawdown, however, failure to achieve plant control can result not only from presence of resistent species but also from failure to achieve sufficient dewatering of lake sediments.

In lakes and ponds where water level can be controlled, drawdowns have been used to consolidate sediments reduce their nutrient release and thus kill aquatic plants. While exposed to air, sediments lose much of their water content and they may no longer release nutrients into lake water when the lake is refilled.

An always present danger is the failure of the lake or pond to refill, caused by insufficient watershed drainage area, drought, or delay in closing dam until too late in the season.

Little Long Pond is a natural pond and with it's geologic placement drawdown is an in-lake management method not to be recommended.

## Biological Controls

Biological control of rooted aquatic plants and algae through grazing activities of such organisms as fish or insects is one of the more recent experimental approaches to controlling excessive vegetation. With few exceptions, such as insect control of alligatorweed, biological control organisms are being viewed by aquatic scientists with caution since the introduction of exotic species to native waters could cause more problems then it solves. A well known example is the common carp, which was brought to this country as a food fish but has probably caused as much damage as benefit. Scientists are therefore attempting to evaluate biological control species in a step-by-step fashion.

There are several different types of organisms presently being evaluated. A fungus which attacks water hyacinth has given good results and insects have been released which give at least local control of both water hyacinth and alligatorweed.

The control of a particular problem species by manipulation of biotic interactions.

1. Predator-prey relationships (the White Amur is a well documented example).
2. Intra and interspecific manipulation (one plant species is introduced or manipulated in order to induce a limiting condition on another.)
3. Pathological reaction (controlling blu-green algae blooms by viruses has been attempted.)

Any use of biological control methods must be approved by the Division of Fish and Wildlife. The use of biological controls on excessive growths of algae and macrophytes has not been developed to the point where any potentially effective agents are likely to be found in the near future.

Herbivorous Fish

The Mozambique Mouth-brooder has been suggested as possible controls of algae and certain rooted plants. The species thrive only in warm water (greater than $10^{o}C$ or $55^{o}F$). It has become a nuisance in Florida where it was introduced to test it's ability to control rooted plants -- it's use has been discontinued.

The White Amor or Grass Carp, has been widely recognized in Europe and the United States as a plant control agent. This species, a native of the Amor Basin in China and Siberia, consumes nearly all forms of vegetation and will also eat invertebrate animals. It grows rapidly, resists low temperatures and can stand low dissolved oxygen concentrations.

Concern about the Grass Carp comes from past experience with exotic animals such as the Common Carp. The role of Grass Carp in cycling plant nutrients and thus in promoting algal blooms, needs further research. In Europe, the Amor are notorious spreaders of fish disease, for example, research has found a tapeworm which is a serious fish pest in Europe in some grass carp from Arkansas. This suggests the parasite could spread in this country. Some findings report no interference with game fish while others found significant declines in fish population. These and other concerns are sufficient to restrict the general use of Grass Carp as a plant control until more research has been completed. At present, only a few states allow possession of Grass Carp, except for experimental purposes. Herbivorous fish may become an important tool in plant control, but the present wide-spread shipment and use of Grass Carp is being done without sufficent knowledge of possible adverse effects and should be stopped until more information is obtained and shared with the public and scientific community.

# BIOMANIPULATION

Several lake techniques which include altering food web of lake to favor that portion of the animal community which grazes on algae. Biomanipulation of food webs may be particularly useful in those situations where diversion of nutrient income is insufficient to lower in-lake concentration and thereby control algae growth.

The next level in the food web which depends on planktonic algae is the small, free-floating animal called zooplankton. This grazen is an important food source of many fish, for example, Blue Gills, Crappies, etc. In many lakes and ponds, huge populations of small fish exist and their predatory activities are so intense that few, if any grazing zooplankton are found in the summer. There is good evidence that in some water bodies, if the dominance of these small fish can be greatly reduced, grazing zooplankton can become a significant force in controlling algae and higher water clarity will result. The fish could be controlled or eliminated by introducing predators or by eliminating all fish followed by balanced restocking. Elimination of all fish would have the additional advantage of removing Carp, Bullheads and other fish which recycle nutrients from sediments to the water column. Biomanipulation is in the experimental stage at this time, but it is a promising approach which avoids the introduction of an exotic fish and could improve water clarity and sport fishing.

Biological controls of nuisance plants and algae are largely undeveloped lake improvement techniques. In the southern part of the country, advances have been made with insects and plant pathogens, but these are largely unavailable to the general public at this time and are aimed at specific problems of aligatorweed and water hyacinths.

The journal of aquatic plant management of Fort Meyors, Florida has published many articles on biomanipulation advances for control of both water hyacinths and alligatorweed.

## DILUTION

Dilution is a process whereby eutrophic lake water is replaced by water lower in nutrients. A lake can be flushed out with less productive water, or it can be pumped out to another watershed and allowed to refill through rain or groundwater infiltration. Dilution simply decreases the lake waters nutrient concentrations. The advantage of dilution is that many nutrients as well as plants are removed from a lake when it is flushed out.

1. Sufficient quantities of low-nutrient water may not be available for such a project.
2. Nutrients may flow into the lake and quickly replace those flushed away.
3. Cost problem on pumping in dilution water.

The State would encourage the implementation of dilution if:

1. Nutrient poor water diverted from it's natural course does not have an adverse effect on it's own ecosystem.
2. No point sources of nutrient rich water discharge directly or indirectly into the lake.
3. Dilution water is well below nutrient levels which promote eutrophication.
4. Nutrient rich sediments do not contribute significant quantities to overall nutrient flux of the lake.

No clearcut advantage could be gained by using this method for two reasons:

1. No significant source of nutrient-free water available.
2. Will not affect basic problems of nutrient influx from point and non-point sources.

This in-lake procedure could not be used in Little Long Pond. Release of the waters into Long Pond would have a deleterious side effect.

# A E R A T I O N

Aeration and circulation can be used to improve water quality for a wide array of beneficial uses including domestic water supply, downstream releases, industrial use, fish management, and algal bloom control. Maintenance of aerobic conditions may also affect nutrient exchange within the lake.

Total aeration would not be encouraged by the state if aeration techniques would de-stratify a lake.

Hypolimnetic aeration increases the oxygen content of a lake without de-stratifying the lake.

Positive Effects:

1. Reduction in sediment/water nutrient exchange.
2. Increased habitat for fish, zooplankton, and benthic fauna.

Hypolimnetic aeration would be encouraged by the state when:

1. Nutrient loading from watershed is not sufficient to promote eutrophic conditions in the lake without the addition of internal nutrient loading.

   (Little Long has a high enough nutrient level without addition by aeration).

2. Where concentrations of DO in the hypolimnion are less than 3.0 mg/l and are not the result of natural springs or ground water seepage.

   (Dissolved oxygen in Little Long is never this low; dissolved oxygen in aquifers leading into Little Long is relatively high).

3. When an increase in hypolimnetic oxygen will significantly decrease the loss of nutrients from sediments in the water column and internal nutrient loading is an important factor contributing to the occurrence of planktonic algal blooms.

Little Long Pond with it's physical characteristics, i.e. shallow depth (5 ft. average); surface area (45 acres); and high flush rate (18 days average) make it an unsuitable candidate for any long-range benefits from any aeration or circulation techniques. Wind, sun and flow would be enough to maintain high DO rates if the nutrient influx problem was solved or even curbed.

Note 500 policy statement of EPA.

# DREDGING

Dredging removes nutrient rich sediments and rooted aquatic plants from shallow water areas. A lake's annual process of self-fertilization and subsequent release of nutrients from sediments to overlying waters may, for some lakes, be one of the primary sources of the lakes nutrients.

Dredging has often been suggested as a means for removing nutrients stored in sediments. The sediments are usually rich in nitrogen and phosphorous and represent an accumulation of years of settled organic materials. Some nutrients may be recirculated within the water mass and furnish food for a new crop of organic growth. However, in an undisturbed mud-water interface nutrient transfer is very small.

The state encourages dredging if:

1. Nutrient loading is not from external sources.
2. Removing substrate would promote plant growth.
3. Sediments are important source of nutrients.
4. No toxic sediments are released during dredging.
5. Dredging will not increase water turbidity.
6. Dredged areas are less than 15 feet deep.
7. Does not affect downstream wetlands.
8. Dredged sediments do not pose a health or environmental problem.

Some problems encountered in dredging:

1. Nutrient content does not change drastically.
2. A possible resulting shift from rooted plants to algae.
3. The buffering capacity of a lade to external changes in nutrient loadings may be lowered.

4. Resuspension of fine particle and plant nutrients.

5. Toxic substnaces may be released in water color.

6. May destroy the community of Benthic organisms which are important to the fish

7. Disposal site - discharge problems

Morse's Pond in Wellesley has been dredged after two or three nutirent inactivation efforts. Dredging was applied to reduce lily growth, but after a short period of time, Milfoil took over as a target species. This project was funded under 314.

Before such a costly, chancey method is used, the more positive, long-range efforts should be put into effect, combined with in-lake methods as recommended in this report.

# ENVIRONMENTAL IMPACT

## Land Use

No effect on residential, agricultural, park, scenic, historical, archeological. No changes in land use patterns.

## Physical

No construction other than sediment basins.

## Air Quality

No effect.

## Hydrology

No effect, no diversion, dredging or construction.

## Aquatic Life

Fish or aquatic organisms - no adverse effect, possible beneficial effects.

## Cultural Impact

None.

## Economic Environment

None.

## Resource Impact

None.

## Energy Use

Not applicable.

## Social Environment

Beneficial, better water quality

## Displacement of People

No.

Changes in Noise Levels

None.

Effect on Flood Plain, Management or Wetlands

None.

Dredging and Other Channel, Bed or Shoreline Modifications

None.

Feasible Alternatives to Proposed Project

None.

Other Necessary Mitigative Measures

None.

Will the project adversely affect short term or long term ambient air quality? ........... No.

Will project be located in flood plain? ..........No.

Will structures be constructed in flood plain? .........NO.

Will the project have a significant adverse effect on fish and wildlife, wetlands or other wildlife habitate? ..........No.

Will the project adversely affect endangered species? ..........No.

Are there other measures not previously discussed which are necessary to mitigate adverse impacts resulting from the project? ........NO.

# C O N C L U S I O N

In most lakes the short retention time of about 50 days would be more than adequate to flush the system, and if the soil series were different the problem would more than likely be within 100 feet of the shoreline; however, on the basis of this report, a broader range of recommendations, and long-range zoning programs are strongly recommended in order to cover the broad spectrum of contributing non-point sources. It is not physically possible for the soil series to tie up, ionically, any appreciable amount of non-point source loading. How much the water-shedis involved will be better determined when data from other lakes and ponds in the area becomes available.

This report has enumerated counter pollution measures such as a voluntary ban on high phosphate detergents; this is considered a very important step - this ban could eliminate 50% of the phosphorous input from domestic sewage or about .8 kg. phosphorous per capita per year. The only cost would be ads in newspapers, radio or any source at the commissions disposal.

It is also recommended that the "Septic Snooper" be applied to locate faulty septic systems and that such systems be replaced with non-water using systems. "The results of the Lake Region Planning Commission ground-water sampling and soil retention study have indicated the effluent from subsurface sewage disposal systems is a primary source of water pollution." There are so few houses around the pond that the cost would be more than off-set by the results. One or two faulty systems would have a disastrous effect on so small an impoundment.

To put teeth into local and state laws it is strongly suggested that the definition of pollution be revised to include acceptable nutrient levels.

The outfall shows such a jump in phosphate readings an added emphasis should be made to used snooper through it's short length. The high volume of flow coupled with high nutrient readings endanger Long Pond and if continued, time would favor a shift from oligotrophic to a eutrophic state of this valuable lake.

Stormwater run-off problem can be solved by initiating catch basins, recharge basins, settling pond and sediment basins; all of which can be designed and implemented by local D.P.W. and engineers.

Street cleaning equipment to be used in the parking area.

Zoning and percolation tests should be upgraded to the Lakes Region Planning Commission, State of Maine soil evaluation concept and Maine and New Hampshire set backs with lot sizes based on soil and ground water criteria.

Harvesting out to a 5 foot contour line will give some immediate relief until long range techniques can be implemented and results achieved.

Water saving devices should be used as both a conservation saving method and for aquifer protection.

Any faulty septic system that is made evident by the septic snooper should be redone with consideration given to the use of closed systems, especially those around the shore line.

A complete updating of all septic systems in the watershed area. Little Pond does not have tributaries and it is mainly feed by the non-confined aquifer. The end conlcusion has to be point and non-point nutrient influx. There are no outside agriculture influences. The nearest agriculture impact is over 12,000 feet away. The aquifer must be protected by long range control techniques, controlling nutrient influx and by water shed management control procedures as previously set forth. It is strongly suggested that the houses around the pond should be checked to see if any plumes are finding their way into Little Long by means of septic snooper. Any contamination here has a direct effect on Long Pond . (see flow data and nutrient loading tables)

## Management Plans

### Time Schedule

Any programs implemented on Little Long Pond will be directly managed by the Plymouth Conservation Commission and coordinated with any other town departments that are needed.

The voluntary phosphate ban should take place immediately
Two year harvesting program 1981-1982
Sediment basins - engineering study by D.P.W.
Construction of non-water using toilets where needed
Water-saving devices to be used
Water-saving devices to be used in the parking area
Street cleaning equipment
Septic snooper program 1981
Updating faulty septic systems 1981-1982
Zoning laws should be updated to include aquifer protection
Pollution laws revised and updated to include nutrient concentration

# A D D E N D A

The following data will provide the Town of Plymouth with necessary information to justify application to the U.S. Environmental Protection Agency for 50% matching funds to conduct the proposed programs, as authorized by Section 314 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500)

The preceeding report has established:

1. Water quality of Little Long Pond
2. Lake restoration procedures
3. Environment Impacts
4. Expected results
5. Management Plans

Funding by the Commonwealth of Massachusetts:

722-1969 - DEQE amended general laws
Chapter 40, Section 5 and Chapter 111, 5F
(A copy of this act is included in Addenda)

This usually covers chemical control and harvesting of aquatic nuisances.

Chapter 91 under DEQE, Waterways Div., is for dredging programs
208 covers sewage construction.

Little Long satisfies the anticipated benefits to the public. Its immediate impact on and possible degradation of Long Pond, one of the most used ponds in South Eastern Massachusetts.

# A D D E N D A

## Revision of Pollution Definition

The general approach is to stress violation of coliform bacteria standards, research shows that nutrient pollution over a period of time is as important, or may be more important than bacterial pollution. A set of general standards should be put forth and it is suggested that violation of nutrient standards be incorporated in the pollution standards.

## GENERAL GUIDELINES

| | Permissible Levels | Critical |
|---|---|---|
| Total phosphorous mg/l | .025 | .04 |
| Orthophosphorous mg/l | .004 | .01 |
| Organic Nitrogen mg/l | .20 | .40 |
| Ammonia mg/l | .02 | .05 |
| Nitrate mg/l | .10 | .25 |
| Nitrite mg/l | less than .001 | .002 |
| Inorganic Nitrogen mg/l | .12 | .30 |

Incorporation of the above nutrient levels in the general pollution standards would be a positive approach toward solving the problem of nutrient loading from all sources and would redefine pollution as it is generally understood.

FEDERAL LEVEL: ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF WATER AND WASTE MANAGEMENT

1. Construction Grants for Wastewater Treatment Works. Project grants (cooperative agreements) are available for the construction of municipal wastewater treatment works including privately owned individual treatment systems if a municipality applies on behalf of a number of such systems. Such works may serve all or portions of individual communities, metropolitan areas or regions. The project may include but may not be limited to treatment of industrial wastes. The program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. The grant may be for 75 percent of eligible project costs or 85 percent for innovative or alternative technology projects. Programs have ranged from $875 to $290,800,000 with an average of $4,000,000. FY 80 estimated obligations are $3,600,000.

Any municipality, inter-municipal agency, state, or interstate agency having jurisdiction over waste disposal is eligible for assistance under this program. It is available to each state, the District of Columbia, and each territory or possession of the United States.

Preapplication assistance is available through the state water pollution agency or the appropriate EPA regional office. Applications must be submitted through these agencies. Applications are subject to state and areawide clearinghouse review. An environmental assessment is required which may lead to the requirement for an environmental impact statement. Approval or disapproval normally requires 90 days.

Contact: Information may be obtained from the state water pollution control agency or the appropriate EPA regional office.

2. Water Pollution Control - State and Interstate Program Grants (106 Grants). Formula grants are available under this program for the establishment and maintenance of adequate measures for prevention and control of water pollution. Broad support is available for permitting, pollution control studies, planning, surveillance, and enforcement. Advice and assistance is available to local agencies. Training and public information are also available. Funds cannot be used for construction, operation or maintenance of waste treatment plants nor for costs financed by other federal grants. This program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. Financial assistance has ranged from $85,400 to $3,086,000 with an average of $938,000. FY 80 estimated obligations are $48,730,000 for grants. State and interstate water pollution control agencies are eligible for funding under this program. It is available to each state, the District of Columbia, and all territories and possessions of the United States.

Informal meetings are held between the regional office and state applicant agency concerning program preparation. Applications are subject to state and areawide clearinghouse review. Completed application forms must be submitted to the appropriate EPA regional office, Grants Administration Branch. Suggested dates of submission are June 1 for draft state/EPA agreements and no later than September 1 for final state/EPA agreements. Approval or disapproval time normally takes 30 days.

Contact: Information may be obtained from the appropriate EPA regional office.

3. Water Pollution Control - State and Areawide Water Quality Management Planning Agency (Section 208 Grants). Project grants are provided to areawide and state planning agencies to develop a water quality management plan for the area or areas approved by the appropriate regional EPA administrator. This program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. The federal assistance rate is 75 percent for all grants. The range of financial assistance has been from $100,000 to $4,000,000 with an average of $440,000. FY 80 estimated obligations are $40,000,000.

This program is available to a local or regional planning agency designated by the governor or appropriate local officials and approved by the administrator or EPA as the official areawide waste treatment management planning agency. The program is available to each state, the District of Columbia, and all territories and possessions of the United States.

Preapplication coordination with the appropriate regional EPA office is recommended. Applications are subject to state and areawide clearinghouse review. Standard application forms are furnished by the agency. Grant applications are submitted to the appropriate EPA regional administration office. In the case of an area designated by the governor, the application and supporting data must be submitted by the state reviewing agencies prior to submission to EPA. In interstate cases, the application must be submitted to the governor of the state wherein the greatest portion of the planning area lies. Grant applications must be submitted according to dates established by the regional EPA administrators. Approval or disapproval time normally is 45 days.

Contact: Information may be obtained from the regional EPA offices.

4. State Underground Water Source Protection Program Grants. Under this program project grants are available for the development and implementation of underground injection control programs adequate to enforce the requirements of the state drinking water act. Federal assistance is limited to 75 percent of eligible costs, not to exceed the state allotment. This program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. FY 80 estimated obligations are $7,795,000.

State agencies designated by the governor or the chief executive officer by one of the states, the District of Columbia or any of the U.S. territories or possessions which has been listed by the EPA administrator as requiring an underground injection control program are eligible for funding under this program.

Preapplication coordination with appropriate regional offices is recommended. Grant applications are submitted to the appropriate EPA regional administrator. Applications are subject to state and areawide clearinghouse review. Approval or disapproval time is approximately 45 days.

Contact: Applicants should contact the appropriate EPA regional office for information concerning this program.

5. Solid and Hazardous Waste Management Program Support Grants. Formula grants and project grants are available to assist in the development and implementation of state and local programs and support rural and special communities in programs and projects leading to the solution of solid waste management problems. Assistance includes support of facility planning, feasibility studies, expert consultation, surveys and analysis of market needs, marketing of recovered resources, technology assessment, legal expenses, construction feasibility studies, source preparation projects, and fiscal or economic investigation or studies. Funds may be used by special communities for conversion, improvement or consolidation of existing solid waste disposal facilities or for construction of new facilities. Assistance is also available to low population municipalities for closing or upgrading existing open dumps or meeting requirements of restrictions on open burning or other requirements arising under the Clean Air Act or the Federal Water Pollution Control Act. This program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. The federal share of a project may be up to 75 percent although 100 percent may be funded for conducting inventories of open dumps. Financial assistance has ranged from $71,500 to $1,318,200 with an average of $250,000. FY 80 estimated obligations are $85,050,000. State and substate solid waste agencies, authorities and organizations in all states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Mariana Islands are eligible for funding under this project.

The standard application forms furnished by the agency are required for this program. Preapplications for resource conservation and recovery projects are solicited in the Commerce Business Daily and evaluated with published criteria. Requests for application forms and completed applications are submitted to the appropriate EPA regional grants administration office. The staff at the appropriate office is available to assist in preparation of the application. Applications are subjected to administrative evaluation to determine adequacy in relation to grant regulations and to technical and program evaluation. Approval or disapproval time ranges from 30 to 90 days depending upon the type of application. Applications are subject to state and areawide clearinghouse review. Environmental impact assessments may be required for implementation projects involving major construction or siting.

Contact: Information may be obtained from the appropriate EPA regional administrator.

6. Solid Waste Management Demonstration Grants. Project grants are available to promote the demonstation and application of solid waste management and resource recovery technology and assistance which preserve and enhance the quality of the environment and conserve resources and to conduct solid waste management and resource recovery studies, investigations and surveys. This program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. Resource recovery system demonstration projects may be funded up to 75 percent by this federal program. Construction of new or improved solid waste disposal facilities serving an area of only one municipality may be funded up to 50 percent of eligible project costs, or 75 percent in any other cases.

State, interstate, municipal, intermunicipal, or other public authorities and agencies are available for the various components of this program. In addition, public or private colleges and universities and private nonprofit agencies and institutions are available for the resource recovery systems demonstration projects or for the construction of new or improved solid waste disposal facilities. All states, the District of Columbia, Puerto Rico, the Virgin Islands, Guam, American Samoa, and the northern Mariana Islands are eligible for assistance under this program.

Standard application forms are furnished by the agency for this program. Requests for application forms and completed applications are submitted to the Environmental Protection Agency, Grants Administration Division. Applications are subject to state and areawide clearinghouse review. An environmental impact assessment is required only for major demonstration and construction projects. Approval or disapproval time normally takes 90 days.

Contact: Information may be obtained from the appropriate EPA regional office.

OFFICE OF RESEARCH AND DEVELOPMENT

1. Environmental Protection - Consolidated Research Grants. Project grants are available under this program to support research to determine the environmental effects and control requirements associated with energy, to identify, develop and demonstrate necessary pollution control techniques, and to evaluate the economic and social consequences of alternative strategies for pollution control of energy systems. Grants may also be used to explore and develop strategies and mechanisms for those in the economic, social, governmental, and environmental systems to use in environmental management. This program is suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. Projects must be cost shared at a minimum of 5 percent. Financial assistance has ranged from $1,000 to $1,816,580. FY 79 average financial assistance was $98,304. FY 80 estimated obligations are $20,800,000 for grants. This program is available for public and private state universities and colleges, hospitals, laboratories, state and local government departments, other public or private nonprofit institutions, and individuals who have demonstrated unusually high scientific ability. It is available to each state, territory and possession of the United States including the District of Columbia.

Preapplication discussions with the EPA program office is advisable. Standard application forms must be used. Requests for application forms and completed applications must be submitted to the EPA Grants Administration Division. An environmental impact assessment is required. Approval or disapproval normally takes 90 days.

Contact: Individuals are encouraged to communicate with the appropriate EPA regional office. For information on grant applications and procedures, contact the Environmental Protection Agency, Grants Administration Division, PM-216, Washington, D.C. 20460. For program information, contact the Environmental Protection Agency, Office of Research and Development, RD-674, Washington, D.C. 20460, (202) 755-8787.

2. Solid Waste Disposal Research Grants. Project grants are available to promote and support the coordination of research and development in the area of collection, storage, utilization, and salvage or final disposal of solid waste. The program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. These grants require a minimum of 5 percent cost sharing. Financial assistance has ranged from $16,000 to $359,000 with an estimated average in FY 79 of $80,000. FY 80 estimated obligations are $2,500,000 for grants.

The program is available to public or private agencies; public, private, state universities and colleges; state and local governments; and individuals in each state, territory and possession of the U.S. including the District of Columbia.

Preapplication discussion with the EPA program is advisable. Requests for required standard application forms and completed applications must be submitted to the EPA Grants Administration Division. An environmental impact assessment is required. The range of approval or disapproval time is 90 days.

Contact: Individuals are encouraged to communicate with the appropriate EPA regional office. Information concerning grant applications and procedures may be obtained from Environmental Protection Agency, Grants Administration Division, PM-216, Washington, D.C. 20460. Program information may be obtained from the Environmental Protection Agency, Office of Research and Development, RD-674, Washington, D.C. 20460, (202) 755-8787.

3. Water Pollution Control Research, Development, and Demonstration Grants. Project grants are available under this program to support and promote the coordination and acceleration of research, development, and demonstration projects relating to the causes, effects, extent, preven-

tion, reduction, and elimination of water pollution. The program is considered suitable for joint funding with closely related federal financial assistance programs in accordance with OMB Circular No. A-111. Grants under certain sections of this program require a minimum of 5 percent cost sharing, while the remainder require 25 percent cost sharing. Research grants have ranged from $1,000 to $772,912 in FY 78 and 79 with an average in FY 79 of $91,710 and a projected average for FY 80 of $75,000. Demonstration grants have ranged from $37,500 to $9,500,000 in FY 78 and 79 with an average of $131,330 in FY 79. FY 80 projected demonstration grant average is $100,000. FY 80 estimated obligations are $17,668,000 for research and demonstration grants.

This program is available to public, private, state and community university and colleges, hospitals, laboratories, state water pollution control agencies, interstate agencies, state and local governments, other public or private non-profit agencies, institutions, and organizations in each state and all territories and possessions of the United States including the District of Columbia. Grants may be awarded to individuals who have demonstrated unusually high scientific ability. Grants under certain sections of this program may be awarded to profit-making organizations.

Preapplication discussion with the EPA Program Office is advisable. Requests for the required standard application forms and completed applications must be submitted to the Environmental Protection Agency Grants Administration Division. Demonstration grant applications are subject to state and areawide clearinghouse review. An environmental impact assessment is required for this program. Range of approval or disapproval time is 90 days.

Contact: Individuals are encouraged to communicate with appropriate EPA regional office. Information concerning grant applications and procedures may be obtained from the Environmental Protection Agency, Grants Administration Division, PM-216, Washington, D.C. 20460. Program information may be obtained from the Environmental Protection Agency, Office of Research Program Management, RD-674, Washington, D.C. 20460, (202) 755-8787.

OFFICE OF PLANNING AND MANAGEMENT

1. Loan Guarantees for Construction of Treatment Works. Guaranteed/Insured loans are available to assist and serve as an incentive in construction of municipal sewage treatment works which are required to meet state and federal water quality standards. The program is designed to insure that inability to borrow necessary funds from other sources on reasonable terms does not prevent the construction of any wastewater treatment works for which a grant has been or will be awarded. Applications for loan guarantees will be limited to financing certain portions of the eligible and allowable local share of a grant for construction of wastewater treatment works. EPA guarantees the loan from the Federal Financing Bank.

A state, interstate agency, a municipality, or an intermunicipal agency which has applied for a construction grant under Title II of the Clean Water Act or which has committed itself to finance the local share of any project for which a grant has been awarded or for which an application is being processed are eligible for funds under this program. It is available to each state, territory and possession of the United States including the District of Columbia.

Preapplication consultation with the appropriate EPA Regional Construction Grants and Grant Administration Offices is recommended. Application is made through the state agency to the appropriate EPA regional office. Fees are charged for processing of the application and for issuance of a commitment to guarantee. If the application is approved by the EPA administrator, loan guaranteed contracts will be issued to the federal financing office which disperses funds.

Contact: Contact the appropriate regional office of the EPA for information concerning this program or Environmental Protection Agency, Grants Administration Division, PM-216, Washington, D.C. 20460, (202) 755-0850.

## STATE/LOCAL PROGRAMS

### STATE LEVEL: MARYLAND

### DEPARTMENT OF NATURAL RESOURCES

Water Resources Administration

1. Clean Lakes Program (Federal). No agency has been officially designated to administer 314 Clean Lakes applications and 314 Clean Lakes grants from the Environmental Protection Agency. The Water Resources Administration has been involved with 208 Planning and some of the 208 Regional Planning Commissions have applied for and received 314 Clean Lakes funding. At the present time, the local project sponsor is required to provide matching monies.

Contact: Maryland Department of Natural Resources, Water Resources Administration, Tawes State Office Building, Annapolis, Maryland 21401, (301) 269-2224.

2. Program Open Space. The Department of Natural Resources provides financial assistance in the form of grants (formula allotment) to local governmental units for the development of park and recreational facilities. Half the monies received by the local community may be used for land acquisition and half for recreational development. A 25% match is required of the local sponsor on the portion that applies to recreational development. No match is required on the portion for land acquisition.

Contact: Appropriate county office or Maryland Department of Natural Resources, Program Open Space, Tawes State Office Building, Annapolis, Maryland 21401.

### STATE DEPARTMENT OF HEALTH

1. Water, Ice and Sewerage Program. This program provides grants to counties and municipalities for sewage and central source system development. Monies are to be used to provide a matching funding for the federal Sewage Construction Grants Program (projects must qualify for federal aid). The state will cost share 50% (the other 50% to be provided by the local sponsor) of the nonfederally funded portion of project costs on a 75% federal grant and 75%/25% (state/local) on a 85% federal grant.

Contact: Maryland State Department of Health.

## STATE/LOCAL PROGRAMS

### STATE LEVEL: MASSACHUSETTS

### DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

Division of Waterways

1. Eutrophication and Nuisance Aquatic Vegetation Control Program. This program involves a preapplication and final application process in order for a community to receive funds for controlling a problem in their lake. Formerly a simple weed control program, this program now gives first priority to projects which seek to solve the eutrophication problem at its source. The complete span of restoration techniques are eligible for funding (about $120,000 available statewide during FY 80). The usual applicant is a city or town through the board of selectmen, conservation commission, health department, etc. This program is expected to be transferred to the Division of Water Pollution Control in order to consolidate and coordinate all lake functions state-wide.

Contact: Massachusetts Department of Environmental Quality Engineering, Division of Waterways, Room 532, 100 Nashua Street, Boston, Massachusetts 02114, (617) 727-4797.

Division of Water Pollution Control (314 designated agency)

1. Massachusetts Lakes Program. This program embodies the state's own program. Activities include statewide lake classification studies, diagnostic-feasibility studies, water assistance research team surveys (WART strikes), 314 coordination and project application administration, limnological data publication, state project priority listing, lake association assistance, coordination of federal-state-local lake rehabilitation efforts, and related activities. Legislation presently under review, if successful, would provide up to $2,000,000 in state matching funds for 314 projects as well as provide a firm legislative mandate for administering a statewide lakes program.

Contact: Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, P. O. Box 545, Westborough, Massachusetts 01581, (617) 366-9181.

2. Accelerated Water Pollution Control Program (Ch. 21, Sect. 31). This program provides grants to public entities representing several municipalities for regional sewage and water pollution abatement planning. Grants are not to exceed $15,000 per public entity.

Contact: Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, 110 Tremont Street, Boston, Massachusetts 02108.

3. Research and Demonstration Projects and Facilities. The Division of Water Pollution Control can provide technical assistance and grant aid for studies and demonstration projects involving innovative ways of treating sewage. Anyone with appropriate ideas, including consultants, universities, communities, etc., may apply. $1,000,000 has been authorized for FY 80. In the past, this program provided some matching monies for the 314 Clean Lakes Program before emphasis shifted to sewage treatment. It is unlikely that it will be used to match 314 funds in the future.

Contact: Massachusetts Department of Environmental Quality Engineering, Division of Water Pollution Control, P. O. Box 545, Westborough, Massachusetts 01581.

208 Regional Planning Commissions

The 208 designated Regional Planning Commissions have been especially active in Massachusetts and have coordinated their efforts with the Department of Environmental Quality Engineering to provide information on priority lakes and to organize public meetings to involve the public in lake restoration plans and projects.

Contact: Local Planning Office or Department of Environmental Quality Engineering, 208 Planning Division, 100 Cambridge Street, Boston, Massachusetts 02109.

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

Division of Conservation Service

1. Self-Help Program. The Division of Conservation Service provides grants to Municipal Conservation Commissions to cover up to 50% of the costs of land acquisition for passive recreational use. Filing deadline for applications is August 31 each year. Only land acquisition costs are eligible and only Municipal Conservation Commissions may apply.

Contact: Executive Office of Environmental Affairs, Division of Conservation Service, John Saltonstahl Building, 100 Cambridge Street, Boston, Massachusetts 02108.

2. Urban Self-Help Program. The Division of Conservation Service reimburses local Park and Recreation Commissions of municipalities with a population of greater than 35,000 for up to 80% of the costs of land acquisition for park and recreational facilities. Only land acquisition costs (including appraisals) are eligible for reimbursement. Applications should be in by August 31 each year. This program is due to end in June 1980 but extension of the program is being requested.

Contact: Executive Office of Environmental Affairs, Division of Conservation Service, John Saltonstahl Building, 100 Cambridge Street, Boston, Massachusetts 02108

MASSACHUSETTS CONGRESS OF LAKE AND POND ASSOCIATIONS, INC.

The major activity of the Congress is to forward the cause of lakes and ponds on every front. Their constitution states the purposes as follows:

1. To perform all acts appropriate to a nonprofit, scientific, literary, and educational corporation dedicated to the promotion and development of environmental quality standards essential for satisfactory life styles and conditions in the natural community.

2. To preserve the aesthetic, recreational, and commercial values of lakes and lakeshore properties through the maintenance and improvement of such environmental factors as watershed ecology, water quality, lake water levels, shoreline woodland management, agricultural soils practices, recreational and residential building standards, and related influences, such as water and boating safety.

Barely one year old, the Congress is only just beginning to grow and continuously experiments in innovative ways to become effective for the cause of lakes and ponds. As their expertise increases the Congress should be able to contribute more and more to the state and federal lake efforts in Massachusetts.

Contact: Massachusetts Congress of Lake and Pond Associations, Inc., P. O. Box 312, Westminster, Massachusetts 01473.

STATE LEVEL: MICHIGAN

DEPARTMENT OF NATURAL RESOURCES

Land Resource Programs Division

1. 314 Clean Lakes Program (Federal). The Department of Natural Resources is the agency designated to administer the 314 Clean Lakes Program. They are able to provide technical assistance to lake boards (special districts empowered to assess for and engage in activities related to lake improvement) concerning in-lake pollution control measures and engineering design. Such assistance may aid in providing an in-kind match for federally-funded 314 Clean Lakes projects.

Contact: Michigan Department of Natural Resources, Land Resource Programs Division, Inland Lake Management Unit, Steven T. Mason Building, Lansing, Michigan 48926, (517) 373-8000.

Clean Lakes Program

U.S. E.P.A. Policy on Grants

Funding preferences will be given to projects which eliminate pollutant sources and reduce pollutant loading in contrast to projects relying solely on in-lake activities to ameliorate the symptoms of lake degradation without attacking it's causes. E.P.A. emphasizes lake watershed management in making funding decisions.

This policy does not mean that in-lake restoration techniques will not be supported. Dredging, aeration, nutrient inactivation and other in-lake techniques are important lake restoration tools in two situations.

Lakes which have problems of excessive shallowness and rooted aquatic plants may benefit most from dredging, harvesting, sediment covering or lake level drawdown, while lakes which have excessive algae may respond to dilution/flushing, nutrient inactivation or aeration. In some cases a combination of procedures may prove to be most beneficial.

1. When sufficient pollutant reduction is being accomplished in the watershed to allow desired lake quality to be maintained, but recovery from degraded condition will be slow or will not occur simply as a result of watershed management.

2. When material accumulated in the lake constitutes a significant source of pollutants which is independent of controllable activitie in the watershed.

Examples of E.P.A. grants using in-lake restoration methods:

E.P.A. 625/2 - 80 - 27 Lake restoration cobbossee watershed - Maine used nutrient inactivation treatment.

E.P.A. 625/2 - 80 - 25 Restoration of Medical Lake - Washington used nutrient inactivation treatment.

## The Clean Lakes Program

Section 314 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500)* directed the United States Environmental Protection Agency to assist the States in controlling sources of pollution which affect the quality of freshwater lakes, and in restoring lakes which have deteriorated in quality. EPA is fulfilling this mandate with the Clean Lakes Program, which provides technical and financial assistance to the States to:

1. Classify publicly owned freshwater lakes according to trophic condition;
2. Conduct diagnostic studies of specific publicly owned lakes, and develop feasible pollution control and restoration programs for them;
3. Implement lake restoration and pollution control projects.

Assistance is made available to the States through the EPA Regional Offices in the form of cooperative agreements. Because program funds are limited, and the number of publicly owned lakes with present or potential water quality problems is large, awards must be made selectively. Projects chosen for funding are those which maximize public benefits. Such projects meet three general criteria.

First, projected public benefits must be significant. A lake to be studied and restored or protected should be one which can provide beneficial uses to a large number of people.

Second, the water quality improvement must be long term, to insure lasting benefits. EPA will not support restoration measures which merely ameliorate symptoms of pollution in a lake. Instead, the Agency emphasizes watershed management -- a comprehensive effort to identify and eliminate present or potential causes of lake water quality deterioration. Pollution is to be controlled at its source, not in the lake. When pollutant sources

*Now known as the Clean Water Act of 1977 (P.L. 95-217).

are being controlled, however, in-lake restoration techniques to speed recovery are also eligible for funding.

Finally, projects should promote integrated, coordinated water quality management. Other Federal, State and local programs can supplement the Clean Lakes Program. For example, the 201 Construction Grants Program can complement a lake restoration agreement by helping municipalities eliminate pollution from domestic sewage. U.S. Department of Agriculture assistance is available to farmers to implement agricultural pollution control measures, supplementing Clean Lakes Program watershed management. Combining water quality management resources in this way enhances the effectiveness of expenditures under any single program.

## THE CLEAN LAKES PROGRAM

This section is summarizes the Clean Lakes Program -- its legislative basis, regulations, program description, application procedures, and results to date.

### Legislative Basis

Section 314 of the Clean Water Act of 1977 is the legislative basis for the Clean Lakes Program.

SEC. 314.

(a) Each State shall prepare or establish, and submit to the Administrator for his approval -

(1) an identification and classification according to eutrophic condition of all publicly owned freshwater lakes in such State;

(2) procedures, processes, and methods (including land use requirements), to control sources of pollution of such lakes; and

(3) methods and procedures, in conjunction with appropriate Federal agencies, to restore the quality of such lakes.

(b) The Administrator shall provide financial assistance to States in order to carry out methods and procedures approved by him under this section. The Administrator shall provide financial assistance to States to prepare the identification and classification surveys required in subsection (a)(1) of this section.

(c) (1) The amount granted to any State for any fiscal year under this section shall not exceed 70 per centum of the funds expended by such State in such year for carrying out approved methods and procedures under this section.

(2) There is authorized to be appropriated \$50,000,000 for the fiscal year ending June 30, 1973; \$100,000,000 for the fiscal year 1974; \$150,000,000 for the fiscal year 1975; \$50,000,000 for the fiscal year 1977; \$60,000,000 for the fiscal year 1978; \$60,000,000 for the fiscal year 1979; and \$60,000,000 for the fiscal year 1980 for grants to States under this section. These sums shall remain available until expended. The Administrator shall provide for an equitable distribution of such sums to the States with approved methods and procedures under this section.

## Restriction of Awards

One of the ways in which the Clean Lakes Program will effect this coordination is by limiting award of Federal lake funds to areas that are applying an integrated watershed management approach. Before making an award, the Regional Administrator must determine that any water pollution control measures in the lake's watershed authorized under section 201, included in an approved 208 plan, or required by section 402, have been completed or are proceeding on approval schedules [40 CFR 35.1650-2(b)(2)].

## Goals

The goal of the Clean Lakes Program is to implement, through assistance to the States, methods and procedures to control sources of pollution to the Nation's publicly owned freshwater lakes and to restore degraded lakes. Recognizing, however, that this applies to all publicly owned lakes and several thousand may need immediate action, the program has established a more specific goal for the 1980-1985 period. The goal is to protect at least one lake whose water quality is suitable for contact recreation, or to restore a degraded lake to that condition, within 25 miles of every major population center. A population center, in this context, usually is a Standard Metropolitan Statistical Area (SMSA) as defined by the U.S. Bureau of the Census. However, this definition will be applied with discretion in selecting projects for funding. Some SMSAs are so populous that a single clean lake would not be sufficient to meet user demand. Conversely, in SMSAs near the ocean beaches, bays, large rivers, or the Great Lakes, there may be little demand for lake protection or restoration.. In vacation and tourist areas where seasonal populations are high, and in other situations where lake water quality is important to regional economy and quality of life, projects may warrant priority equal to that accorded urban lakes. More explicit guidance on this aspect of project selection will be developed, but the need for flexibility will never be eliminated.

## TECHNICAL AND FINANCIAL ASSISTANCE PROGRAMS

As discussed in earlier sections, the Clean Lakes Program provides up to $100,000 per award and requires a 30 percent non-Federal share for Phase 1 diagnostic-feasibility studies. Phase 2 awards are available for pollution control and/or in-lake restoration methods; there is no specified maximum, but they require a 50 percent non-Federal share. Thus, significant amounts of money must be supplied by State, local or private sources. As a general rule, Federal grant programs or other Federal monies cannot be used to supply the State and local share; however, two exceptions do exist. The exceptions are the General Revenue Sharing Funds from the Department of the Treasury and the Community Development Block Grants from the Department of Housing and Urban Development, both of which may be used as a part of the State and local matching funds for the Clean Lakes Program.

### Non-Federal Match

A number of States have set up specific funded programs to be used as non-Federal matching funds for the Clean Lakes Program. Others have programs which, although not specifically designed for that purpose, could be used to provide the local match (see Table 11-1). In the State/local section of the matrices, in Table 11-2, under the "Federal Program Matched" column, the phrase "314" denotes States with funded programs specifically designed to match the Clean lakes funds and "314 possible," denotes States where program funds may provide the match under certain conditions. Thirty-two States do not provide matching funds. Consequently, local units of government must provide all the matching funds for the Clean Lakes Program. However, State technical and administrative assistance may be used as an in-kind match.

As can be seen in Table 11-2, most States have indicated that they do provide technical assistance which can be used as an in-kind match. Such State services as water quality monitoring and installation of monitoring equipment, laboratory services, and analysis of data can and have been

## STATES WITH PROGRAMS TO MATCH CLEAN LAKES FUNDS

| Specifically Designed Programs | Programs Applicable Under Certain Conditions |
|---|---|
| Connecticut | Arizona |
| Florida | Arkansas |
| Massachusetts* | California |
| Maine* | Montana |
| Minnesota | Nebraska |
| New Jersey | Rhode Island |
| North Carolina | |
| Oregon* | |
| Puerto Rico | |
| South Dakota | |
| Washington** | |
| Wisconsin | |

*Proposed.

**Proposed, Phase 2 only.

used as the in-kind match. These services can also be provided at the local level and may include donated time and equipment from qualified local sources. Specific reference to using in-kind services is made in the hypothetical case in Section 12.0 of this manual.

Combination With Other Complementary Efforts

In addition to providing direct matching funds, other programs at the Federal, regional, and State levels can be coordinated with Clean Lakes projects by providing funds for activities that are not directly a part of the work funded under section 314. These are also summarized in Table 11-2. As an example, the Clean Lakes Program regulations specifically exclude costs for controlling point source discharges, where the sources can be alleviated by permits issued under either section 402 of the Clean Water Act, or by the planning and construction of wastewater treatment facilities under section 201 of the Act. Nevertheless, it is recognized that such control of point source discharges is extremely important in the lake restoration process, and that where possible, this work should be coordinated with Clean Lakes projects. Thus, while references to section 201 programs are not included in the State program sections of the matrix, it is important to check with the appropriate program office to determine their applicability to Clean Lakes restoration.

Other examples are recreational facilities development programs, such as the Land and Water Conservation Program under the Department of the Interior's Heritage Conservation and Recreation Service. They may not be used to provide matching funds to a Clean Lakes project, but activities funded under them can greatly enhance the benefits obtainable with Clean Lakes funds. Again, as with 201, no reference appears in the matrix to these LAWCON programs.

Department of Agriculture programs, especially in the Agricultural Stabilization and Conservation Service, the Farmers Home Administration, and the Soil Conservation Service, are other examples of funded programs which may be used with the Clean Lakes Program. It is important to remember that applications for Clean Lakes projects proposing coordination with other complementary activities will receive more favorable consideration for funding by EPA.

## Sources of Additional Information

Written descriptions of Federal, regional, and State programs can be found in Appendix H to this manual. The Federal programs are divided into three sections: those providing financial assistance; those providing technical, informational, or advisory services; and those providing labor. Programs providing financial assistance to be coordinated with the Clean Lakes Program have been summarized in the matrices in this chapter. The matrices indicate the department, agency, and program identification; type of assistance; type of projects which are eligible for the funds; and the eligible recipients. This information, along with the total obligations for fiscal year 1980, average project size, and various application information, has been obtained from the Catalog of Federal Domestic Assistance (available in major libraries, or may be purchased from the Superintendent of Documents, U.S. Government Printing Office). Where necessary, the matrices have been supplemented by data obtained directly from program managers.

Two other Federal programs are not included in the matrix but may be useful. The U.S. Army Corps of Engineers has a program which is primarily research-oriented, dealing with projects such as aquatic plant control, beach erosion control, flood control, debris clearance, and channel straightening. This assistance is usually in the form of technical consulting and research by Corps personnel.

The other Federal program which does not appear in the matrix is the General Services Administration's Disposal of Federal Surplus Real and Personal Property Programs. This program provides for the transfer of property such as abandoned military installations from the Federal government to eligible recipients. The transfer is usually on a specialized basis and depends on the location of the proposed project.

Information concerning State and regional programs was obtained from interviews with State and regional officials. These programs are described in Appendix H, and presented in the matrices in this section.

## RANGES OF PROMULGATED STANDARDS FOR RAW WATER SOURCES OF DOMESTIC WATER SUPPLY

| Constituent | Excellent source of water supply, requiring disinfection only, as treatment | Good source of water supply, requiring usual treatment such as filtration and disinfection | Poor source of water supply, requiring special or auxiliary treatment and disinfection |
|---|---|---|---|
| BOD (5-day) mg/l | | | |
| Monthly average: | 0.75-1.5 | 1.5-2.5 | Over 2.5 |
| Maximum day, or sample: | 1.0-3.0 | 3.0-4.0 | Over 4.0 |
| Coliform MPN per 100 ml | | | |
| Monthly average: | 50-100 | 50-5,000 | Over 5,000 |
| Maximum day, or sample: | Less than 5% over 100 | Less than 20% over 5,000 | Less than 5% over 20,000 |
| Dissolved Oxygen | | | |
| mg/l average: | 4.0-7.5 | 4.0-6.5 | 4.0 |
| % saturation: | 75% or better | 60% or better | --- |
| pH | | | |
| Average: | 6.0-8.5 | 5.0-9.0 | 3.8-10.5 |
| Chlorides, max. mg/l | 50 or less | 50-250 | Over 250 |
| Fluorides, mg/l | Less than 1.5 | 1.5-3.0 | Over 3.0 |
| Phenolic compounds, max. mg/l | None | 0.005 | Over 0.005 |
| Color, units | 0-20 | 20-150 | Over 150 |
| Turbidity, units | 0-10 | 10-250 | Over 250 |

## COMPARISON OF CHEMICAL CONSTITUENTS IN THE DRINKING WATER STANDARDS OF THE WORLD HEALTH ORGANIZATION AND THE U.S. PUBLIC HEALTH SERVICE

| | *Concentrations In Milligrams Per Liter* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *WHO International (1958)* | | | *WHO European (1961)* | | *U.S.P.H.S. (1962)* | |
| *Chemical Constituent* | *Permissible Limit* | *Excessive Limit* | *Maximum Allowable* | *Recommended Limit* | *Tolerance Limit* | *Recommended Limit* | *Maximum Allowable* |
| Alkyl benzene sulfonate | -- | -- | -- | -- | -- | 0.5 | -- |
| Ammonia ($NH_4$) | -- | -- | -- | 0.5 | -- | -- | -- |
| Arsenic | -- | -- | 0.2 | -- | 0.2 | 0.01 | 0.05 |
| Barium | -- | -- | -- | -- | -- | -- | 1.0 |
| Cadmium | -- | -- | -- | -- | 0.05 | -- | 0.01 |
| Calcium | 75 | 200 | -- | -- | -- | -- | -- |
| Carbon chloroform extract | -- | -- | -- | -- | -- | 0.2 | -- |
| Chloride | 200 | 600 | -- | 350 | -- | 250 | -- |
| Chromium (hexavalent) | -- | -- | 0.05 | -- | 0.05 | -- | 0.05 |
| Copper | 1.0 | 1.5 | -- | 3.0* | -- | 1.0 | -- |
| Cyanide | -- | -- | 0.01 | -- | 0.01 | 0.01 | 0.2 |
| Fluoride | -- | -- | -- | 1.5 | -- | 0.8-1.7# | 1.6-3.4# |
| Iron | 0.3 | 1.0 | -- | 0.1 | -- | 0.3 | -- |
| Lead | -- | -- | 0.1 | -- | 0.1 | -- | 0.05 |
| Magnesium | 50 | 150 | -- | 125** | -- | -- | -- |
| Magnesium + Sodium sulfate | 500 | 1000 | -- | -- | -- | -- | -- |
| Manganese | 0.1 | 0.5 | -- | 0.1 | -- | 0.05 | -- |
| Nitrate (as $NO_3$) | -- | -- | -- | 50 | -- | 45 | -- |
| Oxygen, dissolved (minimum) | -- | -- | -- | 5.0 | -- | -- | -- |
| Phenolic compounds (as phenols) | 0.001 | 0.002 | -- | 0.001 | -- | 0.001 | -- |
| Selenium | -- | -- | 0.05 | -- | 0.05 | -- | 0.01 |
| Silver | -- | -- | -- | -- | -- | -- | 0.05 |
| Sulfate | 200 | 400 | -- | 250 | -- | 250 | -- |
| Total solids | 500 | 1500 | -- | -- | -- | 500 | -- |
| Zinc | 5.0 | 15 | -- | 5.0 | -- | 5.0 | -- |

* After 16 hours contact with new pipes; but water entering a distribution system should have less than 0.05 mg/l of copper.
** If there are 250 mg/l of sulfate present, magnesium should not exceed 30 mg/l.
# Recommended limits and maximum allowable concentrations vary inversely with mean annual temperature. See table 5-1.

# WATER QUALITY OBJECTIVES AND MINIMUM TREATMENT REQUIREMENTS

## Water Quality Objectives, Applicable to Receiving Waters, for Salt and Fresh Surface Waters and Underground Waters

| Water quality → / water uses ↓ | Organisms of the coliform group | Floating, suspended & settleable solids & sludge deposits | Taste- or odor-producing substances | Dissolved oxygen | pH | Toxic, colored, or other deleterious substances | Phenolic compounds | Oil | High temperature wastes | Minimum treatment requirements for domestic sewage |
|---|---|---|---|---|---|---|---|---|---|---|
| **A. WATER SUPPLY, DRINKING, CULINARY & FOOD PROCESSING** Without treatment other than simple disinfection and removal of naturally present impurities | Most probable number coliform bacterial content of a representative number of samples should average less than 50 per 100 ml. in any month | None attributable to sewage, industrial wastes or other wastes or which, after reasonable dilution & mixture with receiving waters, interfere with the best use of these waters for the purpose indicated | None attributable to sewage, industrial wastes, or other wastes | Greater than five (5) parts per million except for underground waters | Hydrogen ion concentration expressed as pH should be maintained between 6.5 and 8.5 | None alone or in combination with other substances or wastes in sufficient amounts or of such nature as to make receiving water unsafe or unsuitable for use indicated (U.S.P.H.S. Stds.) | Less than five (5) parts per billion | None | Not in sufficient quantities alone or in combination with other wastes to interfere with the use indicated | Sedimentation and effective disinfection |
| **B. WATER SUPPLY, DRINKING, CULINARY & FOOD PROCESSING** With treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary for removing naturally present impurities | M.P.N. coliform bacterial content when associated with domestic sewage of a representative number of samples should average less than 2000 per 100 ml. and should not exceed this number in more than 20 per cent of samples examined in any month | Same as for use "A" above | None attributable to sewage, industrial wastes, or other wastes which, after reasonable dilution & mixture, will increase the threshold odor number above eight (8) | Greater than five (5) parts per million except for underground waters | Same as for use "A" above | Same as for use "A" above | Less than five (5) parts per billion | None alone or in combination with other substances or wastes as to make receiving water unfit or unsafe for the use indicated | Same as for use "A" above | Sedimentation and effective disinfection |
| **C. BATHING, SWIMMING AND RECREATION** Note: When waters are used for recreational purposes such as fishing & boating, exclusive of bathing & swimming, the number "1000" may be substituted for "240" in statement of coliform objective | Coliform bacterial content of a representative number of samples should average less than 240 per 100 ml. and should not exceed this number in more than 20 per cent of samples examined when associated with domestic sewage (see note under "C" at left) | Same as for use "A" above | None attributable to sewage, industrial wastes, or other wastes which, after reasonable dilution & mixture, will interfere with the best use of these waters for the purpose indicated | Greater than five (5) parts per million | Same as for Use "A" above | Same as for Use "A" above | Less than 25 parts per billion or none in sufficient amounts such as to impart a residual taste to recreational or commercial fish, shellfish, or other aquatic forms | Same as for use "B" above | Same as for use "A" above | Sedimentation and effective disinfection |
| **D. GROWTH & PROPAGATION OF FISH, SHELLFISH & OTHER AQUATIC LIFE** | Coliform bacterial content of a representative number of samples should not have a median concentration greater than 70 per 100 ml. in waters used for the growth & propagation of shellfish | Same as for use "A" above | None attributable to sewage, industrial wastes, or other wastes which will interfere with the marketability or propagation of recreational or commercial fish, shellfish, or other edible aquatic forms | Greater than six (6) parts per million | Same as for use "A" above | None alone or in combination with other substances or wastes to sufficient amount or of such character as to make receiving waters unsafe or unsuitable for use indicated | Same as for use "C" above | Same as for use "B" above | None in sufficient quantity as to be injurious to or interfere with the normal propagation of fish, shellfish, or other aquatic life | Sedimentation for all uses under this group but disinfection required in addition only if discharged into waters used for the growth & propagation of shellfish, either commercial or recreational |
| **E. AGRICULTURAL AND INDUSTRIAL WATER SUPPLY** Without treatment except for the removal of natural impurities to meet special quality requirements, other than those classified under "A" above. Note: For agricultural water supply, salinity and sodium hazards are determined by electrical conductivity ($EC \times 10^6$) and sodium adsorption ratio (SAR). Waters high in both salinity and sodium are generally unsuitable for irrigation purposes. (See "classification and use of irrigation waters", circular No. 969, U.S. Department of Agriculture, November, 1955) | | Same as for use "A" above | None attributable to sewage, industrial wastes, or other wastes which will adversely affect the marketability of agricultural or industrial produce | Greater than three (3) parts per million | Hydrogen ion concentration expressed as pH should be maintained between 6.0 & 9.5 | Same as for use "A" above | None in sufficient quantity as to make receiving water unsuitable for use indicated | Same as for use "B" above | Same as for use "A" above | Sedimentation and effective disinfection |

Figure 4

# THE NITROGEN CYCLE IN SOIL AND GROUNDWATER

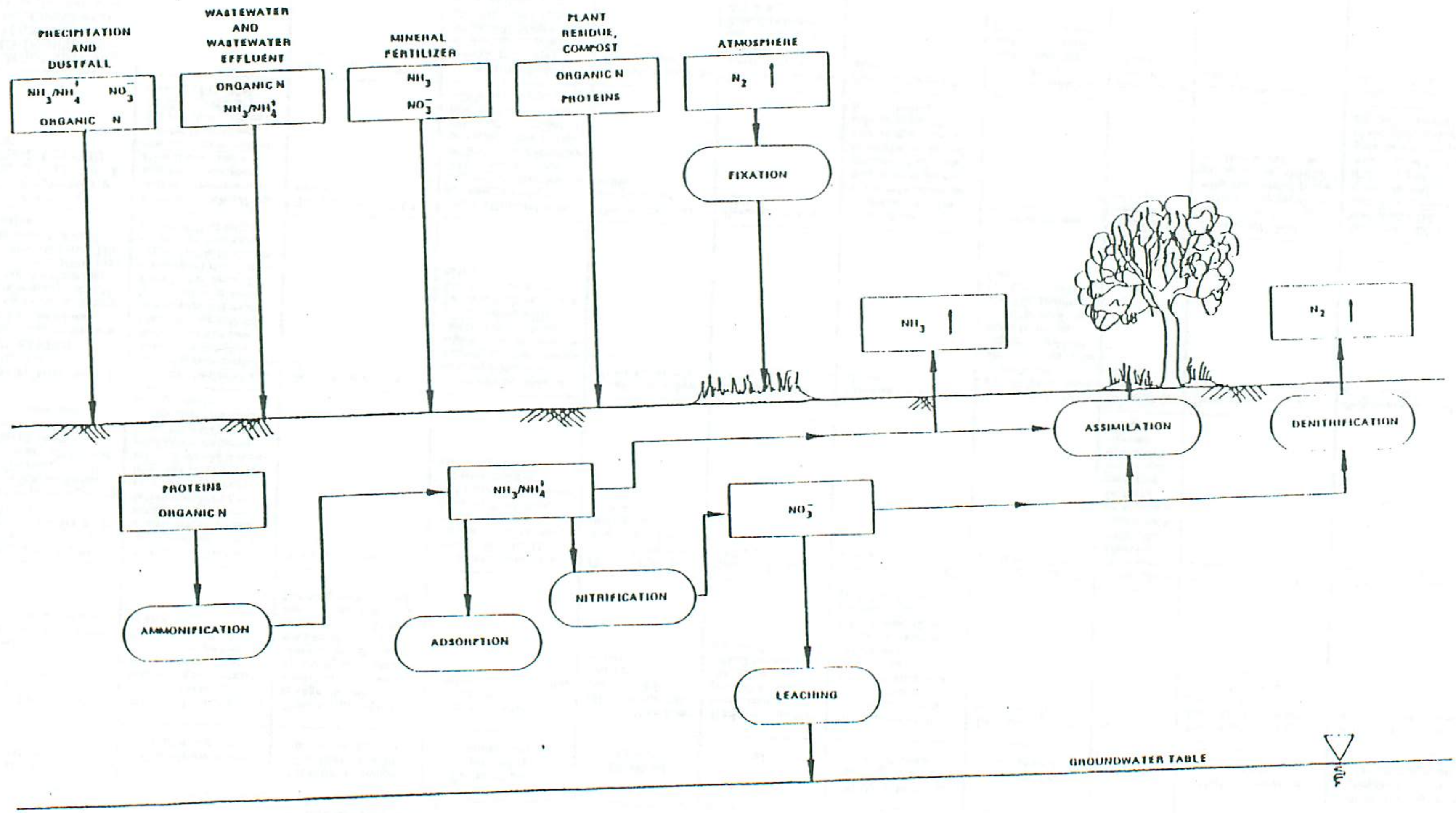
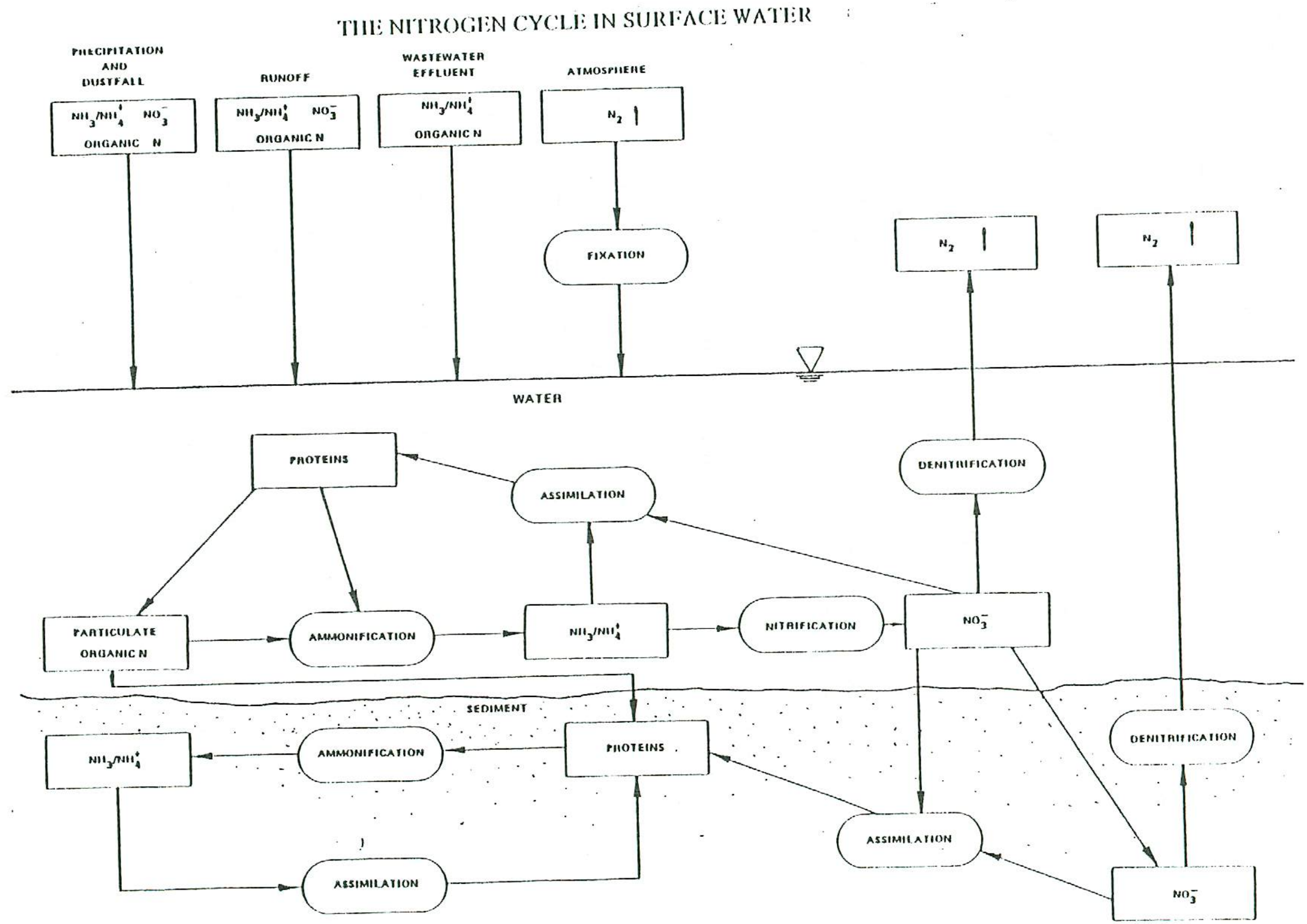


Figure 5



THE NITROGEN CYCLE IN SURFACE WATER
PRECIPITATION AND DUSTFALL
$NH_3/NH_4^+$ $NO_3^-$
ORGANIC N
RUNOFF
$NH_3/NH_4^+$ $NO_3^-$
ORGANIC N
WASTEWATER EFFLUENT
$NH_3/NH_4^+$
ORGANIC N
ATMOSPHERE
$N_2$
FIXATION
$N_2$
$N_2$
WATER
PROTEINS
ASSIMILATION
DENITRIFICATION
PARTICULATE ORGANIC N
AMMONIFICATION
$NH_3/NH_4^+$
NITRIFICATION
$NO_3^-$
SEDIMENT
$NH_3/NH_4^+$
AMMONIFICATION
PROTEINS
DENITRIFICATION
ASSIMILATION
ASSIMILATION
$NO_3^-$

LBs (Kgs) Nutriant in Lake

Nutrient Calculations

1 Gal = 3.85 Liters x ppm = Mg/Gal.

$$\frac{\text{Mg/Gal. x Total Gallons in Lake}}{\text{453 590 Mg/lb.}} = \text{lbs. in lake}$$

lbs. in lake x .454 = Kgs in lake

Flowing Streams ( Need gals. per sec. and ppm)

Cubic Meters

$$\text{Kg/sec} = \frac{\text{Mg/Liter x (Gallons x .00378)}}{1000}$$

Kg/sec x Sec's Day 86400 x Month Days = Kg/mo x 2.2046 = lbs/month

Conversion Factors

Acres x .405 = Hectares

Hectares x 2.741 = Acres

" x 10,000 sq. Meters

Acres x 4047 = sq. Meters ?

Sq. Meters x .0001 = Hectare

Feet x .3048 = Meters

Gallons x 3.785 Liters

Kg = 2.2046 lbs.

lbs. x .454 = Kg

Yds. x .9144 = Meters

1 Acre = 43,560

1 Gal $H_2o$ 8.345 lbs.

1 Cubic foot $H_2o$ = 7.48 Gals.

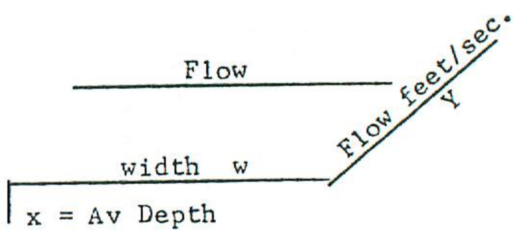
" " " = 62.42 lbs.

1 Acre Foot = 2.719,041 lbs.

" " = 325,829 Gals.

Inches x 2.54 cm.

ug/L = ppb = .001 ppm




X x Y x W = Cubic feet of inches/sec's

$$\frac{\text{inches}}{1725} = \text{C.F. x 7.48 Gals/cf = Gals./sec's}$$

$$\frac{60}{\text{no. of sec's}} \text{ x Gals. = Gallons/minute Flow}$$

Culverts = use Robts computerization

# METHODOLOGY

## Hydraulic Parameters

Hydraulic Residence Time = Theoretical time required to displace lake or pond volume based on known inputs (groundwater* , surface flow) into water body.

Flushing Time = Theoretical time required to displace pond or lake volume, based on flow from body.

Groundwater = (mean inflows surface tribs + rainfall) - (mean discharge outfall + evaporation)

# EVAPORATION

## Methodology

$$E = .771\ (1.465 - .0186B)\ (.44 - .118W)\ (C_8 - C_D)$$

E = Eveporation in inches in 24 hours

B = mean barometric reading, in inches of mercury at 32 F

W = mean speed of ground wind, or water surface wind in miles per hour

$C_8$ = mean vapor pressure of saturated vapor at temperature of water surface, in inches of mercury

$C_D$ = mean vapor pressure of saturated air at the temperature of the dew point, in inches of mercury

National Oceanic and Atmospheric Administration
Environmental Data Service
National Climatic Center
Ashville, N.C.

U.S. Weather Service

Evaporation is measured in the standard weather service type pan of 4 foot in diameter. Maximum and minimum valves in the evaporation and wind table are monthly averages of daily extremes of temperature of water in pan as recorded during 24 hours ending at time of observation. Wind is the total wind movement in miles over the evaporation pan, as determined by a continuous anemometer recorder located 6-8 inches above the pan.

Evaporation readings are inches.

The loss from a natural water surface = evaporation of U.S. Weather Servive x .70

Lake evap.. inches = USWS x .70

D. COMPOST TOILETS

1. Ecolet
Recreational Ecology Conservation of United States, Inc.
9800 West Bluemound Road
Milwaukee, Wisconsin 53226

2. Clivus-Multrum
14A Eliot Street
Cambridge, Massachusetts 02138

3. Biu-Let
Bio-Utility Systems, Inc.
P.O. Box 135
Narberth, Pennsylvania 19072

4. A&A Adhesives & Plastics
P.O. Box 302
Stow, Massachusetts 01775
(Soddy Potty)

5. Toa-Throne Compost Toilet
P.O. Box 752
Corona del Mar, California 92625

E. CHEMICAL TOILETS

1. Fiberglass Chemical Toilets
Chic-Sales Company, Inc.
P.O. Box 689
Hillview Building
Santa Ana, California

2. Vapor-Monogram New-Matic Toilet
Vapor Corporation
6420 West Howard Street
Chicago, Illinois 60648

3. Mansfield Sanitary, Inc.
Perrysville, Ohio
(Sani-Pottie 947)

4. Mile Ahead Industries Inc.
41 West Putnam Avenue
Greenwich, Connecticut 06830

5. Waterless Comfort Station
Burlway Road
P.O. Box 1026
Burlingame, California 94011

6. Thetford Engineering Corporation
P.O. Box 1285
Ann Arbor, Michigan 48106
(Aqua Magic, Porta Potti)

7. Sani-Mate
Zurn Industries, Inc.
Erie, Pennsylvania

8. Todd Enterprises, Inc.
Providence, Rhode Island
(Mini-Pot)

9. Sani-Matic Corporation
(Uncle John Dry flush)

10. Monogram Industries
(Tota-toilet)

F. LOW WATER FLUSH TOILETS

1. Safeway Toilets
Safeway Sanitation
75 Argyle Avenue
Buffalo, New York 14226

2. Microphor Toilets
Microphor, Inc.
475 East San Francisco Avenue
Willits, California 95490

3. American Standard
P.O. Box 2003
New Brunswick, New Jersey 08903

4. Kohler Company
Kohler, WS 53044
(Water guard toilet)

January 1978

TO:

APPROVED UNITS - MAINE PLUMBING CODE, PART II - PRIVATE SEWAGE DISPOSAL REGULATIONS

A. RECIRCULATING TOILETS

1. Thetford Corporation
(Cycle-Let)
Ann Arbor, Michigan

2. Monogram
Monogram Industries
1165 East 230th Street
Carson, California 90745

3. Pureway Corporation
Pureway
301-42nd Avenue
East Mobile, Illinois 61244

4. Vapor Corporation
Main Office
6420 West Howard Street
Chicago, Illinois 60648

5. Sears-Roebuck Company

6. Montgomery Ward

7. J.C. Penny

8. Thiokol MPB-10 Chemical Toilet System
Thiokol Chemical Corporation
Wasatch Division (Model MPB-10)
P.O. Box 524
Brigham City, Utah 84302

9. Multi Flo Home System for Recycling
Wastewater
(Unit RS-1) (Unit RS-2)
Multi-Flo, Inc.
500 Webster Street
Dayton, Ohio

10. Chrysler Corporation
(Aqua-Sans)
Dept. 2100
P.O. Box 29200
New Orleans, Louisianna 70129

B. GAS INCINERATING TOILETS

1. (Destroilet)
LaMere Industries, Inc.
227 N. Main Street
Walworth, Wisconsin 53184

2. (Incinolet)
Research Products Mfg. Co.
P.O. Box 35164
Airlawn Station
Dallas, Texas

3. Tekmar Corporation
(Thermajon)

4. Clear Water Inc. (Pyrolet)
P.O. Box 644
Sheboygan, Wisconsin 53081

5. Lake Geneva A & C Corporation
Box 89
200 Elkhorn Road
Williams Bay, Wisconsin 53191
(A.C. Storburn)

C. ELECTRIC INCINERATING TOILETS

1. Incinolet
Research Products Mfg. Company
P.O. Box 35164
Airlawn Station
Dallas, Texas

2. Incinomode
Incinomode Sales Company
P.O. Box 879
Sherman, Texas 75090

3. N-Con Systems Company, Inc.
Thermox

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