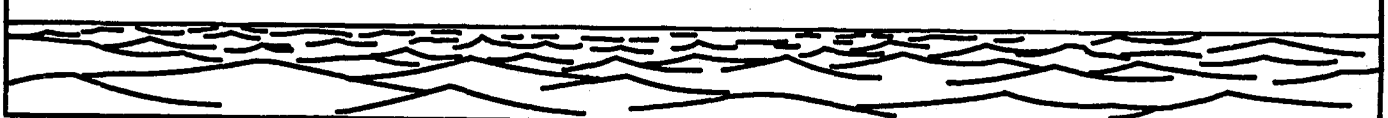
# DIAGNOSTIC/FEASIBILITY

# STUDY REPORT



# WALL LAKE

# RESTORATION

# INTRODUCTION

The current situation at Wall Lake is characteristic of many lakes in eastern South Dakota. Situated, as it is, 12 miles west of Sioux Falls in a rural, agricultural environment, Wall Lake is beset with many of the classic problems associated with a eutrophic lake system.

In lake restoration philosophy, especially for South Dakota's relatively shallow prairie lakes and ponds, it is crucial to recognize that natural successional forces are at work in driving the aquatic system toward a upland climax community. This transition normally occurs very slowly over time by the gradual filling of the basin with sediment and the gradual encroachment of successive vegetational communities. The natural progression is from open-water lake to pond to marsh or swamp or bog to essentially dry land, with perhaps a channel for normal discharge. In deep lakes, this process may take tens of thousands of years but in shallow lakes, like Wall Lake, the changes may be seen in a decade or less.

Given the fact that any body of water is greatly influenced by its watershed and the rate of change in a lake is directly related to the physical composition and forces which occur within its watershed, it is understandable that, in an undisturbed watershed, with erosion-resistent substrate (rocks, cobbles, etc) and natural erosion-control vegetation, the influx of sediment and nutrients is minimal and occurs gradually over time. However, in our "prairie" environment, many artificial factors have accelerated the succession process. Native prairie, containing lakes and their tributaries, have been plowed for cropland (sometimes up to the lake shore or completely across or along small tributaries). Croplands subsequently have received substantial amounts of fertilizers, herbicides, and pesticides. Other lands within the watershed may have been severely degraded by intensive livestock grazing which has left little vegetation to retard erosion and has concentrated animal waste high in water-enriching nutrients. Silt and nutrients, therefore, are readily carried to lakes by snowmelt waters and rainstorm runoff or gradually seep into the lakes by subsurface or groundwater connections. Riparian vegetation has often been destroyed or altered to allow lake shore development of homes, cottages, and businesses. Failing or faulty septic systems and improperly designed feedlots around or near lakes contribute unnecessary nutrients to receiving waters. It is therefore of little surprise to find that many of our lakes are "over-enriched" (hypereutrophic) and are silting in at ever-increasing rates.

The enrichment and silting of our lakes produces conditions incompatible with the public's perception of a high quality, recreational lake. Excessive nutrients stimulate algal growth and productivity. In prolonged or chronic states of enrichment, large mats of algae are produced. The water turns green or brown (depending upon algae species) and is generally unattractive to swimmers, boaters, and fishermen. Fish kills due to overabundant algae or their toxins are not uncommon. Decaying surface mats of algae and dead fish produce offensive odors and attract a myriad of insects and other pests. Dead fish and vegetation that sink to the bottom of a lake contribute to anaerobic conditions and may stimulate the production of hydrogen sulfide. Poor water quality favors rough fish and acts to retard or eliminate most game fish. Polluted waters also stimulate fish-infecting fungi and parasites and may lead to epizootics among the entire fish population in the affected lake. In addition, the siltation of lakes decreases favorable spawning habitat of desirable game fish and disrupts the food base upon which these fish survive. Silt deposition decreases the water depth and may affect thermal stratification. Shallow, warm water holds less dissolved oxygen than does deep cold water. Decreased dissolved oxygen levels may become the significant limiting factor to aquatic life, especially in stressful hot and dry periods.

Obviously then, factors which contribute to a degradation of water quality, do not enhance the lake ecosystem and act to hasten the beginning of the end of healthy and useful lakes. Efforts should be made to reverse the trends, but it is important to recognize that what has happened over many years or decades cannot be expected to revert to pristine (or even acceptable) conditions overnight. Massive, labor-intensive, and expensive programs to remedy lakes ills without consideration of watershed management and treatment of point sources of pollution is a band-aid approach, at best. Most often such approaches result in only temporary abatement of severe problems and may, in themselves, create additional problems.

Therefore, in an effort to specify problem sources within the Wall Lake watershed and to better utilize limited funding, a Diagnostic/Feasibility study consisting of a compilation of existing data and information, and a complete watershed survey and evaluation has been conducted. This report is the result of that study.

# DIAGNOSTIC REVIEW

## General Morphology

Wall Lake is a shallow, glacial lake located in Minnehaha County approximately 12 miles west of Sioux Falls, SD. The lake covers 215 surface acres to an average depth of 9 feet and a maximum depth of 13 feet. The lake basin is generally bowl-shaped and consists of sand and gravel in the littoral or shoreline areas out to the 10 foot depth contour. The remaining central section of the basin is covered with an average of 3.5 feet of sediment. Three intermittent streams feed the lake from the north, northwest and west. The outlet is located on the southeast corner of the lake. Only minor groundwater connections have been detected (SDGS 1980).

The watershed associated with Wall Lake extends, generally, to the west and northwest encompassing 3680 acres of primarily agricultural land. Land use in the watershed is 55% cropland, 29% pasture and 16% other, which consists of water, farmsteads and residential areas (Table 1). Approximately 70 homes or cabins are currently situated adjacent to the lake. Of the 55% cropland, estimates by the Minnehaha County Conservation District and the Department of Water and Natural Resources indicate that 20% or 404 acres are in need of Best Management Practices.

Current beneficial uses and subsequent standards applied to Wall Lake are: warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation and wildlife propagation and stock watering. Table 2 lists the beneficial uses and assigned standards.

## Summary of Existing Information

A number of studies have been done on Wall Lake. Risking oversimplification of complex and lengthy studies, the following brief summaries are provided.

A) SCS Soil Erosion Study (1980):

* 65% of the watershed (1,982 of 3,072 acres) needs Best Management Practices (BMP's) treatment.

* Total erosion per year is 13,121 tons, with 12,693 tons per year coming from cropland.

* Total sediment yield (sediment deposited in Wall Lake) is 1,205 tons per year with 1,049 tons (87%) coming from agricultural land.

B) SDGS Hydrology Study (1981)

* A small outwash deposit of sand and gravel was found along the west inlet of 21 feet thick from 1 foot to 22 feet below the land surface.

* Another deposit occurred along the east shore at 6 to 17 feet below land surface.

* A third deposit occurred at the outlet at 1 to 9 feet below land surface.

* There appears to be no important groundwater connections to Wall Lake.

C) Wall Lake Water Quality Study (1985)

| * Parameter | In-lake status | Tributary status |
|---|---|---|
| D.O. | acceptable | low |
| Alkalinity | acceptable | acceptable |
| Diss. Solids | high | excessive |
| Susp. Solids | high | high |
| B.O.D. | acceptable | acceptable |
| pH | excessive | acceptable |
| Tot. Phos. | excessive | excessive |
| F. Coliforms | acceptable | excessive |
| TKN | high | excessive |
| Ammonia | high | high |
| Nitrate | acceptable | acceptable |
| Nitrite | acceptable | high |
| Inorg. N | high | high |
| Org. N | excessive | excessive |

* Limiting factor appears to be nitrogen.

* Phosphorus and nitrogen loads in 1979 were well above the dangerous level.

* Majority of nutrients (88% phosphorus, 85% nitrogen) came from the watershed feeding the west inlet.

* Loads to the lake from the west and northwest inlets were dangerously high.

* Snowmelt and stormwater runoff are the principle sources of phosphorus and nitrogen to the lake.

* Failing or poor septic tanks are a secondary problem.

* No serious sediment pesticide problems exist, all except atrizine are below detectable limits. Atrizine appears adhered to soil particles and does not release to the water column.

D) Ordinary High Water Mark Study (1983)

* OHWM established at elevation of 1559.5 feet MSL (mean sea level).

E) Individual Feedlot Survey (1986)

* Private pollution control facility located directly north of Wall Lake meets state and federal requirements, but proper operation and maintenance of facility is imperative for continued abatement of nutrient input to the lake.

F) Sediment Nutrient Flux Study (1983)

* Sediments show high concentrations of nutrients but they contribute little to the water column loading.

* Bottom is apparently acting as a nutrient sink.

* Lake should be categorized as HYPEREUTROPHIC.

* Levels of dissolved nitrogen and phosphorus are high in the lake water and provide nutrition for extensive algal blooms which occur throughout the summer and fall.

* Algal production would be limited by nitrogen.

* Anaerobic conditions in the water column occur infrequently during ice-free times.

* Lake has high potential for severe oxygen depletion under ice. Depletion will cause extensive mortality of fish and other aquatic organisms.

* Consolidation of sediments is much greater than reported in previous studies.

* Release of sediment nutrients by wind-caused wave action is not considered an important factor.

* A general flux (movement) of phosphorus appears to be going INTO the sediment from the overlying water column.

* Sediment appears to be releasing ammonia and nitrate-nitrogen.

* Levels of nutrients remain constant throughout a 50 cm sediment profile.

* Dredging is NOT recommended at this time to improve water quality, although it would improve recreational potential and fisheries.

G) Septic Leachate Study (1985-1986)

* Subsurface discharge of septic effluent does not seem to be a significant problem, but does contribute a small amount of loading to the lake.

* Three sites are primary contributors of high phosphorus and fecal coliforms through surface discharges. They are:

  1) north inlet (feed-lot runoff area)

  2) northwest inlet

  3) west inlet (main channel)

H) Wall Lake Dredging Feasibility Study - COE (1979-1980)

* Selective dredging of 2 to 4 feet of sediment would remove approximately 949,000 cubic yards of material.

* Approximately 56.8 tons of phosphorus and 11.3 tons of nitrogen would be removed by selective dredging.

* The dredged material disposal area would require approximately 124 acres.

* COE claims dredging would yield:

  1) decreased potential for winterkills (more diss. oxygen)

  2) decreased nutrient availability

  3) decreased algal bloom severity

  4) decreased turbidity

  5) improved fishery management potential

  6) improved aesthetics

  7) potential agricultural benefits

* Dredging at 4 foot depth would increase lake volume by approximately 688 acre-feet.

* Total project cost would equal approximately $792,000.

I) Copper Intake Study (1981)

* Dr. Emmerick (SDSU, Chem. Dept.) conducted growth and copper intake studies on corn and soybeans grown on Wall Lake Sediment.

* Copper intake was only slightly higher than controls and no problems should exist in converting dredged material to cropland.

J) Wall Lake Septic Tank Survey (1978)

* Data was gathered from 52 of the approximately 70 lakeshore landowners.

* Of the 52 septic tanks reported, 27 (52%) are located less than 100 feet from the lake shore.

* Year-round use of septic systems was reported by 32 (62%) of the 52 lakeshore landowners surveyed, while 20 landowners (38%) reported seasonal or part-time use.

* Nearly half the septic systems (48%) are used for wash disposal, while 87% accept kitchen wastes.

# WALL LAKE

## LAND USE SURVEY

## GENERAL DATA

Total watershed area: 3680 acres

| | | |
|---|---|---|
| Cropland | 2024 acres | 55% |
| Pasture | 1067 acres | 29% |
| Other | 589 acres | 16% |

| LAND USE | PERCENTAGE |
|---|---|
| Row crops | 38% |
| Small grains | 6% |
| Grass-pasture | 29% |
| Alfalfa | 7% |
| Fallow | 4% |
| Slough | 3% |
| Farmstead-residential | 7% |
| Water | 6% |

20% of the cropland or 404 acres are in need of treatment for erosion control

TABLE 1

Table 2

Wall Lake Beneficial Uses, As

Appears in the South Dakota

Water Quality Standards

1. Warm water semipermanent fish life propagation
2. Immersion recreation
3. Limited contact recreation
4. Wildlife propagation and stock watering

| Parameter | Concentration* |
|---|---|
| Nitrate as N | <50 |
| Total Cyanide | <0.02 |
| Free Cyanide | <0.005 |
| Hydrogen Sulfide | <0.002 |
| Suspended Solids | <90 |
| Temperature (°F) | <90 |
| Fecal Coliform | 200/100ml |
| Total Alkalinity | <750 |
| Conductivity | <2500 micromhos/cm@25° |
| Dissolved Oxygen | >5.0 |
| Total Dissolved Solids | <2500 |
| Total Chlorine Residual | <0.02 |
| Unionized Ammonia | <0.04 |
| pH | 6.0<—>8.3 SU |

*All values in mg/l unless otherwise stated

# CURRENT EVALUATION

## Water Quality Status

Sampling of tributary and inlake water, conducted in 1979-1980, represent the most extensive Wall Lake water quality survey effort to date. Two inlake sites and three tributaries (inlets) were selected for study A total of 30 inlake samples and 75 tributary samples were collected and analyzed. Selected values are presented in Table 3.

Average dissolved oxygen levels of both inlake and inlet waters were above water quality standards (5.0 mg/l), but individual readings in the tributaries were frequently low, especially in the west and northeast inlets. Dissolved oxygen levels generally tend to increase during spring runoff and decrease over the summer.

The average field pH levels of inlake waters exceeded the established water quality standard of 8.3, while inlet pH levels were generally acceptable. A consistently high inlake pH level suggests additional monitoring of inlake sediment, direct runoff, and septic systems to determine the source of the elevated pH levels.

Ammonia levels were elevated in both inlake and inlet sites, with average inlet levels approximately twice as high as inlake levels. The west and northeast tributaries had the highest average levels of ammonia.

Average Kjeldahl nitrogen (TKN) levels were similar between inlet and inlake sites. The highest average levels were found in the northeast tributary.

**Orthophosphate, total phosphate, and total organic nitrogen levels were excessive at all sites. The average values for phosphate and organic nitrogen exceeded the Vollenweider eutrophic category of 0.10 and 1.20 mg/l, respectively, and thus the lake and the tributaries were considered hypereutrophic for those parameters.** Average inorganic nitrogen levels were below the hypereutrophic level concentrations of 1.50 mg/l at all sites except in the northeast inlet. However, some individual reading of inorganic nitrogen were high at all sites.

Average levels of total solids, total dissolved solids, and total suspended solids were high to excessive at all sites. Values for each were lower at inlake sites than at inlet sites indicating that the tributaries were contributing to the sediment and mineral load of the lake. Of particular importance, were the very high levels of solids detected in the northeast inlet. Sources of the loadings should be identified and corrective measures should be taken to reduce lake input.

Several parameters measured were found to be in normal ranges or in compliance with standards at both inlet and inlake sites. They were: Biological Oxygen Demand (B.O.D.), alkalinity, and nitrate concentration. Nitrite concentrations were generally low at inlake sites, and ranged from low to high in the tributaries.

In summary, phosphorus (phosphate) and nitrogen levels of the tributary and inlake waters were excessive. The 1985 Wall Lake Water Quality Study Area Report states that phosphorus and nitrogen loads in 1979 were well above the dangerous level, that snowmelt and stormwater runoff are the principle sources of phosphorus and nitrogen to the lake, and that a majority of nutrients (88% phosphorus, 85% nitrogen) came from the watershed feeding the west inlet.

Septic System Status

Two studies related to septic systems at Wall Lake have been conducted. A Wall Lake Septic Tank Survey in 1978 and a Wall Lake Septic Leachate Survey in 1985-1986.

The Wall Lake Septic Tank Survey was conducted from 10 October to 12 November, 1978 via questionnaires to lakeshore landowners. The results of that inquiry were as follows:

1. Of a total of 52 lakeshore landowners that responded, 32 (62%) indicated year round use and 20 (38%) seasonal (part time use).

2. No indication was made of any septic tank overflow surfacing or directly flowing in the lake.

3. 27 (52%) septic systems are located less than 100 feet from the lake shore.

4. 25 (48%) septic systems are located less than 150 feet from drinking water wells or less than 100 feet from a cistern or well 100 feet deep used for drinking water.

5. 25 (48%) septic systems are used for washing machine water disposal and 45 (87%) for kitchen sink water disposal.

6. 1 (2%) survey participant indicated he used a direct lake water hookup for his toilet.

7. Only 1 (2%) survey participant indicated that a fecal coliform bacteria sample taken on his drinking water had been found safe and 7 (13%) indicated that no sample had ever been taken.

8. Many survey participants indicated that they would be hooking up to the local rural water system when it becomes available.

The Wall Lake Septic Leachate Study was conducted by Swanson Environmental, Inc. (SEI) for the Minnehaha County Commission (MCC) and the East Dakota Water Development District (EDWDD). The initial study (November, 1985) was rejected by MCC and EDWDD as incomplete because high winds and rough water influenced sampling and sample results. The lake was resurveyed in May, 1986, during acceptable weather conditions. Results indicated that subsurface discharge of septic effluent did not seem to be a significant problem, but that it did contribute a small amount of loading to the lake. Three sites were of primary concern as major contributors of high phosphorus and fecal coliforms through surface discharges. They were the north inlet, the northwest inlet and the west inlet (main channel).

The study concluded that the above three sites were contributing total phosphorus in excess of background levels and that fecal coliform (origin not determined) concentrations were a potential health hazard. The study recommended that efforts be made to improve water quality at these sites.

Watershed Status

In an effort to determine the status of the Wall Lake watershed, two studies were conducted. The first was a preliminary survey of the 3680 acre watershed by staff members from DWNR and the Minnehaha County Conservation District (MCCD) document land use and mechanical treatment requirements. The results of this survey show that; of the 3680 acres, 55% is cropland, 38% of which is in row crops; 29% is pasture and 16% is other which normally consists of water, wetlands farmsteads or housing development. Of the total cropland, 20% or 404 acres was in need of treatment for erosion control (see Table 2).

The second study, Agricultural Non-Point (AGNPS) modeling, was conducted to provide basic runoff water quality information to classify nonpoint source pollution problems in the Wall Lake watershed. The model provides outputs on hydrology, with estimates of both volume and peak runoff, and outputs on sediment, with estimates of upland erosion, channel erosion, and sediment yield. Along with these the model provides estimates of the pollutants nitrogen (N), phosphorous (P), and chemical oxygen demand (COD), in units of concentration and mass, contained in the runoff and the sediments.

The AGNPS model study of the Wall Lake Watershed conducted in 1986-87 indicated the following: sediment loading to the lake has been reduced to approximately .4 tons per acre per year, which is well below the Soil Conservation Service minimum standard of 5 tons per acre per year (Table 4). However, the model did indicate that several 40 acre tracts exhibited excessive nutrient loading. Subsequent model runs using changes in manageable factors predicted that the concentration of nutrients can be significantly reduced by effective use of fertilizers, reduced tillage and efficient crop rotation. Costs associated with reduced fertilizer application and phosphate runoff as a function of degree of soil incorporation are shown in Figure 1. If the tillage practice for a wheat field is changed from fall plowing with no residue to no till with 30% residue, the phosphorus and nitrogen yield associated with sediment runoff would be reduced by 50%. Proper fertilizer application is also a major factor in reducing excessive nutrient runoff. Frequently, excessive fertilizer is applied and not incorporated into the soil. Cutting fertilizer application in half will reduce the cost to the farmer by $20/acre and insuring complete incorporation into the soil should reduce the nutrient concentrations in the runoff to below the excessive loading limits.

In summary, the majority of the evidence presented to date suggests that, although there has been a significant reduction in sediment loading to the point where it is no longer a serious problem, the Wall Lake watershed continues to produce excessive loads of nutrients to the lake. This continuous source of nutrient inflow must be addressed if there is to be any change in the quality of the lake. Of the three tributaries leading to the lake, the west branch, which drains 80% of the watershed, appears to be the most significant problem area. However, the north tributary, which drains the area adjacent to the only major feedlot in the watershed, should be monitored periodically to insure compliance with the existing permit.

Of secondary concern is the possibility that undetected septic system violations may be occurring. There is some minor evidence, mainly from fecal coliform sampling, that problems may exist, but this has not been documented. It is suggested that septic tank system operation and maintenance be reviewed by the local sanitary district to insure compliance with existing regulations.

Finally, although there are conflicting statements in the reports, the conclusion that the sediment is not a major source of readily-available nutrients to the water column appears to be the most valid. The sediment may be acting as a nutrient sink, especially for phosphorus, but the process may be directly related to the high concentration of dissolved phosphorus in the water column. Most of the sediment appears to be two to four feet thick and is consolidating. The accumulated sediments, however, may have to be considered in the overall management plan.

Potential pollution sources which were reviewed and determined not to be problems and therefore eliminated from further consideration include; direct precipitation, groundwater connection and shoreline development.

Table 3. Wall Lake selected water quality parameters

WALL LAKE WATER QUALITY STATUS
(based upon 1979-1980 data)

INLAKE STATUS

| SITE | # SAMPLES | DISSOLVED OXYGEN | FIELD pH | AMMONIA | TKN | ORTHO-PHOSPHATE | TOTAL PHOSPHATE | TOTAL ORGANIC NITROGEN | TOTAL INORGANIC NITROGEN | TOTAL SOLIDS | TOTAL DISSOLVED SOLIDS | TOTAL SUSPENDED SOLIDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5-INLAKE | 16 | 9.48 | 8.51 | 0.123 | 2.03 | 0.522 | 0.627 | 1.88 | 0.38 | 1139.6 | 1123.3 | 16.3 |
| 6-INLAKE | 14 | 9.03 | 8.50 | 0.178 | 2.04 | 0.566 | 0.622 | 1.92 | 0.33 | 1164.3 | 1153.4 | 10.9 |
| INLAKE AVERAGE | | 9.25 | 8.50 | 0.151 | 2.03 | 0.544 | 0.625 | 1.90 | 0.36 | 1152.0 | 1138.4 | 13.6 |

INLET STATUS

| SITE | # SAMPLES | DISSOLVED OXYGEN | FIELD pH | AMMONIA | TKN | ORTHO-PHOSPHATE | TOTAL PHOSPHATE | TOTAL ORGANIC NITROGEN | TOTAL INORGANIC NITROGEN | TOTAL SOLIDS | TOTAL DISSOLVED SOLIDS | TOTAL SUSPENDED SOLIDS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-W INLET | 25 | 7.97 | 7.53 | 0.385 | 2.18 | 0.650 | 0.763 | 1.89 | 1.02 | 1196.4 | 1184.9 | 11.5 |
| 3-NW INLET | 29 | 10.29 | 7.74 | 0.148 | 1.48 | 0.286 | 0.383 | 1.38 | 0.73 | 793.5 | 776.3 | 17.2 |
| 4-NE INLET | 21 | 7.17 | 7.50 | 0.389 | 2.60 | 0.815 | 0.913 | 2.26 | 1.51 | 1956.3 | 1928.9 | 27.4 |
| INLET AVERAGE | | 8.48 | 7.59 | 0.307 | 2.08 | 0.584 | 0.686 | 1.84 | 1.09 | 1315.4 | 1296.7 | 18.7 |

Table 4. Agricultural Non-Point Source Pollution Model for Wall Lake

```
****************************************************************************
* AGNPS Version 2.3PC    Input file: a:wall.dat                            *
* AGRICULTURAL NON-POINT SOURCE POLLUTION MODEL                            *
* Watershed studied:                          warne                        *
****************************************************************************
```

The area of the watershed is: 3680 acres
The area of each cell is: 40.0 acres
The characteristic storm precipitation is: 4.7 inches
The storm energy-intensity value is: 65
The cell parameters are derived for:

```
==================================================
== VALUES AT THE WATERSHED OUTLET, CELL NUMBER  82 ==
==================================================
```

RUNOFF:

Runoff volume (in.): 2.30
Peak runoff rate (cfs): 1506

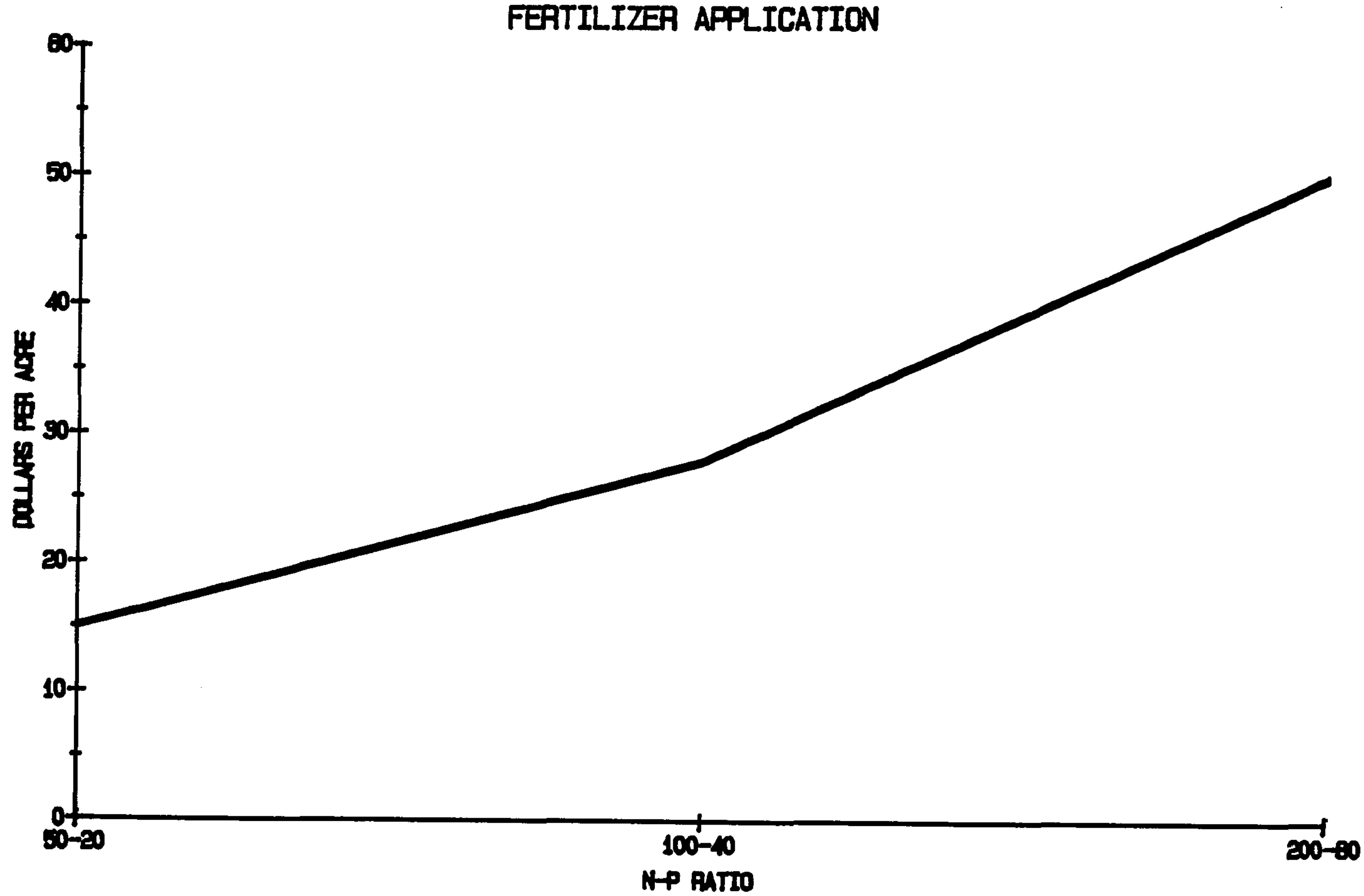
NUTRIENTS:

| | |
|---|---|
| Total nitrogen in sediment (lbs/acre): | 1.81 |
| Total soluble nitrogen in runoff (lbs/acre): | 1.01 |
| Soluble nitrogen concentration in runoff (ppm): | 1.9 |
| Total phosphorus in sediment (lbs/acre): | .91 |
| Total soluble phosphorus in runoff (lbs/acre): | .16 |
| Soluble phosphorus concentration in runoff (ppm): | .3 |
| Total soluble chemical oxygen demand (lbs/acre): | 54.91 |
| Soluble chemical oxygen demand concentration in runoff (ppm): | 105 |

SEDIMENT ANALYSIS:

| Particle Type | Area Weighted Erosion Upland (t/a) | Area Weighted Erosion Channel (t/a) | Delivery Ratio (%) | Enrichment Ratio | Mean Concentration (ppm) | Area Weighted Yield (t/a) | Yield (tons) |
|---|---|---|---|---|---|---|---|
| CLAY | .01 | .05 | 98 | 3 | 219. | .1 | 196.3 |
| SILT | .01 | .05 | 84 | 1 | 189. | .0 | 169.4 |
| SAGG | .07 | .05 | 47 | 0 | 217. | .1 | 194.5 |
| LAGG | .04 | .48 | 37 | 1 | 746. | .2 | 668.3 |
| SAND | .01 | .15 | 38 | 2 | 234. | .1 | 209.5 |
| TOTL | .14 | .78 | 46 | 1 | 1606. | .4 | 1438.1 |

Figure 1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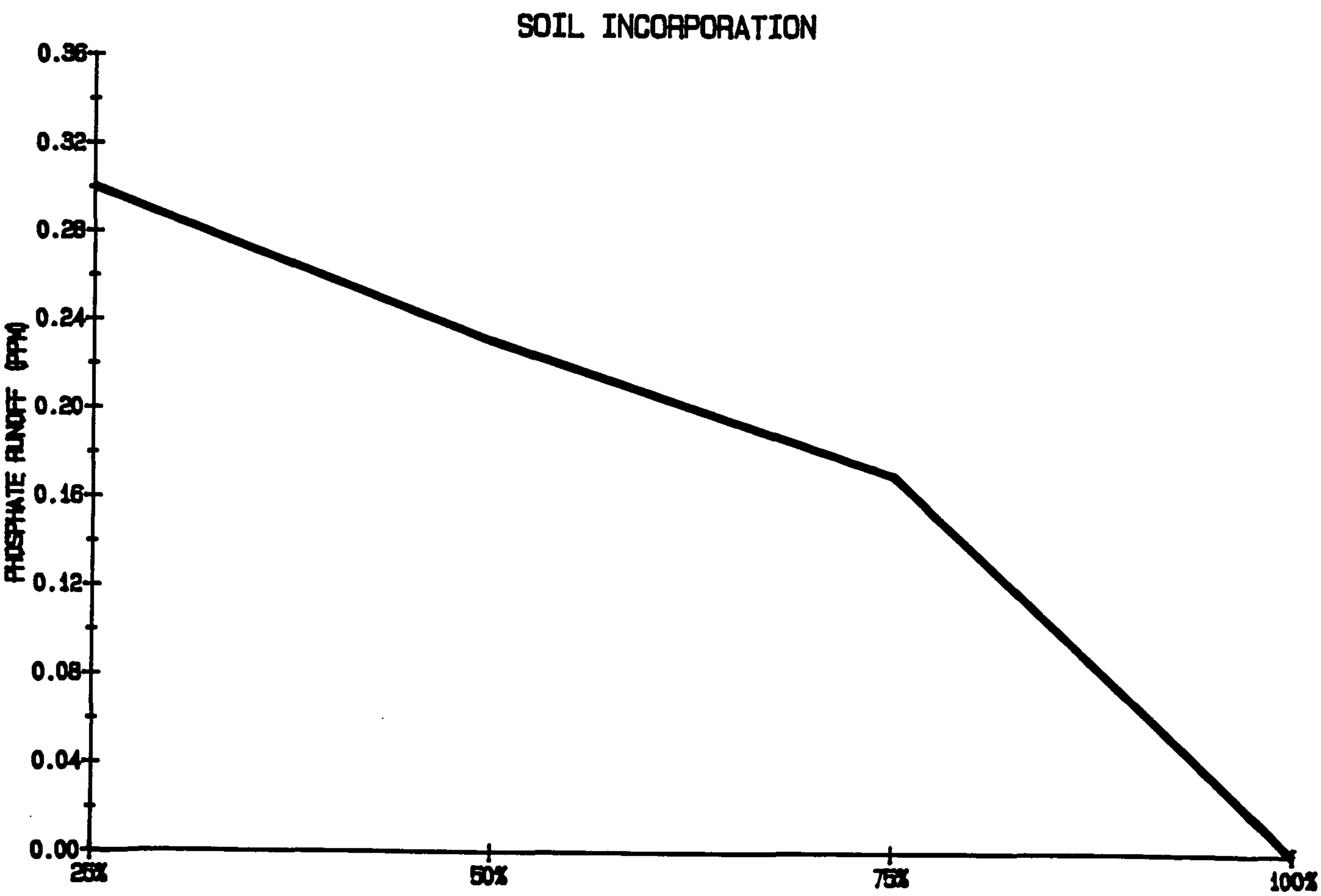
20
30
40
50
60
50-20
100-40
200-80
N-P RATIO


SOIL INCORPORATION
PHOSPHATE RUNOFF (PPM)
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0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
25%
50%
75%
100%

# WALL LAKE MONITORING PROGRAM

## Tributary and Inlake Sampling

Several modifications in sampling site location are proposed for the 1988 Wall Lake Implementation Monitoring program. To assess the sediment and nutrient loading and degree of retention in the north pond and the west inlet, two sampling stations are proposed for each area. The northwest tributary and the outlet will be stationed as before, but only one centrally located inlake site will be sampled. The proposed sampling site locations are shown in Figure 2.

Sampling at the tributaries (sites 2,3,4,5,6) should begin with the onset of snowmelt runoff and inlake sampling (site 7) should commence following ice pack melt. Outlet sampling (site 1) should begin with the onset of discharge flows. If spring sampling is not possible in 1988, sampling should begin as soon as personnel and equipment are available. The monitoring program should then extend beyond the 1989 spring season to gather the necessary runoff data.

Inlake samples are collected twice a month from both the surface and bottom from April through September and once a month from both levels from October through March. A total of 36 inlake samples are collected for the year.

Normally, snowmelt runoff occurs from mid-March to mid-May, but according to snow depth and local climatic conditions, runoff may vary. Several options exist in the duration and frequency of tributary and outlet sampling. The Wall Lake region receives approximately two 24-hour rainstorm events per year. If two automatic samplers are installed at Wall Lake (sites 3 and 6) and samples are taken every two hours during the storm event, a total of 48 storm samples will be collected.

In addition to the water quality analysis, an assessment of the tributary sediment between sites 2 and 3 and between sites 5 and 6 is suggested. This procedure will identify the occurrence and concentration of nutrients of the sediment and will aid watershed management efforts. The project sponsor, with assistance from DWNR and EDWDD, should collect sediment samples. If the sediments contain excessive nutrients, plans can then be developed to remove the sediment thereby eliminating potential nutrient flushing during runoff events. Cost for sediment analysis is $1,500.

Options and costs for sampling Wall Lake are as follows:

**OPTION A** - Tributaries and outlet sampled **twice** weekly

| STUDY LENGTH | TRIB SAMPLES | INLAKE SAMPLES | STORM SAMPLES | TOTAL SAMPLES | SAMPLE COST $ 52/SAMPLE | SED. COSTS | TOTAL COSTS |
|---|---|---|---|---|---|---|---|
| 6 WEEKS | 72 | 36 | 48 | 156 | $8,112 | $1,500 | $9,612 |
| **8 WEEKS** | **96** | **36** | **48** | **180** | **$9,360** | **$1,500** | **$10,860** |
| 10 WEEKS | 120 | 36 | 48 | 204 | $10,608 | $1,500 | $12,108 |

**OPTION B** - Tributaries and outlet sampled **three times** a week

| STUDY LENGTH | TRIB SAMPLES | INLAKE SAMPLES | STORM SAMPLES | TOTAL SAMPLES | SAMPLE COST $ 52/SAMPLE | SED. COSTS | TOTAL COSTS |
|---|---|---|---|---|---|---|---|
| 6 WEEKS | 108 | 36 | 48 | 192 | $9,984 | $1,500 | $11,484 |
| **8 WEEKS** | **144** | **36** | **48** | **228** | **$11,856** | **$1,500** | **$13,356** |
| 10 WEEKS | 180 | 36 | 48 | 264 | $13,728 | $1,500 | $15,228 |

Watershed Monitoring

As previously mentioned, the agricultural non-point source (AGNPS) pollution model was applied to the Wall Lake watershed to assess the nutrient and sediment inflow. A grid of identical 40-acre cells was established to encompass the entire Wall Lake watershed. The model, applied to each cell, simulates nutrient and sediment runoff using current and projected land-use practices and physical characteristics of the land in question. Based upon the analysis of data obtained, eleven 40-acre cells were identified as problem areas. Those cells are contributing excessive amounts of nutrients, primarily nitrogen and phosphorus, and are those most in need of corrective management practices. Although cells which receive drainage from the problem cells may be, in themselves, a contributor of pollution, the intent of the model is to identify the origin of the problem. It is expected that as source pollution is eliminated or greatly reduced, water quality of the adjacent cells will improve. The problem cells are highlighted on Figure 3 and the location and owner(s) are listed in Table 5. Ownership was obtained from the Wall Lake plat map (enclosed).

The South Dakota Department of Water and Natural Resources suggests that the Wall Lake Association be the lead entity in watershed management. The Association should contact the Soil Conservation Service and the Minnehaha County Conservation District and prepare a watershed workplan. The Soil Conservation Service and/or the Minnehaha County Conservation District should contact all watershed landowners to describe and discuss the Wall Lake restoration efforts. Specific efforts should be made to develop cooperative agreements and plans to implement watershed management programs with the owners of the problem cells. The management program would consist of:

1. Soil testing in areas where fertilizer use is high to determine if a reduction in total application is economically feasible.

2. A public information program, in cooperation with the County Extension Service, to promote:

    A. proper timing of fertilizer application
    B. fertilizer incorporation as a regular management practice
    C. integration of reduced tillage operations
    D. crop rotation as a regular management practice.

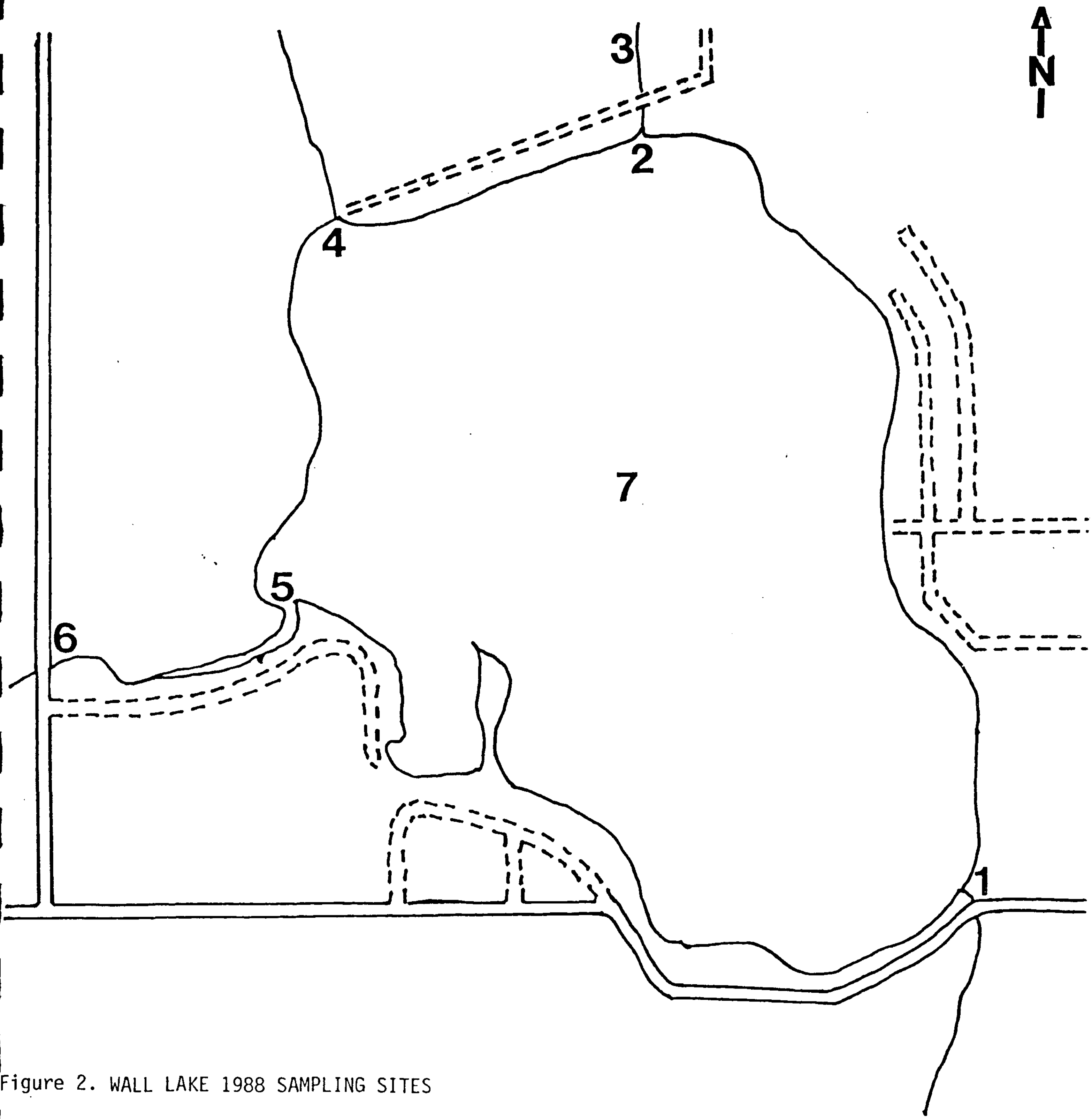



Figure 2. WALL LAKE 1988 SAMPLING SITES

| Site Number | Site Location |
|---|---|
| 1. | Outlet |
| 2. | North Tributary-mouth |
| 3. | North Tributary-between pond by road and feedlot |
| 4. | Northwest Tributary-mouth |
| 5. | West Tributary-mouth |
| 6. | West Tributary-at culvert on north-south road |
| 7. | Inlake-centrally located |

Figure 3. AGNPS Problem Cells of Wall Lake Watershed

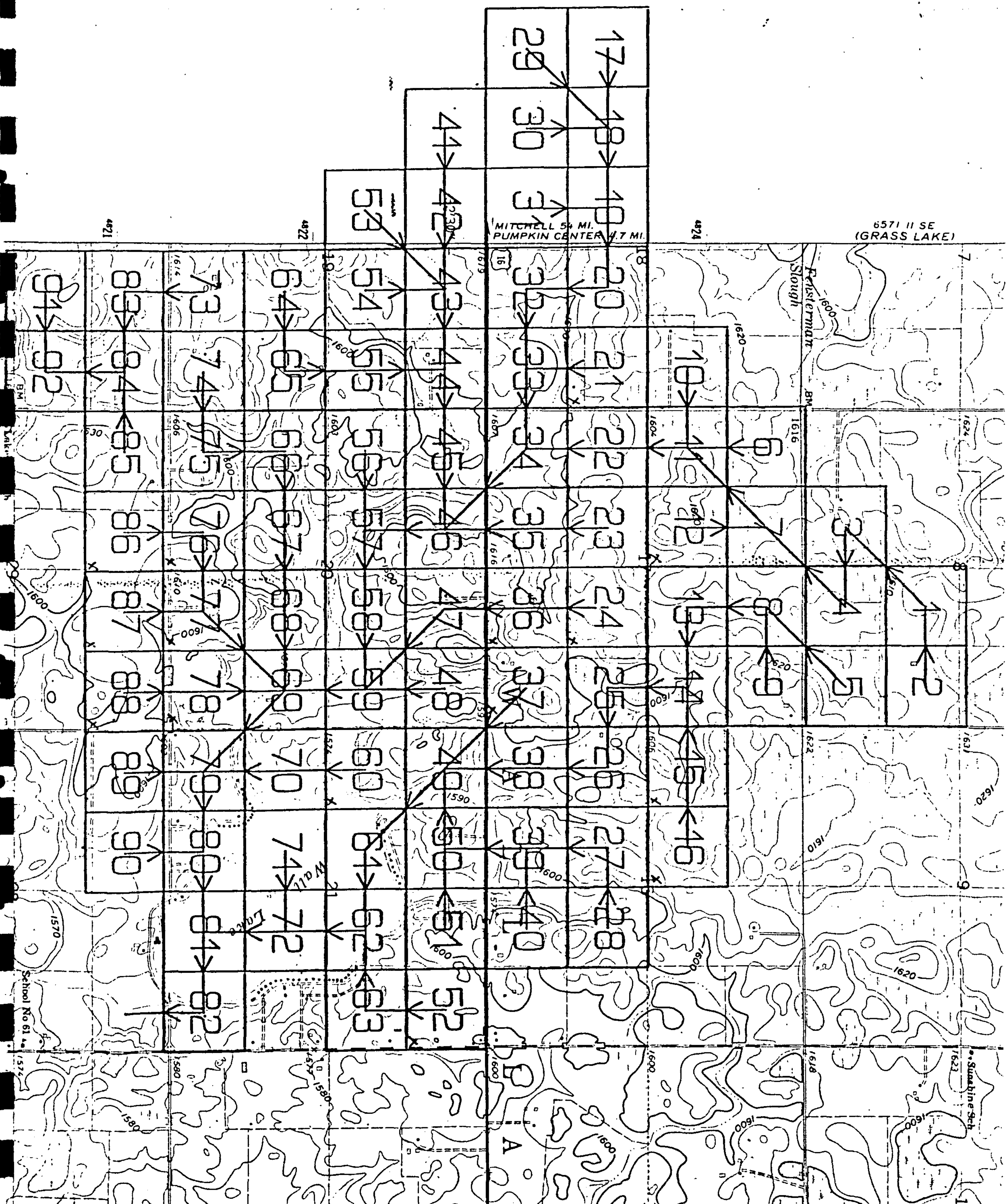


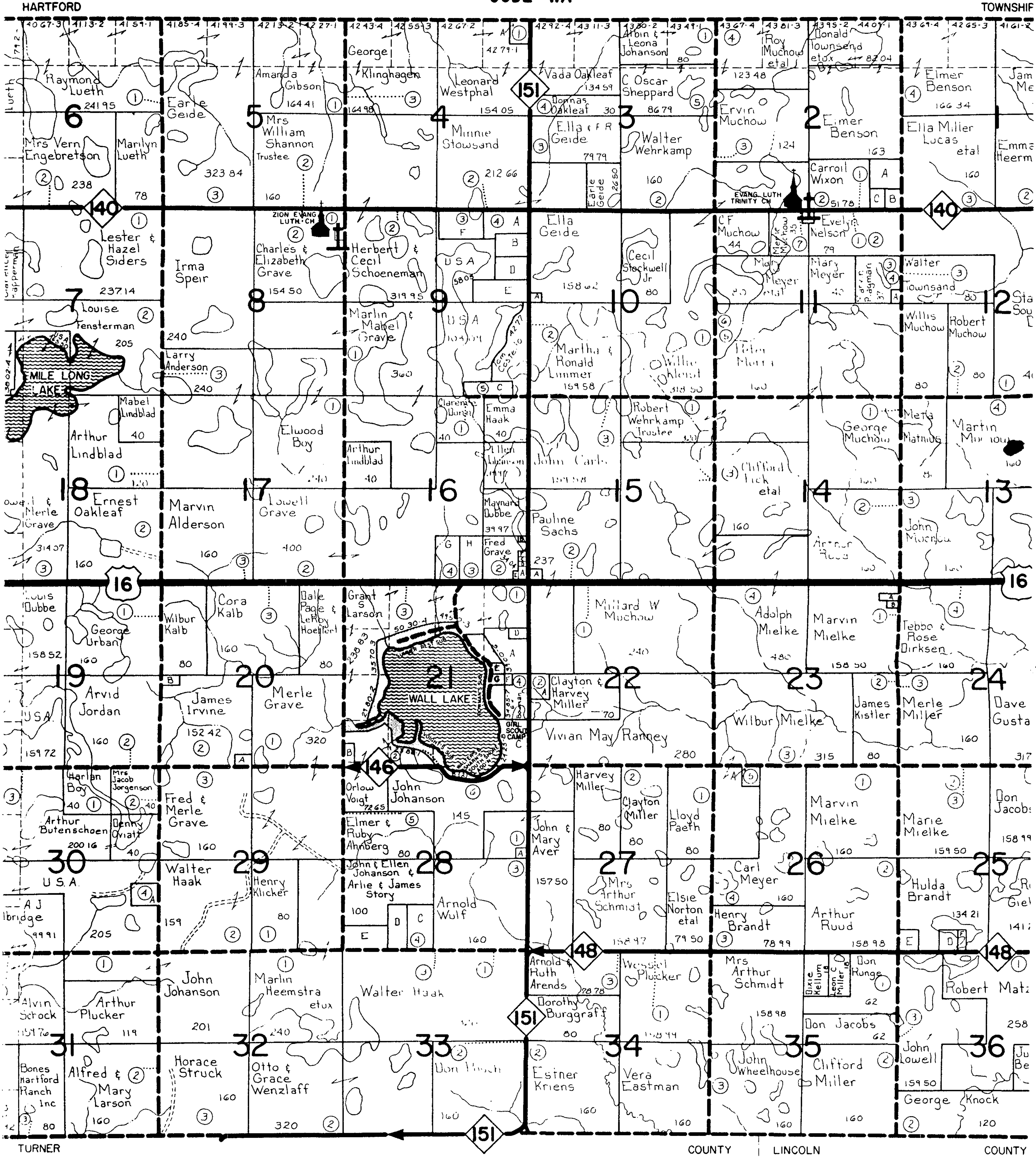
Table 5. Wall Lake Watershed Problem Cells, Location, and Owner(s)

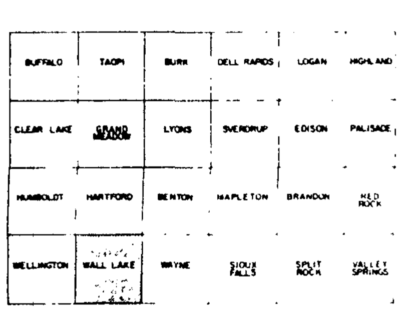
| Cell Number | Cell Geographic Location | Owner(s) |
|---|---|---|
| 12 | SE4,NW4,S17,T101N,R51W | Larry Anderson |
| 16 | SE4,NW4,S16,T101N,R51W | Marlin and Mabel Grave |
| 21 | NE4,SE4,S18,T101N,R51W | Ernest Oakleaf |
| 24 | NW4,SE4,S17,T101N,R51W | Lowell Grave |
| 36 | SW4,SE4,S17,T101N,R51W | Lowell Grave |
| 37 | SE4,SE4,S17,T101N,R51W | Lowell Grave |
| 52 | NE4,NE4,S21,T101N,R51W | Grant Larson |
| 60 | SW4,NW4,S21,T101N,R51W | Grant Larson |
| 86 | NE4,NW4,S29,T101N,R51W | Fred and Merle Grave |
| 87 | NW4,NE4,S29,T101N,R51W | Merle Grave |
| 88 | NE4,NE4,S29,T101N,R51W | Merle Grave |

# WALL LAKE

**TOWNSHIP : 101 N.** **RANGE : 51 W.**

**CODE : WA**



## RECOMMENDATIONS

Based on the available information that has been presented in this report, a variety of alternatives were considered for the restoration of Wall Lake. Among the many practices considered were watershed treatment, dredging, retention ponds and septic system renovation. Although none of the practices were specifically excluded from consideration, one emerged as the most prominent to begin the restoration process. The DWNR recommends that fertilizer application, reduced tillage and crop rotation management on selected areas of the watershed serve as a first step in the restoration of Wall Lake (Figure 4).

Several factors led to the recommendation that these management practices should be given first consideration:

The AGNPS model indicated that although sediment was not a problem, nutrient inflow continued at an excessive rate.

Septic system surveys did not indicate serious or continuing problems although there are indications that they may be a contributing factor.

Nutrient release from the sediments was not a major factor when compared to nutrient inflow.

In order to assess the effectiveness of this first step and to determine if other restoration methodologies are required to attain acceptable water quality in Wall Lake, the following scenario is suggested:

The project sponsor, with assistance from DWNR and the East Dakota Water Development District, develop and implement, as soon as possible, a rigorous water quality monitoring program for the lake and tributaries. This is recommended, first, to collect updated baseline data in light of the changes made in the last 5 years relative to land use and feedlot management. Second, to determine the effectiveness of implementation activities and/or if other restoration methods are required, and, last, to detect any violation of water quality standards. The monitoring program should be in place at least one year prior to the implementation of any restoration measures, although this may vary. The recommended length for regular tributary/outlet monitoring is eight weeks, usually from mid-March to mid-May. We also recommend a regular tributary/outlet sampling frequency of two times a week. Costs for the water quality monitoring program are estimated at \$10,860. These figures include costs for analysis of tributary sediment but they do not include costs for donated time and labor for management implementation.

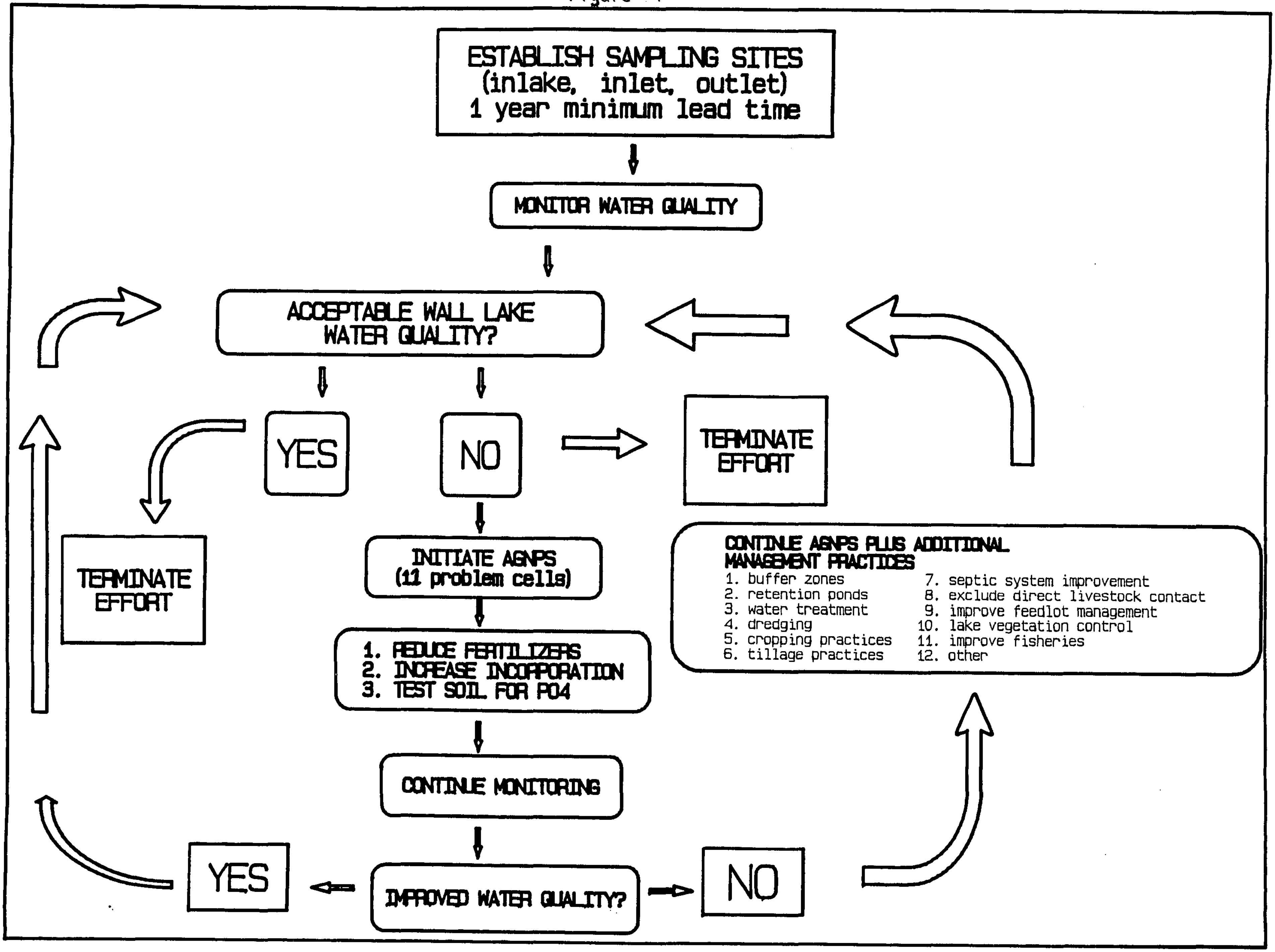
In conjunction with the establishment of a water quality monitoring program, the project sponsor should make appropriate contacts to develop cooperative agreements and plans to implement the watershed management programs. As noted in the AGNPS survey, incorporation alone should reduce phosphorus loading from cropland runoff to below dangerous levels. Average annual cost for soil testing is approximately \$30.00 per unit. Total for the Wall Lake watershed would range from $300 to $500 per year. Total fertilizer costs to the farmer would potentially decrease. However, fuel costs may rise because of necessary incorporation. Neither of these costs will be available until management plans are developed.

In addition to the implementation of monitoring and fertilizer management programs, the project sponsors are urged to revive the existing Wall Lake Sanitary District and conduct a review of individual sewage systems, both in terms of operation and maintenance, to determine if each is in compliance with existing regulations. Should violations be detected, documentation should be prepared and steps taken to correct the problem. DWNR will provide technical assistance on a case by case basis.

At least six groups or agencies have been identified as contributors to the Wall Lake restoration project. Cooperative efforts will be required for a timely and successful completion of the work. The restoration study is multifacted and will require coordination among all parties involved. For each specific restoration activity, the responsible party, and support group(s) have been suggested and are listed in Table 6.

The effect of the proceeding recommendations is to decrease nutrient loading to Wall Lake and subsequently increase water quality at the least possible cost. As noted previously, fertilizer management alone has the potential to reduce nutrient loading to below excessive levels. However, in the event that the management plans are not acceptable or other sources become prominent with the reduction in inflow concentrations, the following section provides additional alternatives that may be considered for restoration.

Figure 4



ESTABLISH SAMPLING SITES
(inlake, inlet, outlet)
1 year minimum lead time
MONITOR WATER QUALITY
ACCEPTABLE WALL LAKE WATER QUALITY?
YES
NO
TERMINATE EFFORT
TERMINATE EFFORT
INITIATE AGNPS
(11 problem cells)
1. REDUCE FERTILIZERS
2. INCREASE INCORPORATION
3. TEST SOIL FOR PO4
CONTINUE MONITORING
IMPROVED WATER QUALITY?
YES
NO
CONTINUE AGNPS PLUS ADDITIONAL MANAGEMENT PRACTICES
1. buffer zones
2. retention ponds
3. water treatment
4. dredging
5. cropping practices
6. tillage practices
7. septic system improvement
8. exclude direct livestock contact
9. improve feedlot management
10. lake vegetation control
11. improve fisheries
12. other

Table 6. Suggested Responsibilities for Wall Lake Restoration

| Restoration Activity | Responsible Group/Agency* | Cooperative Assistance* |
|---|---|---|
| Diagnostic/Feasibility Study Plan | DWNR | WLA |
| Implementation Monitoring Program: Tributary Monitoring, Inlake Monitoring, Sample Analyses | WLA | DWNR |
| Watershed Management | WLA | DWNR, SCS, MCCD, MCC |
| Septic System Evaluation | WLSD | DWNR, WLA |
| Data Evaluation and Report | DWNR | none |
| Prepare Implementation Plan | WLA | DWNR |
| Funding Application | WLA | DWNR |
| Implementation Monitoring | DWNR, WLA | MCC, MCCD, SCS |
| Completed Project Report | DWNR | WLA, MCC, MCCD, SCS WLSD |

*The Players:

DWNR -South Dakota Department of Water and Natural Resources
MCC -Minnehaha County Commission
MCCD -Minnehaha County Conservation District
SCS -United States Department of Agriculture Soil Conservation Service
WLA -Wall Lake Association
WLSD -Wall Lake Sanitary District

# ALTERNATIVE RESTORATION TECHNIQUES

## A) Additional Watershed Management

Although watershed management practices reportedly have been improving, additional efforts should be directed to include 100% of the watershed. Techniques to consider include: 1) increasing buffer-zone width along tributaries by planting native vegetation (grasses and shrubs), 2) restricting live-stock use of the tributaries and eliminating lake-shore use by live-stock, 3) encouraging area farmers to use less fertilizers, pesticides, and herbicides, and to incorporate chemicals used, 4) encourage conservation tillage practices to include contour farming on slopes and erosion-prone soils, 5) identify and eliminate dump sites that may be contributing nutrients or harmful chemicals to the watershed, 6) assess cropland location and types of crops planted to determine if erosion-prone areas could best be planted in a different type of crop that would retard erosion, 7) encourage wise pasture management by minimizing livestock overcrowding and subsequent degradation of pasture vegetation, 8) encourage a pasture rotation system to ensure against overgrazing, 9) encourage landbanking practices to remove from production those lands with erodible soils, or at least to rotate on a regular basis from production to idle land and, 10) assess the lakeshore drainage and recommend corrective actions to the owners (i.e. minimize tree-clearing, use of lawn fertilizers, application of copper sulfate, indiscriminate dumping of waste into the lake, or any other lake treatment done on an individual basis). Cost for these practices are applied on a case by case basis.

## B) Inlet Water Treatment

Assuming that farming and ranching will continue in the area and that runoff of nutrients from farmland may not be sufficiently reduced by recommended management practices, inlet water treatment will have the longest lasting and greatest benefits to the restoration of Wall Lake. The three inlets have been identified as the direct sources of nutrient input to Wall Lake. Consideration of the following restoration methods is suggested:

1) Construction of water-retention basins at two of the three inlets just upstream of where the inlets enter the lake and excavation to the settling area near the mouth of the north tributary. Retention ponds should be of sufficient size to accommodate at least 50% of the probable maximum flood. Estimated costs per structure based on dam construction costs at Lake Herman is $100,000 for the west inlet structure and currently unavailable for the structure on the NW inlet.

2) Construction of a small-scale water treatment facility at each of the above water retention basins (Figure 5). The basin would act as an effective sediment trap and the water treatment facility would serve to eliminate most of the incoming phosphorus. If the phosphorus elimination process, (Bernhardt, 1981) is adaptable to the Wall Lake situation, perhaps a similar percentage (95-99%) of phosphorus could be eliminated from

incoming waters. The removal system has additional benefits in that it removes 95-99% of the coliform bacteria, chlorophyll, and turbidity. Specifications and costs of the treatment facility are not known at present (literature has been requested), but the process apparently uses iron III to precipitate orthophosphate followed by a cationic polyelectrolyte to form a large floc. The water is then filtered through a layered system of activated carbon, hydroanthracite, and quartz sand. The resultant water is of drinking water quality.

Treatment of inlet waters would accomplish several goals: 1) allow ponding of runoff to permit particles of soil and organic material to settle, 2) minimize discharge of particulates and dissolved chemicals, especially phosphorus, to the lake, 3) allow dilution of high inlake chemical concentrations, especially phosphorus and nitrogen, 4) permit natural flushing to occur with clean water and, 5) serve as a reservoir of supplemental water to support lake levels in times of drought or inadequate rainfall/snowfall. It is also possible that the treated water could serve as a secondary source of potable water for the lake's residents and visitors.

Central to this discussion of inlet treatment would be the establishment of a scientifically sound sampling program to document pre-treatment conditions, to gather water quality samples during treatment, and to assess the effectiveness of introducing treated water into Wall Lake for several years during operation of the treatment facility.

DWNR realizes that this suggested treatment is rather unconventional, but if applicable and successful, it just might serve as a model program and a showcase of modern lake restoration methods.

An option to the water treatment facility might be direct treatment of the reservoir water, but such treatment might create more problems (contaminated sludge disposal) than it is intended to solve.

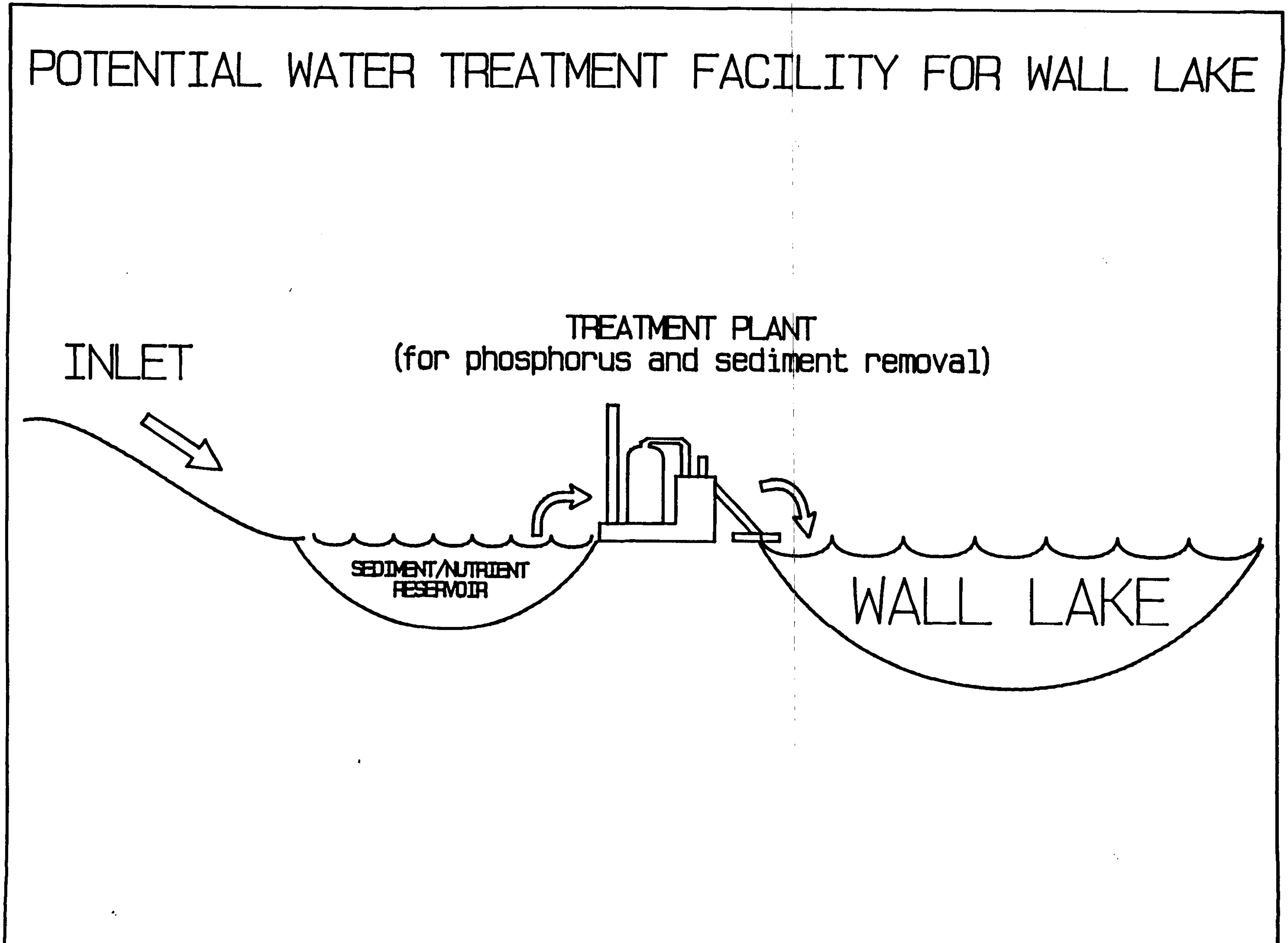
C) Lake Shore Septic System Failures

Periodic monitoring of lakeshore waters should be conducted to detect additional failures and to assess the degree of contamination due to faulty systems. A serious attempt should be made to enlist the support of the homeowners in monitoring and upgrading faulty systems. A positive public relations campaign should stress the benefits of having adequate sewage treatment systems and the result of sewage effluent entering the lake.

D) Existing In-lake Sediment Management

If the inlet water treatment plan is adopted, it would be inadvisable to conduct a dredging program at the same time since quantification of variables and elimination of outside factors is of prime importance during monitoring of the water treatment program. A stirring of the sediments during dredging and subsequent potential release of nutrients to the water column may mask results obtained during the water treatment program. One should recognize that it may take several years to dilute the inlake waters to acceptable levels of nutrients. It is also possible that as water nutrient levels become less than that in the sediment, the sediment may exhibit reverse flux and discharge accumulated nutrients into the water column. However, with continual flushing and abatement of other sources of nutrients, a gradual improvement should be seen in the water quality of Wall Lake. If it is determined, at a later date, that the sediment accumulation of nutrients is excessive and will not respond to dilution and flushing, a program of selective dredging may be appropriate. Estimated dredging costs, not including pond construction, are $500,000.

Figure 5


POTENTIAL WATER TREATMENT FACILITY FOR WALL LAKE
INLET
TREATMENT PLANT
(for phosphorus and sediment removal)
SEDIMENT/NUTRIENT
RESERVOIR
WALL LAKE

# SUMMARY

Wall Lake, like many of the lakes in eastern South Dakota, can be classified as hypereutrophic. However, the lake is somewhat unusual in that it is no longer plagued by excessive sedimentation. The inflow of nitrogen and phosphorus from the watershed appears to be sustaining the present degraded condition of the lake. Recognizing this fact has resulted in the recommendation to apply Best Management Practices to selected areas of the watershed and monitor the water quality to determine effectiveness of the program. If other factors begin to dominate with the reduction of nutrient concentrations in the runoff, other alternatives including dredging and retention basins are provided. Total estimated first year costs, not including time and labor for management implementation is $10,860. Primary participations in the implementation process are expected to be: the Wall Lake Association, Wall Lake Sanitary District, Minnehaha County Commission, Minnehaha County Conservation District, Department of Water and Natural Resources, Soil Conservation Service and Extension Service.