# STATE-OF-THE-ART-SUMMARY

# LAKE RESTORATION
# PROCEDURES AND THEIR EFFECTIVENESS

State-Of-The-Art Summary; Lake Restoration, Procedures and their Effectiveness — Dec. 12,1974

Research & Development Program, Chief
Southeast Region IV

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Thru: Dr. A. F. Bartsch, Director, N.E.R.C. Corvallis

## Summary

We are distributing 300 copies of the attached to the various Water Research Resource Institutes and State Pollution Control Agencies, plus other organizations in the eight States of our Southeast Region.

## Action

Many thanks for the excellent cooperation and consideration in this matter.

## Background

Memo of date September 6, 1974 requesting State-Of-The-Art summaries.

E. P. Lomasney, Chief,
Research & Development Program
Southeast Region IV

cc. Charles Frank

# RESEARCH RESULTS ANALYSES

# R & D PROGRAM

Environmental Protection Agency

Region IV

1421 PEACHTREE STREET, N.E. ATLANTA, GEORGIA 30309

The attached presentation represents the first of a series of State-Of-The-Art papers that will be issued by the Research & Development Program Office of the Southeast Region. The presentations will be geared to the current research needs of our region and will pertain to subject matter with the latest information and data constituting the experience of our Agency's R & D effort. We have selected these particular subjects because of inquiries received from many of the people closely associated with the pollution problems.

It is our intension to offer these presentation at intervals. They will all be concerned with subject matter relative to our program and the latest information on State-Of-The-Art for a number of areas that constitute the major problems in the control and abatement of pollution, for the protection of the environment. These presentations will be brief and simple in context.

Edmond P. Lomasney, Chief
Research & Development Program
Southeast Region IV

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## STATE OF THE ART SUMMARY

## LAKE RESTORATION

## PROCEDURES AND THEIR EFFECTIVENESS

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Lake Restoration: Procedures and Their Effectiveness

Many lakes throughout the world are undergoing accelerated aging (eutrophication). Lakes vary tremendously in their chemical, physical and biological characteristics depending upon their mode of origin, their location, the characteristics of their watershed and their uses.

Contaminants may impact lake environments in various ways, depending upon the nature of the substance. Nutrient rich plant growth stimulators such as domestic sewage and commercial fertilizers accelerate the aging process of a lake. Sedimentation may add to the eutrophication problems. Toxic substances may poison water supplies, interfere with normal biological activity or render commercial and sports fish and crustaceous fish unfit for consumption. Heated water released to the lakes may alter the natural thermal structure and upset the composition of the lake communities.

There are two approaches to rehabilitating degraded lakes; (1) restricting the input of undesirable materials and (2) providing in-lake treatment for the removal or inactivation of undesirable materials. Reducing or eliminating the sources of waste loading is the only restoration measure needed to achieve the desired level of improvement in certain lakes in which natural flushing results in substantial improvements in quality. However, in many lakes, particularly those with slow flushing rates, in-lake treatment schemes may also be required before significant improvements will be realized. Remedial measures which restrict the input of contaminants include advanced waste treatment, nutrient diversion and allocthonous sediment control.

Because of the key role of phosphorus in eutrophication, coupled with the present unfavorable prospect of controlling any other nutrient, elimination of phosphorus to lakes is the goal of most restoration

procedures. Advanced waste treatment (AWT) probably represents the best method currently available for curbing phosphorus input to waterways at moderate costs. Phosphorus removal efficiency of 80-90 percent can be achieved by chemical precipitation with alum, ferric salts or lime. Although to date there has not been documentation evaluating AWT as a means of restoring a lake, preliminary results both in this country and Europe have been encouraging.

In 1972, the Environmental Protection Agency initiated the National Eutrophication Survey. The purpose of the survey is to learn what the impact of municipal sewage treatment is on our nations lakes. During the spring of 1973, its efforts were concentrated in the Southeastern United States. Tributary and Municipal Sewage Treatment Plant (MSTP) sampling had begun or was initiated in all of the states to be sampled east of the Mississippi River. Table 1 lists the number of lakes, stream sites and MSTP's sampled in Region IV during the 1973 sampling year.

Table 1. Number of Lakes, Stream Sites, and Sewage Treatment Plants Sampled During the 1973 Sampling Year in Region IV

| State | Lakes | Stream Sites | Waste Effluents |
|---|---|---|---|
| Alabama | 11 | 118 | 35 |
| Georgia | 17 | 100 | 46 |
| Florida | 42 | 104 | 46 |
| Kentucky | 5 | 48 | 14 |
| Mississippi | 5 | 35 | 12 |
| South Carolina | 14 | 96 | 59 |
| North Carolina | 18 | 102 | 38 |
| Tennessee | 18 | 220 | 44 |

In order to establish the present trophic status of the lakes, each one was sampled at least three times during the sampling year. During each sampling visit, various water parameters were measured and when included with historical data, if available, were used to assess the trophic condition of the lake.

Sampling of municipal sewage treatment plants and selected tributaries allowed for an assessment of the percentage contribution of nutrient loading from each point source as well as non-point sources. MSTP's were selected with the cooperation of the State Water Pollution Control Agencies and sampled on a monthly basis by the plant superintendent. Monthly samples at the designated stream sites were collected through the volunteer efforts of the National Guard in each of the involved states.

After data collection and analysis, an individual lake report will be prepared that summarizes the data from all phases of the Survey as well as any available historical data. These reports will contain several sections:

A. The present trophic condition of the lake presented as a compilation and summarization of Survey data and augmented by historical data when available.

B. Limiting nutrient evaluation of the lake based on algal assay results and supported by field data.

C. Nutrient loading assessment based on an evaluation of the loading estimates (in mass per unit time) of phosphorus and nitrogen and the percentage contribution from point sources and non-point sources.

Based on an analysis of the data for the lakes* sampled in 1973 (of which 88 were in Region IV), some general statements can be made: (1) there are about 15 lakes that can be called oligotrophic, that is they have a very good trophic condition; (2) about 45 lakes can be called mesotrophic; (3) about 51 lakes are considered eutrophic and have occasional nuisance algae problems; and (4) there are about 104 of the 215 lakes ranked that fall into a class than can be expected to have more frequent nuisance conditions.

A final analysis of these data is incomplete, and a comprehensive evaluation of each lake cannot be made until the individual lake reports are written. However, preliminary analysis of these data indicates possibly 40-50 percent of the lakes surveyed in Region IV have symptoms of accelerated eutrophication.

The individual lake reports will present an analysis and evaluation of all phases of the Survey and should assist the states in setting their priorities of implementing lake restoration and should indicate which lakes or reservoirs are the most suitable candidates for restoration. The preparation of the report for the Region IV states have been started and is scheduled for completion during the first half of 1975.

Nutrient diversion offers a possible lake restoration technique in situations where the incoming nutrient load is entering from point sources. This technique has been used successfully in Lake Washington in Washington. During 1963-1968, the sewage was diverted step-wise and, after February 1968, received no more effluent. The condition of the lake changed rapidly and sensitively with the changes in the nutrient input.

Lake dredging not only removes sediment buildup, but also serves to remove a potential nutrient source. Little information is available on

*The Florida lakes were not included because they are generally considered to be unique due to the subtropical Florida climate.

the chemical and biological effects of dredging, but projects are now underway which will evaluate the total environmental effects. When all costs are included, contract unit prices for lake dredging ranges from $0.45 to $1.00 per cubic yard of material removed. The major factors influencing costs are: (1) the project size; (2) to type of material to be excavated; (3) distance to disposal sites; and (4) the availability of properly equipped dredging contractors. The relatively high costs of dredging make this technique prohibitively expensive on most large lakes, but dredging is a restorative technique that has been used for years on small lakes and ponds.

Nutrient inactivation is accomplished by adding some type of material to the water that will bond with, absorb or otherwise make the nutrients unavailable to aquatic plants. Alum, sodium aluminate, fly ash and various other materials have been investigated as nutrient inactivation agents. Although some pilot results with this technique have been encouraging, its applicability on a large-scale has not been determined.

Under certain conditions the water quality of lakes can be improved by diluting or replacing the existing lake water with water of a higher quality. This technique has been successful in restoring some lakes, but its application is limited to lakes with ready access to a large supply of high quality water.

Covering the bottom sediments with sheeting materials or particulate matter is being investigated as a means of preventing nutrient exchange and retarding rooted plant growth. Limited experience with this technique have encoutered problems with balooning of sheeting and rupturing seals of particulate matter when gas is produced within the sediments. Investigation of this technique in pilot lakes is continuing.

It is sometimes possible to replenish the oxygen supply of anaerobic waters of eutrophic lakes by disrupting the thermal stratification by aeration or by aerating the hypolimnion directly without disturbing the thermal regimen. Definite improvements in water quality and in the quality of the biota have occurred as a result of artificial destratification and hypolimnetic aeration. Although the response of a given lake to these treatment measures is unpredictable, destratification and hypolimnetic aeration are potential mechanisms for improving the water quality of certain lakes.

Lake drawdown has been investigated as a control measure for rooted vegetation, as a means of retarding nutrient release from the sediments and as a lake deepening mechanism through sediment consolidation. Much investigation is still needed for a clear understanding of the efficacy of using drawdown as a lake restoration procedure.

In many lakes in advanced stages of eutrophication attempts have been made to control nuisance organisms through mechanical, biological and chemical means. In general, it is felt that the mechanical harvesting of water weeds has only a short-term beneficial effect. Typical operating costs for mechanical harvesting range from $50 to $140 per hour (2.5 acres), but in some cases may be much higher. The efficiency of mechanical harvesting is inversely proportional to the weed density.

Biological control agents under investigation for use as control agents for algae and higher aquatic weeds include microorganisms such as viruses, bacteria and fungi. Many of the organisms being investigated show considerable promise. Other biological control agents under investigation, especially in the Southeast section of the country, include insects, fish and aquatic mammals.

Various chemicals have long been utilized to control or eliminate undesired algae and aquatic weeds. Chemical agents, however, offer only temporary relief and usually the treatment has to be continuously repeated to achieve the desired results. However, use of chemicals is often required; especially in cases where the waters must be kept navigable. Several algicides and herbicides have been registered by the U. S. Environmental Protection Agency for in-lake treatment of algae and macrophytes.