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Status of Current Technology on Constructed Wetlands

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Submitted to the DEC Task Force

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INTRODUCTION

The Demonstration Erosion Control Project in the Yazoo Basin (DEC) was charged by the United States Congress in 1984 to establish demonstration watersheds in a hill land region with extensive erosion. The project is to address critical erosion problems on land and in stream channels by development and testing of systematic soil conservation, channel stability, and flood control measures in demonstration watersheds. This demonstration project includes many innovative structural and non-structural conservation and stabilization efforts combined into a total watershed package where individual measures and combinations of measures can be evaluated for effectiveness. The purpose of this report is to briefly summarize available technology on constructed wetlands for the DEC Task Force so that the concept of wetlands may be evaluated as a possible management practice in DEC watersheds.

BACKGROUND

During the past two decades the beneficial role of aquatic plants for improving water quality has been thoroughly documented (Boyd, 1970; Sheffield, 1967; Yount, 1964). The production-trapping system of wetlands had been shown to remove nutrients, organic chemicals, heavy metals, and sediments from inflowing waters. Environmental engineers have recommended the re-establishment of wetlands where water quality has deteriorated since their removal (Kloetzli, 1981; Jones and Lee, 1980). Seidel (1976) and Wolverton and McDonald (1975, 1976, 1981) documented the efficiency of aquatic plants in removing organic chemicals from water. Simpson et al. (1983) and Peverly (1985) demonstrated the effective role that wetlands play in trapping heavy metals. Wieder and Lang (1984) described how wetlands help regulate stream chemistry and minimize acid mine drainage impact.

A major result of natural wetlands research has been the knowledge that physical, chemical, and biological uptake and degradation processes which occur in wetlands are similar to those occurring in mechanical sewage treatment plants. These processes also result in an efficient uptake of chemicals and metals. Thus, many recent nutrient uptake and cycling studies conducted on wetlands have been concerned with their potential use as natural sewage treatment systems (Simpson et al., 1983; Boyt et al, 1976; Dolan et al., 1981) or as water purifiers (Sloey et al., 1978; Nichols, 1983).

DEFINITION OF WETLANDS

Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to maintain saturated conditions (USEPA, 1988). Natural wetlands are often distinguished by hydric soils or vegetation. Constructed wetlands can result from the creation of a marsh in a natural setting where one did or did not exist before or from an intensive construction effort with introduced wetland vegetation (Reed et al., 1979). A constructed wetland, as a complex ecological system, may be defined as an engineered and constructed complex of saturated substrates; emergent, floating and/or submergent vegetation;

animal life; and open water that simulates natural wetlands for man's desired uses.

The relationship between hydrology and wetland ecosystems is imperative to an understanding of wetlands. Factors such as source of water, velocity, flow rate, water residence time, water level and water level fluctuations have critical bearing on the biological, chemical and physical properties of wetlands.

CURRENT USES OF CONSTRUCTED WETLANDS

The three major ways that constructed wetlands are currently used include:

1. Municipal wastewater treatment
2. Animal waste treatment
3. Mine drainage treatment

The potential exists for treating industrial wastes, agricultural wastes, and inorganic wastes but the majority of currently operating systems are in municipal wastewater treatment. Over 60 secondary or tertiary constructed wetland wastewater treatment facilities are presently being operated across the U. S. These include demonstration systems by NASA, TVA and USEPA. The Mississippi Soil Conservation Service is currently planning an animal waste wetland treatment demonstration at the Newton Experiment Station.

ADVANTAGES AND DISADVANTAGES

The adavantages of waste treatment by constructed wetlands include relatively low capital and operating costs (USEPA, 1988), pollutant removal effectiveness (Watson et al., 1987), operational and maintenance simplicity, ability to handle variations in hydraulic loading, and habitat creation for wildlife (Watson et al., 1988).

One major disadvantage of constructed wetlands is that they require a large land area per volume of water processed. Retention time for water being processed varies from 3 to 10 days. In addition, design features make construction costs escalate rapidly in areas of steep topography, permeable soils, or high groundwater tables which require installation of impermeable liners to prevent groundwater contamination. Large storm events which flush constructed wetlands drastically decrease short-term efficiency. Wetland treatment is designed as one of a series of operational steps. Most currently operating systems researched by this review had primary treatment ponds built into their design. Variations in nutrient trapping from microbe-vascular plant seasonal cycles coupled with the fact that wetlands processing requires a primary treatment or settling pond (hence, a two-step procedure) make wetland wastewater treatment less advantageous than small impoundments for trapping some pollutants. High concentrations of suspended sediments, such as those found in row crop runoff, effectively destroy the microbial processes that create wetland nutrient, metal, and pesticide trapping and municipal wastewater bio-degradation. This factor makes wetlands unacceptable as nutrient and pesticide traps unless suspended sediments are removed before influents enter constructed wetlands. Lack of available technology on some processing and operational aspects of wetland wastewater treatment must also be currently viewed as a disadvantage.

AVAILABLE TECHNOLOGY

Current technological knowledge is adequate for secondary municipal sewage treatment design criteria. USEPA (1988) recently published a design manual which discusses details of several sizes and designs of wetland municipal wastewater treatment facilities. TVA has also published information on its municipal and mine drainage demonstration projects (Brodie et al., 1987; Steiner et al., 1987;

TVA, 1986; Watson et al., 1988) as has NASA (Wolverton, 1986; Wolverton and McDonald, 1982). Within limits, this technology can be applied to agricultural animal waste management systems.

Designs of constructed wetlands have mainly followed two trends. The first, which is the currently accepted design for wastewater treatment, is a more flexible system that can be scaled up or down for different pollutants or efficiency of operation (Fig. 1). The second design has been shown to be effective for low discharges (Fig. 2) such as mine seepage problems. This design consists of several ponds in series with basins shaped so that they become marsh-wetland/ponds. The system requires little maintenance after initial construction is completed, but it is sensitive to increased pollutant loading and operates on the assumption of nearly constant flow. However, many design criteria are still experimental, and little or no information is available on long-term operational procedures for optimal cost/benefits. Limited information is available on most process variables that can occur in different construction designs, and details on important topics like pollutant overloading and recovery recommendations after overloading are virtually nonexistant.

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SUMMARY

1. Wetland technology has been sufficiently developed to allow constructed wetlands to be used in treatment of municipal wastewater and mine drainage effluent.

2. Constructed wetland technology is currently being demonstrated or planned for demonstration by several federal agencies.

3. Constructed wetland technology for municipal wastewater treatment can be applied to animal waste management systems.

4. Artifical wetland treatment functions most efficiently when coupled as a secondary or "polishing" phase of a step-wise cleaning process.

5. Constructed wetlands are management treatments which are specific, rather than general, in nature. Evidence indicates that they would be inefficient in detering many forms of offsite damages, especially sediments.

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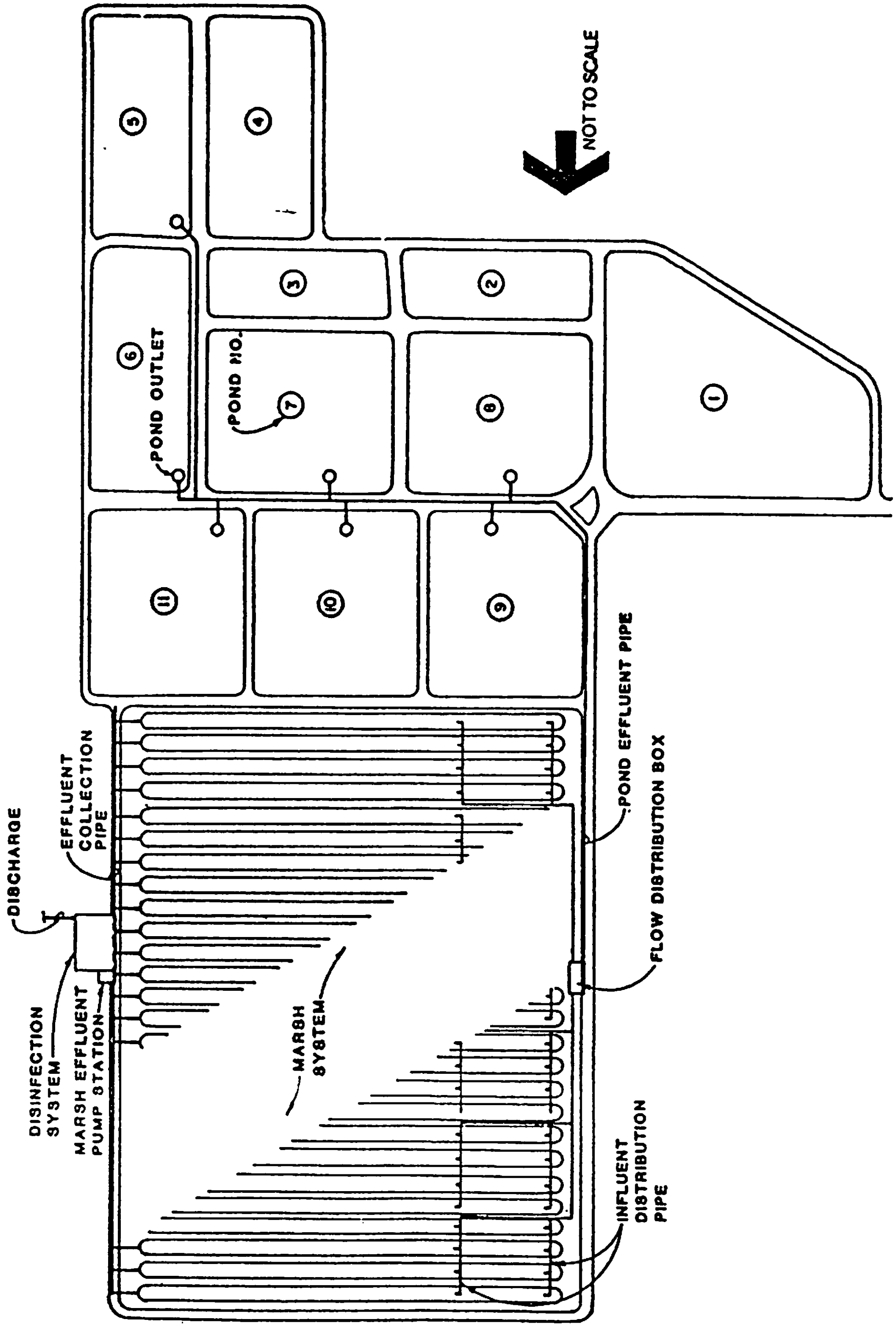

Fig. 1. Gustine, CA marsh system flow schematic (After EPA, 1988).

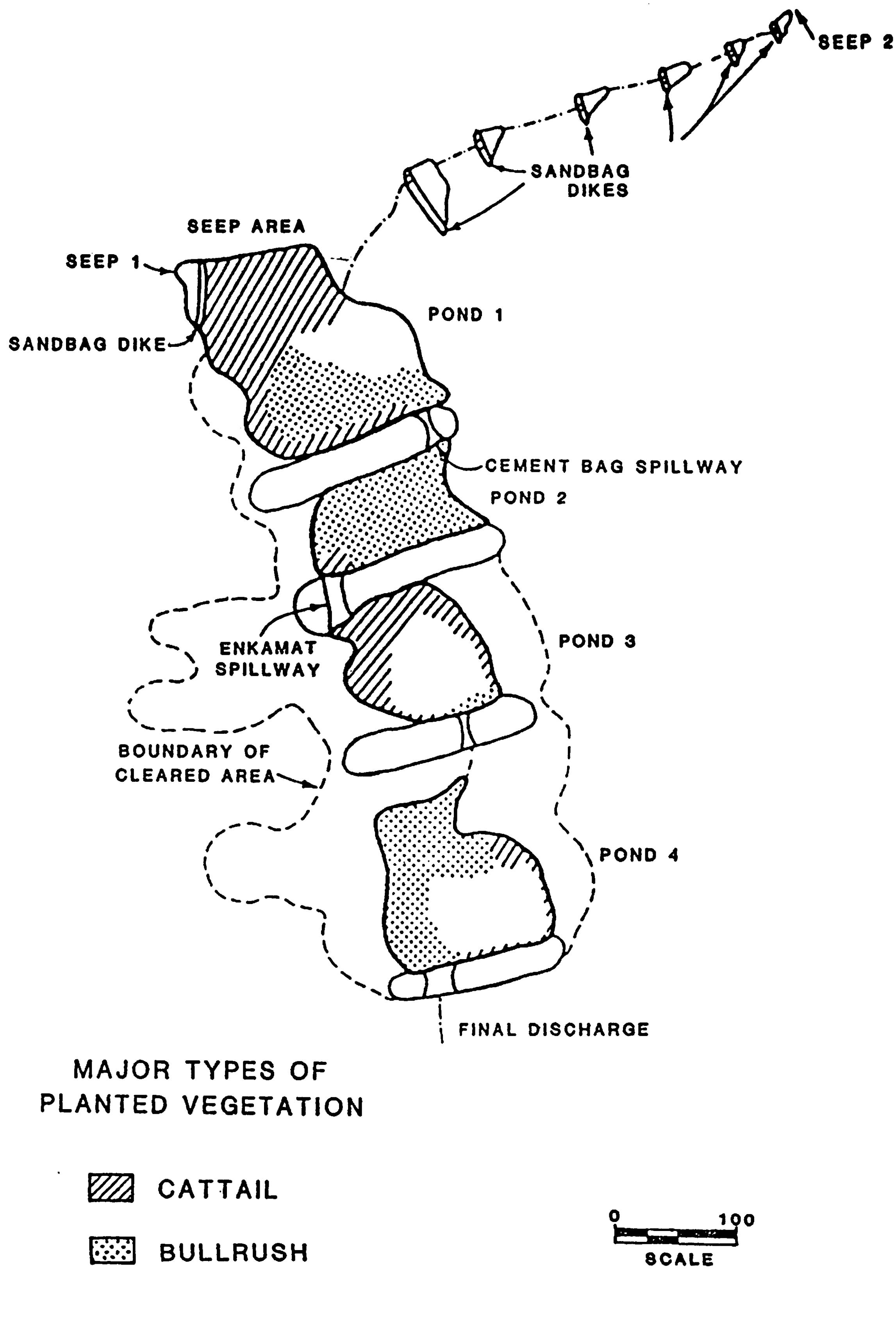

Fig. 2. TVA Fabius Coal Facility, Jackson County, AL (After EPA, 1988, after Hammer, unpublished).