EVALUATION OF SMALL CONSTRUCTED WETLANDS FOR IRRIGATION DRAINWATER MANAGEMENT IN THE UPPER SNAKE RIVER BASIN

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ABSTRACT

Constructed wetlands were considered as an alternative to manage irrigation return water in an area of the upper Snake River Basin in south-central Idaho. A four-year demonstration project was undertaken to examine practical issues and performance characteristics encountered to effectively integrate wetland features with irrigated agriculture operations. The project activities included sites studies to evaluate feasibility and potential environmental consequences, wetland design and construction, and follow-up monitoring of the water quality and habitat values associated with the site features. Early review of results appears positive, although additional monitoring is needed to assess conditions as the wetland become more fully established. The project results are intended to be applicable to other wetland sites in the area and generally contribute to sustainable water use and more effective watershed management approaches.

INTRODUCTION

The North Side Pumping Division (NSPD) of the Minidoka Irrigation Project was established by the U.S. Bureau of Reclamation (Reclamation) in the 1950's. The NSPD covers nearly 77,000 acres in south-central Idaho, north of the Snake River plain as shown in Figure 1. Water for the NSPD service area is supplied by pumping directly from the Snake River and from the underlying Snake Plain Aquifer system. Since 1966, the NSPD irrigation facilities have been operated by the A & B Irrigation District (ABID).

Return flows from the ABID irrigation area have historically been conveyed to passive drain wells that were constructed as part of the original irrigation project facilities. Conversion from flood irrigation systems to sprinkler has reduced return flows sufficiently to allow certain wells to be closed. A few additional wells have been closed due to concerns regarding poor water quality and their proximity to domestic water supply wells. Approximately 60 of the 78 drain wells originally constructed currently remain in operation.

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The State of Idaho, ABID, and Reclamation have undertaken several studies of the water quality and alternative drain water management methods (eg. IDWR, 1983; USBR, 1983; USBR, 1990). In 1991, the eastern Snake River Plain Aquifer was designated as a sole source of drinking water subject to the water quality protection provisions of the Safe Drinking Water Act (EPA, 1991). A Drainwater Management Framework Plan was prepared by Reclamation (1993) to propose a coordinated approach for implementing drain water management improvements. One alternative described in the framework plan involved the use of wetland and pond components that could be integrated to improve water quality and facilitate irrigation reuse systems.

The Minidoka Wetlands Demonstration Project was initiated to evaluate the feasibility and effectiveness of establishing wetland features and integrating wetlands within irrigation operations. The demonstration project facilities were constructed in the terminal reach of the "H-Drain" (named alphabetically) in the ABID drainage system. The H-Drain site was selected as a relatively small drainage that could be used as a practical representative of the typical drainage and site conditions found in the ABID service area.

BACKGROUND

The ABID service area ranges from about 2 to 7 miles wide and 30 miles in length. The ABID is divided into a Unit A service area of about 15,000 acres located contiguous to the Snake River, and Unit B which serves about 62,000 acres that are separated from the river by 3 to 8 miles. Unit A is supplied by water pumped directly from the Snake River, and Unit B utilizes ground water pumped from deep wells extended to the Snake Plain Aquifer. The land area located between Unit B and the Snake River is primarily irrigated agricultural land that is served by the Minidoka Irrigation District (MID).

Area Description

The project area is located in a moderately arid area that is characterized by gentle land slopes and broad flat areas overlying the basaltic rock formations that are common to southern Idaho. Native vegetation generally consists of drought tolerant species such as dryland prairie grasses and sagebrush.

Wildlife habitat is responsive to both the arid climate and agricultural land use that has altered the vegetative cover and hydrologic patterns. Larger trees and riparian cover are uncommon apart from local towns, farm residences, or along the Snake River channel. Aquatic and wetland habitat is sparse, and small drainage courses and vegetation zones near the edges of cultivated fields can provide valuable habitat corridors for resident and migratory wildlife.

Soils in the area are primarily silty loams that are low in total salts, metals, and trace element content. This fairly shallow soil mantle overlies fractured basalt which in turn overlays the Snake Plain Aquifer, a highly transmissive alluvial deposit that occurs at a nominal depth of about 200 feet. This aquifer, is one of the most productive groundwater sources in the world, that provides drinking water to an estimated 275,000 residents (EPA, 1991).

Historic Drainage Conditions

A lack of natural surface drainage outlets to the Snake River and constraints associated with drainage into the adjacent MID require most irrigation return flows and stormwater from Unit B to be disposed of through injection drain wells. These injection drain wells were drilled into highly porous zones of lava rock, passing return flows and stormwater directly into the underlying eastern Snake River plain aquifer. The drain wells were originally constructed to operate as passive, gravity-feed injection wells designed to accept normal irrigation return flows from localized depressions and accommodate minor storm runoff flows. Higher runoff is conveyed to larger catchment ponds and extreme flood flows tend to follow historic paths to the Snake River.

Water Quality

The ABID and the state have periodically monitored the quality of both the water supplies and return flows. The supply water quality from either surface or groundwater sources is generally very good. Irrigation drainwater samples have occasionally indicated elevated turbidity, nutrient, and bacteria content that are attributed to normal agricultural practices. No significant levels of synthetic organics (eg. pesticides) or trace elements (eg. from soil leaching) have been found to indicate toxic contamination problems.

The designation of the Snake Plain Aquifer as a sole source of drinking water requires the water quality to meet the provisions of the Safe Drinking Water Act, and the Underground Injection Control (UIC) program that specifically addresses injection well operations. Drain water monitoring by Reclamation and the ABID indicate that selected drain wells could exceed these standards for coliform bacteria and turbidity (Reclamation, 1993). The State of Idaho, the ABID, and Reclamation have since worked together to resolve these water quality issues in an appropriate manner.

Constructed wetland have been used effectively to remove various substances from water (eg. WPCF, 1990; Moshiri, 1993; Olsen, 1993). Wetland systems are particularly well suited to remove the sediment, nitrogen materials, and bacterial contaminants found in the ABID irrigation drain water.

DEMONSTRATION SITE WORK

The wetland demonstration project was intended to reflect typical activities expected to implement drainage improvement projects as a means to assess the practical feasibility of incorporating wetland and water reuse features into a drainage management program. The project included all site work activities ranging from the initial site investigations through design, construction, and subsequent site monitoring studies.

The H-Drain demonstration site extends about 1.5 miles along the final reach of the drainage system downstream of the contributing irrigated land. Before this project, the H-drain was a typical irrigation drainage course, built by cutting a narrow channel into the bottom of the natural drainage course. The drain channels are often confined by a berm access road on each side and are frequently maintained by clearing or burning bank vegetation and dredging of sediment. The H-Drain originally had two passive injection wells, of which one well is now closed. The other well at the terminal end of the drainage receives water only during extended high inflows. The overall site topography and features developed as part of this project are shown in Figure 2.

Preliminary Investigations

Initial project planning involved a variety of studies to evaluate the benefits and potential problems associated with the H-Drain site and anticipated types of site development features. These preliminary investigations centered on four major topics: (1) complete site surveying to prepare base mapping for use in site planning; (2) evaluate site conditions and potential to create wetland features to improve water quality and provide wildlife habitat; (3) assess the possible changes that the created wetlands could produce in either surface or groundwater hydrology; and (4) assess the potential to inadvertently create conditions harmful to wildlife or human health.

The first two questions were addressed through the initial site review and survey work. Base maps were prepared and field reviews were completed to assess the suitability to restore channels and establish meadow, marsh and pond features that would be consistent with water management objectives.

To evaluate the feasibility and suitability site soils for wetland creation, 16 exploratory test wells were drilled at selected locations throughout the site. These tests indicated that the soils in the area are moderately permeable, but would not necessarily preclude the ability to support wetlands. Subsurface flows were expected to follow the local water table along the natural stream course such that lateral seepage problems did not appear likely.

The question of toxic contamination potential involved more extensive studies undertaken by the U.S. Fish and Wildlife Service to examine the area soils and water chemistry which could indicate sources of contamination to the wetland systems. These investigations were conducted at the H-Drain site and at two other terminal drain catchment ponds that were constructed with the original irrigation facilities. These ponds have been in operation for over 30 years and were useful to provide insight into long-term trends that might be anticipated for constructed wetlands in the area.

These preliminary investigations indicated moderately elevated concentrations of cadmium believed to be a product of volcanic formations, but there was no evidence of significant accumulation of toxic trace elements (FWS, 1991). Periodic flushing by seasonal high flows was suggested as a mechanism that has maintained low levels of trace elements in these older ponds. No pesticide compounds (e.g., organochlorines) were found in either the water or sediment samples taken. Additional studies of the H-Drain site were undertaken during and after the site development work, and again, no significant contamination was reported (Mullins and Burch, 1993). Further studies were recommended to examine the potential for toxic accumulation over longer time.

Design Development Approach

Several criteria were applied in selecting site components and design features for the H-Drain site. The original irrigation development left little area to create large wetland components. The site was accordingly divided into linear stream reaches with specific features identified according to the characteristics of each reach. Design features considered included riparian restoration, small ponds, emergent marsh areas, and upland meadows.

Site features were intended to be low cost, sustainable, and low maintenance to be practical as drainwater management improvements. Site hydrology and soil conditions are largely fixed. This meant earthwork grading was the primary method to establish the desired size, shape, and slopes for features such as open pools, islands, and marsh areas. For example, grading work was utilized to form specific depth zones to encourage defined vegetation patterns in the features created. Water distribution and hydraulic conditions were considered as important factors for both water quality and to resist flood damage.

In addition to water quality objectives, wildlife habitat values were considered where possible. This included aquatic features such as islands and riparian bank zones, upland meadows for terrestrial food and cover, and separation of the higher maintenance areas from more habitat intensive areas. Mild slopes and wet meadow areas were used to provide shore and upland habitat zones.

Water quality improvement was evaluated with respect to important chemical constituents and known wetland functions. Sediment, nutrients, bacteria, and organic materials commonly found in the drain water are consistent with the wetland process mechanisms that are effective in reducing these constituents. The focus of water quality was on sediment removal due to the high loading of sediment in the drain water and the high efficiency for sediment removal mechanisms. Sediment removal can also effectively remove other constituents that are associated with the sediment materials. Sedimentation features were oriented to accommodate the 1 to 5 cubic feet per second base return flows.

The principal water quality component of the H-Drain project is an enhanced sedimentation pond located at the upstream end of the drainage. This pond is an unusual design in that a managed sediment pond is directly integrated with a vegetated marsh filter and willow transition as a means to enhance sediment removal and tolerate greater flood levels. The sediment pond is overexcavated at the upstream end of the pond to isolate sediment removal maintenance and increase the quality and longevity of downstream wetland features. The entire site is excavated below the grades of the overbank to minimize the hydraulic energy grade increase with greater storm flows. Marsh and willow vegetation zones are intended to increase the normal filtration effectiveness and reinforce the system functions against erosion damage during moderate flood events.

Construction and Planting

The design and construction of all the demonstration facilities was closely coordinated with the ABID. This arrangement was both cost effective and advantageous to produce desirable site configurations. Minor adjustments and repairs were according to conditions encountered without requiring expensive changes or more extensive site studies.

Construction work was initiated in the spring of 1992 and was substantially complete by the fall of 1995. Construction work proceeded from the upstream to downstream direction to establish the functional features of the enhanced sediment pond, and prevent disturbance of downstream features as staged construction proceeded. Site construction was primarily oriented toward the low flow channel, with the overbank areas remaining intact in most locations.

Limited planting was done in certain locations to establish desirable species and increase the rate of establishment. The sediment pond emergent marsh zone was planted by a planting contractor and the willow zone was planted by staff from the Natural Resources Conservation Service (NRCS) Plant Materials Center in Aberdeen, Idaho. The NRCS groups also provided assistance to start vegetation in other wetland and upland areas.

Site Monitoring

The demonstration project was monitored to evaluate the effectiveness of water quality improvements, wildlife habitat values and wetland creation techniques applied. As-built conditions were recorded after construction to track the practical attributes of what was actually constructed versus in comparison to the initial design objectives form each component. Wildlife values have only been qualitatively assessed to date due to the small size of the demonstration site and the relatively short time it has been established.

Water quality monitoring was initiated in 1992 and continue to date. Water samples are taken at each of 9 stations on a monthly basis. Analyses include biochemical oxygen demand, total suspended solids, various nitrogen species, total and dissolved phosphorus, turbidity, and coliform bacteria. In addition, the FWS has completed further studies of trace elements and synthetic organics to evaluate toxic hazard risks associated with newly created wetlands.

RESULTS AND DISCUSSION

The wetland demonstration site is rapidly becoming established, although it is evident that some additional time will be required to fully evaluate how things are changed and/or sustained over longer term. Still, the site is already being used effectively to eliminate disposal of irrigation wastewater through the drain injection wells. This may be partly attributed to the reduced water use due to drought conditions and more efficient irrigation practices as many farms are converting from flood irrigation to sprinkler systems. The site also provides additional wildlife habitat for waterfowl and other wetland birds and mammals. The enhanced wildlife values are evident in both wildlife observations and in the increased interest in wildlife related recreation.

The enhanced sediment pond is becoming fairly well-established and appears to be effective in filtering low and moderate flows and has held up well under normal runoff flows. Sediment removal is visually apparent in the increased clarity of the return pond downstream which was very turbid and now supports submerged aquatic vegetation.

Actual water quality data is not conclusive to date; however, there is some indication of net reduction in the downstream direction for samples taken in 1995 for nitrogen and turbidity. Total nitrogen was typically reduced from about 6.0 mg/L to 4.0 mg/L indicating approximately a 30 percent reduction in the downstream direction for samples taken in 1994 and 1995. Similar results were indicated for turbidity, but was not supported by total suspended solids data. Water quality analyses for the other constituents was inconsistent.

Water can be pumped for irrigation reuse from a pond downstream from the enhanced sediment pond. In the past, irrigators were reluctant to us reuse drainage water for irrigation because of large amounts of sediment which usually accompanied the drainage water. Increased reuse may further reduce the water volume conveyed downstream to the drain injection wells.

CONCLUSIONS and RECOMMENDATIONS

This project proved to be valuable to demonstrate the realistic expectations for wetland water management features and the practical considerations required to realize project objectives. The potential for direct application is apparent since there are about 11,000 acres of drainage area within this irrigation district that might be suitable for developing similar wetlands to treat or dispose of return flows. The project appears to be successful in incorporating wildlife habitat and water quality improvement with active agricultural operations.

This project illustrates practical and cost effective approaches to incorporate wetlands into watershed management plans. It is apparent that actual project performance depends on potential environmental consequences, site conditions, operational constraints, and the inherent limitations of wetland functions. Further monitoring is recommended to confirm these results and reveal longer term characteristics of the wetland facilities. Nevertheless, this project illustrates how water remediation and reuse can be effectively integrated with habitat objectives to sustain water and environmental resources.

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