A RESEARCH PROGRAM TO INVESTIGATE THE VIABILITY OF USING URBAN FRESHWATER WETLANDS FOR STORMWATER MANAGEMENT AND NONPOINT POLLUTION CONTROL

PREPARED BY

THE RESOURCE PLANNING SECTION

OF

KING COUNTY DEPARTMENT OF PLANNING AND COMMUNITY DEVELOPMENT

July 1, 1986

The preparation of this report was financially aided through a grant from the Washington State Department of Ecology with funds obtained from the National Oceanic and Atmospheric Administration, and appropriated for Section 306b of the Coastal Zone Management Act of 1972.

ABSTRACT

A Research Program to Investigate the Viability of Using Urban Freshwater Wetlands for Stormwater Management and Nonpoint Pollution Control. Resource Planning Section, King County Department of Planning and Community Development, Seattle, WA., July 1, 1986. Washington State Department of Ecology, WDOE Project Number G0086039, 16 pages.

A review of the literature revealed little information on the long-term effects of using freshwater wetlands for urban stormwater management and nonpoint pollution control. This is especially true for freshwater wetlands in the Pacific Northwest.

King County began a study in 1986 to obtain sound scientific data for management decisions regarding freshwater wetlands. This Research Program is one of three products resulting from the first phase of that study. A research technical advisory committee was formed to help formulate a research design that will answer many of the long-term questions regarding the use of wetlands for urban surface water management. A series of research questions were formulated, and a research methodology prepared to answer those questions according to five subject areas: biology, sediments and soils, water quality, groundwater, and hydrology.

INTRODUCTION

Interest has developed in the Northwest in using freshwater wetlands to store stormwater and absorb nonpoint pollution. While surface water managers and developers have advocated the use of wetlands to route and store urban stormwater runoff, resource managers are concerned about the long-term consequences of such actions on wetlands.

King County first moved to protect the values and functions of wetlands in 1973 through an amendment to its Comprehensive Plan. Since then the County has taken a number of actions to protect wetlands. These actions included conducting an extensive inventory and evaluation of wetland values, developing new Comprehensive Plan policies, prohibiting sewer service extensions in identified wetlands, and passing a Sensitive Areas Ordinance which prohibits most development in wetlands.

While recognizing the values of wetlands, King County and other municipal governments are also striving to control the effects of urban surface water runoff and examining local government's role in nonpoint pollution control. King County's surface water policy recognizes the inherent flood storage value of wetlands and their ability to moderate flows in downstream areas.

Since water quality enhancement and detention of stormwater runoff are among the natural values of wetlands, surface water managers are considering the modification and use of wetlands to detain additional urban stormwater and absorb nonpoint pollution before it reaches streams and ultimately Puget Sound. It is uncertain, however, what the long-term consequences of such actions would be on wetlands.

Modifications of wetlands through outlet control structures and other means may interfere with or unacceptably alter existing natural wetland functions such as food web support, nutrient cycling and wildlife habitat. In addition, aesthetic, recreational and educational values of wetlands may be dimininshed.

The current inadequate data base on the effects of altering freshwater wetlands for urban stormwater management makes effective and rational management decisions difficult.

NEED FOR MANAGEMENT INFORMATION

Due to potential conflicts between protection of wetlands and their use for surface water management and nonpoint pollution control, King County began a study to obtain sound scientific data for management decisions.

To obtain this information an annotated wetlands bibliography was compiled and reviewed. In addition, a wetlands research technical committee consisting of planners, engineers, researchers and regulators from various levels of government and the University of Washington was formed to assist with the development of a wetlands research program.

A review of the wetlands literature has yielded considerable information, but its direct application to Northwest wetlands is uncertain. A complete summary of findings from the literature and all of the citations noted below is found in The Use of Wetlands for Stormwater Storage and Nonpoint Pollution Control: A Review of the Literature (King County 1986). Following is a brief summary of findings from the literature as they relate to wetlands research needs.

Wetlands in the Northwest have not received substantial study as compared to wetlands in other areas of the country.

The bulk of the research conducted in the country has centered on wetlands of the East Coast and in the Midwest. Of the research conducted in the Northwest, most of it has focused on estuarine rather than freshwater systems. Furthermore, much of the related literature pertains to the use of wetlands for wastewater treatment.

The long-term impacts of stormwater discharges to wetlands are unknown.

Several authors have raised warning flags regarding the discharge of stormwater to wetlands:

"Long and short-term impacts of retention of sediments and nutrients in the wetland on flora and fauna is unknown "(Brown 1985).

"Special precautions should be taken with the use of natural wetlands for stormwater control, particularly those with high wildlife habitat values" (Canning 1985).

"The interaction of numerous plant and animal species on pollution removal in a wetland is not well understood" (Chan 1981).

"Insufficient data exist for long-term exposure of receiving waters to pollutants" (Galvin 1982).

"Little is known of the pollutant removal effectiveness of wetlands treating urban stormwater runoff, although the potential is high.... care must be taken to monitor stormwater wetland treatment systems to learn the environmental fate of pollutants" (Silverman 1983).

Effects of changes in detention time and water levels in wetlands were found to be uncertain.

The depth of water in a wetland is closely associated with the water regime of the wetland. Marked changes in water depth can result in plant species shifts and affect reproduction, as well as influence dissolved oxygen levels and many processes related to dissolved oxygen concentrations (EPA 1985).

Impacts of nonpoint toxicants in stormwater to groundwater are uncertain.

Groundwater interactions can be difficult and costly to investigate. Some authors (Carter et al. 1978, Adamus and Stockwell 1983) feel that wetlands may not play significant roles in recharging groundwater. In fact, wetlands may act more often as groundwater surface discharge areas (PSWQA 1986). Many wetland types, such as swamps, wet meadows and riverine-related systems are fed by groundwater at or near the surface for some parts of the year (Reppert et al. 1979). During drier months, however, these same wetlands can act as groundwater recharge zones (Reppert et al. 1979).

Bioaccumulation of nonpoint toxicants in wetlands is uncertain.

"The potential for bioaccumulation of heavy metals from urban runoff to levels detrimental to wildlife has not been examined" (Silverman 1983).

The public health risks of storing stormwater in wetlands are uncertain.

Silverman (1983) states that there is insufficient information on the removal of pathogenic microorganisms through wetlands treatment. Bacteria and viruses from wastewater applied on land have been found to survive for extended periods of time in both soil and groundwater (Silverman 1983). Bacteria do not survive longer than a few days in natural waters, and begin to die off. Viruses survive for longer periods (Canning 1985). The removal efficiency of pathogenic microorganisms through wetlands treatment of stormwater is not known. Research needs to be done on the public health risks of stormwater storage in wetlands.

RESEARCH PURPOSE, GOALS AND QUESTIONS

The purpose of the research program is to obtain scientifically valid data which will assist local governments in making management decisions on the use of wetlands for stormwater management and nonpoint pollution control. The primary gap in the literature is on the long-term impact of using freshwater wetlands for urban stormwater detention and nonpoint pollution control.

Research goals agreed to by the wetlands research technical committee were: (1) to determine the ecological implications of using urban wetlands for stormwater management; and (2) to determine the effect of wetlands on water quality of urban surface water runoff.

Primary questions to be answered through the research program are as follows:

1. What effect does degraded water quality have on a given wetland class?

2. What effect does alteration of the hydrologic regime, specifically detention time, have on a given wetland class?

3. What effect does storage of urban runoff for a given duration have on vegetation diversity, and habitat?

4. What effect do suspended sediments in urban surface water runoff have on soils, plant diversity, succession and habitat?

5. What effect do runoff toxicants and nutrients have on specific plant and animal species?

6. What role do specific wetland plant species have in the assimilation and concentration of nutrients and toxicants?

7. What effect do pollutants identified in urban stormwater have on groundwater?

8. What changes occur to water quality as urban stormwater transits a wetland?

RESEARCH DESIGN

Three study sites were determined to be necessary in order to adequately address the research questions. If sufficient funding is avaliable, additional replicate study sites would be added.

One wetland will be used as a control. The second wetland will be studied primarily to determine the effects of degraded water quality on the wetland and how the wetland will improve water quality. If necessary, this wetland will receive minimal modifications to increase dispersion of stormwater within the wetland and to increase its contact with vegetation and soils.

From a management perspective, if degraded water quality in the second study site has a detrimental effect on the wetland, stronger pretreatment requirements could be placed on upstream development prior to discharge of stormwater to a wetland.

The third wetland will be modified to act as an urban stormwater detention site. This wetland will be studied to determine the effects of storing water of degraded quality for detention times in the range of 20 to 36 hours. This wetland will receive modifications to its outlet in order to increase storage depth and residence time.

A number of wetlands in King County are under consideration as urban stormwater runoff regional detention sites. Research results from the third study site will provide guidance on the use of such sites for detention and water quality improvement.

STUDY SITE SELECTION

Specific study sites will be selected based on biological characteristics, storage capacity and projected urban growth patterns. Furthermore, study wetlands should exhibit high diversity with representation of multiple wetland classes.

The decision to study multiple classed wetlands was based on three assumptions: (1) all freshwater wetlands classes will come under scrutiny for possible use as detention sites; (2) studying numerous single class wetlands would be cost-prohibitive; and (3) most wetlands under review for potential detention use will have multiple rather than single classes.

Listed in order, from highest to lowest priority for investigation in a multiclassed wetland, the wetlands classes are: shallow marsh, scrub-shrub, deep marsh, forested, wet meadow, and open water. Open water wetlands received a low priority due to their similarity to lakes for which a more extensive body of knowledge already exists. Bogs were eliminated from consideration due to their fragile nature, infrequent occurance, and limited pollution removal potential.

Ideally, wetlands study sites will be in public ownership or available for study and manipulation without fee simple purchase. If site purchase is necessary to conduct this wetland research program, acquisition costs are expected to range between $30,000 and $70,000 per site depending on size and location.

If modifications are necessary in the water quality site to increase dispersion of stormwater within the wetland,they are expected to cost under $10,000. Outlet modifications to increase storage and residence time in the detention experimental wetland is expected to range between $30,000 and $100,000.

General criteria for wetland site selection:

- ecologically similar to each other
- receiving minimal or no urban runoff before study begins
- located in the same or similar river basins
- representative of at least three wetland classes
- well-defined inlets and outlets are necessary
- permission must be available to maintain instruments and monitor study parameters

Additional criteria for selection of control site

- not projected to receive urban development in contributing watershed during the next 5 years

Additional criteria for selection of water quality study site

- projected to receive additional urban development in contributing watershed approximately one year after study is initiated
- minimal pretreatment of waters before reaching wetland
- permission available to manipulate site to improve diffusion and increase contact time
- appropriate upstream site available to install water quality controls at a later time if desired (sedimentation pond, grass-lined swales, etc.)

Additional criteria for selection of the detention study site

- projected to receive additional urban development in contributing watershed approximately one year after study is initiated
- minimal pretreatment of waters before reaching wetland
- permission available to construct or modify outlet structure and increase storage
- appropriate upstream site available to install water quality controls at a later time if desired (sedimentation pond, grass-lined swales, etc.)

DATA COLLECTION AND MONITORING

Data will be collected on all three sites for approximately one year before manipulation of sites occurs. After base line conditions are established, monitoring of selected parameters will take place in order to record changes which may occur over the length of the study.

Following is a description of each of the parameters recommended for study by the wetlands research technical committee. The parameters are grouped under biology, sediments and soils, water quality, groundwater and hydrology headings.

BIOLOGY

Specific sampling methods including transects and plots will be established after specific wetland study sites have been selected. At each wetland site and within each class, baseline data will be established on such things as species composition and biological productivity. Inventory data and multivariate analysis will then be used to select species which are dominant or ecologically representative. Representative species, community structure, and biomass productivity as well as tissue concentrations of pollutants will be monitored for vegetation. Representative species, or indicators if identifiable, will be monitored for animals. Collection of water quantity and quality data will be coordinated with, and correlated to, the biological data.

1. Vegetation

parameter: **Species composition and population estimates in each wetland class and the wetland buffer**

monitored for: Changes in species composition, diversity and total populations, and plant communities.

sampling method: Permanent transects, along with study plots in each class and visual observations.

frequency of data collection: Three visits at each site - spring, early and late summer the first year. Monitoring on same schedule for subsequent years, possible reduction to twice per year.

cost estimate: To establish baseline data per site: $3500
to monitor data each subsequent year: $3000

parameter: **Biomass production in each wetland class and the wetland buffer of selected dominants**

monitored for: Changes in biomass production, vigor and health of plants.

sampling method: Measure height and shoot density. Measure above ground biomass of selected dominant plants within established plots via clip and dry weight. Samples from within plots. Measure algae via grab samples and estimated size of blooms. Measure woody growth via dbh, fruit production and new growth production.

frequency of data collection: Monthly during the first growing season, then monitored three times per year during subsequent growing seasons.

cost estimate: To establish baseline data per site: (included in species compositions costs above)
to monitor data per site per year: (included in species composition costs above)

<u>parameter:</u> **Vegetation tissue concentrations of pollutants and nutrients**

monitored for: Concentrations of N, P, metals, and organics if anticipated to be a problem.

sampling method: Quadrants established in biological survey; samples allocated spatially and temporally on basis of a pilot survey.

frequency of data collection: Approximately bimonthly.

cost estimate: Per site per year $3,600 not including organics

2. Animals

<u>parameter:</u> **Mammal species composition, population estimate and habitat use**

monitored for: Changes in species composition, diversity, total population, and habitat use of indicator species.

sampling method: Traps, sign transects, visual observations.

frequency of data collection: Initial inventory then indicator species monitored once per year.

cost estimate: To establish baseline data per site $5000
to monitor data each subsequent year $3000

<u>parameter:</u> **Bird species composition, population estimate and habitat use**

monitored for: Changes in species composition, diversity, total population and habitat use, nesting success.

sampling method: Visual census.

frequency of data collection: Once per month, with increased observation during spring and fall migration.

cost estimate: Per site per year $2,500

parameter: Aquatic benthic invertebrate species composition, relative abundance

monitored for: Changes in species composition, diversity, relative abundance, radical changes in proportion of one species to another, habitat use.

sampling method: Eckman dredge, visual observation, netting, and screening.

frequency of data collection: Once per month composite samples.

cost estimate: Per site per year $3,500

parameter: Amphibian and reptile species composition, population estimates, and habitat use

monitored for: Changes in species composition, diversity, relative abundance and use of habitats by indicator/representative species.

sampling method: Pit fall traps, night live capture and visual.

frequency of data collection: Weekly during spring, once during summer, weekly during fall.

cost estimate: Per site per year $7,500

parameter: Insect population density and breeding success (primarily indicator species from the Orders Diptera, Coleoptera, Hemiptera and Odonata)

monitored for: Radical changes in species populations, elimination, or changes in proportion of one species to another.

sampling method: Dip and sweep nets, possible light and pit traps.

frequency of data collection: Two times per week in summer, then monthly for remainder of first year. Monitoring once per month in subsequent years.

cost estimate: To establish baseline data per site $7,000
to monitor data per site each subsequent year $6,500

SEDIMENTS AND SOILS

Many nutrients and pollutants are attached to or accumulate in sediments and soils. Microbial activity can be responsible for transformation of nutrients and toxicants into forms taken up by plants. This element of the study will measure nutrient and toxicant concentrations occuring in soils and sediments as well as changes in microbial populations and biological activity.

parameter: Toxicant and nutrient concentrations

monitored for: Concentration and distribution of particle size, organic content, N, P, metals, (organics if anticipated to be a problem).

sampling method: Core samples allocated spatially and temporally on basis of pilot survey.

frequency of data collection: Approximately bimonthly.

cost estimate: Per site per year $3600

parameter: Microbial populations

monitored for: Changes in soil microbial populations.

sampling method: Core samples allocated spatially and temporally on basis of pilot survey.

frequency of data collection: Approximately bimonthly, 10 to 20 samples.

cost estimate: Per site per year $6,500

parameter: ATP production

monitored for: Changes in ATP production as an indicator of biological activity.

sampling method: Core samples allocated spatially and temporally on basis of pilot survey.

frequency of data collection: Approximately bimonthly, 10 to 20 samples.

cost estimate: Per site per year $3,500

WATER QUALITY

A review of wetlands literature has established the ability of wetlands to improve water quality. Water quality data will be monitored to establish the degree of improvement Northwest wetlands provide as well as the impact of degraded water quality on the wetlands. Water quality data will be correlated to plant, animal and soil parameters and length of detention time to determine pollution pathways and wetlands impacts.

parameter: **Routine water quality composites**

monitored for: Changes in water quality, between storms, from entrance to exit of wetland of conductivity, TSS, TOC, N, and P forms to be specified, total extractable and soluble metals, (organics to be specified after site selection depending on surrounding land use), Microtox.

sampling method: Inlet and outlet composites.

frequency of data collection: Initial inventory, then April through September and between storms during the winter.

cost estimate: Per site per year $10,000

parameter: **Storm water quality composites**

monitoring for: Storm-associated changes to conductivity, TSS, TOC, N, and P (forms to be decided), total extractable and soluble metals, organics to be decided (depending on surrounding land use), Microtox.

sampling method: Inlet and outlet composites.

frequency of data collection: Five to ten urban storm runoff events per year.

cost estimate: Per site per year $10,000

parameter: Water column samples

monitored for: Changes to temperature, pH, and dissolved oxygen, from entrance to exit of wetland.

sampling method: Grab samples or continuous probe.

frequency of data collection: Biweekly throughout study.

cost estimate: Per site per year $1,700

parameter: Bacteria populations

monitored for: Changes in bacterial concentrations of water at inlet, outlet and interior of wetlands.

sampling method: Grab samples.

frequency of data collection: Dependant on surrounding land use.

cost estimate: per site per year $6,400

GROUNDWATER

The groundwater component of the research design will characterize wetlands in relation to the groundwater setting. The primary factors to be examined are 1) whether the study wetlands act as recharge, discharge areas or both and 2) are contaminants from urban runoff reaching groundwater aquifers?

parameter: Characterization of geologic setting and groundwater flows

monitored for: Not applicable

sampling method: Review of existing drilling and well logs, review of geologic information and reports from the surrounding area.

frequency of data collection: Once, at beginning of study.

cost estimate: Per site one time costs $2,000

parameter: Groundwater level and flow direction

monitored for: Changes in elevation and flow direction.

sampling method: Four to six shallow wells (less than 30 feet) in and around each wetland with pizeometers.

frequency of data collection: Once per month.

cost estimate: Per site one time costs: well installation $1,700, water level survey $500
per site per year costs: Data collection and operations $1,800, interpretation $800

parameter: Groundwater quality

monitored for: Conductivity, pH, DO, bicarbonate, bacteria, nitrate + nitrite-N, selected trace metals, other organics to be specified.

sampling method: Water samples collected with submersible pump and flow chamber from pizeometer in each shallow well.

frequency of data collection: Four times per year.

cost estimate: Per site per year: equipment rental (used at all three sites) $1,000; data collection and operations $1,700, sample analysis $8,000 ($500/sample) data compilation and interpretation $4,500

HYDROLOGY

All three wetland study sites will be monitored for water quantity effects. The water quality study site will be modified as necessary to improve contact between vegetation, soils and water. Modifications may include such things as flow deflectors, baffles, and outlet restrictors. The water quantity study site will be modified to increase wetland active storage with a maximum increase in the wetland stage of 3.5 feet. Detention times will range from 20 to 36 hours. Actual detention times will depend on the storm event. Increased urban runoff detention will be compared with the water quality and control wetlands to determine ecological impacts to wetlands.

As both experimental treatment wetlands may become permanent urban runoff detention sites, it will be important to coordinate selection with area surface water management objectives.

parameter: Physical morphology of site (cross section, area, depth, channel locations, etc.)

monitored for: Changes in areas of inundation, depth, volume and deposition of sediments.

sampling method: Site survey.

frequency of data collection: Initial survey, then yearly field check.

cost estimate: Initial survey per site $5,000
yearly field check per site $1,000

parameter: **Input and output hydrograph**

monitored for: Changes in volume and rate of flow entering and leaving wetland.

sampling method: Continuous discharge gaging station at inlet and outlet to each wetland.

frequency of data collection: Continuous recorder (30 to 60 minute intervals).

cost estimate: Installation per wetland site $8,000
(two gaging stations per wetland @ $3,000 to $5,000 ea)
per year per site operation and data retrieval $4,000
per year per site analysis of data $1,200

parameter: **Wetland interior stage gaging**

monitored for: Stage and wetland storage.

sampling method: Stage recorder to be used with mathematical model to establish wetland storage.

cost estimate: Installation per wetland site $1,500 to $3,000
yearly operation and data retrieval included above
yearly analysis of data included above
software analysis package $1,000

parameter: **Rainfall**

monitored for: Direct rainfall input to wetland, quantity and duration

sampling method: Continuous recording rainfall gage.

cost estimate: Per site installation: $1,500 to 3,000
yearly operation and data retrieval included above
yearly analysis of data included above

RESEARCH PROGRAM ESTIMATED BUDGET

The estimated budget to conduct the research program is based on discussion with experts in biology, soils, water quality and hydrology. Economies of scale through combined site visits and combined studies are difficult to assess until actual site selection occurs. For general purposes, study sites were assumed to be in suburban King County.

Costs are broken down by one time costs, per year costs for a single site, and per year costs for the three site study. The final column provides an estimated cost to conduct a more basic three site study. It includes necessary one time costs, assumes gaging equipment is provided for use without charge, and site identification, acquisition and modification costs are borne by King County.

ESTIMATED COSTS

	one time costs	per site (per year)	3 sites (per year)	3 sites (basic study)
SITE ID & NEGOTIATION	$ 8,500			
SITE ACQUISITION for two study sites:	$90,000			
SITE MODIFICATION for two study sites:	$45,000			
BIOLOGY				
Plant				
species composition		$ 3,500	$10,000	$10,000
biomass production (included in above item)				
pollution & nutrient accumulation		$ 3,600	$10,800	$10,000
Animal				
mammals		$ 5,000	$12,000	
birds		$ 2,500	$ 7,500	$ 7,000
aquatic benthic inverts.		$ 3,500	$10,500	$10,000
amphibians and reptiles		$ 7,500	$21,000	
insects		$ 7,000	$20,000	
SOILS and SEDIMENTS				
Toxicant concentrations		$ 3,600	$11,000	$11,000
Microbial populations		$ 6,500	$19,500	
ATP production		$ 3,500	$10,500	$10,000
WATER QUALITY				
routine water quality composites		$10,000	$30,000	$30,000
storm water composites		$10,000	$30,000	$20,000
water column samples		$ 1,700	$ 5,000	$ 5,000
bacteria		$ 6,300	$19,000	$15,000

ESTIMATED COSTS (CONTINUED)

GROUNDWATER				
geologic characterization	$ 2,000			$ 5,000*
level and flow direction	$ 2,200	$ 2,600	$ 7,000	
groundwater quality		$14,200	$43,000	
WATER QUANTITY				
site physical morphology	$5,000			$ 7,000*
input/output hydrograph	$8,000	$ 5,200	$15,500	$10,000
wetland interior staging	$2,000			$ 1,000*
rainfall	$2,000			
STUDY COORDINATION		$ 8,000	$16,000	$14,000
STUDY REPORT		$ 7,000	$12,000	$12,000
TOTAL	**$164,700**	**$118,800**	**$317,500**	**$165,000**

---

* Theses costs are one time costs to be incurred in the first year of study only.