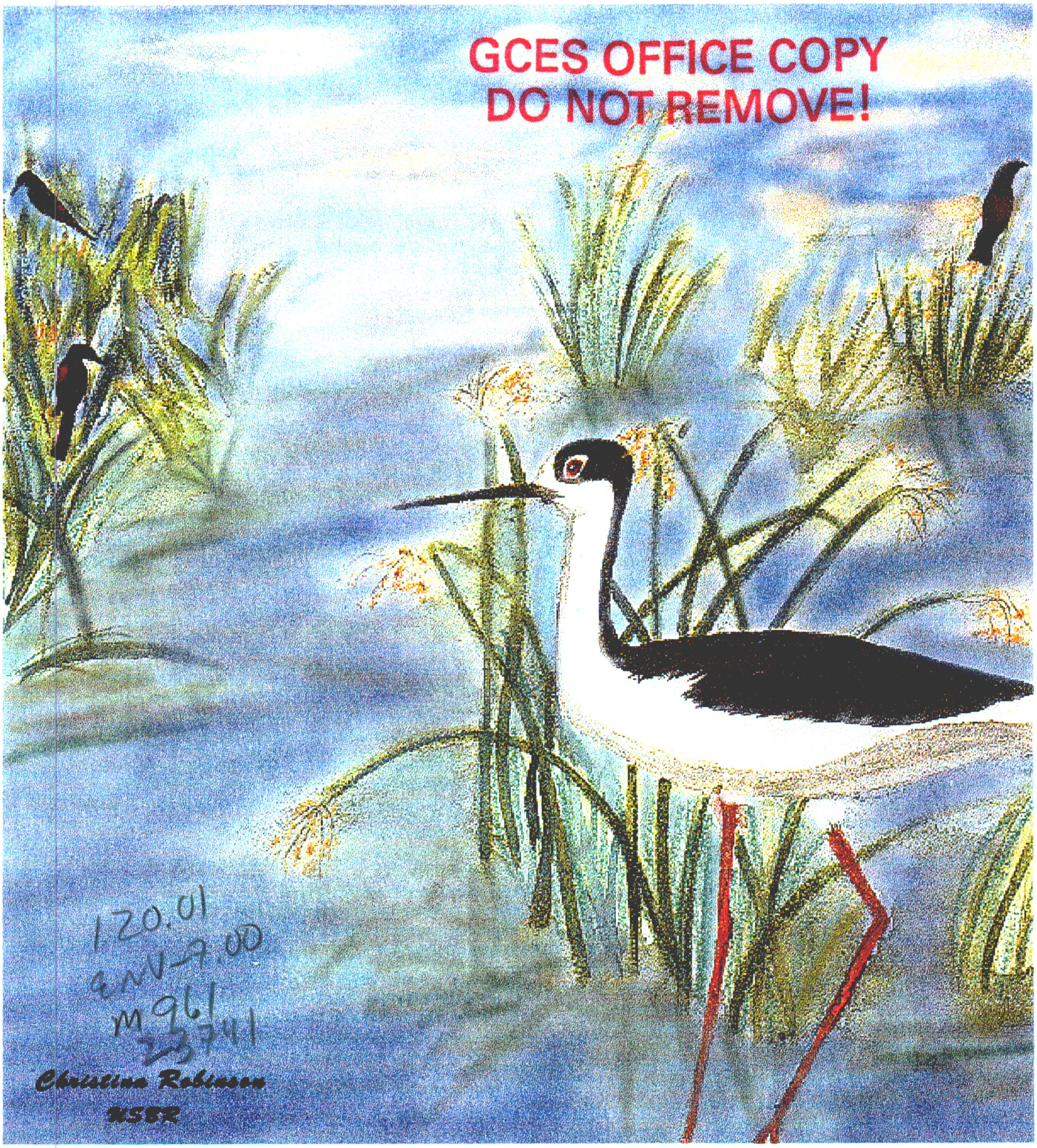
MULTIPURPOSE WETLANDS

PHASE II/III REPORT



BUREAU OF RECLAMATION
NATIONAL BIOLOGICAL SURVEY
EASTERN MUNICIPAL WATER DISTRICT

SEPTEMBER 1994

MULTIPURPOSE WETLANDS

PHASE II/III REPORT

FINAL

FINAL DESIGN AND ONGOING RESEARCH INVESTIGATIONS

BUREAU OF RELCAMATION

BRUCE BABBITT, SECRETARY OF THE INTERIOR
DANIEL P. BEARD, COMMISSIONER OF RECLAMATION
LAWRENCE F. HANCOCK, REGIONAL DIRECTOR, LCR

NATIONAL BIOLOGICAL SURVEY

EASTERN MUNICIPAL WATER DISTRICT

SEPTEMBER 1994

FINAL

MULTIPURPOSE WETLANDS

Phase II/III Report

Final Design and Ongoing Research Investigations

Eastern Municipal Water District
Bureau of Reclamation
National Biological Survey

September 1994

ACKNOWLEDGEMENTS

The Multipurpose Wetlands Research and Demonstration Project represents a comprehensive effort to evaluate the feasibility and effectiveness of integrating wetlands with advanced water treatment, environmental enhancement, and the ultimate reuse of reclaimed water in arid areas of the United States. This program was originally initiated as a cooperative effort between the Eastern Municipal Water District (EMWD) and the Bureau of Reclamation (USBR). In the fall of 1993, the National Biological Survey (NBS) joined the coordinated research and demonstration team.

Because this opportunity for wetlands research has national significance, not only in terms of its objectives but also in advancing wetland habitat and treatment technology, experts within the field were engaged to assist with this study and provide peer review. To achieve the desired level of expertise, EMWD, USBR, and NBS assembled a diverse group of technical experts from governmental agencies, the academic community, and environmental organizations.

Technical Advisory Committee: The following agencies and individuals are members of the Technical Advisory Committee.

Federal Agencies

Environmental Protection Agency
    Dr. Robert K. Bastian
Fish and Wildlife Service
    Mr. Bob James
National Biological Survey
    Mr. Lee S. Ischinger

State of California and Local Agencies

Department of Fish and Game
    Mr. John W. Anderson
    Mr. Tom Paulek
    Mr. Fred Worthley
Regional Water Quality Control Board
    Ms. Linda Garcia
Riverside County Flood Control and Water Conservation District
    Mr. Ken Edwards
Riverside County Health Department
    Mr. Hugh Murray
    Mr. David Richardson

Water Resources Control Board
Mr. Tom Inouye

Academic Community

Humboldt State University
Dr. Robert A. Gearheart
San Diego State University
Dr. Richard Gersberg
University of California at Riverside
Mr. Jewell L. Meyer, P.E.
Dr. Mir S. Mulla
Dr. Marilynn V. Yates

Environmental Groups

Ducks Unlimited
Mr. John Nagel

Consultants to Eastern Municipal Water District

CH2M Hill

Executive Committee: An Executive Committee was also formed to direct the study. This committee is the core management team, assembled periodically to resolve the important issues regarding policy decisions and administrative coordination as required to accomplish the objectives of the Multipurpose Wetlands Research and Demonstration Project. Members include the following:

Eastern Municipal Water District

Mr. Michael Garner	Program Manager; Resource Development Administrator
Ms. LeAnne Hamilton	Project Manager; Research Coordinator
Mr. P. Ravishanker	Assistant General Manager

Bureau of Reclamation

Mr. Bill Boegli	Chemical Engineering Leader
Dr. Jim LaBounty	Environmental Sciences Leader
Ms. Jean Shepherd	Project Manager
Mr. Tim Ulrich	Temecula Area Office Manager; EC Chair

Mr. Ron Willhite	Denver Loan Program Manager (retired)
Mr. Doug Yoder	Denver Wetlands Program Manager

National Biological Survey

Mr. Jim Sartoris	Research Coordinator

Additionally, recognition and thanks are extended to those who worked together in team efforts to accomplish the many tasks involved in bringing the final design to completion and to undertake the research activities that are described in this report. These individuals and respective activities are as follows:

Final Design Team: A technical team was assembled to coordinate the final design effort and to effectively transfer design concepts and preliminary design information into the preparation of plans and specifications for construction, planting, and landscaping of the multipurpose wetlands demonstration system at the Hemet/San Jacinto site. This team consisted of staff from EMWD, USBR, NBS, and final design consultants as follows:

Eastern Municipal Water District

Ms. Christie Moon Crother	Project Coordinator
Mr. Michael Garner	Program Manager; Resource Development Administrator
Ms. LeAnne Hamilton	Project Manager; Research Coordinator
Mr. Bob Page	Hemet/San Jacinto Regional Water Reclamation Facility Plant Manager
Mr. John Ward	Project Engineer

Bureau of Reclamation

Ms. Mary Lou Pierce	Landscape Architect
Mr. Eric Stiles	Design Coordinator
Mr. Richard Straubinger	Technical Review
Ms. Bernice Sullivan	Activity Manager
Mr. Ron Willhite	Loan Program Oversight

National Biological Survey

Dr. Doug Andersen	Wildlife Biology
Ms. Joan Thullen	Wetlands Vegetation

CH2M Hill

Ms. Michelle Girts	Wetlands Specialist
Mr. Christopher Poli	Project Engineer
Mr. Jagdish Salgaonkar	Project Manager

Research Investigations: Various research investigations concerning the test wetland cells, the pilot reverse osmosis system, and the saline marsh have been conducted by the following group of dedicated scientists with enthusiastic assistance provided by laboratory and field support staff members. The collaborative research investigation and technical support team include the following members:

Principal Investigators:

Eastern Municipal Water District

Mr. Steve Crombie	Water Quality; Reverse Osmosis Operation
Ms. Stella Denison	Biology; Public Education

Bureau of Reclamation

Mr. Bill Boegli	Reverse Osmosis Process
Ms. Joy Gober	Soils Chemistry
Ms. Judy Hamilton	Geohydrology

National Biological Survey

Dr. Doug Andersen	Wildlife Biology
Mr. Jim Sartoris	Wetlands Water Quality
Ms. Joan Thullen	Wetlands Vegetation

Wetlands Planting and Landscape Team: This technical team was responsible for preparation of landscaping plans, planting guidelines, and contract specifications for planting of the wetland and upland areas of the Hemet/San Jacinto multipurpose wetlands demonstration site. This small team consisted of staff from EMWD, USBR, and NBS as follows:

Eastern Municipal Water District

Mr. Michael Garner	Program Manager
Ms. LeAnne Hamilton	Research Coordinator
Mr. John Ward	Project Engineer

Bureau of Reclamation

Ms. Mary Lou Pierce	Landscape Architect
Mr. Eric Stiles	Design Coordinator
Mr. Richard Straubinger	Technical Review
Ms. Bernice Sullivan	Activity Manager

National Biological Survey

Ms. Joan Thullen	Wetlands Vegetation

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Eastern Municipal Water District

Mr. Steve Crombie	Water Quality
Ms. Stella Denison	Biology
Mr. Jeff Hale	Special Services
Ms. LeAnne Hamilton	Research Coordinator
Mr. Al Javier	Biologist
Mr. Steve Shockey	Field Services Assistant
Ms. Joanna Tewksbury	Water Quality Specialist

Bureau of Reclamation

Mr. Bill Boegli	Reverse Osmosis Process
Ms. Joy Gober	Soils Chemistry
Ms. Judy Hamilton	Geohydrology
Mr. S. Mark Nelson	Aquatic Biologist
Mr. Rick Wydoski	Biological Technician

National Biological Survey

Dr. Doug Andersen	Wildlife Biology
Mr. Jim Sartoris	Wetlands Water Quality
Ms. Joan Thullen	Wetlands Vegetation

Other Participants: Special thanks is also offered to the following individuals for their efforts and assistance:

Eastern Municipal Water District

Mr. Mike Creighton
Dr. John Crossman
Ms. Betty Gibbel
Ms. Arlene Gomez
Dr. Behrooz Mortazavi

Bureau of Reclamation

Mr. Ed Beddow
Mr. Keith Copeland
Mr. Russ Dodge
Ms. Amy Porter
Ms. Christina Robinson
Ms. Suzanne Sikora
Mr. Mike Walker

State of California and Local Agencies

City of Hemet
Mr. Mark Goldberg
City of San Jacinto
Mr. Mike Chestnut

Academic Community

California State Polytechnic University-Pomona
Ms. April Sleigh
Dr. Laszlo J. Szijj

Our sincere thanks and appreciation is extended to all for their expert counsel, participation, and support.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Eastern Municipal Water District (EMWD), the Bureau of Reclamation (USBR), and the National Biological Survey (NBS), in consultation with other governmental agencies, the academic community, and environmental groups, are involved in a cooperative wetlands research and demonstration effort. This report reflects progress through the first 3 years of a 5-year program. The goal of the Multipurpose Wetlands Research and Demonstration Project is to evaluate and expand the use of reclaimed water and contaminated ground water through the incorporation of multipurpose constructed wetlands into EMWD's total water resources management program. The focus of the wetlands is the development of design, construction, and operational criteria that will provide a cost-effective and innovative alternative for managing water resources and provide other public benefits in arid areas. The program also recognizes the fact that naturally-occurring wetlands, both coastal and inland, have been disappearing at an alarming rate.

Millions of migratory birds funnel through the Pacific Flyway each winter on their annual flight from Alaska and Canada to Latin America. California, a critical 1130-kilometer (km) (700-mile (mi)) link on this corridor, has lost over 90 percent of its natural wetlands since the 1700's, resulting in the loss of habitat for resting, feeding, breeding, and the rearing of young. This project will provide vital habitat in a portion of the corridor as well as valuable information on the use of reclaimed water. Ninety-two different species of birds have already been identified utilizing the Hemet/San Jacinto Research and Demonstration Facility. Threatened and endangered species and species of special concern which have visited the site include the bald eagle, peregrine falcon, American white pelican, double-crested cormorant, white-faced ibis, northern harrier, golden eagle, prairie falcon, burrowing owl, and bank swallow.

Reclaimed water is a vital element in water resources management, especially in arid areas. Its use can minimize the strain on existing water delivery facilities and local water resources. Constructed wetlands designed to treat secondary effluent will directly affect the reclaimed water supply as a functional equivalent of advanced treatment. Concurrently, diminishing ground-water resources could be supplemented or, in some areas, additional recharge water could be provided as part of a comprehensive ground-water remediation program. The net result will be the maximum utilization of local water resources, thereby reducing the dependence on imported water supplies.

The success of the project is demonstrated by the many national and international visitors that have toured the research and demonstration site to date, including two groups from Australia, representatives from Taiwan and the People's Republic of China, and a delegation from 14 Middle Eastern countries. In addition, local school

PHOTO 1.   SAN JACINTO WILDLIFE AREA

children utilize the wetlands as an environmental science laboratory, learning about wetlands ecology, the value of reclaimed water and its reuse, and developing an awareness of water as a finite and precious resource. The site is well-known among bird watchers and is one of the locations used by the Audubon Society for its annual Christmas Bird Count. In contrast to its arid surroundings, the facility provides green space and habitat appealing to both people and wildlife.

National, State, and regional awards that the project has received include the Association of Metropolitan Sewerage Agencies (AMSA) Research and Technology Award for 1994; California's Local Government Commission 1992 Award for Innovation in Water Conservation, Reclamation, and Management; and the Inland Empire West Resource Conservation District 1993 Conservation Partnership Award for Water Quality.

The 5-year study began in December 1990 with the signing of a Memorandum of Agreement. Phase I of the study established specific goals and objectives and developed conceptual designs for multipurpose wetlands at three separate sites comprising up to 243 hectares (ha) (600 acres (ac)). The objective of these demonstration projects was to allow the development of information on wetlands design features that could ultimately be used as guidance for the development of similar projects across the nation. The Phase I Report (November 1991) provided background information and preliminary design concepts for wetlands at the Hemet/San Jacinto Regional Water Reclamation Facility (RWRF), Little Valley, and a site in the vicinity of the San Jacinto Wildlife Area. It contained information on soil characteristics, fauna and flora, and hydrology for each site.

The wetlands which are being developed as part of this project are truly multipurpose in nature, providing water treatment, public education, wildlife habitat, open space, recreation, and other public benefits. In addition, each site has specific water resources objectives. For example, tertiary treatment and nutrient removal are the primary objectives at Hemet/San Jacinto; ground-water remediation and nitrate removal are the focus for Little Valley; and ground-water recharge and remediation of brackish ground water are the main objectives for the San Jacinto Wildlife Area site.

This Phase II/III Report covers the activities which have taken place since the Phase I Report was completed in November 1991. The major accomplishments were the design, construction, and monitoring of the wetlands research facility and final design of the 19-ha (47-ac) Hemet/San Jacinto demonstration wetlands. Work at Little Valley and the San Jacinto Wildlife Area sites has progressed more slowly due to the need to conduct more extensive hydrogeological and environmental investigations.

The EMWD/USBR/NBS Wetlands Research Facility was constructed at EMWD's Hemet/San Jacinto RWRF. This 3.2-ha (7.8-ac) site includes two 0.2-ha (0.5-ac) nursery cells and eight pilot research cells. The nursery cells were constructed first to propagate bulrush for later transplant to research and demonstration projects and determine the most efficient harvesting and planting techniques. The research cells are being used for ongoing research to monitor plant growth and establishment, water quality dynamics, sediment quality, and benthic invertebrates. The first year of monitoring has provided data on baseline conditions and seasonal and long-term variability and trends. The next phase of monitoring (Series 2) will look more closely at nutrient dynamics, nutrient input from wildlife, the significance of open water versus vegetated zones, and other topics.

The research facility also includes a pilot reverse osmosis (RO) desalination unit, saline vegetated marshes, and evaporation cells. The RO/saline marsh project involves studying the feasibility of supporting saline vegetated marshes with the reject stream of the desalter. If successful, the use of desalters and saline marshes will become part of EMWD's total water resources management program, allowing EMWD to reclaim brackish ground water and address the salt balance issue associated with reclaimed water. Brine disposal is a major cost element in the use of desalters in inland areas. The success of the saline marsh effort could result in an additional use of brackish water for the development of habitat, greenbelts, and open space and reduce brine disposal costs. A monitoring program has been initiated to assess bioproductivity, toxic accumulation, and habitat value.

In addition to the research program, EMWD secured a Federal loan through the Small Reclamation Projects Act (SRPA) loan program to develop an extensive reclaimed water distribution system which included construction and enhancement of up to 243 ha (600 ac) of wetlands. The loan program was created in 1956 to stimulate local economies and benefit the nation by extending, reclaiming, and recycling local water supplies. The loan program gives special consideration to wetlands enhancement opportunities in conjunction with local water management techniques.

The original wetlands as envisioned in the loan application were much less sophisticated and beneficial than the wetlands now being constructed. These wetlands were single-purpose in nature, thus requiring minimum grading for shallow ponds and indigenous shoreline vegetation. However, subsequent to the preliminary research effort by EMWD and USBR, it was cooperatively agreed to pursue the development of multipurpose wetlands. This resulted in the development of highly-engineered wetlands to support multipurpose objectives, including control features to enhance water quality, wildlife habitat, and other public benefits.

Design of the 19-ha (47-ac) Hemet/San Jacinto Multipurpose Constructed Wetlands was accomplished in stages with input from EMWD, USBR, NBS, CH2M Hill, and the Technical Advisory Committee (TAC). First, baseline and planning investigations were conducted by USBR and NBS to identify conditions and issues which could affect the design development. The next stage, the wetlands preliminary design investigations, provided critical information pertaining to site engineering, wetlands system design, and landscape and planting features. This resulted in the Design Concepts and Criteria Report, prepared by EMWD and USBR in June 1993. The final stage of design, preparation of construction drawings, specifications, and contract documents, took place between June and November 1993, with engineering consulting services provided by CH2M Hill. This Phase II/III Report covers activities through the final design. A Phase IV report will be prepared after the completion of construction of the Hemet/San Jacinto wetlands.

Construction of the Hemet/San Jacinto wetlands, funded with SRPA loan funds, began in January 1994. Located at the northwest corner of the Hemet/San Jacinto RWRF, the site is well-suited for the evaluation of water treatment efficiency under varying loadings. Being situated within the Pacific Flyway, it is also an excellent location to promote waterfowl diversity and provide public education benefits. This project was designed in collaboration with the USBR and NBS technical team. Several design features are included specifically to enhance habitat and allow public viewing. Planting and upland landscaping began in mid-August and will continue in phases until the end of December 1994. The first phase will involve transplanting of bulrush from the nursery cells. A monitoring program will begin shortly after planting to assess plant establishment, wildlife use, and water quality.

The Hemet/San Jacinto wetlands design is already serving as a model for other cities. The City of Phoenix has proposed a similar conceptual design for the Tres Rios Demonstration Wetlands Project that is currently underway. Constructed wetlands have great public appeal and offer significant advantages in terms of cost over conventional wastewater treatment. The type of information and experience which is being generated by the EMWD/USBR/NBS effort is essential to further the state of the art of constructed wetlands application and design.

Many aspects of the EMWD/USBR/NBS Multipurpose Wetlands Research and Demonstration Project are ongoing. In particular, the research and monitoring efforts up to this point have been devoted largely to gaining data on baseline conditions or conditions during establishment of a mature wetlands system. Therefore, this report presents discussion and recommendations rather than final study conclusions. One of the purposes of the report is to allow input from the Technical Advisory Committee on the interim results and recommendations for further research.

Based on experiences thus far, the creation of a wetlands nursery is recommended to provide adequate plant material when building a large wetland. Establishment of the nursery cells at the Hemet/San Jacinto research facility was very successful. Within 3 months (July to October 1991), the original plant density increased, on average, about 16 times. There was enough plant material in the southwest corner of the north cell to vegetate the eight research cells successfully. The 0.4 ha (1 ac) of material in both nursery cells is expected to be sufficient to vegetate the 8 ha (20 ac) of marsh area in the demonstration wetlands.

Various methods of transplanting bulrush were evaluated. When removing bulrush from the donor site, it was found that there was no difference between the use of a backhoe versus hand-digging with a shovel; however, use of a backhoe may cut labor costs. When planting at the new site, staking the bulrush root clumps on top of the dry substrate, then flooding, is recommended as the best technique. This technique produced the most rapid propagation, which, in turn, provided the shortest time to total coverage. It was also the least labor-intensive and, therefore, the most cost-effective.

The research cells were constructed of two types to allow comparison of water treatment performance. Four of the cells have open water areas in the middle (three-phase), while the other four are fully vegetated (one-phase). Based on preliminary water quality monitoring, the most significant difference between the two types of cells was the performance in reducing nitrogen. The difference may be attributed both to nitrogen input from blackbirds inhabiting the bulrush and to better nitrification in the cells with open water. Further experiments are proposed to study these possibilities.

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

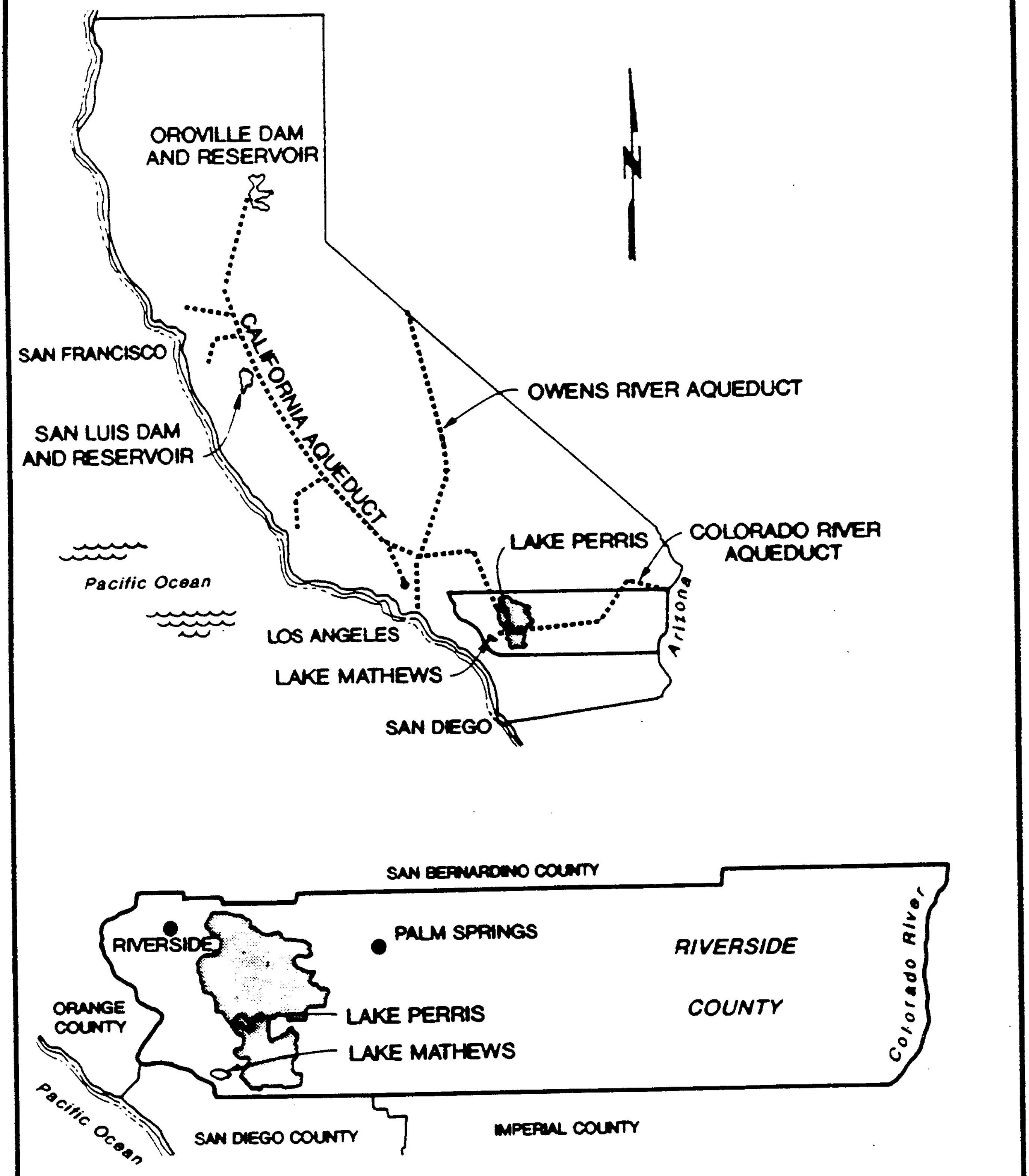
The Multipurpose Wetlands Research and Demonstration Project is examining the role of wetlands in conjunctive management of water, land, and environmental resources. The project is a cooperative effort among EMWD, USBR, and NBS. This wetlands demonstration program and related studies will evaluate and expand the use of reclaimed water and ground-water resources through the incorporation of multipurpose constructed wetlands into comprehensive plans for water resources management.

The focus of the wetlands component of the reclaimed water resources management program is the development of design, construction, and operational criteria that will provide a cost-effective and innovative alternative for managing water resources and provide other public benefits in arid areas. The program recognizes that scarce water resources place increased emphasis on integrated approaches to utilize water resources while protecting valuable ecosystem functions. It is also responsive to indications that naturally-occurring wetlands have been disappearing at an alarming rate, a problem of nationwide concern given the potential implications of losing a highly-productive food base and an extraordinarily dynamic ecosystem resource.

The cost of the wetlands research program has been shared by EMWD, USBR, and NBS through a combination of in-kind services and direct funding. The costs of design and construction of the full-scale demonstration facilities are being funded by a Federal loan and grant under Public Law 84-984. EMWD secured an SRPA loan to develop an extensive reclaimed water distribution system to serve its customers and to build up to 243 ha (600 ac) of wetlands to provide multiple environmental and public benefits.

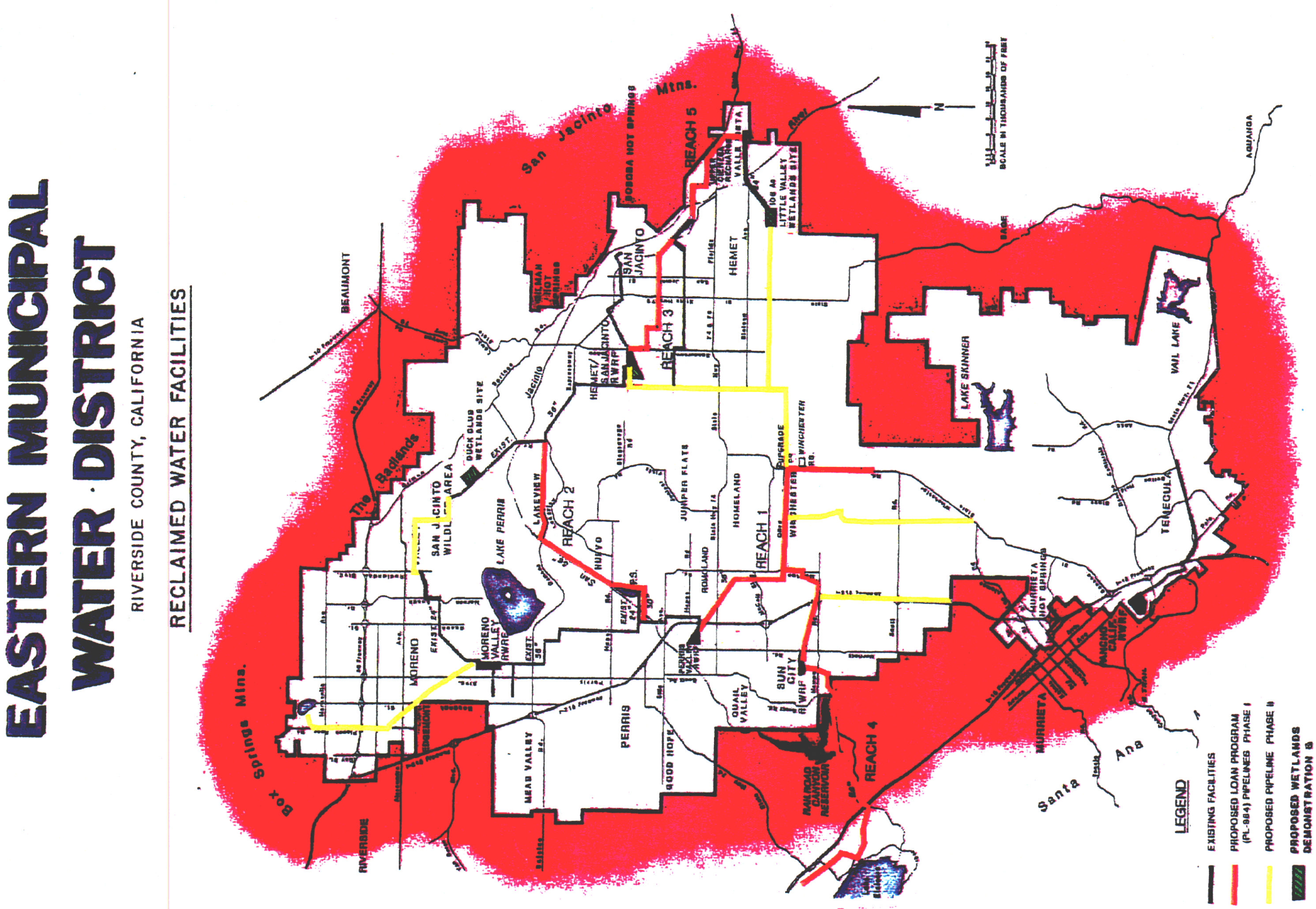
PROJECT HISTORY

In the early planning stages of the project, a five-phase plan was formulated as a basis to establish full-scale wetland demonstration facilities at three selected sites. Upon completion of the first phase, a project report was prepared to delineate project goals, objectives, and principal research issues for the Multipurpose Wetlands Research and Demonstration Project. The Phase I Report also presented conceptual-level design plans for wetland systems to be established at each of the three sites, along with general information on soils, fauna and flora, and hydrologic characteristics associated with each site.



LOCATION MAP
EASTERN MUNICIPAL WATER DISTRICT
FIGURE I-1

FIGURE 1-2


EASTERN MUNICIPAL WATER DISTRICT
RIVERSIDE COUNTY, CALIFORNIA
RECLAIMED WATER FACILITIES
BEAUMONT
RIVERSIDE
Box Springs Mtns.
The Badlands
San Jacinto Mtns.
MORENO
EDGEMONT
SAN JACINTO WILDLIFE AREA
DUCK CLUB WETLANDS SITE
LAKE PERRIS
MORENO VALLEY RWRF
PERRIS
MEAD VALLEY
GOOD HOPE
LAKEVIEW
NUEVO
ROMOLAND
QUAIL VALLEY
SUN CITY RWRF
HEMET/SAN JACINTO RWRF
SAN JACINTO
HEMET
JUNIPER FLATS
HOMELAND
WINCHESTER
SOBOBA HOT SPRINGS
LITTLE VALLEY WETLANDS SITE
REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
LAKE SKINNER
VAIL LAKE
TEMECULA
MURRIETA
MURRIETA HOT SPRINGS
RANCHO CALIF. RWRF
RAILROAD CANYON RESERVOIR
Santa Ana
AGUANGA
SCALE IN THOUSANDS OF FEET
LEGEND
EXISTING FACILITIES
PROPOSED LOAN PROGRAM (PL-984) PIPELINES PHASE I
PROPOSED PIPELINE PHASE II
PROPOSED WETLANDS DEMONSTRATION & RESEARCH SITES
RIVERSIDE COUNTY

The five phases identified correspond to a discrete sequence of activities envisioned for each of the wetland demonstration sites as follows:

Phase I	Conceptual Design
Phase II	Predesign Investigations (and Environmental Assessment/Environmental Impact Statement work)
Phase III	Final Design (and permitting)
Phase IV	Construction of Demonstration Facilities
Phase V	Operations and Monitoring.

The five phases pertain to the conventional engineering development stages rather than distinct types of research studies. The project was initially conceived as a combined research and demonstration effort. As such, the project is comprised of applied science and engineering principles as required to construct wetland facilities while attributes are incorporated to increase the value of the wetland facilities by allowing investigations into the principal topics of interest.

Although three sites were identified in the Phase I Report, most of the subsequent investigation and design efforts have been focused at the Hemet/San Jacinto site. Work at Little Valley and the San Jacinto Wildlife Area sites has progressed more slowly due to the need to conduct more extensive hydrogeological and environmental investigations and to expand the water resource management objective for these areas.

Plans for the Hemet/San Jacinto RWRF site have progressed through the Phase II preliminary design investigations and the Phase III final design. Construction plans and specifications have been completed, and construction began during the winter of 1993. Planting of the wetlands vegetation began in mid-August and will be complete in December 1994. Planting plans for the terrestrial areas of the site are currently in preparation and will likely be implemented in late 1994.

Phases II and III also marked the construction of two wetland nursery cells, which were built and planted for the purpose of providing plant stock for the pilot- and full-scale wetland demonstration facilities. Eight research cells have been fully established, and the first series of pilot-scale research investigations was initiated. Both of these facilities were constructed at the Hemet/San Jacinto site. A pilot-scale RO system and saline marshes and evaporation cells to utilize the RO reject water were built at this site to allow research into ground-water remediation feasibility.

PURPOSE OF REPORT

This Phase II/III Report covers the activities which have taken place since completion of the Phase I Report, dated November 1991. Although several papers have been written and presented on the work which has occurred since then (see Appendix H), the major report which has been issued as part of the study is the Design Concepts and Criteria Report, dated 1993, which served as guidance and direction for final design of the Hemet/San Jacinto demonstration wetlands.

As a result, this Phase II/III Report covers a relatively long period of activity, and it serves several purposes. It is acting as a status report for the EMWD/USBR/NBS cooperative study, a scientific report on the preliminary research results, and a documentary report on the final design and public involvement activities.

The Multipurpose Wetlands Research and Demonstration Project will be completed in September 1995. A Phase IV Report will document the project activities and events through the construction of the demonstration facilities at the Hemet/San Jacinto site. A final report will present findings of the research investigations and the conclusions pertaining to demonstration issues such as the overall feasibility and cost effectiveness of multipurpose constructed wetlands, a summary of what was learned, and recommendations for project planning, design, construction, and operations of wetlands as part of water resources management.

One of the objectives of this study is to provide useful information on the costs to design, build, operate, and maintain the wetland facilities. Financial information will be included in the final report. By that time, the Series 2 monitoring at the research facility will be complete as well as construction and planting of the Hemet/San Jacinto Multipurpose Constructed Wetlands demonstration system. In addition, a monitoring program for the demonstration system will have been implemented.

Once the present study is complete, there will still be many opportunities for further investigations at both the research facility and the demonstration facilities. This may occur through cooperative research agreements between EMWD and other agencies or universities or through grants, loans, or volunteer programs. For example, EMWD, USBR, and the United States Geological Survey (USGS) are cooperating in an effort to characterize the total organic carbon entering and leaving the wetlands. Other areas of interest are virus removal, toxicity reduction, biodiversity, nutrient removal, nonpoint source treatment, habitat enhancement, and public recreation and education. Many other possibilities exist which can be pursued as funds become available.

This report presents activities undertaken in the Phase II task orders, status of final design for the Hemet/San Jacinto site demonstration wetlands, and results of ongoing research investigations at the joint wetlands research facility. Also included are activities related to public involvement and other pertinent information concerning this project.

CHAPTER 2
SUMMARY OF PROGRESS

CHAPTER 2

SUMMARY OF PROGRESS

TASK ORDER NUMBER 1

Most activities comprising Phases II and III were completed through an agreement and two task orders among EMWD, USBR, and NBS. The task orders established a means for accomplishing items necessary to the multiple objectives of the program. The status of each task item included in the first two task orders is briefly described in this section.

Not all project activities were accomplished through these task orders. For example, the final design work was completed by the design consultants, and the design review and coordination was accomplished directly without task orders. The results of these efforts are presented in the summary of the Hemet/San Jacinto site final design in Chapter 3.

Task No. 1.1, Wetlands Nursery Cells

As the initial stage in the EMWD/USBR/NBS Multipurpose Wetlands Research and Demonstration Project, two 0.2-ha (0.5-ac) nursery, or plant propagation, cells were constructed during the first half of 1991. These cells provided a facility for propagating bulrush for later use in research and demonstration projects and for determining effective and practical planting techniques. Secondary-treated reclaimed water from the Hemet/San Jacinto RWRF was piped into the nursery cells at an average flow rate of approximately 56.8 liters per minute (L/min) (15 gallons per minute (gal/min)) per cell.

Between July 1 and 10, 1991, California bulrush and hardstem bulrush were harvested from four local donor marshes, and some bulrush were also purchased from a native plant nursery for the establishment of the nursery cells. Several methods were utilized in planting the bulrush to determine the best methods for later harvesting and transplanting. One objective was to generate enough plant material in the nursery cells to later vegetate the larger-scale demonstration wetlands. The staking of bulrush clumps to the soil surface followed by immediate flooding was determined to be the best method of transplant, the least labor-intensive, and the most cost-effective, while achieving a high survival rate and rapid propagation. In addition, other wetland plants and indigenous riparian plants were introduced into the nursery cells to test their adaptability and survivability.

Water quality within the nursery was monitored for 8 months to gain an early indication of how effectively the planned wetland system would improve the quality of

EMWD's reclaimed wastewater. Additionally, samples of benthic invertebrates were collected to obtain basic information on development of the invertebrate community in the system. These data can give an indication of system developmental rate and status as well as food availability for wildlife that might be expected to use the demonstration wetlands. Mosquito larvae production was also monitored in the nursery; the resulting data will have public health implications for all future wetlands development.

California bulrush taken from the southwest corner of the north nursery cell was used to plant the eight research cells from September 2 to 9, 1992. Since then, that area of the nursery has completely revegetated itself. During the summer of 1994, plant material in the nursery will be used to vegetate the full-scale demonstration wetlands.

Task No 1.2, Research Cells

EMWD/USBR/NBS personnel designed eight wetlands pilot cells for the joint research facility during the spring of 1992. Construction began on June 24, 1992, and the completed cells were planted with California bulrush from the nursery cells from September 2 to 9, 1992. The Series 1 monitoring program began 6 weeks after planting, on October 20, 1992.

The objectives of the Series 1 monitoring program were to document the processes by which the research cells became established as operational water treatment/habitat units and to determine the degree of variability between the three-phase and one-phase cells and among the cells within each type. Monitoring activities were focused on four aspects of cell establishment: vegetation establishment, sediment-water interactions, development of the macroinvertebrate communities, and water treatment functioning.

Initial plans called for the Series 1 monitoring program to continue through April 1993, but heavy winter rains and flooding of the cells forced the suspension of all monitoring activities from February 11 to May 5, 1993. The Series 1 monitoring program was extended, as Series 1A, from May through October 1993 in an effort to compensate for the data lost during the rainy season.

The Series 2 monitoring program is currently under development and will be included in Task Order Number 3 between EMWD, USBR, and NBS. Recommendations for Task Order Number 3 are contained in Chapter 4.

Task No. 2.1, Wetlands Baseline and Planning Investigations

Baseline investigations were undertaken to establish initial conditions for use as a reference in future research at demonstration wetlands. In addition, planning investigations addressed topics which affected the design development, such as

PHOTO 2. HARVESTING CALIFORNIA BULRUSH FROM DeVUYST DRAIN FOR PROPAGATION (NURSERY) CELLS

PHOTO 3. PLANTING THE NURSERY CELLS WITH TLC

PHOTO 4. PLANTING NATIONAL CITY'S BARE ROOT UNITS IN NURSERY CELL

PHOTO 5. PLANTING RESEARCH CELLS; CALIFORNIA BULRUSH STAKED CLUMPS

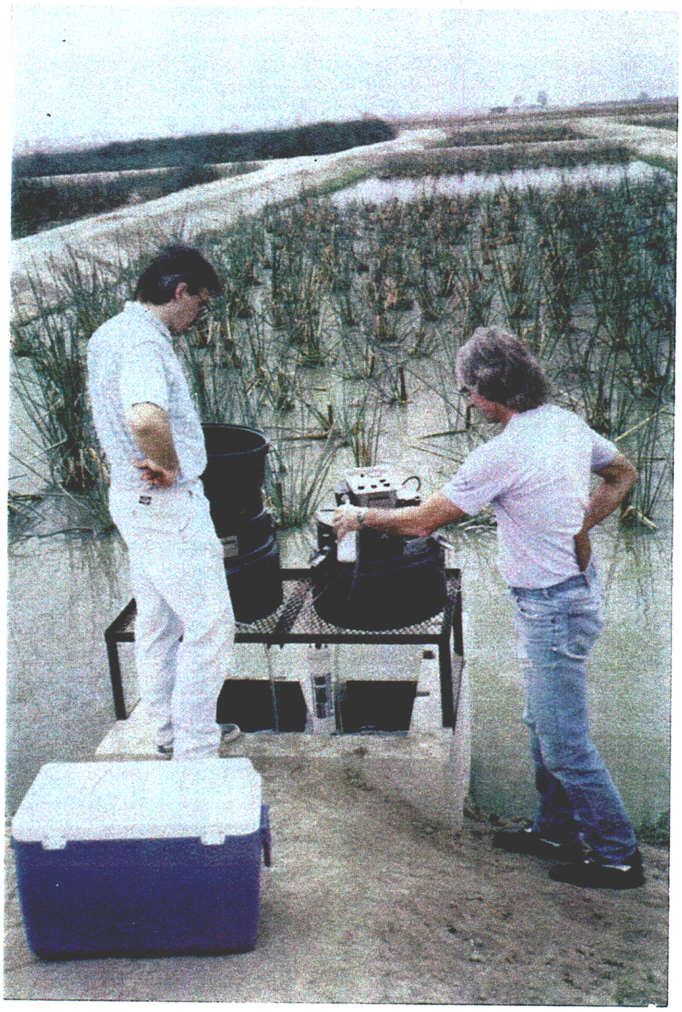


PHOTO 6. SETTING UP WATER QUALITY SAMPLES IN RESEARCH CELLS

PHOTO 7. COLLECTING PLANT GROWTH DATA IN RESEARCH CELL

defining planting, landscaping, and monitoring/testing needs. As such, these activities directly supported the planning of wetland facilities to achieve fundamental wetland system functions, while allowing specific features to be adjusted or integrated for research purposes. Four subtasks were identified to accomplish these tasks:

1. *Wetlands Study and Monitoring Program:* The intent of this task was to identify critical research and demonstration issues as they might affect the incorporation of distinct facilities or features into the demonstration system design. Consideration also included a determination of which types of wetland issues should be investigated at the demonstration sites and the research cells. These issues were presented to the TAC to gain a broad-based perspective of critical issues concerning constructed wetlands. This effort helped to delineate the types of studies appropriate for different facilities, to establish an experimental plan for the initial stages of research, and to answer critical issues regarding preliminary design development of the Hemet/San Jacinto site demonstration facilities. A monitoring and research program will be developed for the Hemet/San Jacinto site within the next year.

2. *Soils Investigations:* These specific investigations were intended to examine and evaluate the potential interactions of the Hemet/San Jacinto site soils with the reclaimed water supply for the wetlands system. Some initial field testing was completed using the nursery and pilot wetland facilities for these studies. There was no indication that wetlands could not be sustained by using reclaimed water at the site, or that constructed wetlands would pose harmful consequences to wildlife that would exceed ambient conditions associated with the supply water and site soils. Transformations and soils characteristics may be researched through ongoing studies; however, the feasibility issues associated with water and soils were considered to be addressed through these investigations.

3. *Vegetation and Propagation Studies:* These studies were intended to determine the appropriate and desirable plant communities for use within the Hemet/San Jacinto wetlands and on the surrounding terrain. The effort also included examination of different methods to propagate large quantities of emergent vegetation as required to initiate vegetation growth in full-scale wetland systems and assessment of the methods to transplant plant materials. Seed germination experiments were conducted, and the growth of plants established by various techniques was monitored in the nursery facilities. A determination was made that staking bulrush clumps prior to flooding is the most effective method of establishing the bulrush communities in the marsh areas. Other plants can be established according to individual needs. A tentative planting plan was developed for both the

terrestrial and wetlands plant varieties to be used in the Hemet/San Jacinto wetlands facilities.

4. *Wetlands Preconstruction Investigations:* The major objective of this task was to identify baseline studies which were needed before proceeding with final design and construction of the wetlands system at the Hemet/San Jacinto site. Included was a review of the wetlands conceptual design in relation to site plans, to evaluate any site characteristics which might be affected by the proposed wetlands system, and to determine a course of action for initiating studies or establishing interim plans to coincide with the ongoing final construction planning. The review of site conditions was simplified by the decision to build the wetlands system within a 19-ha (47-ac) site area that had been used previously as a reclaimed water storage facility. The baseline investigations were largely restricted to consideration of converting open storage ponds and surrounding berms and roads to a constructed wetlands with multipurpose attributes. Existing wildlife use of the proposed site was considered moderate and was predominantly identified with waterfowl using the adjacent duck-hunting club ponds, migrating shorebirds, or songbirds primarily attracted to other parts of the RWRF, or small mammals immigrating onto the site from surrounding agricultural land and fence row habitat.

Research and wetlands system issues will be reviewed during the next year to assemble more detailed plans for monitoring and research to be undertaken at the Hemet/San Jacinto site. As the demonstration program progresses, studies are likely to be continually reviewed and adjusted, as appropriate, to address important objectives within research funding capabilities.

Task No. 2.2, Wetlands Preliminary Design Engineering

This task consisted of preliminary design engineering investigations as required to proceed with final design and preparation of the construction plans, specifications, and contract documents for the Hemet/San Jacinto Multipurpose Constructed Wetlands. Five subtasks were identified to complete the preliminary design engineering:

1. *Engineering Review of Wetlands Systems:* This subtask included review of the wetlands conceptual design and additional information available to ensure that the design direction remained consistent with the full-scale demonstration project objectives. Once the overall constraints to design were established, specific engineering issues were resolved pertaining to the hydraulic systems, site earthwork, and ancillary features comprising the complete multipurpose wetlands system. The intent was to compile all information and findings necessary to allow preparation of final design plans for the construction of all wetlands system components and features.

2. *Geotechnical Investigations:* Site-specific engineering issues pertaining to the properties of site soils were addressed by completing field and laboratory geotechnical investigations. Due to the specialized nature of these investigations and logistical considerations, these investigations were accomplished by contract to a certified professional geotechnical engineering firm. The results and findings of these investigations are presented in a report prepared by Inland Foundation Engineering, Inc., in 1993. The contract was completed, and results of these investigations were used to evaluate two major wetlands engineering issues, namely: (a) the suitability of site soils for earthwork construction, including creating designed slopes, grades, and structural backfill considering the implications of wetlands development; and (b) the ability of site soils to retain water within the wetlands system considering operational objectives and relevant regulatory constraints. These results were used in final design and in consideration of site monitoring wells.

3. *Preliminary Design of Wildlife Features:* Development to a preliminary design level was required due to the specific nature of these features and the potential need to convert biological requirements into distinct engineering terms for use in final design construction plans. The majority of this work centered on details for features that were added to the basic wetlands design. For example, the size, shape, grade, and location of islands, shallow pond zones, and moist-soil areas were all defined to an appropriate level of detail. Design requirements to achieve specific conditions, the practical constructibility, and cost factors were considered in each case. Results were incorporated into the final design criteria and recommendations.

4. *Surveying and Mapping:* Site surveying and preparation of base topographical maps were both accomplished by EMWD. Site surveys were delayed for some time due to water on the site area following the heavy rains during the winter of 1993. Surveys were completed, and base sheets were prepared in digital form for transfer to the final design team.

5. *Preliminary Site Engineering:* This subtask included identification of all remaining concerns to be addressed prior to proceeding with final design. Specific items identified were: (a) location and assessment of utilities that would be affected by the wetlands project; (b) review and assessment of applicable land ownership and right-of-way considerations; and (c) consideration of a land-use master plan for the entire Hemet/San Jacinto RWRF property with respect to the possibility of integrating the wetlands demonstration project with other facilities on the property. All potential utility and ownership issues were resolved and recorded for reference in final design. Development of a master plan was considered;

however, existing site constraints and future needs for storage of reclaimed water within the property precluded development of a master plan within the timeframe of this wetlands demonstration project.

The major product of this subtask was a report entitled Design Concepts and Criteria Report, prepared by EMWD and USBR, June 1993. It includes the critical design information pertaining to site engineering, wetlands system design, and landscape and planting features. The geotechnical investigations report, certification of property ownership, and draft instructions for planting wetland vegetation are included as appendices to the report. For purposes of this project, this report serves as the preliminary design engineering report to provide design constraints and criteria to guide final design. It was transferred to the final design team as a basis for preparing construction plans and specifications for the Hemet/San Jacinto site wetlands demonstration system.

Task No. 2.3, Preliminary Environmental Regulatory Review

Task No. 2.3 consisted of a preliminary review of National Environmental Policy Act and California Environmental Quality Act (CEQA) requirements for demonstration wetlands at three sites.

An initial study and CEQA negative declaration for the Hemet/San Jacinto wetlands facility was adopted by EMWD's Board of Directors on April 7, 1993. The analysis was simplified by the fact that the site had previously served as a reclaimed water storage pond.

Biological and archeological field surveys for the Little Valley site have been completed. The biological survey of Little Valley found that the 12.4 ha (30.6 ac) in the central floodplain portion of the property is relatively constraint-free except for the small amount of existing wet habitat (recharge area). In contrast, the surrounding uplands support primarily coastal sage scrub, a plant community recognized as highly sensitive by local, State, and Federal resource agencies. Any impacts to coastal sage scrub may require mitigation in the form of revegetation or off-site habitat acquisition coupled with the dedication of that habitat to open space. Potential impacts to the limited amount of wet habitat in the center of the site could be mitigated by the creation of wetland habitat associated with the project and yield a net benefit for wetlands.

The cultural resource assessment of Little Valley found a large archeological site in the southwestern corner of the property which would not be impacted directly by the wetlands. However, the site is vulnerable to indirect impacts such as erosion and unauthorized collection of artifacts. These could be mitigated by restricted public access, fencing, and erosion control measures. A Phase II cultural resource assessment is planned to collect more information.

A CEQA Notice of Exemption was obtained for the performance of predesign investigations at Little Valley on August 6, 1993. It covers geophysical and geohydrological studies at the site. These studies will provide scientific information needed to design the wetlands and recharge areas.

Discussion of a potential wetlands location in the San Jacinto Wildlife Area was included in an Environmental Impact Report/Environmental Assessment prepared by K. S. Dunbar and Associates in September 1990.

Further environmental regulatory review work is necessary for both the Little Valley and San Jacinto Wildlife Area sites. However, these sites are no longer part of the EMWD/USBR/NBS Cooperative Research and Demonstration Study, and they will be addressed separately by EMWD.

Task No. 3.1, Investigations and Planning of Ground-water Recharge

This task included examination of factors concerning the feasibility of recharging ground-water aquifers, especially with respect to the use of wetlands-treated reclaimed wastewater. The investigations considered the use of several different ground-water formations in the area, including recharge of water to augment local ground-water resources and the potential for remediation of poor quality ground-water supplies within the EMWD area. This included a review of data and information available pertaining to the major ground-water basins, characteristics of selected recharge sites for either passive percolation or injection recharge, and the prevalent regulatory and public health implications. Also included was an evaluation of current information and the application of computer modeling to address the recharge and aquifer characteristics.

Application of specialized computer models was deferred due to the limited information available to address the complex geohydrology over relatively extensive and undefined aquifer formations in the area. The selection of an appropriate model may depend on the quality of recharge water sources. As a result of early investigations, the focus of this task shifted to evaluation of distinct feasibility issues concerning recharge of wetland-treated water in general and to examine the potential for recharge of alternate fresh and reclaimed water sources at Little Valley.

Investigations of the Little Valley site were to consider the subsurface characteristics which could affect the ability to recharge defined aquifer basins of interest. Recommendations for a geophysical testing program were prepared to guide the collection of information required to address unknown aspects of the Little Valley site. While these specific geophysical investigations were not undertaken as part of this task, a seismic reflection survey of the site was completed by the USGS in August 1993. Preliminary results indicated that the direction of subsurface water flow may be toward a less desirable ground-water basin than was expected. Specific field exploration testing is planned to confirm these initial findings. A cost estimate and specifications for these field tests were also submitted as part of this task. Further geophysical/geohydrologic investigations are beginning in June 1994 under an agreement between EMWD and USGS.

California has produced draft guidelines for recharge of reclaimed water at the time of this task. The draft guidance provides specific criteria for recharge effects on ground-water resources and blending requirements in proportion with the organic carbon content of the water source. As written, the organic carbon issue may have strong implications on the feasibility of recharge with wetland-treated water. These topics will warrant close attention as the final regulations are established.

Task No. 3.2, Wetlands Impacts on Ground-water Aquifers

A topic related to ground-water recharge is the impact of wetlands development on ground water and geologic formations. This includes the effects of seepage losses from wetlands, inadvertent recharge, chemical interactions with ground water, and the potential for seismotectonic damage from either injection or percolation. The emphasis here was on the Hemet/San Jacinto site since this site will be the first to have a full-scale wetlands demonstration system established. The major objective of this task was to evaluate the issues concerning seepage from the wetlands and the possible interactions of wetland water with ground water. Issues related to injection technology were not considered in detail as part of this task. These issues warrant specialized investigations in the event that injection operations are considered for any application.

However, the Hemet/San Jacinto wetlands site has been permitted for several years by the California Regional Water Quality Control Board for storage of reclaimed water. Reports from EMWD and the May 1993 geotechnical investigations by Inland Foundation Engineering, Inc., have indicated that seepage is negligible. USBR recommended that monitoring wells be installed at the Hemet/San Jacinto site to provide information for analysis of effect of the wetland pilot plant on ground-water conditions. Based on the assumption that the demonstration wetlands would not be likely to exhibit effects on the ground-water resources that would be appreciably different from those associated with storage of reclaimed water, and since the volume of water in the wetlands would be considerably less than was historically stored, plans for construction of the wetlands were finalized without inclusion of ground-water monitoring wells.

Task No. 4.1, Saline Marsh System

A pilot study was undertaken at the wetlands research facility to evaluate the use of RO desalting for improving the quality of brackish ground water in the Lower San Jacinto Ground-water Basin to potable standards and also to evaluate the use of RO

PHOTO 8. REVERSE OSMOSIS UNIT

PHOTO 9. SALINE VEGETATED MARSHES AND NONVEGETATED EVAPORATION PONDS

reject brine for the support of salt-tolerant emergent vegetation. The benefits derived from the successful demonstration of these goals would include the reduction of RO reject brine volume through plant transpiration and evaporation (evapotranspiration) and the creation of irrigated greenbelts, open spaces, and habitat areas.

The pilot facility consists of an RO treatment unit, two saline vegetated marshes, and two non-vegetated evaporation cells.

Task No. 4.1 dealt with the saline marshes and evaporation cells. (Task No. 4.2 dealt with the RO system). Task No. 4.1 consisted of four parts: (1) research and design; (2) construction; (3) planting; and (4) monitoring. Parts 1, 2, and 3 have been completed. Monitoring will continue for at least one more year to measure the long-term effects of saline marsh operation on the biota. This will be done as part of the cooperative research and demonstration program under a future task order (Task Order Number 3) or independently by EMWD.

Two 12.2-meter (m) by 24.4-m (40-foot (ft) by 80-ft), lined vegetated cells (saline marshes) and similarly-sized, lined, non-vegetated evaporation cells were constructed in April 1993 under the same construction contract as the wetland research cells. The piping system for the saline marshes and evaporation cells were installed by EMWD crews. The marshes were planted with four salt-tolerant species on April 27 and 28, 1993, by EMWD/USBR/NBS staff. The plants received fresh water to promote establishment for 6 weeks; reject brine from the RO unit was first added June 7, 1993.

During peak evapotranspiration periods in the summer of 1993, the addition of 4.7 cubic meters (m^3) (1250 gal) of reject brine each weekday was insufficient to keep both saline marsh cells continuously wet. Therefore, beginning on September 20, 1993, 9.4 m^3 (2500 gal) of potable water from a local fire hydrant was added weekly to the north cell. The south cell continued to receive the reject brine through February 1994.

Operation of the RO unit for 2 weeks at the beginning of February 1994 was hindered by rain, making the road to the RO unit inaccessible to the water hauling truck. After the rains, road regrading work was performed by EMWD crews. An electrical failure at the well supplying the RO unit also caused a brief shutdown while EMWD electricians made repairs. The ownership of the well supplying water to the RO unit suddenly changed in February 1994, and water could not be pumped from the well after February 23, 1994. Negotiations to form a license agreement with the attorney for the new owner have taken longer than anticipated. From approximately February 24, 1994, until the present (June 1994), the RO system has been shut down, and both saline vegetated marshes are being supplied by the winter rains or fresh water from a nearby fire hydrant. At the time of this writing, the trustee for the new owner of the well is reportedly close to signing the new license agreement.

Task No. 4.2, Reverse Osmosis Water System

Twelve subtasks were associated with Task No. 4.2, as follows:

a. Design RO pilot plant; select membrane elements to be tested;
b. Conduct bench-scale tests to evaluate pretreatment alternatives;
c. Procure process equipment, instrumentation, and membrane elements;
d. Fabricate RO test skids and assemble pilot plant;
e. Document operation and maintenance (O&M) procedures; prepare test plan and data sheets;
f. Perform shakedown testing at the Denver laboratories;
g. Complete test site preparation;
h. Ship pilot plant to test site;
i. Installation at the site, plant start-up, and operator training;
j. Complete testing and evaluation of RO membranes; lab analyses;
k. Prepare final report;
l. Continue operation in support of saline marshes; and lab analyses.

Of the 12 subtasks listed above, the first nine have been completed. The first five were accomplished at USBR's Denver laboratories. Site preparation (concrete slab and shade structure) was performed by EMWD personnel. The shipment, installation, and start-up of the pilot plant equipment and training of an EMWD operator were completed by the end of April 1993. Subtask 4.2(j) began on May 3, 1993, and is within 4 months of completion. Subtask 4.2(k) will be accomplished following the completion of membrane testing. Subtask 4.2(l) will continue for approximately another year.

Operators from EMWD are charged with the day-to-day operation of the RO pilot plant. They operate and maintain the system, in accordance with the system O&M manual, and collect data. Overall direction for the RO test program is provided by USBR's Denver Office.

Subtask 4.2(b), "bench-scale testing", was conducted in anticipation that RO operations were to be performed using the Walker Duck Club well water. It consisted of laboratory experiments to evaluate brine-regenerated ion exchange as a pretreatment process. Because of the high concentrations of calcium and bicarbonate in the Walker Duck Club well water, it would have been necessary to add a considerable amount of acid plus anti-scalant to avoid the precipitation of calcium carbonate in the RO membranes. Ion exchange experiments were conducted using a strong acid cation exchange resin operated in a sodium cycle to remove calcium. Regeneration of the resin was attempted using a brine solution synthesized to duplicate the anticipated RO reject brine. These experiments were completed in April 1992, and the results were documented in a May 1992 memorandum report to EMWD from USBR. Subsequent to these experiments, the Walker Duck Club well was abandoned as a potential RO feedwater source because of severe flooding and access problems.

EMWD located another well known as the Moreno Highlands well. This well was determined to have acceptable water chemistry. It is located in the lower San Jacinto Ground-water Basin, as was the Walker Well, but it is more accessible.

TASK ORDER NUMBER 2

Task No. 1.1, Hemet Invertebrate Sampling

The primary objective of the invertebrate sampling program was to provide evidence of the establishment of equilibrium conditions within the research cells. This information would support or refute the water quality and plant establishment studies. Secondary objectives were to: (1) document the pattern and pace of development of the invertebrate communities in order to gain insight into the invertebrate communities likely to develop within the demonstration wetland; (2) to develop or refine invertebrate sampling procedures for experimental work in the research cells; and (3) to develop procedures for monitoring the demonstration unit.

Samples of benthic macroinvertebrates were collected on three occasions during 1993 using two different methods. There was no evidence of equilibrium establishment within the sampled community, and the sampling problems encountered have led to significant revisions in proposed methods to be employed in the demonstration wetlands.

Task No. 1.2, Electrical for Reverse Osmosis Pilot Plant

Installation of electrical service for the RO pilot plant was successfully completed in April 1993. This service will also serve the pumping plant for the Hemet/San Jacinto RWRF site demonstration wetlands in the future. To provide the 1200-volt, 200-amp service, EMWD dug a 975-m (3200-ft) trench from Sanderson Road to the RO facility, and Southern California Edison laid the cable.

Task No. 1.3, Hemet/San Jacinto Site Geotechnical Investigations

This task was a continuation of the geotechnical investigations undertaken in the first task order. Task No. 1.3 consisted of coordination with the geotechnical subcontractor, a review of the results and findings for incorporation into the final design, and in consideration of the need for site monitoring wells.

The geotechnical investigations were conducted by Inland Foundation Engineering. They included five borings between April 5 and 7, 1993. The borings were made to depths ranging from 15.7 to 16.9 m (51.5 to 55.5 ft). Standard penetration tests were conducted during drilling at approximate 1.5-m (5-ft) intervals, and selected samples were tested to determine moisture content and dry unit weight. Ground-water levels determined during drilling ranged from 3.8 to 6.6 m (12.5 to 21.5 ft). The report prepared by Inland Foundation Engineering, Inc., Geotechnical Testing, Wetlands Demonstration Unit, Hemet/San Jacinto Treatment Plant, San Jacinto Area, Riverside County, CA, dated May 21, 1993, was reviewed and evaluated by USBR staff (Appendix A). The report indicated that seepage losses from the ponds were expected to be minimal and that the proposed facility would not be expected to have any significant effect on underlying ground water. Absent concerns on seepage from the ponds, no additional geotechnical activities are being considered for the site.

Task No. 1.4, Hemet/San Jacinto Site Final Landscape Design

Landscape design plans were prepared by USBR personnel for the upland site areas outside of the main wetlands system footprint. Originally, the landscape design included both the landform contours for the upland areas and the vegetation planting and seeding plans for the area. The decision was made to separate the contract for this landscape work from the construction contract for the wetlands system. The conceptual landscape grading plan was incorporated into the final design for site earthwork construction, and plans for the landscape planting, the public overlook area, and other site amenities were developed separately. USBR's landscape architect has completed final landscape plans. The landscape features will be installed after the wetlands system construction is completed. The upland planting plan consists primarily of seeding native, drought-tolerant varieties over most of the site land area, with more intensive planting of selected shrubs and trees in areas near the public overlook and riparian areas. This plan is being revised and finalized. Provisions required for temporary or permanent irrigation systems will have to be developed prior to installation of the upland planting.

Task No. 2.1, Little Valley Pilot Wetlands

The 43.7-ha (108-ac) Little Valley site is located southeast of the City of Hemet. The site is well-suited for a constructed wetlands demonstration project related to ground-water remediation and recharge while fulfilling the multipurpose objectives of the cooperative study. An excellent opportunity exists for using wetlands to treat nitrate-contaminated ground water collected from adjacent agricultural (citrus) areas and then percolate the denitrified water into local aquifers. The natural setting and ease of public access also provide an ideal opportunity for integrating park, open space, and public education/passive recreation elements with wetlands development to achieve water resource management objectives.

A preliminary conceptual design for a pilot wetlands at Little Valley was included in the Phase I Report. This concept has been revised, resulting in several possible variations of water treatment wetlands which would blend more with the natural environment. The two main proposals were to use either upflow gravel filters or horizontal subsurface flow plant beds to achieve a cienega effect while providing denitrification. Either the filters or the submerged beds would create a zone of saturated soil and allow an upwelling effect similar to that found in a natural cienega. The water would surface and flow through a riparian zone and a recharge zone.

Since ground-water recharge with wetlands-treated water is envisioned at Little Valley, detailed ground-water investigations are necessary. To enable evaluation of recharge characteristics and ground-water flow, a geophysical investigation was performed consisting of running several seismic lines across the valley. It yielded information on depth to bedrock and slope of bedrock, which was used to determine ground-water flow direction. An agreement has been developed with the USGS to perform additional geophysical and geotechnical work, including drilling several test holes and monitoring wells. With this information, a site plan can be developed.

The EMWD/USBR/NBS Cooperative Research and Demonstration Study Executive Committee determined that time and funding constraints made it necessary to put the Little Valley Project on hold while concentrating on the successful completion of the Hemet/San Jacinto Multipurpose Constructed Wetlands. In the interim, EMWD is continuing with the hydrogeological work and environmental compliance documentation.

Task No. 3.1, Hemet/San Jacinto Site Demonstration Wetlands Development

The purpose of this task was to assemble technical information for use as a guide in the final design of the Hemet/San Jacinto Multipurpose Constructed Wetlands. Activities centered on the gathering of information to produce a set of instructions, criteria, and constraints, as a basis for writing the contract specifications, rather than the actual writing of the contract documents. This task was a follow-up to the preliminary design activities cited previously in Task No. 2.2 of the Task Order Number 1 summary. The activities also included initial coordination with the final design engineering consultant in preparation for proceeding with the final design process. The two subtasks identified are briefly described as follows:

1. *Construction Specifications:* Materials compiled to define the final design construction plans and specifications were presented in the Design Concepts and Criteria Report previously cited. The reader is referred to this report for specific details regarding the criteria imposed on the final design process. Upon completion of final design, the construction plans and specifications were reviewed and approved by EMWD and USBR staff prior to release for competitive bidding and contracting procedures.

2. *Planting Specifications:* Technical information regarding planting of the wetlands vegetation was compiled as a basis for preparing contract documents for this work. The decision was made to separate the construction work from the planting contract, due to significant differences in the nature of the work, and to simplify the scheduling and coordination of site work activities. Draft specifications, prepared by EMWD and USBR, have been completed. Final specification and contract documents were completed in July 1994.

CHAPTER 3
SUMMARY OF FINAL DEMONSTRATION WETLANDS DESIGN

CHAPTER 3

SUMMARY OF FINAL DEMONSTRATION WETLANDS DESIGN

HEMET/SAN JACINTO SITE FINAL DESIGN

Description

The 19-ha (47-ac) Hemet/San Jacinto Multipurpose Constructed Wetlands site, located at the northwest corner of the Hemet/San Jacinto RWRF, will focus on reclaimed water treatment, migratory and resident waterfowl and shorebird habitat enhancement and wildlife diversity, and public education and recreation. Funded with SRPA (Public Law 84-984) loan funds, this cooperative effort among EMWD, USBR, and NBS is an innovative use of multipurpose constructed wetlands in a comprehensive water resources management program which will greatly benefit the local area as well as other regions of the country.

Final Design Process

The design is a three-phase integrated system consisting of five separate wetlands treatment units, a combined open water and marsh habitat area, and a final polishing wetland. The basic 3785 m^3/d (1 Mgal/d) integrated system occupies approximately 10 ha (25 ac) of the site. The system concept is based on marsh and pond areas sized to achieve certain retention times within the desired water depth and configuration. Secondary reclaimed water from the Hemet/San Jacinto RWRF will be distributed to the five wetland treatment units, or arms, then will be recombined in the central area to flow through the open pond prior to flowing through the final polishing wetland. The larger final wetlands will combine all flows to remove biological input produced in the open water habitat area. From the air, the system is "amoeba-shaped" and, on the ground, the curved lines give the appearance of a natural system.

Wetlands for wastewater treatment have received widespread interest as communities nationwide attempt to solve water and wastewater management problems. In existing treatment wetlands, the final step in the treatment process is disposal, and the wetland is designed with the single purpose of treatment in mind. This project introduces a new application; it is truly multipurpose--incorporating water treatment, recovery, and reuse with wildlife values, public education and recreation, and enhancement of environmental resources.

Wildlife Features

Included in the design are as follows:

1. A habitat-intensive central pond isolated from operational activities at the inlets;

2. Two types of moist soil areas to evaluate feasibility and wildlife values;

3. Islands to provide habitat and assess the wildlife value and constructibility;

4. Pond bench and riparian areas to increase shoreline habitat and allow for specialized vegetation studies;

5. Public amenities and access features designed to minimize interference with wildlife while allowing viewing, public education, and recreational opportunities; and

6. A landscape plan, including seeding with native grasses and selective planting of trees and shrubs.

Water Resources Design Considerations

Included to improve water quality performance of the system are the following:

1. A three-phase, marsh-pond-marsh system with directly-connected components;

2. Inlet marshes sized according to process functions and having an elongated shape to promote even flow and localize intensive treatment near the inlets;

3. Faster flow rates in the open pond and outlet marsh areas, relative to the inlet marshes, to reduce internal production and evaporation effects;

4. Arrangement of islands and planting scheme to induce even flow distribution through the marsh; and

5. Subdivision of inlet and outlet marshes to allow periodic maintenance of component areas without requiring shutdown of the entire wetlands system.

Public benefits also include education and recreation opportunities. Trails for walking and hiking, picnic areas, and areas for wildlife viewing and bird watching are planned. Interpretive centers, displays, and guided tours are included to increase public awareness of the environment, the value of reclaimed water, and respect for water as a precious and finite resource. Use of the wetlands by school children as an environmental science laboratory for the study of wetlands ecology, the local environment, and water resources is also of great importance and another public benefit.

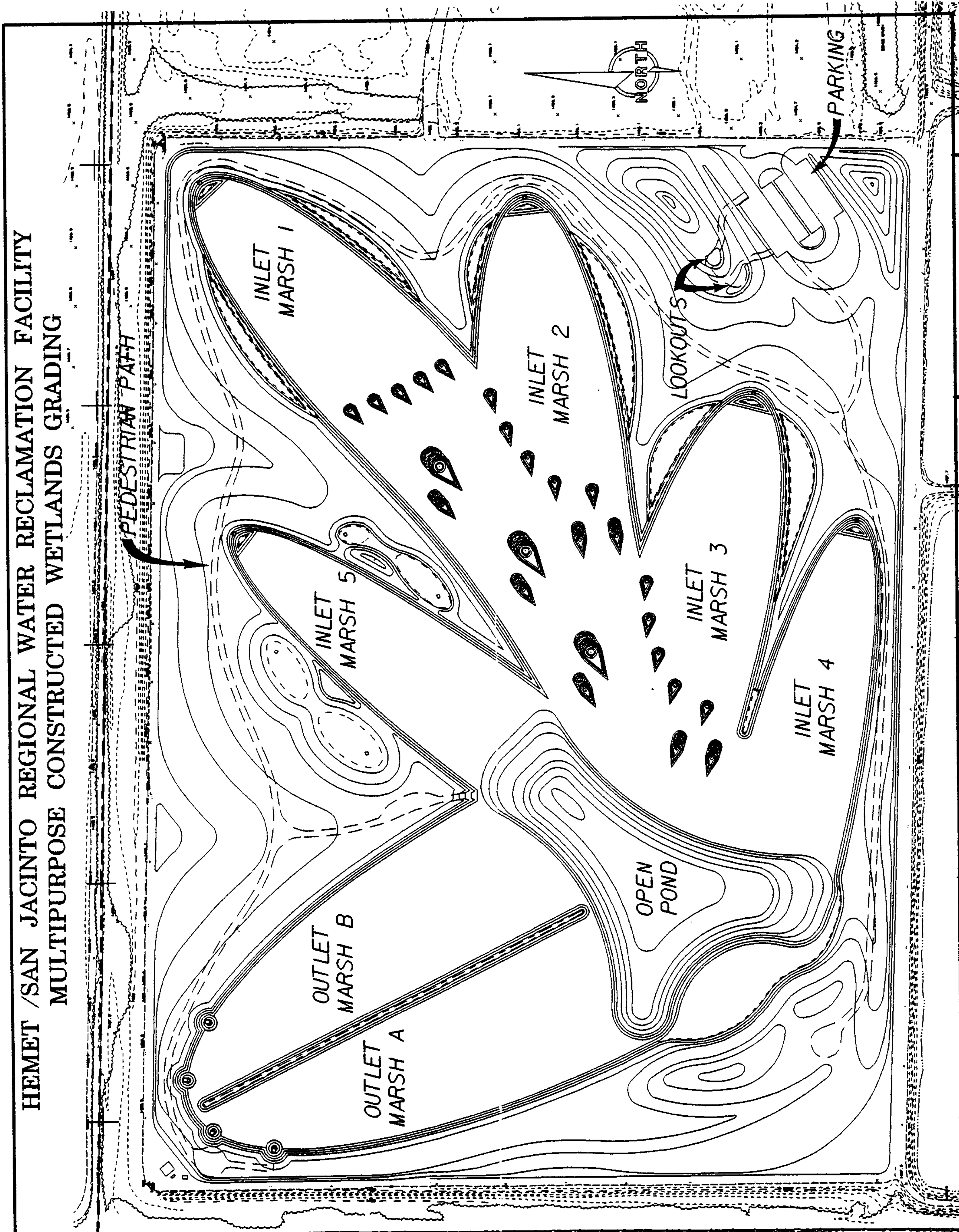
The final design and preparation of construction plans and specifications for the Hemet/San Jacinto Multipurpose Constructed Wetlands was completed by CH2M Hill, Santa Ana, California, as consultants to EMWD. An initial meeting and two progress meetings were held to coordinate the major final design topics concerning EMWD, USBR, NBS, and the consultant. Design submittals were prepared for review at the 50 percent and 90 percent completion points, and the final product consisted of construction drawings and specifications for incorporation into EMWD contracting procedures. A fourth project-end meeting was held to resolve certain design issues remaining at the 99 percent completion stage.

Coordination of final design consisted primarily of ensuring that critical design features were correctly interpreted and translated into practical construction plans. Other site-related engineering problems were also resolved through the final design collaboration. Development and coordination of final design was accomplished separately from the task items described previously. Completion of final design constitutes Phase III of the Multipurpose Wetlands Research and Demonstration Project.

It is important to note that the conceptual design development focused on functional aspects of the wetlands; consequently, water supply and conveyance facilities were defined in terms of operational constraints, from a biological perspective, rather than engineering design. The Design Concepts and Criteria Report served as the preliminary document used to translate the operational constraints and objectives into engineering terms and functions. The construction plans and specifications were prepared by CH2M Hill.

At the onset of final design, the consultants were requested to review the conceptual design plans and the results of preliminary design investigations to assess the overall engineering feasibility and the practicality of constructing the wetland features. They also employed their environmental experience when reviewing the conceptual plan. No significant flaws were identified at that time. Any issues regarding site features or system components which were not clear were addressed and resolved through the final design engineering process.

The final site plan for the Hemet/San Jacinto demonstration wetlands is shown in Figure 3-1. This figure includes refinements and adjustments made during final design and is a graphical representation of the features included in the construction plans. Note that this site plan indicates considerable modification and refinement from that illustrated in the Phase I conceptual design report, but the major conceptual design elements remain intact.


HEMET /SAN JACINTO REGIONAL WATER RECLAMATION FACILITY
MULTIPURPOSE CONSTRUCTED WETLANDS GRADING
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INLET MARSH 2
INLET MARSH 3
INLET MARSH 4
INLET MARSH 5
OPEN POND
OUTLET MARSH A
OUTLET MARSH B

FIGURE 3-1

PHOTO 10. AERIAL VIEW OF HEMET/SAN JACINTO REGIONAL WATER RECLAMATION FACILITY WETLANDS RESEARCH FACILITY

PHOTO 11. CONSTRUCTION OF DEMONSTRATION WETLANDS

PHOTOS 12 AND 13. TECHNICAL ADVISORY COMMITTEE AND EXECUTIVE COMMITTEE VISIT DEMONSTRATION WETLANDS SITE

Operational parameters and design constraints described in the Design Concepts and Criteria Report are not restated here. Significant results, changes in the wetlands design elements, and events that transpired throughout the course of the wetlands design development stages are summarized as follows:

Wetlands Configuration and Site Grading

Prior to the development of the Design Concepts and Criteria Report, a decision was made to locate the wetlands demonstration site within a specific 19-ha (47-ac) portion of the Hemet/San Jacinto RWRF site. This decision created some constraints unique to this site and not necessarily typical of future wetland sites. The earthen foundation of the site provided in situ seepage control at no additional cost, whereas other wetland sites may require the addition of a liner system, such as geomembranes, to provide seepage control. This site consisted of two abandoned, rectangular, water storage ponds, bounded on all sides by low earthen berms. The earthen site had been excavated, backfilled, and reworked many times prior to the construction of this project. Therefore, a major portion of the cost of the construction earthwork was due to the need to level, import fill, and compact the site. The size and shape of this site required a reconfiguration of the original overall wetlands system design to fit within the designated area. The final design consultants noted that the reconfiguration had resulted in changes to the size of the wetland compartments comprising the three-phase large compartment process design. This effect on fundamental process functions was considered to be within the defined range of operational control for the system.

Wetlands Base Elevation. The design elevation for the bottom of the wetlands system was a key issue since the site area was to be leveled and compacted to restore flat grades, within ± 0.03 m (± 0.1 ft), across the bottom of the wetland marsh areas. This was considered essential to promote even distribution of water flow throughout the wetlands and, thereby, enhance the effective area and volume relationships that influence the water quality transformation processes. All of the surface grades at the site, from the pond invert to the uplands contours, were tied to the base elevation of the inlet and outlet marshes invert. Thus, revisions in the base elevation caused changes in the amount of earthwork required at the site or affected the net balance between the amount of earth being imported or removed from the site. In the initial final design workshop, a final base elevation of 453.5 m (1488.0 ft) was established. It was concluded that a net import of material, from some concurrent excavation work at some of EMWD's holding ponds a short distance southeast of the site, would optimize the amount of earthwork being done in total by EMWD.

Slope Grades and Drainage. To minimize erosion of the fine soils, site slopes were held to 4 horizontal to 1 vertical (4:1) or flatter slopes. For the most part, the final site grading plans were able to accommodate this objective except in local areas where moderately steeper slopes were required to allow for access and drainage around the northeastern and western corners of the site area.

A deeper pool was added to the grading plan in the vicinity of each inlet and outlet control structure to reduce problems with plant encroachment and to allow some access space around the structures. Each control box will have an excavated zone of 1.2 m (4 ft) deep, 0.76 m (2.5 ft) below the base elevation, for a distance of 7.62 m (25 ft) from each of the inlet or outlet control structures.

Design of Marsh Areas. The overall dimensions and shape of the inlet marsh areas were retained from the conceptual design. Of the five inlet marsh compartments, the three connected inlet marsh units have 2:1 length to width aspect ratios, and the other two inlet marshes each have 3:1 aspect ratios. The designated site required that the length of the outlet marsh be shorter than the original design. The outlet marsh was split along the centerline by incorporating a dividing berm. This was done to maintain a minimum aspect ratio of 2:1 within each half of the 2.43-ha (6-ac) total area. The shape of the connecting marsh area was adjusted slightly; however, the overall size and configuration were not greatly affected.

Open Pond Design. The shape of the open pond was revised and the size increased to accommodate the site configuration. This change did not appear to compromise the functional attributes intended for the pond. The capability of draining the open pond by an installed drain and sump pipe was eliminated due to the relatively high cost and low probability of need. If the pond did need to be drained, portable pumps could handle the task.

Special Emergent Test Area. This feature was moved to the shallow bench area on the southwest bank of the open pond from its original location at the outlet end of the connecting marsh. The raised test plot posed some construction problems and concerns regarding the potential effects on water flow within the wetlands system. As a result, the new position and implementation of this feature allowed for a simpler grading plan. The planting plans were also modified accordingly. This area is currently identified on the construction plans as a "shallow bench" or "shallow emergent test area".

Island Location and Details. Spatial relationships and orientation of all islands were delineated, and coordinates were determined for construction. The height, shape, and earthwork tolerances for the islands were also reviewed and details adjusted to clarify the construction plans.

Moist Soil Test Areas. The water supply systems for the moist soil test areas were revised to better handle the proposed seasonal hydrograph for the wetlands. Some refinements were made to the dividing berms due to freeboard and earthwork geometry considerations. The berm heights were modified by dropping the heights to

76.2 centimeters (cm) (30 inches (in)) above the base elevation, which would then provide 30.5 cm (12 in) of freeboard at the design water surface, 15.2 cm (6 in) of freeboard above the design high water (winter) condition, and 7.6 cm (3 in) of freeboard above the peak operational inundation level. The type 2 moist soil test areas adjacent to inlet marsh 5 have low saddle zones between the inlet marsh and the moist soil test area. This feature allows for a different way of flooding the moist soil test area during high water times.

Permanent Location Markers. Permanent site markers will be installed to serve as reference points for use in research studies, O&M work, and to allow for visual orientation once the wetlands are fully established. A location plan was prepared to indicate the installation of markers at 30.48-m (100-ft) intervals as projected and offset perpendicularly from the centerline of each marsh area and around the remaining perimeter of the wetlands system. The exact type of marker remains to be determined. The permanent marker should be constructed out of a durable material; however, light duty or temporary markers may be used initially to lay out the planting work or for specific research studies. The permanent markers will be installed by a survey contractor upon completion of the main site construction contract.

Tie Down Posts. This refers to posts that will be installed at 15.24-m (50-ft) intervals around the margins of the open pond or marsh/pond interface. The intent of these posts is to provide a mechanism for anchoring floating features and to form a point of reference similar to the permanent markers installed around the wetlands perimeter. Since these structures need to be installed before the wetlands area is flooded, they were included in the site construction plans. The final design consists of 10.2- by 10.2-cm (4- by 4-in) wooden posts, 2.4 m (8 ft) in length, to be set upright, with 0.91 m (3 ft) buried below the base elevation.

Monitoring Wells. No ground-water monitoring wells will be installed as part of the initial site construction and development. This decision was based on the previous use of the site for storage of reclaimed water, as permitted by the State of California. This issue is also discussed in the task summary for the preliminary geohydrology investigations.

Related Site Work and Features

Several site features related to public use amenities and wildlife habitat that were indicated in the original concept design were excepted from the main site construction contract. This was done because their construction is substantially different from the type of work being done in the construction contract and the deletion of these relatively minor features would not interfere with completion of the major construction work. Only the items that had to be installed along with the construction or prior to flooding were included in the construction plans. Construction of these features will be done later by others.

Most of these features are optional, although they will enhance and contribute to the multipurpose attributes of the site. Installation of some features will be fairly simple and could present an opportunity for public and educational participation. Typical features are briefly described as follows:

Public Amenities. These could include pathways, trails, interpretive signs, displays, shade structures, viewing platforms, or other features that would enhance the public recreation, safety, and educational values of the site.

Site Facilities. A parking area, overlook, and grading to allow for access paths are already in the construction plans. Additional facilities could be installed, particularly for use in research, operational monitoring, and maintenance (for example, a portable building for equipment storage or work area). Other items might include electrical and phone lines, more lighting, or restrooms. All of these items may be installed by EMWD according to future needs and funding availability.

Wildlife Features. An initial set of wildlife features was suggested for installation at the completion of wetlands construction and planting. Only the base set of features needed to establish suitable wildlife habitat were included in the final design. As the wetlands become established, it is likely that additional features could be identified and added in support of the wildlife response to actual site characteristics.
A description of wildlife features under consideration for the site upland and wetland is summarized below.

Suggested Wildlife Amenities. The following wetland amenities are recommended for consideration, subject to availability of funding.

1. *Floating Platforms (Islands).* Thirty-five small, floating platforms, linked to form an elongated island, to be anchored in the northern portion of the open water pond.

2. *Bat Boxes.* Four bat boxes are to be placed on poles at appropriate locations. Boxes are to be mounted 3.6 to 4.6 m (12 to 15 ft) above the ground and below a horizontally-placed shading platform (sized to ensure shading occurs and topped with gravel so that it can also serve as a Lesser Nighthawk/Common Poorwill/White-throated Swift Roosting and/or nesting platform).

3. *Cliff Swallow Boxes.* Three swallow shelters are to be placed on poles at appropriate locations. Shelters are open "boxes" intended to provide protection for nests and birds from sun, wind, and precipitation. At least one artificial Cliff Swallow nest should be attached to the back of each shelter near the junction of the back and top.

4. *Shorebird Beaches.* Two areas, about 3- by 10-m (9.8- by 32.8-ft) each, are to be located at the edge of the open water pond covered with sand and/or gravel to a depth of 10 to 15.2 cm (4 to 6 in) (i.e., adequate depth to ensure it will remain a "beach" and not revert to "rocky soil"). The purpose is to attract shorebirds and provide a source of grit for waterfowl.

5. *Viewing Blinds.* Three blinds are to be constructed, two southwest of and overlooking open water pond and one at the research boat access point on the north end of the open water pond.

Suggested Upland Features. The following features are suggested for review and consideration as possible amenities to include in the site at a later date.

1. *Aesthetic Features.* Visually and spatially appropriate arrangements of trees, shrubs, and herbaceous plants that provide seasonal interest and some level of solitude for the observer, linking him/her to nature; paths for viewing plant arrangements; benches for contemplating arrangements. Other features that might be included are ordinary or man-made objects, e.g., sculpture, placed to enhance their aesthetic value.

2. *Wildlife Habitat Features.* Vegetation of various kinds and amounts planted in spatial patterns to directly or indirectly furnish food and/or shelter cover and concealment cover for waterfowl, shorebirds, songbirds, small mammals, reptiles, and amphibians; habitat structural features, such as rock piles, standing and down large woody litter (tree trunks), and running water.

3. *Educational Features.* Trails and viewing stands and/or blinds providing opportunities to view wildlife, the wetlands' structure, or specific kinds of wildlife habitat; signs depicting species-specific natural history and general ecological information (or numbers coordinated with pamphlet).

4. *Recreational Features.* Paths for wildlife viewing; viewing stands and/or blinds.

Water Supply Systems and Hydraulic Controls

The Design Concepts and Criteria Report indicated that the main water supply system to the site should be capable of delivering 11,355 m^3/d (3 Mgal/d) total flow, based on having at least two times the design flow, plus an excess to allow for raising the system water surface rapidly. The criteria for the five separate inlet controls was to allow up to 3785 m^3/d (1 Mgal/d) flow to each, thereby ensuring the inlets did not restrict the capacity of the total system and placing maximum flow well within the range of the inlet measurement capabilities. The ability to provide a constant, steady flow and the ability to measure flows were also specified as design criteria.

While preliminary design established the operational constraints for the wetlands system, specific design details were not developed. As a result, final design included a complete design of the water supply systems, hydraulic controls, and design of water connections to and from the wetlands site. The major components of these systems and conclusions of the final design process can be broken into the following topics.

Chlorination of the Water Supply. The plant is now chlorinating year-round. EMWD is considering whether or not to dechlorinate, or whether to use unchlorinated water.

Main Water Supply System. The water supply to the wetlands system is limited by the capacity of existing pipes, pumps, and treatment facilities. Currently, this is estimated to be about 11,355 m^3/d (3 Mgal/d) to the Buena Vida pipeline, which will supply the wetlands. To help maintain steady flows, the pipe system to the inlet controls was designed for low pressures by using fairly large-diameter piping. The result of this is that the entire water supply manifold and inlet controls can handle a total flow rate of 18,925 m^3/d (5 Mgal/d). Although this is in excess of the operating design criteria, it required only a minor increase in pipe size, and this excess flow capacity could be beneficial in the future.

Inlet Controls. Each of the five inlet controls consists of a concrete box that is fitted with an adjustable sliding weir gate for fine control. The boxes are connected to the water supply manifold with piping sized to reduce the water pressure of from approximately 207 kiloPascals (kPa) (30 pounds per square in (lb/in^2)) at the manifold down to 34.5 kPa (5 lb/in^2) at the entrance to each inlet box. Coarse flow control is provided by a butterfly valve upstream of each box. Slots are formed into the sides of the boxes to allow stop logs to be installed as baffles to reduce inflow turbulence, as required. The adjustable weir has a 60 degree V-notch to allow for calibration of flow rates.

Each box is sized to accommodate 3785 m^3/d (1 Mgal/d) maximum flow. This is done so that the maximum flow rate of 2271 m^3/d (0.6 Mgal/d) lies within the range of control and measurement devices.

Outlet Controls. Final design of outlet controls consists of four concrete box structures similar to the inlet controls. These boxes are also fitted with an adjustable weir to provide depth control, flow measurement, and allow changes in depth to be done more easily than by fixed controls such as stop logs. Each box will accommodate installation of a "skimmer" board across the front to reduce floating debris from entering the outflow systems.

Outlet boxes are sized to handle the design flow range of up to 18,925 m^3/d (5 Mgal/d) based on the 11,355 m^3/d (3 Mgal/d) operating flows and an allowance to evacuate storm flows or to increase the outflow rate to lower the wetlands water surface.

Outflow Pump Station. A concrete wet well structure will collect flows from the four individual outlet boxes. The installed pumping capacity will accommodate up to 11,355 m^3/d (3 Mgal/d). This is sufficient for an operating flow of 7570 m^3/d (2 Mgal/d), plus an excess capacity to drain the system down, or to handle moderate storm flows. The well box is designed to accommodate a total outflow of 11,355 m^3/d (5 Mgal/d), although extending the pump capacity to 11,355 m^3/d (5 Mgal/d) would require additional pumps to be installed either on a temporary or permanent basis. If it becomes desirable to extend the pumping capacity to 11,355 m^3/d (5 Mgal/d) permanently, the wet well has two empty bays designed into the structure to allow pumps to be added to the pump station systems. The main outflow pipe will have a continuous flow counter installed for use in recording the total outflow removed from the system.

At the normal operating flow of 3785 m^3/d (1 Mgal/d), the three pumps installed with initial construction will operate in a cycle pattern to distribute wear. This design also allows for complete shutdown of a single pump for periodic maintenance or repairs without altering the outflow pump rate. Space is available in the concrete well box to install additional pumps for either temporary or permanent operations. Each pump will have screens installed to reduce overheating problems caused by debris. The control system is designed to shut down the pumps and turn on a warning light when pump pressures exceed a certain limit.

Flow Measurement. Facilities to be constructed will allow inflow and outflow rates to be recorded by visual readings of the V-Notch weir scales on each box. The inflow system is designed to allow flow adjustment at each inlet such that, once set, the inflow does not vary with upstream pressure fluctuations in main water supply pipe. Continuous flow monitoring or the ability to send signals by radiotelemetry were both discussed but not included in the design plans due to the expense. These systems could be installed at a later date, as appropriate.

Wetlands Planting

Planting of wetland vegetation in the marsh and pond areas will be accomplished under separate contract from the site construction work. Draft specifications for the planting work were prepared for incorporation into contract documents to be administered by EMWD. This contract is scheduled to be awarded after the site construction is complete in the summer of 1994.

A related topic addressed in the final design was the need for features to allow access into the dense marsh areas of the wetlands. Structural methods such as hardened pathways or over-excavated zones were considered. The decision was made to accomplish this by leaving unplanted areas at regular intervals, transverse to flow, in the main marsh areas. The intent is to allow access for monitoring and possibly to improve the function of the wetlands system by inhibiting extensive short circuit flow routes.

These open zones and other features of the planting plan are shown in Figure 3-2. Further discussion of plant propagation and transplanting studies is provided in Chapter 4.

Landscape Vegetation and Irrigation

Planting of upland areas and any corresponding irrigation systems was separated from the main site construction contract. This, again, was considered as a type of work that is distinctly different from the construction and can be installed at any time after the wetlands system is established. Draft landscape planting plans and specifications were prepared by USBR for use by EMWD. Perhaps the most important component identified in the upland landscaping plan concerns getting some type of vegetation cover over the surrounding site areas to reduce erosion of site soils. Similar concerns have surfaced with respect to the riparian areas along the margins of the wetlands system. Experience gained at the pilot facility has indicated noxious weeds can become a significant problem due to the abundant water in these areas. A recommendation was made to seed with native grasses and other drought-tolerant species soon after the wetlands work is completed.

A related issue concerns irrigation of the upland areas. Even though the upland vegetation plans have been directed primarily toward drought-tolerant species as appropriate to the region, some temporary irrigation may be required to establish the vegetation from seed. Without temporary irrigation systems, invasive weeds are likely to grow and could exceed desired varieties or retard the rate of establishing desirable vegetation at the site. Permanent irrigation was considered as a possibility to serve about 0.4 to 0.8 ha (1 to 2 ac) near the public viewing area. In all areas, the need for and design of irrigation systems was deferred until plans for installing the landscaping can be confirmed.

Cost Estimates

The final contract award amount was $942,000 for construction of the demonstration wetland facilities. The construction bids probably came in lower than the estimate due to local economic conditions at the time of construction.

As expected, the construction cost estimates indicated that earthwork is the predominant cost for wetlands development at this site. This conclusion has important implications regarding selection of future sites for constructed wetland systems. Based on the final design, it is evident that the components that control costs for

HEMET /SAN JACINTO REGIONAL WATER RECLAMATION FACILITY
MULTIPURPOSE CONSTRUCTED WETLANDS PLANTING

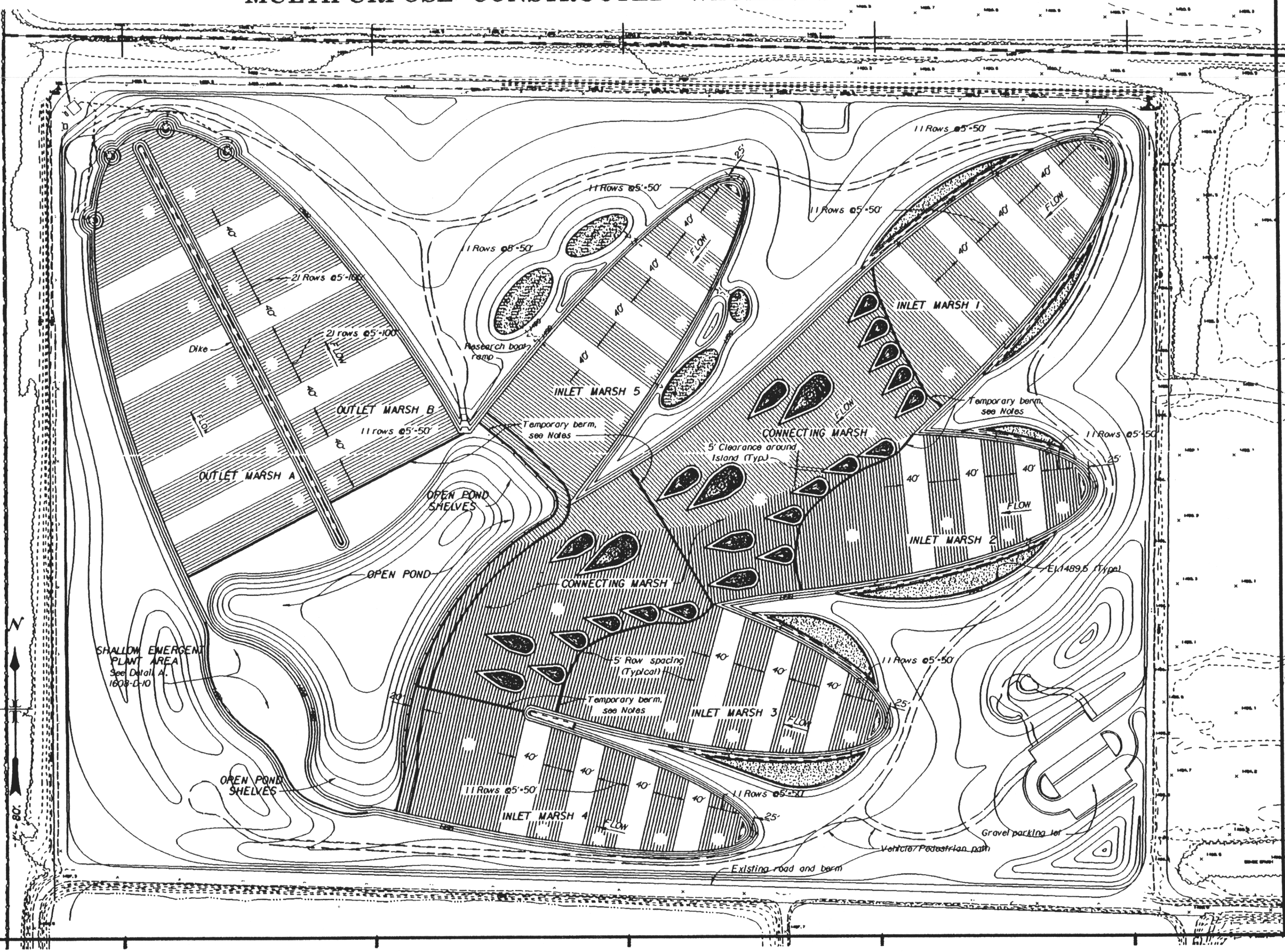

FIGURE 3-2

wetlands construction are the earthwork requirements, permeability of site soils as they could affect the need for impervious liners, land acquisition costs, and the extent of water supply pumping and conveyance systems required.

The total costs associated with final design, construction, planting, and landscaping for the Hemet/San Jacinto demonstration wetlands are as follows:

Final Design

Engineering Consulting Services:	$75,000
Geotechnical Investigation and Report:	8,000
EMWD Planning and Engineering Costs:	13,000
USBR Planning and Engineering Costs:	30,000

Construction Costs

Excavation, earthwork, grading, pump station, inlet and outlet structures, and yard piping: $942,000.

Wetlands Vegetation Planting

Planting of bulrush, moist soil test areas, shallow emergent test area, pond shelves, seed islands, and revegetation of nursery cells: $98,000.

Landscape Planting and Site Amenities (Estimated Costs)

Seeding of upland areas, trees and shrubs, shade shelter and bench in visitor overlook area, riparian trees and willows in riparian area, duck blind, irrigation and initial maintenance: $109,000.

CHAPTER 4
ONGOING RESEARCH INVESTIGATIONS

CHAPTER 4

ONGOING RESEARCH INVESTIGATIONS

PART 1: METHODS

Prior to construction of the large-scale multipurpose constructed wetlands, the EMWD/USBR Wetlands Research Facility was developed. The research facility is used for ongoing wetlands research, focusing on the ability of a wetlands system to polish and remove nutrients from secondary-treated wastewater. Evaluation of marsh habitat for wildlife diversity (migratory and resident waterfowl and shorebirds) as well as educational opportunities and other public benefits are also being studied. Located at the northwest corner of EMWD's Hemet/San Jacinto RWRF, this 3.16-ha (7.8-ac) facility was begun in 1991. It consists of the following (Figure 4-1):

1. Two 0.2-ha (0.5-ac) nursery cells for wetland plant propagation;

2. Eight research cells (approximately 13.7- by 69.2-m (45- by 227-ft)); and

3. An RO desalination unit, two saline marshes, and two evaporation cells.

Nursery Cells

Design and Construction. Two nursery, or plant propagation, cells were constructed to propagate bulrush for later transplant to research and demonstration projects and to determine the most efficient planting techniques. Design of the nursery cells was performed by EMWD, USBR, and NBS personnel. They were constructed in an old, effluent storage pond by constructing separating berms. The berms were graded by taking soil from the west end of the site and placing it along the berm alignments. A pressurized supply system to transport secondary reclaimed water from the Hemet/San Jacinto RWRF was constructed, and a gravity collection pipeline was installed. The water enters each cell by way of three inlets, flows through the cells, exits through three outlets in each cell, and flows to a sump. The sump is pumped into a reclaimed water distribution system for downstream use. The flow rate through each of the cells is approximately 37 to 57 L/min (10 to 15 gal/min).

Planting. The two nursery cells were planted from July 1 through 10, 1991, with California bulrush and hardstem bulrush. These species were selected because they are native to the area; they thrive in water up to 91 cm (3 ft) deep; they provide an excellent substrate for wastewater treatment; they provide excellent wildlife food and habitat; and their growth habit enables mosquito larvae-eating fish access through the marsh. Additional species planted in or around the nursery included a rush,

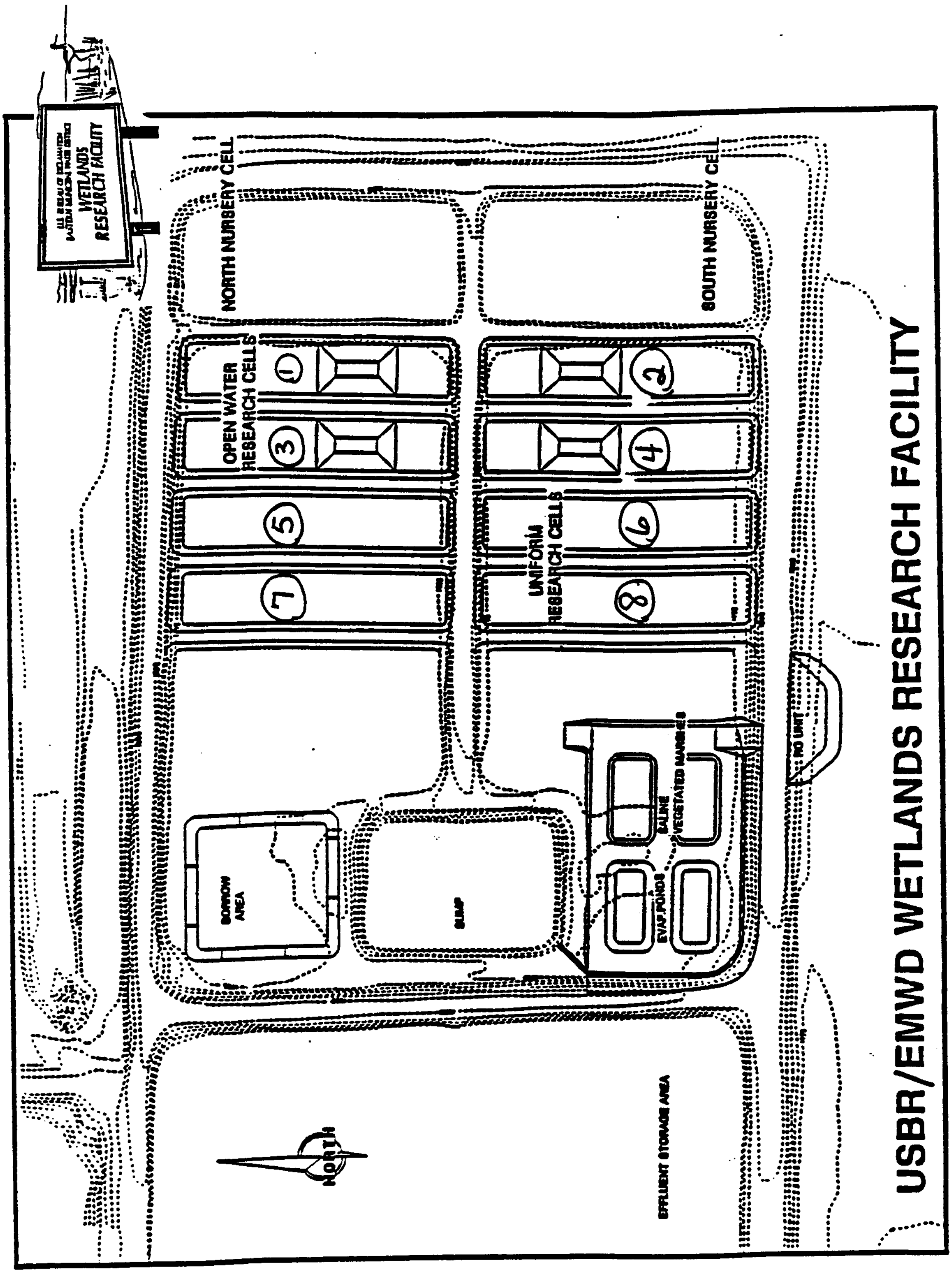
USBR/EMWD WETLANDS RESEARCH FACILITY
WETLANDS RESEARCH FACILITY
NORTH NURSERY CELL
SOUTH NURSERY CELL
OPEN WATER RESEARCH CELLS
UNIFORM RESEARCH CELLS
1
2
3
4
5
6
7
8
SALINE
VEGETATED MARSHES
EVAP. PONDS
BORROW AREA
SUMP
NO UNIT
EFFLUENT STORAGE AREA
NORTH

FIGURE 4-1

duckweed, marsh pennywort, and seepwillow. These plants were introduced because such species may be utilized later in the demonstration wetlands, and their survivability as transplants was unclear. The bulrush plant material came from five donor marshes: the San Jacinto Wildlife Refuge (SJWR) where the San Jacinto River crosses Davis Road (hardstem bulrush); Sanderson Road (SR) north of Ramona Expressway (hardstem bulrush); DeVuyst's cornfield drain (DV) west of Bridge Street (California bulrush); Walker Canyon (WC) along Interstate Highway 15 (hardstem bulrush); and a donor marsh used by Pacific Southwest Biological Services, Inc., in National City (NC), California (California bulrush). The soil substrates of the SJWR and SR donor marshes were very dry during the harvest period while plants were removed from standing water in DeVuyst's drain and Walker Canyon.

Forty-four plots were created in the two nursery cells. The plots represented separate harvesting or planting treatments. Many of the plots were replicates of each other. The holes were dug (unless stated otherwise) to depths of 20 to 30 cm (8 to 12 in) using a gas-powered auger. Ninety-one-cm (3 ft) lath stakes were used to stake the bulrush plant clumps to the soil surface to prevent them from floating away with the rising water. Once a treatment plot was completed, a small soil berm was built around the perimeter and the area flooded with water from the reclaimed water pipeline until the entire cell was completed. The various treatments were:

1. Clumps dug by backhoe planted in holes with tops trimmed to 61 to 91 cm (2 to 3 ft);
2. Hand-dug clumps planted in holes with tops not trimmed;
3. Hand-dug clumps planted in holes with tops trimmed to 91 to 122 cm (3 to 4 ft);
4. Bare root plants from Pacific Southwest Nursery, National City, California, planted in holes with tops trimmed to 61 to 76 cm (2 to 2 1/2 ft);
5. Hand-dug clumps planted in holes (hand-dug) with tops not trimmed and tied up with special care[1] (TLC);
6. Hand-dug clumps staked onto the soil surface with tops not trimmed;
7. Hand-dug clumps staked onto the soil surface with tops trimmed to 92 to 122 cm (3 to 4 ft);
8. Hand-dug clumps placed on a plastic sheet with tops not trimmed;
9. Hand-dug clumps placed on and in between the planks of wooden pallets with tops trimmed to 91 to 122 cm (3 to 4 ft);

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[1] The special care consisted of holding up the bulrush culms by hand during transit, carrying each plant to its position in the nursery so that no culms would bend or touch the ground, and tying the culms up to laths once the plant clumps were placed gently in their holes. The culms were left tied up when the planting was completed.

10. Hand-dug clumps placed on chain-link fence with tops trimmed to 91 to 122 cm (3 to 4 ft); and
11. "Junk tubers" (bare rhizomes with no shoot attached) pushed gently into the wet soil.

Most plants from the four local donor marshes were planted on 112-cm (44-in) centers in the various treatments. However, the 1500 bare root units from the nursery in National City, California, were planted only in holes with spacings of 56 by 112 cm (22 by 44 in).

Monitoring. USBR personnel monitored the nursery cells on August 15, 1991 (6 weeks after planting), October 8, 1991 (3 months after planting), and February 26, 1992 (almost 8 months after planting).

Plant Growth and Establishment. Two techniques were used for monitoring the bulrush growth and establishment in the nursery cells. The first technique focused on 19 plant clumps which were subjectively selected immediately following the planting. For easy access, all are located close to the perimeter of the marsh. Weekly, for the next 9 weeks, the total number of new shoots (the culms, or above-ground stems, put out by the plant since being transplanted into the nursery cells) from each of the 19 selected plants were counted and recorded. A final count was made approximately 3 1/2 months (on October 24, 1991) after planting; the bulrush culm density was so great after that time that accurate individual plant culm counts were no longer practical. New culms arising from the horizontally-growing rhizomes emerged between the original plant clumps, and it was impossible to tell which culm came from which plant by visual inspection alone.

The second technique used for evaluating the bulrush growth involved monitoring each of the 44 plots in the two nursery cells. The entire area of each plot was carefully surveyed to determine a representative plant clump for that plot (avoiding the largest and smallest clumps in the plot). That representative clump could change between sample dates. The new shoots were counted and recorded. Likewise, the largest plant clump in the plot was determined, and its new shoots were counted and recorded. The average height for the plants in each plot and the maximum height for the plants in each plot were estimated by inspection and recorded to the nearest 0.15 m (0.5 ft).

Additional indicators of condition, such as phenology (i.e., flowering or seeding), general health of the plants, presence of fungi or insect pests, and presence of other plant species were also noted within each plot. Photographs were taken during each of the monitoring trips to document appearance.

The data from each treatment replicate (similarly planted plots) were averaged to obtain a value for that planting technique. The data were compared, and planting

PHOTO 14. NURSERY PLOT; PLANTING ON AND IN WOODEN PALLETS

PHOTO 15. HORIZONTAL RHIZOME GROWTH. NOTE HOW CULMS ARE IN LINES RADIATING OUT FROM ORIGINAL CLUMP

PHOTO 16. MONITORING GROWTH IN NURSERY CELL

techniques were evaluated. Evaluations and planting technique recommendations are reported in the conclusions section below.

Water Quality and Invertebrates. Water quality and benthic invertebrate data were collected by members of the USBR technical team during site visits in August and October 1992 and February 1993. In each case, the water quality monitoring effort consisted of in situ measurements of water temperature, pH, conductivity, dissolved oxygen concentration, and oxidation-reduction potential at nine points within each cell and collection of inflow and outflow water samples for laboratory analyses. The inflow water samples were collected from the inlets of each cell, and the outflow sample was collected from the combined outflow of the two cells. Major analyses performed on each sample included determinations of ammonia and nitrate nitrogen, orthophosphate phosphorus, total dissolved solids (TDS), and total suspended solids concentrations.

Sediment samples for identification and counting of benthic macroinvertebrates were collected with a 5-cm (2-in) coring tube and screened through a No. 30-mesh littoral bucket. Composite samples, consisting of five individual core samples each, were collected on three transects perpendicular to the flow in each of the two cells.

Mosquito Larvae. Mosquito larvae were sampled at four points on each of three transects in each nursery cell. The three transects were located perpendicular to the direction of flow at points approximately 9 m (30 ft) downstream of the inlets, across the middle of the cell, and approximately 9 m (30 ft) upstream of the outlets.

At each sampling point, the mosquito larvae sampling cup was dipped smoothly and quickly into previously undisturbed water to remove a sampler-full (400 ml) (24 cubic inches (in^3)) of the surface water. The number of mosquito larvae in the cup was counted and recorded, then the cup contents were discarded. The floating vegetation types or other relevant observations at each sampling site were also recorded.

Research Cells

Design and Construction. In the fall of 1992, eight research pilot cells were constructed and planted with California bulrush transplanted from the nursery cells. The research cells were designed by EMWD, USBR, and NBS staff, plans were compiled by EMWD, and earthwork grading was performed by an EMWD contractor. The pressurized supply and gravity collection systems, including concrete inlet and outlet boxes, were installed by EMWD. The cells are of two types: four cells with inlet and outlet emergent marshes separated by an open area, 1.2 m (4 ft) deeper than the surrounding marshes (three-phase cells), and four cells which are uniform emergent marshes with no open pools (one-phase cells). These cells were designed to be experimental mesocosms in which researchers can perform various wetland loading and treatment process studies with a high degree of control over external variables.

Planting. The eight research cells were planted from September 2 to 9, 1992. California bulrush plants with 30.5-cm (12-in) diameter root clumps were dug out of the southwest corner of the north nursery cell with shovels. The clumps were carried up the berm, their culms (the above-ground stems) cut to about 91.4 cm (3 ft), then carried to the appropriate research cell. Once the clumps were put in place on 121.9-cm (4-ft) centers in the cells, they were staked in place with 91.4-cm (3-ft) wooden laths. The cells were flooded at different times. The deep water pools were pre-flooded; staked plants were sprayed by an EMWD water truck to keep them moist prior to flooding.

Monitoring.

Plant Growth. Plant growth monitoring was initiated 6 weeks after planting. Bulrush growth, vigor, and establishment were evaluated on October 20 and 21, 1992; April 28 and 29, 1993; July 27 and 28, 1993; and November 2, 1993. The quarterly sampling planned for the end of January 1993 was missed due to torrential winter rains and unseasonably cooler temperatures in the area. Plant growth during that time was minimal.

Plant growth monitoring consisted of recording several parameters during the October 1992 and April 1993 sample. The new shoots (culms put out by the plant since being transplanted into the research cells) of 10 sample plant clumps distributed throughout each cell were counted and recorded. The maximum culm height and the mean culm height were measured and recorded for each sample plant. Means are presented in the results section as the mean plus or minus the standard deviation. The general health of the plants in each cell was recorded as well as the range in the culms' width (measured as the length of one side of the triangular culms). Survival percentage was also noted throughout the evaluation periods.

At the time of the July 1993 samples, the bulrush culm density was so great that accurate individual plant culm counts were no longer possible. New culms arising from the horizontally-growing rhizomes emerged between the original plant clumps, and it was impossible to tell which culm came from which plant. Maximum and mean heights of the plants, culm widths, and the general health of the plant communities in each of the eight cells were measured and recorded. Additionally, many photographs were taken during each of the monitoring trips.

Water Quality and Inflow Rates. Series 1 of the monitoring program was originally intended to last 6 months, from October 1992 until March 1993. However, heavy rains and flooding forced suspension of all monitoring activities from February 11 to May 5, 1993. The Series 1 monitoring was extended as Series 1A for

PHOTO 17. COLLECTION OF HYDROLAB MEASUREMENTS IN OPEN WATER OF RESEARCH CELL

PHOTO 18. COLLECTION OF BENTHIC INVERTEBRATE SUBSTRATES FROM BULRUSH IN RESEARCH CELL

6 months to allow the cells to reach maturity and allow a distinct baseline condition to be established.

In the following, Series 1 refers to the period from October 20, 1992, to May 5, 1993 (weeks 1 to 30), and includes the 15-week period (weeks 16 to 30) when monitoring was suspended. Series 1A refers to the period from May 5 through November 10, 1993 (weeks 30 through 56).

Weekly Monitoring. Paired three-phase and one-phase cells were monitored in weekly rotation throughout Series 1/1A. For example, cell 1 (three-phase) and cell 5 (one-phase) would be monitored for 1 week, followed by cell 2 (three-phase) and cell 6 (one-phase) the next week, then cell 3 (three-phase) and cell 7 (one-phase) for another week, and finally cell 4 (three-phase) and cell 8 (one-phase), after which the weekly paired cell cycle would begin again with cells 1 and 5. This paired cell rotation was developed in response to equipment and funding limitations.

The typical weekly monitoring consisted of three components:

1. Three Hydrolab Corporation DataSonde 3 water quality data loggers were used to make hourly measurements of water temperature, pH, conductivity, dissolved oxygen concentration, and dissolved oxygen saturation in the outlet of each cell and in the inlet of one of the pairs of cells. This arrangement was necessitated by the fact that only three data loggers were available for the Series 1 and 1A program, but it was assumed that, since the inflow to all eight cells came from the same pipeline, the water quality at all eight inlets should be essentially the same.

2. Water samples were collected weekly from one inlet and both outlets for laboratory chemical and biological analyses. The sample collection was usually done about midway through the weekly cycle. The specific analyses performed varied from week to week because the sampling schedule was different for different parameters. For example, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, orthophosphate phosphorus, and turbidity analyses were performed weekly, while total Kjeldahl nitrogen, total phosphorus, biochemical oxygen demand, total suspended solids, total organic carbon, and total and fecal coliform bacteria analyses were performed every third week.

3. Two ultrasonic flowmeters became available during Series 1A, and these were used to record total and average daily flows on the inlets of the paired cells. Cell outflows were not measured during the Series 1/1A monitoring program.

Quarterly Surveys. Quarterly surveys of the research cells were carried out on April 28 and 29, July 27 to 29, and November 3, 1993. The objectives of these surveys were to evaluate vegetation condition and growth, sample the macroinvertebrate communities, and document variations in water quality conditions within and among the research cells. The water quality component of these quarterly surveys consisted of taking Hydrolab measurements of water temperature, pH, conductivity, and dissolved oxygen in the inlet, middle, and outlet of each cell. Chlorophyll-a concentrations were also measured in the inlet and outlet of each cell.

Invertebrates.

Artificial Substrate Design and Installation. Artificial substrates were used to sample benthic macroinvertebrates resident within the research cells. Three groups of nine substrate assemblies (27 per cell total) were placed in each of three-phase ("open water area") cells 1 and 2, and one-phase ("uniform marsh") cells 5 and 6 on February 12, 1993 (total of 108 assemblies). Each assembly consisted of six 5.12-cm (2-in) Tri-pack spheres in a 0.47 L (1-pint) plastic container (with lid) that had eight 3.2-cm (1.25-in) holes punched in its wall, and one 3.2-cm (1.25-in) hole punched through the lid. Approximately 190 cm^3 (11.59 in^3) of soil was placed in the container bottom (below the lowest holes). A plastic electrical tie threaded through the upper wall holes served as a handle for the container; a nylon fishing line "lead line" connected the handle to a 2.5-cm (1-in) plastic bobber. Soil for the containers was obtained from a 0.5-m^2 (1.64-ft^2) area of the berm separating cells 3 and 4; the soil was friable and mixed well before placement into the containers and, once filled, containers were selected from the total pool available in a manner to further ensure that any variations in soil quantity or quality was distributed among the 12 groups. EMWD assisted with assembly, and NBS added all soil to containers and placed all assemblies into cells.

The containers were arranged in three groups of nine containers each, with groups placed to sample the inlet, middle (or open water area), and outlet portions of the planted section of each cell. Assemblies were placed in the cells by hand, using positions of bulrush plants as reference points (i.e., no distances were measured): the approximate center point of the groups were (1) 13 rows from inlet; (2) 30 rows from inlet or center of open water; and (3) five rows from outlet. Each assembly was slowly lowered via the lead line at a position within the cell where it was believed the container would rest on the flat cell bottom. In no case was the assembly, once lowered, visible. Thus, it is possible that some are actually resting in a tipped position due to placement in a depression (e.g., footprint), on a root, or (in the open water) on the cell sideslope. Open water groups were installed from a small (one- to two-person) inflatable boat. Because of the inability to maintain the boat in a stationary position, the assembly placement in the open water is rather spread out but centered to the degree possible on the flat-bottomed portion of the deep water area. Lead lines varied in length, resulting in some bobbers remaining a few cm below the

PHOTO 19. COLLECTION OF MACROINVERTEBRATES IN RESEARCH CELL; SWEEP NET METHOD

PHOTO 20. TRICOLORED BLACKBIRDS USING RESEARCH CELL

water surface and others drifting perhaps as much as 1.5 m (4.92 ft) off the vertical position above the container in the deep water. Within the marsh portions, assemblies were placed in a grid to the degree possible, with 0.5 to 1.0 m (1.64 to 3.28 ft) separating assemblies; the offset rows of bulrush and their variable size made a more regular placement impossible. Bobbers may be up to 15 cm (5.86 in) off the vertical position due to drift and lead line length. Specific locations of all assemblies were mapped.

At the time of installation, the bulrush within cells 1 and 2 appeared similar in stature; plants in either of these cells appeared fuller than those in cell 6, however, and plants in cell 6 appeared fuller than those in cell 5. In all cases, individual transplants and planting rows were easily discernable. Cell 5 was the only one that contained an algal mat on the water surface. No water was flowing into the cells (due to an inability to handle outflow in the flooded sump); all cells appeared to have water levels slightly below the nominal 0.46-m (1.5-ft) depth.

Collection Procedures. The following procedure was used for collecting the artificial substrate samples. The substrate assembly was slowly lifted from the bottom using the nylon line and placed in a soil sieve (250 micron mesh size was desired, but mesh size as large as No. 30 (600 micron openings) was used for July 28, 1993, collections). The six spheres were put into two containers containing 10 percent formalin solution along with any invertebrates noted on the container surface. The container was then inverted and sediment dumped into the sieve. This material was "panned" for invertebrates using the pond water to flush sediment out of the sieve. A squirt bottle filled with RO unit product water was used to concentrate the remaining material and organisms within the sieve, and then a flexible pocket ruler or other "spoon" was used to transfer the matter out of the sieve and into the formalin bottles.

Samples were sorted and invertebrates identified by USBR's Denver Office personnel. Personnel corroborated identifications made by others. Rose bengal stain was used in some cases to aid in differentiating animals and plant debris. Many, but not all, sorted samples have been retained.

Sweep Net Sampling. By November, many substrates were inaccessible because of the combination of effectively complete closure of bulrush transplants to form a uniformly dense stand without access channels and the falling over and "lodging" of bulrush stems due to wind or other factors. Retrieval of the substrates would have required cutting a path through the bulrush, and the associated level of disturbance to the cells was deemed undesirable. In place of the substrate samples, samples were collected using a custom, fine-screen dip net (use of the net was initiated during July sampling). The following procedure was used: a point close to the location of artificial substrates was sampled by dipping the net into the water and, if possible, substrate three times in rapid succession. All invertebrates collected in the net were preserved in the same manner as artificial substrate samples (10 percent Formalin solution). Actual sites sampled varied from 1 to 5 m (3.28 to 16.4 ft) from edge of cell, depending upon degree to which entry into the cell was possible. Sweep net samples were sorted and invertebrates identified in Denver by USBR personnel in the same manner as noted for samples from artificial substrates.

Sediments. Monitoring of bottom sediments has been conducted since initial flood-up in September 1992. The objective of monitoring was to identify substrate influences upon (1) the fate of toxic constituents; (2) nutrient availability; (3) denitrification; and (4) phosphorus removal. The following parameters were monitored in research cells 1 and 2 in an effort to characterize substrate impacts:

• pH	monthly
• redox potential	monthly
• electrical conductivity	monthly
• nitrate nitrogen	monthly
• phosphorus (total and orthophosphate)	monthly
• trace elements	yearly
• particle-size analysis	yearly
• organic carbon	yearly
• calcium carbonate	yearly
• cation exchange capacity	yearly

Four sampling sites were selected (cell 1 - inflow, cell 1 - outflow, cell 2 - inflow, and cell 2 - outflow). Each site sample was a surface composite 0.0- to 7.5-cm (0.0- to 3-in depth) obtained along a transect at six equally spaced points. The transects crossed the cells perpendicular to the flow approximately 3 m (10 ft) from inlet and outlet points. Data for pH, redox potential, and electrical conductivity (EC) were obtained from in situ readings at these points. The remaining parameters were measured through laboratory analysis on collected samples. Composites were placed in ziploc bags, refrigerated, and delivered to the laboratory the same day. At the laboratory, samples were air-dried, thoroughly mixed, and analyzed according to standard Environmental Protection Agency (EPA) methodology.

Reverse Osmosis System, Saline Marshes, and Evaporation Cells

Design and Construction. The RO treatment/saline marsh study is being conducted at the Hemet/San Jacinto RWRF to investigate the potential for using the reject stream of the RO desalting process in vegetated saline marshes to reduce brine volume and provide an additional use of brackish water in arid areas while providing much-needed habitat, greenbelts, and open space. The research site is comprised of a 22.7 L/min (6 gal/min) RO pilot system, designed and built at USBR's Denver Office laboratories, two 12- by 24- by 0.6-m (40- by 80- by 2-ft) deep, lined saline vegetated marshes, and two similarly-sized lined evaporation cells.

PHOTO 21. REVERSE OSMOSIS UNIT AND SALINE MARSHES

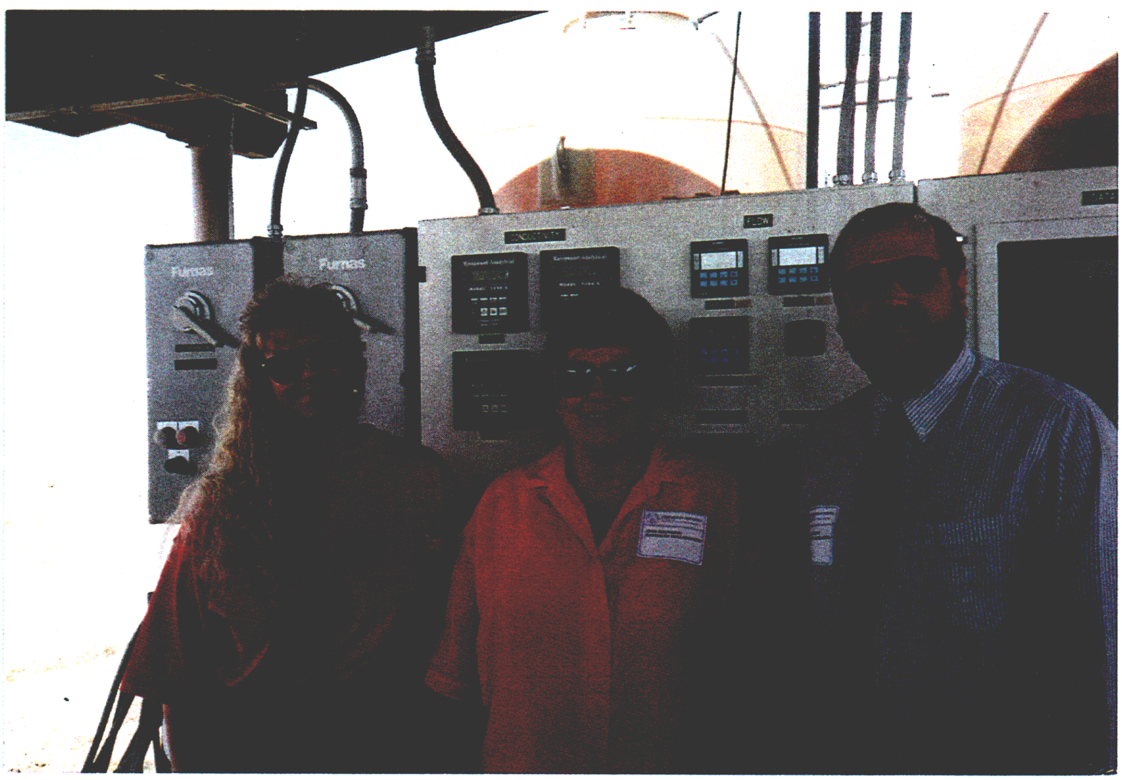


PHOTO 22. EXECUTIVE COMMITTEE MEMBERS VISIT REVERSE OSMOSIS UNIT

Installation of the pilot RO system was accomplished during the month of April 1993. The reject line from the RO system was plumbed such that flows of brine could be directed to either or both of the saline marsh cells. Initially, the two saline marshes were operated in parallel. Outflows from each vegetated marsh went into evaporation cell number one and then into evaporation cell number two in series. Due to lack of sufficient brine from the RO unit to meet the demands of the saline marshes during peak evapotranspiration periods, the underground piping and valve system was modified in September 1993 to allow the south pond to receive all of the brine and the north pond to receive RO product water as a control (Figure 4-2). Plumbing modifications were also made to allow the overflow from the north pond to flow into a sump instead of into the evaporation cells.

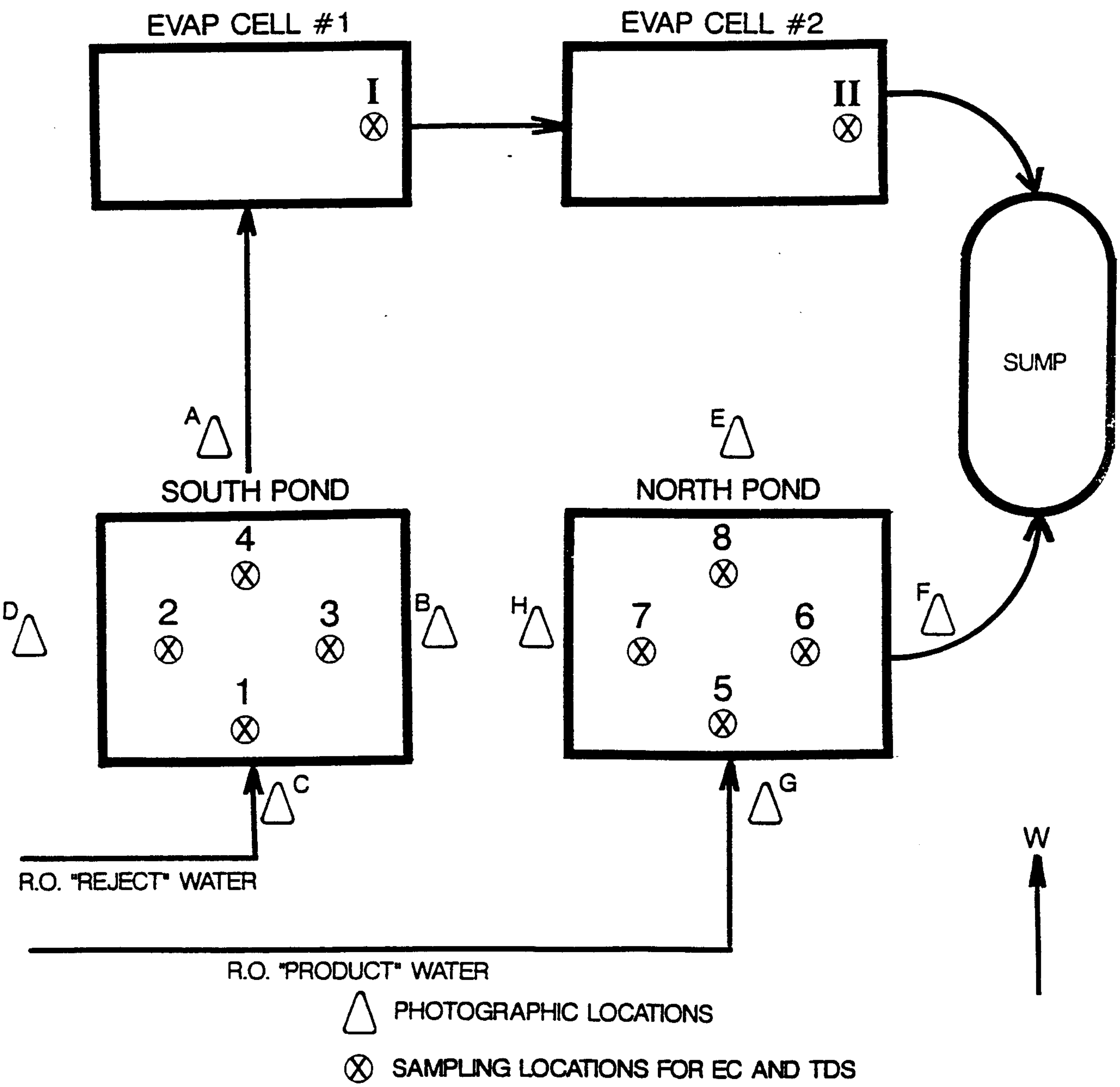
The evaporation cells are nonvegetated. They were designed to be as unattractive to wildlife as possible because of concern that some constituents in the brine could be concentrated to toxic levels. They were constructed with steep sides so that no food, shelter, or nesting areas would be available to wildlife.

To prevent seepage of concentrated brine into ground water, the evaporation cells were lined with a high-density polyethylene liner of relatively high thickness (0.08 m) (0.26 ft). In April 1994, a leak formed in the north evaporation cell and, a short time later, the south cell appeared to be leaking. Both cells were drained. It was determined that the north cell was leaking because a weld along the liner seam had failed. The south cell leaked through the inlet pipe penetration. The manufacturer of the lining was called to repair the leaks. All of the seams on the linings of both cells were resealed to prevent future leaks. This work was performed under warranty by the manufacturer.

About 19 m^3 (5000 gal) of RO feedwater is trucked to the site each weekday from a nearby well (presently from the Moreno Highlands well). This water is first pretreated: (1) to remove suspended materials (i.e., silts and clays); (2) to kill microbial organisms to prevent biofouling of the membranes; and (3) to suppress the scaling tendencies of selected minerals. The unit processes involved in pretreatment include: polymer addition, two-stage pressure filtration, ultraviolet disinfection, acid addition, anti-scalant addition, and cartridge filtration. The RO system then desalts the feedwater using thin-film composite (TFC) membrane elements at an operating pressure of about 1555 kPa (225 lb/in^2). Operating at 75 percent recovery, the RO system yields 17.0 L/min (4.5 gal/min) of product water and 5.7 L/min (1.5 gal/min) of reject brine. A total of about 4.7 m^3 (1250 gal) of brine is produced and stored each weekday to support the saline marshes.

Figure 4-2

FLOW SCHEMATIC OF SALINE VEGETATED PONDS AND EVAPORATION CELLS



Planting of Saline Marshes. Alkali bulrush, creeping spikerush, marsh smartweed, and Pennsylvania smartweed were planted in the two saline marshes. The plants were chosen because they tolerate high brine ion concentrations, 15 cm (6 in) of water depth, are plants which wildlife use, and are native to the area.

The species were planted in horizontal bands, and each species band was repeated three times per marsh to expose the plants to different positions along the salinity gradient expected to develop as brine moved from inlet to outlet within the cell. Seed was broadcast, but plants and rhizomes were planted in offset rows on about 46-cm (18-in) centers. Alkali bulrush and creeping spikerush plants were collected from local donor marshes; Pennsylvania smartweed seeds and marsh smartweed rhizomes were purchased from a Wisconsin wetland plant nursery. Three additional species were suggested for the plant palette but were not available.

Monitoring. The "Saline Marsh Research Program and Proposed Monitoring Program" are contained in Appendix E. The overall objective of the research is to determine the feasibility of using the reject stream of the desalting process in vegetated saline marshes to provide an additional use of brackish water in arid areas through the irrigation of amenities such as greenbelts, open space, and habitat areas. Specific areas of research include plant survival, water and soil analysis, plant and benthic tissue analysis, and wildlife use.

Plant Growth and Survival. Plant growth and survival are monitored weekly by EMWD personnel utilizing general observations and a photographic record (Appendix D). Plant growth, establishment, and health are also evaluated during quarterly trips by USBR personnel. The main objective has been to determine plant survivability based on the color of the vegetation and presence of new shoots. During the late winter, when vegetation had turned completely brown, survival was determined by digging up several rhizomes and cutting them open. If root buds were present on the outside of the rhizomes and the insides were firm and fleshy, with no presence of rot, the plants were determined to be alive. As confirmation, several plants were transplanted into a glass aquarium and kept indoors in water from the saline marsh. Production of new shoots was used as an indicator of plant survival.

In Situ Water Analyses. EC and temperature data were collected weekly at four sampling points in each marsh between July 13 and August 18, 1993, and at one location in each evaporation cell using a hand-held meter. The EC readings are converted to an estimated TDS concentration using an empirically-derived conversion factor. Spot collections were made thereafter. Hydrolab data were collected on July 28 and November 3, 1993, during quarterly sampling tests.

Water Quality Analyses. One RO reject sample was taken on August 13, 1993, and analyzed by Associated Laboratories of Orange, California, for metals using EPA methods. The RO reject sample also served as the "inflow" sample for the saline marsh. There was no outflow from the saline marsh into the first evaporation cell until it began to rain in later November. Overflow into the second evaporation cell from the first did not occur until mid-January.

Water quality samples will be taken at five locations: inflow (RO reject); in front of the outlets of the saline marshes; and in front of the outlets of each evaporation cell.

Plant and Benthic Invertebrate Tissue Analyses. The research program calls for tissues to be analyzed annually to determine the long-term bioaccumulation of toxics. The proposed monitoring program calls for the primary species of plants (stems, tubers, and leaves) to be collected, marked, and analyzed by an outside contract laboratory for toxic accumulation, specifically metals and nonmetal analytes. A minimum of two grams (dry weight) of plants will be needed for analysis. In addition, benthic invertebrates will be sampled by removing some sediment substrate, placing in a pan, and removing 100 individual organisms at random. Sample locations will be immediately in front of the influent and effluent areas of each vegetated marsh.

Soil and Sediment Analyses. The baseline soil sampling was performed on April 28, 1993, just before initial flooding of the marshes. Samples were collected near the inlet, middle, and outlet of each marsh by USBR personnel. The six samples were stored at 4° C (39.2° F) for 9 months before being analyzed by a contract laboratory for metals, ions, particle size, and organochlorine pesticides and polychlorinated biphenyls. The lab was requested to use the lowest possible detection limits.

The proposed monitoring program calls for sediment samples to be collected on June 30 and December 30 of each year. Sample locations will be along two transects in front of the inlet and outlet areas of each vegetated marsh. Several grab samples from each transect will be composited by mixing in a glass bowl.

Wildlife Use. General observations of wildlife use are made by EMWD personnel during weekly visits. Signs of wildlife use, such as tracks and droppings, are noted, and a carcass log is used to record findings of any dead animals in or around the marshes.

PART 2: RESULTS

Nursery Cells

Plant Growth and Establishment. The data from the 19 selected plants, evaluated weekly, illustrate the rate of growth and differences in the average number of new shoots per plant between the donor marshes (Figure 4-3). After 3 1/2 months, the

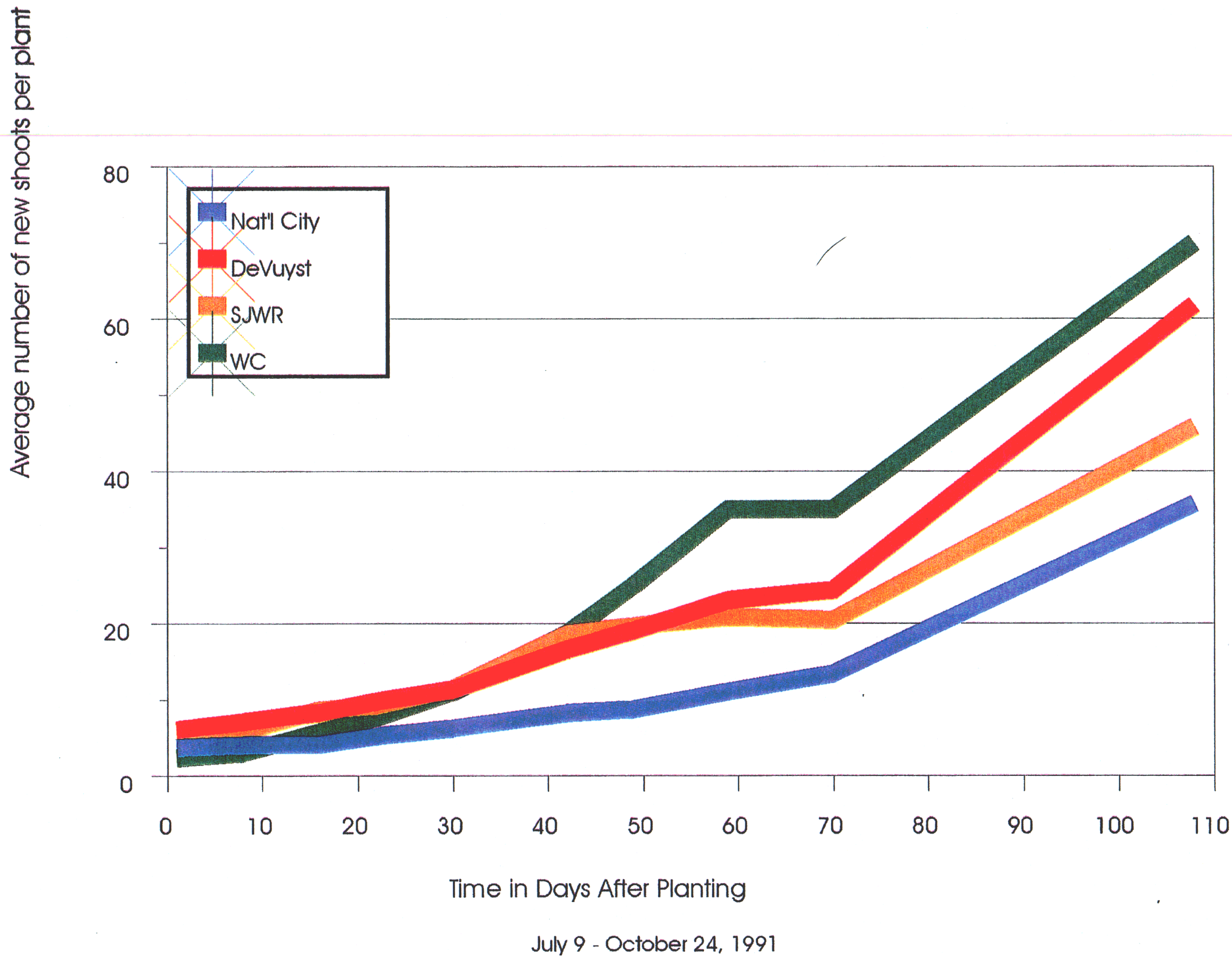


FIGURE 4-3. Scirpus growth data by donor marsh location, technique 1.

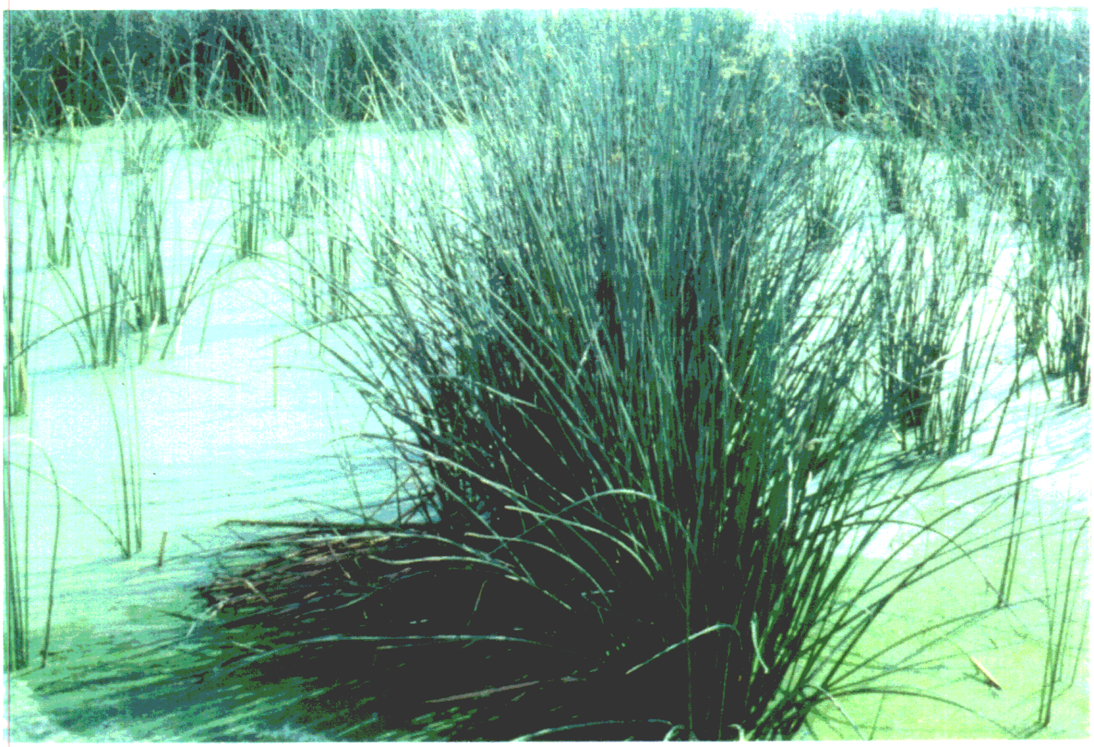


PHOTO 23. STAKED CALIFORNIA BULRUSH IN CENTER COMPARED TO NATIONAL CITY'S CALIFORNIA BULRUSH ON EITHER SIDE (3 MONTHS AFTER PLANTING)

average number of new shoots per plant harvested from the Walker Canyon donor marsh was 70; from DeVuyst's cornfield drain, 62; from the SJWR, 46; and from the Pacific Southwest Nursery, 36. Growth increased steadily with time.

The data from the second monitoring technique illustrate similar results; however, the average number of new shoots per plant differs considerably. The average number of new shoots per plant in October was 117 for Walker Canyon plants, 97 for DeVuyst's drain, 63 for SJWR, 22 for Pacific Southwest Nursery, and 83 for Sanderson Road (Figure 4-4).

The likely reason for the difference was that the 19 subjectively-selected plants were not necessarily representative of their donor marsh group. Nevertheless, the growth trends for each of the donor marshes were similar.

Plant source and harvesting technique affected subsequent transplant growth. There were virtually no differences in new growth and establishment between the harvesting of plants by hand or by a skilled backhoe operator. On the other hand, the plants purchased from the nursery in National City grew much slower than any of the other plants (Figures 4-3 through 4-6). There were several reasons for this. The harvested plant culms were cut to 61 to 76 cm (2 to 2 1/2 ft), their roots washed of all soil and microorganisms, then they were put into wet burlap bags and transported for 3 hours in an open truck in temperatures near 38° C (100° F). Their cut culms appeared dry when they arrived. They were obviously stressed. Mortality would have been higher if each bare root unit was planted in an individual hole, but planting one large to several small units (3 to 10 shoots) in each hole maintained the overall survival over 80 percent. By February 1992, when many of the other plants were growing together, open areas still existed between the National City plants (Photo 23).

Planting technique affected how fast the plants put out new shoots. In Figure 4-5, the data are separated by donor marshes but also by whether those plants were planted into holes, staked to the soil surface, given special care, planted on pallets, planted on plastic, or planted as "junk tubers". It was fairly obvious that the plants which produced new culms most rapidly were those that were staked to the soil surface and, thus, not restricted by the hard clay substrate that surrounded the plants in holes. The plants staked on top of the substrate with their roots bathed in nutrient-rich water, so that they were essentially being grown hydroponically, were unconstrained and, therefore, had the ability to expand horizontally.

The plants from the two donor marshes that were moisture-stressed (SJWR and Sanderson Road) produced about twice as many new shoots when staked to the soil surface or set on plastic than when planted in holes. An average of 38 new shoots per plant planted in holes versus 85 staked for SJWR, and 50 versus 100 for Sanderson Road in October 1993 (Figure 4-5). The stressed plants were probably not as robust and, therefore, their new horizontal roots and rhizomes were less able to

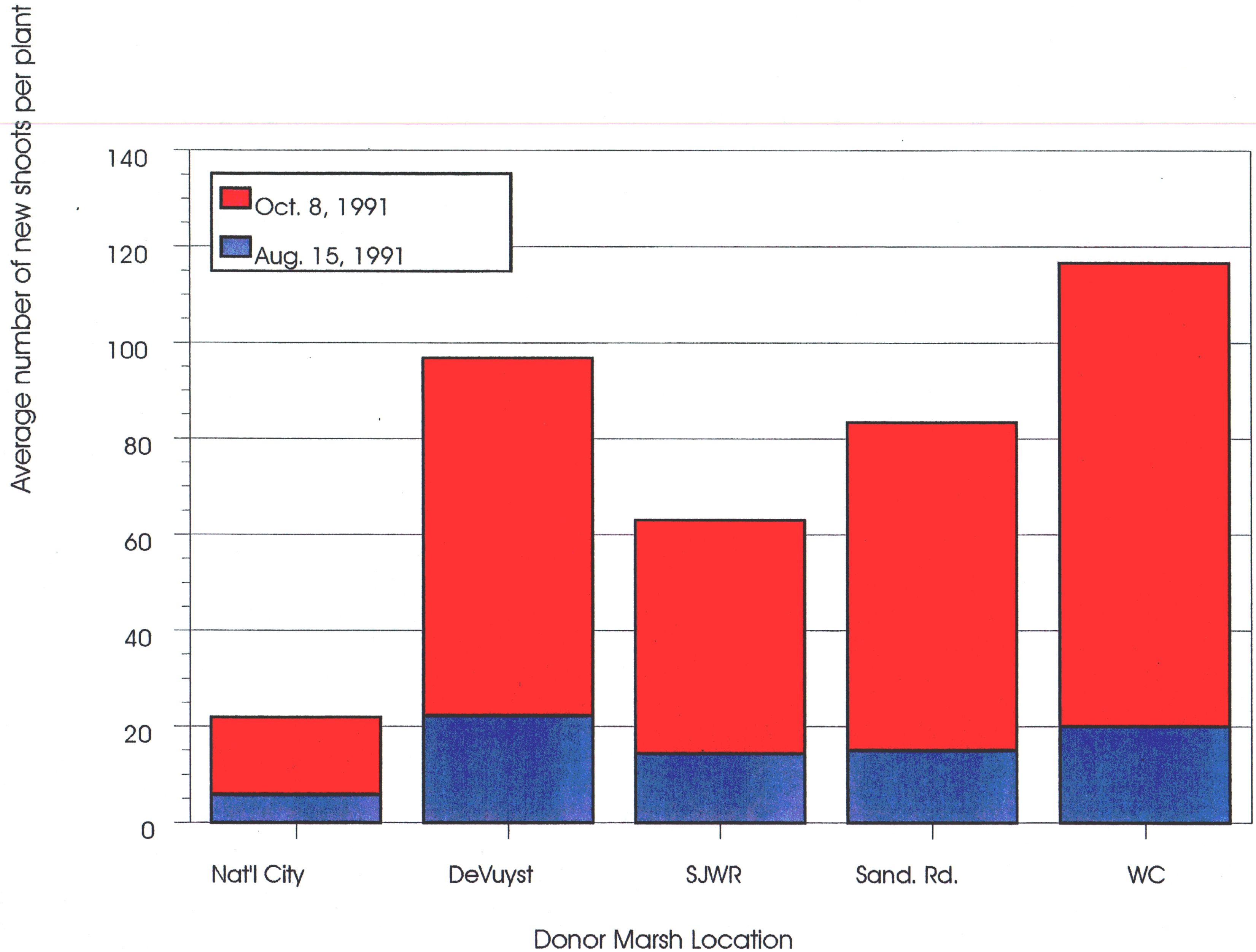


FIGURE 4-4. Scirpus growth data by donor marsh location, technique 2.

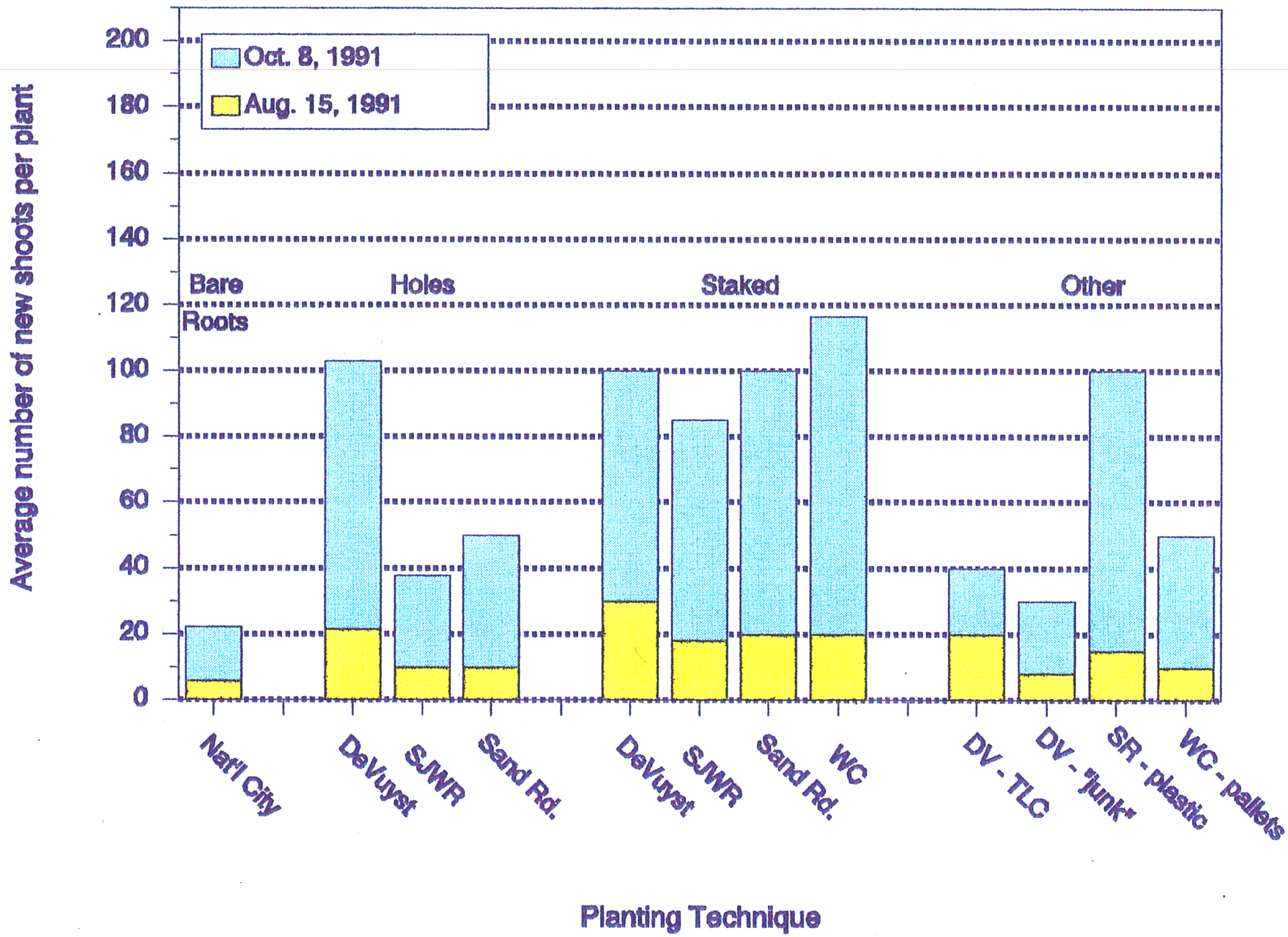


FIGURE 4-5. Average Scirpus growth data by planting technique and donor marsh.

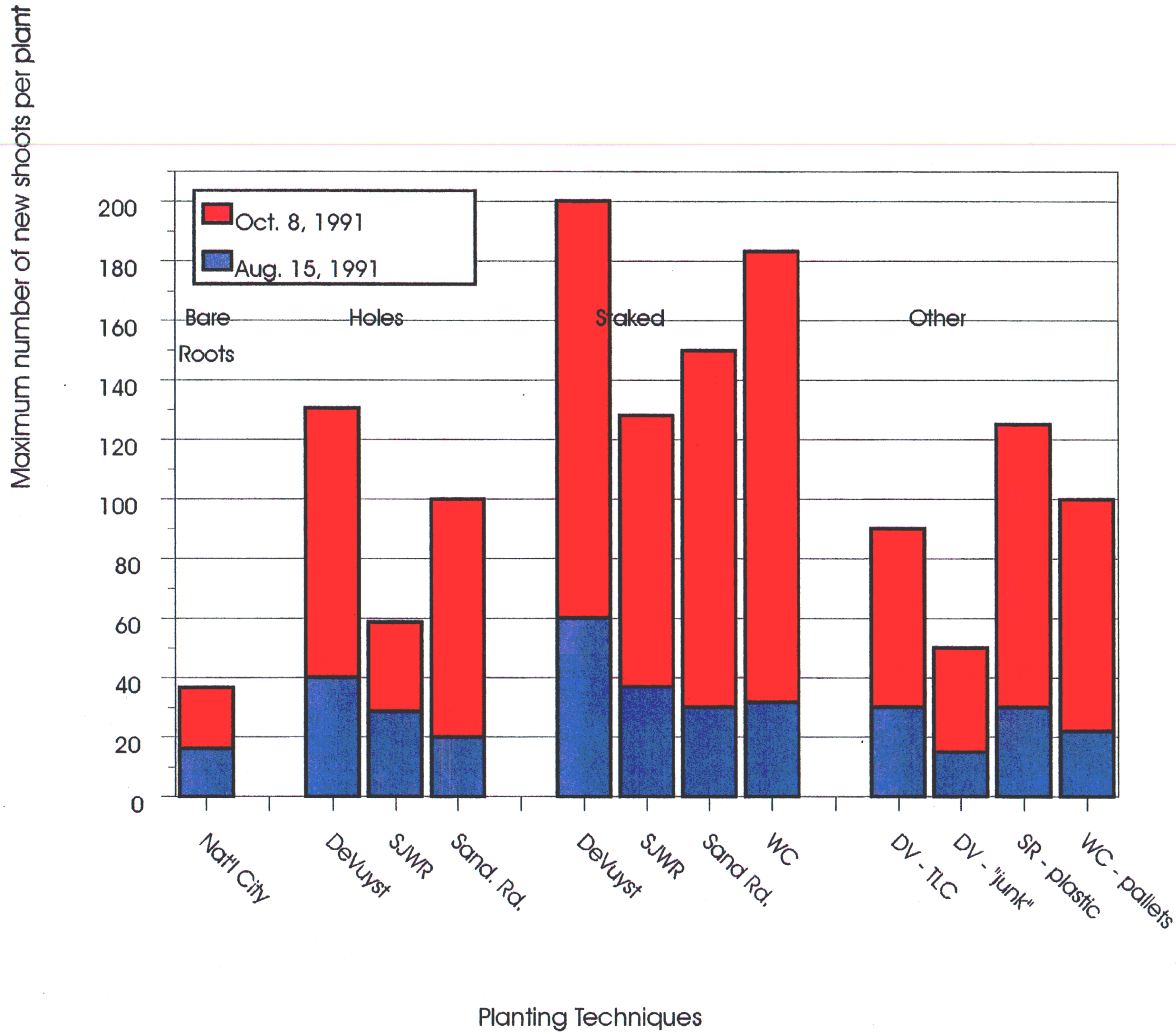


FIGURE 4-6. Maximum Scirpus growth data by planting technique and donor marsh.

penetrate the hard clay substrate that surrounded them. Stressed plants that were staked on top of the hard clay surface were in an ideal situation and were able to grow unrestricted. The plants from the DeVuyst drain grew equally well in either planting technique, with the exception of the plants treated with special care, probably because they were so healthy and were little stressed during transport (the site was only 11.3 km (7 mi) away). Their rhizomes remained robust and, thus, were able to penetrate the clay substrate.

Healthy plants from DeVuyst's drain given special care were planted in holes, but their growth was limited compared to the other DeVuyst plants. Similarly, the Walker Canyon plants placed on and in the wooden pallets, although healthy going in, were restricted by the pallets. The "junk tubers" from DeVuyst's drain, always behind in growth, produced new shoots faster on average than the National City plants (30 versus 22 in October, respectively). Therefore, the plants set on top of the soil surface had a more ideal situation in which to expand unhindered. In addition to being the least labor-intensive of the planting techniques and, therefore, the most cost-effective, the staked plants provided the shortest time to full coverage of the area.

Special handling of the bulrush plants did not enhance the rate of growth after transplanting. The slower growth of the plants given special care, compared to the other DeVuyst plants, implies that damage to the culms (by trimming or breaking) seemed to encourage the rhizomes to produce new shoots more rapidly. In fact, trimming or not trimming the tops (but allowing them inadvertently to bend or break during transport) made no difference in the subsequent growth of the plant. Trimming the culms beforehand, however, makes transport easier.

In comparing the differences in growth between the two marshes with the fastest growth, the only discernable difference is the plant species. The plants from DeVuyst's drain were California bulrush; the plants from Walker Canyon were hardstem bulrush. When healthy and staked, both species were very prolific.

The height of the plants increased with time, but it was not a good measurement for comparing the different harvesting and planting techniques. For example, the plants from National City had average and maximum heights similar to the others although their shoot numbers were much fewer (Figures 4-6 through 4-8). On average, the staked plants were about 30 cm (1 ft) taller than their counterparts planted in holes with the exception of the DeVuyst plants. Three months after planting, the maximum heights of the bulrush from DeVuyst's drain and Walker Canyon were 2.7 to 3.0 m (9 to 10 ft) tall.

Experiments to examine ease of subsequent harvesting included the use of plastic, wooden pallets, and chain-link fencing. The plants planted on plastic lacked soil for support and fell over when growth became tall and high winds occurred. The wooden pallets restricted horizontal and basal plant growth and interfered with hydraulic flow.

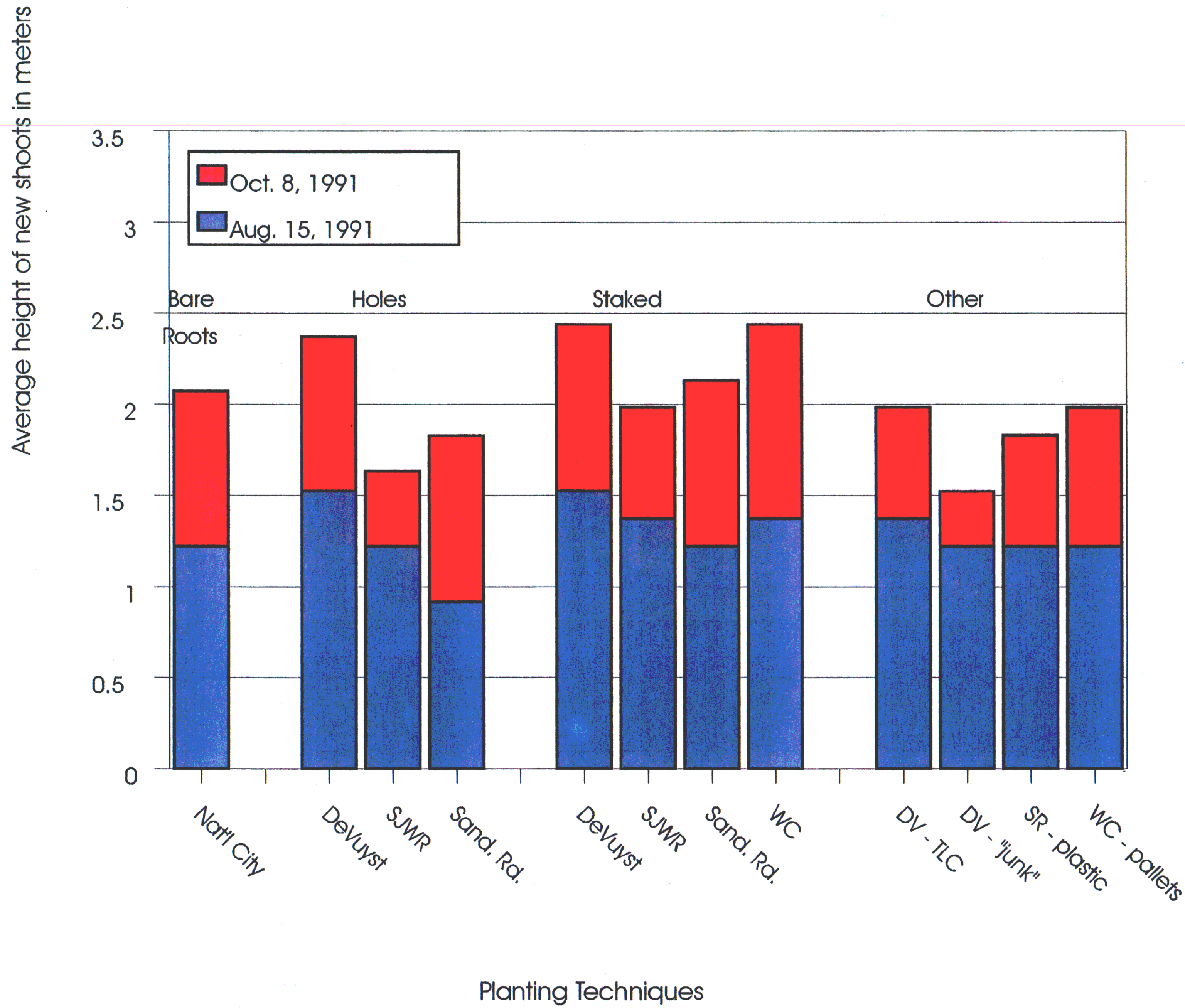


FIGURE 4-7. Average height of new Scirpus shoots by planting technique and donor marsh.

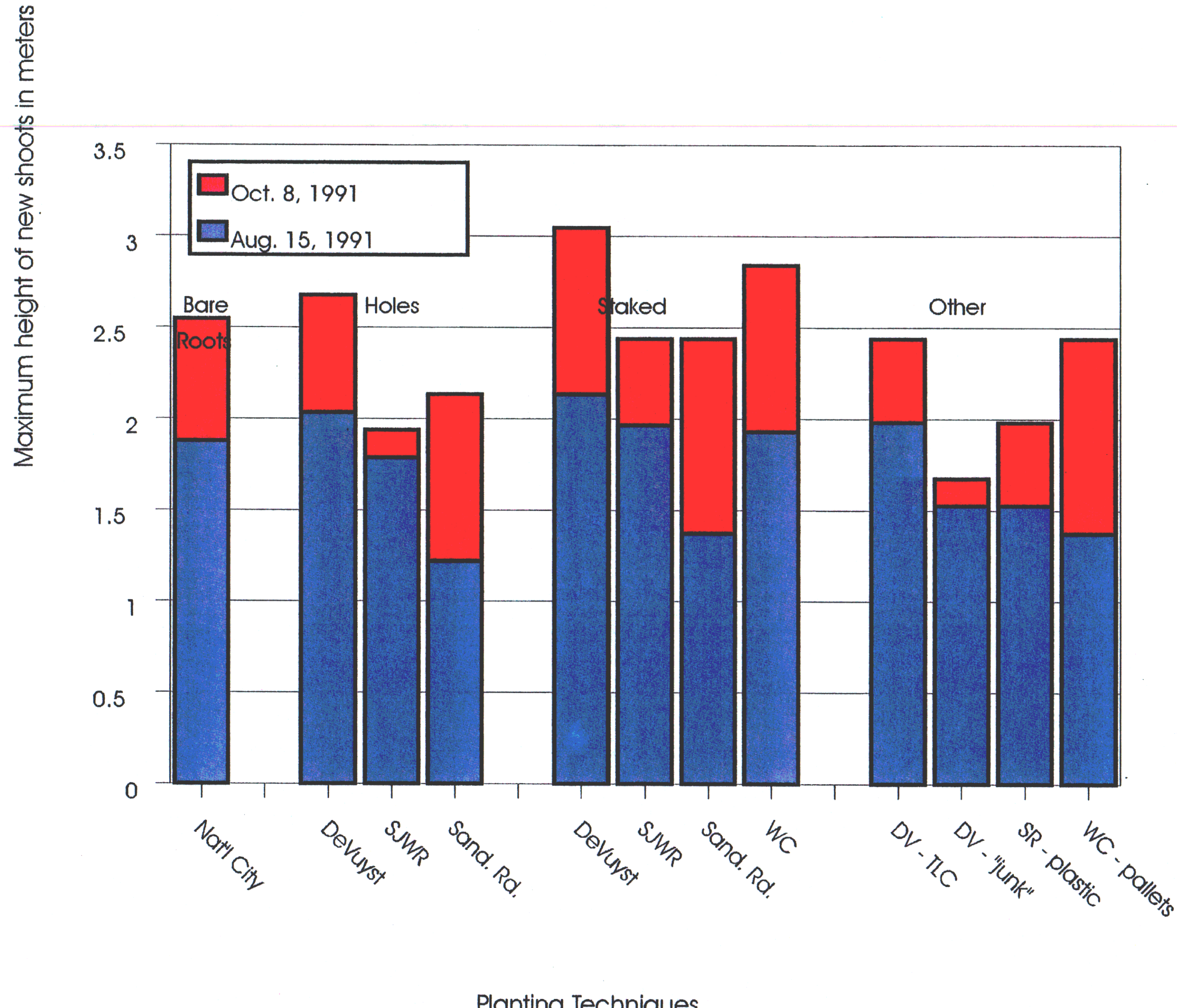


FIGURE 4-8. Maximum height of new Scirpus shoots by planting technique and donor marsh.

Plants planted on chain-link have put extensive roots in and around the fencing. Damage to the plants is probable when they are harvested. Therefore, these planting techniques, designed to make later harvesting easier, were mostly unsuccessful and may prove to be just the opposite.

Additional observations during the August 1991 monitoring trip indicated that most of the plants were healthy and actively growing. Some of the plants from DeVuyst's drain were flowering, while the plants from National City were spindly and had a white fungus growing on their culms. In October, the fungus was gone, and some of the plants had formed seed heads. The other plants were generally healthy with some seed heads (most flowering had already passed). A variety of other organisms was observed using the plants, including insects, spiders, small frogs, and birds.

During the winter, the hardstem bulrush culms senesced and, by the February 1992 monitoring trip, many had bent over and were lying in the water. The California bulrush culm tops turned brown, but most of the plant remained green and upright. In February, new shoots were beginning to come up through the older material of both species, marking the first of the new spring growth.

Chlorine was added to the reclaimed water supply from early October 1992 into January 1993. It was noted during the October sampling that the duckweed around the inlets was bleached white. By January 1993, the duckweed had disappeared in both cells. The chlorine did not appear to damage the other plant species. By April 1993, some duckweed had reappeared.

Marsh pennywort tended to wilt or die back when temperatures were too hot or too cold. The rush survived and flourished along the eastern edge of the north nursery. The seepwillow survived the transplanting but was pulled out because it would be in the way of harvesting activities. A few additional species came in naturally when the water levels were low in October, including alkali bulrush and several grass species. Once the colder temperatures arrived and water depths increased, these species died out for the winter. In the spring, the species did not reappear due to the water depths and lack of available light and space between the larger bulrushes.

Predation, or the eating, of new shoots by American Coots, a small black waterbird, was initially a concern. The coots require "runways" for takeoff and landing. Therefore, immediately after planting, some nylon netting was erected to provide a visual barrier to the birds. As the new culms shot upwards and filled in the bare areas, predation was no longer a threat, so the netting was removed. Very little predation occurred anywhere in the nursery.

Water Quality. Mean inflow to each nursery cell was about 57 L/min (15 gal/min), which resulted in an average hydraulic loading rate of 4 cm/d (1.56 in/d) and an average retention time of 5 days.

Table 4-1 summarizes the results of the in situ water quality measurements of water temperature, dissolved oxygen saturation, pH, and conductivity taken at nine points within each nursery cell on each of the three survey dates. Water temperature in the cells basically reflected ambient air temperatures on the survey dates. Dissolved oxygen saturation percentages and pH's, however, reflected the shift from algae-dominated, sparsely-vegetated cells, in August, to established emergent marshes by October. Supersaturated dissolved oxygen levels and basic pH's, in August, are the result of algal photosynthesis under highly eutrophic conditions. By October, the emergent vegetation had become dense enough to shade out the algae, leaving dissolved oxygen levels below saturation and nearly neutral pH's, which are more typical of a marsh environment. The rise in conductivity from August to February may have been due to evapotranspiration, but, given the range of error in these measurements, the rise is probably not significant.

TABLE 4-1. NURSERY CELL WATER QUALITY COMPARISON
North and South Cell Mean Constituent Values

	AUG 1991		OCT 1991		FEB 1992	
	S	N	S	N	S	N
Water Temperature (°C)	30.5	31.2	20.5	25.1	16.5	14.4
Dissolved Oxygen (% sat)	133.0	173.0	28.0	37.0	82.0	55.0
pH	8.8	9.2	7.4	7.6	7.6	7.5
Conductivity (μS/cm)	1060.0	957.0	1076.0	1015.0	1135.0	1131.0

Table 4-2 summarizes the results of the laboratory analyses of the water samples collected from the cell inlets and the combined outlet of the two cells on each survey date. Because the outlet sample represents the combined outflows of the two nursery cells, the removal efficiencies shown in Table 4-2 were estimated using the average of the two cell inlet concentrations.

TABLE 4-2. NURSERY CELL WATER TREATMENT
Estimated Mean Constituent Removal Efficiencies

	AUG 1991	OCT 1991	FEB 1992
AMMONIA NITROGEN	26%	38%	-58%
NITRATE NITROGEN	75%	90%	-20%
ORTHOPHOSPHATE PHOSPHORUS	-145%	-85%	-77%
TOTAL ORGANIC CARBON	0%	-56%	NO DATA
TOTAL SUSPENDED SOLIDS	38%	0%	-157%
TOTAL DISSOLVED SOLIDS	-22%	-7%	-9%

Ammonia and nitrate nitrogen removal efficiencies in August probably reflected uptake by the algae that dominated the cells at that time (Table 4-2). By October, however, the emergent vegetation was well enough established to have shaded out the algae, so removal efficiencies at that time most likely reflected nitrification-denitrification transformations in the marsh environment. It appeared that the chlorination of the nursery cells from October to January severely impacted the microbial biofilm on the stems of the emergent vegetation as well as killing the floating duckweed, so rather than removing nitrogen from the water, the dead organic material actually increased ammonia and nitrate nitrogen concentrations.

Orthophosphate phosphorus was added to the wastewater within the cells from August through February, although the amount added declined steadily throughout this period (Table 4-2). The pattern of declining orthophosphate phosphorus additions suggests that leaching from the newly inundated soils may have been the main source of the added phosphorus.

The last three constituents shown in Table 4-2--total organic carbon, total suspended solids, and TDS--are difficult to interpret with the available data. The downward trend in TDS additions may, however, reflect a decrease in evapotranspiration as the emergent vegetation began to shade the water surface and air temperatures declined with the passing season.

Invertebrates. Table 4-3 summarizes the results of the benthic invertebrate sampling on the three survey dates. In August, the benthos were almost entirely composed of chironomids, non-biting midge larvae, often called "blood worms". Such a benthic community is typical of a wastewater oxidation pond, which is essentially what the nursery cells were at that time. By October, the benthic community had increased in numbers of organisms and in the number of taxa present. The predominance of chironomids had declined somewhat, and oligochaetes, or aquatic earthworms, had begun to appear, reflecting the shift toward a more typical marsh benthic community. The shift from a benthic community completely dominated by chironomids to one with a higher percentage of oligochaetes continued into February, although both numbers of organisms and number of taxa had declined sharply since the October survey, perhaps as a result of the chlorination of the cells in the interim period.

TABLE 4-3. NURSERY CELL BENTHIC COMMUNITY COMPARISON

	AUG 1991		OCT 1991		FEB 1992	
	S	N	S	N	S	N
Number of taxa present	6	6	16	13	4	3
Total number of organisms	448	551	753	1176	241	94
% Chironomids	97	97	81	82	75	73
% Oligochaetes	0	0	3	11	24	26

Mosquito Larvae. Mean mosquito larvae counts were 0.83 larvae per sample in the north cell during August 1991. In October, the mean data were 0.83 larvae per sample in the north cell and 1.1 in the south cell. The larvae were more dense under the marsh pennywort than under duckweed or algae. In February, no mosquito larvae samples were collected due to high winds.

Research Cells

Plant Growth and Establishment. Six weeks after planting, the bulrush plants were actively growing with a 99.97 percent survival rate (one out of 3652 clumps died). A few clumps had floated away from their staked positions but were found growing along a nearby shoreline. Since that time, no plants have died.

The mean number of new bulrush shoots per sampled clump was 21.4 in October 1992. The mean illustrates how quickly the bulrush proliferated in the research cells in just 6 weeks. The actual number of new shoots per sampled clump ranged from 2 to 80 throughout the cells (Figure 4-9). Major differences in development of new shoots between cells were probably due to the hydraulic problems of the cells. During planting, the water to each of the research cells was delivered at various times so the transplanted clumps were exposed to differing periods of drying out, causing a

PHOTO 24. RESEARCH CELLS (14 MONTHS AFTER PLANTING)

PHOTO 25. NEST MADE OF BULRUSH CULMS IN RESEARCH CELL

FIGURE 4-9

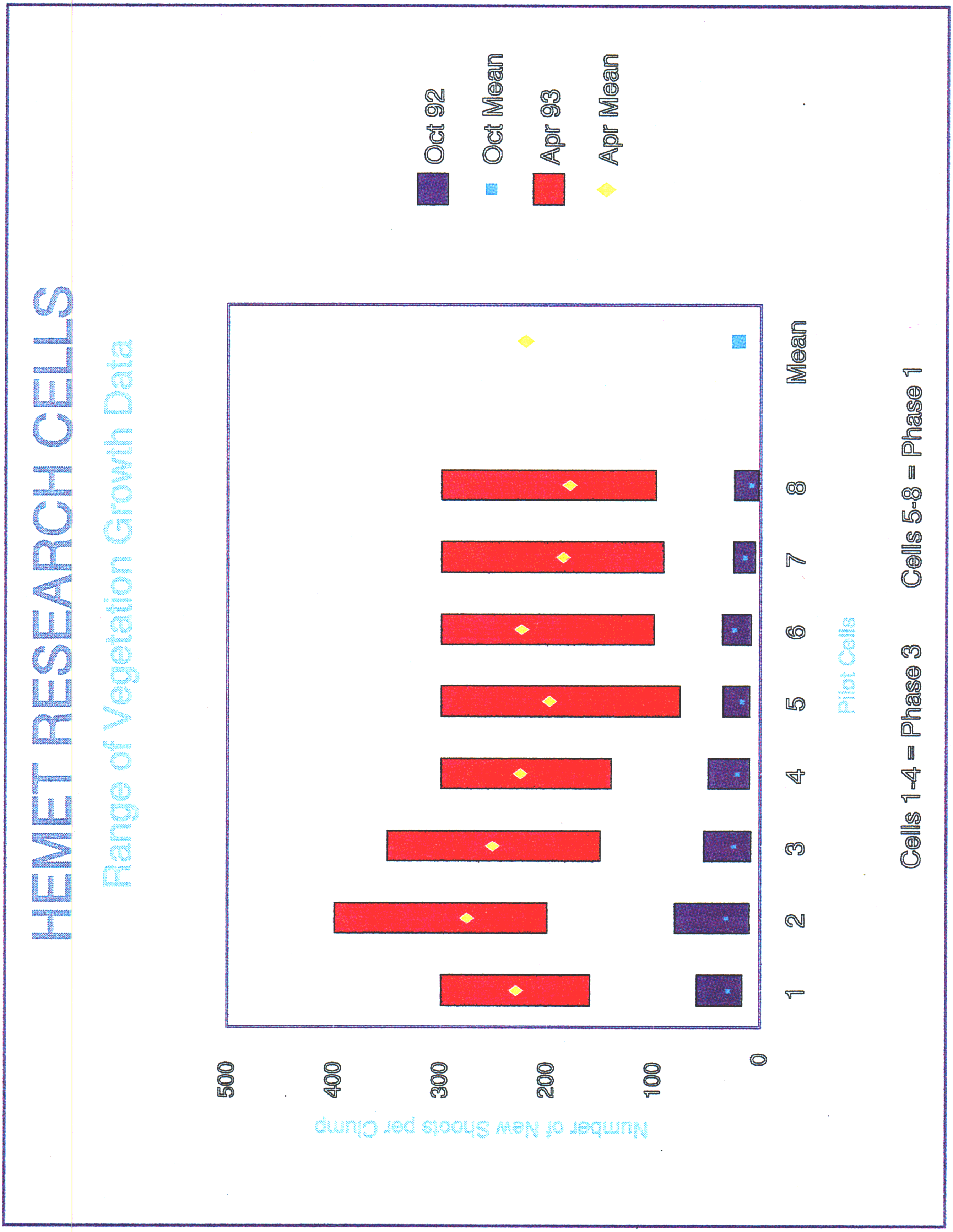
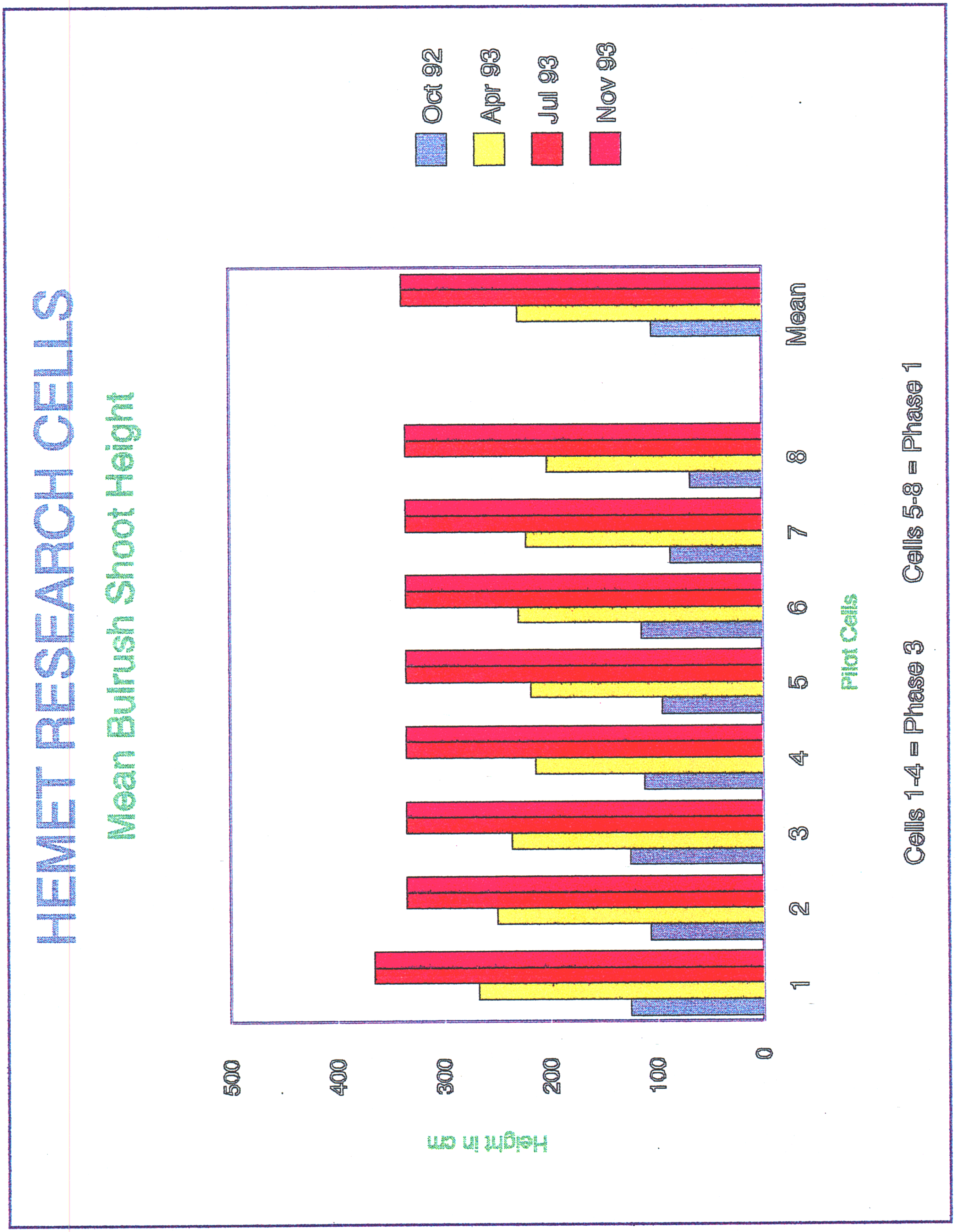
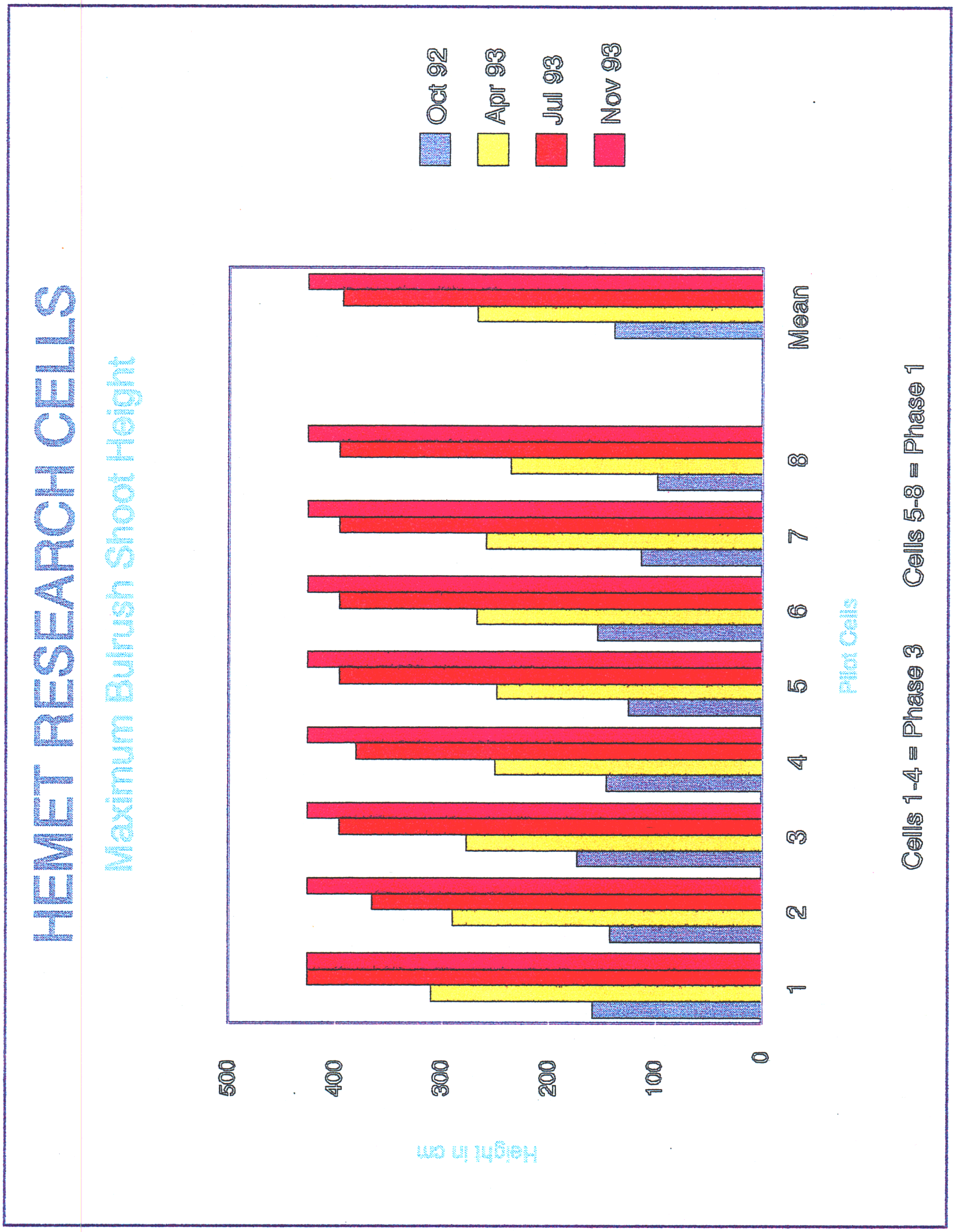

HEMET RESEARCH CELLS
Range of Vegetation Growth Data
Oct 92
Oct Mean
Apr 93
Apr Mean
Number of New Shoots per Clump
0
100
200
300
400
500
1
2
3
4
5
6
7
8
Mean
Pilot Cells
Cells 1-4 = Phase 3
Cells 5-8 = Phase 1

FIGURE 4-10



HEMET RESEARCH CELLS
Mean Bulrush Shoot Height
Oct 92
Apr 93
Jul 93
Nov 93
Height in cm
500
400
300
200
100
0
1
2
3
4
5
6
7
8
Mean
Pilot Cells
Cells 1-4 = Phase 3
Cells 5-8 = Phase 1

FIGURE 4-11


HEMET RESEARCH CELLS
Maximum Bulrush Shoot Height
Oct 92
Apr 93
Jul 93
Nov 93
Height in cm
0
100
200
300
400
500
1
2
3
4
5
6
7
8
Mean
Pilot Cells
Cells 1-4 = Phase 3
Cells 5-8 = Phase 1

variation in initial conditions. The research cells were engineered to be level; however, before planting, fill dirt was deposited in each of the cells to provide loose soil for rhizome penetration. The soil was not re-leveled in order to avoid compaction. This created an unevenness in the bottom of the cells, and some cells contained high spots which were above the water level 6 weeks after planting. Additionally, daily water flow into each of the cells was erratic, and each cell's daily flow was different from the others.

By April 1993, the number of new shoots had increased dramatically in each cell; most of the increase occurred during the previous month. The mean number of new shoots per sample clump throughout the cells jumped to 220, an increase of over 10 times per October's mean. The range of new shoots per sample clump was 91 to 400, with variation both between and within the cells. All of the plants were healthy. The horizontal growth of the rhizomes was causing the plants to grow toward each other, filling in the spaces between the plants. By July 1993, the new shoots along the new rhizomes had increased in number so much that it was impossible to determine which clump the new shoots came from without digging the plants out. The variation within the cells was not as apparent as in the previous months. Cells 7 and 8 were visually not as dense with new culms as cells 1 through 6, but the plants were still very healthy and robust. By November 1993, the plants were so dense throughout all of the cells that the use of a machete was necessary to walk through them. Visual variations between or within the cells in regard to bulrush growth could not be discerned. The research cells had reached 100 percent plant coverage.

The mean bulrush culm height of all the sampled plants throughout the research cells was 104 cm (± 25 cm) (41 in) in October 1992, 230 cm (± 31 cm) (90 in) in April 1993, and 339 cm (± 10 cm) (132 in) in July and November 1993 (Figure 4-10). Maximum culm heights of the bulrush plants averaged 140 cm (± 34 cm) (55 in), 268 cm (± 36 cm) (105 in), 394 cm (± 16 cm) (154 in), and 427 cm (± 0.0 cm) (167 in), respectively (Figure 4-11). Initially, bulrush culm height also varied within and between the research cells, but by July and through November 1993, culm heights became more uniform. It appeared the 427-cm (167-in) height was maximum for this species, and the 339-cm (132-in) height was typical under Hemet/San Jacinto conditions.

The maximum culm width (the length of one of the three sides of the largest culm) sampled in October 1992 was 1.9 cm (0.75 in). The maximum culm width sampled in April, July, and November 1993 was 3.2 cm (1.25 in). Although 3.2 cm (1.25 in) appeared to be the maximum culm size in this system, few were noted in April and, as time went on, progressively larger culms were noted.

The research cells were designed to be as similar to each other as possible in order to serve as replicates in specific studies; therefore, only one plant species, California bulrush, was intentionally planted. One hardstem bulrush plant was inadvertently planted along the eastern edge of cell 1. No other species were deliberately planted. However, many other plant species have appeared in and around the research cells, presumably introduced by natural means (wildlife or wind) or unavoidable contamination during planting. Duckweed and water pennywort were observed growing on the water surface in many of the cells by July 1993. Cattail were growing in the north end of cell 5 by November 1993. Many other plant species have established themselves around the perimeter of each of the research cells on the 4:1 sloped berms. The first plant to establish itself was swamp timothy, which was noted during the April 1993 sampling trip. By July, more swamp timothy, two species of smartweed, willow, seepwillow, and a mallow were observed. In November, prickly lettuce, and a brown surface algae were observed in addition to the other species.

To date, the additional plant species have not impacted the California bulrush community and, therefore, are not considered a cause of any variation in water quality.

In Situ Water Analyses.

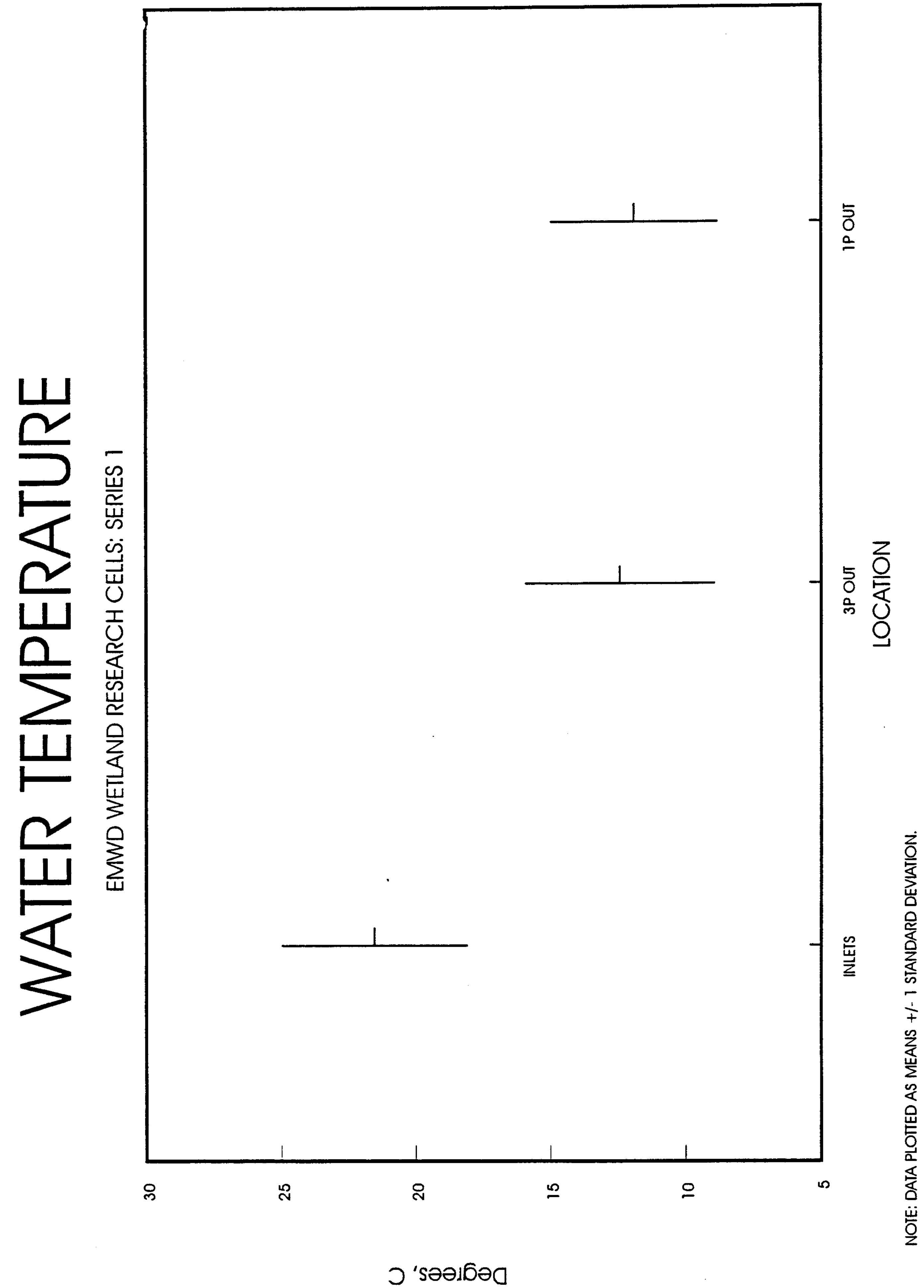
Hydrolab DataSonde Measurements. Mean water temperature, conductivity, pH, and dissolved oxygen saturation measured on the inflows and outflows of both types of cells during Series 1 and Series 1A are shown in Figures 4-12 through 4-19. The mean parameter values were calculated on the basis of over 1680 hourly measurements during Series 1 and over 1100 hourly measurements during Series 1A. Figures 4-12 through 4-19 show mean parameter values along with their plus and minus one standard deviation ranges.

Water Temperature. Figures 4-12 and 4-13 indicate that the water cooled as it flowed through both types of cells during both Series 1 and Series 1A. This cooling averaged about 9° C during Series 1 and about 7° to 8° C during Series 1A. There does not appear to have been any significant difference between the two types of cells in the degree of cooling during either Series 1 or 1A.

Conductivity. Figures 4-14 and 4-15 indicate no significant change in the conductivity of the water as it flowed through either type of cell during either Series.

pH. Figures 4-16 and 4-17 show generally neutral to slightly basic pH's in the inflow and outflow of both types of cells throughout Series 1 and 1A. During Series 1, both the three-phase and one-phase cells exhibited a slight increase in pH from the inflow to the outflow, perhaps as a result of photosynthesis by the algae that predominated in the open water of the still sparsely vegetated cells. During Series 1A, neither type of cell exhibited a significant difference in pH between inflow and outflow.

FIGURE 4-12



WATER TEMPERATURE
EMWD WETLAND RESEARCH CELLS: SERIES 1
Degrees, C
30
25
20
15
10
5
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-13

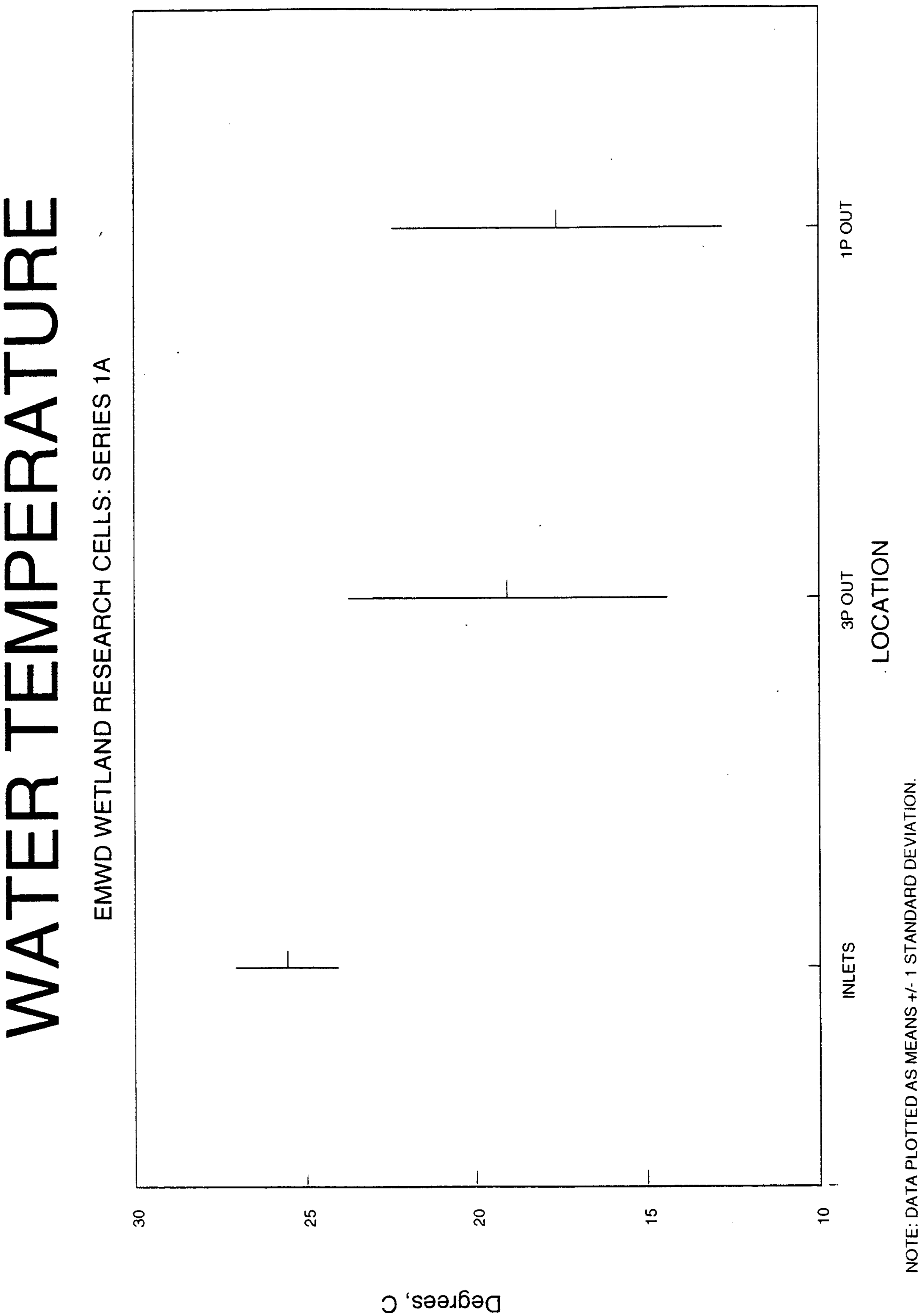
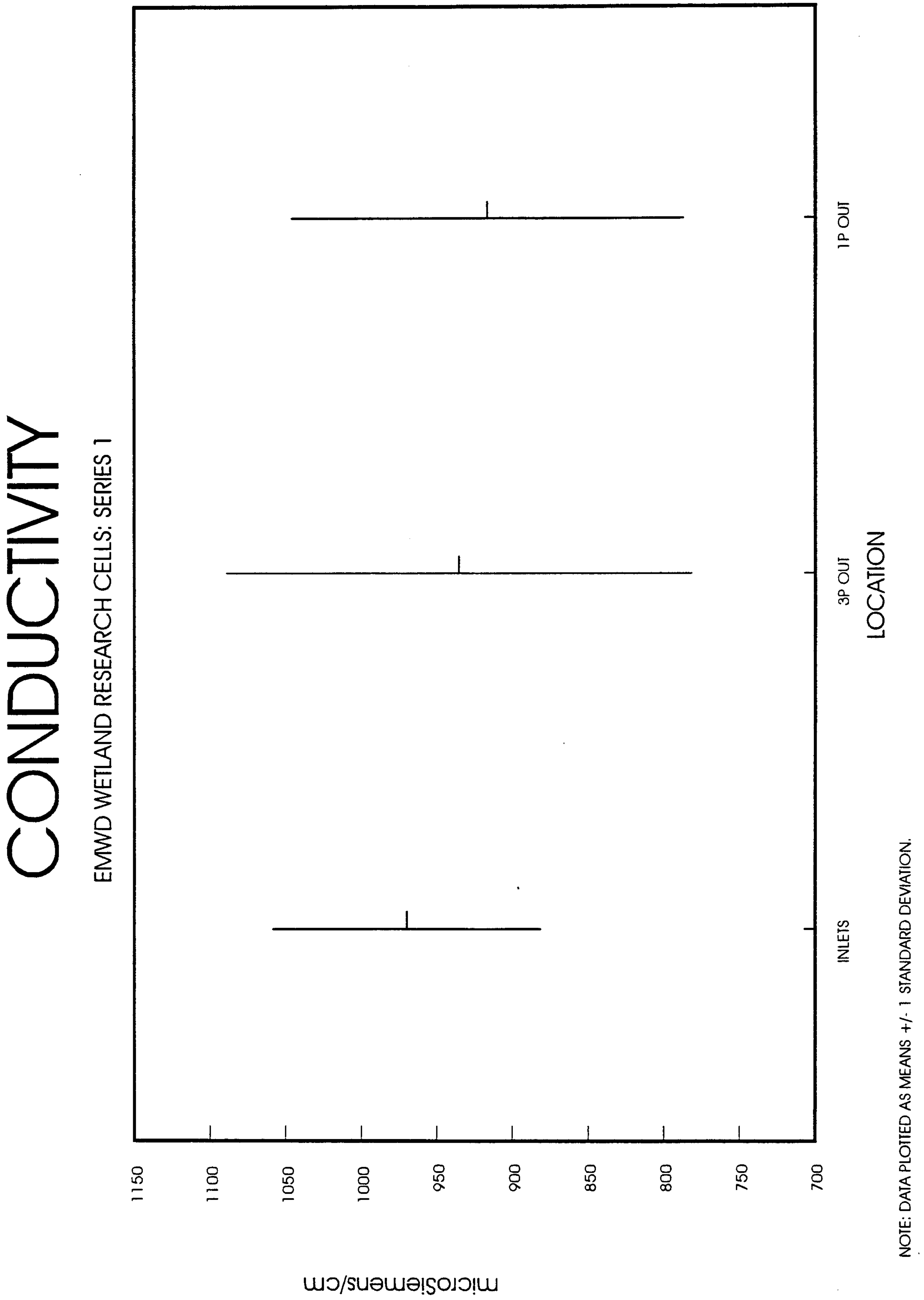
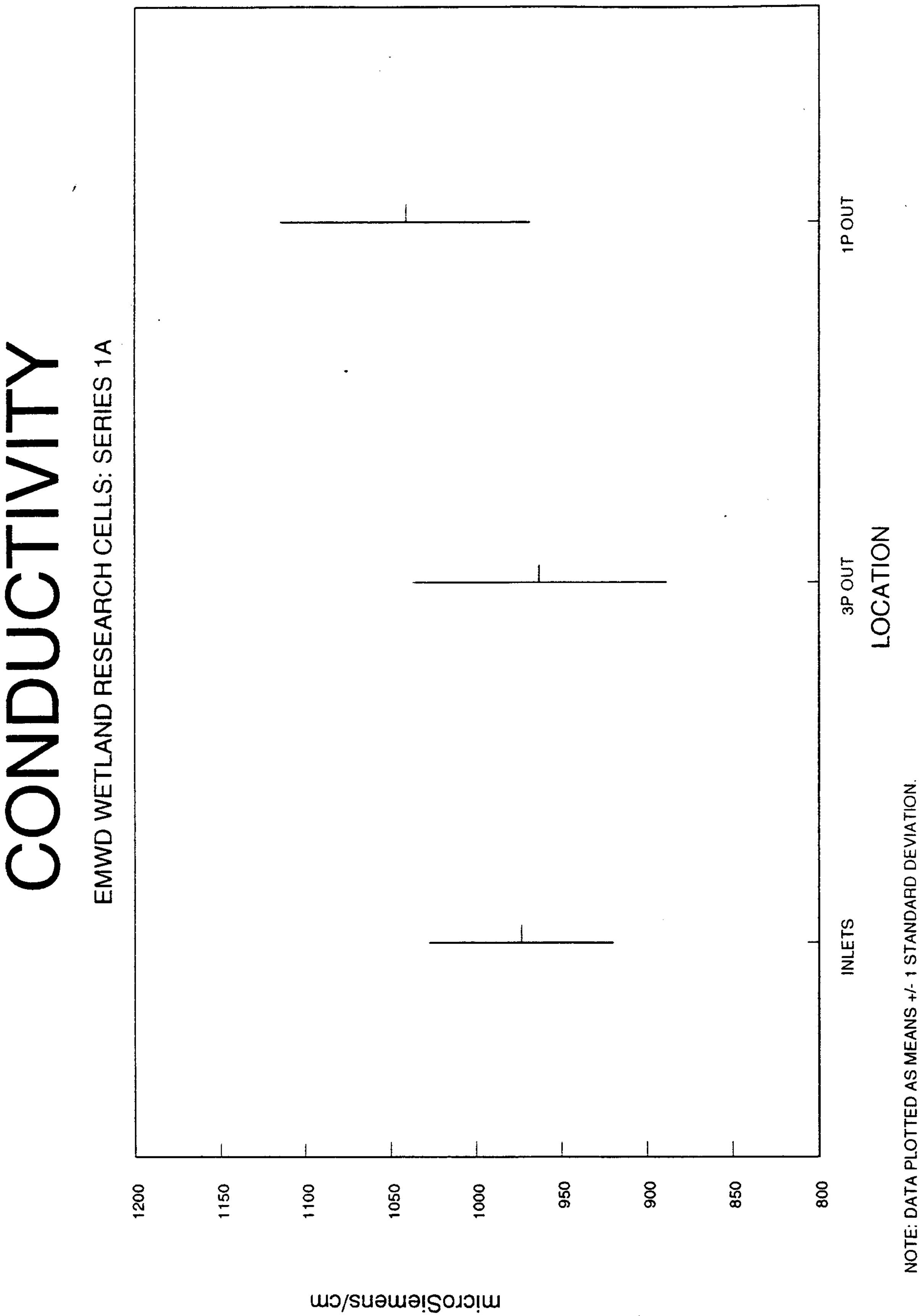

WATER TEMPERATURE
EMWD WETLAND RESEARCH CELLS: SERIES 1A
Degrees, C
30
25
20
15
10
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-14



CONDUCTIVITY
EMWD WETLAND RESEARCH CELLS: SERIES 1
microSiemens/cm
1150
1100
1050
1000
950
900
850
800
750
700
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-15



CONDUCTIVITY
EMWD WETLAND RESEARCH CELLS: SERIES 1A
microSiemens/cm
1200
1150
1100
1050
1000
950
900
850
800
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-16

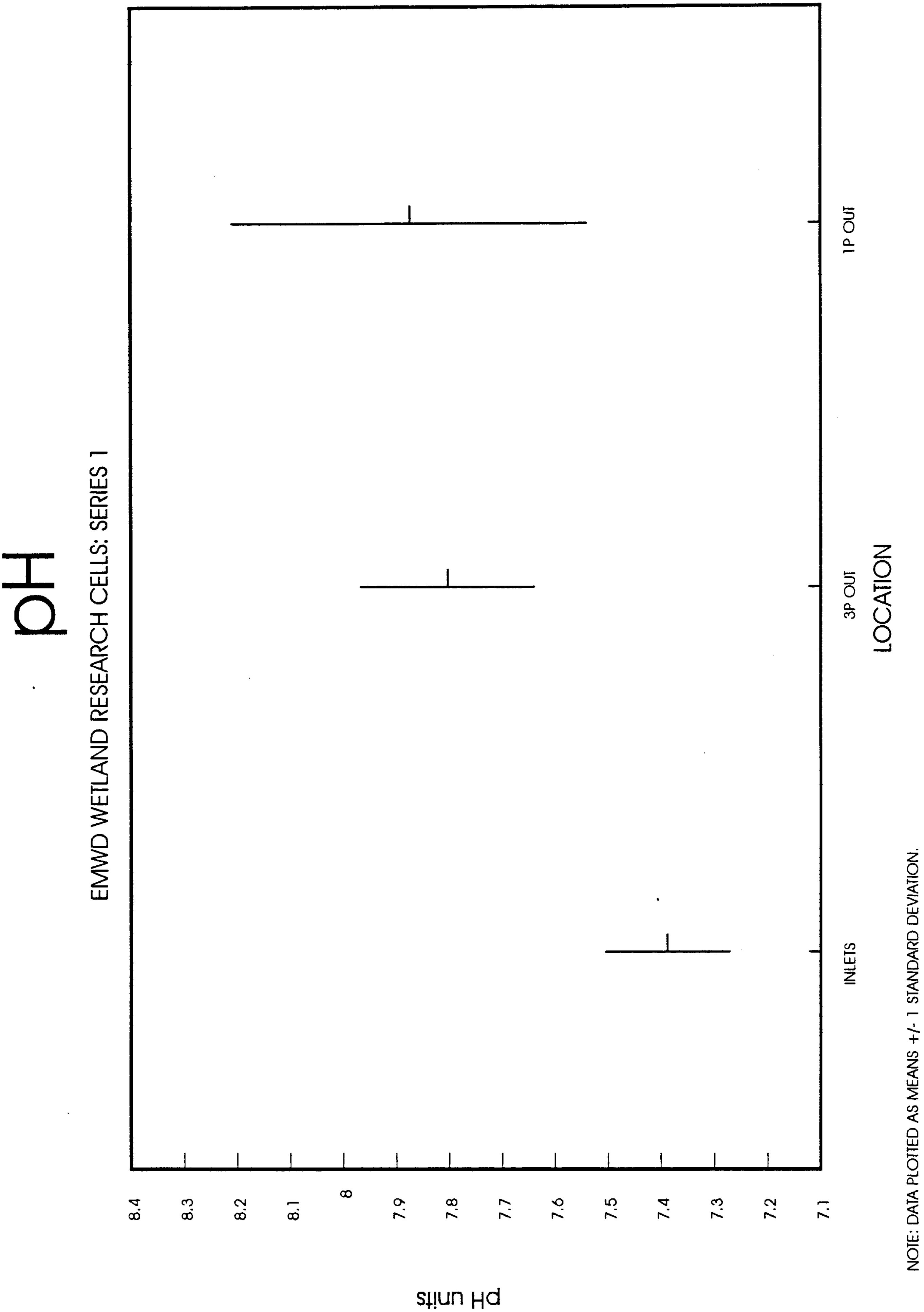

pH
EMWD WETLAND RESEARCH CELLS: SERIES 1
pH units
8.4
8.3
8.2
8.1
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-17

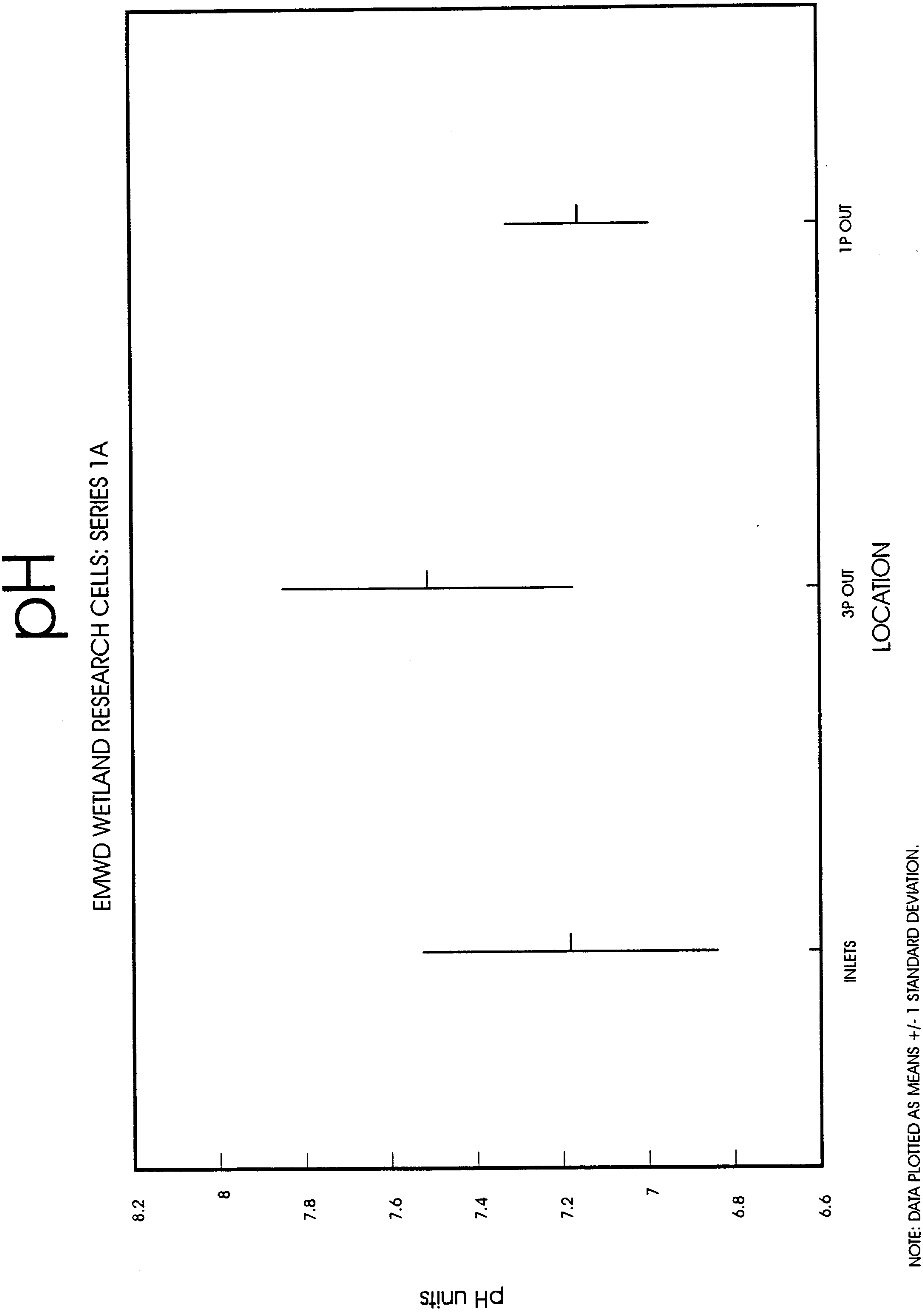
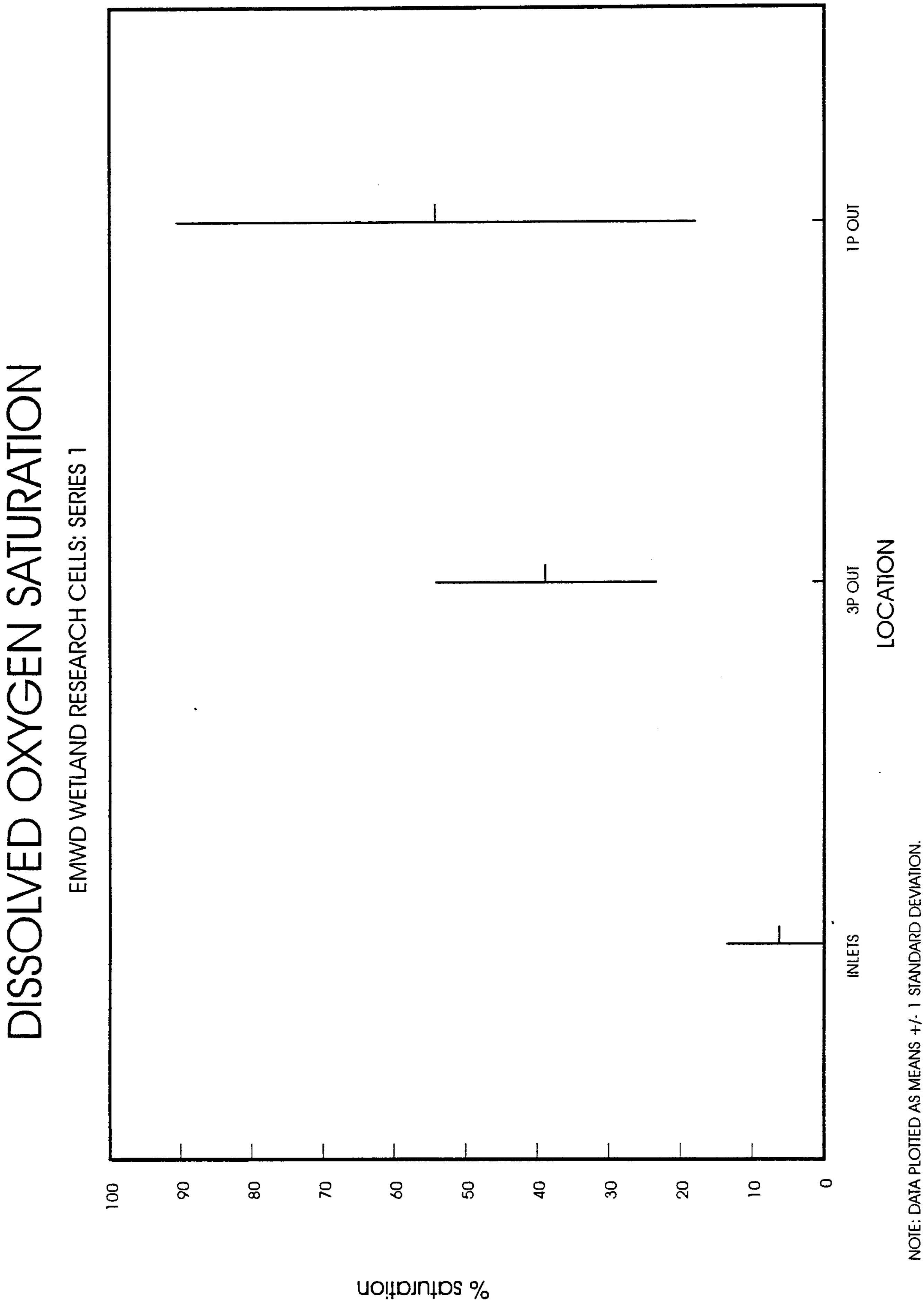
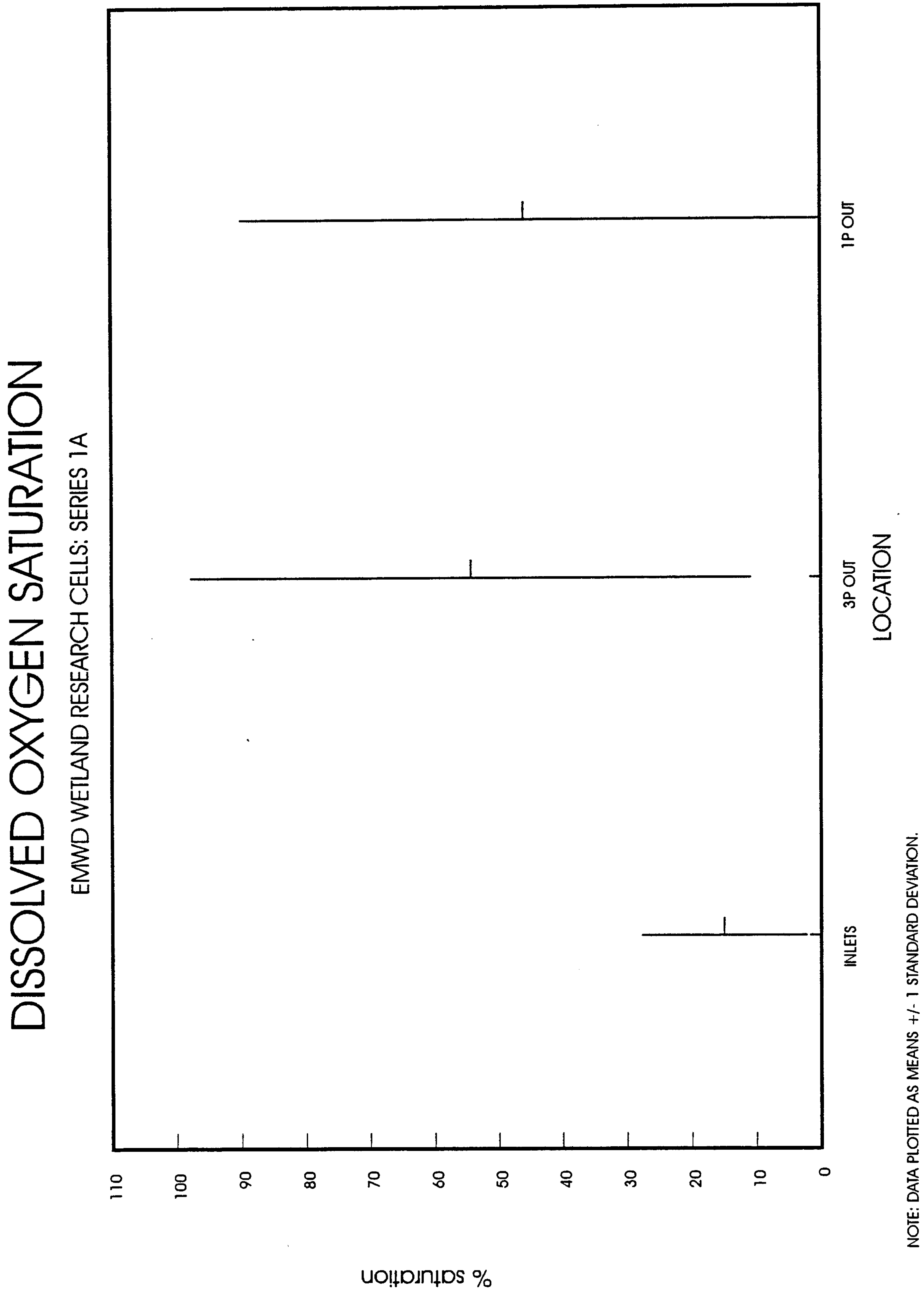

pH
EMWD WETLAND RESEARCH CELLS: SERIES 1A
pH units
8.2
8
7.8
7.6
7.4
7.2
7
6.8
6.6
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-18



DISSOLVED OXYGEN SATURATION
EMWD WETLAND RESEARCH CELLS: SERIES 1
% saturation
0
10
20
30
40
50
60
70
80
90
100
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

FIGURE 4-19


DISSOLVED OXYGEN SATURATION
EMWD WETLAND RESEARCH CELLS: SERIES 1A
% saturation
0
10
20
30
40
50
60
70
80
90
100
110
INLETS
3P OUT
1P OUT
LOCATION
NOTE: DATA PLOTTED AS MEANS +/- 1 STANDARD DEVIATION.

Dissolved Oxygen Saturation. Figures 4-18 and 4-19 show that the reclaimed water enters the research cells at a consistently low percentage of dissolved oxygen saturation. (This low dissolved oxygen content accounts for the fact that nitrite is an important component of the total nitrogen concentration of the cell inflows.) The outlets of both types of cells exhibit a significant increase in mean dissolved oxygen saturation. A marked diurnal cycle of high daylight and low nighttime dissolved oxygen saturation accounts for the wide variation about the means. This diurnal cycle is mainly the result of algal photosynthesis and respiration.

NOTE: The fact that the DataSondes were suspended in wells within the inlet and outlet structures of the cells may sometimes have affected the data, especially the pH and dissolved oxygen saturation data. Very low, slow flows, at times, allowed thick algal scums to build up on the water surface within the wells; pH and dissolved oxygen variations at such times could have been exaggerated by the photosynthesis and respiration of the algae within the wells.

Inflow Rates. Two flowmeters became available during the Series 1A monitoring program, and both of them were used to monitor inflows on the paired three-phase and one-phase cells. Monitoring of inflow rates to the three-phase and one-phase cells began on June 5 and July 6, respectively. Figure 4-20 shows the mean daily inflows to the three-phase cells, and Figure 4-21 shows the same data for the one-phase cells. The Series 1A average daily inflow to the three-phase cells was 32.2 L/min (8.5 gal/min), which resulted in an average retention time of 13.21 days. Corresponding series averages for the one-phase cells were an inflow rate of 23.1 L/min (6.1 gal/min) and a retention time of 13.05 days.

Using an average daily inflow rate of 32.2 L/min (8.5 gal/min) for the three-phase cells during Series 1A, average retention times were estimated for each of the three components of the marsh-pool-marsh system:

Inlet marsh component = 4.7 days (36 percent of total cell retention time)
Pool component = 6.6 days (50 percent of total cell retention time)
Outlet marsh component = 1.9 days (14 percent of total cell retention time).

Although the Series 1A average retention times in both types of cells were roughly equal, there was an important difference in the fact that 50 percent of the time, the water in the three-phase cells was residing in an open, relatively deep pool and was not exposed to marsh conditions.

The pool component of the three-phase cells, thus, has the potential of affecting the water treatment process in at least two major ways:

FIGURE 4-20

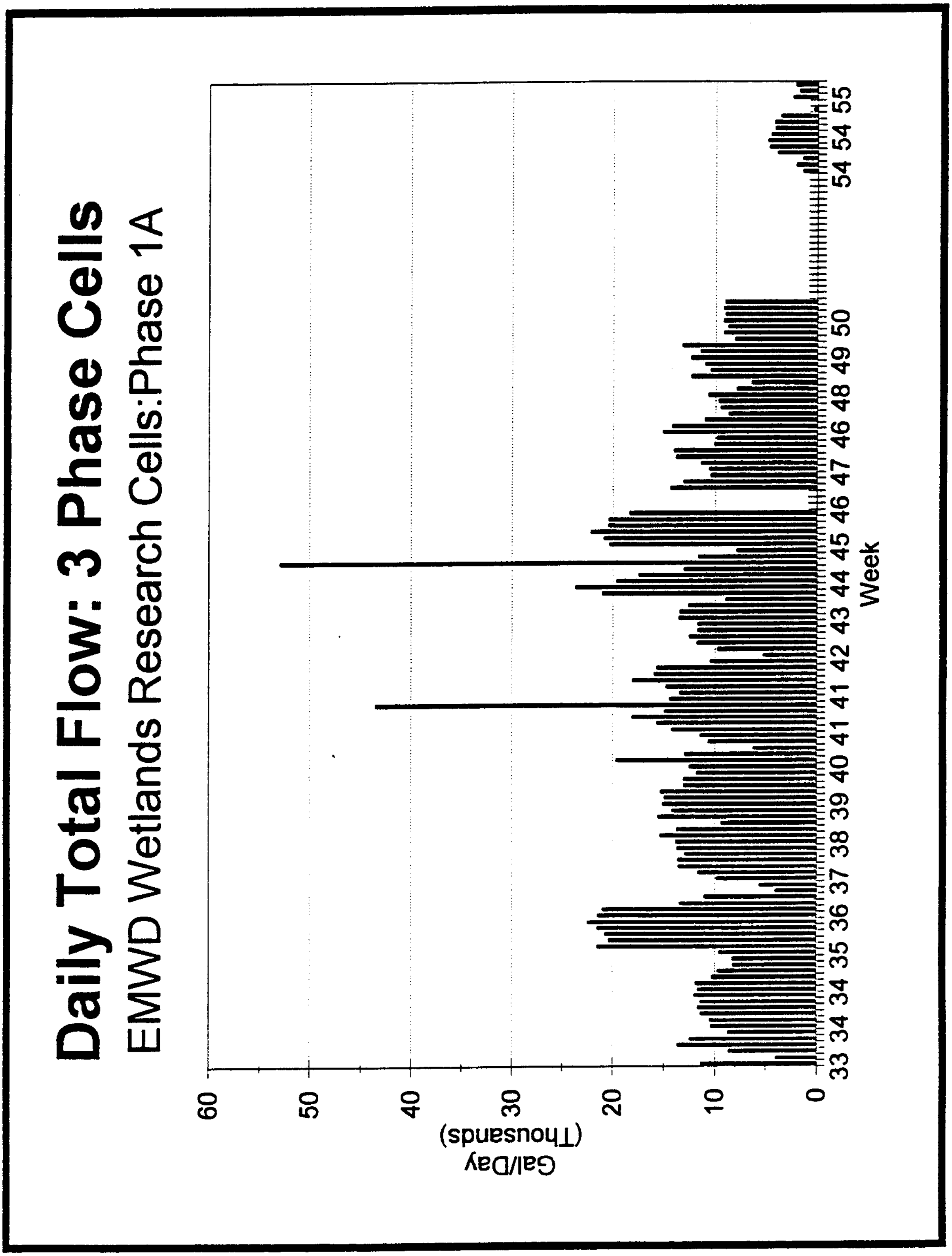
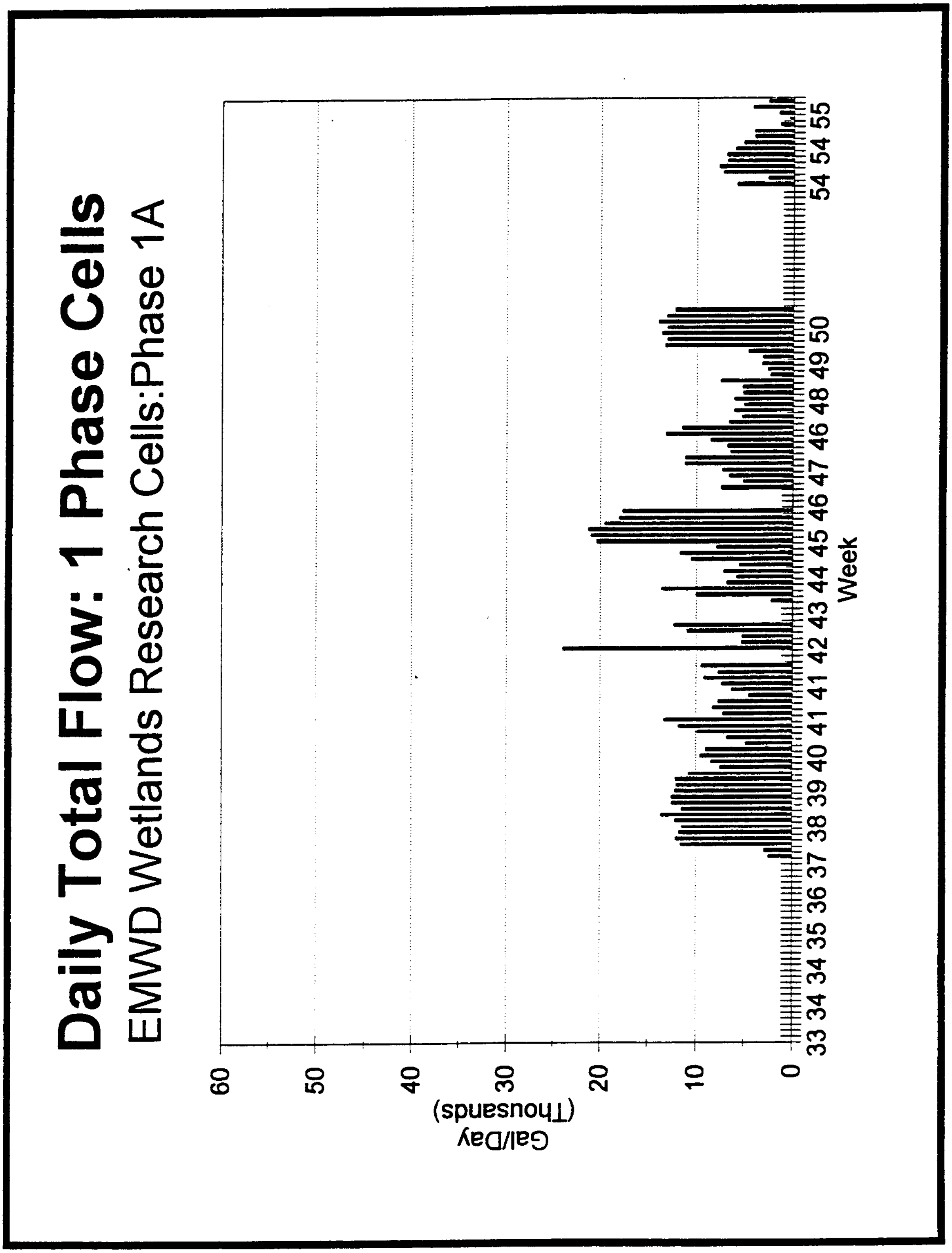

Daily Total Flow: 3 Phase Cells
EMWD Wetlands Research Cells:Phase 1A
Gal/Day (Thousands)
60
50
40
30
20
10
0
33 34 34 34 35 36 37 38 39 40 41 41 41 42 43 43 44 45 45 46 47 46 48 48 49 50 54 54 55
Week

FIGURE 4-21


Daily Total Flow: 1 Phase Cells
EMWD Wetlands Research Cells:Phase 1A
Gal/Day
(Thousands)
60
50
40
30
20
10
0
33 34 34 34 35 36 37 38 39 40 41 41 41 42 43 44 45 46 47 46 48 49 50 54 54 54 55
Week

1. It could act as a facultative wastewater treatment lagoon within the emergent marsh system, which would enhance the efficiency of the nitrogen transformation in particular.

2. Given equal retention times, it would reduce by half the amount of time the water is exposed to organic loading by nesting and perching birds in the emergent marsh vegetation of the one-phase system.

Laboratory Water Quality Analyses. The following data analysis and discussion is limited to those data collected during Series 1A (i.e., during the period from May 5, 1993, when monitoring was resumed after the winter rains and flooding, through November 10, 1993, when all initial research cell monitoring was terminated). Series 1 data are not included because of the sparsity of the data and the long hiatus between Series 1 and 1A.

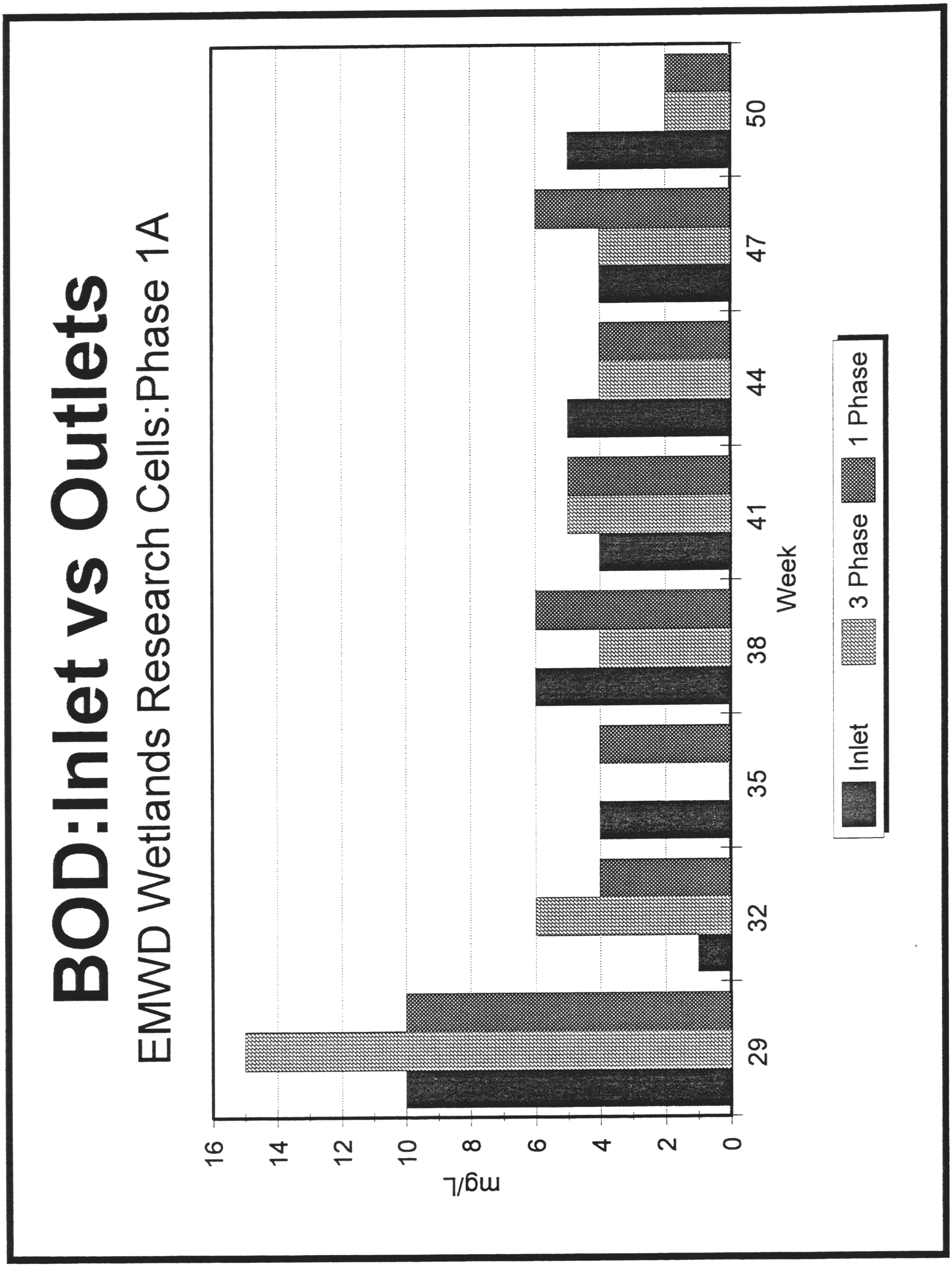
The paired sample t-test was selected as the statistical method for evaluating the water quality data and determining if there were significant differences between the laboratory chemical data for the three-phase and one-phase systems. Simply averaging the data for each system and comparing means would not take into account either the variance of the measurements or the number of samples used. The paired sample t-test takes these factors into consideration and can be used to determine if the differences between two sets of data, taken in pairs, are significant.

In the paired sample test, the "t" factor is calculated as the average of the differences between the pairs of measurements divided by the standard error of that set of differences. The "t" factor is then compared to the critical value of "t" for the degrees of freedom in the set and the desired level of significance. If the absolute value of a computed "t" value is found to be greater than the critical value, then the hypothesis is rejected. For the present analysis, the difference between the sets of paired data was hypothesized to be null, and the level of significance was set at 0.05, which means that rejecting the premise that the two data sets are the same would have less than 5 percent probability of being in error. The two-tailed critical "t" value was used in this analysis because a difference in either direction was considered to be grounds for rejecting the null hypothesis.

Summary tables of the Series 1A data, general statistics, and paired t-test results, for each of the following parameters, are included in Appendix A of this report.

Biochemical Oxygen Demand (BOD). BOD increased slightly in both the three-phase and the one-phase cells when outlet concentrations were compared with inlet concentrations (Figure 4-22). The average BOD for the inlet, three-phase outlets, and one-phase outlets were 4.9, 5.7, and 5.1 milligrams per liter (mg/L), respectively. The highest BOD concentration was 15 mg/L, observed in a three-phase outlet; the lowest BOD concentration was 1 mg/L, measured in the inlet. For the

FIGURE 4-22



BOD:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
mg/L
16
14
12
10
8
6
4
2
0
29
32
35
38
41
44
47
50
Week
Inlet
3 Phase
1 Phase

three-phase cells, the increase in BOD over inlet concentrations amounted to 17.2 percent; for the one-phase cells, the corresponding increase was 5.1 percent.

The paired sample t-test, however, did not show either of these differences to be significant, due mainly to the small number of samples and the large variance in their values.

Considering the low BOD concentrations coming into the wetlands, it is not surprising that the outlet concentrations are somewhat higher. The increase in outlet BOD concentrations probably reflects organic production (i.e., assimilation of nutrients and shedding of organic material) within the wetlands. A "background" BOD of approximately 5 mg/L is probably the lower limit that can be expected from a wastewater treatment wetland.

Total Organic Carbon (TOC). TOC concentrations in the inlet, three-phase outlets, and one-phase outlets averaged 10.4, 11.7, and 11.1 mg/L, respectively (Figure 4-23). The highest concentration recorded was 17 mg/L, in a one-phase outlet, and the lowest was 5.2 mg/L, also in a one-phase outlet. As with BOD, average TOC concentrations showed a slight increase in the outlets of both types of cells compared with the inlet. The average TOC increase was 12.4 percent in the three-phase systems and 6.4 percent in the one-phase, neither of which the paired sample t-test indicated to be statistically significant. The slight apparent increase in TOC concentrations in the research cell outlets probably reflects the same internal production noted in the previous discussion of BOD.

Total Suspended Solids (TSS). TSS results were skewed by one inlet sample that contained a very high concentration (25 mg/L) compared with the average concentration of 10 mg/L (Figure 4-24). Without that one sample, the results would have shown an increase in TSS concentrations in the three-phase cells. The highest TSS was 25 mg/L, in an inlet, and the lowest was 3 mg/L, in a one-phase cell outlet. Average TSS concentrations for the inlet, three-phase outlets, and one-phase outlets were 10, 8.4, and 4.6 mg/L, respectively. The paired t-test did not indicate any significant differences between inlet and outlet TSS concentrations, once again because of high variance in the inlet samples and the small total number of samples. There was, however, a significant difference between the three-phase and one-phase outlets, but this result does not take into consideration the poor accuracy of the TSS analytical method at these low concentrations.

Visual inspection of the graphed data suggests that there may have been a decline in TSS during Series 1A. It is interesting that the graphed turbidity data also suggest a decline. If such declines actually occurred, they may have been due to seasonal phenomena or due to conditions in the research cells stabilizing. More monitoring of

FIGURE 4-23

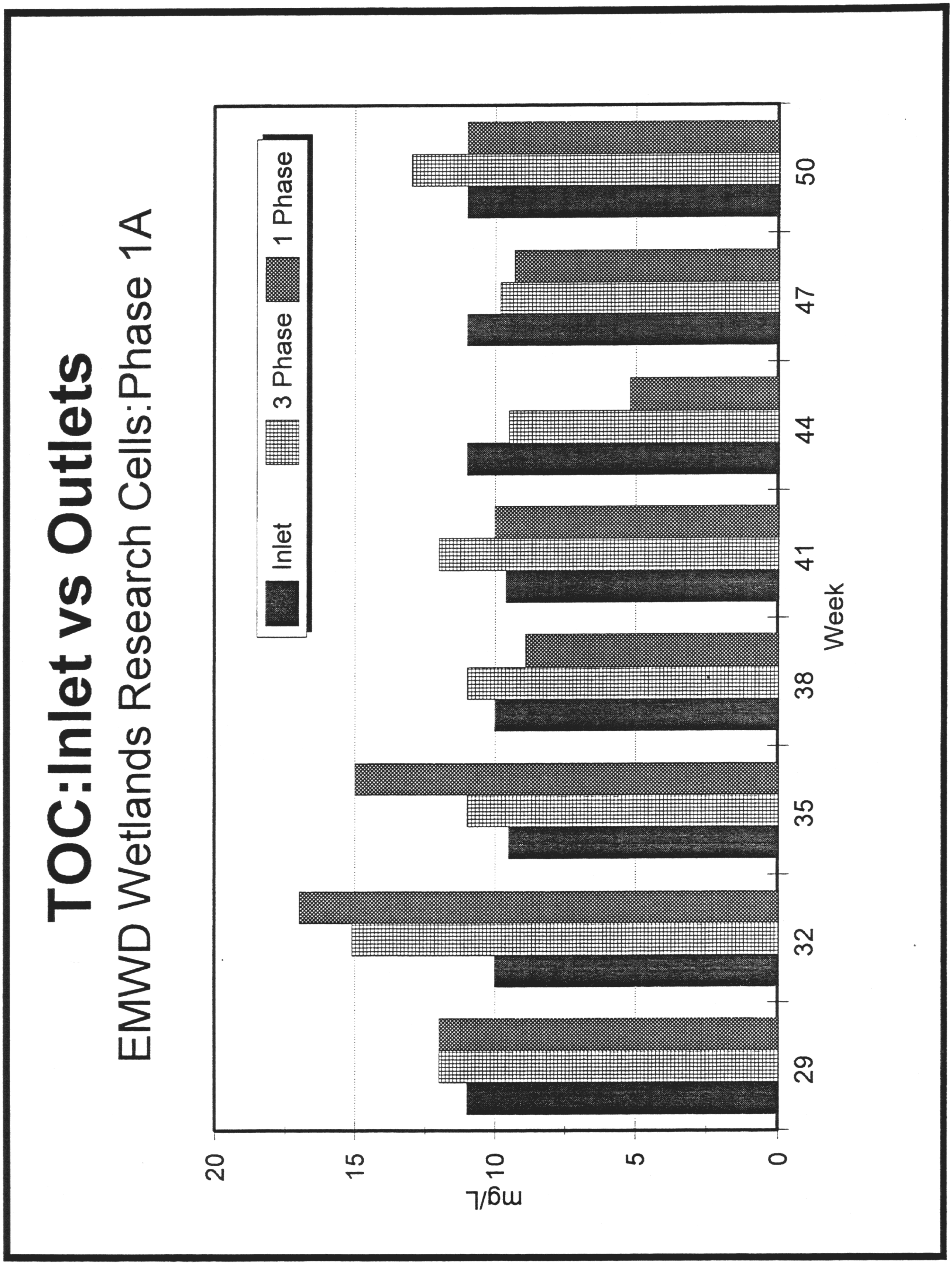
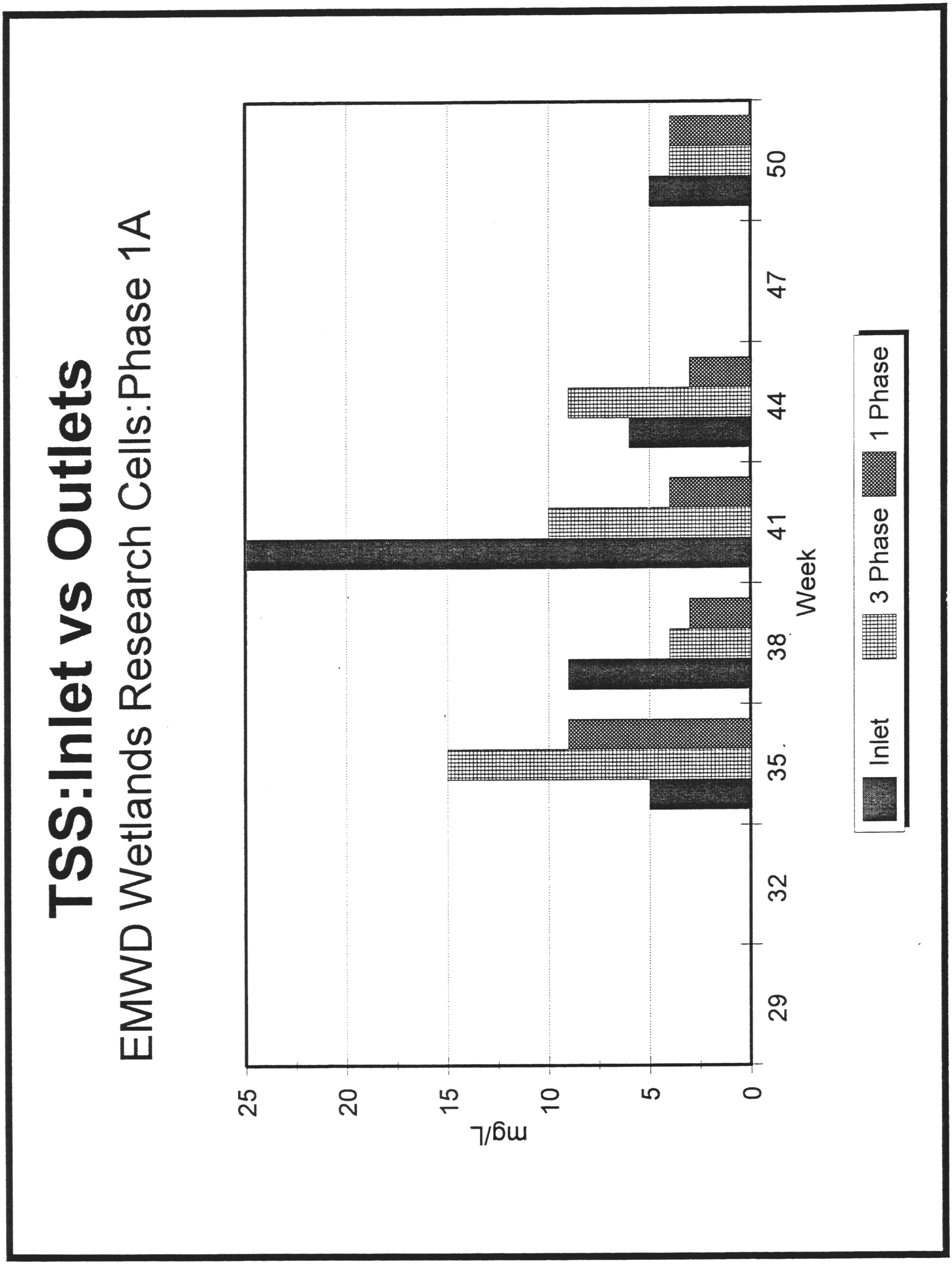

TOC:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
Inlet
3 Phase
1 Phase
mg/L
0
5
10
15
20
29
32
35
38
41
44
47
50
Week

FIGURE 4-24


TSS:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
mg/L
0
5
10
15
20
25
29
32
35
38
41
44
47
50
Week
Inlet
3 Phase
1 Phase

effluent suspended solids is needed before any definite conclusions can be reached in a comparison between the three-phase and one-phase systems or between the inlet and outlets.

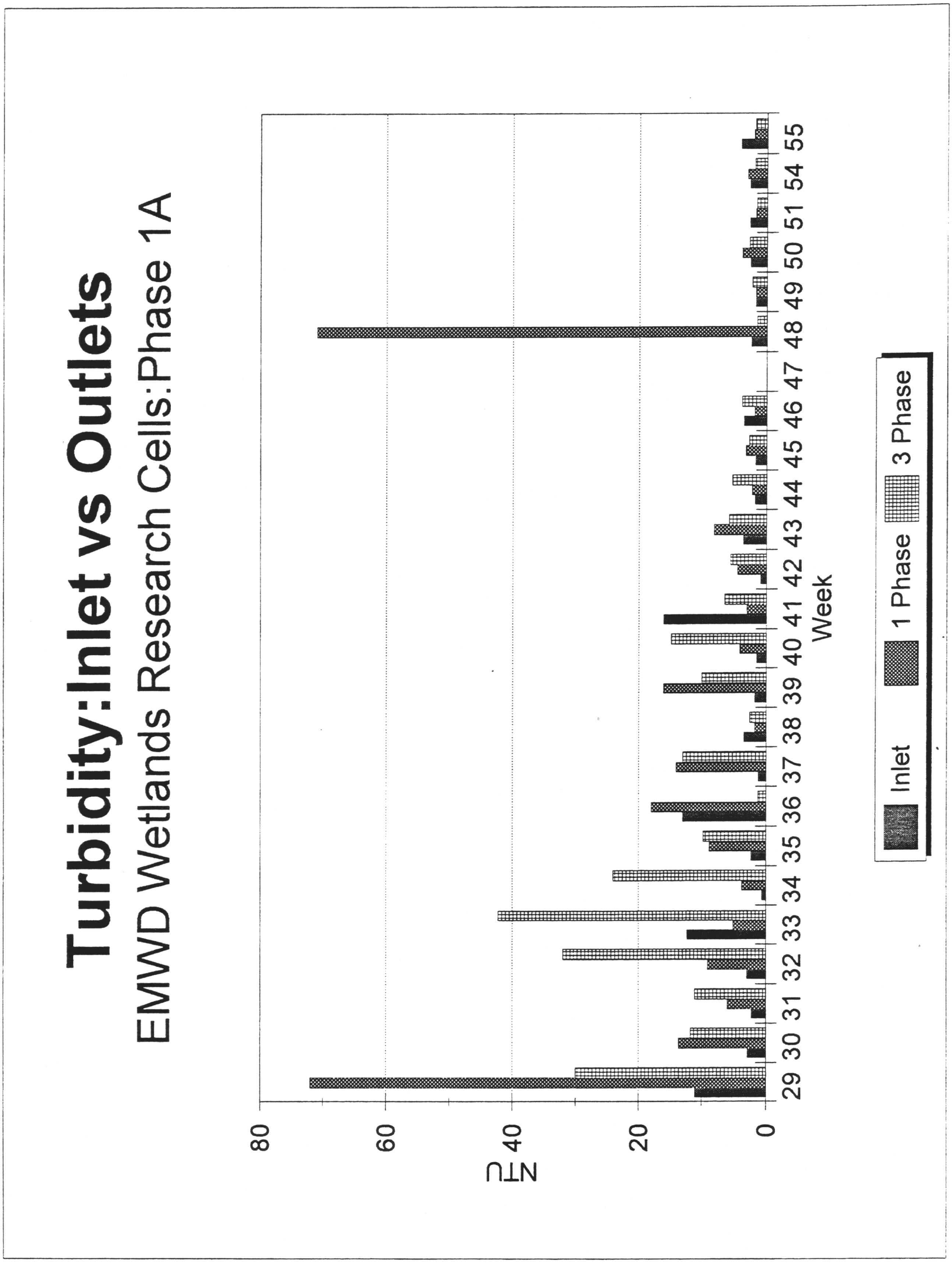
Turbidity. Turbidity increased in both the three-phase and one-phase outlets compared with inlet turbidity levels (Figure 4-25). The average increase over inlet values was 148 percent for the three-phase system and 183 percent for the one-phase system. Turbidity averaged 4.1, 10.2, and 11.6 nephelometric turbidity units in the inlet, three-phase, and one-phase systems, respectively. The difference between the three-phase and one-phase systems was not significant. Three-phase outlet turbidity did differ significantly from the inlet turbidity, and, although the t-test did not show a significant difference for the one-phase outlets compared with the inlet, the computed "t" value was nearly equal to the critical value.

Graphed turbidity data for the outlets suggest a general trend toward lower turbidities during Series 1A, but this trend was punctuated, at times, with very high values, mostly in the one-phase cells. Speculation as to the cause of the various high turbidity readings has included algae, chemical leachate from the soil reacting with something in the water, decaying plant matter, bacteria, fungus, bird droppings, and/or any combination of these. Microscopic examination for algae, which was suspected because the gray-green color of the water, showed that not only was algae not a factor but that there was a conspicuous absence of algae in the samples. Further microscopic examination, involving fixing and staining a slide, revealed a preponderance of filamentous bacteria resembling varieties commonly found in the treatment plant (e.g., Beggiotoa and Sphaerotilus). This suggested a highly eutrophic environment.

In later January 1994, a white slime was observed on the weirs and outlet boxes of the one-phase cells, and turbidity in these cells was also observed to be much higher than usual. It was hypothesized that the source of the white slime might be the large number of birds producing fecal matter, coupled with recent rains that washed it off the bulrush and into the water. This could have been exacerbated by recent cold weather which may have lowered microbial activity enough so that the uric acid in the fecal matter was not decomposed. If this were the case, the white slime should have had a high nitrogen content. A sample of the slime was taken to the EMWD lab and analyzed for total Kjeldahl nitrogen (TKN). The slime sample was found to have a TKN of 2800 mg/L, compared to an inlet TKN of 24 mg/L, 32 mg/L at the midpoint of the cell, and 36 mg/L at the outlet. The hypothesis that the white slime was uric acid seemed to be supported by the laboratory analytical results.

Total and Fecal Coliforms. During duck hunting season, which usually spans the period from October to January, reclaimed water sold to the neighboring duck clubs must be disinfected so all secondary effluent from the treatment plant is chlorinated before it is released. To protect the wetland research cells from being

FIGURE 4-25



Turbidity:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
NTU
0
20
40
60
80
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
54
55
Week
Inlet
1 Phase
3 Phase

directly chlorinated during this period, secondary effluent being sent to the facility was dechlorinated with sodium bisulfite. A dechlorination unit was installed which could handle residual chlorine levels of up to 10 mg/L. When the residual chlorine level was expected to rise above the 10 mg/L level, flow into the research cells was halted until chlorination returned to a level the dechlorination unit could handle. Fecal and total coliform samples collected from the inlets during this period, which coincided with the later part of Series 1A, were not comparable to the earlier undisinfected samples.

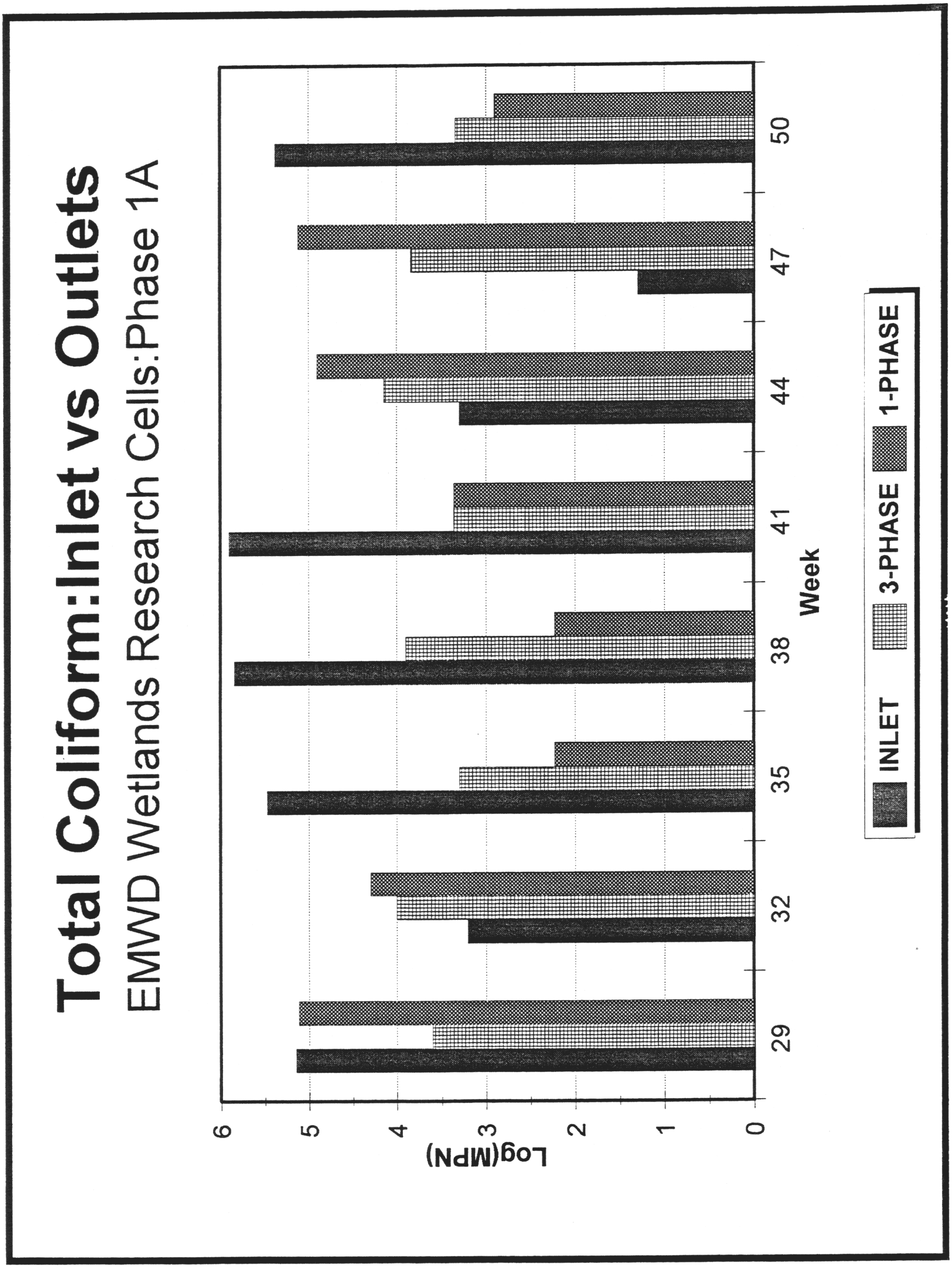
A total of eight samples were analyzed for total and fecal coliforms during Series 1A (Figures 4-26 and 4-27, respectively); two of these samples had been chlorinated and then dechlorinated. Included in the graphs and analyses are two sets of data: one with the chlorinated samples included and one without them. Total coliform counts in the three-phase outlets averaged 97.7 percent less than inlet counts when the chlorinated samples were not included. Fecal coliform counts in the three-phase outlets averaged 98.6 percent less than inlet counts with the chlorinated samples included and 99.3 percent less without them. The one-phase outlet total coliform counts averaged 83.4 percent less than inlet counts when the chlorinated samples were included (93.0 percent less than inlet counts overall) and 92.5 percent less when the chlorinated samples were excluded. The small number of samples and the high variability of the results cast some doubt on any conclusions that might be drawn from these data. Despite the high average differences between inlet and outlet coliform counts, paired t-tests indicated only marginal significance.

Nitrogen.

Ammonium Nitrogen (NH_4-N). Twenty-five samples were analyzed for ammonium nitrogen concentrations (Figure 4-28). Ammonium is the major form of nitrogen in the reclaimed water coming into the wetland research facility, with an average inlet concentration during Series 1A of 11.7 mg/L. Mean outlet concentrations were 5.7 mg/L for the three-phase systems and 13.4 mg/L for the one-phase systems. Compared with the inflow concentrations, then, the three-phase systems decreased NH_4-N by an average of 51.6 percent, while the one-phase systems actually increased NH_4-N by 14.6 percent on average. Paired t-tests indicated that the differences between the three-phase outlets and the inlet and between the outlets of the two types of cells were statistically significant; however, the outlet concentrations of the one-phase systems were not found to be significantly different from the inlet concentrations.

Nitrite Nitrogen (NO_2-N). Due to the dynamic nature of this form of nitrogen and its rapid oxidation to nitrate under aerobic conditions, it would be incorrect to talk about "removal" of nitrite. Nitrite nitrogen concentrations in the inlet samples were relatively high (Figure 4-29) because the reclaimed water was relatively anoxic when it entered the research cells. The inlets averaged

FIGURE 4-26



Total Coliform:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
Log(MPN)
0
1
2
3
4
5
6
29
32
35
38
41
44
47
50
Week
INLET
3-PHASE
1-PHASE

FIGURE 4-27

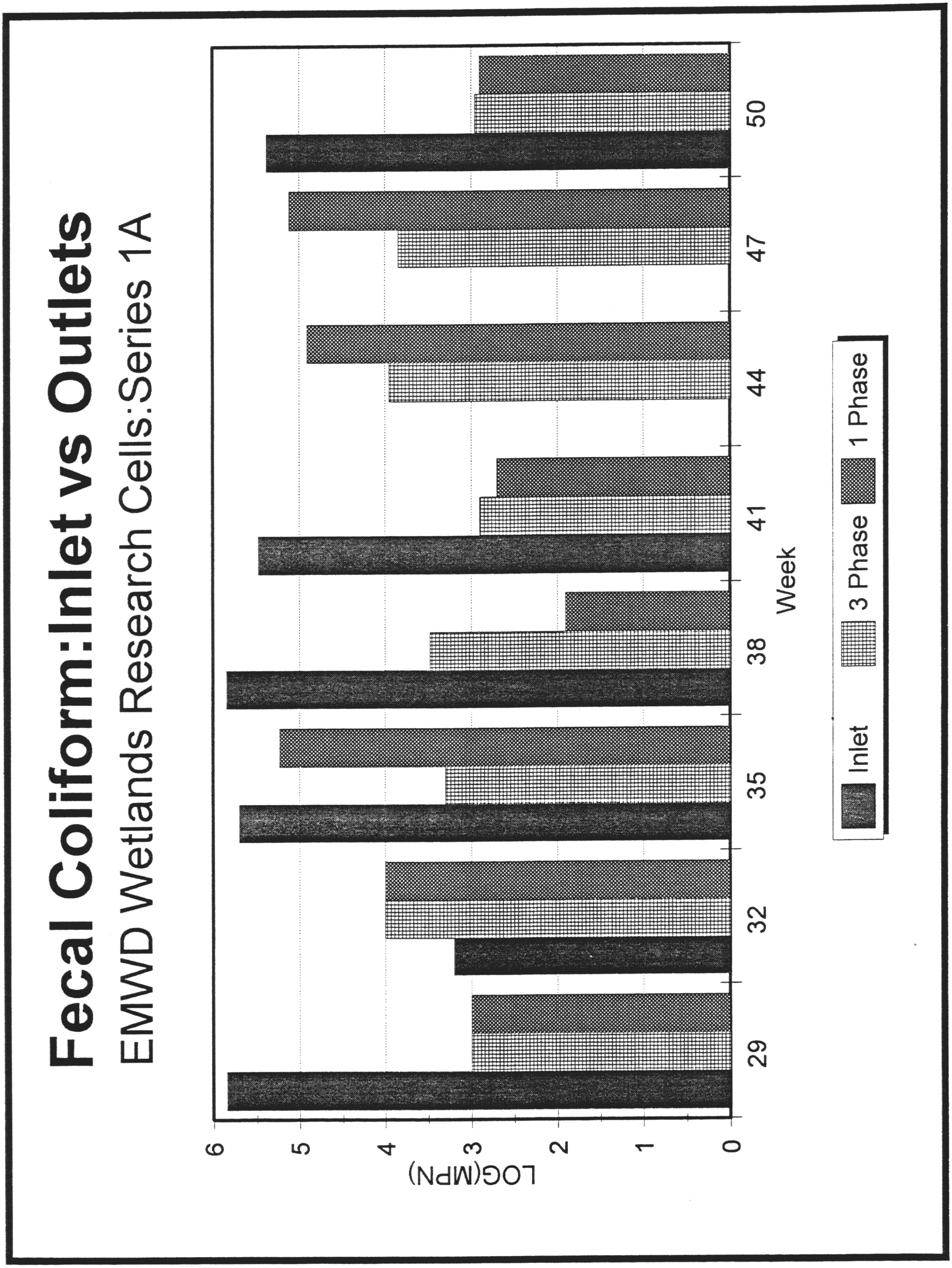

Fecal Coliform:Inlet vs Outlets
EMWD Wetlands Research Cells:Series 1A
LOG(MPN)
0
1
2
3
4
5
6
29
32
35
38
41
44
47
50
Week
Inlet
3 Phase
1 Phase

FIGURE 4-28

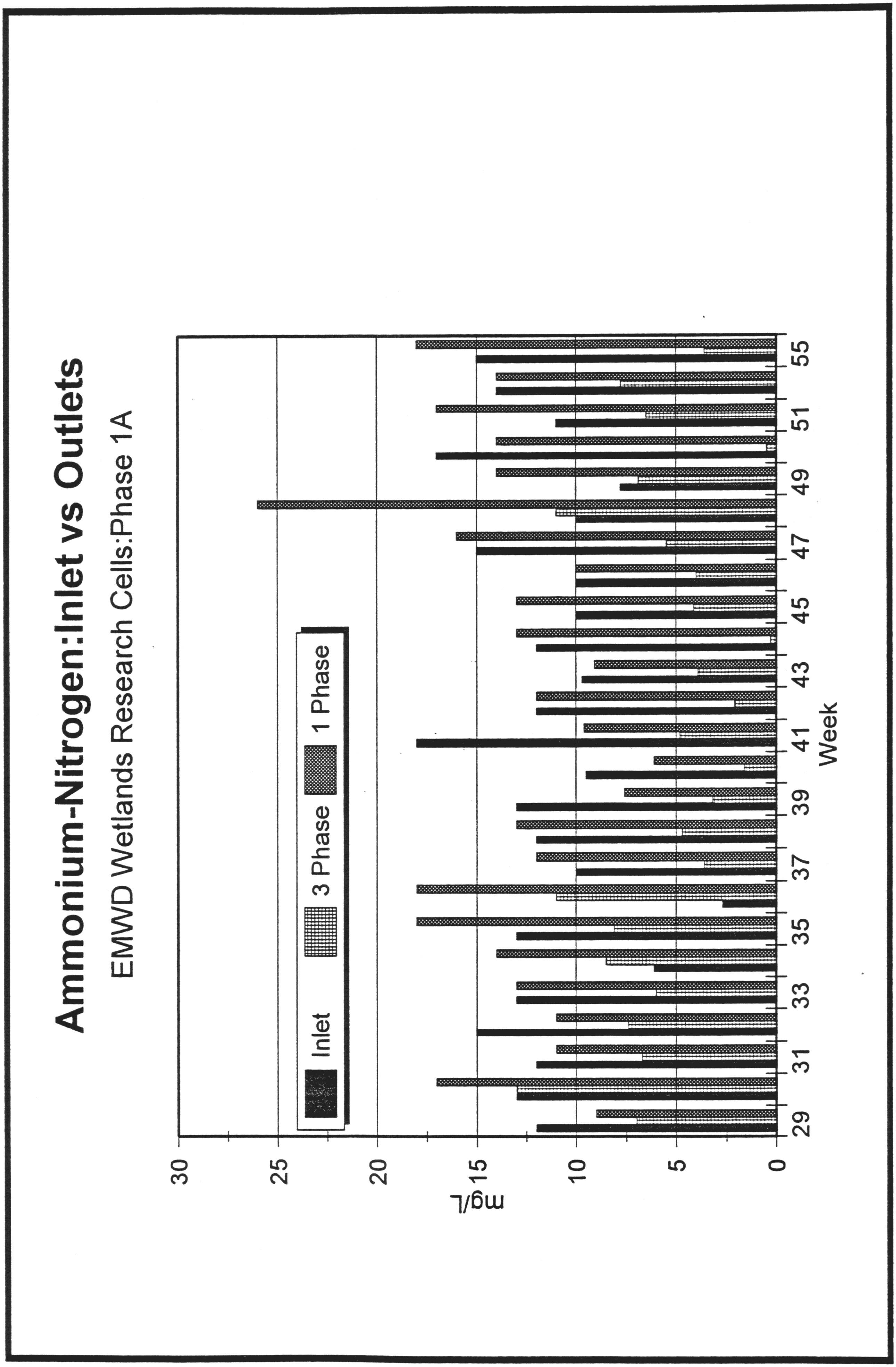
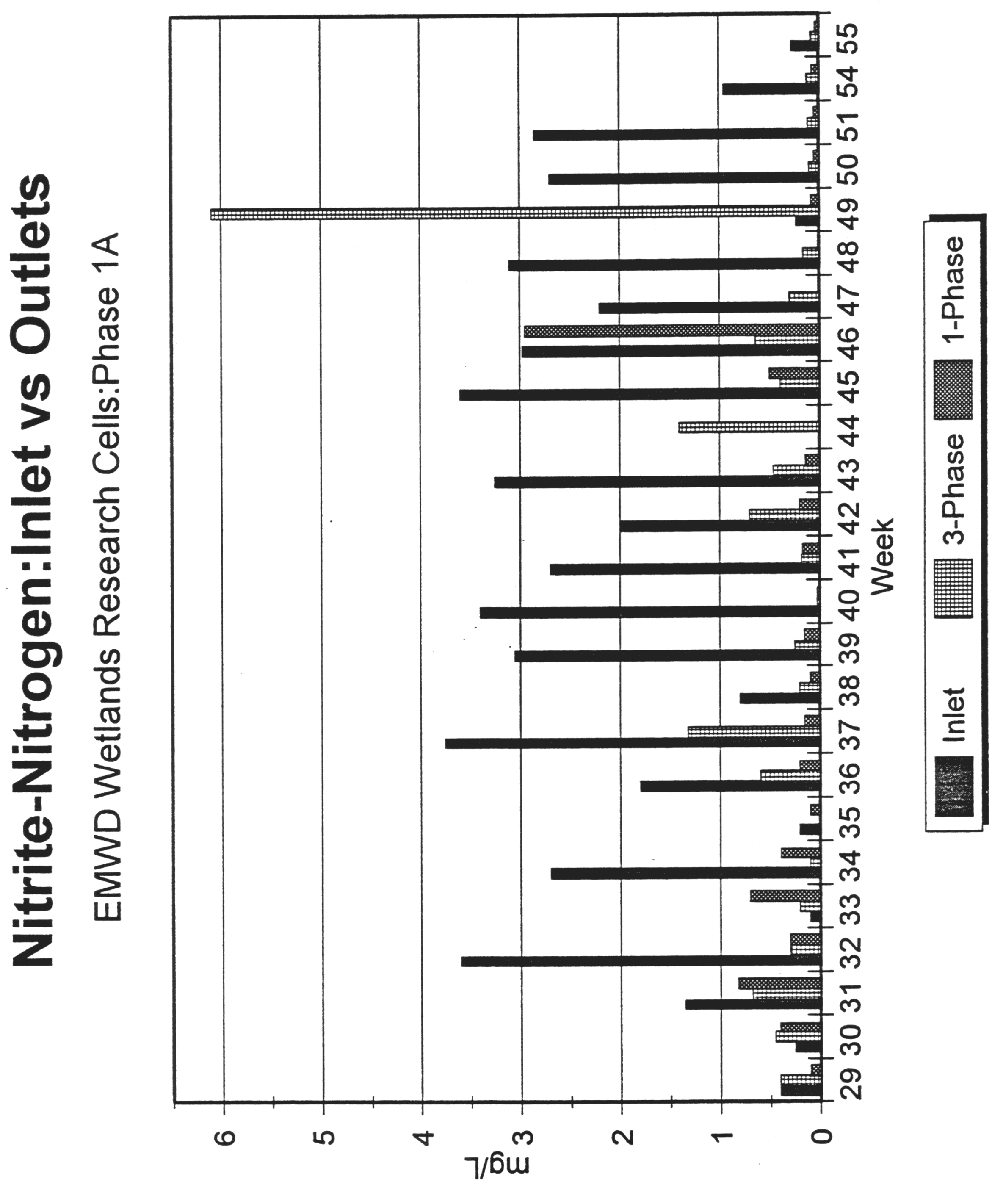

Ammonium-Nitrogen:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
Inlet
3 Phase
1 Phase
mg/L
30
25
20
15
10
5
0
Week
29
31
33
35
37
39
41
43
45
47
49
51
55

FIGURE 4-29


Nitrite-Nitrogen:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
mg/L
0
1
2
3
4
5
6
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 54 55
Week
Inlet
3-Phase
1-Phase

1.93 NO_2-N mg/L, the three-phase outlets averaged 0.61 mg/L, and the one-phase outlets averaged 0.31 mg/L. The three-phase and one-phase outlet concentrations were not significantly different from each other, but the differences between the outlet and inlet concentrations in both systems were statistically significant.

Nitrate Nitrogen (NO_3-N). Nitrate nitrogen concentrations averaged 0.8 mg/L in the inlet samples, 0.8 mg/L in the three-phase outlets, and 0.6 mg/L in the one-phase outlets (Figure 4-30).

Total Inorganic Nitrogen (TIN). There were 25 samples that could be analyzed as TIN (i.e., NH_4-N + NO_2-N + NO_3-N) (Figure 4-31). When total inorganic nitrogen concentrations are considered, the data show an average increase of 1.2 percent in the one-phase outlets and an average decrease of 60.6 percent in the three-phase outlets, compared with the inlet concentration. It is clear that these TIN removal efficiencies are largely influenced by the difference in the ability of the two systems to decrease ammonium nitrogen concentrations relative to inlet concentrations.

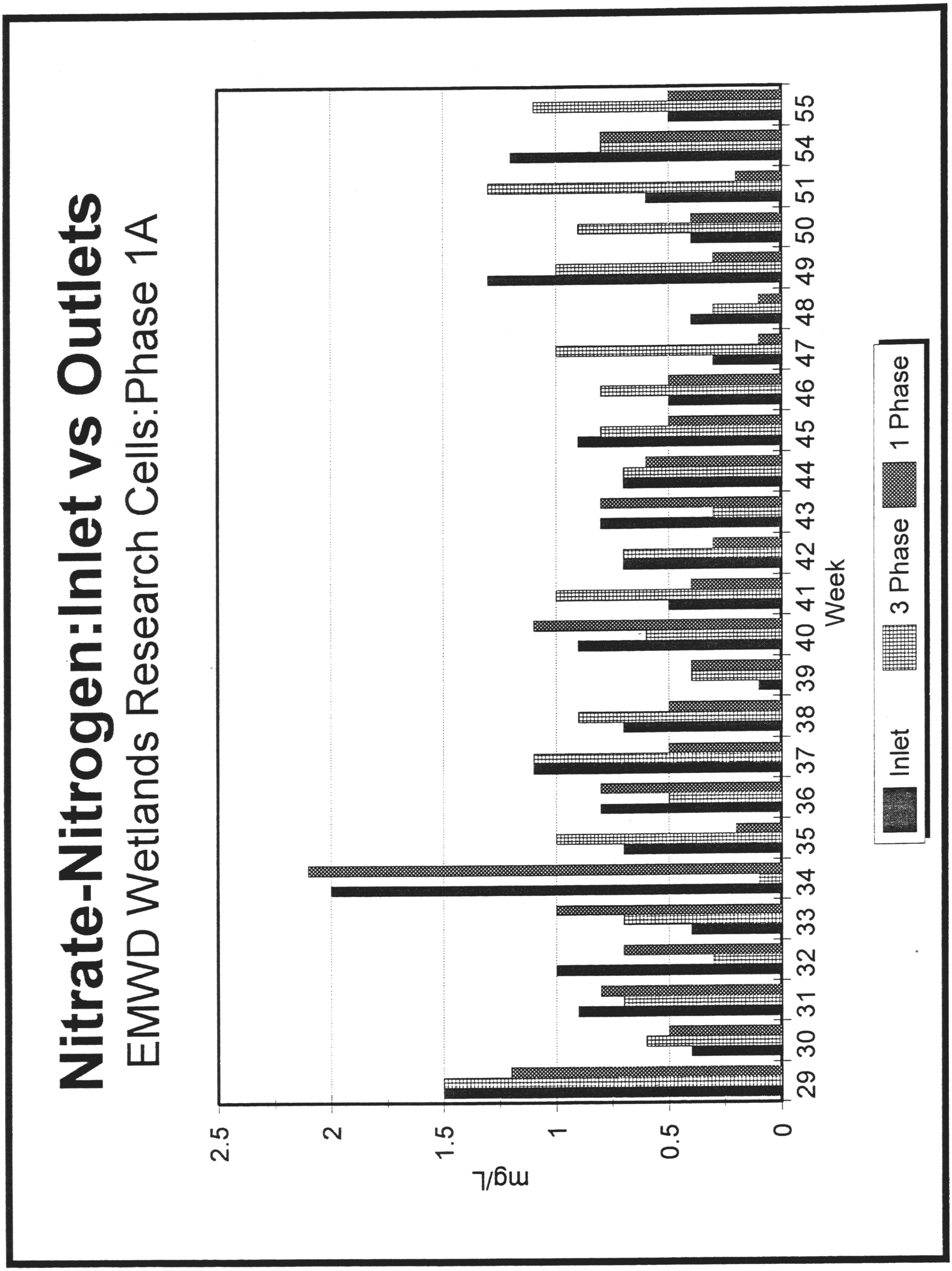
Total Kjeldahl Nitrogen (TKN). Seven samples were analyzed for TKN (Figure 4-32). The three-phase outlet concentrations averaged 58.5 percent less and the one-phase outlet concentrations 3.5 percent less than inlet concentrations. When TKN is broken down into organic-N and NH_4-N, it is apparent that the difference between the two systems is in NH_4-N concentrations. Outlet organic-N concentrations in both systems showed small average increases compared with the inlet concentrations. While this apparent increase in organic-N may reflect a variety of internal and/or external nitrogen sources, it may also reflect assimilation of inorganic nitrogen and subsequent shedding of organic material by the biotic communities within the cells.

Total Nitrogen. The seven samples that were analyzed for TKN were also used to calculate total nitrogen concentrations (i.e., total inorganic nitrogen plus organic nitrogen) (Figure 4-33). For these samples, the three-phase outlet concentrations averaged 57.7 percent less than inlet concentrations, while the one-phase outlet concentrations averaged 11.1 percent less than inlet concentrations. The paired t-test results indicated no significant difference between the one-phase outlet and inlet concentrations. Three-phase outlet and inlet concentrations, however, were significantly different. Once again, it is clear that it was the differing ability of the two systems to handle ammonium nitrogen that accounted for the difference in total nitrogen concentrations in the outlets relative to the inlet.

The sequence of bacterially-mediated nitrogen transformations is as follows:

$$\text{Organic-N} \rightarrow NH_4 \rightarrow NO_2 \rightarrow NO_3 \rightarrow N_2O\uparrow \rightarrow N_2\uparrow$$

FIGURE 4-30


Nitrate-Nitrogen:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
mg/L
0
0.5
1
1.5
2
2.5
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 54 55
Week
Inlet
3 Phase
1 Phase

The first step is the "ammonification", or reduction, of nitrogenous organic material to ammonium nitrogen. This process involves both aerobic and anaerobic bacteria. Organic nitrogen material added to a wetland, from whatever source, will eventually break down and contribute to the ammonium load of the wetland and, thus, affect the ammonium concentrations in the wetland.

The next two steps are the "nitrification", or oxidation, of ammonium to nitrite and then to nitrate. This process requires free oxygen and, therefore, takes place under aerobic conditions. It appears that the pool component is the key factor in the three-phase systems' demonstrated ability to decrease ammonium nitrogen concentrations relative to the inlet concentrations.

The last two steps in the sequence are the "denitrification", or reduction, of nitrate to nitrogen oxide and elemental nitrogen gases. This process takes place under anaerobic conditions and requires the simultaneous oxidation of carbon to remove the oxygen from the nitrogen ions. Denitrification is the ultimate step in removing nitrogen from the reclaimed water into the atmosphere. It is likely that most denitrification in both systems takes place in the anoxic to anaerobic areas of the marsh components. The longer marsh retention time in the one-phase systems could account for the apparent greater decrease in nitrate in the one-phase versus the three-phase systems.

It is important to note, however, that it will be necessary to use flow-weighted nitrogen budgets, taking into account retention times, to adequately address the questions of how much nitrogen is actually being removed and whether or not nitrogen loading other than that through the inlets is having a significant impact on the nitrogen dynamics of the two types of wetland systems. Bird exclusion experiments might also be useful in determining the impact of bird usage of marshes on nitrogen budgets.

Phosphorus.

Total Phosphorus (TP). Eight samples were analyzed for TP during Series 1A (Figure 4-34). Average concentrations were 4.0 mg/L in the inlet, 5.4 mg/L in the three-phase outlets, and 4.9 mg/L in the one-phase outlets. The three-phase systems averaged a 33.8 percent increase and the one-phase systems a 23.1 percent increase in TP concentration relative to the inlet concentration. Both system outlet concentrations were significantly greater than the inlet concentrations, but the outlet concentrations did not differ significantly from each other.

The significant increase in TP concentrations from inlet to outlet in each of the wetland systems suggests that phosphorus is being added to the systems from some source other than the inflow. Two likely candidates for this source during Series 1A are leaching from the sediments and bird droppings, which contain relatively high

FIGURE 4-31

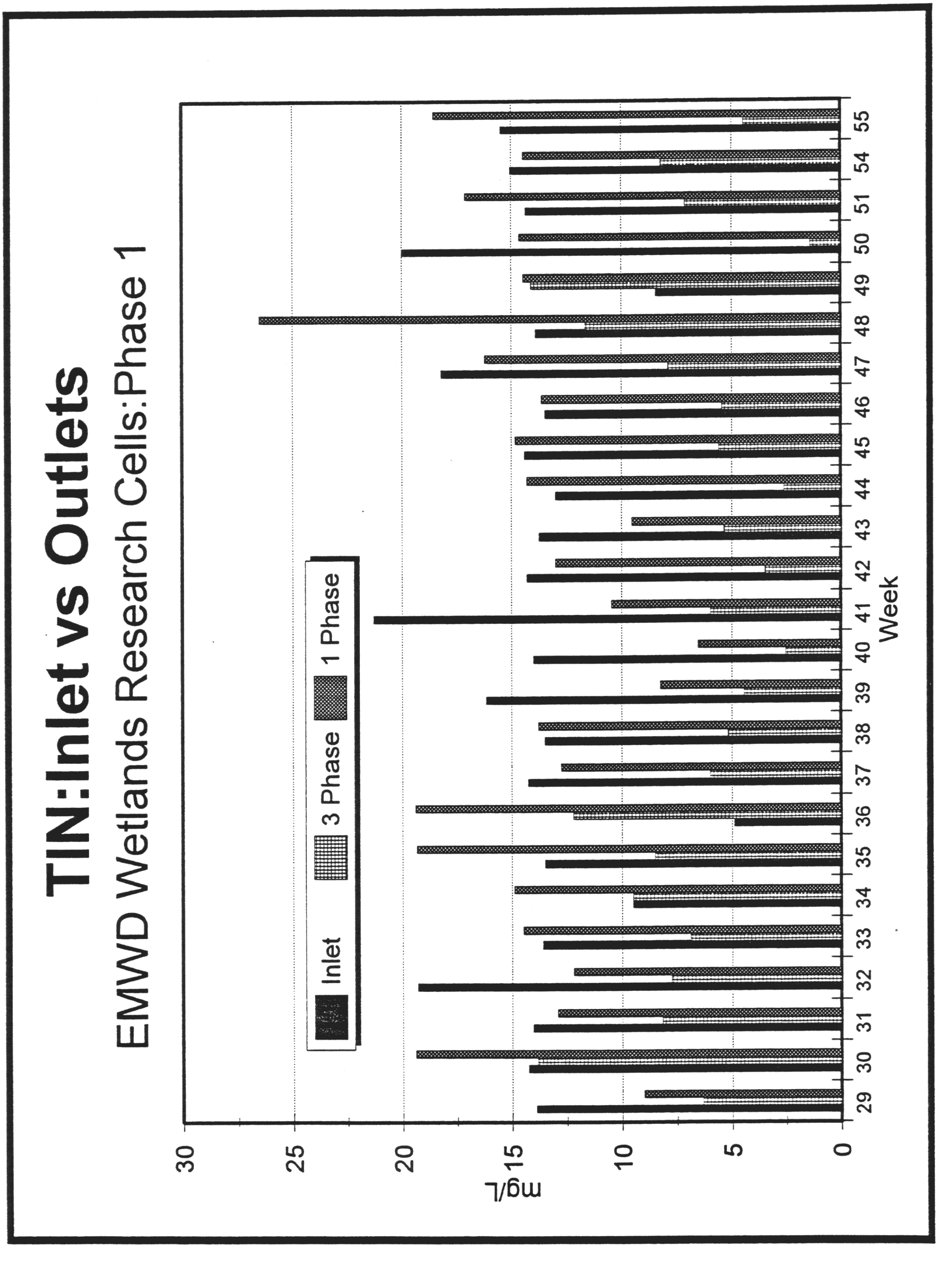

TIN:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1
Inlet
3 Phase
1 Phase
mg/L
Week
0
5
10
15
20
25
30
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
54
55

FIGURE 4-32

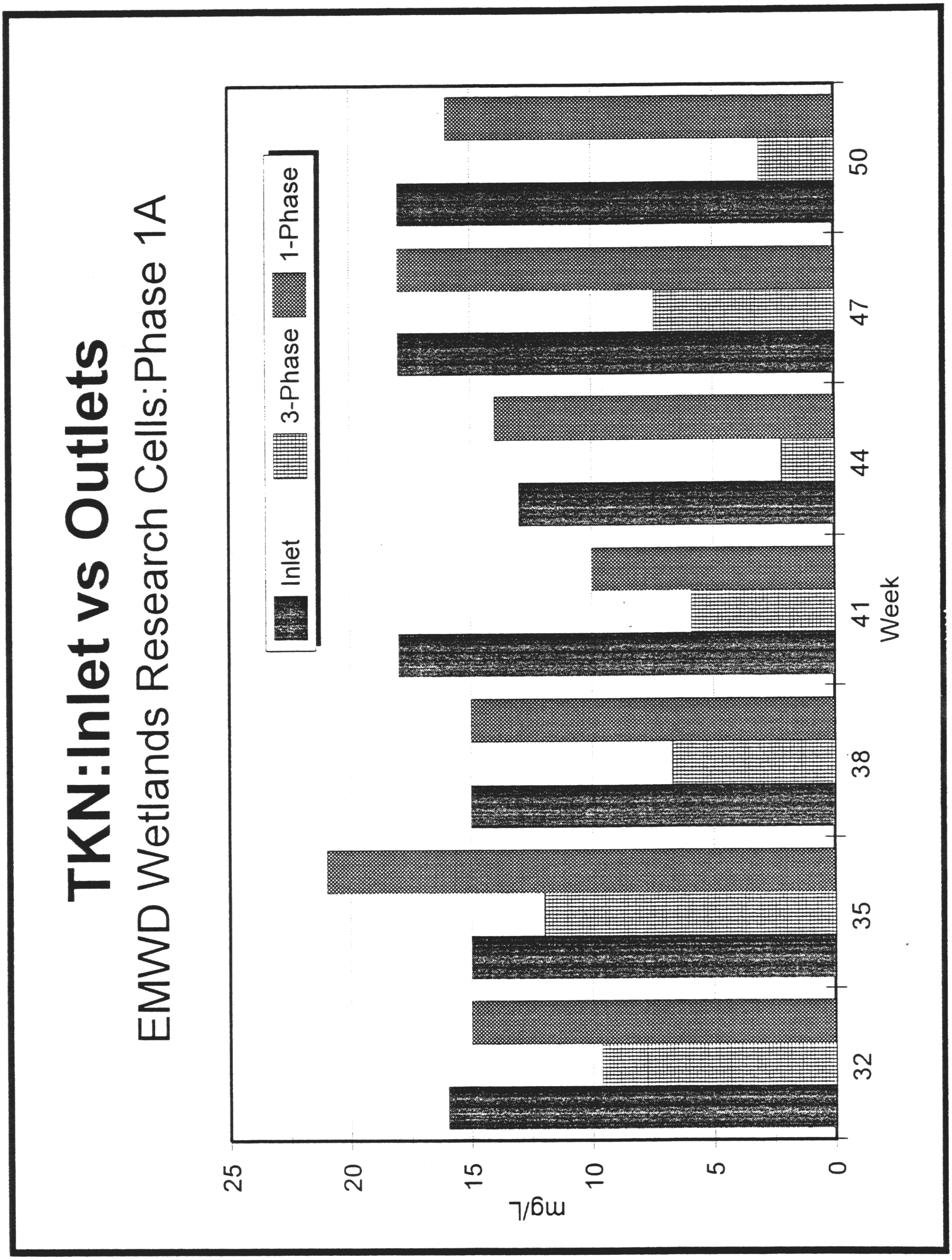
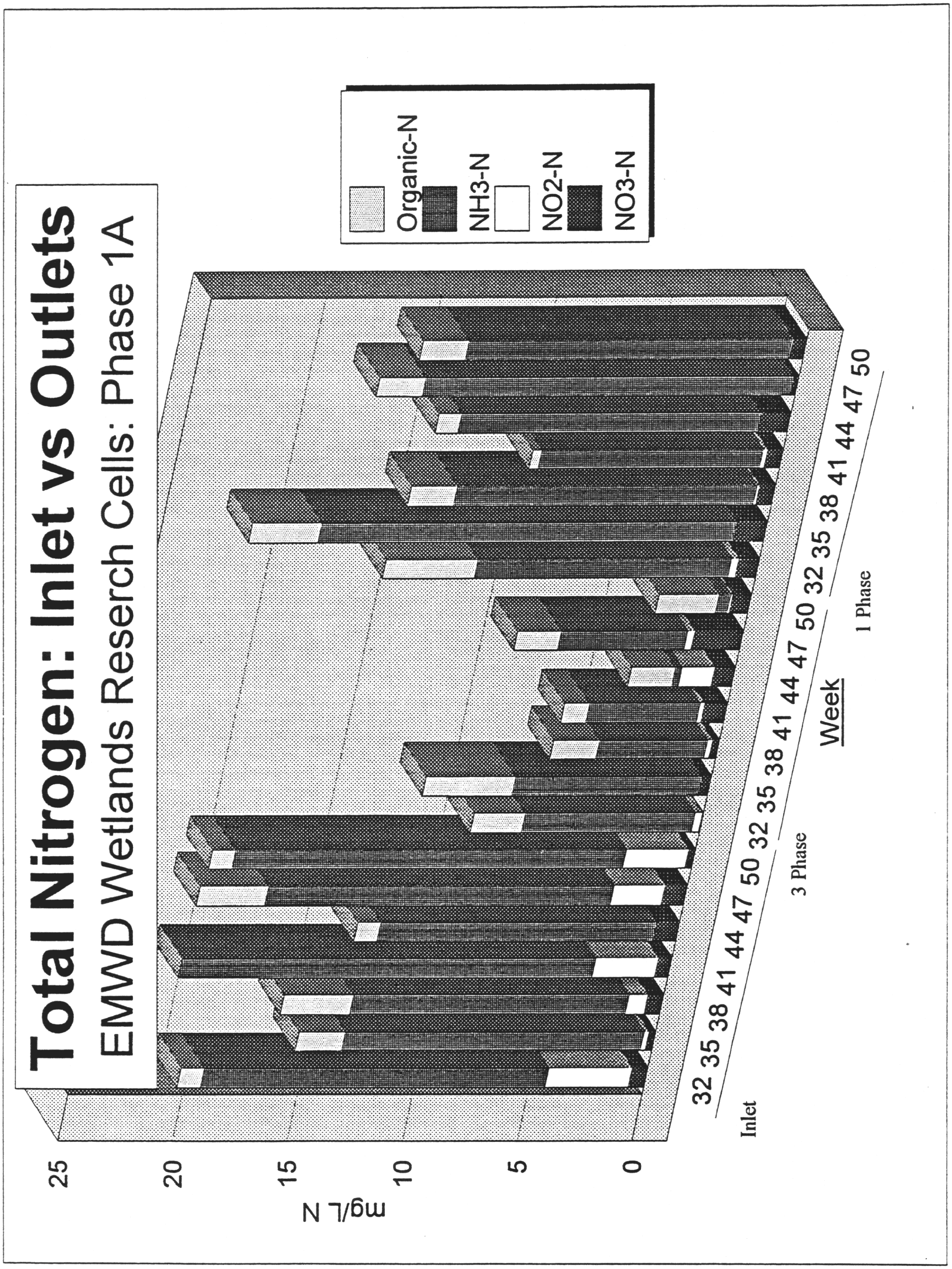
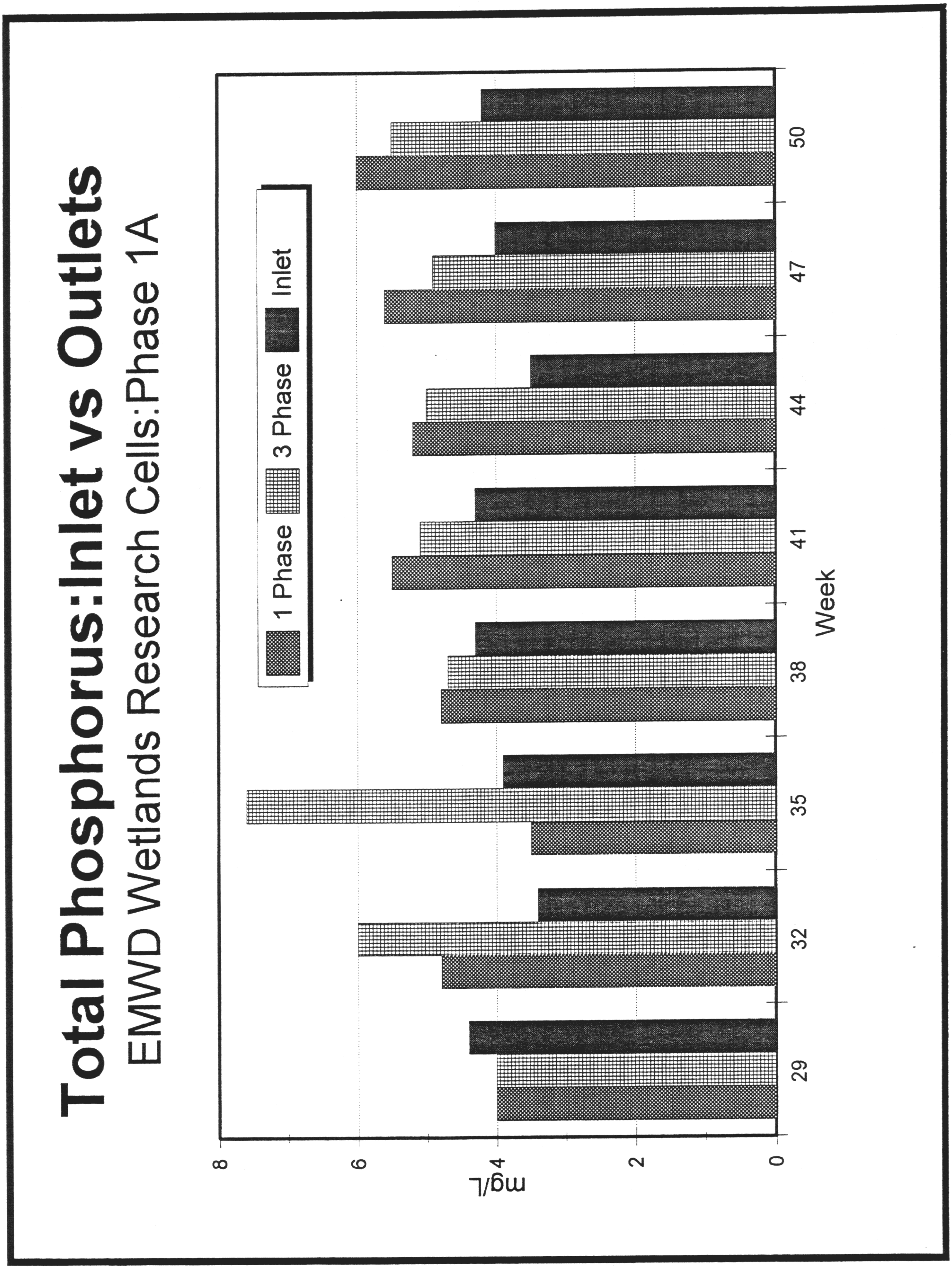

TKN:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
Inlet
3-Phase
1-Phase
mg/L
0
5
10
15
20
25
32
35
38
41
44
47
50
Week

FIGURE 4-33



Total Nitrogen: Inlet vs Outlets
EMWD Wetlands Reserch Cells: Phase 1A
Organic-N
NH3-N
NO2-N
NO3-N
mg/L N
25
20
15
10
5
0
32 35 38 41 44 47 50 32 35 38 41 44 47 50 32 35 38 41 44 47 50
Inlet
3 Phase
1 Phase
Week

FIGURE 4-34


Total Phosphorus:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
1 Phase
3 Phase
Inlet
mg/L
0
2
4
6
8
29
32
35
38
41
44
47
50
Week

amounts of phosphorus. The rather consistent difference between inlet and outlet concentrations (Figure 4-34) and the long period of time that the cells were flooded before Series 1A sampling began would favor bird droppings as the source. Comparing observations of bird usage of the marshes to flow-weighted TP budgets and/or bird exclusion experiments would go far toward resolving the question of bird impact on wetland phosphorus dynamics.

Orthophosphate Phosphorus (PO_4-P). Twenty-five samples were analyzed for PO_4-P during Series 1A (Figure 4-35). For these 25 samples, the PO_4-P concentrations averaged 3.3 mg/L in the inlet, 4.3 mg/L in the three-phase outlets, and 5.3 mg/L in the one-phase outlets. The 30.9 percent increase in three-phase outlet concentrations and the 62.3 percent increase in one-phase outlet concentrations, relative to the inlet concentrations, were both statistically significant. Three-phase and one-phase outlet concentrations were also significantly different.

Orthophosphate is the inorganic phosphorus form that is most readily available for plant uptake. This fraction of the TP concentration would be expected to increase under anoxic conditions. Eight of the 25 samples were also analyzed for TP, and, for these eight samples, the PO_4-P concentrations averaged 3.3 mg/L in the inlet, 4.4 mg/L in the three-phase outlets, and 4.5 mg/L in the one-phase outlets. As percentages of the mean TP concentrations, these average PO_4-P concentrations become 83.4 percent of TP in the inlet, 81.8 percent of TP in the three-phase outlets, and 92.1 percent of TP in the one-phase outlets. The high percentage of the TP concentration in the orthophosphate form suggests relatively anoxic conditions in the one-phase systems; this observation seems consistent with the previous discussion of greater apparent nitrate removal in these same systems.

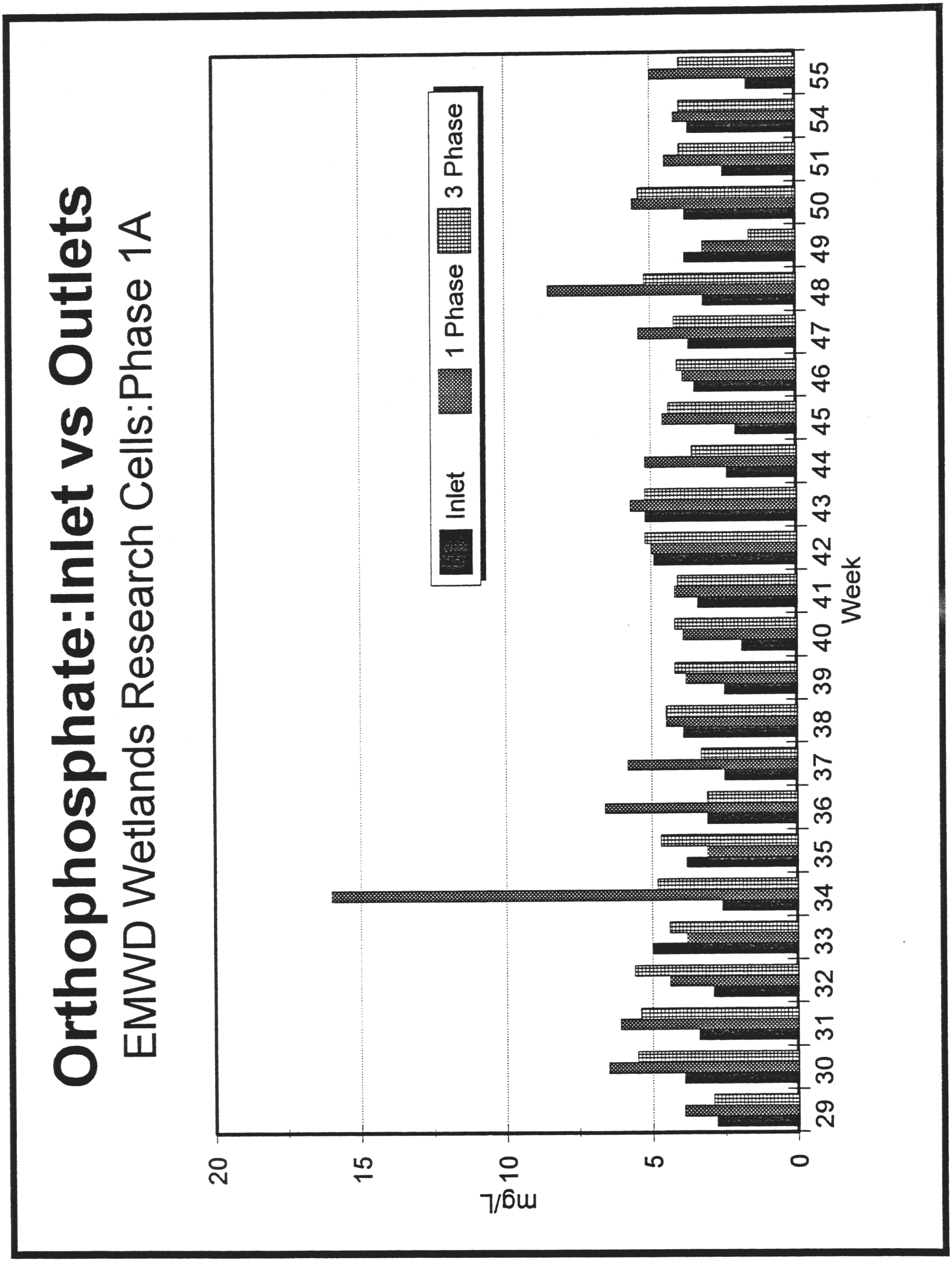
Invertebrates. Invertebrates were sampled within the research cells in April, July, and November 1993. It was intended that artificial substrates would be retrieved from inlet, middle, and outlet portions of each of cells 1, 2, 5, and 6. However, substrates were successfully retrieved only from some locations within both sets of cells, and sweep net samples were taken in place of collection of artificial substrates. The sampling schedule is presented in Table 4-4.

TABLE 4-4. SAMPLING DATES FOR BENTHIC MACROINVERTEBRATES
Samples were collected from the Hemet research cells via artificial substrates (AS) and via use of a sweep net (SN). Note that during July sampling, both methods were used at four sampling locations.

Sampling Date	One-phase system						Three-phase system					
	Cell 5			Cell 6			Cell 1			Cell 2		
	I	M	O	I	M	O	I	M	O	I	M	O
April 1993	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS
July 1993	AS		AS SN	AS		AS SN	AS	AS SN	AS	AS	AS SN	AS
November 1993	SN	SN	AS	SN	SN	AS	SN	AS	SN	SN	AS	SN

c:\word\emwd\invert01.rpt

FIGURE 4-35


Orthophosphate:Inlet vs Outlets
EMWD Wetlands Research Cells:Phase 1A
Inlet
1 Phase
3 Phase
mg/L
0
5
10
15
20
Week
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
54
55

A total of 24 taxa were identified from the artificial substrate and sweep net samples (Table 4-5). The highest number recorded in any type of cell during a particular sampling period was 15. Eight taxa were relatively common in the artificial substrates. These included aquatic earthworms, snails, midges, and ostracods (seed shrimp). Representative count data for two of these species are shown in Figures 4-36 and 4-37. Predaceous diving beetles, water fleas, biting midges, and mosquitos were less common. Mean counts of mosquito larvae within the research cells on each quarterly sampling visit are shown in Table 4-6. The complete set of research cell invertebrate data is presented in Appendix A.

In all cases where the July sampling included both collection of an artificial substrate and use of the sweep net, the sweep net collections contained more taxa (cell 5: 13 vs. 7; cell 6: 10 vs. 4; cell 1: 12 vs. 4; cell 2: 11 vs. 3). Because of the poor ability to quantify the sweep net sampling compared to the artificial substrate sampling, plus the great likelihood that different portions of the system were being sampled, comparison across methods should generally be avoided. For example, the abundances of taxa common to both collections were usually greater in the sweep net samples, but actual densities may be more accurately reflected in the artificial substrate samples.

The total number of benthic macroinvertebrate species collected within the cells (richness) showed a continuous decline between the first sample in April and the last in November, whether based on artificial substrates or on sweep net samples (Figure 4-38).

The number of invertebrate species that were present in the research cells but escaped collection is unknown. Flatworms were noted during the November mosquito sampling in cells 2 and 4 (outlet area). None were collected in the artificial substrate or sweep net samples. Aquatic vertebrates were present in the cells, but no attempt was made to sample them in even a qualitative manner. At least one species of frog was noted present in one cell, and small fish were noted present in several cells. These two species are likely present in all eight research cells, but their distribution has not yet been confirmed. Fish, probably Gambusia sp., were added to some or all research cells by EMWD personnel.

Sediments. A complete year of data has been collected, including the second set of annually-monitored parameters. The trends and potential concerns which have been observed regarding (1) the fate of toxic constituents; (2) nutrient availability; (3) denitrification; and (4) phosphorus removal are described. Tables 4-7 and 4-8 summarize the results of sediment sampling, and additional new data are on file at EMWD offices in San Jacinto, California.

Fate of Toxic Constituents. Baseline sampling indicated that all trace elements in the substrate were well within acceptable limits. Therefore, it was considered

TABLE 4-5

Invertebrates collected at EMWD constructed wetland research sites during 1993 by sampling via artificial substrates and sweep net.

TAXON ID NO.	TAXONOMIC GROUP			COMMON NAME
1	ANNELIDA	OLIGOCHAETA		Aquatic earthworm
2	ANNELIDA	HIRUDINEA		Leech
3	ARACHNOIDEA	HYDRACARINA		Mite
4	COLEOPTERA	DYTISCIDAE		Predaceous diving beetle
5	COLEOPTERA	HYDROPHILIDAE		Water scavenger beetle
6	COLEOPTERA	STAPHYLINIDAE		Aquatic rove beetle
15	COLLEMBOLA			Springtail
20	CRUSTACEA	CLADOCERA		Water flea
21	CRUSTACEA	COPEPODA		Copepod
22	CRUSTACEA	AMPHIPODA	Gammarus	Scud
30	DIPTERA	CERATAPOGONIDAE		Biting midge
31	DIPTERA	CHIRONOMIDAE		Midge
34	DIPTERA	CULICIDAE	Culex	Mosquito
35	DIPTERA	CULICIDAE	Anopheles	Mosquito
40	EPHEMEROPTERA	BAETIDAE		Mayfly
50	GASTROPODA			Snail
60	HEMIPTERA	CORIXIDAE		Water boatman
61	HEMIPTERA	NAUCORIDAE		Creeping water bug
62	HEMIPTERA	NOTONECTIDAE		Back swimmer
70	LEPIDOPTERA			Aquatic caterpillar
80	ODONATA	ANISOPTERA		Dragonfly
81	ODONATA	ZYGOPTERA		Damselfly
90	OSTRACODA			Seed shrimp
99	PELECYPODA			Bivalve clam

TABLE 4-6

Sampling Date	Mean count of mosquito larvae									
	CELL 1	CELL 2	CELL 3	CELL 4	CELL 5	CELL 6	CELL 7	CELL 8	Mean for all cells	Comments
20 Oct 92	0	0	0	0	0	0	0	0	0	North nursery cell loaded with mosquito larvae
29 Apr 93	0	0	0	0	0	0	0	0	0	
3 Nov 93	0.4	1.2	1.0	0	0.2	7.8	0.6	1.4	1.6	

Mean count of mosquito larvae within Research Cells on the three quarterly sampling visits. Each cell was sampled in five locations with a standard sampling cup during each visit.

FIGURE 4-36

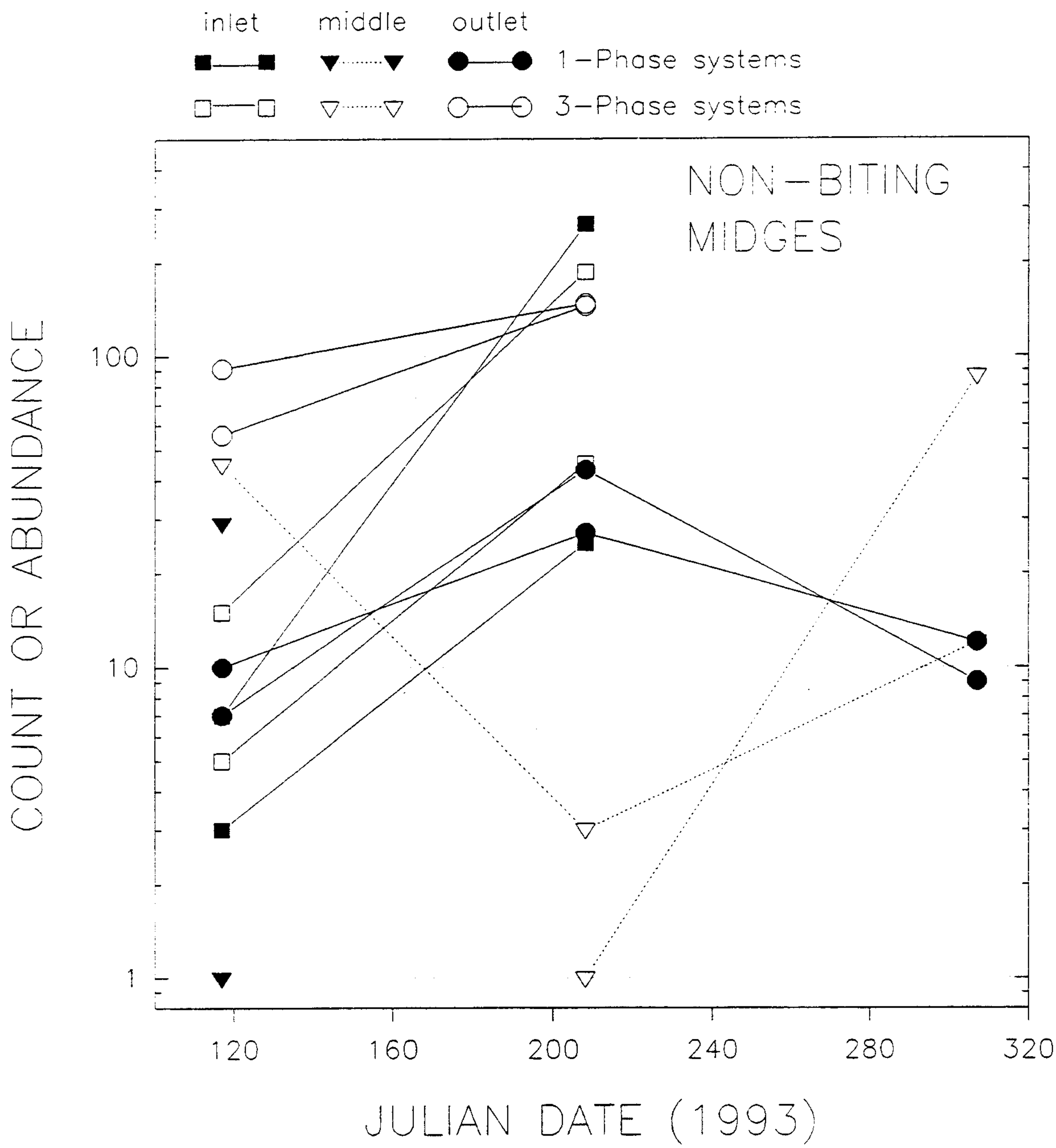


Fig. 4-36. Temporal change in counts of non-biting midge larvae (Chironomidae) associated with artificial substrates installed at inlet, middle, and outlet positions within 1-Phase research cells (cells 5 and 6) and 3-Phase cells (1 and 2) at the Hemet site in 1993 (Julian Date 44). Lines link counts from the same location (cell and position). Counts of zero are not shown due to the log scale, but all occurred during the first sampling (Julian Day 119), the only date when substrates from all cell/position combinations were collected (see Table 4-4).

FIGURE 4-37

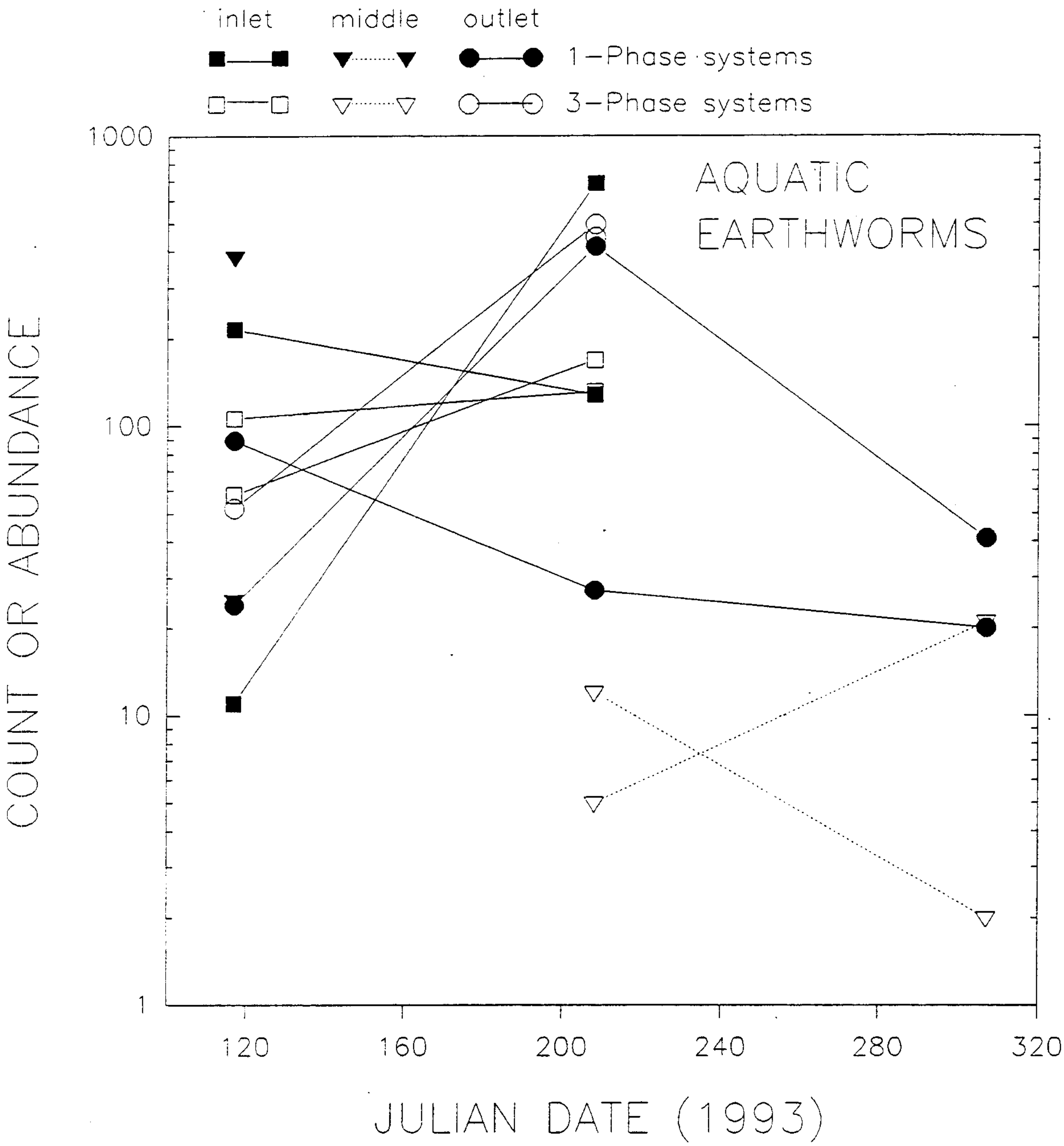


Fig. 4-37. Temporal change in counts of aquatic earthworms (Oligochaeta) associated with artificial substrates installed at inlet, middle, and outlet positions within 1-Phase research cells (cells 5 and 6) and 3-Phase cells (1 and 2) at the Hemet site in 1993 (Julian Day 44). Lines link counts from the same location (cell and position). Counts of zero are not shown due to the log scale, but all occurred during the first sampling (Julian Day 119), the only date when substrates from all cell/position combinations were collected (see Table 4-4).

FIGURE 4-38

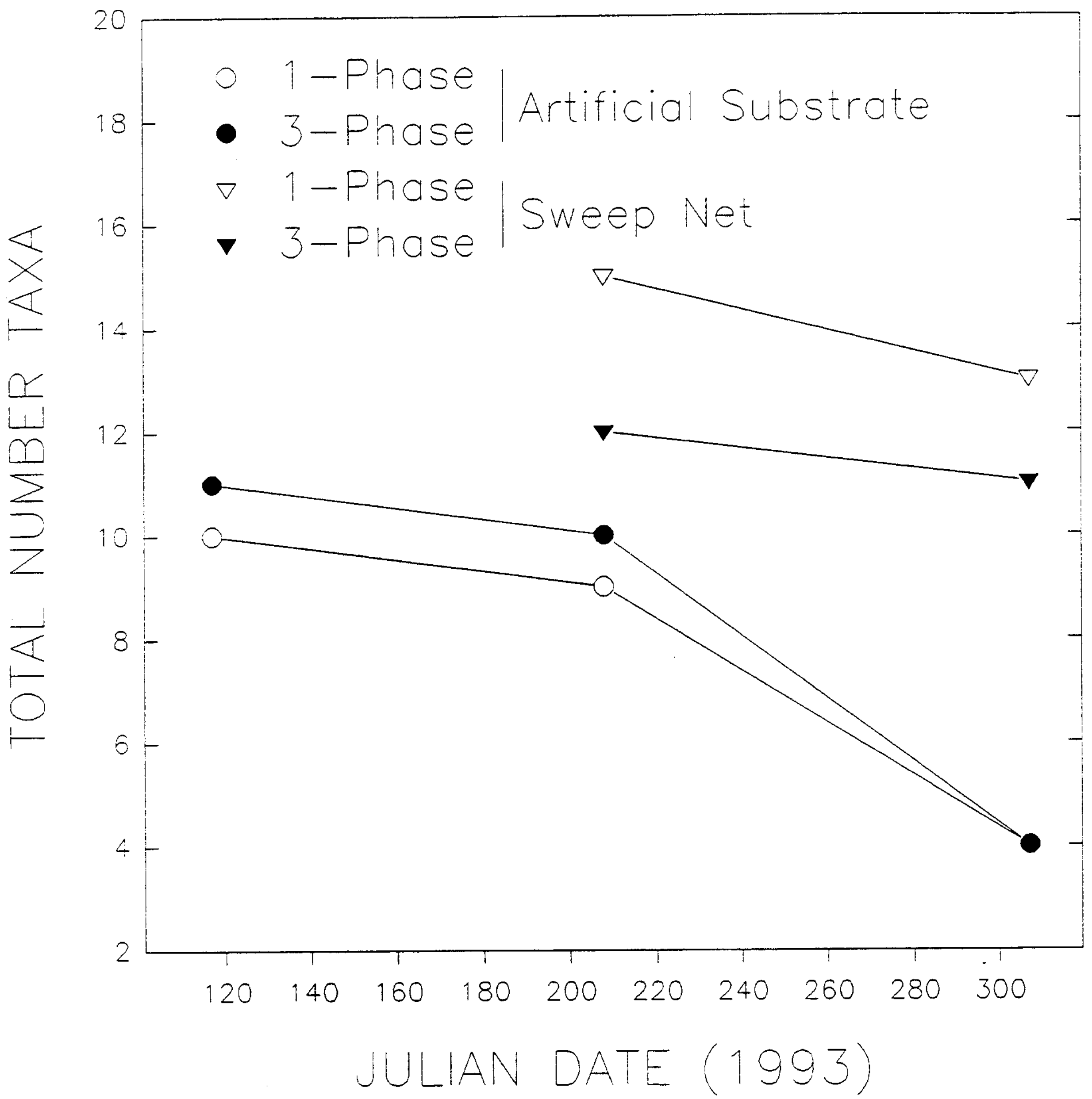


Fig. 4-38. Changes in total number of macroinvertebrate taxa collected (an estimate of biodiversity) in 1-Phase research cells (cells 5 and 6) and 3-Phase research cells (cells 1 and 2) at the Hemet site during 1993.

TABLE 4-7

ANALYSIS OF PARAMETERS SAMPLED YEARLY
IN SEDIMENT OF RESEARCH CELLS

Parameter (units)	Cell 1 - in 92/93	Cell 1 - out 92/93	Cell 2 - in 92/93	Cell 2 - out 92/93
Arsenic (ppm)	1.27/17	<1/21	<1/18	1.07/20
Selenium (ppm)	<1/<0.5	<1/<0.5	<1/<0.5	<1/<0.5
Mercury (ppm)	<0.07/<0.1	<0.07/<0.1	0.07/<0.1	0.10/<0.1
Boron (ppm)	16/5	14/6	14/5	19/6
Silver (ppm)	<0.1/<1	<0.1/<1	0.98/<1	1.11/<1
Aluminum (%)	1.4/1.1	1.3/1.3	1.3/1.1	1.35/1.2
Barium (ppm)	190/150	181/160	198/150	193/170
Beryllium (ppm)	0.73/<0.5	0.68/<0.5	0.66/<0.5	0.70/<0.5
Cadmium (ppm)	<0.2/2.4	<0.2/2.7	<0.2/2.4	0.22/2.7
Calcium (%)	0.96/0.67	0.85/0.79	0.84/0.64	0.87/0.87
Cobalt (ppm)	8.56/6	8.39/7	8.41/6	8.19/7
Chromium (ppm)	10.7/8	10.4/9	11.1/8	11.2/9
Copper (ppm)	7.81/8	7.59/9	18.9/14	20.2/13
Iron (%)	1.7/1.6	1.6/1.7	1.6/1.5	1.6/1.7
Potassium (%)	0.65/0.50	0.63/0.55	0.61/0.45	0.61/0.53
Magnesium (ppm)	7070/5400	6800/6000	6600/4900	6700/6100
Manganese (ppm)	281/250	268/270	269/230	264/270
Sodium (ppm)	2260/1000	2070/1300	2030/970	2500/960
Nickel (ppm)	6/4	5/5	6/4	6/5
Antimony (ppm)	6/2	6/3	4/2	5/2
Vanadium (ppm)	31.7/25	30.6/28	30.5/23	30.6/26
Zinc (ppm)	57.3/51	57.0/58	89.3/90	92.1/70
Molybdenum (ppm)	<0.5/<1	<0.5/<1	<0.5/<1	<0.5/<1
Lead (ppm)	-/<1	-/<1	-/9	-/3
Thallium (ppm)	-/<5	-/<5	-/<5	-/<5
$CaCO_3$ (%)	2.39/2.16	2.13/2.30	2.09/1.45	2.18/2.23
Organic C (%)	1.20/0.16	0.07/0.08	0.35/0.24	0.31/0.08
Clay Content (%)	18/1	4/1	10/<1	9/<1
CEL (meq/100g soil)	11/2.5	16/10.0	20/2.5	24/8.8

TABLE 4-8

NUTRIENT CONCENTRATION IN
SEDIMENT OF RESEARCH CELLS

Date	Nitrate (mg/kg dry wt.) Cell #1 in/out	Nitrate (mg/kg dry wt.) Cell #2 in/out	Total P (mg/kg dry wt.) Cell #1 in/out	Total P (mg/kg dry wt.) Cell #2 in/out	Ortho P (mg/kg dry wt.) Cell #1 in/out	Ortho P (mg/kg dry wt.) Cell #2 in/out
9/4/92	22/6	100/507	22/75	107/61		
10/6/92			Equipment Breakdown			
11/19/92	12/13	9/22	1351/1017	1669/1489	509/485	1229/1088
12/18/92	49/37	17/19	947/955	1501/2179	540/477	1033/1350
1/13/93	18/15	8/11	1012/1080	1575/1620	891/926	1225/1239
2/5/93	2/2	3/3	931/887	1581/1882	501/494	960/1013
			Spring Floods			
5/14/93	2/2	3/3	848/983	1433/1449	364/356	328/391
6/17/93	1/2	1/1	1667/3284	1516/2344	985/791	859/1078
7/30/93	13/14	11/11	957/972	1338/2029	449/338	779/797
8/17/93	10/11	9/12	843/914	1271/1406	457/457	757/797
9/14/93	>.5/>.5	>.5/>.5	791/705	1007/1151	4/4	5/5
10/21/93	>1/>1	>1/>1	837/727	884/1046	3/6	6/6

unlikely that the substrate would serve as a source for any toxic constituents. Instead, it was anticipated that the substrate would act as a sink, potentially removing certain constituents from the water through adsorption and precipitation processes. Little information is available regarding toxic concentrations in substrate. However, arsenic and cadmium have shown a considerable increase. It would appear that significant quantities of arsenic and cadmium are being brought into the wetlands via the treated wastewater. Both elements are common waste products. Arsenic is a component of many pesticides, wood treatment processes, and swine and poultry feed supplements. Cadmium is a by-product in the manufacture of paint, batteries, and textiles.

Arsenic and/or cadmium could have adverse impacts to wetland plants and animals if the lab data are correct and if the trend continues. Arsenic concentrations greater than 25 mg/L in the sediment may cause adverse impacts to sensitive plant species (Eisler, 1988). Initial symptoms include wilting, then decreased root and top growth. Precipitation is the primary removal mechanism for arsenic (McLean and Bledsoe, 1992). Little information is available regarding toxic concentrations substrate. However, cadmium concentrations from 0.8 to 9.9 micrograms per liter (μg/L) in water are lethal to several species of insects, crustaceans, and teleosts (Eisler, 1985). Adsorption mechanisms may be the primary source of cadmium removal (Dudley et al., 1991). Sediments may, therefore, reach a maximum capacity with regard to cadmium. At this point, cadmium concentration in the water would begin to increase.

Nutrient Availability. Nutrient availability is usually not critical in wetlands constructed for wastewater treatment. Inputs of nitrogen and phosphorus are generally considerable. Potassium levels in the bottom sediment of the research cells are low but still within the range of what would normally be considered adequate. However, it is possible that potassium might become a limiting factor in plant productivity.

Denitrification. Nitrate levels in the soil showed a sharp decline following the initial flood-up and have remained fairly stable since. This would indicate that nitrogen loss through volatilization during denitrification is occurring.

Phosphorus Removal. The effect of sediments upon phosphorus removal in the research cells remains unclear. No discernable trend is evident. The substrate can act as a source or sink for phosphorus. If the sediments were acting as a sink, as expected, a gradual increase in concentration should be evident.

Reverse Osmosis and Saline Marshes

Reverse Osmosis Unit Operations. Operation of the RO system began on May 3, 1993, using feedwater trucked in daily from the nearby Moreno Highlands well.

Initially, only a partial complement of six Filmtec BW30-2540 membrane elements was tested. This was done to observe the performance of the newly-constructed system without risking too many elements. On June 6, 1993, after a month of successful operation (i.e., without noticeable degradation in performance), the initial six elements were removed and replaced with a full load of 18. During the following 8 months of testing, a total of 1860 hours of RO operations were logged. In that time, 2.53×10^6 L (6.70×10^5 gal) of Moreno Highlands well water was processed yielding 1.90×10^6 L (5.02×10^5 gal) of product water and 6.34×10^5 L (1.67×10^5 gal) of reject brine. RO feed pressure averaged 1267 kPa (184 lb/in^2) during the 8 months. Average feed and product concentrations were 988 and 14.2 mg/L TDS, respectively. Given these concentrations, a 50:50 blend of the two would yield an effective total recovery of nearly 86 percent (RO system recovery was 75 percent) and a blended TDS of about 500 mg/L (California's secondary drinking water standard).

Except as noted below, the pilot plant performed as anticipated with minimal interruption caused by equipment or operational difficulties. Midway through the test period, some early signs of membrane degradation were observed, which was suspected of occurring from the weekly use of biocide Minncare™. Because the system operates intermittently (nightly and weekend shutdowns), which is uncharacteristic of most RO plants, the membrane elements have required periodic disinfection to avoid biofouling. The biocide Minncare was selected for this purpose because of its advertised compatibility with TFC membranes. During the first 1400 hours of operation, membrane salt rejection dropped slightly, by 0.35 percent, and normalized permeate flow increased by about 8 percent. Since Minncare contains hydrogen peroxide, a strong oxidant, as a principal constituent, it is suspected of causing some degradation of the membrane surface. To combat or slow down this degradation, the disinfection protocol was changed to include less frequent disinfection and weekend storage of the elements in dilute sodium bisulfite solution to inhibit microbial growth. Based on the last 200 hours of operational data (i.e., since the change in disinfection procedures), it appears that the salt rejection and normalized permeate flow values have leveled out.

Saline Marsh Plant Survival. Appendix D contains a representative selection of photographs of the vegetation in the saline marshes, showing the progression of growth. By July 1993 (3 months after planting), the alkali bulrush had spread to every available area in each cell except for the six bands where the spikerush were planted and at the inflow ends. Most of the original alkali bulrush plants had turned brown, but the plants were green, robust, and taller than the original plants. The spikerush were healthy and spreading, but flower and seed production was less than normal. Both smartweed species had been completely eliminated due to a combination of insufficient water (drying out some seedlings), too much water (drowning some seedlings), and bird predation. A few cattail plants, which came in on their own, were growing in both cells, and a few watergrass plants also began to grow. Although the cattails and watergrass appeared to be healthy, neither species spread a great deal, and cattail flower production was minimal.

Because the smartweed failed to survive, USBR personnel suggested in July 1993 that mature smartweed plants be transplanted from along the sides of the research cells into two bands in the saline marshes where smartweed seed and rhizomes had originally been planted. On August 25, 1993, EMWD personnel transplanted the smartweed and began making evaluations. Prior to transplanting, it was observed that the smartweed had set seed, and the plants lacked luster and vitality. Within 2 weeks, the plants appeared dead to the casual observer. The smartweed were removed, thus, no conclusions can be made regarding these species.

Throughout the first growing season, the plants appeared to be thriving, but, to the trained observer, some plants of each species exhibited stress (i.e., some browning, slower growth, less seed production). Both higher salinity and lack of water may have been contributing factors.

As of November 2, 1993, it was evident that the alkali bulrush, spikerush, cattail, and watergrass had survived in both cells, although plants were mostly brown due to the colder winter temperatures. A quillwort mat had formed in the inflow end of the north cell and appeared to be very healthy. Alkali bulrush seed was floating over the water surface in both cells.

The plants were brown throughout the winter because of normal seasonal dormancy. In the spring of 1994, plants regenerated by producing new growth from their rootstock. Although alkali bulrush seed was floating over the water surface in both marshes in the fall of 1993, no evidence of seed germination appeared in the spring. The new growth is very lush and tall, and all plants appear healthy. Cattails have expanded in the north marsh to about three times the area they covered in the fall. It is possible that, in addition to the change in seasons, the lush growth reflects the fact that brine flow into the marshes has been interrupted since February 4, 1994. Long-term evaluation using the appropriate water is, therefore, very important to accurately assess the final outcome of this pilot study.

Saline Marsh Water Analyses. The EC and TDS data are summarized in Appendix C. The mean (average of four sample sites) EC values for each saline marsh are listed in Table 4-9. The salt concentrations in the saline marshes were influenced by the occasional addition of fresh water, which was necessary to keep the marshes from drying out during peak summer evapotranspiration periods. The RO facility produces about 14.7 x 10^3 to 18.4 x 10^3 L (3880 to 4850 gal) of brine per week. Using data from the evaporation pan at the site to calculate water losses, evaporation from both marshes is between 15.9 x 10^3 and 21.2 x 10^3 L/week (4200 and 5600 gal/week). Thus, it was necessary to make up the shortfall by adding fresh water from the fire hydrant in front of the RWRF. Approximately 2500 gal of fresh water were added to each marsh on July 21, 1993, and again on August 13, 1993. In September, EMWD decided that, rather than continue adding fresh water to both marshes, all of the brine would be fed to the south marsh, and the north marsh would receive 100 percent fresh water. Thus, the south cell would not be diluted, and the north cell would act as a sort of "control".

The data in Table 4-9 show how the saline marshes gradually became more saline until the fresh water was added. Measurements taken immediately after the addition of fresh water to the north marsh on November 3, 1993, showed that the inflow end experienced an EC of 2070 μS/cm. The inflow sampling site on the south marsh was 6200 μS/cm at the same time.

Laboratory Water Quality Analyses. The analysis of the marsh influent (RO reject) on August 17, 1993, is contained in Appendix C. The constituents present above detection levels in mg/L were: arsenic (0.006), barium (0.22), copper (0.01), molybdenum (0.15), selenium (0.007), vanadium (0.02), zinc (0.05), iron (0.03), manganese (0.05), silicon (40.1), and boron (0.66).

Wildlife Observations. Wildlife usage of the saline vegetated marshes was documented on several occasions in 1993. Actual sightings, prints, scat, or sounds have provided evidence of usage. Raccoon and rabbit prints were observed as well as evidence that waterfowl usage occurred (e.g., paths and tunnels through the spikerush). Predaceous diving beetle larvae, beetles, and snails were also observed in the marshes.

During 1994, the usage has increased with the sprouting of the plants. Numerous tadpoles have been observed. Ducks, blackbirds, and a variety of invertebrates have also been observed in and around the vegetated marshes.

TABLE 4-9

The Mean EC (Electrical Conductivity) Data (in μS/cm) for Each Saline Vegetated Marsh by Sample Date

Date	MARSH South	North
7/13/93	7,123	6,543
7/14	7,125	6,670
7/21	7,708	6,895
7/23		(18.8 m^3 (5000 gal) of fresh water added each marsh)
7/23	2,985	3,083
7/28	6,495	5,230**taken by USBR Hydrolab
7/29	6,015	5,203
8/02	6,500	5,478
8/04	6,963	5,473
8/09	8,628	7,100
8/12	8,225	7,483
8/13		(18.8 m^3 (5000 gal) of fresh water added each marsh)
8/18	6,173	4,808
9/01	8,833	6,968
		beginning 9/20/93, 9.4 m^3 (2500 gal) of potable water was added about weekly to the North marsh
11/03	6,680	3,790**taken by USBR Hydrolab
12/02	5,095	no data *determined by EMWD lab
1/18/94	6,113	3,875
1/21	6,438	4,275
1/26	5,525	no data
2/24	2,525	1,350
3/03	2,900	1,625
3/11	3,150	1,813
3/18	4,075	2,375
3/28	2,275	1,675
4/04	2,900	2,125
4/19	2,725	1,913
4/27	1,988	1,575

Observations have confirmed the original assumption that wildlife would not be attracted to the evaporation cells. Because of their steep, nonvegetated sides and plastic lining, the evaporation cells provide no food, shelter, or nesting areas. Without those attractions, transient waterfowl do not linger around the cells, limiting their exposure to any concentrated constituents. Usage by waterfowl has been brief and transient. Two ducks were observed on different days in the evaporation cells, but they did not stay for more than 3 days. It has been observed that small mammals cannot get out of the evaporation cells once they get in due to the steep sides and smooth lining.

PART 3: CONCLUSIONS AND RECOMMENDATIONS

Many aspects of the EMWD/USBR/NBS Multipurpose Wetlands Research and Demonstration Project are ongoing. In particular, the research and monitoring efforts up to this point have been devoted largely to gaining data on baseline conditions or conditions during establishment of a mature wetlands system. Therefore, this section presents discussion and recommendations rather than final study conclusions.

Nursery Cells

The creation of a wetland nursery is recommended to provide adequate plant material for building large wetlands. The spacing of the plants in the nursery cells (112- by 112-cm (44- by 44-inch) intervals) produced dense vegetation in the 90 days from July 10 to October 8, 1991. The original plant material increased, on average, about 16 times during that period.

In September of 1992, the plant material in the southwest corner of the north nursery cell was used to vegetate the eight research cells. The one corner of material was sufficient to plant an area approximately 20 times its size. The 20:1 ratio will be tested again when the 0.4 ha (1 ac) of material in the two nursery cells is used to vegetate the 8 ha (20 ac) of marsh area in the demonstration wetland.

Various methods of removing bulrush from the donor sites and transplanting at the new site were evaluated. It was found that there was no difference between the use of a backhoe versus hand-digging with a shovel; however, use of a backhoe may cut labor costs. Trimming the plant tops made transport easier and appeared to stimulate new shoots.

Staking the bulrush root clumps on top of the dry substrate, then flooding, is recommended as the best planting technique. This technique produced the most rapid propagation, which, in turn, provided the shortest time to total coverage. This method proved to be the least labor-intensive and, therefore, the most cost-effective.

The addition of chlorine to the reclaimed water supply from October 1991 through January 1992 adversely affected the duckweed. The chlorine was added during this period to meet the regulatory requirements for use of reclaimed water by local duck clubs during the hunting season. The marsh was no longer improving the quality of the reclaimed water. The addition of chlorine may have been one of the causes. It was noted by January that the duckweed had disappeared in both cells. None of the other plant species appeared to be affected by chlorination. By April 1992, some duckweed had reappeared.

To prevent reoccurrence of this problem, a ratio-feeder dechlorination system was installed by EMWD in early 1993 specifically for the wetlands. Problems with clogging of the ratio-feeder screen by algae have made it very difficult to operate. As a consequence, EMWD is planning to construct a separate pipeline to the wetland cells in 1994 that will bypass the chlorination system.

Research Cells

Plant Growth. Rapid growth and establishment of bulrush, in terms of both new shoot numbers and culm height, was documented. This suggests that the combination of Hemet/San Jacinto climate and the soil and water constituents at this site created optimum conditions for bulrush propagation. New shoots per bulrush clump increased from an overall mean of 21.4 in October 1992 to 220.7 in April 1993 (over 10 times in 6 months). By July 1993, they were too dense to count accurately. Likewise, overall mean culm height had increased from 104 cm to 339 cm (3.4 to 11 ft) in 9 months. By November 1993 (14 months after planting), the bulrush culms were sufficiently dense and robust that the research cells were considered to be completely vegetated and established.

By November 1993, a great deal of lodging of plants had occurred probably due to their height and the strength of the Santa Ana winds, which were heavy at that time. Some bulrush plants showed chlorotic spots which were identified as fungus under the microscope. There was a question as to whether the spots could indicate a potassium deficiency. Since the soils data indicated that potassium levels in the sediments at the bottom of the research cells were slightly low, this is recommended as a subject of future research.

Wildlife Usage. Habitat creation, environmental enhancement, and wildlife usage were not design objectives for either the nursery or research cells. However, use by various forms of wildlife at the facility has been surprisingly intense. American coots and common moorhen were among the first to take up residence. Various ducks, herons, and other birds are frequently observed feeding or resting in the cells. Coots, moorhen, and mallard ducks have used the cells for nesting and rearing of

PHOTO 26. HABITAT CREATION; RUDDY DUCKS IN RESEARCH CELL

PHOTO 27. BLACK-NECKED STILTS AT HEMET/SAN JACINTO REGIONAL WATER RECLAMATION FACILITY

PHOTOS 28 AND 29.
RARE FLAMINGO PLASTICUS
SPOTTED IN RESEARCH CELL
DURING TECHNICAL ADVISORY
COMMITTEE'S VISIT

young. Ruddy ducks have bred, nested, and raised young in the three-phase cells for the last 2 years, but they have not been observed in the single-phase, fully vegetated cells.

Mammals that have either been directly observed by EMWD personnel or identified by prints or tracks include raccoon, skunk, coyote, mice, bobcat, opossum, cottontail and jack rabbits, and California ground squirrel. Some domestic cogs and cats from nearby farms have also visited the site. Gopher and garter snakes have been seen in and around the cells. Gambusia, or mosquito fish, appeared in the nursery cells, probably carried in by birds. They were then intentionally introduced into the research cells by EMWD personnel as a means of controlling mosquitos. They, along with frogs, tadpoles, and arthropods, provide food for many of the visiting and resident waterfowl.

The bird population at the Hemet/San Jacinto RWRF has been documented for 1 year by two graduate students from California Polytechnic University, Pomona, California. Their data are included in Appendix J. Approximately 100 species of birds are listed with dates and numbers of individuals indicated.

Weed Abatement. Weed growth along the banks of the research cells has become an O&M problem. Tumbleweeds, thistles, and other weeds as well as willow trees grew aggressively to such size and density that access to the inlet and outlet structures was restricted, roads along the berms were blocked, and the appearance of the cells was negatively affected. Various methods of weed control were attempted in an effort to remove undesirable species while allowing more desirable plants to remain--plants which provide ground cover, prevent erosion, and provide food for waterfowl.

It is recommended that the banks of future full-scale wetlands be seeded immediately after construction with desirable low-growing ground cover before weeds have a chance to become established. Plants that have value as a waterfowl food source are preferred. In addition, banks should be constructed with 4:1 side slopes to allow maintenance vehicles to get close to the water's edge, especially around inlet and outlet structures.

Water Quality Monitoring. The data indicate that the three-phase (marsh-pool-marsh system) cells are doing a better job of removing inorganic nitrogen from the treatment plant effluent than are the one-phase (uniform marsh system) cells. This may be due to better nitrification of the ammonia-dominated effluent in the pools of the three-phase cells. The data also suggest that a net loading of organic nitrogen may be occurring in both the three-phase and one-phase cells, perhaps from birds perching and nesting in the emergent vegetation of the marsh sections. This organic nitrogen load may account for the increase in ammonia nitrogen concentrations that has been observed at times in the outlets of both types of cells relative to the inflow concentrations.

It is impossible to be more specific in identifying the nitrogen transformation and removal mechanisms operating in the cells or to draw conclusions as to loading rates, retention times, and operating criteria because there was insufficient hydraulic control during the monitoring and because the data are not sufficiently detailed. The data collection program focused on the inlets and outlets of the cells and assumed a relatively steady inflow and outflow rate. As it transpired, the flow through the cells was highly erratic, and two flow meters were not enough to adequately monitor the flow variations.

In general, the research to date has raised questions about how much data is adequate to allow statistically-valid conclusions about wetland water quality dynamics. This question is important to answer before beginning the Series 2 research program. The paired sample t-test failed to show any significant differences in many of the water quality parameters measured when comparing influent and effluent samples or when comparing three-phase versus one-phase cells. This was attributed to the small number of samples and the large variance in their values.

How much data necessary is an interesting question because wetlands change in response to a variety of natural factors, such as weather and climate. Changes in the quality of the influent reclaimed water may also perturb the system. Both the invertebrate data and TSS data seemed to show trends that may have been seasonal in nature, but more data are needed to know whether the trends were seasonal or whether they simply indicated the trend toward establishment of an equilibrium condition as the wetlands became established.

The value of the Series 1 water quality data from the research cells is limited due to problems which were experienced with the control of inflow rates. While the average retention times in the three-phase and one-phase cells were roughly equal, there were nonetheless wide day-to-day fluctuations in influent flow rates. The original intent was to maintain a retention time of approximately 8 days in both the three-phase and one-phase cells, which required inflows of about 53 L/min (14 gal/min) and 37.5 L/min (9.9 gal/min), respectively. Mean daily inflows to the three-phase and one-phase cells during Series 1A averaged 32.2 L/min (8.5 gal/min) and 23.1 L/min (6.1 gal/min), respectively, and ranged from 0.0 to 139 L/min (0.0 to 36.7 gal/min). Average Series 1A retention times, based on the average of the mean daily inflow rates, were slightly more than 13 days for both the three-phase and one-phase cells. Longer than optimum retention times can lead to secondary effects within the cells that interfere with the treatment process and result in increases in some water quality constituents, such as BOD and organic nitrogen.

The fluctuations in inflow resulted from the fact that the water supply line for the research facility was tied into the main supply line serving reclaimed water to agricultural users. In the summer, the demand for reclaimed water was very high and also very variable based on the patterns of a few large agricultural users. When agricultural demand suddenly increased, the RWRF operators did not always respond to ensure that there was not a pressure drop in the supply line to the wetlands. EMWD is designing a new supply line for the research facility to solve that problem; completion is expected in September 1994. Since the Series 2 monitoring program is expected to begin in July 1994, an interim solution is also under investigation.

Another factor which may have affected the flow variability was the use of a portable, manually-operated pump in the collection sump for the effluent from the research cells and nursery cells. The collection sump had to be periodically emptied into a larger reclaimed water storage pond. The pump was a problem for the RWRF operators because it had to be manually turned on and off and sometimes moved to other locations. To correct this problem, in April 1993, an automatic floating submersible pump was designed, fabricated, and installed by EMWD.

A third modification has recently been made to improve the distribution of flow to the research cells. A pipeline was installed along the west end of the research facility that ties together the influent supply lines running along the north and south sides. This completes a circuit around the facility rather than having dead-end supply lines.

Invertebrate Monitoring. The results of the benthic macroinvertebrate monitoring were unexpected in that a decline in species richness over time was observed. Further, there was no pattern in abundance or richness of benthic invertebrates that could be interpreted as indicating that an "equilibrium" condition had been attained within either the one-phase or the three-phase research cells. The data collected to date suggest that the invertebrate assemblages within the cells are undergoing either seasonal shifts that mask equilibrium or a general shift in composition toward an equilibrium that has yet to be attained.

It is recommended that the benthic macroinvertebrate sampling be continued in the Series 2 monitoring program. The original objectives remain appropriate and should be pursued. More data are needed in order to be able to distinguish between annual cycles and long-term trends. Identification of seasonal and long-term cycles will have implications for the frequency of monitoring in the Hemet/San Jacinto demonstration wetlands, which is under construction.

The main problem which was encountered in the invertebrate monitoring was placement and retrieval of artificial substrates in the dense bulrush. At the time of the July 1993 sampling, bulrush density was high, and the normal intertwining of the plants' drooping stems made travel through the stand extremely difficult in some areas. The original planting rows had grown together so that the rows, used to identify locations of the clusters of artificial substrates at the time of their installation, were no longer discernable. Some of the artificial substrates could not be located or retrieved.

Based on these problems, future research will require creating a means to ensure collection of all substrates. It is recommended that a path leading to substrate locations be created and maintained by cutting of vegetation at or below the waterline. Each path should be marked at its origin and at about 1-m intervals with brightly-colored stakes that extend at least 15 cm above the waterline. The positions of substrates should be marked with flagging on overhead vegetation or by other means. In addition, anchoring points for research boats are recommended in open water areas to allow more accurate placement of sampling materials.

Saline Vegetated Marshes

The amount of brine produced by the RO was insufficient to supply both the north and south marshes during the first year because evaporation rates exceeded inflow during the hot summer months. During the second year of operations, all of the brine will be fed to the south marsh, and fresh water will be fed to the north marsh as a control. Both the brine and fresh water flows will be kept at a constant rate as nearly as possible, and the flows will be recorded. Rainfall and evaporation rates will continue to be recorded.

Detailed protocols for all of the types of analyses that are called for in the research program were not available in 1993. A proposed Saline Marsh Monitoring Program (dated July 5, 1994) is contained in Appendix E. It contains more specific protocols for performing the types of analyses that are outlined in the Research Program. It explains record-keeping procedures and provides monitoring frequencies and dates.

Soil, plant, and benthic invertebrate tissues will be collected from both marshes and analyzed for trace elements. If funds are obtained, benthic samples will be split, and the organisms in one split will be counted and identified to determine diversity while the other split is analyzed for trace elements. Water samples will be collected and analyzed annually for specific ions, trace elements, and other constituents. Trace elements will be analyzed more frequently (e.g., monthly) if funds are available. In situ EC, temperature, and TDS measurements will be continued on a weekly basis. Data will be provided to experts in wildlife toxicology.

CHAPTER 5
PUBLIC INVOLVEMENT

CHAPTER 5

PUBLIC INVOLVEMENT

INTRODUCTION

Public involvement is a process, or processes, by which interested and affected individuals, organizations, agencies, and governmental entities are consulted and included in decision-making. In addition to informing the public, public involvement programs solicit public response regarding the public's needs, values, and evaluations of proposed solutions. Before the public can become involved, they must be informed. Therefore, education is a critical element of any public involvement program.

The shifts in social values by which governmental actions are measured and the loss of governmental credibility have affected all aspects of government at all levels. Many agencies, which once considered themselves to be "the good guys", now find themselves being challenged, questioned, and criticized. The benefits of a public involvement program can far surpass the particular project for which the program was designed. The overall image of an agency can be positively affected and the program originator viewed as an environmentally aware, concerned, and responsible agency. Public input can provide unanticipated perspectives and information which can greatly enhance any project.

The use of a public involvement program is analogous to preventive medicine. If any proposed project is controversial or contains potentially misunderstood or controversial elements, the use of a public involvement program can redirect opposition into positive participation. Through the development and implementation of a good public program, the Multipurpose Wetlands Research and Demonstration Project will, hopefully, be received favorably by the general public and the environmental community. By informing and involving the public, support for the Multipurpose Wetlands Research and Demonstration Project, districtwide water resource management plans and perception of EMWD itself as a trustworthy, environmentally-aware, and concerned service agency can be achieved.

MAJOR ISSUES

The major informational issue is the feasibility of using multipurpose constructed wetlands incorporating wastewater treatment, recovery, and reuse with wildlife values, public education and recreation opportunities, and other public benefits as part of a total water resources management plan.

Potential issues of concern include the use of reclaimed water, mosquitoes, proximity of duck hunting clubs to bird watching areas, and/or cost to the consumer.

PUBLIC INVOLVEMENT PROGRAM GOAL AND OBJECTIVES

Goal: To develop acceptance of the Multipurpose Wetlands Research and Demonstration Project with the resultant acceptance of the use of reclaimed water.

Objectives:

1. Inform public of the Multipurpose Wetlands Research and Demonstration Project;
2. Identify public concerns and values; assess levels of interest in projects; and address concerns, if any;
3. Develop a consensus on the value of the project and the use of reclaimed water to the region;
4. Promote participation in the project by diverse groups and interests; and
5. Encourage public input as to the amenities to be included at constructed wetland sites with regard to the locations of future wetlands sites.

TARGET GROUPS

1. Local Groups. Citizen groups comprise the arena most commonly thought of as "the public", though there may be overlap within groups. In any area with a large population of retirees, senior citizen groups are very aware, interested, and active in community affairs. Members of civic and service groups are interested and involved in their community and provide an organized forum for the dissemination of information and opinion-gathering. Service organizations such as Rotary, Lions, or American Business Women's Association provide ideal forums for educating the public. In addition, they frequently contain the "movers and shakers" and are, consequently, important advocates.

Schools/Colleges. This project offers a natural opportunity and vehicle to educate young people about water and, in the process of establishing rapport with school systems, to also extend that element to the staff and parents. We do not want our young people to have misconceptions about reclaimed water, its reuse, or water quality in general. These are our future voters and home owners; educating them and including them in the process can be of great benefit to EMWD. In addition to educating students about water, we can raise their level of awareness of the variety of potential work opportunities in resources management and the need for the appropriate education to qualify for such opportunities.

EMWD Employees. A major opportunity for public information is education of employees. Although an employee may know his/her job and do it well, he/she does not automatically know what is happening outside his/her immediate area of activity. Employees who are kept informed of EMWD's policies and programs will improve performance and have job satisfaction because they have a common goal and a feeling of being valued. These same employees "represent" EMWD in their personal contacts throughout the community; therefore, having well-informed employees is important for effective management and for improving community relations. Employee education activities can include employee newsletters, tours, and briefings or presentations. A brochure about the project containing facts and figures for the employee to refer to and share with friends, relatives, and neighbors provides an inexpensive means of disseminating information. Responsibility for operation of the constructed wetlands will be turned over to the Operations Branch; therefore, it is important to include them early in the process.

2. Regional Groups. The Planning Task Force (PTF) is comprised of elected representatives of the cites of Hemet, Moreno Valley, Murrieta, Perris, San Jacinto, and Temecula; the Riverside County Board of Supervisors; and water agencies, including Lake Hemet Municipal Water District, Murrieta County Water District, Rancho California Water District, and EMWD. The PTF provides a forum for inter-agency collaboration to ensure long-term availability of water resources and to develop planning and finance strategies which integrate water and environmental resources to formulate programs that are cost-effective while addressing environmental issues and meeting societal needs.

EMWD also participates in quarterly planning meetings with the Directors of Public Works and Directors of Planning with the Cities of Hemet, Moreno Valley, Murrieta, Perris, San Jacinto, and Temecula. The purpose of these meetings is to share information, coordinate planning efforts, and avoid duplication of services.

Involving and informing the above entities with regard to the multipurpose constructed wetlands is an ongoing effort consisting of written materials, presentations, site tours, and briefings, and serves as a mechanism for providing information to and receiving input from a broad public base.

3. Regulatory/Governmental Agencies. Other governmental agencies should be thought of as "public" just as various interest groups or individuals are. Like any public, they are likely to feel resentful and put upon if not consulted, or if included too late, in the decision-making process. Of primary value in working with other governmental agencies is that they are an important source of information on both technical matters and public preferences.

Various Federal, State, and local governmental agencies were included in the review of the Multipurpose Wetlands Phase I Report and will continue to be consulted and asked for input. Governmental agencies are well-represented on the Technical Advisory and Technical Review Committees or are included on an informal basis.

They include the State Water Resources Control Board and Regional Water Quality Control Board; Departments of Health Services: State, County, and local; State of California Department of Fish and Game and the United States Fish and Wildlife Service; local units of government: cities, county; PTF members; and the United States EPA.

4. The Environmental Community. These are the very groups that frequently find themselves in adversarial positions with respect to water purveyors and public agencies. The study is an ideal project with which to build rapport with these groups due to the habitat creation, environmental enhancement, and educational elements of the project. Environmental groups active in the area include the Audubon Society, Sierra Club, Friends of Northern San Jacinto Valley, Moreno Valley Ecological Protection Committee, California Waterfowl Association, and Ducks Unlimited, Inc.

A representative from Ducks Unlimited, Inc. serves on the TAC and various environmental groups were asked to review and comment upon the Phase I Report. The Hemet/San Jacinto site is a favorite with local bird watchers and is one of the locations made available to and used by the Audubon Society for its Annual Christmas Bird Count. The California Waterfowl Association is interested in putting wood duck nesting boxes at the constructed wetlands and is willing to provide advice and assistance.

PUBLIC INVOLVEMENT TECHNIQUES AND STRATEGIES

1. TAC and Technical Review Committee (TRC). The TAC and TRC reviewed and commented upon the Phase I Report. This process will continue with subsequent documents. Individuals and organizations are frequently added to the review process. In addition to the regulatory and governmental agencies listed above, the TAC includes representatives from Humboldt State University; the Graduate School of Public Health, San Diego State University; the University of California, Riverside; and Ducks Unlimited, Inc. The TRC is even broader, including additional representatives of governmental and regulatory agencies, local entities, and environmental groups.

2. Presentations/Briefings/Promotional Materials. Numerous presentations have been given and will continue on an ongoing basis. Diverse groups have shown great interest in the project. Presentations have been made in-house and/or on-site, to visiting dignitaries and international visitors, to local groups and schools, to academicians and water industry technicians, to EMWD/USBR/NBS staff, and to representatives of environmental interests.

USBR, Lower Colorado Region, produced a 9 1/2 minute video which has been shown and distributed with very positive results. Constructed Wetlands: Helping Man

PHOTO 30. MEMBERS OF THE TECHNICAL ADVISORY COMMITTEE AND EXECUTIVE COMMITTEE

and Nature provides an overview of the project, discusses goals and objectives, and reports preliminary research results. It is suitable for all segments of the population.

An extensive collection of color 35 mm slides has been developed for use in presentations, publications, and promotional materials. An informative newsletter is produced and distributed to interested individuals and groups as well as brochures, booklets, and other descriptive materials.

Technical papers and conference presentations have been made by both EMWD and USBR staff. A listing of papers and publications is included in Appendix H.

3. Site Tours. The Hemet/San Jacinto RWRF sites, the EMWD/USBR/NBS Wetlands Research Facility and the Multipurpose Constructed Wetlands, are visited by a wide range of groups. Local elementary and high schools utilize the site for environmental science field trips to learn about wetlands ecology, the local environment, the value of reclaimed water, and the importance of water as a precious and finite resource. EMWD staff have developed educational resource materials for use with school children at the wetlands and by teachers in the classroom.

A graduate student from California Polytechnic University, Pomona, is compiling a species list and bird census at the Hemet/San Jacinto site and has introduced banded, juvenile burrowing owls at the site as part of a research project.

International interest in the project is evidenced by the number of foreign visitors who have toured the site including two groups from Australia, one from Taiwan, another from the Peoples Republic of China, and participants from 14 countries as part of the Middle East Peace Process, sponsored by the United States Department of State and the Agency for International Development.

National, Federal, regional, and local visitors also frequent the site. It is anticipated that the public will provide input and some assistance with regard to the type of amenities (walking/jogging/bike riding trails, bird/wildlife watching points, and other) to be incorporated into the large-scale constructed wetlands. In the future, the public could suggest sites for wetlands in the PTF Multipurpose Corridor.

EVALUATION

The success or effectiveness of a public involvement program cannot always allow for quantifiable, objective measurement. However, it is not difficult to determine the general level of acceptance and interest in the project based on requests for information and tours, the tone of newspaper articles or stories, the use of the site by educational groups, and cooperation by environmental groups. Effectiveness can also be measured by volunteer hours or monies contributed to the project for such diverse items as docents, interpretive guides and signs, or wildlife-watching platforms; letters of endorsement, praise, or awards; participation from environmental or governmental groups; or utilization of facilities by the public for passive recreational activities.

Awards presented to the project include:

- AMSA Research and Technology Award for 1994;

- California's Local Government Commission 1992 Award for Innovation in Water Conservation, Reclamation, and Management; and

- Inland Empire West Resource Conservation District, 1993 Conservation Partnership Award for Water Quality.

A chronological listing of presentations, tours, awards, visitors, newspaper articles, and other pertinent events is included Appendices F through I.

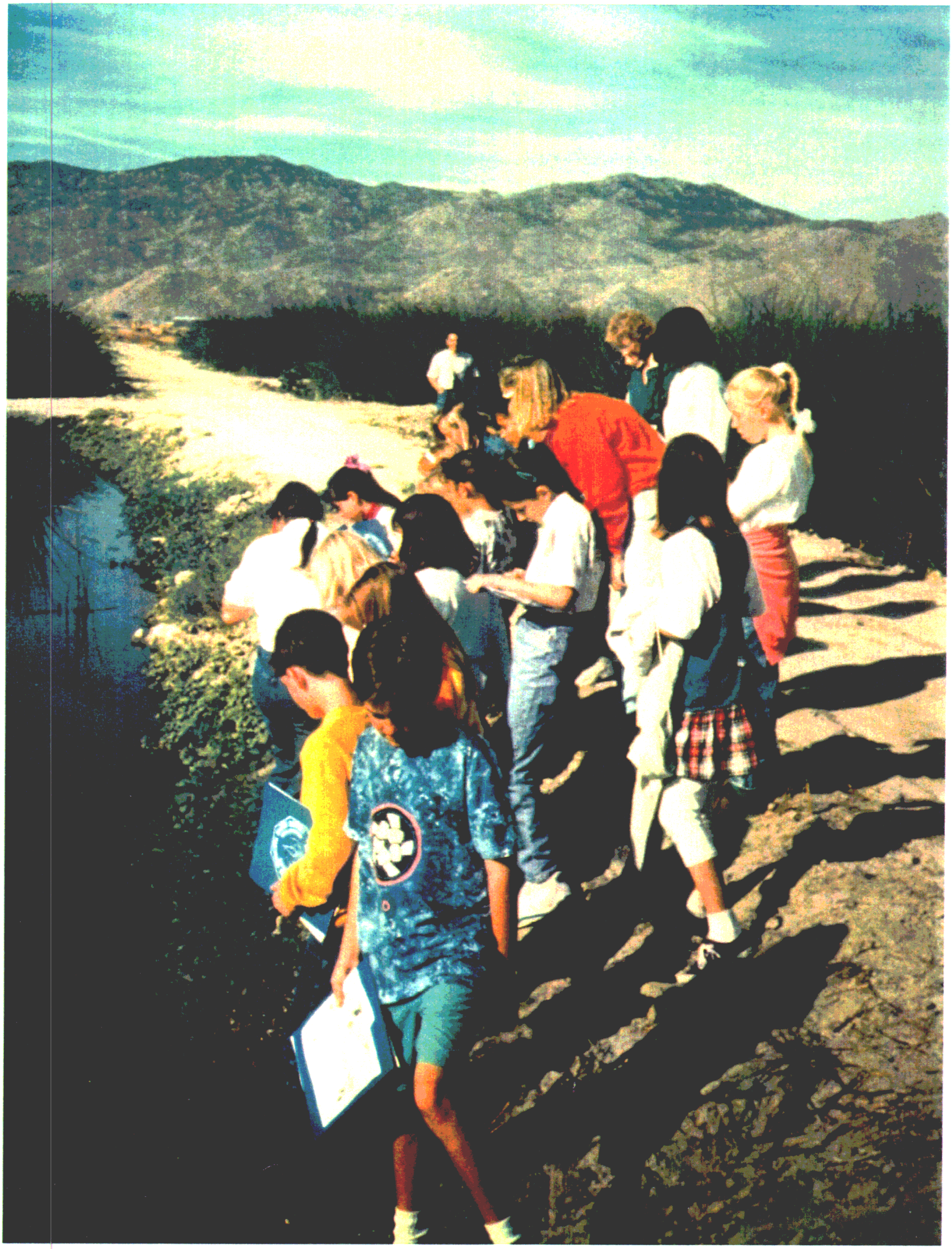


PHOTO 31. PUBLIC BENEFIT: SCHOOL CHILDREN STUDYING WETLANDS ECOLOGY AND RECLAIMED WATER REUSE

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LITERATURE CITED

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GLOSSARY

GLOSSARY

advanced wastewater treatment: any combination of physical, chemical, or biological treatment process used to accomplish a degree of treatment greater than that achieved by secondary treatment; usually implies removal or a greater level of suspended solids and BOD removal.

aerobic: environment with the presence of air. Organisms that require air for life.

AMSA: Association of Metropolitan Sewerage Agencies.

anaerobic: environment without air. Organisms capable of living without oxygen or requiring the absence of air for life.

aquifer: a confined layer or formation of permeable rock that is both overlain and underlain by impermeable strata through which ground water can flow.

base elevation: reference elevation for all earthwork elevation control and water surface elevation definitions. The base elevation is set equal to the invert elevation of the inlet and outlet marshes.

basin: a naturally-occurring depression in the landscape; or, as an alluvial basin, a filled geologic formation, often bounded by other physical or hydrologic formations.

benthic: of, relating to, or occurring at the bottom of a body of water.

benthos: organisms that live on or in the bottom of bodies of water.

biochemical oxygen demand (BOD): (1) the quantity of oxygen consumed in the biochemical oxidation of organic matter; and (2) a standard test used in assessing wastewater strength.

biota: fauna and flora together.

brackish: waters with total dissolved solids content between sea water and those that are suitable for man's purposes.

CEQA: California Environmental Quality Act.

chlorophyll-a: pigment measurement commonly used to estimate algal production.

chlorotic: a condition in green plants marked by yellowing or blanching.

cienega: a swamp or marsh, especially one supported by springs or seepage.

connecting marsh: area between inlet marshes and the open pond. Contains nesting islands and special emergent test areas.

culm: the specialized stem of grasses, sedges, and rushes.

denitrification: the reduction of nitrate and nitrite to nitrogen by certain anaerobic microorganisms.

donor marsh: a natural wetland which supplies plant material for a constructed or mitigated wetland.

effluent: partially or completely treated wastewater flowing out of a treatment facility, reservoir, or basin.

electrical conductivity (EC): the ability of water to conduct an electrical charge, used to give a rough measure of salinity.

EMWD: Eastern Municipal Water District.

EPA: United States Environmental Protection Agency.

evapotranspiration: the combined loss of water from a given area and during a specified period of time by direct evaporation and by transpiration from plants.

gal/min: gallons per minute.

imported water: water supplied by the State Water Project or Colorado River water.

influent: generally considered as wastewater flowing into a treatment plant or treatment process.

inlet marsh: wetlands region between inlet structures and connecting marsh. Each of the five inlet marshes will have a length to width ratio of 2:1 or greater. The initial size and shape is based on preliminary water treatment design capacity and research requirements.

invertebrate: an animal lacking a backbone and internal skeleton.

in situ: in the natural or original position.

"junk tubers": bare rhizomes with no shoot attached.

kPa: kilopascals.

lb/in^2: pounds per square inch.

lodging: plants falling or lying down.

macroinvertebrates: aquatic invertebrate organisms, such as beetles, worms, insects, arachnids, etc., that can easily be seen with the naked eye.

Mgal/d: million gallons per day.

mg/L: milligrams per liter.

moist-soil test areas: areas adjacent and parallel to inlet marsh 1, 2, and 3. These areas can be flooded or drained at selected times, depending on wildlife management requirements.

NBS: National Biological Survey.

O&M: operation and maintenance.

open pond: central pond in wetlands system, connecting inlet marshes with outlet marshes through either connecting marsh or direct connection. Bottom contours, shape, and cross-sections are designed to produce specific shallow-bench areas at pond margins.

outlet marsh: connects open pond to four-system outlet structures. Marsh is divided into two parts for redundancy, to satisfy water treatment design requirements, and allow for whole wetlands system to fit onto site.

outlet structure: hydraulic control structure designed to collect and measure flow out of system and to regulate depth of water through entire wetlands system.

oxidation-reduction potential (ORP): a measurement of instantaneous tendency of redox conditions.

pH: hydrogen-ion concentration; a measurement of acid or basic conditions, defined as the negative logarithm of hydrogen ion concentration in a solution.

PTF: Planning Task Force.

polychlorinated biphenyls (PCB's): any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are poisonous environmental pollutants which tend to accumulate in animal tissues.

recharge: the process, by man or nature, of putting water into soil or into a ground-water aquifer zone.

reclaimed water: wastewater that, as a result of treatment, is suitable for a second beneficial use.

reverse osmosis (RO) process: a system for separating salts and other mineral constituents from water by using differential osmotic pressures across a semi-permeable membrane.

riparian: an ecological zone defined as water-influenced, such as along the bank of a river or lake.

RWRF: Regional Water Reclamation Facility.

shallow emergent test area: southwest portion of open pond area designed to be less than 2 feet deep at design water depth.

SJWR: San Jacinto Wildlife Refuge, a 5000-acre wildlife refuge in the San Jacinto River Valley, which is owned and operated by the California Department of Fish and Game.

TAC: Technical Advisory Committee.

TFC: thin-film composite.

TRC: Technical Review Committee.

tertiary treatment: see advanced wastewater treatment.

total dissolved solids (TDS): the sum of all dissolved solids in water or wastewater and an expression of water salinity in mg/L.

total organic carbon (TOC): the total quantity of carbon of organic material that is either in solution or suspended.

total suspended solids (TSS): the sum of all suspended materials in water or wastewater. Generally considered materials which are retained by a .45 micron filter.

transects: a line established as a basis for measuring wetland attributes.

transpiration: release of water vapor from leaves and other plant parts.

USBR: United States Bureau of Reclamation.

USGS: United States Geological Survey.

wetlands, constructed: man-made wetlands constructed and operated expressly for the purpose of wastewater treatment or multipurpose objectives incorporating environmental enhancement or other features.

wetlands, natural: those naturally-occurring and sustained areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that normally do support, a prevalence of vegetation species that are adapted to saturated soil conditions.

wetlands system: set of constructed water system components linked together to form a natural wastewater treatment system. The system can also provide environmental enhancements, a wildlife refuge, and a cost-effective means of reusing and recycling clean water back into the environment.

APPENDICES

APPENDIX A

APPENDIX A

WATER QUALITY AND SEDIMENT DATA

Water Quality and Sediment Data

NURSERY CELLS WATER QUALITY

These data are on file with the National Biological Survey in Denver, Colorado.

RESEARCH CELLS

1. Sediment Data: Monthly in situ measurements of pH, redox potential, EC, nitrate-N, and phosphorus (total and ortho) and yearly measurements of trace elements, particle-size analysis, organic carbon, calcium carbonate, organic carbon, calcium carbonate, cation exchange capacity are on file at EMWD offices in San Jacinto, California, and are discussed in Chapter 4 of this report.

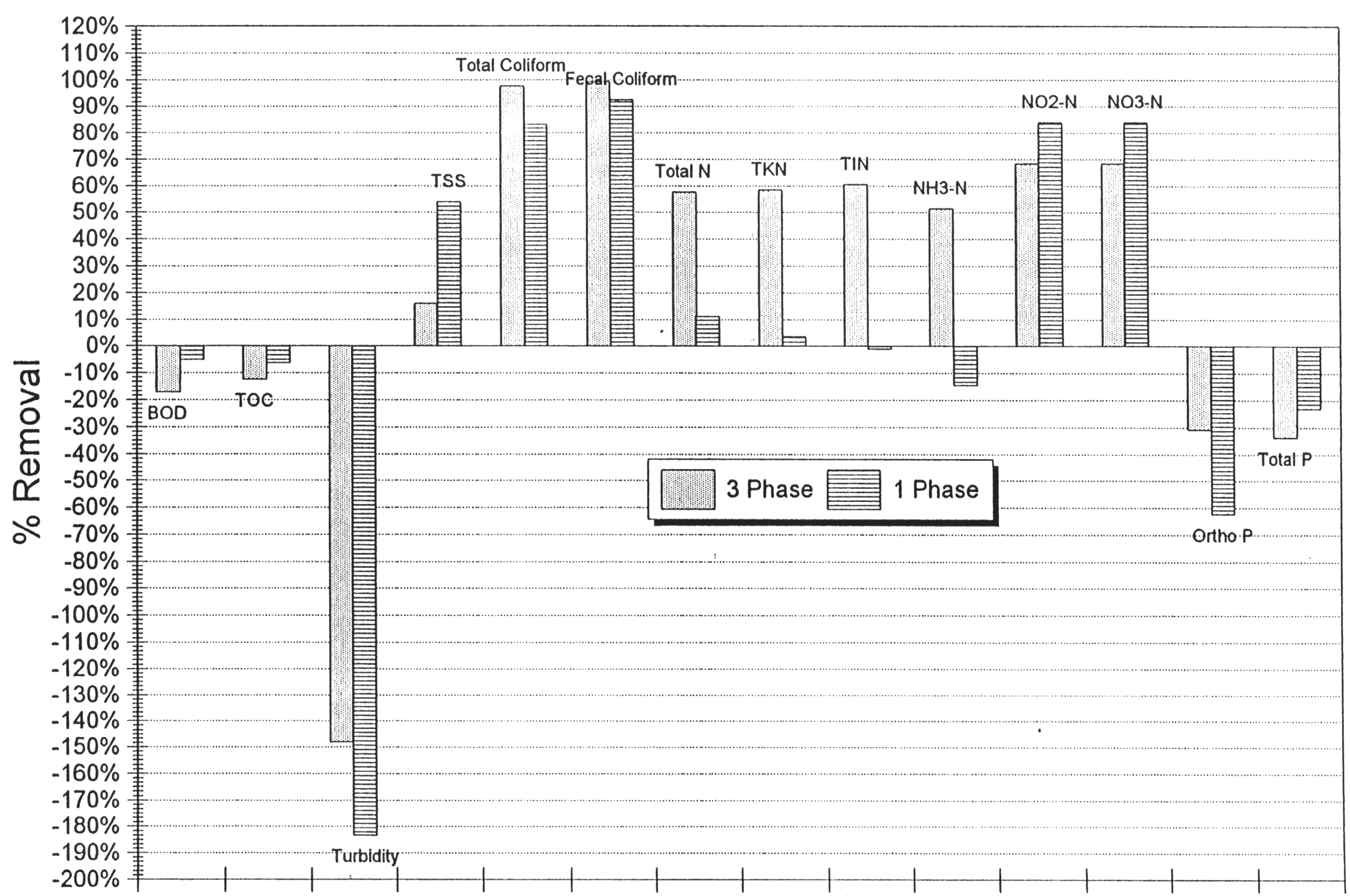
2. Hydrolab DataSonde Measurements: Hourly in situ measurements of water temperature, conductivity, pH, and dissolved oxygen concentrations and saturation percentages from both the inlet box and the outlet boxes of the three-phase and one-phase cells are on file on floppy disks at EMWD offices in San Jacinto, California.

3. Inflow Rate Measurements: Daily inflow rate measurements obtained during Series 1A are on file on floppy disks at EMWD offices in San Jacinto, California.

4. Laboratory Chemical Analyses Results: Appended hereafter are 17 Series 1A data and statistical tables for the water quality constituents discussed in this report. The entire Series 1/1A laboratory analyses results data set is on file on floppy disks at EMWD offices in San Jacinto, California.

%Removal Summary: Inlet vs. Outlets

EMWD Wetlands Research Cells:Phase 1A



Biochemical Oxygen Demand

General Statistics

	Inlet	3 Phase	1 Phase
Mean	4.875	5.714286	5.125
Standard Error	0.895176	1.614138	0.833185
Median	4.5	4	4.5
Mode	4	4	4
Standard Deviation	2.531939	4.270608	2.356602
Variance	6.410714	18.2381	5.553571
Kurtosis	2.764435	5.334343	2.505268
Skewness	0.890022	2.198768	1.19934
Range	9	13	8
Minimum	1	2	2
Maximum	10	15	10
Sum	39	40	41
Count	8	7	8
Confidence Level(0.950000)	1.754512	3.163653	1.633012

Data Table

Week	Inlet	3 Phase	1 Phase
29	10	15	10
32	1	6	4
38	6	4	6
41	4	5	5
44	5	4	4
47	4	4	6
50	5	2	2

Average Removal/Gain

	3 Phase	1 Phase
Change	0.84 Gained	0.25 Gained
% Change	17.22% Gain	5.13% Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	5.714286	5.285714	5	5.7142857	5	5.285714
Variance	18.2381	6.238095	7.333333	18.238095	7.3333333	6.238095
Observations	7	7	7	7	7	7
Pearson Correlation	0.86833		0.662928		0.7146116	
Pooled Variance	12.2381		12.78571		6.7857143	
Hypothesized Mean Differenc	0		0		0	
df	6		6		6	
t	0.464758		-0.59062		-0.382546	
P(T<=t) one-tail	0.329246		0.288163		0.3576204	
t Critical one-tail	1.94318		1.94318		1.9431803	
P(T<=t) two-tail	0.658492		0.576327		0.7152408	
t Critical two-tail	2.446912		2.446912		2.4469119	

Total Organic Carbon

General Statistics

	Inlet	3 Phase	1 Phase
Mean	10.3875	11.675	11.05
Standard Error	0.239372	0.638847	1.301922
Median	10.5	11.5	10.5
Mode	11	11	NA
Standard Deviation	0.677047	1.806931	3.682391
Variance	0.458393	3.265	13.56
Kurtosis	-2.26799	0.756242	0.135877
Skewness	-0.23608	0.809615	0.215431
Range	1.5	5.6	11.8
Minimum	9.5	9.5	5.2
Maximum	11	15.1	17
Sum	83.1	93.4	88.4
Count	8	8	8
Confidence Level(0.950000)	0.469161	1.252116	2.55172

Data Table

Week	Inlet	3 Phase	1 Phase
29	11	12	12
32	10	15.1	17
35	9.5	11	15
38	10	11	8.9
41	9.6	12	10
44	11	9.5	5.2
47	11	9.8	9.3
50	11	13	11

Average Removal/Gain

	3 Phase	1 Phase
Change	1.29 Gained	0.66 Gained
% Change	12.39% Gain	6.38% Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	11.675	11.05	10.3875	11.675	10.3875	11.05
Variance	3.265	13.56	0.458393	3.265	0.458393	13.56
Observations	8	8	8	8	8	8
Pearson Correlation	0.75295		-0.25602		-0.47301	
Pooled Variance	8.4125		1.861696		7.009196	
Hypothesized Mean Differen	0		0		0	
df	7		7		7	
t	0.677659		-1.74605		-0.46304	
P(T<=t) one-tail	0.259875		0.062154		0.328695	
t Critical one-tail	1.894579		1.894579		1.894579	
P(T<=t) two-tail	0.51975		0.124307		0.65739	
t Critical two-tail	2.364624		2.364624		2.364624	

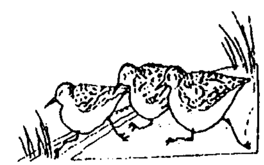
Total Suspended Solids

General Statistics

	Inlet	3 Phase	1 Phase
Mean	10	8.4	4.6
Standard Error	3.820995	2.063977	1.122497
Median	6	9	4
Mode	5	4	3
Standard Deviation	8.544004	4.615192	2.50998
Variance	73	21.3	6.3
Kurtosis	4.228373	-0.68836	4.225246
Skewness	2.044212	0.514732	2.017344
Range	20	11	6
Minimum	5	4	3
Maximum	25	15	9
Sum	50	42	23
Count	5	5	5
Confidence Level(0.950000)	7.489012	4.04532	2.200054

Data Table

Week	Inlet	3 Phase	1 Phase
35	5	15	9
38	9	4	3
41	25	10	4
44	6	9	3
50	5	4	4



Average Removal/Gain

	3 Phase		1 Phase	
Change	1.60	Removed	5.40	Removed
% Change	16.00%	Removal	54.00%	Removal

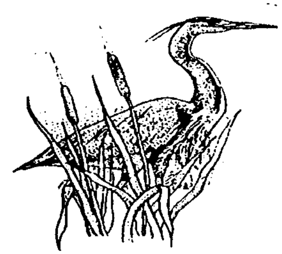
t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	8.4	4.6	10	8.4	10	4.6
Variance	21.3	6.3	73	21.3	73	6.3
Observations	5	5	5	5	5	5
Pearson Correlation	0.794196		0.0951		-0.233152	
Pooled Variance	13.8		47.15		39.65	
Hypothesized Mean Differen	0		0		0	
df	4		4		4	
t	2.801397		0.384012		1.277771	
P(T<=t) one-tail	0.024371		0.360255		0.1352239	
t Critical one-tail	2.131847		2.131847		2.1318468	
P(T<=t) two-tail	0.048742		0.720509		0.2704478	
t Critical two-tail	2.776445		2.776445		2.7764451	

Turbidity

General Statistics

	Inlet	3 Phase	1 Phase
Mean	4.091667	10.15417	11.59167
Standard Error	0.866902	2.267061	3.892141
Median	2.55	5.7	4.3
Mode	1.7	2.7	1.7
Standard Deviation	4.246934	11.10628	19.06752
Variance	18.03645	123.3495	363.5704
Kurtosis	2.387984	2.199001	7.6118
Skewness	1.893403	1.677189	2.87947
Range	15.4	40.9	70.3
Minimum	0.6	1.3	1.7
Maximum	16	42.2	72
Sum	98.2	243.7	278.2
Count	24	24	24
Confidence Level(0.950000)	1.699096	4.443357	7.628457



Average Removal/Gain

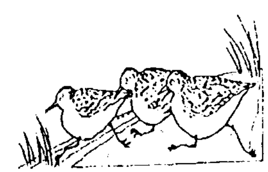
	3 Phase		1 Phase	
Change	6.06	Gained	7.50	Gained
% Change	148.17%	Gain	183.30%	Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	10.15417	11.59167	4.091667	10.15417	4.091667	11.59167
Variance	123.3495	363.5704	18.03645	123.3495	18.03645	363.5704
Observations	24	24	24	24	24	24
Pearson Correlation	0.189047		0.279614		0.219005	
Pooled Variance	243.46		70.693		190.8034	
Hypothesized Mean Differen	0		0		0	
df	23		23		23	
t	-0.34914		-2.76944		-1.97489	
P(T<=t) one-tail	0.365081		0.005454		0.030202	
t Critical one-tail	1.713872		1.713872		1.713872	
P(T<=t) two-tail	0.730163		0.010908		0.060404	
t Critical two-tail	2.068658		2.068658		2.068658	

Data Table

Week	Inlet	3 Phase	1 Phase
29	11	30	72
30	2.8	11.7	13.6
31	2.2	11	6
32	2.9	32	9
33	12.2	42.2	5.1
34	0.6	24	3.7
35	2.3	9.8	8.8
36	13	1.3	18
37	1.2	13	14
38	3.4	2.5	1.8
39	1.8	10	16
40	1.5	14.8	4.1
41	16	6.5	3
42	0.9	5.6	4.5
43	3.6	5.8	8.1
44	1.8	5.3	2.2
45	1.7	2.7	3.2
46	3.5	3.8	1.9
48	2.4	1.5	71
49	1.7	2.2	1.7
50	2.5	2.7	3.8
51	2.6	1.6	1.7
54	2.6	1.9	3
55	4	1.8	2



Total Coliform

With Chlorinated Samples

General Statistics

	Inlet	3 Phase	1 Phase
Mean	272952.5	6187.5	45430
Standard Error	111897.8	1540.227	20742.86
Median	190000	5500	11150
Mode	NA	NA	170
Standard Deviation	316494.6	4356.42	58669.67
Variance	1E+11	18978393	3.44E+09
Kurtosis	-0.55715	-0.36952	-1.42835
Skewness	0.971601	0.766474	0.830027
Range	799980	12000	129830
Minimum	20	2000	170
Maximum	800000	14000	130000
Sum	2183620	49500	363440
Count	8	8	8
Confidence Level(0.950000)	219315.6	3018.789	40655.26

Data Table

Week	Inlet	3 Phase	1 Phase
29	140000	4000	130000
32	1600	10000	20000
35	300000	2000	170
38	700000	8000	170
41	800000	2300	2300
44	2000	14000	80000
47	20	7000	130000
50	240000	2200	800

Average Removal/Gain

	3 Phase		1 Phase	
Change	1.644572	Logs Removed	0.778744	Logs Removed
% Change	97.73%	Removal	83.36%	Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	6187.5	45430	272952.5	6187.5	272952.5	45430
Variance	18978393	3.44E+09	1E+11	18978393	1E+11	3.44E+09
Observations	8	8	8	8	8	8
Pearson Correlation	0.285036		-0.44957		-0.60475	
Pooled Variance	1.73E+09		5.01E+10		5.18E+10	
Hypothesized Mean Difference	0		0		0	
df	7		7		7	
t	-1.92767		2.369168		1.812442	
P(T<=t) one-tail	0.047624		0.024833		0.056405	
t Critical one-tail	1.894579		1.894579		1.894579	
P(T<=t) two-tail	0.095248		0.049667		0.112811	
t Critical two-tail	2.364624		2.364624		2.364624	

Total Coliform

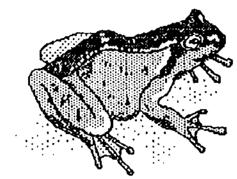
Without Chlorinated Samples

General Statistics

	Inlet	3 Phase	1 Phase
Mean	363600	6416.667	25573.33
Standard Error	129611.3	2869.892	21120.3
Median	270000	3150	1550
Mode	NA	NA	170
Standard Deviation	317481.6	7029.77	51733.96
Variance	1.01E+11	49417667	2.68E+09
Kurtosis	-1.49602	3.801549	5.517888
Skewness	0.566394	1.956144	2.335667
Range	798400	18000	129830
Minimum	1600	2000	170
Maximum	800000	20000	130000
Sum	2181600	38500	153440
Count	6	6	6
Confidence Level(0.950000)	254033.5	5624.884	41395.03

Data Table

Week	Inlet	3 Phase	1 Phase
29	140000	4000	130000
32	1600	20000	20000
35	300000	2000	170
38	700000	8000	170
41	800000	2300	2300
50	240000	2200	800



Average Removal/Gain

	3 Phase		1 Phase	
Change	1.753314	Logs Removed	1.152837	Logs Removed
% Change	98.24%	Removal	92.97%	Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	6416.667	25573.33	363600	6416.667	363600	25573.33
Variance	49417667	2.68E+09	1.01E+11	49417667	1.01E+11	2.68E+09
Observations	6	6	6	6	6	6
Pearson Correlation	-0.0307		-0.4336		-0.43053	
Pooled Variance	1.36E+09		5.04E+10		5.17E+10	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t	-0.89511		2.729064		2.414336	
P(T<=t) one-tail	0.205872		0.020663		0.03027	
t Critical one-tail	2.015048		2.015048		2.015048	
P(T<=t) two-tail	0.411744		0.041326		0.060539	
t Critical two-tail	2.570582		2.570582		2.570582	

Fecal Coliform

With Chlorinated Samples

General Statistics

	Inlet	3 Phase	1 Phase
Mean	305200.3	4212.5	49047.5
Standard Error	106270	1359.417	24296.03
Median	270000	2500	5500
Mode	1	NA	NA
Standard Deviation	300576.8	3845.011	68719.55
Variance	9.03E+10	14784107	4.72E+09
Kurtosis	-1.71208	-1.6117	-0.56043
Skewness	0.318069	0.681519	1.06533
Range	699999	9200	169920
Minimum	1	800	80
Maximum	700000	10000	170000
Sum	2441602	33700	392380
Count	8	8	8
Confidence Level(0.950000)	208285.3	2664.408	47619.35

Data Table

Week	Inlet	3 Phase	1 Phase
29	700000	1000	1000
32	1600	10000	10000
35	500000	2000	170000
38	700000	3000	80
41	300000	800	500
44	1	9000	80000
47	1	7000	130000
50	240000	900	800

Average Removal/Gain

	3 Phase		1 Phase	
Change	1.860045	Logs Removed	0.793968	Logs Removed
% Change	98.62%	Removal	83.93%	Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	4212.5	49047.5	305200.3	4212.5	305200.3	49047.5
Variance	14784107	4.72E+09	9.03E+10	14784107	9.03E+10	4.72E+09
Observations	8	8	8	8	8	8
Pearson Correlation	0.226785		-0.74329		-0.23266	
Pooled Variance	2.37E+09		4.52E+10		4.75E+10	
Hypothesized Mean Difference	0		0		0	
df	7		7		7	
t	-1.86624		2.805517		2.239296	
P(T<=t) one-tail	0.052126		0.013157		0.03007	
t Critical one-tail	1.894579		1.894579		1.894579	
P(T<=t) two-tail	0.104252		0.026315		0.06014	
t Critical two-tail	2.364624		2.364624		2.364624	

Fecal Coliform

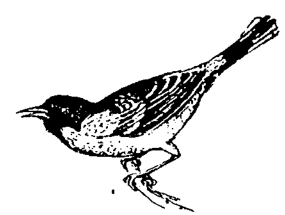
Without Chlorinated Samples

General Statistics

	Inlet	3 Phase	1 Phase
Mean	406933.3	2950	30396.67
Standard Error	113142.1	1451.838	27963.16
Median	400000	1500	900
Mode	NA	NA	NA
Standard Deviation	277140.4	3556.262	68495.48
Variance	7.68E+10	12647000	4.69E+09
Kurtosis	-1.17988	4.798989	5.934998
Skewness	-0.30049	2.158329	2.433139
Range	698400	9200	169920
Minimum	1600	800	80
Maximum	700000	10000	170000
Sum	2441600	17700	182380
Count	6	6	6
Confidence Level(0.950000)	221754.5	2845.55	54806.79

Data Table

Week	Inlet	3 Phase	1 Phase
29	700000	1000	1000
32	1600	10000	10000
35	500000	2000	170000
38	700000	3000	80
41	300000	800	500
50	240000	900	800



Average Removal/Gain

	3 Phase		1 Phase	
Change	2.139701	Logs Removed	1.126697	Logs Removed
% Change	99.28%	Removal	92.53%	Removal

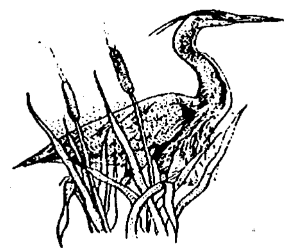
t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	2950	30396.67	406933.3	2950	406933.3	30396.67
Variance	12647000	4.69E+09	7.68E+10	12647000	7.68E+10	4.69E+09
Observations	6	6	6	6	6	6
Pearson Correlation	-0.07854		-0.59472		0.12535	
Pooled Variance	2.35E+09		3.84E+10		4.07E+10	
Hypothesized Mean Difference	0		0		0	
df	5		5		5	
t	-0.97625		3.543355		3.329458	
P(T<=t) one-tail	0.186889		0.008252		0.010396	
t Critical one-tail	2.015048		2.015048		2.015048	
P(T<=t) two-tail	0.373778		0.016504		0.020791	
t Critical two-tail	2.570582		2.570582		2.570582	

Ammonium Nitrogen

General Statistics

	Inlet	3 Phase	1 Phase
Mean	11.712	5.672	13.416
Standard Error	0.660059	0.64134	0.839855
Median	12	5.5	13
Mode	12	3.6	13
Standard Deviation	3.300293	3.206701	4.199274
Variance	10.89193	10.28293	17.6339
Kurtosis	1.381588	-0.015411	2.08235
Skewness	-0.610008	0.410044	0.92197
Range	15.3	12.7	19.9
Minimum	2.7	0.3	6.1
Maximum	18	13	26
Sum	292.8	141.8	335.4
Count	25	25	25
Confidence Level(0.950000)	1.293691	1.257004	1.646085



Average Removal/Gain

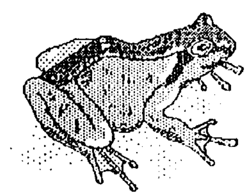
	3 Phase		1 Phase	
Change	6.04	Removed	1.70	Gained
% Change	51.57%	Removal	14.55%	Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	1 Phase	Inlet	3 Phase
Mean	5.672	13.416	11.712	13.416	11.712	5.672
Variance	10.28293	17.6339	10.89193	17.6339	10.89193	10.28293
Observations	25	25	25	25	25	25
Pearson Correlation	0.563034		-0.123822		-0.310093	
Pooled Variance	13.95842		14.26292		10.58743	
Hypothesized Mean Differenc	0		0		0	
df	24		24		24	
t	-10.84232		-1.507129		5.73412	
P(T<=t) one-tail	4.95E-11		0.072414		3.29E-06	
t Critical one-tail	1.710882		1.710882		1.710882	
P(T<=t) two-tail	9.9E-11		0.144829		6.57E-06	
t Critical two-tail	2.063899		2.063899		2.063899	

Data Table

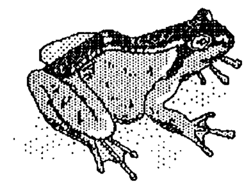
Week	Inlet	3 Phase	1 Phase
29	12	7	9
30	13	13	17
31	12	6.7	11
32	15	7.4	11
33	13	6	13
34	6.1	8.5	14
35	13	8.1	18
36	2.7	11	18
37	10	3.6	12
38	12	4.7	13
39	13	3.2	7.6
40	9.5	1.6	6.1
41	18	4.8	9.6
42	12	2.1	12
43	9.7	3.9	9.1
44	12	0.3	13
45	10	4.1	13
46	10	4	10
47	15	5.5	16
48	10	11	26
49	7.8	6.9	14
50	17	0.5	14
51	11	6.5	17
54	14	7.8	14
55	15	3.6	18



Nitrite Nitrogen

General Statistics

	Inlet	3 Phase	1 Phase
Mean	1.929	0.6106	0.306
Standard Error	0.266609	0.2397	0.118255
Median	2.2	0.3	0.14
Mode	2.7	0.1	0.05
Standard Deviation	1.333045	1.198499	0.591275
Variance	1.777008	1.436401	0.349606
Kurtosis	-1.60912	20.1774	18.05453
Skewness	-0.22147	4.333803	4.043819
Range	3.745	6.095	2.945
Minimum	0.005	0.005	0.005
Maximum	3.75	6.1	2.95
Sum	48.225	15.265	7.65
Count	25	25	25
Confidence Level(0.950000)	0.522544	0.469803	0.231776



Data Table

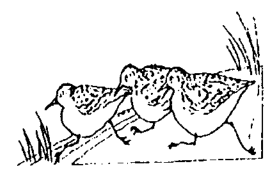
Week	Inlet	3 Phase	1 Phase
29	0.4	0.4	0.1
30	0.25	0.45	0.4
31	1.35	0.68	0.82
32	3.6	0.3	0.3
33	0.1	0.2	0.7
34	2.7	0.1	0.39
35	0.2	0.005	0.05
36	1.8	0.6	0.2
37	3.75	1.32	0.15
38	0.8	0.2	0.1
39	3.05	0.25	0.15
40	3.4	0.02	0.02
41	2.7	0.18	0.17
42	2	0.7	0.2
43	3.25	0.46	0.14
44	0.005	1.4	0.005
45	3.6	0.39	0.5
46	2.97	0.64	2.95
47	2.2	0.3	0.01
48	3.1	0.16	0.005
49	0.23	6.1	0.08
50	2.7	0.1	0.05
51	2.85	0.11	0.05
54	0.95	0.12	0.07
55	0.27	0.08	0.04

Average Removal/Gain

	3 Phase		1 Phase	
Change	1.32	Removed	1.62	Removed
% Change	68.35%	Removal	84.14%	Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	1 Phase	Inlet	3 Phase
Mean	0.6106	0.306	1.929	0.306	1.929	0.6106
Variance	1.436401	0.349606	1.777008	0.349606	1.777008	1.436401
Observations	25	25	25	25	25	25
Pearson Correlation	-0.02407		0.133077		-0.25802	
Pooled Variance	0.893003		1.063307		1.606704	
Hypothesized Mean Differen	0		0		0	
df	24		24		24	
t	1.128883		5.861332		3.280516	
P(T<=t) one-tail	0.135053		2.4E-06		0.001579	
t Critical one-tail	1.710882		1.710882		1.710882	
P(T<=t) two-tail	0.270105		4.8E-06		0.003158	
t Critical two-tail	2.063899		2.063899		2.063899	



Nitrate Nitrogen

General Statistics

	Inlet	1 Phase	3 Phase
Mean	0.772	0.764	0.612
Standard Error	0.08377	0.066803	0.085307
Median	0.7	0.8	0.5
Mode	0.4	0.7	0.5
Standard Deviation	0.418848	0.334016	0.426536
Variance	0.175433	0.111567	0.181933
Kurtosis	1.852442	-0.095591	5.199766
Skewness	1.131153	0.021083	1.863956
Range	1.9	1.4	2
Minimum	0.1	0.1	0.1
Maximum	2	1.5	2.1
Sum	19.3	19.1	15.3
Count	25	25	25
Confidence Level(0.950000)	0.164185	0.130932	0.167199

Data Table

Week	Inlet	3 Phase	1 Phase
29	1.5	1.5	1.2
30	0.4	0.6	0.5
31	0.9	0.7	0.8
32	1	0.3	0.7
33	0.4	0.7	1
34	2	0.1	2.1
35	0.7	1	0.2
36	0.8	0.5	0.8
37	1.1	1.1	0.5
38	0.7	0.9	0.5
39	0.1	0.4	0.4
40	0.9	0.6	1.1
41	0.5	1	0.4
42	0.7	0.7	0.3
43	0.8	0.3	0.8
44	0.7	0.7	0.6
45	0.9	0.8	0.5
46	0.5	0.8	0.5
47	0.3	1	0.1
48	0.4	0.3	0.1
49	1.3	1	0.3
50	0.4	0.9	0.4
51	0.6	1.3	0.2
54	1.2	0.8	0.8
55	0.5	1.1	0.5

Average Removal/Gain

	3 Phase		1 Phase	
Change	0.01	Removed	0.16	Removed
% Change	1.04%	Removal	20.73%	Removal

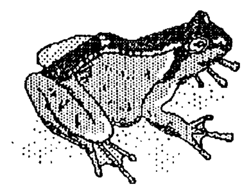
t-Test: Paired Two-Sample for Means

	1 Phase	3 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	0.764	0.612	0.772	0.764	0.772	0.612
Variance	0.111567	0.181933	0.175433	0.111567	0.175433	0.181933
Observations	25	25	25	25	25	25
Pearson Correlation	-0.344868		-0.03431		0.708633	
Pooled Variance	0.14675		0.1435		0.178683	
Hypothesized Mean Difference	0		0		0	
df	24		24		24	
t	1.214227		0.073447		2.478709	
P(T<=t) one-tail	0.118237		0.47103		0.010303	
t Critical one-tail	1.710882		1.710882		1.710882	
P(T<=t) two-tail	0.236474		0.942059		0.020606	
t Critical two-tail	2.063899		2.063899		2.063899	

Total Inorganic Nitrogen

General Statistics

	Inlet	3 Phase	1 Phase
Mean	14.261	5.622	14.429
Standard Error	0.6804425	0.638971	0.8465701
Median	14.05	5.5	14.47
Mode	13.5	3.6	19.4
Standard Deviation	3.4022125	3.1948552	4.2328504
Variance	11.57505	10.2071	17.917023
Kurtosis	2.0950966	0.066016	1.6735474
Skewness	-0.45371	0.4624078	0.6734865
Range	16.4	12.7	19.985
Minimum	4.9	0.3	6.52
Maximum	21.3	13	26.505
Sum	356.525	140.55	360.725
Count	25	25	25
Confidence Level(0.950000)	1.3336428	1.2523602	1.6592469



Average Removal/Gain

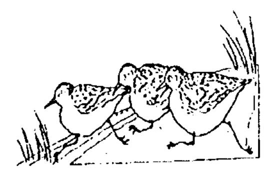
	3 Phase		1 Phase	
Change	8.64	Removed	0.17	Gained
% Change	60.58%	Removal	1.18%	Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	5.622	14.429	14.261	5.622	14.261	14.429
Variance	10.2071	17.917023	11.57505	10.2071	11.57505	17.917023
Observations	25	25	25	25	25	25
Pearson Correlation	0.6076931		-0.374068		-0.249895	
Pooled Variance	14.062061		10.891075		14.746036	
Hypothesized Mean Differen	0		0		0	
df	24		24		24	
t	-12.88034		7.8976107		-0.138678	
P(T<=t) one-tail	1.424E-12		1.981E-08		0.4454308	
t Critical one-tail	1.7108821		1.7108821		1.7108821	
P(T<=t) two-tail	2.847E-12		3.961E-08		0.8908616	
t Critical two-tail	2.0638986		2.0638986		2.0638986	

Data Table

Week	Inlet	3 Phase	1 Phase
29	13.9	5.75	9
30	14.25	13	19.4
31	14.05	6.7	12.92
32	19.3	7.4	12.2
33	13.6	6	14.5
34	9.5	8.5	14.89
35	13.5	8.1	19.35
36	4.9	11	19.4
37	14.25	3.6	12.75
38	13.5	4.7	13.8
39	16.15	3.2	8.25
40	14	1.6	6.52
41	21.3	4.8	10.47
42	14.3	2.1	13
43	13.75	3.9	9.54
44	13.005	0.3	14.305
45	14.4	4.1	14.825
46	13.47	4	13.65
47	18.2	5.5	16.21
48	13.9	11	26.505
49	8.43	6.9	14.48
50	20	0.5	14.65
51	14.35	6.5	17.1
54	15.05	7.8	14.47
55	15.47	3.6	18.54



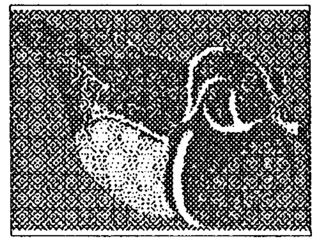
Total Kjeldahl Nitrogen

General Statistics

	Inlet	3 Phase	1 Phase
Mean	16.143	6.7	15.571
Standard Error	0.7377	1.2987	1.2884
Median	16	6.7	15
Mode	18	NA	15
Standard Deviation	1.9518	3.4361	3.4087
Variance	3.8095	11.807	11.619
Kurtosis	-1.0054	-0.5844	1.0748
Skewness	-0.465	0.2031	-0.0166
Range	5	9.8	11
Minimum	13	2.2	10
Maximum	18	12	21
Sum	113	46.9	109
Count	7	7	7
Confidence Level(0.950000)	1.4459	2.5454	2.5251

Data Table

Week	Inlet	3 Phase	1 Phase
32	16	9.6	15
35	15	12	21
38	15	6.7	15
41	18	5.9	10
44	13	2.2	14
47	18	7.4	18
50	18	3.1	16



Average Removal/Gain

	3 Phase		1 Phase	
Change	9.44	Removed	0.57	Removed
% Change	58.50%	Removal	3.54%	Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	6.7	15.571	16.143	6.7	16.14286	15.571
Variance	11.807	11.619	3.8095	11.807	3.809524	11.619
Observations	7	7	7	7	7	7
Pearson Correlation	0.5521		0.0199		-0.13957	
Pooled Variance	11.713		7.8081		7.714286	
Hypothesized Mean Differenc	0		0		0	
df	6		6		6	
t	-7.2461		6.3768		0.363636	
P(T<=t) one-tail	0.0002		0.0003		0.364299	
t Critical one-tail	1.9432		1.9432		1.94318	
P(T<=t) two-tail	0.0004		0.0007		0.728599	
t Critical two-tail	2.4469		2.4469		2.446912	

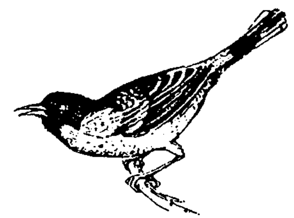
Total Nitrogen

General Statistics

	Inlet	3 Phase	1 Phase
Mean	18.543571	7.8478571	16.483571
Standard Error	1.1732305	1.1549159	1.2990119
Median	20.3	7.2	16.2
Mode	NA	NA	NA
Standard Deviation	3.1040762	3.0556203	3.4368623
Variance	9.6352893	9.3368155	11.812023
Kurtosis	-1.976841	-1.060173	1.9197187
Skewness	-0.548346	0.1320851	0.1619009
Range	7.295	8.405	11.48
Minimum	14.005	4	10.87
Maximum	21.3	12.405	22.35
Sum	129.805	54.935	115.385
Count	7	7	7

Data Table

Week	Inlet	3 Phase	1 Phase
32	20.3	9.95	16.2
35	15.5	12.405	22.35
38	16.5	7.2	15.8
41	21.3	7.08	10.87
44	14.005	4.5	15.305
47	21.2	9.8	18.21
50	21	4	16.65



Average Removal/Gain

	3 Phase	1 Phase
Change	10.70 Removed	2.06 Removed
% Change	57.68% Removal	11.11% Removal

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	7.8478571	16.483571	18.543571	7.8478571	18.543571	16.483571
Variance	9.3368155	11.812023	9.6352893	9.3368155	9.6352893	11.812023
Observations	7	7	7	7	7	7
Pearson Correlation	0.5962001		-0.00074		-0.345033	
Pooled Variance	10.574419		9.4860524		10.723656	
Hypothesized Mean Differen	0		0		0	
df	6		6		6	
t	-7.779087		6.4944221		1.0154327	
P(T<=t) one-tail	0.0001188		0.0003171		0.1745417	
t Critical one-tail	1.9431803		1.9431803		1.9431803	
P(T<=t) two-tail	0.0002376		0.0006341		0.3490834	
t Critical two-tail	2.4469119		2.4469119		2.4469119	

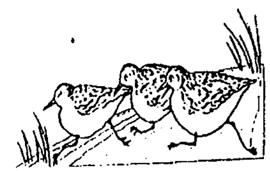
Total Phosphorus

General Statistics

	Inlet	3 Phase	1 Phase
Mean	4	5.35	4.925
Standard Error	0.133631	0.381257	0.296859
Median	4.1	5.05	5
Mode	4.3	NA	4.8
Standard Deviation	0.377964	1.078359	0.839643
Variance	0.142857	1.162857	0.705
Kurtosis	-0.94192	2.546164	-0.406441
Skewness	-0.761976	1.334269	-0.620469
Range	1	3.6	2.5
Minimum	3.4	4	3.5
Maximum	4.4	7.6	6
Sum	32	42.8	39.4
Count	8	8	8
Confidence Level(0.950000)	0.261911	0.747251	0.581832

Data Table

Week	Inlet	3 Phase	1 Phase
29	4.4	4	4
32	3.4	6	4.8
35	3.9	7.6	3.5
38	4.3	4.7	4.8
41	4.3	5.1	5.5
44	3.5	5	5.2
47	4	4.9	5.6
50	4.2	5.5	6



Average Removal/Gain

	3 Phase	1 Phase
Change	1.35 Gained	0.92 Gained
% Change	33.75% Gain	23.12% Gain

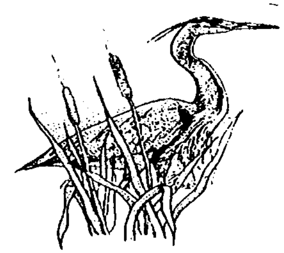
t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	3 Phase	Inlet	1 Phase
Mean	5.35	4.925	4	5.35	4	4.925
Variance	1.162857	0.705	0.142857	1.162857	0.142857	0.705
Observations	8	8	8	8	8	8
Pearson Correlation	-0.369199		-0.42761		0.027009	
Pooled Variance	0.933929		0.652857		0.423929	
Hypothesized Mean Differenc	0		0		0	
df	7		7		7	
t	0.754784		-2.968749		-2.870522	
P(T<=t) one-tail	0.237501		0.010422		0.011987	
t Critical one-tail	1.894579		1.894579		1.894579	
P(T<=t) two-tail	0.475001		0.020845		0.023974	
t Critical two-tail	2.364624		2.364624		2.364624	

Orthophosphate

General Statistics

	Inlet	3 Phase	1 Phase
Mean	3.288	4.304	5.336
Standard Error	0.185051	0.187126	0.50629
Median	3.4	4.2	4.6
Mode	2.5	4	3.9
Standard Deviation	0.925257	0.935628	2.531449
Variance	0.8561	0.8754	6.408233
Kurtosis	-0.24551	1.509879	13.67578
Skewness	0.353274	-0.93323	3.3674
Range	3.5	4	12.9
Minimum	1.7	1.6	3.1
Maximum	5.2	5.6	16
Sum	82.2	107.6	133.4
Count	25	25	25
Confidence Level(0.950000)	0.362694	0.366759	0.99231



Data Table

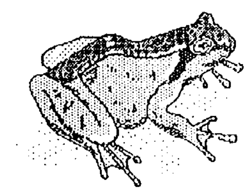
WEEK#	Inlet	3 Phase	1 Phase
29	2.8	2.9	3.9
30	3.9	5.5	6.5
31	3.4	5.4	6.1
32	2.9	5.6	4.4
33	5	4.4	3.8
34	2.6	4.8	16
35	3.8	4.7	3.1
36	3.1	3.1	6.6
37	2.5	3.3	5.8
38	3.9	4.5	4.5
39	2.5	4.2	3.8
40	1.9	4.2	3.9
41	3.4	4.1	4.2
42	4.9	5.2	5
43	5.2	5.2	5.7
44	2.4	3.6	5.2
45	2.1	4.4	4.6
46	3.5	4.1	3.9
47	3.7	4.2	5.4
48	3.2	5.2	8.5
49	3.8	1.6	3.2
50	3.8	5.4	5.6
51	2.5	4	4.5
54	3.7	4	4.2
55	1.7	4	5

Average Removal/Gain

	3 Phase		1 Phase	
Change	1.02	Gained	2.05	Gained
% Change	30.90%	Gain	62.29%	Gain

t-Test: Paired Two-Sample for Means

	3 Phase	1 Phase	Inlet	1 Phase	Inlet	3 Phase
Mean	4.304	5.336	3.288	5.336	3.288	4.304
Variance	0.8754	6.408233	0.8561	6.408233	0.8561	0.8754
Observations	25	25	25	25	25	25
Pearson Correlation	0.274724		-0.12327		0.273440801	
Pooled Variance	3.641817		3.632167		0.86575	
Hypothesized Mean Differen	0		0		0	
df	24		24		24	
t	-2.10968		-3.65673		-4.52909974	
P(T<=t) one-tail	0.022751		0.000624		6.87696E-05	
t Critical one-tail	1.710882		1.710882		1.710882077	
P(T<=t) two-tail	0.045502		0.001248		0.000137539	
t Critical two-tail	2.063899		2.063899		2.063898559	



APPENDIX B

APPENDIX B

NURSERY CELLS
AND
RESEARCH CELLS INVERTEBRATE DATA

APPENDIX B

NURSERY CELLS AND RESEARCH CELLS INVERTEBRATE DATA

Nursery Cells Invertebrate Data

These data are on file with the National Biological Survey in Denver, Colorado.

Research Cells Invertebrate Data

Appended hereafter are the benthic invertebrate data for the research cells.

BENTHIC INVERTEBRATE DATA

Research Cells

Invertebrate data from Research Cells at the EMWD Hemet facility. Coding is as follows: Cell Number; Position (I=Inlet, M=Middle, O=Outlet); Sampling Method (AS=Artifical substrate, SN=Sweep net); Date of collection (Year-month-day); Sample number; Replicate number; Taxonomic identification (Three columns possible); Abundance in sample; Taxon ID Code; Celltype (1P=1-Phase, 3P=3-Phase). Duplicate records indicate a split sample; counts presented in results are the sums of such records for a given sample.

5I	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		215	11P
5I	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		1	41P
5I	AS	19930427	1	1COLEOPTERA	HYDROPHILIDAE		1	51P
5I	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		3	311P
5I	AS	19930427	1	1GASTROPODA			1	501P
5I	AS	19930427	1	1HEMIPTERA	CORIXIDAE		2	601P
5I	AS	19930427	1	1OSTRACODA			158	901P
5I	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		128	11P
5I	AS	19930727	1	1COLEOPTERA	DYTISCIDAE		2	41P
5I	AS	19930727	1	1COLEOPTERA	HYDROPHILIDAE		1	51P
5I	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		25	311P
5I	AS	19930727	1	1GASTROPODA			15	501P
5I	AS	19930727	1	1OSTRACODA			96	901P
5M	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		382	11P
5M	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		9	41P
5M	AS	19930427	1	1COLEOPTERA	HYDROPHILIDAE		1	51P
5M	AS	19930427	1	1COLLEMBOLA			1	151P
5M	AS	19930427	1	1DIPTERA	CERATAPOGONIDAE		1	301P
5M	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		1	311P
5M	AS	19930427	1	1GASTROPODA			50	501P
5M	AS	19930427	1	1HEMIPTERA	CORIXIDAE		1	601P
5M	AS	19930427	1	1OSTRACODA			440	901P
5O	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		89	11P
5O	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		9	41P
5O	AS	19930427	1	1COLEOPTERA	HYDROPHILIDAE		1	51P
5O	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		7	311P
5O	AS	19930427	1	1GASTROPODA			9	501P
5O	AS	19930427	1	1HEMIPTERA	CORIXIDAE		1	601P
5O	AS	19930427	1	1OSTRACODA			78	901P
5O	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		27	11P
5O	AS	19930727	1	1COLEOPTERA	DYTISCIDAE		2	41P
5O	AS	19930727	1	1CRUSTACEA	GAMMARUS		8	221P
5O	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		43	311P
5O	AS	19930727	1	1GASTROPODA			106	501P
5O	AS	19930727	1	1OSTRACODA			50	901P
5O	AS	19931103	1	1ANNELIDA	OLIGOCHAETA		11	11P
5O	AS	19931103	2	1ANNELIDA	OLIGOCHAETA		9	11P
5O	AS	19931103	1	1DIPTERA	CHIRONOMIDAE		2	311P
5O	AS	19931103	2	1DIPTERA	CHIRONOMIDAE		7	311P
5O	AS	19931103	1	1GASTROPODA			3	501P
5O	AS	19931103	1	1OSTRACODA			90	901P
5O	AS	19931103	2	1OSTRACODA			33	901P
6I	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		11	11P
6I	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		7	311P
6I	AS	19930427	1	1GASTROPODA			10	501P
6I	AS	19930427	1	1OSTRACODA			20	901P
6I	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		685	11P
6I	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		266	311P
6I	AS	19930727	1	1DIPTERA	CULICIDAE	CULEX	1	341P

6I	AS	19930727	1	1OSTRACODA			314	901P
6M	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		25	11P
6M	AS	19930427	1	1COLLEMBOLA			1	151P
6M	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		29	311P
6M	AS	19930427	1	1EPHEMENOPTERA	BAETIDAE		1	401P
6M	AS	19930427	1	1GASTROPODA			5	501P
6M	AS	19930427	1	1OSTRACODA			240	901P
60	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		24	11P
60	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		10	311P
60	AS	19930427	1	1GASTROPODA			20	501P
60	AS	19930427	1	1OSTRACODA			217	901P
60	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		415	11P
60	AS	19930727	1	1CRUSTACEA	COPEPODA		2	211P
60	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		27	311P
60	AS	19930727	1	1DIPTERA	CULICIDAE	CULEX	2	341P
60	AS	19930727	1	1GASTROPODA			19	501P
60	AS	19930727	1	1OSTRACODA			200	901P
60	AS	19931103	1	1ANNELIDA	OLIGOCHAETA		31	11P
60	AS	19931103	2	1ANNELIDA	OLIGOCHAETA		10	11P
60	AS	19931103	1	1DIPTERA	CHIRONOMIDAE		9	311P
60	AS	19931103	2	1DIPTERA	CHIRONOMIDAE		3	311P
60	AS	19931103	1	1OSTRACODA			12	901P
60	AS	19931103	2	1OSTRACODA			8	901P
1I	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		58	13P
1I	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		2	43P
1I	AS	19930427	1	1COLEOPTERA	STAPHYLINIDAE		1	63P
1I	AS	19930427	1	1CRUSTACEA	CLADOCERA		1	203P
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1I	AS	19930427	1	1GASTROPODA			15	503P
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1I	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		168	13P
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1M	AS	19930427	1	1CRUSTACEA	CLADOCERA		3	203P
1M	AS	19930427	1	1OSTRACODA			1839	903P
1M	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		5	13P
1M	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		1	313P
1M	AS	19930727	1	1GASTROPODA			16	503P
1M	AS	19930727	1	1OSTRACODA			200	903P
1M	AS	19931103	1	1ANNELIDA	OLIGOCHAETA		6	13P
1M	AS	19931103	2	1ANNELIDA	OLIGOCHAETA		15	13P
1M	AS	19931103	2	1ANNELIDA	HIRUDINEA		1	23P
1M	AS	19931103	1	1ANNELIDA	HIRUDINEA		1	23P
1M	AS	19931103	2	1DIPTERA	CHIRONOMIDAE		39	313P
1M	AS	19931103	1	1DIPTERA	CHIRONOMIDAE		47	313P
1M	AS	19931103	2	1OSTRACODA			55	903P
1M	AS	19931103	1	1OSTRACODA			39	903P
10	AS	19930427	1	1DIPTERA	CULICIDAE		6	3P
10	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		7	43P
10	AS	19930427	1	1CRUSTACEA	CLADOCERA		25	203P
10	AS	19930427	1	1CRUSTACEA	COPEPODA		1	213P
10	AS	19930427	1	1DIPTERA	CERATAPOGONIDAE		3	303P
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10	AS	19930427	1	1GASTROPODA			9	503P
10	AS	19930427	1	1OSTRACODA			168	903P
10	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		447	13P
10	AS	19930727	1	1CRUSTACEA	CLADOCERA		14	203P
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10	AS	19930727	1	1GASTROPODA			322	503P

10	AS	19930727	1	1OSTRACODA			472	903P
2I	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		106	13P
2I	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		1	43P
2I	AS	19930427	1	1CRUSTACEA	CLADOCERA		1	203P
2I	AS	19930427	1	1DIPTERA	CERATAPOGONIDAE		1	303P
2I	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		5	313P
2I	AS	19930427	1	1GASTROPODA			43	503P
2I	AS	19930427	1	1OSTRACODA			47	903P
2I	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		131	13P
2I	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		45	313P
2I	AS	19930727	1	1GASTROPODA			2	503P
2I	AS	19930727	1	1ODONATA	ZYGOPTERA		1	813P
2I	AS	19930727	1	1OSTRACODA			19	903P
2M	AS	19930427	1	1CRUSTACEA	CLADOCERA		1	203P
2M	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		13	313P
2M	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		32	313P
2M	AS	19930427	1	1GASTROPODA			1	503P
2M	AS	19930427	1	1OSTRACODA			40	903P
2M	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		12	13P
2M	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		3	313P
2M	AS	19930727	1	1OSTRACODA			128	903P
2M	AS	19931103	2	1ANNELIDA	OLIGOCHAETA		2	13P
2M	AS	19931103	2	1ANNELIDA	HIRUDINEA		1	23P
2M	AS	19931103	1	1ANNELIDA	HIRUDINEA		3	23P
2M	AS	19931103	2	1DIPTERA	CHIRONOMIDAE		7	313P
2M	AS	19931103	1	1DIPTERA	CHIRONOMIDAE		5	313P
2M	AS	19931103	2	1OSTRACODA			52	903P
2M	AS	19931103	1	1OSTRACODA			74	903P
20	AS	19930427	1	1ANNELIDA	OLIGOCHAETA		52	13P
20	AS	19930427	1	1COLEOPTERA	DYTISCIDAE		14	43P
20	AS	19930427	1	1COLLEMBOLA			2	153P
20	AS	19930427	1	1CRUSTACEA	CLADOCERA		2	203P
20	AS	19930427	1	1CRUSTACEA	COPEPODA		2	213P
20	AS	19930427	1	1DIPTERA	CHIRONOMIDAE		91	313P
20	AS	19930427	1	1GASTROPODA			51	503P
20	AS	19930427	1	1OSTRACODA			134	903P
20	AS	19930727	1	1ANNELIDA	OLIGOCHAETA		497	13P
20	AS	19930727	1	1CRUSTACEA	COPEPODA		43	213P
20	AS	19930727	1	1CRUSTACEA	GAMMARUS		4	223P
20	AS	19930727	1	1DIPTERA	CHIRONOMIDAE		147	313P
20	AS	19930727	1	1DIPTERA	CULICIDAE	CULEX	2	343P
20	AS	19930727	1	1EPHEMEROPTERA	BAETIDAE		1	403P
20	AS	19930727	1	1GASTROPODA			1432	503P
20	AS	19930727	1	1ODONATAA	ZYGOPTERA		14	813P
20	AS	19930727	1	1OSTRACODA			1397	903P
5I	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		78	11P
5I	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		6	311P
5I	SN	19931103	1	1GASTROPODA			1	501P
5I	SN	19931103	1	1HEMIPTERA	CORIXIDAE		1	601P
5I	SN	19931103	1	1OSTRACODA			11	901P
5M	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		43	11P
5M	SN	19931103	1	1CRUSTACEA	CLADOCERA		7	201P
5M	SN	19931103	1	1CRUSTACEA	GAMMARUS		2	221P
5M	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		5	311P
5M	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	1	341P
5M	SN	19931103	1	1GASTROPODA			3	501P
5M	SN	19931103	1	1HEMIPTERA	CORIXIDAE		1	601P
5M	SN	19931103	1	1OSTRACODA			10	901P
50	SN	19930727	1	1	BIVALVE CLAM		129	1P
50	SN	19930727	1	1ANNELIDA	OLIGOCHAETA		6834	11P
50	SN	19930727	1	1CRUSTACEA	CLADOCERA		57	201P
50	SN	19930727	1	1CRUSTACEA	COPEPODA		200	211P

50	SN	19930727	1	1CRUSTACEA	GAMMARUS		5	221P
50	SN	19930727	1	1DIPTERA	CHIRONOMIDAE		148	311P
50	SN	19930727	1	1DIPTERA	CULICIDAE	CULEX	9	341P
50	SN	19930727	1	1EPHEMEROPTERA	BAETIDAE		62	401P
50	SN	19930727	1	1GASTROPODA			75	501P
50	SN	19930727	1	1HEMIPTERA	CORIXIDAE		90	601P
50	SN	19930727	1	1HEMIPTERA	NAUCORIDAE		37	611P
50	SN	19930727	1	1HEMIPTERA	NOTONECTIDAE		9	621P
50	SN	19930727	1	1OSTRACODA			479	901P
6I	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		27	11P
6I	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		9	311P
6I	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	7	341P
6I	SN	19931103	1	1HEMIPTERA	CORIXIDAE		9	601P
6I	SN	19931103	1	1OSTRACODA			3	901P
6I	SN	19931103	1	1OSTRACODA			3	901P
6M	SN	19931103	1	1CRUSTACEA	CLODOCERA		638	1P
6M	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		29	11P
6M	SN	19931103	1	1CRUSTACEA	GAMMARUS		2	221P
6M	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		3	311P
6M	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	6	341P
6M	SN	19931103	1	1DIPTERA	CULICIDAE	ANOPHELES	1	351P
6M	SN	19931103	1	1EPEHEMEROPTERA	BAETIDAE		1	401P
6M	SN	19931103	1	1HEMIPTERA	NAUCORIDAE		1	611P
6M	SN	19931103	1	1LEPIDOPTERA			1	701P
6M	SN	19931103	1	1ODONATA	ANISOPTERA		5	801P
6M	SN	19931103	1	1OSTRACODA			7	901P
6M	SN	19931103	1	1OSTRACODA			7	901P
60	SN	19930727	1	1ANNELIDA	OLIGOCHAETA		1209	11P
60	SN	19930727	1	1COLEOPTERA	DYTISCIDAE		1	41P
60	SN	19930727	1	1CRUSTACEA	COPEPODA		57	211P
60	SN	19930727	1	1DIPTERA	CHIRONOMIDAE		43	311P
60	SN	19930727	1	1EPHEMEROPTERA	BAETIDAE		51	401P
60	SN	19930727	1	1GASTROPODA			84	501P
60	SN	19930727	1	1HEMIPTERA	CORIXIDAE		33	601P
60	SN	19930727	1	1HEMIPTERA	NOTONECTIDAE		4	621P
60	SN	19930727	1	1ODONATAA	ZYGOPTERA		1	811P
60	SN	19930727	1	1OSTRACODA			29	901P
1I	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		85	13P
1I	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		20	313P
1I	SN	19931103	1	1HEMIPTERA	CORIXIDAE		24	603P
1I	SN	19931103	1	1OSTRACODA			1	903P
1M	SN	19930727	1	1ANNELIDA	OLIGOCHAETA		497	13P
1M	SN	19930727	1	1ARACHNOIDEA	HYDRACARINA		9	33P
1M	SN	19930727	1	1CRUSTACEA	CLADOCERA		57	203P
1M	SN	19930727	1	1CRUSTACEA	COPEPODA		1201	213P
1M	SN	19930727	1	1CRUSTACEA	GAMMARUS		11	223P
1M	SN	19930727	1	1DIPTERA	CHIRONOMIDAE		29	313P
1M	SN	19930727	1	1EPHEMEROPTERA	BAETIDAE		4	403P
1M	SN	19930727	1	1GASTROPODA			30	503P
1M	SN	19930727	1	1HEMIPTERA	CORIXIDAE		114	603P
1M	SN	19930727	1	1HEMIPTERA	NAUCORIDAEAE		44	613P
1M	SN	19930727	1	1HEMIPTERA	NOTONECTIDAE		40	623P
1M	SN	19930727	1	1OSTRACODA			172	903P
10	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		324	13P
10	SN	19931103	1	1CRUSTACEA	CLADOCERA		9	203P
10	SN	19931103	1	1CRUSTACEA	COPEPODA		30	213P
10	SN	19931103	1	1CRUSTACEA	GAMMARUS		1	223P
10	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		12	313P
10	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	1	343P
10	SN	19931103	1	1HEMIPTERA	CORIXIDAE		13	603P
10	SN	19931103	1	1ODONATA	ANISOPTERA		4	803P
10	SN	19931103	1	1OSTRACODA			20	903P
2I	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		39	13P
2I	SN	19931103	1	1DIPTERA	CHIRONOMIDAE		5	313P
2I	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	3	343P

2I	SN	19931103	1	1ODONATA	ANISOPTERA		2	803P
2I	SN	19931103	1	1ODONATA	ZYGOPTERA		1	813P
2M	SN	19930727	1	1ANNELIDA	OLIGOCHAETA		99	13P
2M	SN	19930727	1	1ARACHNOIDEA	HYDRACARINA		2	33P
2M	SN	19930727	1	1CRUSTACEA	CLADOCERA		14	203P
2M	SN	19930727	1	1CRUSTACEA	COPEPODA		1101	213P
2M	SN	19930727	1	1CRUSTACEA	GAMMARUS		1	223P
2M	SN	19930727	1	1DIPTERA	CHIRONOMIDAE		11	313P
2M	SN	19930727	1	1GASTROPODA			24	503P
2M	SN	19930727	1	1HEMIPTERA	CORIXIDAE		78	603P
2M	SN	19930727	1	1HEMIPTERA	NAUCORIDAEAE		16	613P
2M	SN	19930727	1	1HEMIPTERA	NOTONECTIDAE		10	623P
2M	SN	19930727	1	1OSTRACODA			201	903P
2O	SN	19931103	1	1ANNELIDA	OLIGOCHAETA		66	13P
2O	SN	19931103	1	1CRUSTACEA	CLADOCERA		540	203P
2O	SN	19931103	1	1CRUSTACEA	COPEPODA		8	213P
2O	SN	19931103	1	1CRUSTACEA	GAMMARUS		1	223P
2O	SN	19931103	1	1DIPTERA	CULICIDAE	CULEX	8	343P
2O	SN	19931103	1	1DIPTERA	CULICIDAE	ANOPHELES	2	353P
2O	SN	19931103	1	1HEMIPTERA	CORIXIDAE		1	603P
2O	SN	19931103	1	1ODONATA	ANISOPTERA		4	803P
2O	SN	19931103	1	1OSTRACODA			21	903P

APPENDIX C

APPENDIX C

SALINE MARSH AND EVAPORATION CELLS DATA

Saline Vegetated Marsh Conductivity Readings

South Marsh Cell										
Date	Station 1	TDS	Station 2	TDS	Station 3	TDS	Station 4	TDS	Avg EC	Avg TDS
07/13/93	6520	4238	7220	4693	7330	4765	7420	4823	7123	4630
07/14/93	6820	4433	6810	4427	7360	4784	7510	4882	7125	4631
07/21/93	7200	4680	7220	4693	8080	5252	8330	5415	7708	5010
07/23/93	3220	2093	2780	1807	2390	1554	3550	2308	2985	1940
07/29/93	5510	3582	5470	3556	6520	4238	6560	4264	6015	3910
08/02/93	6600	4290	6450	4193	6510	4232	6440	4186	6500	4225
08/04/93	6870	4466	6730	4375	7040	4576	7210	4687	6963	4526
08/09/93	7580	4927	8840	5746	8630	5610	9460	6149	8628	5608
08/12/93	7500	4875	7260	4719	9090	5909	9050	5883	8225	5346
08/18/93	6040	3926	6180	4017	6220	4043	6250	4063	6173	4012
09/01/93	7680	4992	7640	4966	9990	6494	10021	6514	8833	5741
01/18/94	5200	3380	6250	4063	6500	4225	6500	4225	6113	3973
01/21/94	5800	3770	6400	4160	6700	4355	6850	4453	6438	4184
01/26/94	5400	3510	5500	3575	5700	3705	5500	3575	5525	3591
02/24/94	2600	1690	2500	1690	2500	1625	2500	1625	2525	1658
03/03/94	2900	1885	2900	1885	3000	1950	2800	1820	2900	1885
03/11/94	3200	2080	3100	2015	3100	2015	3200	2080	3150	2048
03/18/94	4100	2665	4200	2730	4000	2600	4000	2600	4075	2649
03/28/94	2300	1495	2300	1495	2300	1495	2200	1430	2275	1479
04/04/94	2800	1820	3000	1950	2900	1885	2900	1885	2900	1885
04/19/94	2500	1625	2700	1755	2900	1885	2800	1820	2725	1771
04/27/94	750	488	1600	1040	2800	1820	2800	1820	1988	1292
05/06/94	3400	2210	4000	2600	3800	2470	4000	2600	3800	2470

North Marsh Cell										
Date	Station 5	TDS	Station 6	TDS	Station 7	TDS	Station 8	TDS	Avg EC	Avg TDS
07/13/93	6360	4134	6680	4342	6580	4277	6550	4258	6543	4253
07/14/93	6470	4206	6710	4362	6570	4271	6930	4505	6670	4336
07/21/93	6250	4063	6550	4258	7140	4641	7640	4966	6895	4482
07/23/93	2120	1378	2190	1424	3530	2295	4490	2919	3083	2004
07/29/93	5200	3380	5100	3315	5200	3380	5310	3452	5203	3382
08/02/93	5400	3510	5640	3666	5520	3588	5350	3478	5478	3560
08/04/93	5280	3432	5490	3569	5630	3660	5490	3569	5473	3557
08/09/93	6860	4459	7000	4550	7220	4693	7320	4758	7100	4615
08/12/93	6270	4076	8710	5662	7070	4596	7880	5122	7483	4864
08/18/93	4860	3159	4870	3166	4790	3114	4710	3062	4808	3125
09/01/93	5570	3621	7420	4823	7990	5194	6890	4479	6968	4529
01/18/94	3500	2275	3800	2470	3950	2568	4250	2763	3875	2519
01/21/94	4050	2633	4190	2724	4360	2834	4500	2925	4275	2779
02/24/94	1400	910	1350	878	1300	845	1350	878	1350	878
03/03/94	1550	1008	1600	1040	1650	1073	1700	1105	1625	1056
03/11/94	1650	1073	1850	1203	1800	1170	1950	1268	1813	1178
03/18/94	2300	1495	2400	1560	2400	1560	2400	1560	2375	1544
03/28/94	1450	943	1800	1170	1700	1105	1750	1138	1675	1089
04/04/94	1900	1235	2200	1430	2100	1365	2300	1495	2125	1381
04/19/94	950	618	1800	1170	2500	1625	2400	1560	1913	1243
04/27/94	550	358	1050	683	2100	1365	2600	1690	1575	1024
05/06/94	1550	1008	2200	1430	2900	1885	2900	1885	2388	1552

South Evap Cell		North Evap Cell	
Date	Outlet		
02/24/94	4900	02/24/94	5100
03/03/94	4900	03/03/94	5200
03/11/94	5000	03/11/94	5300
03/18/94	5200	03/18/94	5600
03/28/94	4400	03/28/94	4800
04/04/94	4700	04/04/94	500

TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 5/6/94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS	Temperature
Station 1	3,400	2,435	16° C
Station 2	4,000	2,923	15° C
Station 3	3,800	2,759	15° C
Station 4	4000	2,923	16° C
Average	3,800	2,760	15.5

	EC	TDS	Temperature
Evap. Cell #1			
Evap. Cell #2			
R.O. Reject Stream			

Pond #2	Electric Conductivity	TDS	Temperature
Station 5	1,550	1001	16° C
Station 6	2,200	1,490	14° C
Station 7	2,900	2,037	16° C
Station 8	2,900	2,037	14° C
Average	2,388	1,641	15° C

GALLONS OF WATER PER WEEK

Pond #1

Date	# Gallons
5-6-94	2,500

Pond #2

Date	# Gallons
5-6-94	2500

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 4-27-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	750	453
Station 2	1,600	1,037
Station 3	2,800	1,958
Station 4	2,800	1,958
Average	1,988	5,406

Evap. Cell #1	NO water
Evap. Cell #2	NO water
R.O. Reject Stream	NO water

Pond #2	Electric Conductivity	TDS
Station 5	550	326
Station 6	1,050	651
Station 7	2,100	1,413
Station 8	2600	1,801
Average	1,575	1,048

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 4-19-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	2,500	1,723
Station 2	2,700	1,879
Station 3	2,900	2,037
Station 4	2,800	1,958
Average	2,725	1,899

Pond #2	Electric Conductivity	TDS
Station 5	950	584
Station 6	1,800	1,185
Station 7	2,500	1,723
Station 8	2,400	1,645
Average	1,913	1,234

Evap. Cell #1	No water
Evap. Cell #2	No water
R.O. Reject Stream	No water

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TO: LEANNE HAMILTON

FROM: STEPHEN SHOCKEY

DATE: 4-4-94

SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	2,800	1,958
Station 2	3,000	2,116
Station 3	2,900	2,037
Station 4	2,900	2,037
Average	2,900	2,037

Pond #2	Electric Conductivity	TDS
Station 5	1,900	1,260
Station 6	2,200	1,490
Station 7	2,100	1,413
Station 8	2,300	1,567
Average	2,125	1,433

Evap. Cell #1	4,700/3,500
Evap. Cell #2	5,000/3,754
R.O. Reject Stream	NO water

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 3-28-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	2,300	1,567
Station 2	2,300	1,567
Station 3	2,300	1,567
Station 4	2,200	1,490
Average	2,275	1,548

Evap. Cell #1	4,400/3,253
Evap. Cell #2	4,800/3586
R.O. Reject Stream	no water

Pond #2	Electric Conductivity	TDS
Station 5	1,450	929
Station 6	1,800	1,185
Station 7	1,700	1,111
Station 8	1,750	1,148
Average	1,675	1,093

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 3-18-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	4,100	3,005
Station 2	4,200	3,067
Station 3	4,000	2,923
Station 4	4,000	2,923
Average	4,075	2,980

Pond #2	Electric Conductivity	TDS
Station 5	2,300	1,567
Station 6	2,400	1,645
Station 7	2,400	1,645
Station 8	2,400	1,645
Average	2,375	1,626

Evap. Cell #1	5,200/3920
Evap. Cell #2	5600/4,260
R.O. Reject Stream	No water

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 3-11-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	3,200	2,275
Station 2	3,100	2,195
Station 3	3,100	2,195
Station 4	3,200	2,275
Average	3,150	2,235

Evap. Cell #1	5,000/3,754
Evap. Cell #2	5,300/4,010
R.O. Reject Stream	no water

Pond #2	Electric Conductivity	TDS
Station 5	1,650	1,074
Station 6	1,850	1,222
Station 7	1,800	1,185
Station 8	1,950	1,298
Average	1,813	1,195

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TO: LEANNE HAMILTON
FROM: STEPHEN SHOCKEY
DATE: 3-3-94
SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	2,900	2,037
Station 2	2,900	2,037
Station 3	3,000	2,116
Station 4	2,800	1,958
Average	2,900	2,037

Evap. Cell #1	4,900/3,670
Evap. Cell #2	5,200/3,920
R.O. Reject Stream	No water

Pond #2	Electric Conductivity	TDS
Station 5	1,550	1,001
Station 6	1,600	1,037
Station 7	1,650	1,074
Station 8	1,700	1,111
Average	1,625	1,056

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TO: LEANNE HAMILTON

FROM: STEPHEN SHOCKEY

DATE: 2-24-94

SUBJECT: ELECTRIC CONDUCTIVITY & TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Pond #1	Electric Conductivity	TDS
Station 1	2,600	1,801
Station 2	2,500	1,723
Station 3	2,500	1,723
Station 4	2,500	1,723
Average	2,525	1,743

Pond #2	Electric Conductivity	TDS
Station 5	1,400	893
Station 6	1,350	858
Station 7	1,300	823
Station 8	1,350	858
Average	1,350	858

Evap. Cell #1	4,900/3,670
Evap. Cell #2	5,100/3,838
R.O. Reject Stream	no water

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- CERTIFICATE OF ANALYSIS -

To: WATER RESOURCES, WETLANDS
RESOURCE DEVELOPMENT

Attn: STEVE CROMBIE Phone: (909)203-2804 Sample date: 12/02/1993
Acct: 10041516391309 Sample time: 09:30

Lab# : EMWD9309529
Sample ID : SALINE MARSH SUMP OVERFLOW EVAP. POND
Sample Matrix : RECLAIMED

PARAM_NAME	RESULTS	UNITS
TOTAL DISSOLVED SOLIDS	5860	mg/L
CONDUCTIVITY	7990	umhos/cm

Approved By

- CERTIFICATE OF ANALYSIS -

To: WATER RESOURCES, WETLANDS
RESOURCE DEVELOPMENT

Attn: STEVE CROMBIE   Phone: (909)203-2804   Sample date: 12/02/1993
Acct: 10041516391309   Sample time: 09:30

Lab# : EMWD9309527
Sample ID : SALINE MARSH CELL 1, INLET
Sample Matrix : RECLAIMED

PARAM_NAME	RESULTS	UNITS
TOTAL DISSOLVED SOLIDS	3055	mg/L
CONDUCTIVITY	4800	umhos/cm

Approved By

- CERTIFICATE OF ANALYSIS -

To: WATER RESOURCES, WETLANDS
RESOURCE DEVELOPMENT

Attn: STEVE CROMBIE
Acct: 10041516391309

Phone: (909)203-2804

Sample date: 12/02/1993
Sample time: 09:30

Lab# : EMWD9309525
Sample ID : SALINE MARSH CELL 1, STATION 2
Sample Matrix : RECLAIMED

PARAM_NAME	RESULTS	UNITS
TOTAL DISSOLVED SOLIDS	3605	mg/L
CONDUCTIVITY	5390	umhos/cm

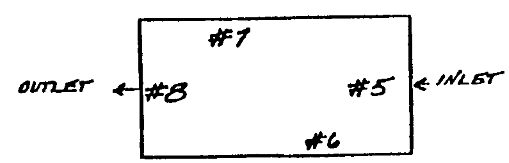
Approved By

TO: RAVI, MIKE GARNER, BEHROOZ M[illegible]AZAVI &
CHRISTIE CROTHER, LEANNE HAM[illegible]ON & JOAN THULLEN
FROM: STEPHEN SHOCKEY
DATE: SEPTEMBER 1, 1993 11:10
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

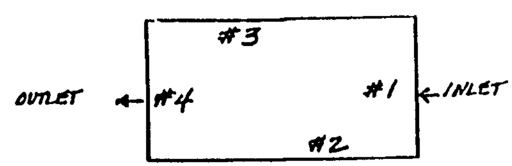
Cell #1	Electric Conductivity	TDS	Temperature	Water Added
Station 1	7,680	4,915	29	
Station 2	7,640	4,885	27	No Water Added
Station 3	9,990	6,363	26	
Station 4	10,021	6,413	24	
Average	8,832.75	5644	26.5	

Cell #2	Electric Conductivity	TDS	Temperature	Water Added
Station 5	5,570	3,564	30	
Station 6	7,420	4,748	31	No Water Added
Station 7	7,990	5,113	25	
Station 8	6,890	4,409	23	
Average	6967.5	4458.5	27.25	

NORTH CELL



SOUTH CELL

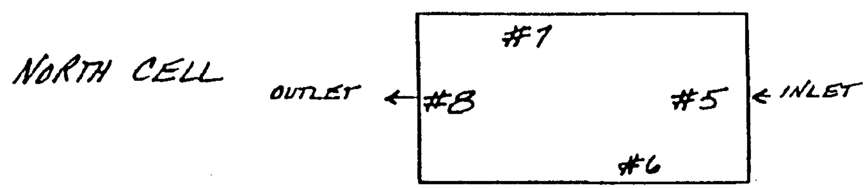


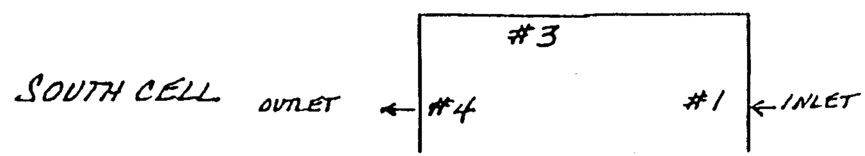
Q-Pro\EC&TDS\SS.ag 7.14.93

TO: RAVI, MIKE GARNER, BEHROOZ MORTAZAVI
CHRISTIE CROTHER, LEANNE HAMILTON & JOAN THULLEN
FROM: STEPHEN SHOCKEY
DATE: AUGUST 18, 1993 8:00 a.m.
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature	Water Added
Station 1	6,040	3,865	19	
Station 2	6,180	3,955	19	5,000 Gallons
Station 3	6,220	3,980	20	
Station 4	6,250	4,000	20	
Average	6,172.50	3950	19.5	

Cell #2	Electric Conductivity	TDS	Temperature	Water Added
Station 5	4,860	3,110	19	
Station 6	4,870	3,116	19	5,00 Gallons
Station 7	4,790	3,065	19.5	
Station 8	4,710	3,014	19.5	
Average	4807.5	3076.25	19.25	





Q-Pro\EC&TDS\SS.ag 7.14.93

TO: [illegible]
CHRISTIE CROTHER, LEANNE HAMILTON AN THULLEN
FROM: STEPHEN SHOCKEY
DATE: AUGUST 12, 1993 15:00
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

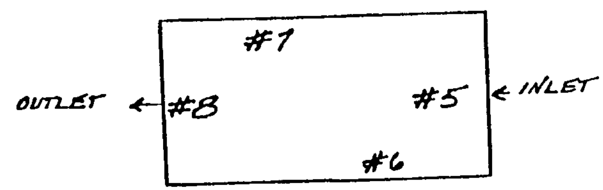
Cell #1	Electric Conductivity	TDS	Temperature
Station 1	7,500	4,800	32
Station 2	7,260	4,646	30
Station 3	9,090	5,817	29
Station 4	9,050	5,817	29
Average	8,225.00	5270	30

NO WATER ADDED

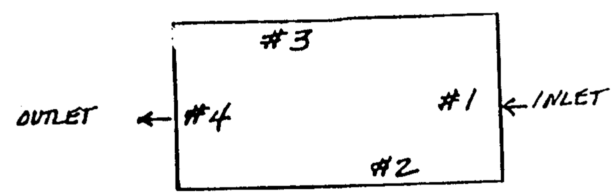
Cell #2	Electric Conductivity	TDS	Temperature
Station 5	6,270	4,012	35
Station 6	8,710	5,574	34
Station 7	7,070	4,574	28
Station 8	7,880	5,043	30
Average	7482.5	4800.75	31.75

NO WATER ADDED

NORTH CELL



SOUTH CELL



Q-Pro\EC&TDS\SS.ag 7.14.93

TO: RAVI, MIKE GARNER, BEHROOZ MORTAZAVI &
CHRISTIE CROTHER, LEANNE HAMILTON & JOAN THULLEN
FROM: STEPHEN SHOCKEY
DATE: AUGUST 9, 1993 8:54 a.m.
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

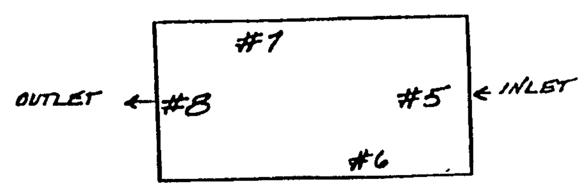
Cell #1	Electric Conductivity	TDS	Temperature
Station 1	7,580	4,851	20.2
Station 2	8,840	5,657	19.9
Station 3	8,630	5,523	20.1
Station 4	9,460	6,054	20.3
Average	8,627.50	5521.25	20.125

NO WATER ADDED

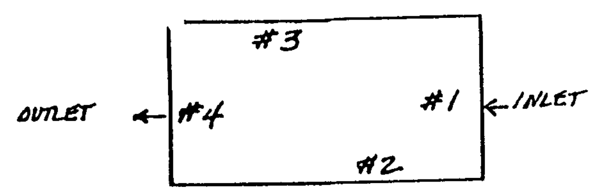
Cell #2	Electric Conductivity	TDS	Temperature
Station 5	6,860	4,390	20
Station 6	7,000	4,480	21
Station 7	7,220	4,620	20.2
Station 8	7,320	4,684	20.2
Average	7100	4543.5	20.35

NO WATER ADDED

NORTH CELL



SOUTH CELL



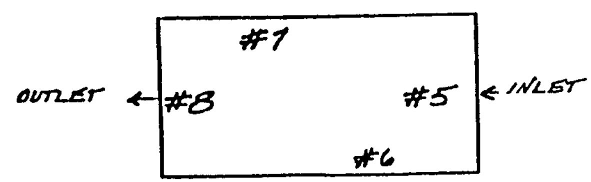
Q-Pro\EC&TDS\SS.ag 7.14.93

TO: RAVI, MIKE GARNER, BEHROOZ MO[illegible]ZAVI & CHRISTIE CROTHER, LEANNE HAMILTON & JOAN THULLEN
FROM: STEPHEN SHOCKEY
DATE: AUGUST 4, 1993 13:23
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

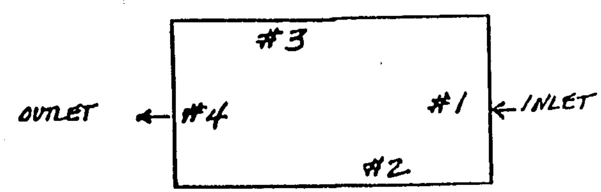
Cell #1	Electric Conductivity	TDS	Temperature	
Station 1	6,870	4,396	33.4	
Station 2	6,730	4,307	31.8	NO WATER ADDED
Station 3	7,040	4,505	30.7	
Station 4	7,210	4,614	30.2	
Average	6,962.50	4455.5	31.52	

Cell #2	Electric Conductivity	TDS	Temperature	
Station 5	5,280	3,379	35.3	
Station 6	5,490	3,513	33.9	NO WATER ADDED
Station 7	5,630	3,603	28.3	
Station 8	5,490	3,513	30.1	
Average	5472.5	3502	31.90	

NORTH CELL



SOUTH CELL



Q-Pro\EC&TDS\SS.ag 7.14.93

TO: RAVI, MIKE GARNER, BEHROOZ MC ZAVI &
CHRISTIE CROTHER, LEANNE HAMILTON & JOAN THULLEN

FROM: STEPHEN SHOCKEY

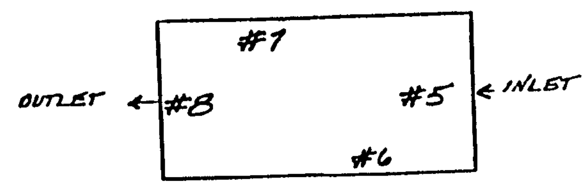
DATE: AUGUST 2, 1993 9:00 a.m.

SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

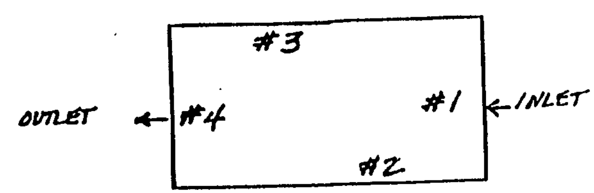
Cell #1	Electric Conductivity	TDS	Temperature	
Station 1	6,600	4,224	24.2	
Station 2	6,450	4,128	22.6	NO WATER ADDED
Station 3	6,510	4,166	22.8	
Station 4	6,440	4,121	22.4	

Cell #2	Electric Conductivity	TDS	Temperature	
Station 5	5,400	3,456	25.5	
Station 6	5,640	3,609	24.9	NO WATER ADDED
Station 7	5,520	3,532	22.7	
Station 8	5,350	3,424	22.4	

NORTH CELL



SOUTH CELL



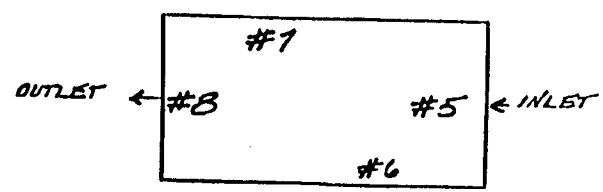
Q-Pro\EC&TDS.ag 7.14.93

CHRISTIE CROTHER, LEANNE HAMI[illegible]N & JOAN THULLEN
FROM: STEPHEN SHOCKEY
DATE: JULY 29,1993 14:00
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature	
Station 1	5,510	3,526	30.2	
Station 2	5,470	3,500	31.3	NO WATER ADDED
Station 3	6,520	4,172	28.7	
Station 4	6,560	4,198	22.7	

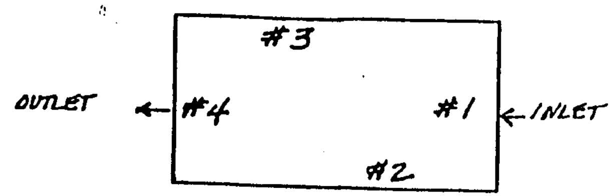
Cell #2	Electric Conductivity	TDS	Temperature	
Station 5	5,200	3,328	32.1	
Station 6	5,100	3,264	30.7	NO WATER ADDED
Station 7	5,200	3,328	25.3	
Station 8	5,310	3,398	25.4	

NORTH CELL



Q-Pro\EC&TDS.ag 7.14.93

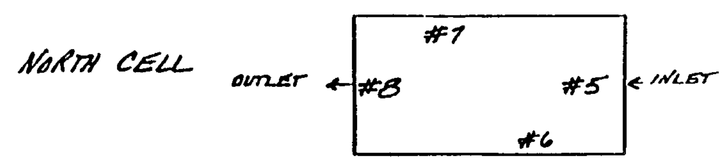
SOUTH CELL

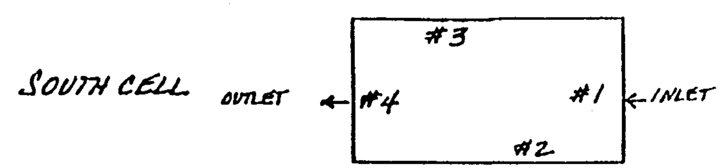


TO: RAVI, MIKE GARNER, BEHROOZ MORTAZAVI & CHRISTIE CROTHER
FROM: STEPHEN SHOCKEY
DATE: JULY 23, 1993 15:00
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature	
Station 1	3,220	2,060	24.1	
Station 2	2,780	1,779	23.8	5,000 Gallons
Station 3	2,390	1,529	24.6	
Station 4	3,550	2,272	22.7	

Cell #2	Electric Conductivity	TDS	Temperature	
Station 5	2,120	1,356	23.6	
Station 6	2,190	1,401	24.1	5,000 Gallons
Station 7	3,530	2,259	22.8	
Station 8	4,490	2,873	23.4	



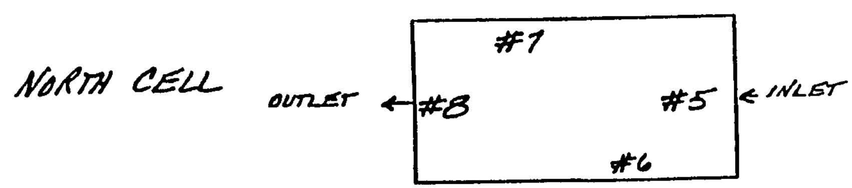


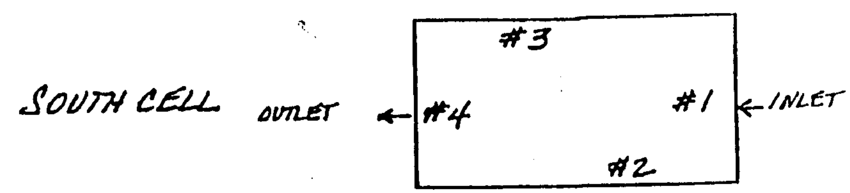
Q-Pro\EC&TDS.ag 7.14.93

TO: RAVI, MIKE GARNER, BEHROOZ MORTAZAVI & CHRISTIE CROTHER
FROM: STEPHEN SHOCKEY
DATE: JULY 21, 1993 9:00 a.m.
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature
Station 1	7,200	4,608	20.7
Station 2	7,220	4,620	19.7
Station 3	8,080	5,171	20.9
Station 4	8,330	5,331	21.4

Cell #2	Electric Conductivity	TDS	Temperature
Station 5	6,250	4,000	19.9
Station 6	6,550	4,192	20.5
Station 7	7,140	4,569	20.7
Station 8	7,640	4,889	20.1



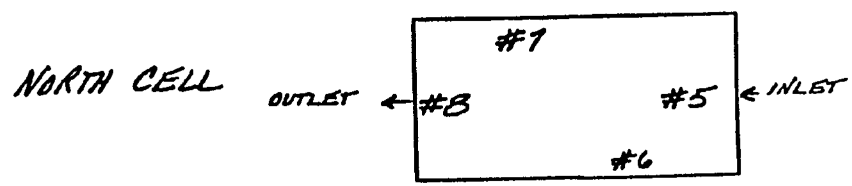


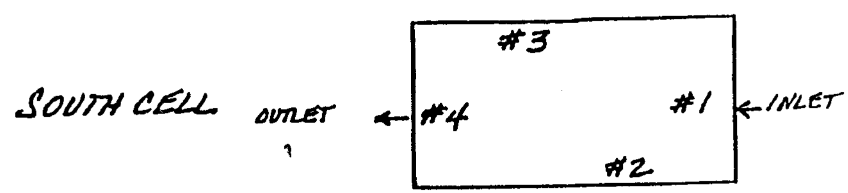
Q-Pro\EC&TDS.ag 7.14.93

TO; MIKE GARNER
FROM: STEPHEN SHOCKEY
DATE: JULY 14, 1993 14:41
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature
Station 1	6820	4364	24.4
Station 2	6810	4358	24
Station 3	7360	4710	23.8
Station 4	7510	4806	23.2

Cell #2	Electric Conductivity	TDS	Temperature
Station 5	6470	4140	28
Station 6	6710	4294	26.1
Station 7	6570	4204	23.4
Station 8	6930	4435	22.3





cc: B. Mortazavi
C. Crother
Q-Pro\EC&TDS ag 7.13.93

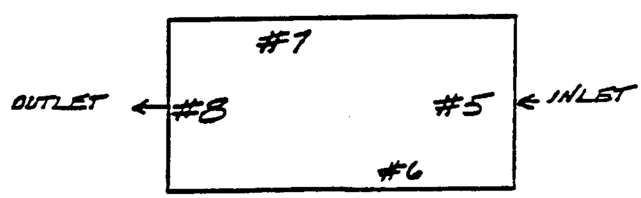
TO; MIKE GARNER
FROM: STEPHEN SHOCKEY
DATE: JULY 13, 1993 10:30 a.m.
SUBJECT: ELECTRIC CONDUCTIVITY AND TOTAL DISSOLVED SOLIDS IN THE SALINE VEGETATED MARSHES

Cell #1	Electric Conductivity	TDS	Temperature
Station 1	6520	4172	21.1 c
Station 2	7220	4620	20.6
Station 3	7330	4691	21.3
Station 4	7420	4748	21

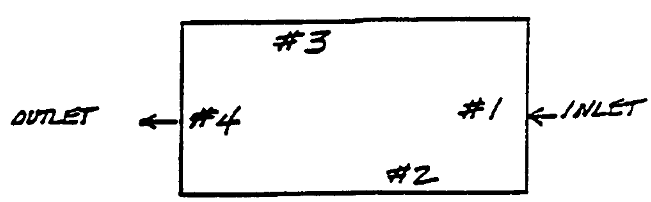
Cell #2	Electric Conductivity	TDS	Temperature
Station 5	6360	4070	20.5
Station 6	6680	4275	20.8
Station 7	6580	4211	21.2
Station 8	6550	4192	21.2

cc: B. Mortazavi
C. Crother
Q-Pro\EC&TDS.ag.7.13.93

NORTH CELL



SOUTH CELL



Additional Data for the Saline Vegetated Marshes

from U.S.B.R. field notebook

7-28-93

Cell	Location	Time	Condition	Temp. °C	DO mg/L	DO % sat.	pH	EC µS/cm
North	inlet area	11:23	open/algae	22.8	7.8	91	8.5	5210
	outlet area	11:36	plants	21.9	5.2	60	8.4	5250
South	inlet area	11:26	open/algae	23.4	14.1	168	8.9	6380
	outlet area	11:33	plants	22.0	5.2	60	8.9	6610

11-3-93

Cell	Location	Time	Condition	Temp. °C	DO mg/L	DO % sat.	pH	EC µS/cm
North	inlet area	14:40	open/silty	20.1	9.3	104	8.6	2070*
	outlet area	14:35	plant/algae	16.3	10.9	114	8.8	5510
South	inlet area	14:25	open	19.9	12.1	139	8.6	6200
	outlet area	14:30	plant/algae	14.6	9.3	96	9.1	7160

*Note: the North cell inlet area received 9.4 m^3 (2500 gal) potable water just prior to measurement.

from EMWD data sheets

Date	Cell	Location	Time	EC µS/cm	TDS mg/L
12-2-93	South	inlet	9:30	4800	3055
		station 2	9:30	5390	3605
		station 3	9:30	5990	3950
		outlet	9:30	6190	3320
	Sump overflow Evap. pond		9:30	7990	5860

ASSOCIATED LABORATORIES
806 North Batavia - Orange, California 92668 - 714/771-6900 FAX 714/538-1209

CLIENT
Eastern Municipal Water Dist. (2027)
Attn: Mike Creighton
P.O.Box 8300
San Jacinto, CA 92581-8300

LAB NO. G58472-03
REPORTED 08/27/93

SAMPLE Wastewater
Wetlands, R.O. Reject
RECEIVED 08/17/93
IDENTIFICATION Lab #93081305 Acct. #10045643491309 P.O. #92-08534
Date Collected 08/13/93
BASED ON SAMPLE As Submitted

Constiteunt	Method	Results	
Antimony	EPA 200.7	ND<0.04	mg/l
Arsenic	EPA 206.2	0.006	mg/l
Barium	EPA 200.7	0.22	mg/l
Beryllium	EPA 200.7	ND<0.002	mg/l
Cadmium	EPA 200.7	ND<0.003	mg/l
Chromium	EPA 200.7	ND<0.004	mg/l
Cobalt	EPA 200.7	ND<0.01	mg/l
Copper	EPA 200.7	0.01	mg/l
Lead	EPA 239.2	ND<0.002	mg/l
Mercury	EPA 245.1	ND<0.0004	mg/l
Molybdenum	EPA 200.7	0.15	mg/l
Nickel	EPA 200.7	ND<0.03	mg/l
Selenium	EPA 270.2	0.007	mg/l
Silver	EPA 200.7	ND<0.004	mg/l
Thallium	EPA 279.2	ND<0.002	mg/l
Vanadium	EPA 200.7	0.02	mg/l
Zinc	EPA 200.7	0.05	mg/l

Cont'd on next page

TESTING & CONSULTING
Chemical •
Microbiological •
Environmental •

Client: Eastern Municipal Water Dist.
Lab No: G58472-03

Constiteunt	Method	Results	
Iron	EPA 200.7	0.03	mg/l
Soluble Iron	EPA 200.7	0.03	mg/l
Manganese	EPA 200.7	0.05	mg/l
Silicon (Si)	SM16/425C	40.1	mg/l
Soluble Silicon (Si)	SM16/425C	38.9	mg/l
Aluminum	EPA 200.7	ND<0.04	mg/l
Boron	EPA 200.7	0.66	mg/l
Total Organic Carbon	EPA 415.1	3.9	mg/l

ASSOCIATED LABORATORIES, by:

Robert A. Webber
Vice President

RAW/gk

Rev. 09/20/93 RAW/gk

NOTE: Unless notified in writing, all samples will be discarded by appropriate disposal protocol 30 days from date reported.

EASTERN MUNICIPAL WATER DISTRICT
Contracted Laboratory Analysis Request Form

Edward S. Babcock & Sons
P.O. Box 432
Riverside, Ca 92502
(909)653-3351

DATE SAMPLED: Apr 28, 1993
DATE SENT: Jan 25, 1994
REQUESTED BY: LeAnne Hamilton
APPROVED BY: Ken Marshall

Purchase Order #93-12583

ANALYSIS REQUESTED:

Beryllium Chromium Cobalt Nickel Copper Zinc Arsenic Selenium Silver Cadmium Antimony Barium Mercury Thallium Lead Iron Manganese Molybdenum, Aluminum

Calcium as $CaCO_3$, Boron, Cyanide, %Solids,

Cation Exchange Capacity, Particle Size (down to 2 μm)

EPA Method 608 (specifically Lindane, DDT, and PCBs)

SOURCE	RELEASE/LAB#	ACCOUNT #
1. Saline Marsh Soil, South Inlet	940124043	10041516391309
2. Saline Marsh Soil, South Middle	940124044	"
3. Saline Marsh Soil, South Outlet	940124045	"
4. Saline Marsh Soil, North Inlet	940124046	"
5. Saline Marsh Soil, North Middle	940124047	"
6. Saline Marsh Soil, North Outlet	940124048	"

REMARKS: LOWEST POSSIBLE DETECTION LIMITS NEEDED. DIGEST WITH A MINIMUM OF 10 GRAMS OR ANALYZE BY ICP/MS.

Note: Please refer to the PO, EMWD lab, and account numbers on the billing invoice and analytical report.

Carrier Release Reling'd By: [signature] Time: 1340 **Chain of Custody Attached?** YES ☐ NO ☐ Date: 1-25-94 Rec'd By: [signature]

P.O. Box 8300, San Jacinto, California 92383-1300,
(714)925-7676, Fax (714)929-0257

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

RECEIVED
FEB 23 1994
E.M.W.D.

Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)

	South Inlet 940127-1978	Blank Detect. Limit
Aluminum	19200	0.4
Antimony	ND<0.3	0.3
Arsenic	ND<0.7	0.7
Barium	273	0.05
Beryllium	ND<0.4	0.4
Cadmium	0.09	0.03
Chromium	15.2	0.6
Cobalt	7.43	0.04
Copper	18.3	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	1.2	0.1
Nickel	7.4	0.3
Selenium	ND<2	2
Silver	0.85	0.02
Thallium	ND<0.5	0.5
Zinc	92.9	0.2

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

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Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)

	South Middle 940127-1979	Blank Detect. Limit
Aluminum	20300	0.4
Antimony	ND<0.3	0.3
Arsenic	ND<0.4	0.4
Barium	245	0.05
Beryllium	0.7	0.4
Cadmium	0.06	0.03
Chromium	13.4	0.6
Cobalt	7.04	0.04
Copper	12.2	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	1.2	0.1
Nickel	6.8	0.3
Selenium	ND<2	2
Silver	0.16	0.02
Thallium	ND<0.5	0.5
Zinc	79.2	0.2

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)

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	South Outlet 940127-1980	Blank Detect. Limit
Aluminum	21400	0.4
Antimony	ND<0.3	0.3
Arsenic	ND<0.6	0.6
Barium	279	0.05
Beryllium	0.7	0.4
Cadmium	0.16	0.03
Chromium	14.6	0.6
Cobalt	7.76	0.04
Copper	13.1	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	1.5	0.1
Nickel	8.9	0.3
Selenium	ND<2	2
Silver	ND<0.02	0.02
Thallium	ND<0.5	0.5
Zinc	76.8	0.2

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

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Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)

	North Inlet 940127-1981	Blank Detect. Limit
Aluminum	20300	0.4
Antimony	ND<0.3	0.3
Arsenic	ND<0.4	0.4
Barium	274	0.05
Beryllium	ND<0.4	0.4
Cadmium	0.16	0.03
Chromium	15.4	0.6
Cobalt	7.14	0.04
Copper	23	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	1.1	0.1
Nickel	8.1	0.4
Selenium	ND<2	2
Silver	1.09	0.02
Thallium	ND<0.5	0.5
Zinc	109	0.2

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

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Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)
Wet Weight

	North Middle 940127-1982	Blank Detect. Limit
Aluminum	17200	0.4
Antimony	ND<0.3	0.3
Arsenic	0.9	0.4
Barium	212	0.05
Beryllium	0.5	0.4
Cadmium	0.23	0.03
Chromium	12.2	0.6
Cobalt	6.1	0.04
Copper	15.4	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	1.5	0.1
Nickel	6.2	0.2
Selenium	ND<2	2
Silver	0.49	0.02
Thallium	ND<0.5	0.5
Zinc	76.4	0.2
Percent Solids	80.6	

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

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Selected Metals
Quantitative Analysis Report
Inductively Coupled Plasma-Mass Spectrometry
Parts Per Million (mg/Kg)
Wet Weight

	North Outlet 940127-1983	Blank Detect. Limit
Aluminum	16000	0.4
Antimony	ND<0.3	0.3
Arsenic	ND<0.4	0.4
Barium	198	0.05
Beryllium	1.3	0.4
Cadmium	0.13	0.03
Chromium	11.2	0.6
Cobalt	6.24	0.04
Copper	15.3	0.05
Lead	ND<5	5
Mercury	ND<0.4	0.4
Molybdenum	0.8	0.1
Nickel	6.1	0.3
Selenium	ND<2	2
Silver	0.44	0.02
Thallium	ND<0.5	0.5
Zinc	76	0.2
Percent Solids	78.9	

Date Analyzed: 2/10/94

WEST COAST ANALYTICAL SERVICE, INC.

EDWARD S. BABCOCK & SONS, INC.
Ms. Janet Harrison

Job # 25718
February 15, 1994

LABORATORY REPORT

Sample: 940127-1981 North Inlet
Matrix: Soil

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Parts Per Million (mg/Kg)

	Sample	Spike Conc ppm	MS	% Recovery	MSD	% Recovery	% RPD
Aluminum	20300	20	18100		18100		0.0
Antimony	ND<0.3	20	18.5	92.5	17.7	88.5	4.4
Arsenic	ND<0.4	20	22	110	29.2	146*	28.1*
Barium	274	20	266		281		5.5
Beryllium	ND<0.4	20	20.8	104	22.2	111	6.5
Cadmium	0.16	20	19	94.2	18.1	89.7	4.9
Chromium	15.4	20	33.1	88.5	35.7	101.5	7.6
Cobalt	7.14	20	26.6	97.3	27	99.3	1.5
Copper	23	20	38		48.5		24.3
Lead	ND<5	20	24	120	27	135	11.8
Mercury	ND<0.4	2	2	100	1.6	80	22.2
Molybdenum	1.1	20	18.1	85	17.5	82	3.4
Nickel	8.1	20	26.1	90	26.3	91	0.8
Selenium	ND<2	200	194	97	207	103.5	6.5
Silver	1.09	20	19.6	92.6	20.4	96.6	4
Thallium	ND<0.5	20	15.4	77	15.4	77	0
Zinc	109	20	110		135		20.4

Date Analyzed: 02/10/94

* Outside warning limits

Abbreviations Summary

General Reporting Abbreviations:

B — Blank - Indicates that the compound was found in both the sample and the blank. The sample value is reported without blank subtraction. If the sample value is less than 10X the blank value times the sample dilution factor, the compound may be present as a laboratory contaminant.

D — Indicates that the sample was diluted, and consequently the surrogates were too dilute to accurately measure.

DL — Detection Limit - Is the minimum value which we believe can be detected in the sample with a high degree of confidence, taking into account dilution factors and interferences. The reported detection limits are equal to or greater than Method Detection Limits (MDL) to allow for day to day and instrument to instrument variations in sensitivity.

J — Indicates that the value is an estimate.

ND — Not Detected - Indicates that the compound was not found in the sample at or above the detection limit.

ppm / ppb — parts per million (billion) in liquids is usually equivalent to mg/l (ug/l), or in solids to mg/kg (ug/kg). In the gas phase it is equivalent to ul/l (ul/m^3).

TR — Trace - Indicates that the compound was observed at a value less than our normal reported Detection Limit (DL), but we feel its presence may be important to you. These values are subject to large errors and low degrees of confidence.

kg kilogram	mg milligram	l liter	m meter
g gram	ug microgram	ul microliter	

QC Abbreviations:

Control — Control Limits are determined from historical data for a QC parameter. The test value must be within this acceptable range for the test to be considered in control. Usually this range corresponds to the 99% confidence interval for the historical data.

% Error — Percent Error - This is a measure of accuracy based on the analysis of a Laboratory Control Standard (LCS). An LCS is a reference sample of known value such as an NIST Standard Reference Material (SRM). The % Error is expressed in percent as the difference between the known value and the experimental value, divided by the known value. The LCS may simply be a solution based standard which confirms calibration (ICV or CCV - initial or continuing calibration verification), or it may be a reference sample taken through preparation and analysis.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK
& SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

RECEIVED
FEB 23 1994
E.M.W.D.

]From: Edward S. Babcock & Sons, Inc.
6100 Quail Valley Ct.
Riverside, CA 92507

To: West Coast Analytical
9840 Alburtis Avenue
Santa Fe Springs, CA 90670

Date Shipped: 02-03-94
 # Containers Shipped: 6
Shipped Via: UPS

Please Reference the Following on Laboratory Report

Babcock Lab #	Sample I.D.	CT	Matrix	Sampled Date	Sampled Time	By	Analysis Requested
Eastern Municipal Water District							
Saline Marsh Soil:							
✓940127-1978	South Inlet	1	soil	4/28/93	---	--	*See Below ON ALL SAMPLES
✓940127-1979	South Middle	1	soil	4/28/93	---	--	
✓940127-1980	South Outlet	1	soil	4/28/93	---	--	
✓940127-1981	North Inlet	1	soil	4/28/93	---	--	
✓940127-1982	North Middle	1	soil	4/28/93	---	--	
✓940127-1983	North Outlet	1	soil	4/28/93	---	--	

*Lowest Possible Detection Limits (ICP/MS)
Be, Cr, Co, Ni, Cu, Zn, As, Se, Ag, Cd, Sb, Ba,
Hg, Tl, Pb, Mo, and Al

CDHS Drinking Water Report Forms Required: No

CT	Container Type	Preservative	Special Comments
6	glass	None	**Please report each sample on a separate sheet.**

Sample Received By: Mary Malachy #25718

Date Sample Received: 2-4-94

Time Sample Received: 11:42 A.M.

(Janet) 1-~~805~~-948-2725
310

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

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P.O. BOX 432
RIVERSIDE, CA 92502

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2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1984
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
South Inlet
EMWD #940124043

Parameter	**Result**
Iron (Fe)	23000 ppm
Manganese (Mn)	400 ppm
Calcium as $CaCO_3$	2.65 %
Boron (B)	6.4 ppm
Cyanide (CN)	<0.8 ppm
% Solids	93.4 %
Cation Exchange Capacity	3.75 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	2.2 %
35	Coarse sand	0.5 mm	4.8 %
60	Medium sand	0.25 mm	16 %
140	Fine sand	0.10 mm	13 %
300	Very fine sand	0.05 mm	21 %
(hydrometer)	Silt	0.002 mm	30 %
(hydrometer)	Clay	<0.002 mm	13 %

Date Analysis Completed: 02/23/94

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

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FAX 909/653-1662

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RIVERSIDE, CA 92502

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E.M.W.D.

2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1985
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
South Middle
EMWD #940124044

Parameter	Result
Iron (Fe)	22000 ppm
Manganese (Mn)	390 ppm
Calcium as $CaCO_3$	2.35 %
Boron (B)	5.9 ppm
Cyanide (CN)	<0.8 ppm
% Solids	90.6 %
Cation Exchange Capacity	3.75 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	2.7 %
35	Coarse sand	0.5 mm	5.8 %
60	Medium sand	0.25 mm	15 %
140	Fine sand	0.10 mm	14 %
300	Very fine sand	0.05 mm	14 %
(hydrometer)	Silt	0.002 mm	27 %
(hydrometer)	Clay	<0.002 mm	17 %

Date Analysis Completed: 02/23/94

Edward S. Babcock & Sons, Inc.

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WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

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2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1986
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
South Outlet
EMWD #940124045

Parameter	Result
Iron (Fe)	26000 ppm
Manganese (Mn)	430 ppm
Calcium as $CaCO_3$	2.63 %
Boron (B)	7.3 ppm
Cyanide (CN)	<0.8 ppm
% Solids	95.0 %
Cation Exchange Capacity	1.25 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	2.6 %
35	Coarse sand	0.5 mm	5.6 %
60	Medium sand	0.25 mm	14 %
140	Fine sand	0.10 mm	13 %
300	Very fine sand	0.05 mm	19 %
(hydrometer)	Silt	0.002 mm	28 %
(hydrometer)	Clay	<0.002 mm	18 %

Date Analysis Completed: 02/24/94

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
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CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

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2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1987
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
North Inlet
EMWD #940124046

Parameter	Result
Iron (Fe)	23000 ppm
Manganese (Mn)	390 ppm
Calcium as $CaCO_3$	2.58 %
Boron (B)	5.7 ppm
Cyanide (CN)	<0.8 ppm
% Solids	93.0 %
Cation Exchange Capacity	3.75 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	2.5 %
35	Coarse sand	0.5 mm	4.5 %
60	Medium sand	0.25 mm	15 %
140	Fine sand	0.10 mm	15 %
300	Very fine sand	0.05 mm	26 %
(hydrometer)	Silt	0.002 mm	30 %
(hydrometer)	Clay	<0.002 mm	14 %

Date Analysis Completed: 02/24/94

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
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HAZARDOUS WASTE TESTING
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LABORATORIES
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2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1988
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
North Middle
EMWD #940124047

Parameter	Result
Iron (Fe)	23000 ppm
Manganese (Mn)	400 ppm
Calcium as $CaCO_3$	2.65 %
Boron (B)	4.4 ppm
Cyanide (CN)	<0.08 ppm
% Solids	78.8 %
Cation Exchange Capacity	2.50 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	1.2 %
35	Coarse sand	0.5 mm	4.6 %
60	Medium sand	0.25 mm	15 %
140	Fine sand	0.10 mm	13 %
300	Very fine sand	0.05 mm	24 %
(hydrometer)	Silt	0.002 mm	28 %
(hydrometer)	Clay	<0.002 mm	19 %

Date Analysis Completed: 02/25/94

Edward S. Babcock & Sons, Inc.

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WATER TESTING
HAZARDOUS WASTE TESTING
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6100 QUAIL VALLEY COURT, RIVERSIDE

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2 March, 1994

To:
Eastern Municipal Water District
ATTN: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92351-8300

Lab No. 940127-1989
Invoice No. 99907

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	13:33	

Chain of Custody on File: No

Sample Marked: Saline Marsh Soil
North Outlet
EMWD #940124048

Parameter	Result
Iron (Fe)	22000 ppm
Manganese (Mn)	390 ppm
Calcium as $CaCO_3$	2.70 %
Boron (B)	4.8 ppm
Cyanide (CN)	<0.08 ppm
% Solids	78.1 %
Cation Exchange Capacity	1.25 me/100g

SIEVE ANALYSIS

Sieve Size	Soil Particle Size	Particle Size Diameter	Fraction Retained
18	Very coarse sand	>1.0 mm	1.8 %
35	Coarse sand	0.5 mm	1.0 %
60	Medium sand	0.25 mm	14 %
140	Fine sand	0.10 mm	15 %
300	Very fine sand	0.05 mm	16 %
(hydrometer)	Silt	0.002 mm	26 %
(hydrometer)	Clay	<0.002 mm	19 %

Date Analysis Completed: 02/25/94

Edward S. Babcock & Sons, Inc.

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HAZARDOUS WASTE TESTING
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02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No.	940127-1990
Invoice No.	99908
Customer No.	ea0103

Sample Marked: Saline Marsh Soil South
Inlet EMWD#940124043
Acct#10041516391309

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(μg/kg)	Parameter	Results(μg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
y-BHC	ND	PCB-1248	ND
Chlordane	12**	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * μg/kg
Date analysis completed: 02/04/94

NI=Not identifiable
NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 μg/kg **Second column confirmation utilized.

cc: Sample submitted past holding time.

Edward S. Babcock & Sons, Inc.

[signature]

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

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FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

RECEIVED
MAR 03 1994
E.M.W.D.

02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No. 940127-1991
Invoice No. 99908
Customer No. ea0103

Sample Marked: Saline Marsh Soil South
Middle EMWD#940124044
Acct#10041516391309

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(µg/kg)	Parameter	Results(µg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
y-BHC	ND	PCB-1248	ND
Chlordane	ND	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * µg/kg NI=Not identifiable
Date analysis completed: 02/04/94 NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 µg/kg Sample submitted past holding time.
cc:

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662
P.O. BOX 432
RIVERSIDE, CA 92502

RECEIVED
MAR 0 3
E.M.W.D.

02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No. 940127-1992
Invoice No. 99908
Customer No. ea0103

Sample Marked: Saline Marsh Soil South Outlet EMWD#940124045 Acct#10041516391309

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(μg/kg)	Parameter	Results(μg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
y-BHC	ND	PCB-1248	ND
Chlordane	ND	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * μg/kg NI=Not identifiable
Date analysis completed: 02/04/94 NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 μg/kg Sample submitted past holding time.

cc:

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

RECEIVED
MAR 03 1994
E.M.W.D.

02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No.	940127-1993
Invoice No.	99908
Customer No.	ea0103

Sample Marked: Saline Marsh Soil North
Inlet EMWD#940124046
Acct#10041516391309

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(μg/kg)	Parameter	Results(μg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
y-BHC	ND	PCB-1248	ND
Chlordane	19**	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * μg/kg NI=Not identifiable
Date analysis completed: 02/04/94 NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 μg/kg **Second column confirmation utilized.
cc: Sample submitted past holding time.

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

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RIVERSIDE, CA 92502

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MAR 0 3 1994
E.M.W.D.

02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No.	940127-1994
Invoice No.	99908
Customer No.	ea0103

Sample Marked: Saline Marsh Soil North Middle EMWD#940124047 Acct#10041516391309

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(μg/kg)	Parameter	Results(μg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
y-BHC	ND	PCB-1248	ND
Chlordane	ND	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * μg/kg NI=Not identifiable
Date analysis completed: 02/04/94 NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 μg/kg Sample submitted past holding time.
cc:

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

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FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

RECEIVED
MAR 03 1994
E.M.W.D.

02/08/94

To: Eastern Municipal Water Dist.
Attn: Mike Creighton
P.O. Box 8300
San Jacinto, CA 92581-8300

Lab No. 940127-1995
Invoice No. 99908
Customer No. ea0103

	Submitted	Sampled
By	BW	
Date	01/25/94	04/28/93
Time	15:15	

Sample Marked: Saline Marsh Soil North Outlet EMWD#940124048 Acct#10041516391309

Chain of Custody on file: N

Organochlorine Pesticides and PCB's

EPA Method 608/8080

Parameter	Results(µg/kg)	Parameter	Results(µg/kg)
Aldrin	ND	PCB-1016	ND
α-BHC	ND	PCB-1221	ND
b-BHC	ND	PCB-1232	ND
δ-BHC	ND	PCB-1242	ND
γ-BHC	ND	PCB-1248	ND
Chlordane	ND	PCB-1254	ND
4,4'-DDD	ND	PCB-1260	ND
4,4'-DDE	ND	Kepone	ND
4,4'-DDT	ND	Mirex	ND
Dieldrin	ND		
Endosulfan I	ND		
Endosulfan II	ND		
Endosulfan sulfate	ND		
Endrin	ND		
Endrin aldehyde	ND		
Heptachlor	ND		
Heptachlor epoxide	ND		
Toxaphene	ND		

ND=None detected, detection limit: * µg/kg NI=Not identifiable
Date analysis completed: 02/04/94 NA=Not analyzed

Notes: *Practical Quantitation Limit = MDL's x 670; See attached sheet.
PCB's PQL = 500 µg/kg Sample submitted past holding time.

cc:

Edward S. Babcock & Sons, Inc.

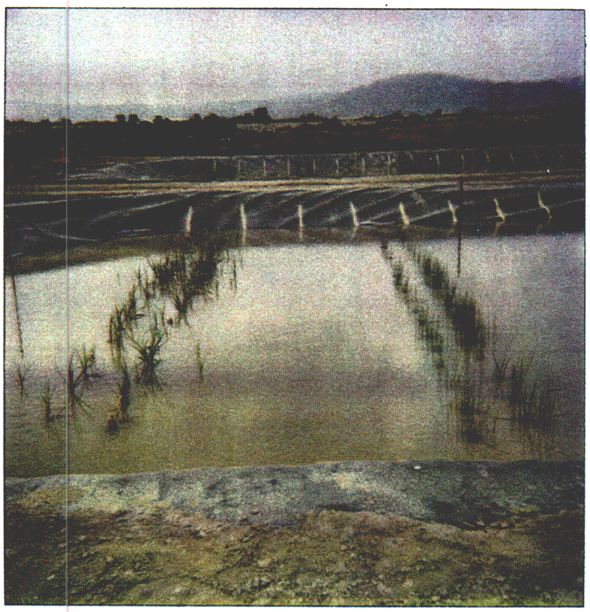
[signature]

APPENDIX D

APPENDIX D

PICTORIAL HISTORY OF VEGETATION GROWTH AND ESTABLISHMENT IN SALINE MARSH

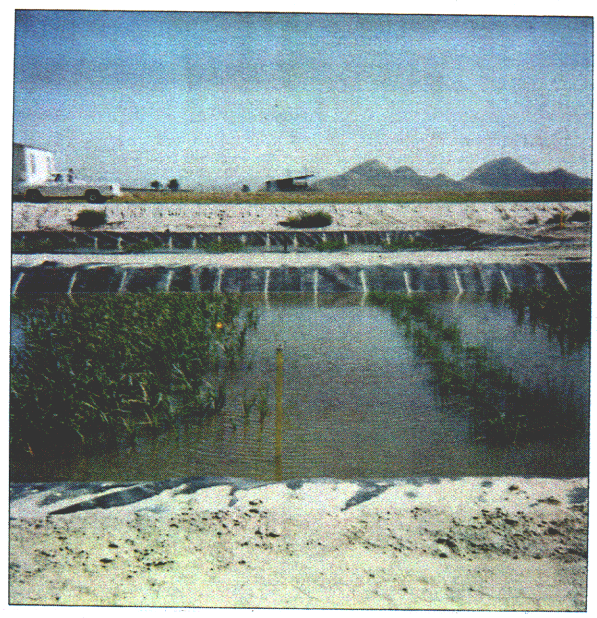
Note: S = South pond
N = North pond



S1 25 MAY 93. South Saline Pond. One month after planting. Different salinity tolerant species were planted between the yellow bands to expose plants to increasing concentrations of salinity.

N1 25 MAY 93. North Saline Pond. Same as S1.

S2 11 JUNE 93. Six weeks after planting. Plants from corms spreading.



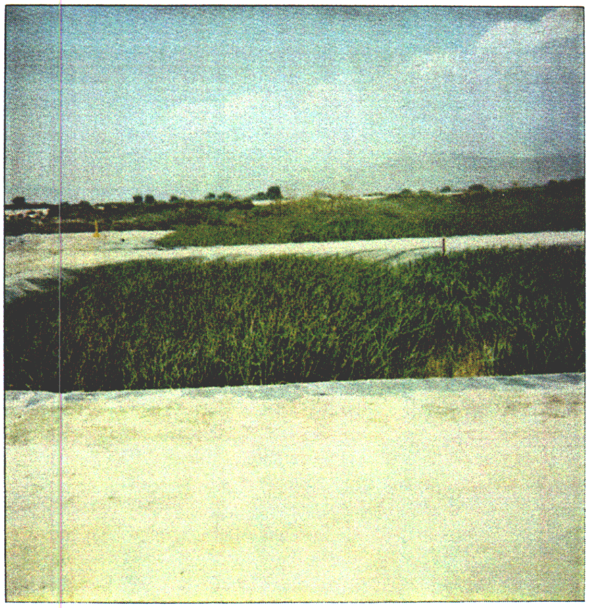
N2 11 JUNE 93. Same as S2.

S3 23 JUNE 93. Rapid growth.

N3 23 JUNE 93. Same as S3.

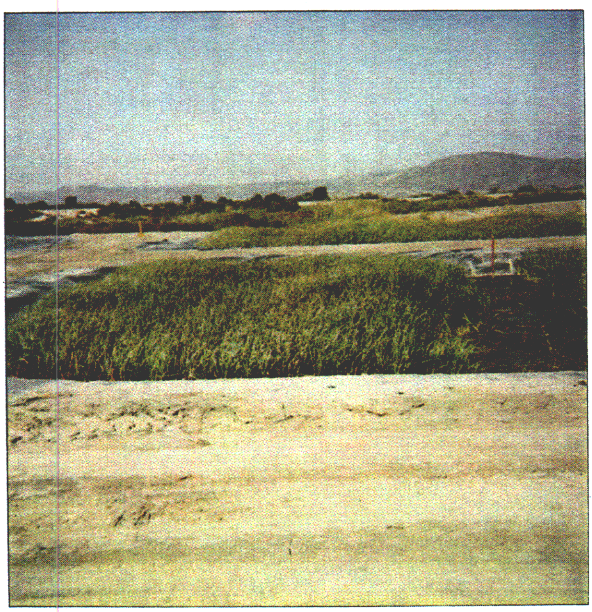
S4 19 JULY 93. *Scirpus robustus* is still in a rapid growth phase and flowering. *Eleocharis palustris* showing die back.

N4 19 JULY 93. *S. robustus* and *E. palustris* showing rapid growth and flowering.

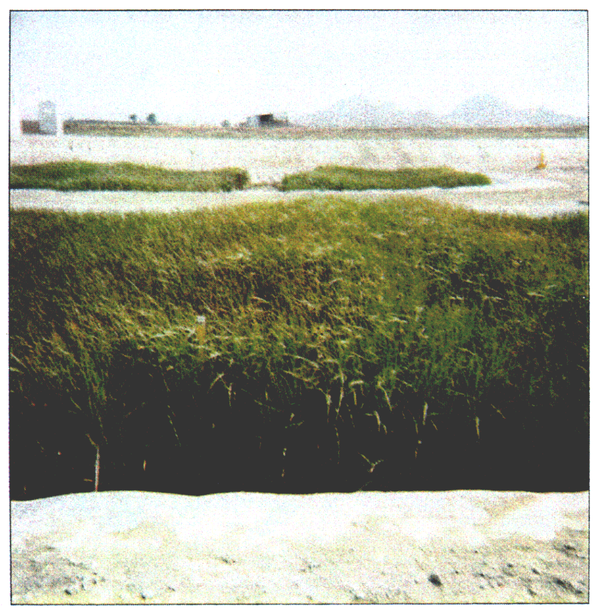


S5 5 AUGUST 93. *S. robustus* encroaching on *E. palustris*.

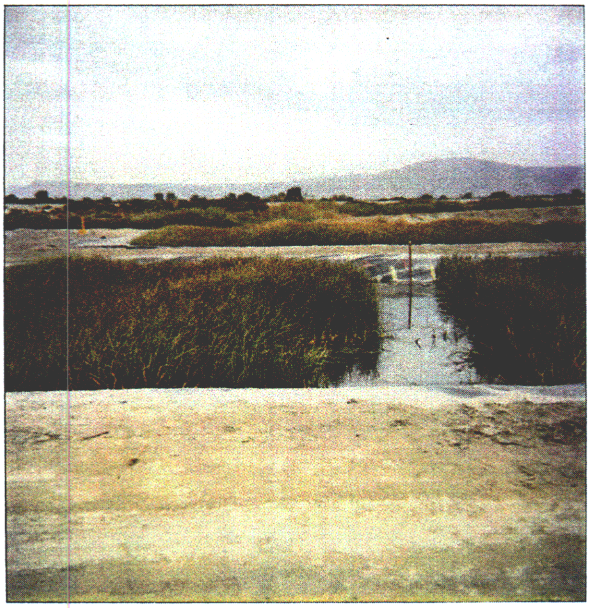
N5 5 AUGUST 93. *S. robustus* encroaching on *E. palustris*.



S6 2 SEPT 93. Overall browning. Unvegetated band with smartweed.

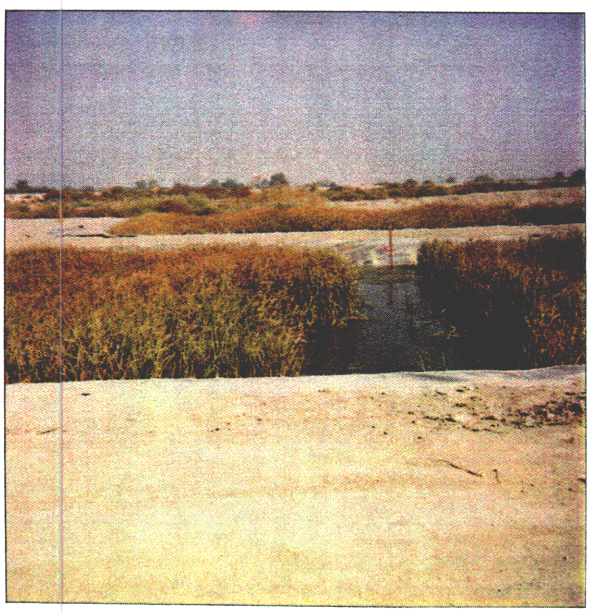


N6 2 SEPT 93. Overall browning.



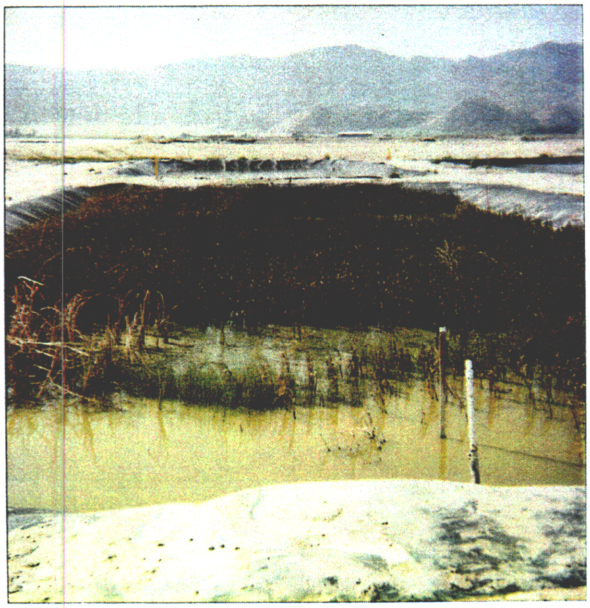
S7 16 SEPT 93. Continued browning.

N7 16 SEPT 93. Continued browning.



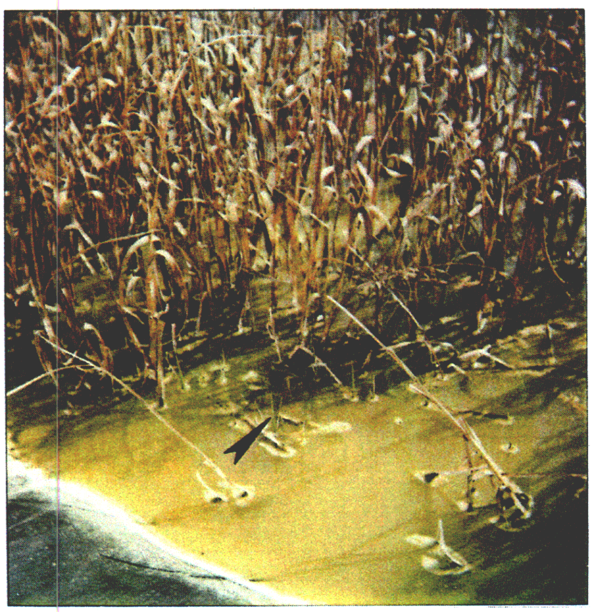
S8 4 OCT 93. Continued browning.

N8 4 OCT 93. Continued browning.

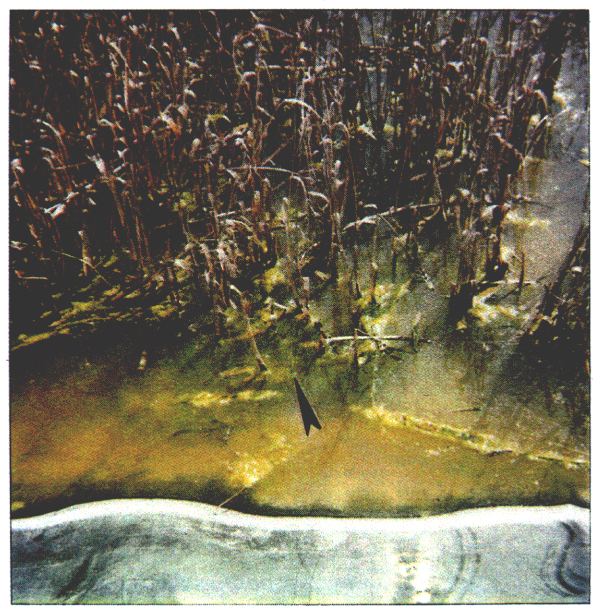


S9 25 FEB 94. *E. palustris* greening.

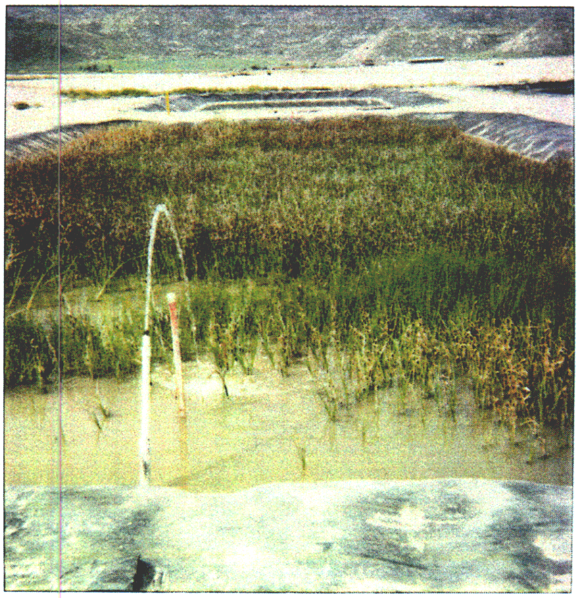
N9 25 FEB 94. *E. palustris* greening.



S10 25 FEB 94. *S. robustus* shows new growth.

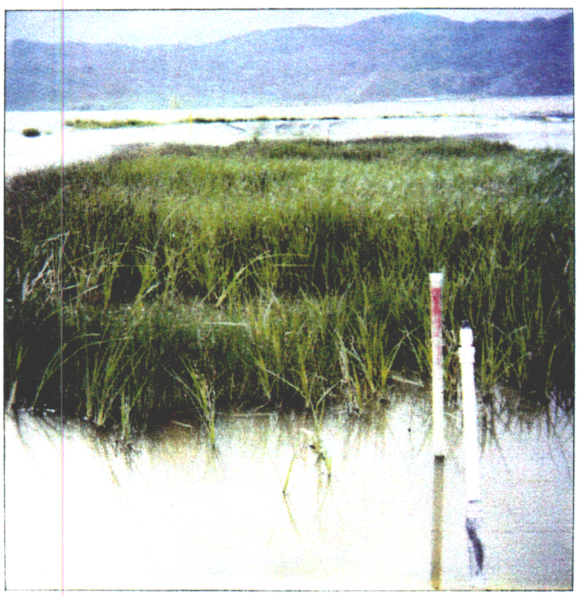


N10 25 FEB 94. *S. robustus* shows new growth.

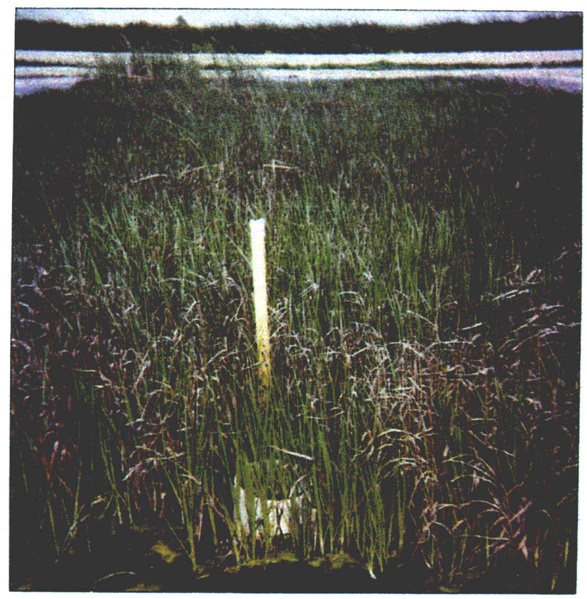


S11 18 MARCH 94. Rapid growth.

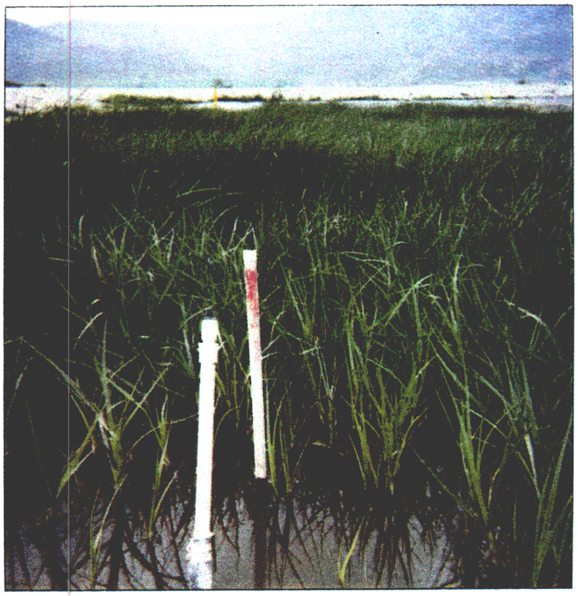
N11 18 MARCH 94. Rapid growth. Algal mats (*Spirogyra*) floating on water surface and covering bottom.



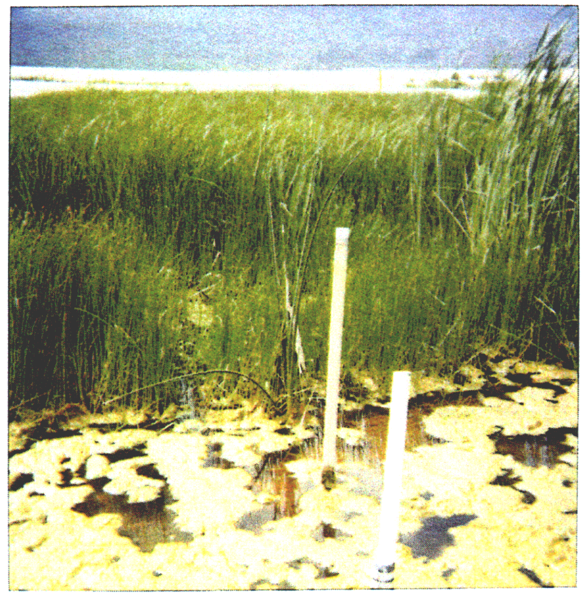
S12 24 MARCH 94. Rapid growth.



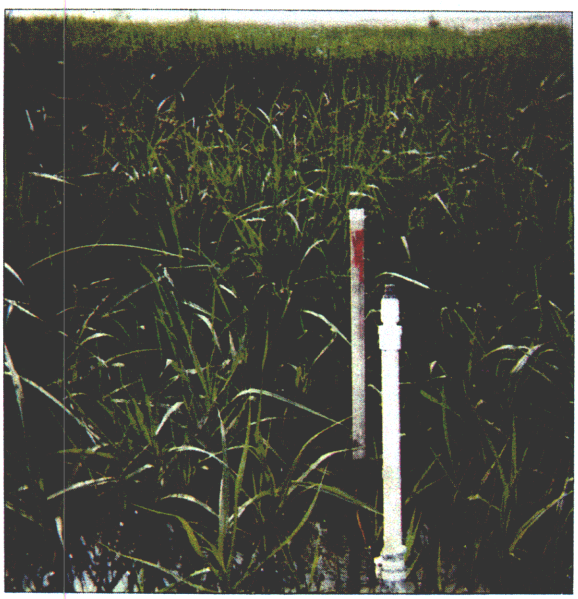
N12 24 MARCH 94. Rapid growth. Algal mats still visible.



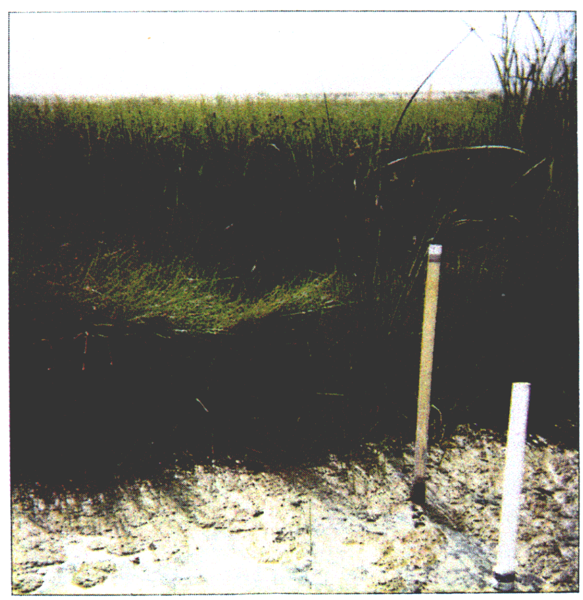
S13 8 APRIL 94. Continued rapid growth.



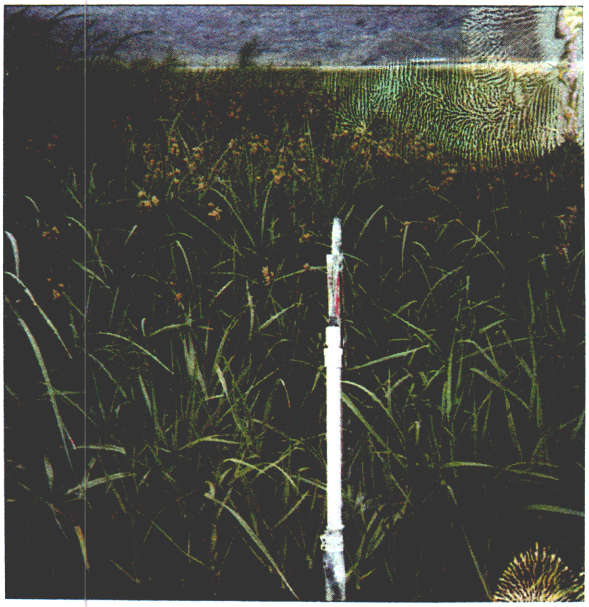
N13 8 APRIL 94. Continued rapid growth. Algal mats still visible.



S14 22 APRIL 94. Rapid expansion of growth area.

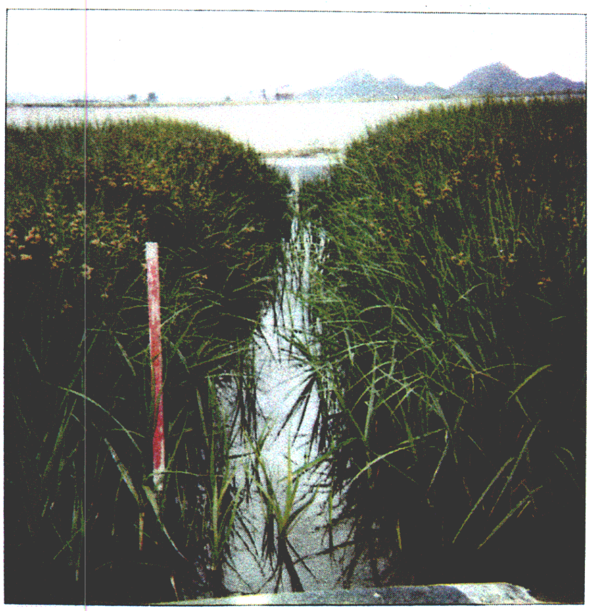


N14 22 APRIL 94. Rapid expansion of growth area. *E. palustris* beginning to fall over.

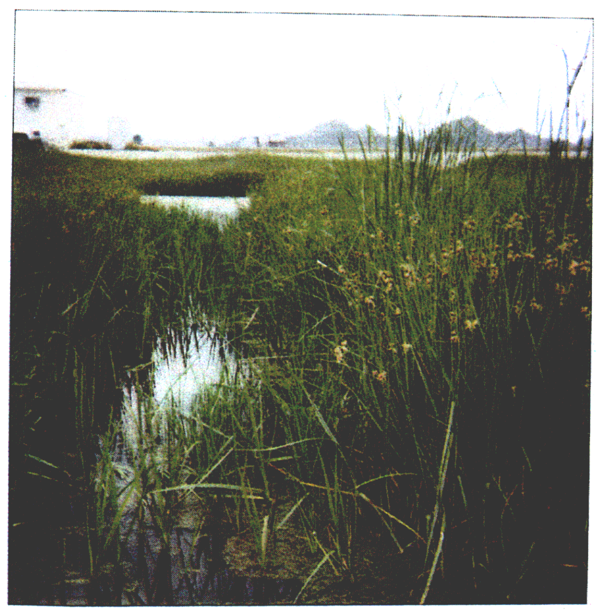


S15 6 MAY 94. Continued rapid growth. Flowering evident.

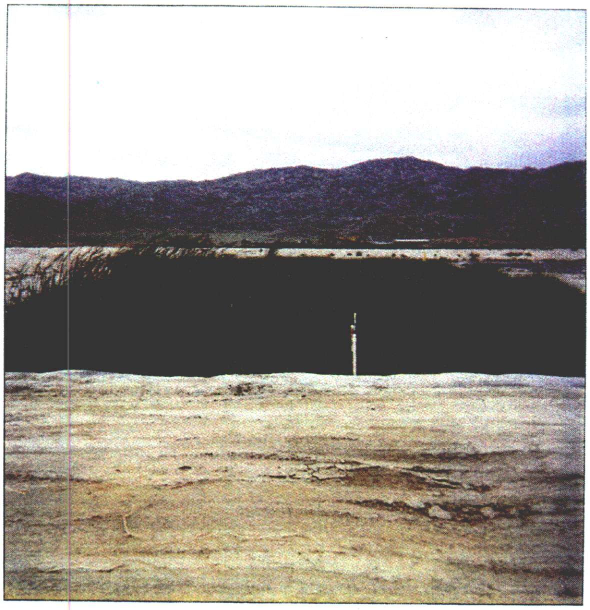
N15 6 MAY 94. Continue rapid growth. Flowering evident. Algal mat still present.



S16 6 MAY 94. *S. robustus* invading removed bands.



N16 6 MAY 94. *S. robustus* and to a lesser degree *E. palustris* invading removed bands.



S17 6 MAY 94. Overview of South Saline Pond.

N17 6 MAY 94. Overview of North Saline Pond.

LOCAL DONOR MARSH 1
22 APRIL 94. *E. palustris* in natural setting. Flowering evident.

LOCAL DONOR MARSH 2
22 APRIL 94. *S. robustus* in natural setting. Flowering evident.

APPENDIX E

APPENDIX E

SALINE MARSH RESEARCH PROGRAM
AND
PROPOSED MONITORING PROGRAM

Saline Vegetated Marshes and Evaporation Ponds Research Program

(Revised 02\22\94)

Background

EMWD is interested in the use of reverse osmosis (RO) units for treating brackish groundwater for M&I use and/or groundwater recharge. This initial investigation will determine the feasibility of additional uses of the RO reject stream, to sustain saline vegetated marshes, prior to final concentration and disposal. The pilot investigation will evaluate the quality of the reject stream and changes in the reject stream characteristics as it passes through the marshes. It will also examine the issues of toxicity and bioaccumulation in the marshes and evaporation ponds. Another tentative aspect of the research is investigation of the use of a framework/hose netting system to mechanically assist evaporation.

As part of the pilot studies program of the Multipurpose Wetlands Research and Demonstration Study, the saline marshes and the evaporation ponds have been constructed at the Hemet/San Jacinto RWRF site at the USBR/EMWD Wetlands Research Facility.

Project Overview

Two ~~20~~ 40 x 80 x 2 ft. lined ponds (saline marshes) have been constructed and planted with three types of saline tolerant vegetation. The saline marshes will operate in parallel. The south pond receives reverse osmosis unit reject water and the north pond, which acts as a control, receives a blend of reject water and product water from the RO unit.

The overflow from the south pond flows into two evaporation ponds to achieve further evaporative concentration of the salts. The evaporation ponds operate in series. Rather than flowing to the evaporation cells, the overflow from the north pond goes to a sump, as shown on Figure 1.

NOTE: There is potential for evaporation of the RO reject stream to concentrate toxic constituents to levels that may be hazardous to wildlife. Therefore, the evaporation ponds have been made as unattractive to wildlife as possible. The ponds have been constructed with steep nonvegetated sides so that no food, shelter or nesting areas are available. Other measures to discourage use by wildlife shall be employed if necessary.

Research Program Objectives

General

This investigation will determine the feasibility of using the reject stream of the desalting process in vegetated saline marshes to provide an additional use of brackish water in arid areas through the irrigation of amenities such as green belts, open space and habitat areas.

Specific areas of research

Saline Marshes

1. To determine whether the reject stream of a desalination process can be used to sustain a variety of flora and fauna.
2. To demonstrate that saline marshes will not accumulate toxic materials or result in hazards to wildlife due to water quality.

Evaporation Ponds

1. To determine the effectiveness of pond design and engineering in discouraging use by wildlife.
2. To determine rates of evaporation in evaporation ponds equipped with the netting framework as opposed to standard evaporation ponds (Optional).
3. To determine whether toxics are present and concentrate to significant levels in the RO reject stream as indicated by their presence in the evaporation pond concentrate.

Specific Studies

STUDY I. Bioproductivity: Sustaining Habitat With An RO Reject Stream.

Background: The combined problems of drought and brine disposal have lead to the suggestion that high TDS, non-potable, water be used to sustain greenbelts instead of potable water. Only specific plants are tolerant to high salt content in water and soil and many of these may not tolerate the other constituents in the RO reject stream. If desalination becomes more prevalent, it will be useful to know if the reject stream can be used for providing irrigation for greenbelts prior to final concentration and disposal. Additionally, the variety of vegetation and invertebrates present in an environment is a good indicator of habitat quality.

The Hypothesis is that the reject stream of the RO process will sustain a variety of flora and fauna as measured by plant growth and invertebrate studies.

The Experiment:

1. Reclamation's botanist will monitor plant growth quarterly. Plant growth will be monitored biweekly at first and then monthly through a combination of methods designed to assess the "sustainability" of the reject stream by District personnel utilizing general observations and a photographic record. The main consideration will be growth or no growth. The "sustainability" of the particular reject stream should be quite obvious from the photographic record.
2. Benthic invertebrates will be collected, counted, and identified annually by USBR personnel to indicate the bioproductivity and biodiversity of the system and its habitat value.
3. General observations will be made on each visit to the site by Reclamation and District personnel and observed wildlife use will be documented.

How EMWD and USBR may benefit from this study:

If saline marshes can be sustained by an RO reject stream, an otherwise "disposable" source of water can provide an additional benefit wherever brackish aquifers are reclaimed by RO or other technologies where brine disposal is a problem.

STUDY II. General Water Quality And Accumulation Of Toxics In Saline Marshes Sustained With An RO Reject Stream.

Background: Constituent concentrations present in the RO source water, and/or the particular combination of constituents, may pose a danger to the flora and fauna present in the marsh system and/or the surrounding environment. Additionally, metals and other constituents can become harmful to living organisms at low concentrations when exposure is over a prolonged period. In order to propose use of RO reject streams to sustain marsh habitat, it is essential to demonstrate that there are no problems associated with the RO reject stream quality that may harm the environment.

The Hypothesis is that the saline marshes sustained by the RO reject stream will not accumulate toxics.

The Experiment:

1. Water quality parameters will be monitored in the saline marsh influent and effluent

semi-annually. EC and TDS may be monitored more frequently if necessary. Parameters measured will include TDS, EC, Cyanide, Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Total Chromium, Cobalt, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc), Ammonium, Calcium, Magnesium, Potassium, Sodium, Bicarbonate, Chloride, Fluoride, Nitrate, Sulfate, BOD, Hardness, Suspended Solids, Ammonia-N, Nitrate-N, Boron and pH.

2. Soil sediment analysis will be performed at initial flooding of the marshes, one time several months after introduction of RO reject water and annually thereafter. Soil samples will be analyzed for presence of metals.

3. Plants growing in the saline vegetated marshes will be collected annually and analyzed to determine the accumulation of toxics, specifically metals, in their tissues.

4. Benthic invertebrates in the saline vegetated marshes will be collected annually and analyzed for accumulation of toxics, specifically metals.

How EMWD and USBR may benefit from this study:

If there are no significant water quality problems in the RO reject stream that pose a danger to the environment, saline marshes could be used to provide habitat on a region-wide basis without the use of potable or reclaimed water. Saline vegetated marshes may also be more acceptable to the general public than acres of evaporation ponds at desalter locations in populated areas.

STUDY III. Controlling Wildlife Use Of Evaporation Ponds.

Background: Because of the possible toxicity of the brine, it is necessary to keep wildlife from using the evaporation ponds. The evaporation ponds will be designed to discourage use by wildlife and will be maintained with no surrounding vegetation. Effectiveness of these features is an important consideration if wide use of evaporation ponds becomes an issue.

The Hypothesis is that the engineering controls, in conjunction with the maintenance controls, will discourage use of the evaporation ponds by wildlife.

The Experiment:

1. Observations will be made formally on a weekly basis during the course of the study. Signs of wildlife use such as tracks and droppings will be looked for as well

as presence of fauna in and around the ponds. Guidance from the California Department of Fish and Game will be sought if necessary.

2. A photographic record will be kept of any significant findings. A carcass log to record any dead animals found in and around the ponds will also be kept.

How EMWD and USBR may benefit from this study:

If no significant wildlife use is observed in the evaporation ponds it will demonstrate that it is possible to design and maintain saline evaporation ponds with little risk to wildlife.

STUDY IV. The Presence Of Toxics In Evaporation Pond Concentrate.

Background: Toxic constituents may be present in source water concentrations that are not detectable using standard laboratory methods. After concentration in evaporation ponds, these constituents, primarily metals, may be at detectable levels in the water. In order to determine whether evaporation ponds pose a significant danger to wildlife, it is necessary to gather data on constituents present in the evaporation ponds.

The Hypothesis is that toxic metals are not present in the saline vegetated marshes or evaporation ponds at levels that may be harmful to wildlife.

The Experiment:

1. Evaporation pond water quality will be sampled annually for metals.

2. Rainfall data will be monitored simultaneously to assure that monitoring/measuring is not done immediately after a storm event.

How EMWD and USBR may benefit from this study:

Determining the levels of toxic constituents in brine concentrate will help to determine whether additional precautions to discourage evaporation pond use by wildlife are necessary.

STUDY V. (TENTATIVE) The Effect of Using a Framework/Hose/Netting System On Evaporation Rate In A Brine Concentration Pond Network.

Background: The primary purpose of the evaporation ponds is to use solar radiation to reduce the volume of brine through evaporation. As a result of this process, the brine becomes more concentrated. In this study, the first evaporation pond will be equipped with a framework of overhead cables, 'leaky or sweaty' hose, and monofilament netting to increase surface area for evaporation. The effect of the framework/hose/netting system will be quantified and the results will be used to determine if its use increases evaporation and makes economic sense for future projects.

The Hypothesis is that brine evaporation rates can be significantly increased using the framework/hose/netting system over rates attained by using standard evaporation ponds.

The Experiment:

1. Pan Evaporation Readings will be taken weekly.

2. Rainfall data will be monitored simultaneously to assure monitoring/measuring is not done immediately after a storm event.

3. Flow into the system from RO unit will be recorded.

4. Using total flow into the system, staff gauge reading, and pan evaporation rates, the effectiveness of the framework/hose/netting system to increase evaporation will be determined to compare with evaporation without mechanical assistance.

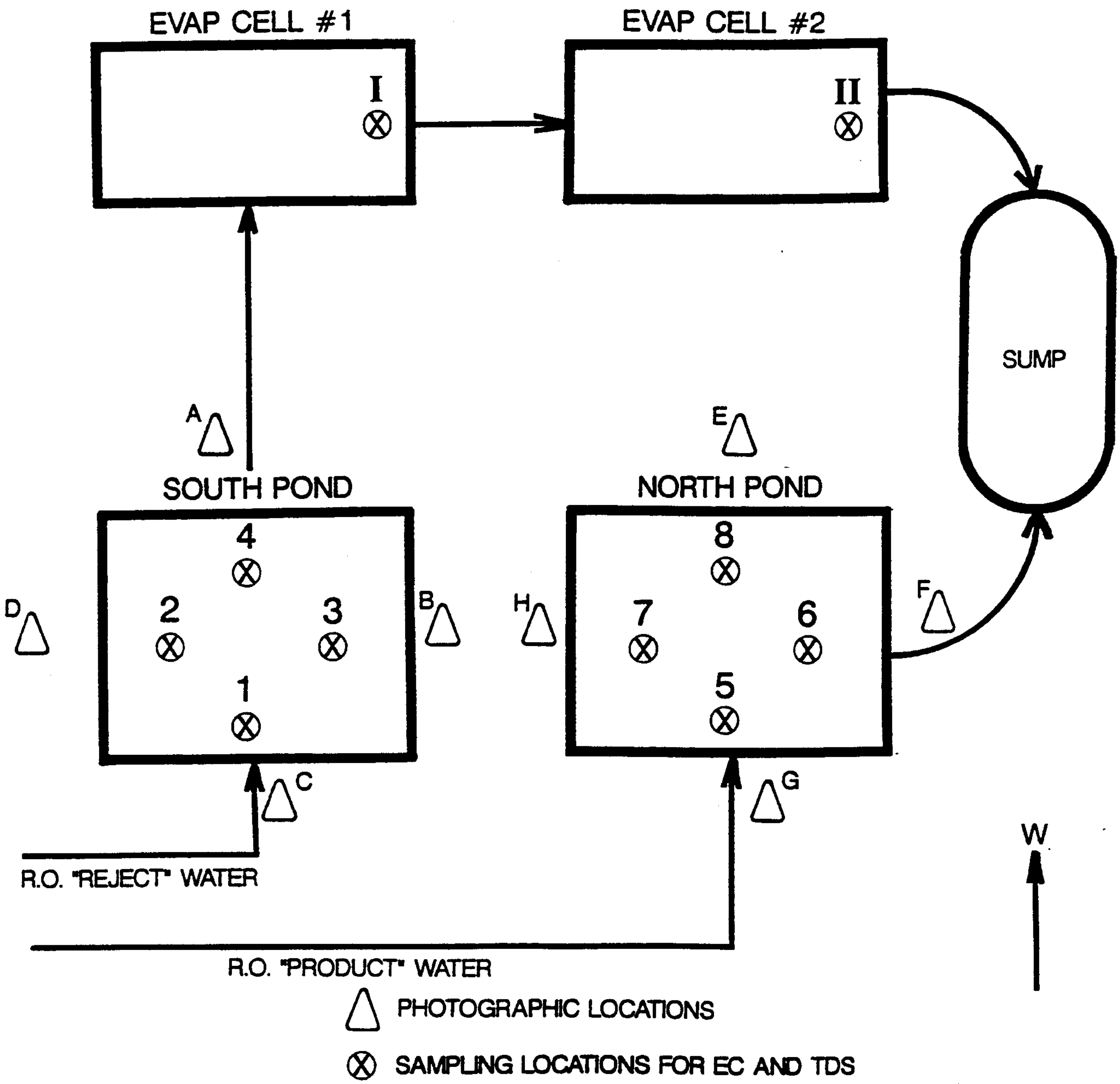
How EMWD and USBR may benefit from this study:

The data gathered in this study can be used to determine the economic feasibility of using the framework/hose/netting system in future brine concentrating projects.

J:\WORDPROC\WP\RES_DEV\LEANNE\SALIN.MON

FIGURE I

FLOW SCHEMATIC OF SALINE VEGETATED PONDS AND EVAPORATION CELLS



Proposed
Saline Marsh Monitoring Program

(July 5, 1994)

STUDY I. Bioproductivity: Sustaining Habitat With A Reverse Osmosis Reject Stream

1. NBS' botanist will monitor plant growth quarterly.

2. District personnel will monitor plant growth weekly in both the control and experimental saline marshes. Written observations are to placed in both an Observation Bound Notebook and Observation Form. Copies of the Observation Forms are to be submitted monthly to the Wetland's Project Manager. If possible, the different species plant growth are to be measured weekly. Observation from plant growth by species will be ranked as follows:

<u>Plant Health Rating Scale</u>
from USBR

0 =	No effect
1, 2, 3 =	Leaf injury, epinasty, elongation abnormalities, discoloration, and/or chlorosis, minor to moderate
4, 5, 6 =	Severe symptoms of conditions 1, 2, 3 and possibility of some upper stem injury
7 =	Severe 1, 2, 3 symptoms plus 50 percent (%) stem injury
8 =	Severe 1, 2, 3 symptoms plus rhizome and stem injury; stem usually 75 percent (%) dead
9 =	Upper leaves and stem dead except for remaining 4 to 5 cm above soil; strong possibility of severe rhizome damage
10 =	Plant dead

Also, weekly Polaroid photographic records will be taken at eight (8) locations, and the photographs are permanently placed in a Photo-Logbook. In Figure 1, letters mark the photographic locations. On the photographs will be written the date and photographic location. In addition, monthly photographs on slide film will be taken at the same eight (8) locations as mentioned previously. Significant changes in plant health will also be photographed on slide film.

3. Annually, benthic invertebrates are to be collected, counted and identified, by USBR, District personnel and/or outside benthic invertebrate specialist (if funds are available). In both the control and experimental saline marshes, ten (10) random subsamplings will be collected into a large flat pan to form a composite sample. The random subsamplings will use either a core sampler or Petersen grab sampler. From the composite sample, grids are placed and all benthic organisms within a grid are removed for counting and identification. This is done either by sifting through the sediments or utilizing a series of seives. Grids will be randomly selected until at least one hundred (100) organisms have been obtained from the composite sample. The benthic organisms are to be preserved in formalin, Lugol's solution or some other preservation media for later identification. These organisms are to be classified by family and/or genus. A diversity index will be used to quantify the biological information in both the control and experimental saline marshes.

4. Wildlife and other general observations, such as weather, are to be written daily in the Observation Bound Notebook and summarized weekly on the Observation Form. Again, the Wetland's Project Manager will receive monthly copies of the Observation Forms.

STUDY II. General Water Quality And Accumulation of Toxics In Saline Marshes Sustained With A Reverse Osmosis Reject Stream

1. Semi-annually, water quality parameters will be measured by analyzing five (5) grab samples in the Saline Marshes. The five (5) sample locations are shown in figure 1, location #1, 4, 5 & 8 and the reject stream. Parameters to be measured will include:

   General Minerals - Ammonium (NH_4), Ammonia-N (NH_3-N, Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Bicarbonate (HCO_3), Carbonate (CO_3), Hydroxide (OH), Chloride (Cl), Fluoride (F), Nitrate (NO_3), Nitrate-N (NO_3-N), Sulfate (SO_4), Hardness (Hard), Total Dissolved Solids (TDS), Conductivity (EC), Boron (B) and pH

   Miscellaneous - ortho-Phosphate (o-PO_4), Total Phosphate-P (Total PO_4-P), Suspended Solids (TSS), % Sodium, and Sodium Adsorption Ratio (SAR)

Metals - Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Cadmium (Cd), Total Chromium (Total Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Selenium (Se), Silver (Ag), Thallium (Tl), Zinc (Zn), and Boron (B)

If funding is available, Mercury (Hg), Selenium (Se), Copper (Cu) and Boron (B) will be monitored more frequently (preferably, monthly) at the five (5) sampling sites mentioned above.

2. Conductivity (EC) and Temperature (and TDS by estimation) are to be monitored weekly at nine (9) sampling sites, locations #1 thru 8 in Figure 1 and the Reverse Osmosis (R.O.) reject line.

3. Monthly, Total Dissolved Solids (TDS @ 180°C) is to be monitored at nine (9) sampling sites , locations #1 thru 8 in Figure 1 and the Reverse Osmosis (R.O.) reject line.

4. Annually, composite soil samples of the inlet and outlet of the Control and Experimental Saline Marshes (location #1, 4, 5, & 8 of Figure 1) are to be analyzed for metals (see above STUDY II Paragraph 1 "Metals"). At each sample location, a minimum of three (3) soil grab samples, 0-3 inches in depth using a core sampler or a Petersen grab sampler, are to be taken across the width of the marsh. These samples are then composited, in a large glass beaker, as one sample for each site. In addition to the "Metals" analyses, the following constituents will be tested for the soil samples.

   Particle-size analysis (PSA), pH, Conductivity (EC), Sodium Adsorption Ratio (SAR), Cation Exchange Capacity (CEC), and Organic Matter Content

5. Annually, the primary species of plants (stems, tubers and leaves) are to be collected, marked and analyzed by an outside contract laboratory for toxic accumulation, specifically Metals (see above STUDY II Paragraph 1 "Metals"). A minimum of two (2) grams (dry weight) of plants are needed for analysis, however, five (5) grams (dry weight) will be optimal. Estimated wet weight needed will be approximately one hundred (100) grams.

6. Annually, the benthic invertebrates in the saline marshes are to be collected randomly (see above STUDY I Paragraph 3) and sent to an outside contract laboratory for analysis of Metal accumulation (see above STUDY II Paragraph 1 "Metals"). In addition to the collection of the benthic organisms, rinsing and purging are required for sample

preservation. Again, a minimum of two (2) grams (dry weight) of benthic invertebrates are needed for analysis, however, five (5) grams (dry weight) will be optimal. Estimated wet weight needed will be approximately one hundred (100) grams. Once this is collected, the live benthic organisms are rinsed with filtered ambient water and held in a beaker with the filtered ambient water for four (4) to six (6) hours. This time period allows for ingested materials to be purged from the benthic organisms. After the purging period, the ambient water is drained. Again, a final rinse is done with filtered ambient water and drained.

7. Flows will be monitored daily for the control and experimental saline marshes. Flow data will be recorded in the Observation Bound Notebook, and weekly summarized on the Observation Form. Monthly, the Wetland's Project Manager will receive copies of the Observation Forms.

STUDY III. Controlling Wildlife Use of Evaporation Ponds.

1. Observations are to be made daily of wildlife use in the marshes or evaporation cellss and recorded in the Observation Bound Notebook. Weekly, the daily observations are to be summarized on the Observation Form. Also, a detailed weekly observation shall include signs of wildlife use such as tracks and droppings and be written down in both the Observation Bound Notebook and Observation Form. Again, the Wetland's Project Manager will receive monthly copies of the Observation Forms. Photographic records are to be kept of any significant findings, and the photographs will then be kept in the Photo-Logbook. On the photographs, the date, time and description of the photographs will be written down.

STUDY IV. The Presence Of Toxics In Evaporation Pond Concentrate.

1. Semi-annually, the water in the evaporation cells is to be sampled for metals (see above STUDY II Paragraph 1 "Metals"). A grab sample shall be taken at location I and II in Figure 1.

2. In addition, weather characteristics such as rainfall and evaporation (from the evaporation pan) are to be observed daily and written down in the Observation Bound Notebook. Weekly, the weather characteristics are to be summarized in the Observation Form, and monthly, copies sent to the Wetlands Project Manager.

Proposed
Saline Marsh Monitoring Program
Summary

Daily

1. Wildlife and other observations such as weather, flow data, and pan evaporation rate are to be observed and written in the Observation Bound Notebook.

Weekly

1. Wildlife and other observations such as daily flow data, weather, pan evaporation rate, are to summarized on the Observation Form.

2. Photographic records are to be taken of the Saline Marshes from eight (8) locations (see figure 1, A thru H), and the photographs are to be permanently placed in a photo-logbook.

3. Detailed wildlife use observations of the Saline Marshes and Evaporation Ponds and are to be written in the Observation Bound Notebook and Observation Form.

4. EC and Temperature (and TDS by summation) are to be monitored at locations #1 thru 8 in Figure 1 and at the R.O. Reject line.

Monthly

1. Copies of the Observation Forms are to be submitted to Wetland's Project Manager.

2. TDS @ 180°C are to be monitored at location #1 thru 8 in Figure 1 and at the R.O. Reject line.

3. Slide photographes are to be taken of the Saline Marshes from eight (8) location (see figure 1, A thru H), and the slides are to be stored in the photo-logbook.

4. Five (5) grab samples (see Figure #1, 4, 5 & 8 and reject stream) will be monitored for Selenium (Se), Mercury (Hg), Copper (Cu) and Boron (B) -- **optional.**

Quarterly

1. NBS' botanist will monitor plant growth. Dates: unknown

Semi-Annually

1. Five (5) grab samples (water) from the Saline Marshes (see Figure 1, #1, 4, 5 & 8 and reject stream for sample locations) will be sampled for General Minerals, Metals and other constituents.

Dates: June 30th and January 30th

2. Two (2) grab samples (water) from the Evaporation Ponds (see Figure 1, I & II for sample locations) are to be sampled and analyzed for Metals. Dates: June 30th and January 30th

Annually

1. From ten (10) random subsamples collected to form a composite sample, benthic invertebrates are to be collected and split. One hundred (100) random specimens are to be preserved in preservation media and identified -- **optional.** For the other split, approximately one hundred (100) grams (wet weight) of specimens will be sent to an outside laboratory for Metals analyses. Dates: June 30th

2. Four (4) composited sediment sample are to be analyzed for Metals (see figure 1, #1, 4, 5 & 8 for sample location. In addition to Metals analyses, Particle-Size Analysis (PSA), pH, Conductivity (EC), Sodium Adsorption Ratio (SAR), Cation Exchange Capacity (CEC) and Organic Matter Content will be analyzed. Dates: June 30th

3. A minimum of two (2) grams (dry weight) for each plant species are to be collected and sent to an outside laboratory for Metals analyses. Dates: June 30th

Notes

1. If samples are to be held overnight, samples are to be preserved according to either the contract laboratory's preservation procedure or 18th Edition of Standard Methods.
2. Dates are approximate days to sample.

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Saline Marsh Monitoring Program
Cost

Daily

1. *Wildlife and other observations such as weather, flow data and pan evaporation rate are to be observed and written in the Observation Bound Notebook.*

0.5 hr./day; 5 day/wk. = 130 hrs./yr.	$ 3,510
Supplies (Observation Bound Notebook)	$ 25

Weekly

1. *Wildlife and other observations such as weather, flow data, and pan evaporation rate are to summarized on the Observation Form.*

1 hr./wk. = 52 hrs./yr.	$ 1,404

2. *Photographic records are to be taken of the Saline Marshes from eight (8) location (see figure 1, A thru H), and the photographs are permanently placed in a photo-logbook.*

0.5 hr./wk. = 26 hrs./yr.	$ 702
Supplies (Polariod Film)	$ 400

3. *Detailed wildlife use observation of the Saline Marshes and Evaporation Ponds and are to be written in the Observation Bound Notebook and Observation Form.*

0.5 hr./wk. = 26 hrs./yr.	$ 702

4. *EC and Temperature (and TDS by summation) are to be monitored at location #1 thru 8 in Figure 1 and at the R.O. Reject line.*

Sampling: 1 hr./wk.; 52 hrs./yr. =	$ 1,404
Testing: $19.00/wk. =	$ 988

Monthly

1. *Copies of the Observation Forms are to be submitted to Wetland's Project Coordinator.*

	$ NC

2. *TDS @ 180°C are to be monitored at location #1 thru 8 in Figure 1 and at the R.O. Reject line.*

Sampling: 1 hr./sampling; 12 hrs./yr. =	$ 324

Testing: $18/sample; $162/mo.; per year = $ 1,944

3. *Slide photographs are to be taken of the Saline Marshes from eight (8) location (see figure 1, A thru H), and the slides are to be stored in the photo-logbook.*

Sampling: see above "Weekly #2" $ NC
Supply: Film $ 50

4. *Five (5) grab samples (see Figure #1, 4, 5, & 8 and reject stream) will be monitored for Selenium (Se), Mercury (Hg), Copper (Cu) and Boron (B)* **-- optional.**

Sampling: 1 hr./sampling; 12 hrs./yr. = $ 324
Testing: $58/sample; $232/mo.; per year = $ 2,784

Quarterly

1. *USBR's botanist will monitor plant growth.* Dates: unknown

$ NC

Semi-Annually

1. *Five (5) grab samples from the Saline Marshes (see figure 1, #1 4, 5 & 8 and reject stream for sample locations) will be sampled for General Minerals, Metals and other constituents.*
Dates: June 30th & January 30th

Sampling: 4 hrs./sampling = 16 hrs./yr. $ 432
Testing: $398/sample; $1,592/semi-annually per year = $ 3,184

2. *Two (2) grab samples from the Evaporation Ponds (see figure 1, I & II for sample locations) are to be sampled and analyzed for Metals.* Dates: June 30th and January 30th

Sampling: 1 hr./sampling; 2 hrs/yr. = $ 54
Testing: $250/sample; $500/semi-annually per year = $ 1,000

Annually

1. *Benthic invertebrates are to be collected and split. One hundred (100) random specimens are to be preserved in formalin and identified* **-- optional** *. For the other split, approximately one hundred (100) grams (wet weight) of specimens will be sent to an outside laboratory for Metals analyses.* Dates: June 30th

Sampling & Preserving: 12 hrs./yr. $ 324
Testing: $321/sample; per year = $ 642
Identifying: (optional) $ 200?

2. Four (4) composited sediment sample are to be analyzed for Metals (see figure 1, #1, 4, 5 & 8 for sample location). In addition to Metals anlayses, Particle Size Analysis (PSA), pH, Conductivity (EC), Sodium Adsoprtion Ratio (SAR), Cation Exchange Capacity (CEC) and Organic Matter Content will be analyzed.
Dates: June 30th

Sampling: 2 hrs./yr.	$ 54
Testing: $394/sample; per year =	$ 1,576

3. A minimum of two (2) grams (dry weight) for each plant species are to be collected and sent to an outside laboratory for Metals analyses. Dates: June 30th

Sampling: 8 hrs./yr.	$ 216
Testing: $319/sample; per year =	$ 642

Subtotal

Sampling:	$ 9,450
Testing:	$12,960
Supply:	$ 475

Total = $22,885

Notes
1. Laboratory Sampling/Field Cost per hour is $27.
2. Testing Cost is from Babcock & Sons, Laboratory in Riverside, CA; Price reflects E.M.W.D.'s price discount.
3. Metals will be performed on an ICP-MS (West Coast Laboratory, in Santa Fe Springs, CA).
4. Dates are approximate days to sample.

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APPENDIX F

APPENDIX F

PUBLIC INVOLVEMENT

1994 Multipurpose Constructed Wetlands
Public Involvement & Community Relations

Presentations, Tours, Articles, and Awards

Jan. Moreno Valley Chamber Outlook, article: Dr. Wm. Aldridge, EMWD Board of Directors, accepting NWRA award and mention of international interest in wetlands project.

27 Planning Task Force, Working Committee Meeting, presentation and wetlands video shown by Christie Crother.

Feb. 3 Dr. Sue Yoder, Sea Grant Program, USC. Request for wetlands information and request for presentation at So. Calif. Academy of Sciences 1994 Annual Meeting, May 6-7.

3 Bob Bastian, EPA, Technical Advisory Committee member. Request for EMWD wetlands photos for EPA publication. Also sent copy of video.

9 Society of Iranian Environmental Professionals, presentation with color slides and handout materials. EMWD: Dr. Behrooz Mortazavi.

10 Multipurpose Constructed Wetlands Dedication. Speakers: Daniel P. Beard, USBR Commissioner; Kay Ceniceros, Supervisor, 3rd District, Riverside County; Patrick A. Williams, Mayor Pro Tem, City of San Jacinto; Wm. G. Aldridge, Vice President, EMWD Board of Directors; and J. Andrew Schlange, General Manager, EMWD. Wetlands video shown at ceremony. Tour for Commissioner Beard and selected guests following press conference. Articles: Riverside Press Enterprise and The Hemet News.

16 American Business Women's Association, Hemet/San Jacinto Chapter. Wetlands slide presentation and handouts, Christie Crother.

22 Notification from AMSA of selection of project for 1994 Research and Technology Award. Presentation to be in Washington, D.C., May 23, 1994.

25 Aida Raymond, Elsinore Valley Municipal Water District. Requested copy of wetlands video, made copy for EVMWD video library.

28 At request of Dr. Aldridge, wetlands information packet and video sent to Jerry Uecker, Merrill Lynch, Hemet, CA. Mr. Uecker volunteered for any public involvement activities on project.

28 Copy of wetlands video sent to Jag Salgaonkar, CH2M Hill.

Feb. Article: Commissioner Beard Dedicates Wetland Project, Employees in Action, USBR Lower Colorado Region Newsletter.

Mar. 1 Three sets of wetlands information packets given to Ted Haring, EMWD Conservaton Coordinator, to be sent to Fred Etheridge, Attorney, East Bay MUD; Connie at ACWA; and one other.

10 Designing Wetlands to Clean Wastewater, Reclamation/EMWD, Multipurpose Constructed Wetlands Project, Joan S. Thullen, Currents...Developing Technology for Tomorrow's Challenges, USBR Publication.

11 Director Chet Gilbert, Citizen Ambassador Program, Water Management Delegaton to Australia, The Role of Multipurpose Wetlands in Water Resources Management in Southern California. Slide presentation, video, handouts.

15 Dave Erlenbach, Mechanical Engineer, and Brenda L. Land, Sanitary Engineer, US Forest Service Technology & Development Center, San Dimas, Calif. Slide presentation and video, handouts, site tour. Copy of video requested and given.

15 Multipurpose Constructed Wetlands, Progress Report by Eastern Municipal Water District, March 15, 1994, A Cooperative Program with the US Bureau of Reclamation.

30/31 Career Festival, Fruitvale Elementary School, Hemet Unified School District. EMWD: Joanna Tewksbury, Stella Denison, Cathy Pierce, and Holly Devine. Display included Resource Development poster presentation; four wetlands aquariums containing frogs, tadpoles, gambusia, diving beetles, California and alkali burlush, spikerush, and marsh pennywort; and water conservation materials. Approximately 600 children participated.

Apr. 13 West Valley High School, Hemet Unified School District, Tour: Mr. Jay Morse and Mr. Jim Hofrock, teachers, and thirty students. Tour of Regional Water Reclamation Facility and Wetlands Research Facility, student handouts, teachers packets, and video provided. EMWD: Betty Gibbel, LeAnne Hamilton, Al Javier, and Christie Crother.

18 John Wodraska, General Manager, Metropolitan Water District (MWD) of Southern California and Greg Taylor, General Counsel to MWD. Slide Presentation and wetlands tour.

21 Bill Havert, Dangermond & Associates. EMWD: LeAnne Hamilton and John Crossman. Wetlands tour.

May Wetlands Newsletter #3 (May 1994) distributed.

May 6 Arizona Water & Pollution Control Association, 67th Annual Conference, Prescott, AZ. Technical Program, Wetlands Panel Discussion: Bob Bastian, EPA; Brian Munson, AQEQ, Phoenix; Jim Sartoris, USBR; Mike Gritzuk, City of Phoenix; and Christie Crother, EMWD.

Scheduled:

May 25 Role of Constructed Wetlands in Water Resources Management. Christie Crother, John Crossman, and P. Ravishanker. ASCE Annual Conference, Denver, Colorado, May 25, 1994.

1993 - Multipurpose Wetlands Research & Demonstration Study
Public Involvement
Presentations, Tours, Awards, Articles

Jan.	12	Moreno Valley Rotarians, luncheon meeting, Moreno Valley. Slide presentation and handouts.
Jan.	21	WESTCAS - Western Coalition of Arid States, Tempe, Arizona. Quarterly meeting, January 20-22, 1993. Slide presentation and handout packets.
Jan.	28	Luis A. Garcia, Ph.D., Department of Agricultural and Chemical Engineering, Colorado State University, Fort Collins, CO. Site tour and handouts.
Feb.		Wetlands Newsletter (#1) distributed.
Feb.		<u>EMWD Water News, Vol. 1, No. 1</u>, February 1993, page 3, article: Wetlands Treat Water, Attract Wildlife.
Mar.	3	Tres Rios Wetlands Study, Phoenix, Az. Slide presentation and handouts. (requested by Bill Chase, City of Phoenix and Bill Weisenborn, USBR, Boulder City, NV)
Apr.	6	Hemet Breakfast Lions Club, Hemet. Presentation and handouts.
Apr.	19	Mr. Adron W. Richert, Tres Rios Study participant, 6402 S. 107th Ave., Tolleson, AZ 85353. Presentation, site tour, and handouts.
Apr.	21	Ronald W. Crites, P.E., Nolte and Associates, Sacramento, Calif. Site tour.
Apr.	29	Graduate Seminar, Soils and Environmental Science Department, University of California, Riverside. Slide presentation and handouts.
May	8	Ag. Celebration Day, West Valley High School, Hemet, CA. Manned booth, continuous slide presentation, bulrush display, handouts.
May	11	Daryl McGregor, Manager of Investigation and Design, City of Albury, New South Wales, Australia. Slide presentation, site tour, and handouts.

May	11	Dr. Laszlo J. Szijj, California State Polytechnic University, Pomona. Site tour.
May	27	Mr. Robert Erickson, Director Design/Development, Moreno Highlands (well for RO pilot project at Wetlands Research Facility). Site Tour Wetlands Research Facility.
May	28	Brad Evans, B.E. (Civil), Managing Director, Shepparton Irrigation, Benala Road, Shepparton, Victoria 3630, Australia. Presentation, site tour, handouts.
June		Wetlands Newsletter #2 (June 1993) distributed.
June	4	Colleen Mathews, P.E., Parker Consultants, El Cajon, CA. Presentation and H/SJ site tour.
June	9	District Facilities Tour, EMWD employees. H/SJ RWRF wetlands tour and handouts.
June	10	April Sleigh, Ornithologist (grad. student), California State Polytechnic University, Pomona. H/SJ site tour and information packet.
June	15	City of Hemet, H/SJ site tour following Quarterly Planning Meeting with EMWD Planning Dept. City of Hemet: Sandra Massa-Lavitt, Director of Planning and Mark Goldberg, Director of Community Development and EMWD Planning Department staff. Information packet along with site tour.
June	16	EMWD Engineering Dept. Team for Wetlands Project: Victor Barreto, Sherry Davis, Bob van Dorn, Gene Knott, Cory Wallis, and John Ward. Slide presentation, information packet, site tour.
June	17	EMWD New Employee Orientation. Slide presentation and information packet.
June	21	Mari Nord, Riverside Sewage Treatment Plant, Riverside, CA. Site tour and information packet.
June		California Water Journal, June 1993, Vol. 3, No. 6, page 5, full page profile on EMWD and Wetlands project.
June		Bulletin of the Ecological Society of America, Vol. 74, No. 2, June 1993, page 97, article on USBR/EMWD Wetlands Research Facility.

July 8 Riverside County Farm Bureau Tour for Douglas Wheeler, Secretary, The Resources Agency, and James Strock, Secretary, CAL-EPA. Tour participants also included Craig O. Schmidt, Special Assistant, Secretary of Resource; Mike Chrisman, Deputy Secretary for Operations, The Resources Agency; Jim Wells, Pesticide Enforcement, Cal-EPA; Jim Wallis, Riverside County Agricultural Commissioner; Cynthia A. Crothers, Mayor, Moreno Valley; Robert Perkins, Executive Manager, Riverside County Farm Bureau; representatives of the California, Riverside County and San Diego County Farm Bureaus; and EMWD: Rodger D. Siems, Board of Directors; Doyle F. Boen, Director, Metropolitan Water District; and Larry Libeu, Deputy Assistant General Manager, Legislative Affairs.
Information packets and tour of USBR/EMWD Wetlands Research Facility and H/SJ Demonstration Wetlands site.

July 19 Riverside Land Conservancy, Stewardship Committee for Friendly Hills Ranch (immediately adjacent to Little Valley).
Presentation on Little Valley conceptual plans, handouts.

July 28 Workshop on Appropriate Small Community Wastewater Treatment and Reuse Approaches for the Middle East sponsored by Agency for International Development, E.P.A., U.S. Dept. of Interior, Bureau of Reclamation, California Water Resources Control Board and Regional Water Quality Control Board and hosted in California by EMWD, Humbolt State University, Arcata, CA, and National Water Reuse and Reclamation Association. Participants represented the following countries: Algeria, Egypt, Israel, Jordan, Morocco, Oman, West Bank, Gaza Strip, Tunisia, Yemen, and Russia. This forum was part of the Middle East Peace Talks. The days activities included an overview of EMWD, the Total Water Resources Management Program, and reclaimed water reuse; a slide presentation on multipurpose constructed wetlands project; and a presentation on the USBR, the Region, and the Comprehensive Water Reclamation and Reuse Study in Southern California. The afternoon field trip included a visit to the Alessandro Reclaimed Water Recharge Ponds, crops irrigated with reclaimed water, the USBR/EMWD Wetlands Research Facility, and the H/SJ Demonstration Wetlands site. A large information packet was distributed to each participant.

July 29 City of Murrieta Planning Department: Fred Buss, Assistant Planning Director, Advanced Planning; Daniel R. Clark, Assistant City Engineer; and Roger Scherer, Planning Technician.
Wetlands Research Facility and H/SJ Demonstration site tours and information packets.

July 30 California Department of Fish and Game: Tom Paulek, Manager San Jacinto Wildlife Area.
Wetlands Research Facility and H/SJ Demonstration site tour.

Aug. 19 Dr. Stanley Ponce, Chief, Research & Lab. Services Division, and Dr. Jim LaBounty, USBR.
Wetlands Research Facility, H/SJ Demonstration site, and Little Valley site tour and information packet.

Aug. 20 Ronald B. Linsky, Executive Director, National Water Research Institute (NWRI).
Wetlands Research Facility and H/SJ Demonstration site tour and information packet.

Aug. 23 Stanley J. Hightower, Head, Analysis and Water Treatment Section, and Bill Boegli, USBR.
Wetlands Research Facility and H/SJ Demonstration site tour and information packet.

Aug. EMWD Reports, Vol. 2, No. 1, August 1993, page 1, article: Wetlands Enhance Local Ecology.

Sep. 1 Ms. Aida Raymond, Civil Engineering Associate, Elsinore Valley Municipal Water District. EMWD: LeAnne Hamilton and Christie Crother.
Wetlands packet and tour of H/SJ RWRF Wetlands Research Facility and Demonstration sites.

Sep. 15 EMWD Employees District Facilities Tour (conducted by Charles Kratch.)
Handouts and tour of H/SJ RWRF sites.

Sep. 17 Inland Empire West Resource Conservation District, 1993 Conservation Partnership Awards. EMWD wins in Water Quality Category. The first annual Conservation Partnership Awards were presented for Water Quality, Technical Innovation, Community Outreach, Conservation Leadership, Employee Awareness, and Media Coverage. Over 120 projects, organizations and/or individuals were nominated.

Sep. 22 Mr. John Sayre, former Assistant Secretary, U.S. Department of the Interior. EMWD: P. Ravishanker and Christie Crother.
Wetlands packet and facilities tour including Little Valley, USBR/EMWD Wetlands Research Facility, H/SJ RWRF Demonstration Wetlands, and PL-84-984 sites.

Sep. 22 Recon (Regional Environmental Consultants) representatives: Cameron C. Patterson, Director Resources Group; Paul S. Fromer, Director Conservation Biology; and Candice Heavin Benn, Business Development Director. Conducted by Roger Turner, Senior Environmental Planner, and Betty Gibbel, Education Specialist/Community Relations.
USBR/EMWD Wetlands Research Facility and Demonstration Wetlands site tour and information packets.

Sep.23-25 WESTCAS (Western Coalition of Arid States) Display booth at Tri-State Technical Conference.
Photographs and information on Wetlands and reclaimed water reuse projects provided for display to Mr. James K. Brown, III, City of Phoenix.

Sep. 23 The Human Resource, Vol. II, Number 10, September 1993, (Newsletter included with employee paychecks), page 1, article: EMWD Hosts International Group.

Sep. 30 People's Republic of China: Mr. Li Quihon, Agronomist, Station of Agro-Ecological Environmental Protection, Hubei Province; Mr. Wang Drong, Associate Research Fellow, Institute of Agro-Environmental Protection and Monitoring, Ministry of Agriculture, Beijing; Mr. Yan Cheng, Engineer, Department of Environmental Protection and Energy, Ministry of Agriculture, Beijing; Ms. Bian Hua, Interpreter, Department of International Cooperation, Ministry of Agriculture, Beijing; and, host, Dr.Andrew Chang, Director of Kearney Foundation of Soil Science, University of California, Riverside. Tour sponsored by U.S. Department of Agriculture. EMWD: Roger Turner and Christie Crother.
Slide presentation, H/SJ RWRF site tour, and information packets.
Newspaper articles and pictures appeared in all editions of the Riverside Press Enterprise and The Hemet News.

Oct. 1 Sub-Regional Operating Group (SROG) and U.S. Bureau of Reclamation. Participants: City of Phoenix - Bill Chase, Water Advisor, Mike Gritzuk, Water Services Director, Paul Kinshella, Water Service Department, and Andrew Richardson, Consultant; City of Glendale - Grant Anderson, City Engineer; City of Mesa - William Haney, Assistant Utilities Manager; City of Tempe - Denzil Jones, Water/Wastewater Supervisor; Gila River Indian Community - - Lee Thompson, Director; and Reclamation - Carol Erwin, Planning Chief, Marvin Murray, Civil Engineer, Eric Stiles, Hydraulic Engineer, and Bernice Sullivan, Project Manager. EMWD: C. Crother, L. Hamilton, and B. Gibbel. Slide presentation, H/SJ RWRF Wetlands Research Facility and Demonstration Wetlands sites and SJWA tour, and information packets.

Oct. EMWD Reports, Vol. 2, No. 2, October 1993. Page 2 article and picture on Middle East visit and tour.

Oct. 8 Mr. Dennis Underwood, former Commissioner, Bureau of Reclamation, and Mrs. Carmen Underwood. EMWD: Mike Garner and Christie Crother.
Tour Wetlands Research Facility and H/SJ Demonstration site; information packet.

Oct. 26 Mr. David Reynolds, Federal Relations Director, Association California Water Agencies (ACWA), Washington, D.C. EMWD: J. Crossman and L. Hamilton.
Site tour, information packet.

Oct. 28 Letter rec'd: David Kincaid, Senior Scientific Advisor, Research and Exchange Division, U.S. Department of Agriculture, Office of International Cooperation and Development re: Sept. 30 visit by Chinese.

Oct. 29 Mr. Robert James, U.S. Fish & Wildlife Service, Fish & Wildlife Biologist, Carlsbad Field Office. EMWD: LeAnne Hamilton/Christie Crother.
H/SJ site tour and information packet.

Nov. 9 City of Temecula Planning Department: Saied Naaseh, Planner; Matthew Fagan, Asst. Planner; and Linda Beaudoin, Planning Technician. EMWD: Betty Gibbel
H/SJ site tour and information packet.

Nov. 12 Tom Ash, Environmental Education Coordinator, Irvine Ranch Water District, and Horticulturist, U.C. Cooperative Extension. EMWD: LeAnne Hamilton. Tour of H/SJ site and information packet.

Nov. 14 Hemet Junior Womans Club. Judging of grant applications by area teachers by Christie Crother.

Nov. 15 Nancy Rengert, Senior District Aid to Senator Bill Leonard. EMWD: Christie Crother, Dick Heil, Betty Gibbel.
Tour of H/SJ site, overview of District and Wetlands Research & Demonstration Study, information packet.

Nov. 16 City of Temecula Planning Department. EMWD: Betty Gibbel
H/SJ site tour and information packet.

Nov. 18 Margaret, research asst. to Dr. Bill Frankenburger, UCR. Bulrush for research project.

Nov. 19 Park Hill Elementary School (Teresa Gonter, 5th grade teacher and parents) visit to H/SJ RWRF and Wetlands Research Facility with Gene Hertzog, USBR, to take photos for video. Special presentation by Stella Denison - ecology games and instruction. EMWD: Betty Gibbel, Christie Crother, Steve Crombie, Joanna Tewksbury.

Nov. 20 Dr. Bill Frankenburger (UCR) and Margaret, research asst. Packet, tour of H/SJ site, bulrush for research project for US Navy on Guam (wetlands fouled with oil).

Dec. 1 Press Release: EMWD Praised for National Water Policy Contributions (wetlands project mentioned).

Dec. 9 City of Moreno Valley Planning Department. Moreno Valley: John Feenstra, Dep. City Engineer; Jeff Specter, Nita Bullock, and Chris Ormsby, Moreno

Valley Planning. EMWD: Betty Gibbel
H/SJ site tour and information packet.

Dec. 12/16 Conserve '93, Las Vegas, Nevada. Paper presented by Mike Garner. Poster Presentation by P. Ravishanker and John Crossman, EMWD, and Ron Willhite, USBR.
Requested wetlands materials sent:
Michael A. Nolan, Vernon Irrig. Dist., Vernon, BC, Canada
Phyllis Connor, San Juan Suburban Water District
Robert Kourik, West Coast Editor, Garbage Magazine
John Prendergast, Managing Editor, Civil Engineering
Rosalie Bock, Alameda County Water District

To be Scheduled: 1) USBR, Lower Colorado Region, Boulder City, Nevada, Finance Department.
2) Advisory Committees to EMWD Directors Gilbert and Ashley.

Wetlands Presentations and Tours

1991

Oct. 28 — Ted M. Weggeland, District Representative for Congressman Al McCandless, U. S. House of Representatives, and Rodger Siems, President, EMWD Board of Directors.
Slide presentation and site tour.

Nov. 1 — U.S. Soil Conservation Service: Robert D. Slayback, Plant Materials Specialist, Davis, and Bob Hewitt, San Jacinto.
Tour of Wetlands Research Facility.

Nov. 8-9 — California Water Policy - Toward a New Consensus - Conference, Los Angeles, CA.
Manned booth, continuous slide presentation, handouts.

Nov. 13 — J. L. Meyer, P.E., Irrigation and Soils Specialist, Department of Soil and Environmental Sciences, University of California, Riverside.
Slide presentation and site tour.

Nov. 15 — John Taylor, Public Works Operations Superintendent, City of Sierra Vista, Arizona.
Slide presentation and site tour (at request of USBR staff, Denver).

Dec. 11 — Steven Moise, Supervising Environmental Health Specialist, and Hugh Murray, Vector Ecologist, Riverside County Department of Health; and Dave Sandell, Vector Control Technician, City of Moreno Valley.
Slide presentation and tour.

1992

Jan.10-12 — Planning and Conservation League 1992 Environmental Legislative Symposium, Sacramento, CA.
Manned booth, continuous slide presentation, handouts.

Feb. 4 — Regional Water Quality Control Board, Santa Ana Region, Riverside Office: Bob Nicklen, Linda Garcia, Hope Smythe, and Pat Carrol.
Slide presentation and site tour.

Feb. 6 — Wetlands Executive Committee.
Slide presentation and site tour.

Mar. 5 USBR - Ed Backstrom.
Slide presentation and site tour.

Mar. 10 EMWD New Employee Orientation.
Slide presentation and handouts.

Mar. 27 Moreno Valley Regional Water Reclamation Facility: treatment plant operators and water operators.
Slide presentation and handouts.

Mar. 27 Hemet/San Jacinto Regional Water Reclamation Facility: treatment plant operators and water operators.
Slide presentation and handouts.

Apr. 2 Tom Inouye, Water Resources Control Board and TAC; Dr. Mir Mulla, Entomologist, UCR; and Dr. William K. Reisen, Research Entomologist & Director, Arbovirus Field Station, UC Berkeley.
Slide presentation and site tour.

Apr. 10 California Water Pollution Control Association Conference, Sacramento, CA.
Paper and slide presentation.

Apr. 24 Hidden Valley Wetlands Task Force: Gordon Anderson, RWQCB; Tom Paulek, Calif. Dept. Fish & Game; Gail Briggs McPherson and Patsy Chavez, City of Riverside Dept. of Public Works; Terry Frizzal, Mayor of Riverside; and Carla Wakeman, Riverside County Parks Dept.
Slide presentation, handouts and site tour.

Apr. 27 Chuck Williams and Ken Eickelberg, Sacramento Regional Wastewater Treatment Plant, Sacramento.
Slide presentation and site tour of plant propagation cells.

May 2 EMWD Administrative Branch staff.
Slide presentation and handouts.

May 12 USBR: John Johnson, Bernice Sullivan, Dick Schaefer.
Slide presentation and site tour.

May 20 Sun City Regional Water Reclamation Facility: treatment plant operators and water operators.
Slide presentation and handouts.

May 26 The Planning Center, Newport Beach: Randy Jackson and Greg Way; and Bill Dyer, EMWD.
Slide presentation and handouts.

June 5 Hemet/San Jacinto Groundwater Association (including Francis Boykin, Mayor of San Jacinto; Pam Easter, S.J. City Manager; Clayton Record, NBS Lowry; Larry Minor, Agri-Empire; and Leonard Hale and Bob Elliot, Lake Hemet Municipal Water District.)
Site tour, handouts, and article written for GW Association Newsletter.

June 9 EMWD New Employee Orientation.
Slide presentation and handouts.

June 23 Nolte & Associates: Ron Crites, Sacramento; Jon Walters and Thomas Chadwick, San Diego; and Tom Stephenson, Mission Viejo.
Slide presentation, handouts and site tour.

July 8 EPA: Harry Seraydarian, Director Water Management Division Region IX; Phil Oshida, Wetlands Section Chief; Mary Butterwick, Santa Margarita Watershed Planning; Stephanie Wilson, Wastewater on Wetlands; Rebecca Tuden; and Dave Liden. USBR: Gary Bryant. EMWD: J. A. Schlange, General Manager; Peter Archuleta; Assistant General Manager; and Mike Garner; Resource Development Administrator.
Slide presentation, handouts and tour of Wetlands Research Facility.

July 11 Moreno Valley Ecological Protection Committee (including Director Chet Gilbert; Dr. Laszlo J. Szijj, Cal Poly Univ., Pomona; City of Moreno Valley: Nita Bullock, Chris Ormsby, Stuart Sheldon, Bob Bullock, and Glen Krieger; Planning Commission and Candidate for City Council Charles White; EPC: Peter Sturtevant (Chairman), John Ryan (Chairman-elect), Cathy Godfrey, Thea Lee, Coralee Dada, Jerry Budlong, Jan Byers; and Louise Heil.
Slide presentation, handouts and site tour.

July 16 EMWD Student Interns (16).
Slide Presentation and handouts.

July 28 San Jacinto City Council and Annexation 66 Committee (including Mayor and City Manager of San Jacinto, City Council, Duck Club owners, and property owners adjacent to H/SJ RWRF).
Slide presentation, handouts, and tour of H/SJ RWRF site.

Aug. 15 ACWA (Association of California Water Agencies) Congressional Staff Tour.
Slide Presentation, Special Packets, Tour of USBR/EMWD Wetlands Research Facility and Demonstration Wetlands Site, and driving tour of San Jacinto Wildlife Area.

Aug. 17 Technical Advisory Committee for Multipurpose Wetlands Research & Demonstration Study including Linda Garcia, RWQCB; Dr. Robert Gearheart, Humbolt State University; Dr. Richard Gersberg, San Diego State University; Dr. Lee Ischinger, US F&WS NERC; John Konecny, US F&WS, Earl Lauppe,

Cal F&G; Dr. Mir Mulla, UCR; Hugh Murray and David Richardson, Riv. Co. Dept. of Health; Tom Paulek, Cal F&G San Jacinto Wildlife Area: Dr. Marilynn Yates, UCR; et al.
Slide presentation and site tour.

Aug. 25 EMWD/Metropolitan Water District (MWD) Staff Meeting. MWD Staff: Greg Taylor, Wiley Horne, Debra Man, Grace Chan, and Adam Tear. EMWD Staff: J. A. Schlange, P. Ravishanker, Tony Pack, Joe Grindstaff, Hooite Rugge, B. Mortazavi, Mike Garner, John Fricker, Jack Devers, Ted Haring, Chuck Rathbone, et al.
Slide presentation and handouts.

Sep. 25 William P. Magdych, PhD, Woodward-Clyde Consultants, San Diego, CA.
Slide presentation, handouts, and tour of H/SJ RWRF site.

Sep. 29 EMWD New Employee Orientation.
Slide presentation and handouts.

Oct. 8 US Geological Survey, San Diego Office: Dr. Terry Rees et al.
Slide presentation, site tour, and handouts.

Oct. 9 Michael Van Erdewyck, Lemna Corporation, St. Paul, MN.
Slide presentation, handouts, and site tour.

Oct. 23 Y.S.Lin, Y.S.Lin Associates, Inc., Monrovia, CA; Feng Weixing, Senior Engineer, Director, Weifang City Science Research Institute of Environmental Protection, Task Group of Prevention of Water Pollution of Wei River Basin, Aiding Item of UNDP; Yang Weirui, Senior Engineer, Associate Director of Environmental Protection Bureau of Weifang City, Member of Environment Science council of Shandong Province, Leader of Task Group of Prevention of Water Pollution of Wei River Basin, Aiding Item of UNDP; Chou-fa Yauo, Weifang City Manager; and Ye-shih Lin, P.E., DEE, President, Weifang City, China.
Slide presentation, handout packet, and site tour.

Oct. 26 EMWD Purchasing, Contracts, and Warehouse Staff Meeting.
Slide Presentation and handouts.

Oct. 26 CH2M Hill: Jag Salgaonkar - Santa Ana, CA, Michelle A. Girts - Portland, Lynn Hosley, and Tom Peterson.
Slide presentation, handouts and site tour.

Nov. 18 USBR, Lower Colorado Regional Office, Boulder City, Nevada: John E. Peterson II, William G. White, Michael T. Walker, Mary Laswell, Kathy Hedges. EMWD: Virgal Woolwolk, Roger Turner, George Borlace.
Slide presentation and tour of all three sites.

Nov. 20 California's Local Government Commission Award for Innovation in Water Conservation, Reclamation and Management for USBR/EMWD Multipurpose Wetlands Research and Demonstration Study. Award accepted by Craig Weaver, Member, EMWD Board of Directors, at annual California Water Policy: Toward a New Consensus II Conference, Los Angeles.

Nov. 24 Al McCandless, Member of Congress, David J. Schroeder, Legislative Assistant. EMWD: Rodger Siems, President, Board of Directors; Ed Hallenbeck, Deputy General Manager; Anthony Pack, Assistant General Manager, Administration; Larry Libeu, Deputy Assistant General Manager - Administration; and Dick Heil and Peter Odencrans, Community Relations Officers.
Slide presentation, site tour, special handout packet.

APPENDIX G

APPENDIX G

NEWS ARTICLES

SERVING THE SAN JACINTO VALLEY

The Hemet News

FRIDAY MORNING
February 11, 1994

One hundred first year Number 65 Hemet, California © The Hemet News, 1994 23¢ per copy

Aguanga, Anza, East Hemet, Gilman Hot Springs, Hemet, Homeland, Idyllwild, Lakeview, Menifee, Nuevo, Romoland, Sage, San Jacinto, Sun City, Valle Vista, Winchester

Washington official dedicates wetlands

by DAYNA STRAEHLEY
The Hemet News

Wetlands such as Eastern Municipal Water District is building will be the future of the U.S. Bureau of Reclamation, its commissioner said Thursday.

Daniel P. Beard, commissioner of the U.S. Bureau of Reclamation, came from Washington to dedicate the new Hemet-San Jacinto Multipurpose Constructed Wetlands that EMWD began building last month. The new wetlands are just north of the wetlands research cells behind the Hemet-San Jacinto Regional Water Reclamation Facility on Sanderson Avenue in San Jacinto.

A scheduled tour of the 43.5-acre site for the Planning Task Force, made up of water and other governmental agencies, had to be called off because recent rains turned the area to mud.

Instead, Beard cut a cake at EMWD's main offices after a short ceremony.

He called the project "a bright shining star in the Bureau of Reclamation," which recently submitted a budget that is $93 million less than last year's.

"We have less money, but we're going to do more," Beard said.

He said the bureau's old days of building massive dams are gone. Building wetlands to purify waste water is far cheaper than building sewage treatment plants, he said.

The wetlands will purify secondary-treated effluent to advanced reclaimed water standards, according to EMWD officials. At the same time, they will provide feeding, breeding and resting areas to a myriad of waterfowl. EMWD officials said 60 species of birds, including bald eagles, have been identified at its research wetlands ponds.

The ponds filled with marsh grasses remove up to 51 percent of inorganic nitrogen from the water. That water can then replenish groundwater basins, from which much of the area's drinking water is pumped.

"You're achieving water supply objectives," Beard told EMWD directors and staff. "It's a wise use of taxpayers money ... and a good environmental project."

Grants from a variety of government sources help pay for the wetlands construction. He said EMWD General Manager Andrew Schlange and former General Manager Doyle Boen, now EMWD's representative to Metropolitan Water District, showed up at his door in Washington to lobby for the wetlands funding repeatedly.

"I really think you will be looked on in the future as visionaries," for this approach to purifying waste water, replenishing groundwater and helping the environment, Beard said.

THE HEMET News
February 11, 1994

Project touted as tool to solve water problems

By Gail Wesson
The Press-Enterprise

SAN JACINTO

The mile-wide Grand Coulee Dam along the Columbia River is a monument to the past history of the federal Bureau of Reclamation, and officials yesterday touted a man-made wetlands in San Jacinto as a vision of the bureau's future water resource management.

The age of federal dam building is over and the bureau is looking at less costly, environmentally sensitive ways to solve water problems that involve cooperation among agencies, said bureau Commissioner Daniel Beard.

Gail Wesson / *The Press-Enterprise*

Inspecting the man-made wetlands project at the Hemet-San Jacinto Regional Water Reclamation Facility in San Jacinto are Daniel Beard, Bureau of Reclamation commissioner, and Christie Moon Crother, Eastern Municipal Water District project manager.

Beard called the philosophy "reclamation lite" in an afternoon stop at Eastern Municipal Water District to dedicate a multi-purpose wetlands under construction at Eastern's Hemet-San Jacinto Regional Water Reclamation Facility.

"We're in a new era and a new agenda and we have a different vision than we had in the past. This project fits that mold. There is nothing else in our program like it," Beard said.

In a joint five-year project between the bureau and Eastern, water quality experts and scientists are studying how bulrush and other selected plants grown in wetlands can improve the quality of wastewater passing through a marsh en route to re-use for irrigation. The study is also looking at how the artificial marsh can create an attractive habitat for waterfowl.

Beard spoke in a ceremony at Eastern's San Jacinto headquarters attended by representatives of cities, Riverside County and other public agencies that regularly meet to discuss water management policies.

Then he walked the levee at the wetlands for a first-hand look at federal dollars in action. He learned that ruddy ducks use the man-made marshes for breeding and watched flocks of blackbirds sally over the bulrushes.

Eastern started a small-scale research site in 1992. Excavation of a much larger 43-acre demonstration wetlands began last month. The marshes should be finished by summer. Educational programs for visitors will be developed later. The bureau administers federal water policy in the west and administers dams and irrigation projects. It is the largest water wholesaler in the country.

The wetlands is among water reclamation projects financed by almost a $50 million federal grant and loan package in its fourth year. The government has provided $17 million to Eastern already. Part of the package is a network of pipelines linking the district's five sewage treatment plants so the water can be delivered to customers throughout the district.

The federal budget proposal released earlier this week includes $4.1 million in continued funding for Eastern's reclaimed water projects, half from the bureau.

The bureau's budget proposal includes $14.7 million for wastewater reuse and conservation programs in Southern California.

THE PRESS ENTERPRISE
Hemet/San Jacinto
February 11, 1994

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Press-Enterprise
(Moreno Valley)

2/11/94

WaterWatch

EMWD WETLANDS PROJECT EARNS AWARD

Eastern Municipal Water District, San Jacinto, Calif., has been honored with the Conservation Partnership Award for its efforts in improving water quality.

EMWD's Multi-purpose Wetlands Demonstration and Research Study in San Jacinto treats wastewater to higher standards for wider industrial and agricultural reclaimed water use. Initial studies have proven successful in removing pollutants, such as heavy metals and nitrates, while providing needed wetland habitat for waterfowl, fish and wildlife.

Three large-scale wetlands demonstration sites are planned, with each site to accomplish the equivalent of a 1 mgd. conventional facility.

The award was one of six given by the Inland Empire West Resource Conservation District, Inland Empire Business Journal and The Gas Company.

SOURCE
Winter 1993/94

MORENO VALLEY CHAMBER OUTLOOK
The Official Publication of the Moreno Valley Chamber of Commerce
Vol. 9, No. 9, Nov/Dec 1993

Wetlands Project Earns Conservation Partnership Award

Eastern Municipal Water District's efforts in improving water quality have been honored with the Conservation Partnership Award, it was one of six such awards.

The presentation was held in Redlands September 17. It was sponsored by the Inland Empire Business Journal and the Southern California Gas Company. EMWD's project was selected from more than 1200 nominations for outstanding conservation accomplishments in community outreach, conservation leadership, employee awareness, media coverage, technical innovation or water quality.

EMWD's Multipurpose Wetlands Demonstration and Research Study in San Jacinto treats wastewater to higher standards for wider industrial and agricultural reclaimed water use. Initial studies have proven successful in removing pollutants such as heavy metals and nitrates, while also providing needed wetland habitat for waterfowl, fish and wildlife.

Three large scale wetlands demonstration sites are planned, with each site to accomplish the equivalent of one-million gallon-per-day conventional facility.

The Inland Empire West Resource Conservation District is a self governed, non-profit local government agency established by conservation+minded, local residents through state law. Its purpose is to help all residents within its boundaries conserve and develop their natural resources through good conservation practices.

EMWD is a water rēsource agency that in addition to supplying fresh water, normally treat about 25 million gallons a day of wastewater at five regional facilities, which serve some 280,000 residents.

MORENO VALLEY
CHAMBER OUTLOOK
Nov/Dec/ 1993

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PERRIS PROGRESS
12/8/93

EMWD receives a high award for its local wetlands projects

SAN JACINTO - Eastern Municipal Water District (EMWD), a national leader in the field of water management, has received the President's Award during the National Wter Resources Association (NWRA) annual meeting in San Diego.

Dr. Wm. Aldridge, EMWD board vice-president, accepted the award from NWRA Immediate Past President James Trull. The award is given annually to those persons or groups who have made an outstanding contribution to national water management and policy. Dr. Aldridge represents EMWD on NWRA's Municipal Caucus.

EMWD was noted for its outstanding efforts working with the U.S. Bureau of Reclamation and the Department of Interior, and for assistance to NWRA in working with the congressional delegation.

One program EMWD is successfully pursuing with the Bureau of Reclamation includes a wetlands project that has drawn international interest. Major benefits in the reclamation effort include increased groundwater recharge and replenishment, wildlife enhancement and increased availability of reclaimed water for agriculture and other landscaping needs.

EMWD serves a 539-square-mile service area, larger than the city of Los Angeles, and a population approaching 400,000.

EMWD receives conservation award

Eastern Municipal Water District's efforts in improving water quality have been honored with the Conservation Partnership Award. It is one of only six such awards.

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The Valley Times
Friday, October 15, 1993

San Jacinto ponds draw eyes from around world

By Gail Wesson
The Press-Enterprise

SAN JACINTO

Like the waterfowl that have discovered the place in the past two years, tourists increasingly are flocking to marsh-like ponds at the western edge of San Jacinto.

Yesterday the visitors came from the People's Republic of China and today another group from Arizona will get a similar tour from Eastern Municipal Water District project coordinator Christie Moon Crother.

The attraction is the wetlands research and demonstration study at the Hemet-San Jacinto Regional Water Reclamation Facility.

In the joint five-year project of Eastern and the federal Bureau of Reclamation, water quality experts and scientists are studying how bulrush and other selected plants grown in wetlands can improve the quality of wastewater passing through a marsh en route to re-use for irrigation. The study is also looking at how the artificial marsh can create a luring habitat for waterfowl.

The tour emphasis was water quality management related to agriculture for four Chinese visitors who toured the wetlands yesterday. They were midway through a week-long coast-to-coast trip arranged through the U.S. Department of Agriculture.

"This is one of the most progressive water districts in California," said Andrew C. Chang, director of the Kearney Foundation of Soil Science at the University of California, Riverside, who arranged the visit to San Jacinto and served as their host for the day. They also met with UCR researchers.

Eastern is the fourth largest user of treated sewage water in the state. It has teamed with the government agencies, academic institutions and private groups on research projects involving water supply and quality issues.

Wang Derong, assistant research fellow in the Ministry of Agriculture in Beijing, came with rolled-up sleeves and a camera, occasionally bending down for a closer look at the plants growing in research ponds.

"He is quite interested in this kind of a system," Chang explained. In Beijing, Wang is using different types of aquatic plants, but like Eastern, is interested in finding out which produce the best results.

Wang, speaking through an interpreter, said Eastern's ponds are larger than the ones in Beijing.

In China ponds have been used to treat pollution, such as the highly saline water associated with mining in areas that in ancient times were marine areas.

Other experiments involve growing crops, such as a salt-resistant rice, agronomist Li Qui-hong explained to Chang.

Eastern's project has two plant nursery ponds, called cells, eight research cells and a small reverse-osmosis plant where highly saline concentrate is removed from water, then used to grow salt-tolerant plants. Work will start on a 43-acre demonstration wetlands in January, said Crother.

Australians, another Chinese group and a multinational contingent from north Africa and the Middle East have visited the site recently.

Like Eastern, the Middle Eastern visitors were interested in use of the ponds for environmental enhancement because their countries are also along a waterfowl migratory route, Crother explained.

The Press Enterprise
Riverside Edition
October 1, 1993

Greg Vojtko / The Press-Enterprise

Chinese visitors listen to Christie Moon Crother, second from right, explain the wetlands research and demonstration study at the Hemet-San Jacinto Regional Water Reclamation Facility yesterday. Crother works for Eastern Municipal Water District.

The Press Enterprise
Hemet-San Jacinto Edition
October 1, 1993

Greg Vojtko / The Press-Enterprise

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Please see **WETLANDS, B-6**

WETLANDS

Continued from **B-1**

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Chinese delegation visits Eastern

■ Reclamation plant latest stop on national tour of water sites

by FRANK GEARY

The Hemet News

Americans are fortunate because from sea to shining sea there is plenty of water for everyone, according to a delegation of Chinese scientists who toured Eastern Municipal Water District's water reclamation plant Thursday.

"In his opinion water distribution is more equal in the United States because water goes to everyone despite geographical and climate differences between regions," stated Andrew Chang, a professor from the University of California, Riverside, who interpreted for Li Quihong, director of the delegation.

"Throughout most of the world, and in China, the demand for fresh water is always increasing, but the supply is decreasing at the same time," Quihong stated through the interpreter.

Quihong and his associates are part of an international exchange program. Before coming to the San Jacinto Valley, they toured water management facilities in New York, Washington D.C. and Michigan earlier this week, said Christie Moon Crother, project coordinator for the reclamation plant on Sanderson Avenue, west of San Jacinto.

The representatives from the People's Republic of China were not the first group of foreigners to tour the local facility. A group of representatives from countries in the Middle East, and scientists from Australia also visited the plant within recent months, Crother said.

"The thing that makes our reclamation plant unique is

(See WATER, Page A-8)

DeeAnn Jorgensen/The Hemet News

Christie Crother, left, with interpreter Hua Bian, second from left. From right are Quihong Li, Cheng Yan, Dr. Andrew Chang of UC Riverside.

WATER -

(Continued from Page A-1)

that it is multipurpose and that it was intentionally designed to be multipurpose," she said.

It is important for underdeveloped nations to acquaint themselves with wetlands reclamation projects because they clean dirty water using low-cost and all-natural methods, Crother said.

The large-scale local plant is used to test new methods of preserving reclaimed water, and it provides an important environmental function since its marsh lands are beneficial to migrating birds, she added.

Also, the facility provides a perfect bird-watching site and is an excellent educational resource for students in local science classes.

Additionally, according to Roger Turner, senior planner for EMWD, the reclamation plant has practical purposes for water customers as well as water scientists because it will eventually help to subdue increasing water rates.

"The plant won't lower the water bills. But it will help because 80 percent of the water we use comes from outside vendors, and the reclaimed water will help us to cut down on the amount of outside water we will need in the future," Turner said.

The Hemet News
October 1, 1993

EMWD honored for wetlands project

by The Hemet News

Eastern Municipal Water District's efforts to improve water quality through its wetlands research have been honored with the Conservation Partnership Award.

It is one of only six such awards in the Inland Empire.

The presentation was earlier this month in Redlands and sponsored by the Inland Empire West Resource Conservation District, Inland Empire Business Journal and The Gas Co.

EMWD's wetlands project was selected from more than 120 nominations for outstanding conservation leadership, employee awareness, media coverage, technical improvements or water quality.

EMWD's Multipurpose Wetlands Demonstration and Research Study off Sanderson Avenue in San Jacinto treats wastewater to higher standards for wider industrial and agricultural reclaimed water use. Initial studies have proved successful in removing pollutants, such as heavy metals and nitrates, while also providing needed wetland habitat for waterfowl, fish and wildlife.

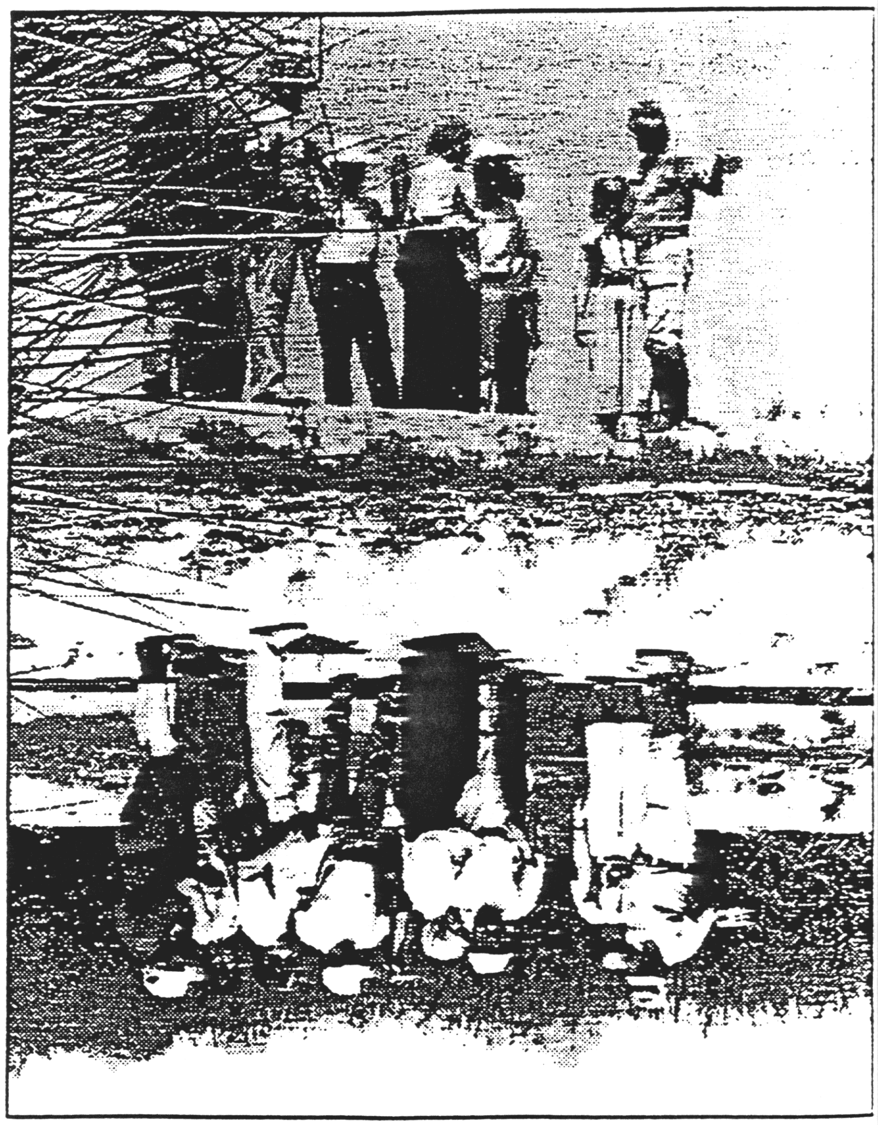
Three large-scale wetlands demonstration sites are planned, with each to accomplishing the equivalent of a one-million-gallons-per-day conventional facility.

Inland Empire West RCD is a self-governed, nonprofit local government agency established by conservation-minded local residents through state law. Its purpose is to help all residents within its boundaries to conserve and develop their natural resources through good conservation practices.

EMWD is a water resources agency that, in addition to supplying fresh water, normally treats about 25 million gallons a day of wastewater at five regional facilities, which serve some 280,000 residents from the San Jacinto Valley through Moreno Valley and Temecula.

THE HEMET NEWS
TUES, SEPTEMBER 28, 1993

EMWD Contributes to Middle East Peace. Historic Middle East peace agreement and Israel-Jordan pact to cooperate on development of water resources reflect a part of EMWD. State Department brought 16 water experts from 11 governments to U.S. in July and August to study American techniques. Group spent a day with the District in San Jacinto observing use of constructed wetlands to economically reclaim wastewater. Water purity surprised some. This photo shows visitors reflected in clear, treated water; actual visitors beside pond are in upended image at bottom.



WATER PROFILE

EMWD in the Spotlight

Eastern Municipal Water District covers a good part of what is known as the *Inland Empire*. Located south of Riverside and west of Palm Springs, it includes the cities of Moreno Valley, Hemet, Temecula, Perris, San Jacinto, Murrieta, and parts of Riverside.

People moving out of LA and Orange counties have made it one of the fastest growing areas in California.

Shortly after forming in 1950, Eastern joined the Metropolitan Water District of Southern California to take advantage of the water that was being brought through the region to other southland areas. Lake Perris, the terminus for the 647 mile-long California Aqueduct, is located in the center of the district, and the Colorado River Aqueduct bisects the district on its way to nearby Lake Mathews.

Originally encompassing 86 square miles with a population of 20,000, the service area now exceeds 537 square miles - larger than the city of Los Angeles - and serves a population of over 400,000.

EMWD serves water directly to Moreno Valley, Murrieta, and Perris, and wholesales water to local water agencies which serve the remainder of the district.

EMWD also provides sewer service to most of the area, and maintains five regional reclamation facilities that can produce up to 43 million gallons of reclaimed water a day.

Eastern's Water Projects

Responsible for a large arid area, EMWD has been busy and innovative in the goal to develop available local water resources in order to reduce the district's reliance on imported water which was about 80 percent last year.

The district is considered to be at the leading edge of reclaimed water use and research, nationally, and has received federal funding to continue some of this innovative work.

In 1993-94, the district plans to begin brackish groundwater desalination and "water harvesting", a strategy where rainfall runoff from new developments in the area is captured and stored in groundwater basins.

Eastern's Wetlands Project

One of the most interesting projects is Eastern's experiment to use marshlands for water reclamation.

The district has constructed a 4-acre marsh-like wetlands near one of its wastewater treatment facilities. Using gravity, partially treated water is channeled through the wetlands.

Densely planted bulrushes feed on nutrients in the water as it seeps from one end of the wetlands to the other where it is then pumped out.

The result is a more-highly treated discharge from the processing facility, a thriving marshland for birds and small animals, and treated water safe enough for irrigation. This winter the marsh experienced an intense migratory bird population.

Jointly funded by Eastern and the US Bureau of Reclamation, a 30-acre project is planned for later this year that could supply up to one million gallons of usable water per day.

Eastern's Public Service

Of equal importance to EMWD are its public involvement activities. These include public information and education programs, demonstrations and seminars on water-wise landscapes, and a bi-monthly newsletter sent out with the water bill.

Last year, and this is ongoing, they distributed free home plumbing retrofit kits to about 5,000 customers.

In 1992, Eastern won prestigious awards from the Association of California Water Agencies (ACWA), the California Local Government Commission, and local agencies for the district's excellent public service and water conservation programs.

Eastern Municipal Water District

P.O. Box 8300
2045 S. San Jacinto Street
San Jacinto, CA 92581-8300
Telephone (909) 925-7676

Established
1950

Member
Metropolitan Water District of Southern California

Location
South-West Riverside County

Service Area
Square Miles - 537
Population - 400,000

Water Services
Connections - 74,000

Sewer Services
Connections - 87,000

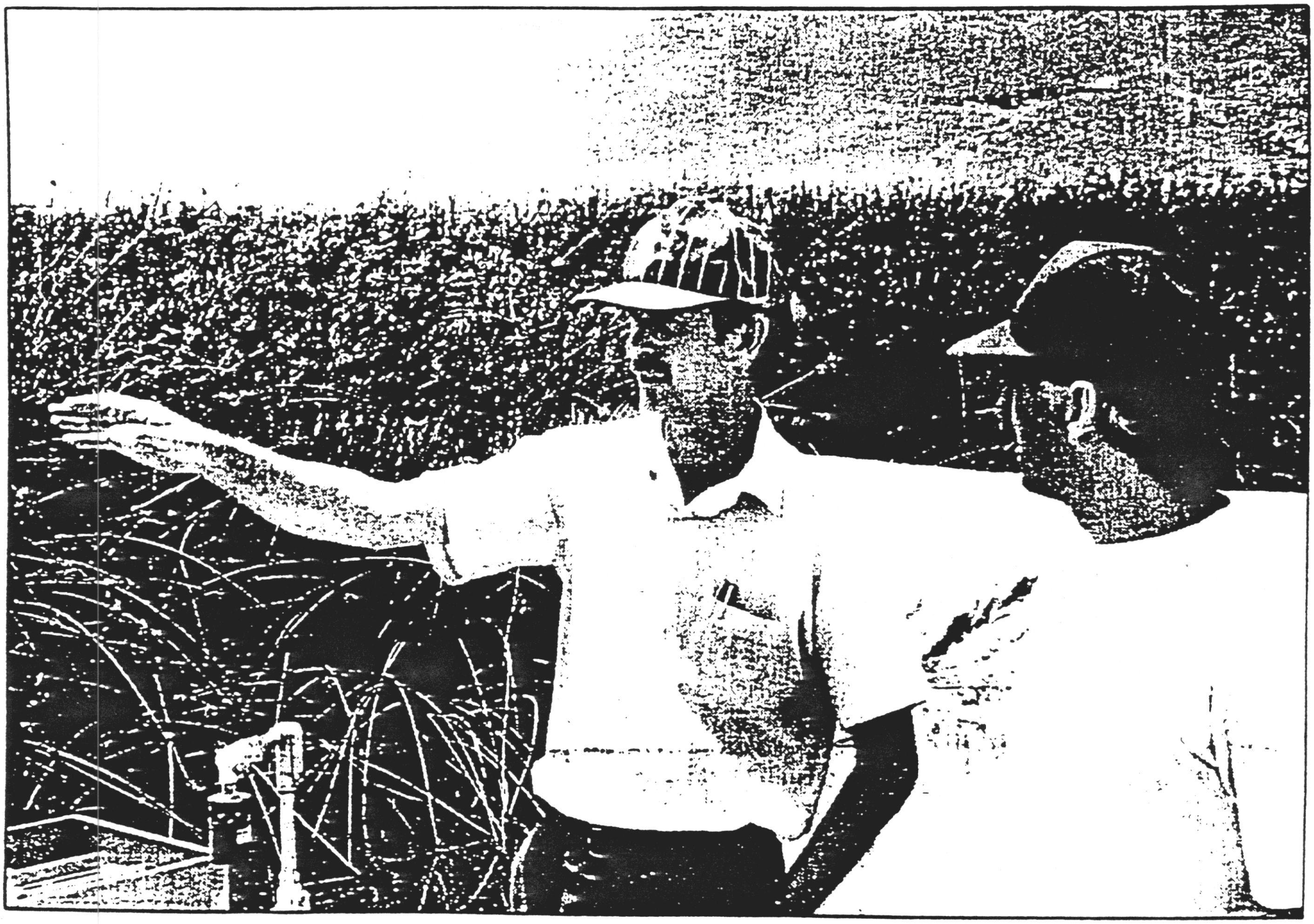
Water Supply
Imported - 60,000 AF
Groundwater - 15,000 AF
Reclaimed - 14,000 AF

Personnel
Employees - 546

General Manager
J. Andrew Schlange

Directors
Chester C. Gilbert President
Wm. G. Aldridge V. President
Rodger D. Siems
Craig A. Weaver
Marion V. Ashley

Metropolitan Water District Board Member
Doyle F. Boen



Dayna Straehley/The Hemet News

Daryl McGregor of Australia, left, looks over the wetlands research project as EMWD chemist Steve Crombie explains the project.

Wetlands catch Aussie's eye

EMWD project visited by Australian city rep seeking treatment solutions

by DAYNA STRAEHLEY
The Hemet News

A San Jacinto Valley project to use marsh grasses to treat sewage effluent is being studied by an Australian city.

Daryl McGregor, manager of investigation and design for the Albury City Council, visited Eastern Municipal Water District's wetlands research project behind the Hemet-San Jacinto Regional Water Reclamation Facility on Sanderson Avenue.

Albury is an inland city on the Murray River between Sydney and Melbourne.

In EMWD's wetlands project, effluent that has been treated to secondary standards slowly flows through a 50- by 230-foot pond filled with bullrushes and teeming with blackbirds and other wildlife.

EMWD's project, with the U.S. Bureau of Reclamation, has eight research ponds and two nursery ponds growing bullrushes to propagate.

The plants' roots are fertilized by the impurities in the water. Researchers are trying to determine the quality of the water when it comes out of the other end of the pond, said Christie Moon Crother, project coordinator.

Secondary-treated effluent is often used to irrigate golf courses and crops such as livestock feed or tree crops.

But unlike arid Southern California, Albury receives enough rain that there is no demand for reclaimed water for irrigation, McGregor said. "We couldn't give it away," he said.

Cities downstream of Albury are concerned about the Murray River's water quality and don't want the city's treated effluent, no matter how well treated, he said.

(See EMWD, Page A-11)

EMWD -

(Continued from Page A-1)

McGregor said he and his wife have been traveling around the World the past five weeks to see how effluent is handled in various places. They visited Johannesburg, Pretoria and Capetown, South Africa, as well as four cities in Florida and five stops in California, all recommended by California Water Pollution Control, including EMWD on Tuesday, he said.

"We'll be recommending wetlands with probably some irrigation of woodlands and parks .. with no direct discharge into the river," McGregor said. Effluent would be put into wetlands in the winter when it can't be used for irrigation, he said. From the wetlands it could then seep into the river.

Although Australians downstream of Albury don't see reclaimed water as a valuable resource yet, "We've reached the point where all water has been spoken for," McGregor said.

"If we took it out to dryland areas and irrigated, it's just gone, whereas with wetlands, it's still there," he said.

McGregor seemed to be impressed Tuesday with all the birds that have made the 8-foot-tall marsh grasses their home.

"With such a dry land, it's kind of a boon," he said about the wetlands.

The Hemet News Thursday, November 26, 1992

EMWD honored for conservation

by The Hemet News

California's Local Government Commission has recognized Eastern Municipal Water District for innovation in water conservation, reclamation and management.

EMWD was honored for its Multipurpose Wetlands Research and Demonstration Study, an approach to expanded use of reclaimed water.

The five-year project involves the use of wetlands constructed to treat wastewater and brackish groundwater in order to reuse it for agricultural and groundwater recharge purposes.

Craig A. Weaver, a member of EMWD's board of directors, accepted the award Friday on behalf of the agency during the commission's statewide conference on critical water policy issues.

Eastern is conducting the research and development study in cooperation with the U.S. Bureau of Reclamation and in consultation with other government agencies, the academic community and environmental groups.

Eastern Municipal Water District provides water and wastewater services throughout a 534-square mile area of western Riverside County with a population of about 380,000.

Water district wins kudos for conservation efforts

Eastern one of five agencies so honored

The Press-Enterprise

SAN JACINTO

Industry associations have been showering awards on Eastern Municipal Water District for leadership in preaching and practicing water conservation.

Eastern was one of five Association of California Water Agencies' member districts to receive a water management certificate recognizing its commitment to efficient water use.

The association noted several examples of Eastern's strategy, including education, programs to reduce demand and research into alternative supplies. The district also has drafted other public agencies in the campaign to conserve water.

The district serves central and southwest Riverside County.

Last month the Local Government Commission, a non-profit educational group comprised of public agency officials, honored the district for its experimental wetlands project at the San Jacinto Regional Water Reclamation Facility.

In a joint experiment with the U.S. Bureau of Reclamation, Eastern is studying how bulrush plants grown in a wetlands can improve the quality of wastewater passing through a marsh en route to re-use for irrigation.

The district received one of 14 awards given to private industry, agriculture and water agencies.

Also last month, General Manager J. Andrew Schlange received an award for innovation in addressing water supply challenges from the Valley Group, an organization of community leaders dedicated to economic advancement of western Riverside County.

Eastern will vote on continuing wetlands project

■ **PLANS:** *District may join government in creating three marsh land sites*

CHUCK HARVEY/*The Californian*

SAN JACINTO — Eastern Municipal Water District likely will continue a joint four-year project with U.S. Bureau of Reclamation to create wetlands for water reclamation.

The district board will vote Jan. 22 on spending $430,000 to complete the program. Total project cost is $928,000 and the Bureau of Reclamation has agreed to pay half.

Project plans include use of treated waste water to create wetlands in three locations within the district: west of Eastern's Hemet-San Jacinto Regional Water Reclamation Facility, Little Valley in east Hemet and the Hemet-San Jacinto Wildlife area near Lake Perris.

Phase I of the project, design and environmental assessment of trial marshes, has been completed. Phase II, which includes a demonstration project, is underway at the Hemet, San Jacinto Regional Water Reclamation Facility.

There, bulrush plants are being used in two half-acre plots to purify treated waste water. The plots are a first step in breeding bulrush plants for transfer to a nearby 20-acre marsh.

Secondary treated water, which has had solid materials removed, will enter the marsh at one end and highly clarified water will flow out of the other end. Nutrients like nitrogen and phosphorous are removed from the water by bulrush plants.

The 20-acre marsh will be capable of treating 1 million gallons of treated waste-water each day.

In later phases of the wetlands project, marshes will be created using brackish water from the Menifee area. The bulrush plant, a narrow-stemmed member of the sedge family, will again be used with the salty water, said district spokesman Peter Odencrans.

Once demonstration projects are completed, much larger wetlands will likely be created, covering as much as 20 acres, Odencrans said. Some of the reclaimed water produced will be used to enhance wildlife and recreation corridors around area streams, he said.

The Californian
January 9, 1992

Water district to create wetlands for project

By LINDA M. HICKMAN
Staff Writer

To the Eastern Municipal Water District, conservation means more than low-flow shower heads and efficient lawn maintenance.

The EMWD is attempting to enhance the environment while easing the effects of the drought through a five-year plan to build more than 600 acres of wetlands.

According to Christie Crother, project coordinator for the water district, the wetlands would be marshy areas that would provide a habitat for various kinds of plants and animals.

In addition, they would serve as a natural filter for water that otherwise would not be safe for domestic use, Crother said.

The wetlands would be built using reclaimed water, sewage water that has gone through various chemical treatments. Usually, the water would be too high in nitrates to be consumed, Crother said.

However, the wetlands would include plants such as bullrushes that use nitrates as fertilizer. The plants would draw the contaminants out of the water, increasing its purity. Crother said this water then could be used for agricultural irrigation, or even pumped into the area's groundwater for eventual domestic use.

Crother said other water agencies have experimented with wetlands projects, but none has attempted to reuse

See PRESERVE, A-3

Staff photo by Linda M. Hickman

A riparian area similar to the one shown above will be developed by the Eastern Municipal Water District as part of an effort to make more efficient use of reclaimed water.

Preserve: Wetlands job started

From Page A-1

that water."

According to Crother, the water district has completed the first phase of the project and is beginning the second. In the first phase, EMWD technicians grew more than two acres of bullrushes in a nursery and studied the plants' development.

Next, the district will place the plants in a miniature version of the wetlands, a structure approximately 20 by 230 feet long. Technicians then will study the project to see what changes will have to be made before the plan can proceed.

Once this phase of the research is complete, the district will build three small wetlands areas, an average of 20 acres each, in the San Jacinto and Hemet area. These sites will be studied before other, larger wetlands are built, Crother said.

She said each of the three demonstration projects would be able to treat approximately 1 million gallons of water per day.

According to Crother, the sites for the final acreage of wetlands will not be chosen until later in the study. "This is a very long-term project," she said.

However, EMWD literature on the project said one site probably will be 160 acres near the San Jacinto Wildlife Refuge. Another 300 acres probably will be placed along the Temescal Creek from Lake Elsinore to the Santa Ana River.

The project also can be used for recreation, the report said. One of the demonstration projects will include a trail around the wetlands with animal observation points and displays.

EMWD officials have said they do not yet know how much the completed project will cost. However, the district will share the expense with the United States Bureau of Reclamation, and may get loans or grants from the government under the Small Reclamation Project Act of 1956.

According to documents distributed by the EMWD, the project was a reaction not only to the need to use reclaimed water more efficiently, but also to President Bush's policy of "no net loss" of wetlands.

The document said approximately 90 percent of the wetlands in California, and half of those in the U.S., have been drained or filled and the land used for other purposes.

The wetlands construction will be part of a larger expansion of the EMWD's reclaimed water treatment facilities. Other projects included will be the construction of 45 miles of pipeline, two pumping plants, and an additional water treatment plant in San Jacinto.

Menifee Valley News
10/24/91

Bulrush root of wetlands experiment

By Mark Henry
The Press-Enterprise

HEMET

A papyrus-like plant once used in constructing a basket for the baby Moses, as told in the Bible, is at the root of a wetlands experiment designed to improve water quality and create a refuge for wildlife.

Water quality experts say the plant, called bulrush, is growing beyond all expectations in a nursery at the Hemet-San Jacinto Regional Water Reclamation facility on Sanderson Avenue in Hemet. If the bulrush continues to grow and spread across two half-acre areas, the plant will be transplanted by next spring into a 20-30 acre marshland at the reclamation facility, said Project Coordinator Christie Moon Crother.

Two species of hard-stem bulrush have reached a height of 6 to 8 feet and are spreading rapidly from where they were originally planted in July, she said.

"It's growing like a weed — they're growing great," Crother said.

The joint experiment by the Eastern Municipal Water District and the U.S. Bureau of Reclamation is designed as a low-tech method of improving the quality of wastewater that has already gone through treatment at the reclamation facility, Crother said.

A report on the experiment said previous studies in the United States have shown wetlands reduce the level of nutrients and many pollutants in wastewater as it passes through the wetlands system. The water can be used for landscape irrigation, golf courses and fodder and feed crops.

The four-to-five year experiment will further evaluate the effectiveness of combining traditional treatment techniques with the marshland.

Water reclamation experts also hope the marshland will attract wildlife, specifically shorebirds, migratory birds and other waterfowl, she said. The wetlands acreage also would include public access for bird watching, hiking and environmental studies.

The cost of the project was not available, though it is part of a $46-million program to improve water quality and add water pipelines, said Easter spokesman Peter Odencrans.

Joan Thullen checks growth.

Press Engerprise
Hemet
10/12/91

Wetlands gain focus in area

RANCHO NEWS 10/10/91

Rancho News Opinion

Wetlands. The word and concept are trickling down from the national to the state and now the local level as an issue to watch for the 1990s.

A collective term for swamps, marshes, bogs and estuaries, wetlands as a whole have become increasingly scarce. An estimated 200 million acres have disappeared nationally since the mid-1800s, either drained or filled for various uses, including agriculture, flood control, regional highways and urban development. In California about 90 percent of the original wetlands have been displaced, according to the Association of California Water Agencies.

Officials at all levels of government are pushing to preserve natural wetlands and create new, artifical ones, for example, at water reclamation sites or in unlined canals. President Bush has pledged a "no net loss" commitment to ensure wetlands protection. California Governor Pete Wilson provides for wetlands as part of his "Resourceful California," a big, multi-agency resource management plan.

The local area is no exception. We're beginning to hear about about wetlands construction. Officials sing praises of their environmental benefits as places for waterfowl to inhabit, for example. And more to the point of water business, their benefits in treatment of municipal wastewater are being touted. The marshy areas act as a filter for pollutants and reduce undesired nutrients, which make them an asset in wastewater treatment.

Eastern Municipal Water District, which sells wholesale water to the Temecula-based Rancho California Water District, has begun a four- to five-year wetlands demonstration and research project. The project will provide reclaimed water for expansion and creation of three separate wetlands, covering approximately 600 acres, that would not otherwise be possible because of the area's water shortage.

This week, researchers are examining the merits of bullrushes as natural filters for treating water in the Hemet/San Jacinto Regional Water Reclamation Facility. If all goes well, EMWD may propagate this wetland plant.

The Lake Elsinore Management Project, meanwhile, has begun a plan to restructure the lake's boundaries as part of an overall project to stabilize its water resource. A new pipeline, wells and pumping stations will be installed to move water between the lake and wetlands areas. A man-made 356-acre wetlands area will provide habitat for birds, small mammals, reptiles and amphibians. The United States Bureau of Reclamation will fund $26 million of the project with an estimated $18.5 million expected to be raised in local contributions, according to Lake Elsinore Management Authority.

There is little argument that water management activities like conservation, storage, reclamation, reuse and conveyance facilities are essential in meeting local and statewide water supply needs. To gain public support and financial backing for wetlands, however, officials will have to show, among other things, that they are striking a balance between human demands for water and those of the natural environment.

Riverside Press Enterprise 10-12-91

Carla Conti-Bender / *The Press-Enterprise*

Jim Sartoris of the U.S. Bureau of Reclamation sifts through samples taken from the mud in the south nursery at the Eastern Municipal Water District. Specimens will be studied to see how the wetland can be best used.

Bulrush root of wetlands experiment

By Mark Henry
The Press-Enterprise

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Joan Thullan checks growth

STEVE THORNTON/The Californian

Doug Andersen of the U.S. Bureau of Reclamation counts mosquito larvae in the experimental treatment pond.

Water district enlists Mother Nature in effort to reclaim waste water

ECOLOGY: *Pilot project uses plants instead of chemicals*

CHUCK HARVEY/The Californian

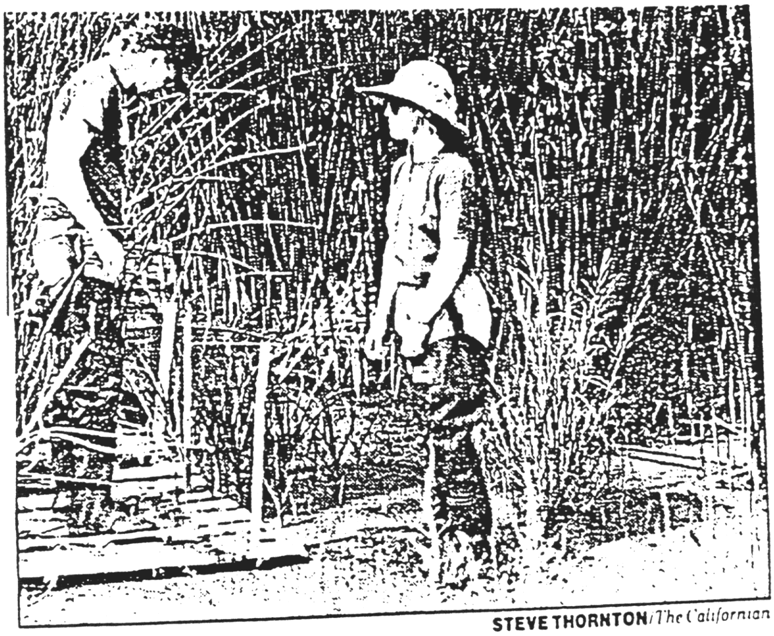
HEMET — An Eastern Municipal Water District project to reclaim waste water with vegetation has passed its first hurdle.

Bulrush plants are flourishing in two half-acre plots at Eastern's Hemet, San Jacinto Regional Water Reclamation Facility. The plots are the first step in raising bulrush plants for transfer to a nearby 20 acre marsh. There the plants will help reclaim 1 million gallons of reclaimed water each day.

Water will be purified to an advanced level acceptable for golf course irrigation, percolation into underground reserves and use in lakes. A secondary goal of the project is to halt the loss of wetlands in the U.S. by introducing water reclamation marshes.

"The plot is doing well," said Jim Sartoris, an engineer with the U.S. Bureau of Reclamation's Denver office. "It is just thriving. We are very

Please see WATER, A4 ▶



STEVE THORNTON/The Californian

Jim Sartoris and Joan Thullen of the U.S. Bureau of Reclamation take measurements in the experimental pond.

WATER: Mother Nature put to use

Continued from A1

pleased. This has really turned into a marsh."

The bureau would like to know if bulrush marshes can reclaim water in arid areas such as Riverside County.

So far the answer is a resounding "yes." Bulrush was planted in 3-foot tall clumps six weeks ago and have grown to 7 feet and have started seeding.

"They *are* heat tolerant," Sartoris said.

The plants, found in parts of Riverside County, were provided by private land owners and state parks. Parks provided the plant following lake- and stream-clearing operations.

If success continues with the narrow-stemmed sedge, it may someday replace expensive water purification equipment at sewage treatment plants. On Tuesday, Sartoris visited the Hemet test plot with bureau biologist and botanist Joan Thullen and wildlife biologist Doug Andersen.

Andersen checked the marsh for mosquito larvae and found 13. The goal is to eliminate mosquitos from the marsh and bats will probably be brought in to do the job, Sartoris said.

Elevated boxes will be set up around the marsh to provide homes for the bats.

Sartoris said the 20-acre marsh will be planted next year. Secondary treated water which has had solid materials removed, enters the marsh at one end and highly clarified water flows out the other end.

Nutrients like nitrogen and phosphorous are removed from the water by the bulrush plants. Algae, which is not welcome in the marsh, is kept under control by floating plants that choke it out.

The floating plants, duckweed and hydrocotyl (also known as pennywort) also provide feed for water fowl. Control of algae is important, Sartoris said, because it causes a foul taste and odor in water.

(THE CALIFORNIAN) - Temecula Edition
Wednesday, October 9, 1991

Wetlands to make comeback

by DAYNA STRAEHLEY

Hemet News staff writer

Before humans developed the San Jacinto Valley, wetlands were home to many plants and animals.

In a few years, wetlands will again be home to plants and nests for birds, said Christie Moon Crother, project coordinator for EMWD's multipurpose wetlands study.

Eastern Municipal Water District, with help for the U.S. Bureau of Reclamation, has planted two half-acre nurseries with hard-stem bulrushes to study the best ways to create marshes with reclaimed water.

Some of the partly treated effluent from the Hemet-San Jacinto Regional Wastewater Reclamation Facility on Sanderson Avenue has filled the two nursery areas where the plants are busy feeding on the impurities still in the water.

"That's what the plants are eating," Crother said Tuesday as she watched scientists from the Bureau of Reclamation wade through the research ponds full of bulrushes, collecting samples they will analyze when they get back to Denver.

The bulrushes, which she said were small and bent over when they were planted in early July, now stand more than 6 feet tall and some are more than 8 feet.

She said the survival rate and growth of the transplanted bulrushes has far exceeded expectations. The two varieties were chosen because biologists expect they will provide the best treatment for the water.

Staff photo by Brian L. Robson

Jim Sartoris, an environmental engineer for the U.S. Bureau of Reclamation, stirs up the mud found in the wetlands to research different types of life forms in the sediment.

Planted among the two species of bulrushes, *scirpus equtus* and *scirpus Californicas*, are some tiny, flowering duck weed and marsh pennywort. Dragonflies buzz in around, feeding on smaller insects.

"The dragonflies were among the first to arrive after we planted," Crother said. "They started breeding and seem very happy here."

By the end of this month, when snow falls in Canada, birds migrating the Pacific Flyway will stop here, too, she said.

The research project is the beginning of three wetlands EMWD plans as natural treatment systems for reclaimed water.

"It creates open areas and habitats for wildlife," Crother said.

Wildlife that researchers expect will be attracted include raptors such as eagles and hawks, native song birds, deer and small mammals.

(See WETLANDS, Page A-12)

WETLANDS: Project to return plants, wildlife to swamps

(Continued from Page A-1)

The first wetland, a 20- to 30-acre marsh behind the regional wastewater treatment plant, is expected to be able to treat one million gallons a day of effluent that can be re-used for irrigation. District officials hope construction on the wetland can begin by July or August.

That first demonstration wetland will have public access for bird watching, hiking paths and educational displays, said Mike Garner of EMWD's resource development branch.

Crother said the area behind the Sanderson Avenue plant is full of migratory birds in the fall.

One bird already prevalent at the regional wastewater reclamation facility is the *Himantopus himantopus*, or black-necked stilt, a long-legged migrant wading bird that is black on top and white on the bottom with pink legs. It winters in California, Crother said.

The second marsh will be at Little Valley, southeast of Hemet, and the third will be at the San Jacinto Wildlife Area, north of Lakeview. The wildlife area is operated by the California Department of Fish and Game and was designed to offset the wetlands lost when Lake Perris was created, Crother said.

"The district wants the public to know that reclaimed water is a valuable asset," Garner said as he talked about the possibilities for passive recreation in the future green area.

"That's an additional use of (reclaimed) water providing for green space and recreation," Crother said. "In this area of California, let's face it, we don't have potable water to use for open green space.

The wetland have "aesthetic value," she continued. "It's a prudent management of resources."

Wetlands in the United States have been disappearing at an alarming rate, leading President Bush to issue a statement there should be no further net loss, Crother said. "So if we can construct new wetlands, we don't have a net loss," she said.

In addition to providing green space and wildlife habitat, wetlands help treat water as it filters back down to replenish groundwater reserves. The process may also help treat effluent naturally.

The wastewater in the research ponds has been treated to a secondary treatment level to remove most of the solids and dissolved organic carbon, Garner said. The clear-looking water flowing in the area still has "minor undissolved solids" and bacteria, primarily coliform bacteria, he said.

The roots of the bulrushes filter out the bacteria and solids, and the rest of the bacteria die in the oxygenated environment, he said.

"We're interested in whether a system like this can provide tertiary treatment," Garner said. Tertiary treatment is an advanced, or third stage, level of treating effluent.

"This is low-tech compared to high-tech treatment plants," Crother added.

The next phase of the four- to five-year research project, which began in December, would be construction of six more half-acre ponds that would be planted with bulrushes being propagated in the first two ponds.

The research ponds have inlets from the main treatment plant where water flows in at either end of the pond. After it flows around the roots of the bulrushes, it flows back out the other end of the rectangular pond into a sump. From there it is pumped back out for agricultural uses.

"If we're capable of producing enough water equal to tertiary treatment, it can be used for other irrigation," Garner said. A major customer will be the San Jacinto Wildlife Area.

Many golf courses in the Valley also use reclaimed water that has been treated to the tertiary level.

Reclaimed water to be used for wetlands project

By KRISTIN HOFFMAN
Special to the Rancho News

An experimental wetlands-creation project is under way at Eastern Municipal Water District, according to agency documents. The wetlands will provide another means of purifying sewer water if successful, said Christie Crother, project director.

"I've visited several sites where wetlands have been constructed, and they are beautiful. There is no smell at all, they are natural looking, and provide wonderful scenery," Crother said.

EMWD serves the Menifee Vally/Sun City area with residential, agricultural, and industrial water.

Unlike naturally occurring wetlands, the water in the EMWD wetlands will not flow to the sea, said Crother. It will form a loop, beginning with treated sewer water piped to the area. The water will flow through the wetlands, which is a meandering system of streams with dense plant growth. The process will purify the sewer water, and probably flow into ground water basins, she said.

"The water could be drunk by our grandchildren," Crother said.

Phase I of the project will cost $50,00? and result in selection of one or two sites, research goals, a construction plan, cost estimates, and time tables, said Crother. The Phase I report, which will be written by a panel of seven wetlands specialists, will be done by late April or early May.

Four sites have been chosen for study, a fifth will be added to the list. The four sites are: 173 acres in the area known as Skiland, north of Romoland and southeast of Lake Perris; 108 acres in an area called Little Valley in southeast Hemet; a portion of the San Jacinto Wildlife Refuge northeast of Lake Perris; 90 acres near the Hemet-San Jacinto Regional Water Reclamation plant in northwest Hemet.

Phase II will be a four-to-five-year project to demonstrate the feasibility of wetlands construction in an arid region, effectiveness of sewer water purification, viability as a wildlife habitat, and effect on water quality in the region, Crother said.

The cost of phase II will not exceed $10 million. The budget will be determined by the scope of the project, Crother said.

"We could choose one 15 acre site, or one large 90 acre site, or do a combination of one large with one small site, two small sites, etc. The goals of the project will also determine the cost," Crother said.

VALLEY LIFESTYLE
2-14-91

APPENDIX H

APPENDIX H

PUBLICATIONS, PAPERS, AND PRESENTATIONS

Boegli, B. and Thullen, J. **Eastern Municipal Water District RO Treatment/Saline Vegetated Wetlands Pilot Study**, Currents magazine, Department of the Interior, Bureau of Reclamation, published August 1994.

Crother, C. M. **Reclaiming Water With Wetlands**, Civil Engineering magazine, published July 1994.

Crother, C. M. **Multipurpose Constructed Wetlands**, Quarterly Meeting Western Coalition of Western States, Tempe, Arizona, January 1993.

Crother, C. M. **Groundwater Research in Little Valley**, Hemet/San Jacinto Groundwater Association Newsletter, July 1992.

Crother, C. M. **Wetlands Research Facility Plant Propagation Cells, History, and Methodology**, EMWD, April 1992.

Crother, C. M., Crossman, J., and Ravishanker, P. **Role of Constructed Wetlands in Water Resources Management**, presented at American Society of Civil Engineers Annual Conference, Denver, Colorado, May 1994, and published in conference proceedings.

Crother, C. M. and Tewksbury, J. **Multipurpose Constructed Wetlands in a Legislated Environment**, 64th Annual California Water Pollution Control Association Conference, Sacramento, California, April 1992.

Garner, Michael W. **New Roles for Constructed Wetlands in Water Resources Management**, Conserve '93, Las Vegas, Nevada, December 12-16, 1993.

Ravishanker, P., Crossman, J., Willhite, R. **Ensuring an Adequate Future Water Supply - The Eastern Municipal Water District Experience**, poster presentation, Conserve '93 sponsored by ASCE, AWRA, and AWWA, Las Vegas, Nevada, December 12-16, 1993.

Thullen, J. **Designing Wetlands to Clean Wastewater**, Currents magazine, Department of the Interior, Bureau of Reclamation, March 1994.

Thullen, J. and Eberts, D. ***Scirpus acutus* Muhl. Seed Germination Investigations**, submitted to Wetlands magazine, January 1994.

Thullen, J. and Eberts, D. ***Scirpus acutus* Muhl. Seed Germination Investigations**, Weed Science Society of America, Denver, Colorado, February 10, 1993.

Thullen, J. and Sartoris, J. **Experiences With Establishing Bulrush in Wastewater Treatment Wetlands**, American Society of Limnology and Oceanography/Society of Wetland Scientists, Edmonton, Alberta, Canada, June 1, 1993.

Thullen, J., Sartoris, J., Waller, G., and Tewksbury, J. **Techniques and Success of Planting a Wetlands Nursery**, 11th Annual Symposium of North American Lake Management Society, Denver, Colorado, November 13, 1991.

CURRENTS...

Developing Technology for Tomorrow's Challenges

United States Department of the Interior
Bureau of Reclamation

FEATURES

Technology Transfer

Current Projects

CURRENTS — TRANSFERRING INFORMATION
ON WATER TECHNOLOGY AND ENVIRONMENTAL RESEARCH

Research and Laboratory Services Division

Reclamation activities with the Great Plains Region and the Eastern Colorado Projects Office have improved water quality by reducing mine drainage in the Arkansas River.

USBR/EMWD MULTIPURPOSE WETLANDS RESEARCH & DEMONSTRATION STUDY

Newsletter - June 1993

EASTERN MUNICIPAL WATER DISTRICT, P.O. BOX 8300, SAN JACINTO, CA 92581-8300

Wetlands Research Facility
Hemet/San Jacinto Site - Update

EMWD is interested in the use of desalting units for reclaiming brackish groundwater for municipal and industrial use and/or groundwater recharge. The Reverse Osmosis (RO)/Saline Vegetated Marsh Pilot Study will evaluate the quality of the reject stream of the RO desalting unit, impacts of the source water on RO technology, ability of the reject stream to sustain saline vegetated marshes, and changes in the reject stream characteristics as it passes through the marshes. If the saline marshes prove feasible, the marshes will provide an additional use of brackish water in arid areas for development of habitat, green belts and open space.

Installation of the RO desalination unit began on April 12, 1993 and continued for three weeks through operation and shakedown testing. Bill Boegli from the Chemical Engineering Unit, USBR Denver Office, designed and constructed the RO unit in Denver and supervised the installation and testing on site.

Source water for the RO unit is being hauled to the unit daily. It takes approximately eleven hours for the 4,500 gallons of well water to pass through the RO system.

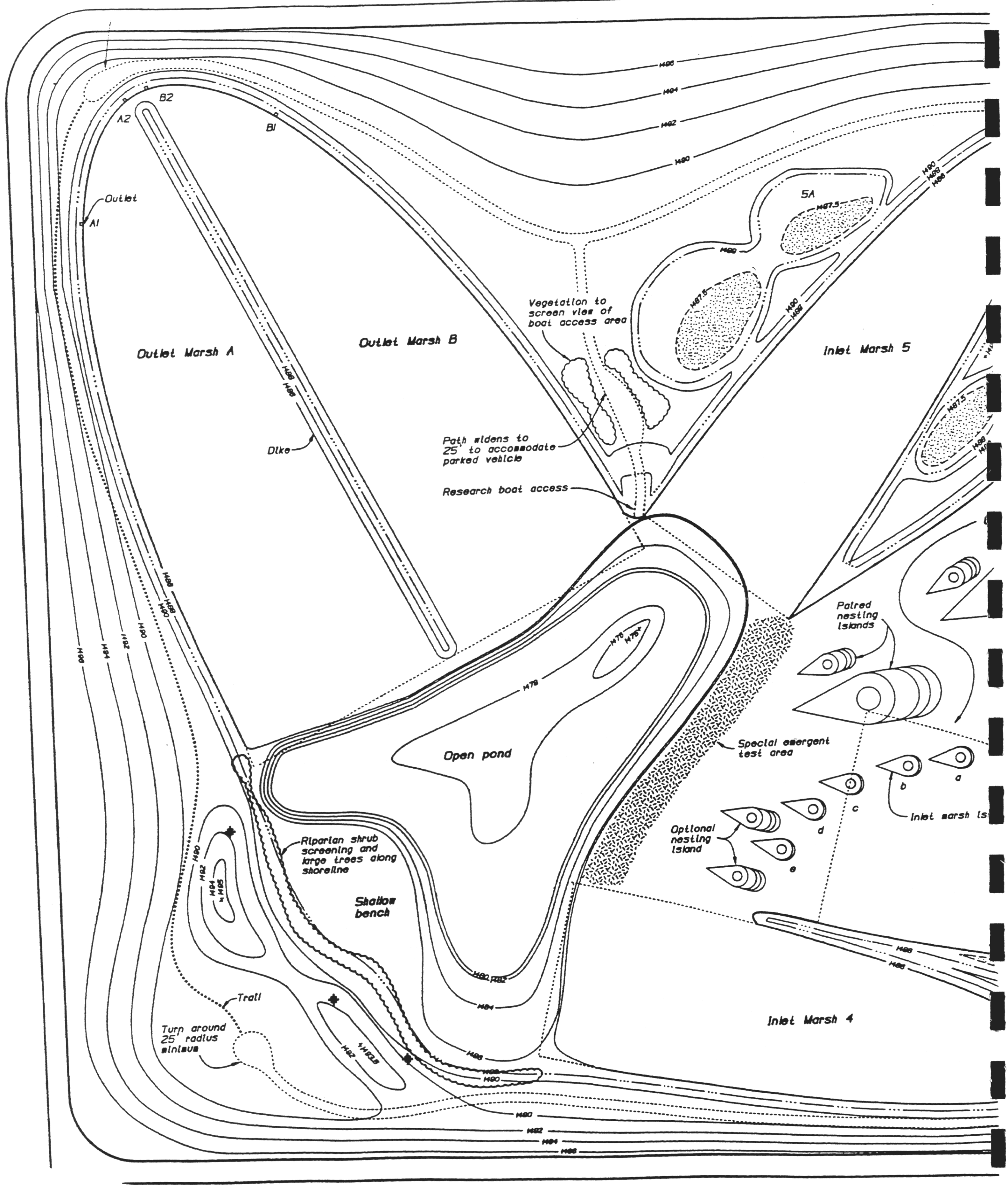
The two, lined, saline marshes (20 x 80 x 2 ft. each) were planted on April 27 and 28 by a team from the USBR Denver Office headed by Joan Thullen with assistance from EMWD staff. Alkali bulrush (Scirpus robustus) and creeping spikerush (Eleocharis palustris) were harvested from the San Jacinto Wildlife Area and transplanted into the marshes. Pennsylvania smartweed seeds (Polygonum pensylvanicum) and marsh smartweed tubers (Polygonum muhlengergii) were purchased from a wildlife nursery in Wisconsin. The plants are watered with the reject stream of the RO unit. The marshes operate in parallel.

The effluent from the saline marshes will flow into two evaporation ponds to achieve further salt concentration. The evaporation ponds will operate in series. A monitoring program that includes water quality analyses, flows, evaporation, plant growth, and soil sediment, plant tissue, and benthic invertebrate analyses has been developed and is underway.

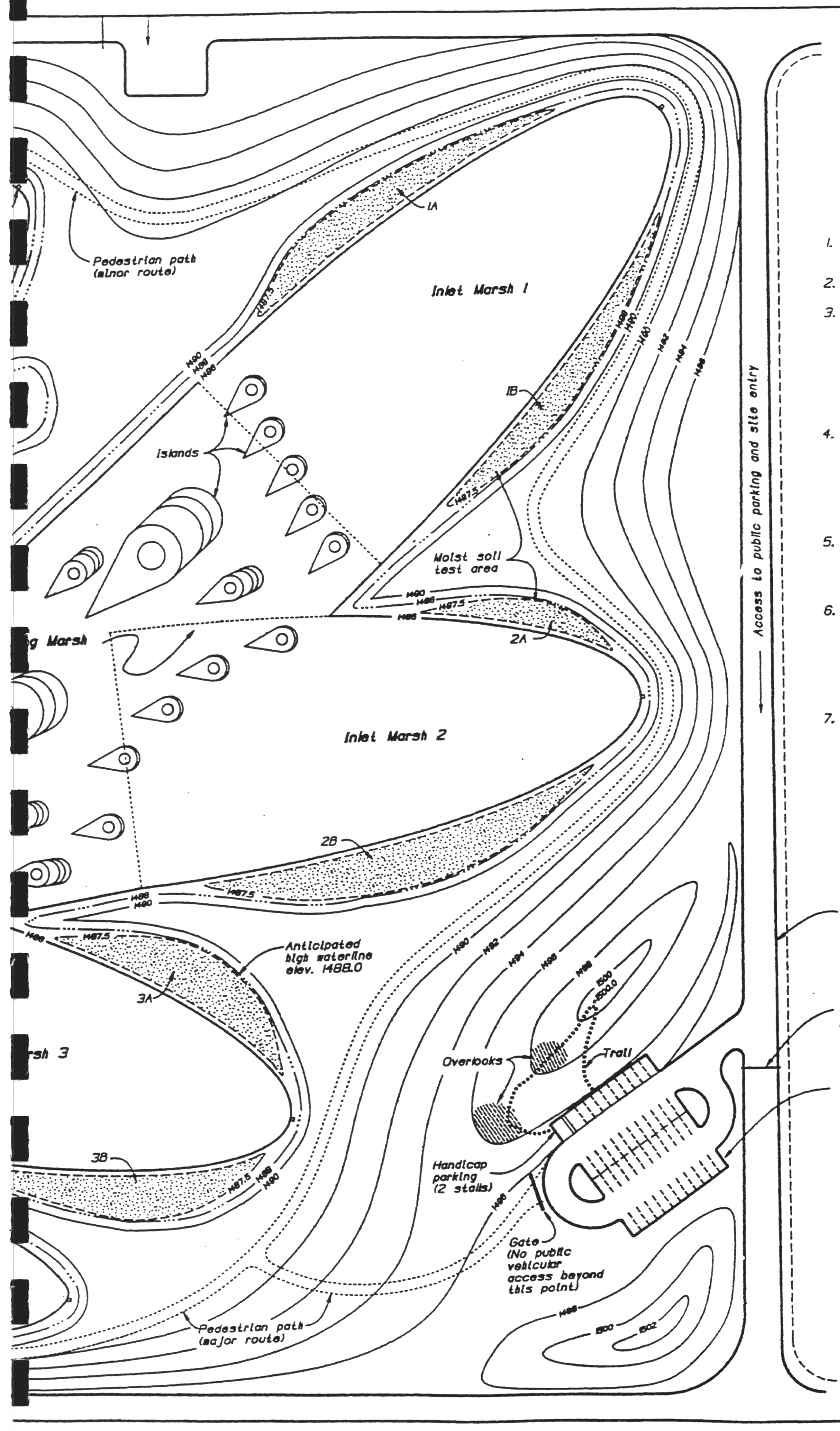
The combined problems of drought and brine disposal have lead to the suggestion that high total dissolved solids, non-potable water be used to sustain greenbelts. Only specific plants are tolerant of high salt content in water and soil and many of these may not tolerate the other constituents in the RO reject stream. When desalination becomes more prevalent, it will be useful to know if the reject stream can be used for providing irrigation for greenbelts prior to final concentration and disposal. If the saline marshes can be sustained by the RO reject stream, an otherwise "disposable" source of water can provide an additional benefit wherever brackish aquifers are reclaimed by RO or other technologies where brine disposal is a concern.

Above: Tom Bonnelle, USBR Denver Office, positions the skid with the Reverse Osmosis Unit at the site where EMWD had previously constructed the concrete pad, roof cover, and piping.

CONCEPTUAL SITE DESIGN



ONSTRATION WETLANDS



USBR/EMWD
Multipurpose Wetlands
Research & Demonstration
Study

NOTES

1. ▫ Indicates inlet and outlet flow structures

2. ✚ Indicates duck viewing blind

3. Vegetation Regime:
Vegetation in inlets and outlet to be bulrush marsh and is a focus of this research project. Vegetation in moist soil areas to provide winter food for waterfowl. Vegetation in upland areas to be California coastal scrub communities.

4. Moist Soil Areas:
Moist soil areas to be level at elevation 1487.5. Soil in these areas to be amended with organic material to increase water retention. These areas to be designed for water regime manipulation.

5. Overlooks:
Overlooks to have native dryland vegetation landscaping, shade, and interpretive signs.

6. Trail:
Trail to connect overlooks and highpoint of knoll. Trail grade to provide handicap access to upper overlook at elevation 1498.0. Trail to be paved or hard packed earth.

7. Pedestrian Path:
Pedestrian path to be gravel surfaced and able to accommodate research vehicles. Public vehicular use of the paths to be prohibited.

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USBR/EMWD MULTIPURPOSE WETLANDS RESEARCH & DEMONSTRATION STUDY

Newsletter - February 1993

EASTERN MUNICIPAL WATER DISTRICT, P.O. BOX 8300, SAN JACINTO, CA 92581-8300

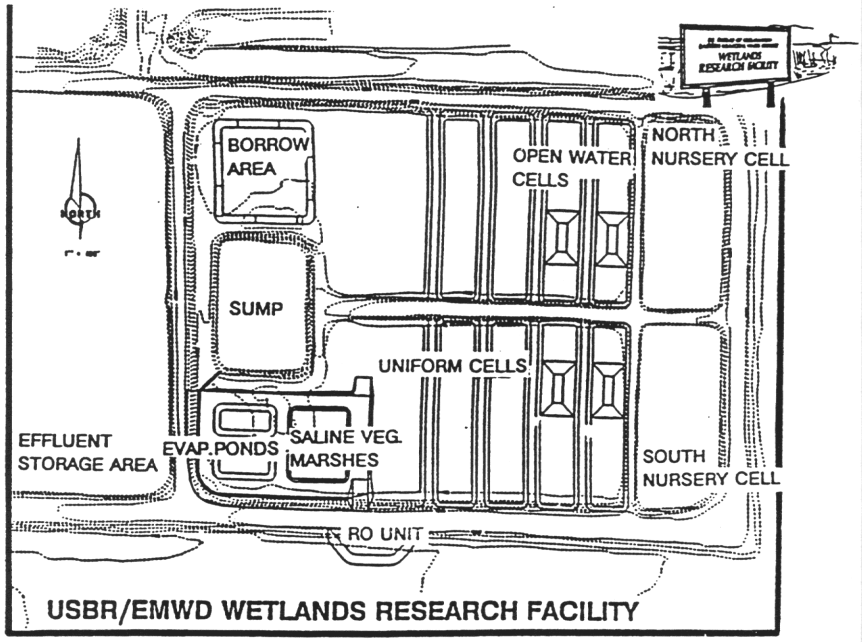
Wetlands Research Facility Hemet/San Jacinto Site - Update

Construction of the eight research cells was completed in September 1992. The cells were successfully planted with over 3,600 bulrush *(Scirpus californicus)* clumps by a crew from Pacific Southwest Biological Services with supervision by George Waller. The bulrush was transplanted from the adjacent North Nursery Cell. The first quarterly sampling in October showed that the plants were actively growing with a 100 percent survival rate. For consistency, all of the nursery stock used was from the same original donor marsh. Four of the 50 by 230 foot cells are fully vegetated and four contain an open water area.

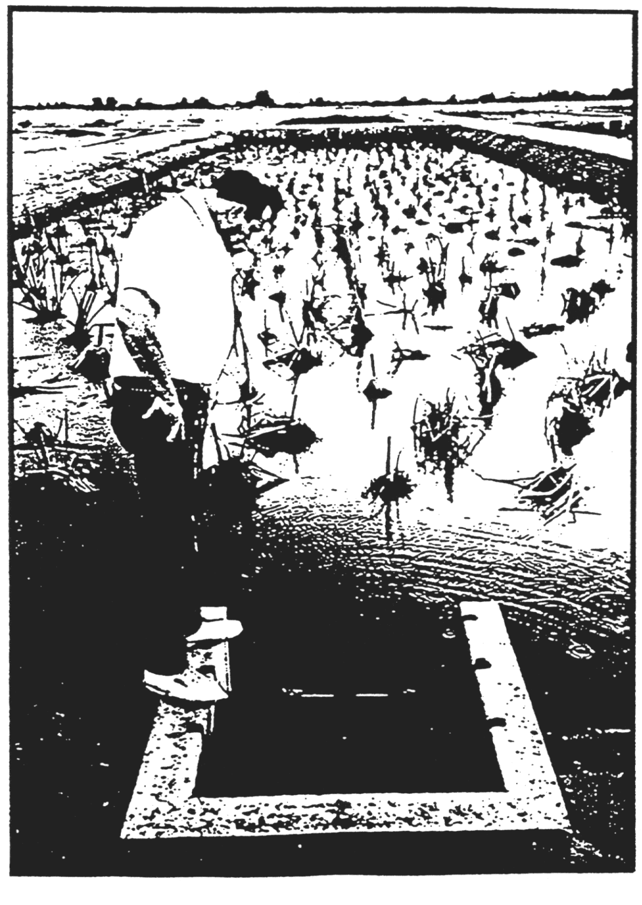
The first quarterly survey of the research cells consisted mainly of equipment installation and working out field sampling procedures, i.e. a "shake down run" in the field. EMWD personnel ran a series of approximately one-week Hydrolab data monitoring sets on selected pairs of cells, and collected sets of water samples for laboratory analyses once during each period. The data are being analyzed at the Bureau of Reclamation Denver Office by their Technical Team.

Monitoring

To date, 12 weeks of paired-cell, inflow/outflow, hourly records of water temperature, pH, conductivity, and dissolved oxygen concentration and percent saturation were obtained with Hydrolab Datasondes. The Datasondes are placed on the inflow and outflow of a pair of cells (one cell each with and without an open-water area) for 5-7 days, and are monitored in rotation. Outflow to inflow data comparisons to date show that the water cools as it passes through the cell; pH increases from inlet to outlet with a more pronounced diurnal cycle at the outlet; and dissolved oxygen increases from nearly zero at the inlet to anywhere from 40 to 100 percent of saturation at the outlet. The diurnal cycle parallels the pH diurnal cycle at the



Above: Research Facility plan showing location of fully vegetated and open water research cells.



Below Right: George Borlace checks flow from V-notch weir inlet box into research cell. Flow into each cell is controlled to approximately 7 to 8 gallons per minute. Actual flow rates will be monitored by ultrasonic flow meters.

outlet. Conductivity is relatively uniform from hour to hour at the outlet, but there is a definite diurnal cycle evident at the inlet.

Water samples are collected from the pair of cells being monitored each week. In general, there is no sign of nutrient removal in the cells, but this is expected as the plants are not yet established. Limited nitrification is taking place in the cells. Increases in turbidity from inflow to outflow are not surprising considering algae blooms, stirring of bottom sediments, and bank erosion due to this winter's heavy rains. There are no noticeable differences between the cells with and without open-water areas at this point.

All is proceeding as planned except the second quarterly survey was abandoned due to the heavy rains (see accompanying photos). The next quarterly survey is scheduled for April 1993. If you have any questions about these activities, please do not hesitate to call Jim Sartoris, Bureau of Reclamation, Denver Office, (303) 231-5180.

RO Pilot

The concrete pad and shelter for the Reverse Osmosis/Saline Vegetated Marsh Pilot Study has been completed along with earthwork and piping for the saline marshes and evaporation ponds. The source water, product water, and reject stream tanks have been installed. Installation of the linings for the marshes and evaporation ponds has also been delayed due to the heavy rains. It is anticipated that the RO unit will be delivered, weather permitting, in late March this year.

Phase III of Wetlands Study to Begin Shortly

As several phases of the Multipurpose Wetlands Research and Demonstration Study have been ongoing, Phase III, Final Design, is just getting underway.

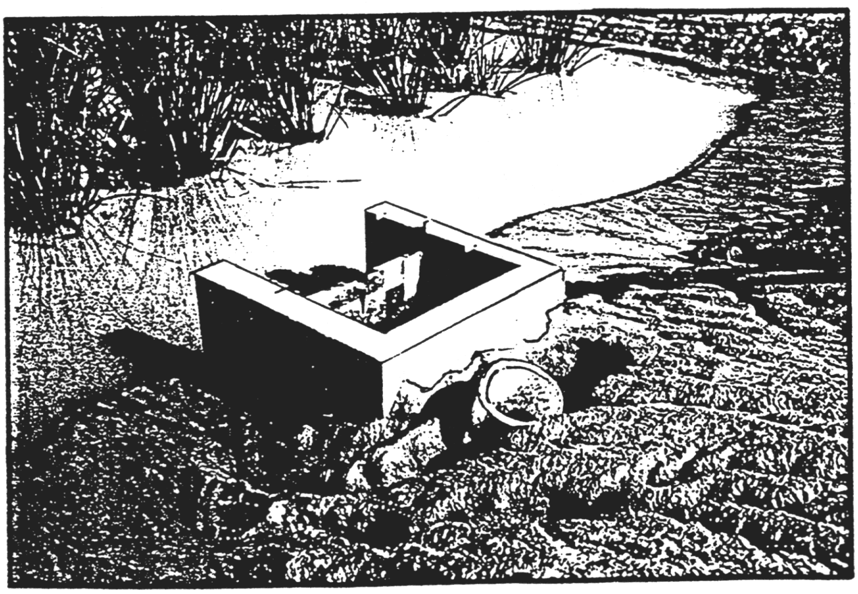
An agreement with the Bureau of Reclamation to begin final landscape and wetlands design of the Hemet/San Jacinto Regional Water Reclamation Facility (H/SJ RWRF) demonstration site is expected to be signed shortly. At the same time, the agreement provides for invertebrate sampling of the research facility at the H/SJ RWRF site, and installation of electric service for the reverse osmosis pilot unit. Plans are to begin construction of the H/SJ RWRF site in early fall of this year.

The agreement also provides for Little Valley site activities including contained pilot wetlands research and design, demonstration wetlands preliminary design engineering, geotechnical investigation, preliminary site engineering, wetlands system design, site master plan, and final design.

Further development for the San Jacinto Wildlife Area/Duck Club site remains in the planning stages.

Rain... Rain... RAIN...

The Hemet/San Jacinto area has received 27 inches of rain so far this season (July - Feb. 19.), a considerable amount coming on the heels of six years of drought. Photos bottom and right show berm damage at the USBR/EMWD Wetlands Research Facility following a Mid-January rainstorm.



and MORE RAIN...

For further information, contact Ms. Christie Crother, Project Coordinator, Eastern Municipal Water District, P.O. Box 8300, San Jacinto, CA 92581-8300 or (909) 925-7676, ext. 228.

Employees in ACTION

Bureau of Reclamation

Lower Colorado Region

Boulder City, Nevada

February 1994

Commissioner Beard Dedicates Wetland Project

In the July 1993 issue of the newsletter, an article reported early progress in the construction of Eastern Municipal Water District wetlands near the southern California cities of Hemet and San Jacinto. The construction is funded through the Lower Colorado Region's administration of the Small Reclamation Projects Act loan program.

EMWD Project Coordinator Christie Crother, Commissioner Beard, and EMWD Director Rodger Siems take a first-hand look at federal dollars in action as they view wetland waterfowl.

On February 10, at a ceremony at the Hemet/San Jacinto Regional Water Reclamation Facility, **Commissioner Beard** dedicated this wetland project, citing it as "one of the bright, shining stars of the Reclamation program."

The 43.5-acre site focuses on reclaimed water treatment, waterfowl habitat enhancement and wildlife diversity, and public education and recreation. The wetlands also provide an alternate water supply for irrigating about 21,000 acres; the existing facilities could supply only 8,340 acres.

"The Hemet/San Jacinto project is an innovative and unique way to use a limited water supply," the Commissioner said. "It is part of a new system that will purify a million gallons of water a day. It meets competing water demands while creating jobs and promoting conservation."

In a joint 5-year project, Reclamation and EMWD will examine how bulrushes and other selected plants grown in wetlands can improve the quality of wastewater passing through a marsh before it is used for irrigation. The study will also look at how the artificial marsh can create habitat for waterfowl.

Reclaimed water is a vital element in water resources management, especially in arid areas. Its use can minimize the strain on existing water delivery facilities and local water resources. When properly designed, operated, and maintained, constructed wetlands offer an attractive alternative to other energy-intensive treatment facilities needed to meet water quality standards for reclaimed water reuse.

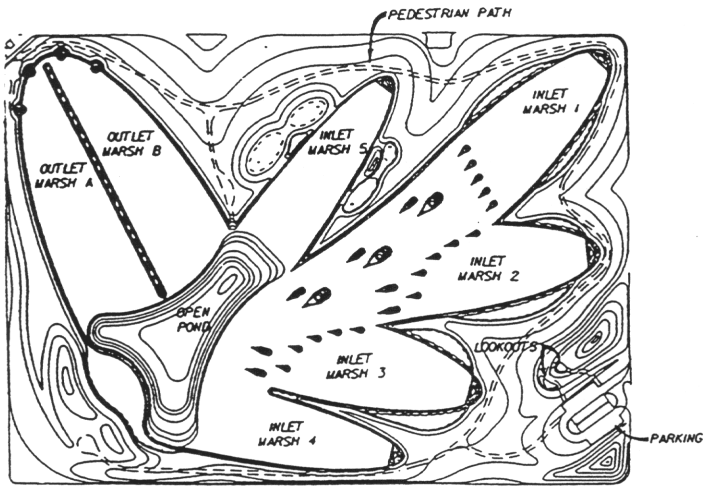
The site is located along the Pacific Flyway where waterfowl use wetland ecosystems extensively during migration. The design of these wetlands isolates the central pond habitat from operational activities at inlets and public facilities and access features are designed to minimize disturbances to wildlife.

[Story & pictures continued on page 6.]

WHAT'S INSIDE

EMWD Wetlands Dedication

continued from page 1



The wetland design, which occupies nearly 25 acres of the site, is quite unique. It is a three phase integrated system consisting of five separate wetland treatment units, a combined open water and marsh habitat area, and a final polishing wetland. **[See drawing at left.]** Secondary reclaimed water (of a quality that can be used on feed and seed crops not eaten by humans) is distributed to five wetland treatment "arms", then combined in the central area to flow through the open pond. The larger final wetlands combine all flows to remove biological impurities produced in the open water habitat area. The divisions within the inlet and outlet marshes allow maintenance of separate areas without shutting down the entire system.

"It's a terrific example of what we at the Bureau of Reclamation are trying to do on a national level: develop a balanced water resource policy that meets a variety of water needs and meets them in an economical way," said Commissioner Beard. Thanks to efforts of the Planning and Loans Division, the Lower Colorado Region is setting the trend for future projects.★

Public Colloquium To Be Held

Within the Bureau of Reclamation are several unique and specialized professions in the science and engineering fields. Over the years, this part of the workforce has become more diverse as more women begin working in such occupations.

To promote a greater understanding of the challenges that face women in science-related professions, the University of Nevada, Las Vegas, announces a public colloquium on the subject, "Revolution in Science? Women's Perspectives," to be held on the UNLV Campus from March 21-24 beginning at 7:30 p.m. each evening. Speakers include Professor Sandra Harding of the University of Delaware and UCLA, Professor Sue Rossner of the University of South Carolina, a panel of six local health practitioners, and Carol Jo Crannell of the NASA Goddard Space Flight Center.

Topics to be discussed include new challenges and opportunities for women in science, gender bias in health research, health care practices sensitive to women's varied needs, and the future of women in science. All events are free and open to the public. For more detailed information, please contact **Jayne Harkins** at x190.★

Safeguarding Government Property

by Len Dumph

During the Fiscal Year 1993 Departmental Property Review of the Regional Office, the review team found a few non-expendable items **not marked** as Government property. Non-expendable property includes hand tools and equipment costing less than $300 that is not expended through use in a short period of time.

As taxpayers and Government employees, we ask for your help in safeguarding and protecting our Government property and preventing this from happening in the future. If you find, receive, or purchase items of this nature that are not marked USBR, please bring it to the attention of the Property Office at x448.

If you have any questions or if you need assistance, do not hesitate to contact the Property Office. We would appreciate your help in this matter.★

HEMET/SAN JACINTO DEMONSTRATION CONSTRUCTED WETLANDS

The development plan for the Hemet/San Jacinto Demonstration Constructed Wetlands is in the final design phase. The conceptual plan for the site, shown on the inside of this newsletter, is a three-phase integrated system of five separate wetlands treatment units, a combined open water and marsh habitat area, and a combined final polishing wetland.

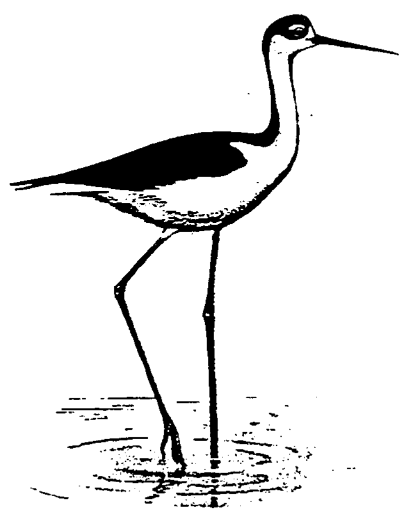
This undertaking is a joint effort between the U.S. Bureau of Reclamation and the Eastern Municipal Water District (EMWD), and in consultation with other government agencies, the academic community, and environmental groups, to evaluate and expand the use of reclaimed water through the incorporation of wetlands into EMWD's water management program. The focus of the wetlands component is the development of design, construction and operational criteria for constructed wetlands to achieve multipurpose objectives. This project will enhance the environment and provide a cost-effective and innovative alternative for managing water resources in arid areas.

The site is located immediately adjacent to the Hemet/San Jacinto Regional Water Reclamation Facility (H/SJ RWRF) approximately 2 1/2 miles west of the city of San Jacinto. The demonstration project will consist of a 20-25 acre wetlands system, equivalent to a 1 MGD (million gallons per day) process unit, which can be incorporated into the long term development plans for the RWRF or adapted to other suitable locations. The project is truly multipurpose with specific water resources management, environmental, and public education/recreation objectives in mind.

Water Resources Objectives: The demonstration wetlands will evaluate the ability of a wetland system to achieve the equivalent of tertiary treatment of secondary treated domestic wastewater and nutrient removal (nitrogen) as well as the removal of low levels of metals and certain organic materials.

Environmental and Public Education/ Recreation Objectives: Located along the Pacific Flyway, the H/SJ RWRF provides a valuable resting area for migratory waterfowl and shorebirds. The demonstration wetlands is designed to provide marsh, riparian, and upland habitat for wildlife diversity - migratory and resident waterfowl and shorebirds. Educational/recreational opportunities will be provided by bird watching points, trails, and interpretive displays which demonstrate the value of reclaimed water use.

Final design plans and specifications for construction of the site facilities will be initiated in early June. The final design work will be accomplished by a consultant -- CH2M Hill, Santa Ana, CA. Construction start date for this site is anticipated for mid-October 1993.



Black-necked Stilt
Himantopus mexicanus
13 - 16 inches

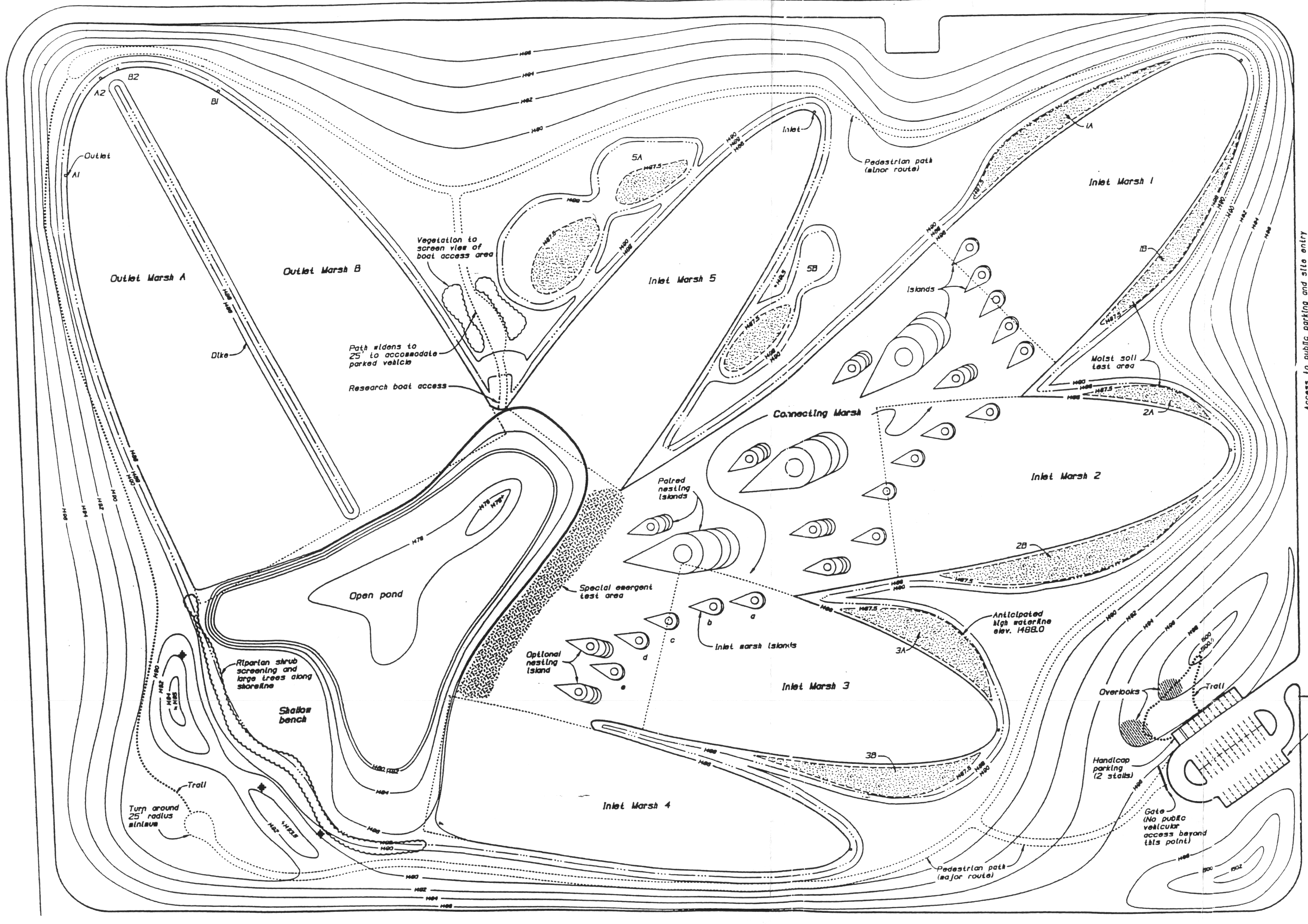
An extremely long-legged wader; black above, white below with long neck and needle-like bill. Pink legs trail in flight.
Migrant, but winters in California.

For further information, contact Christie Crother, Project Coordinator, Eastern Municipal Water District, P.O. Box 8300, San Jacinto, CA 92581-8300 or (909) 925-7676, ext. 228.

CONCEPTUAL SITE DESIGN

SEE ARTICLE ON BACK PAGE

H/SJ DEMONSTRATION WETLANDS



USBR/EMWD
Multipurpose Wetlands Research & Demonstration Study

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Scale: 60 Feet

CHT 216

USBR/EMWD MULTIPURPOSE WETLANDS RESEARCH & DEMONSTRATION STUDY

Newsletter - May 1994

Eastern Municipal Water District P.O. Box 8300, San Jacinto, California 92581- 8300

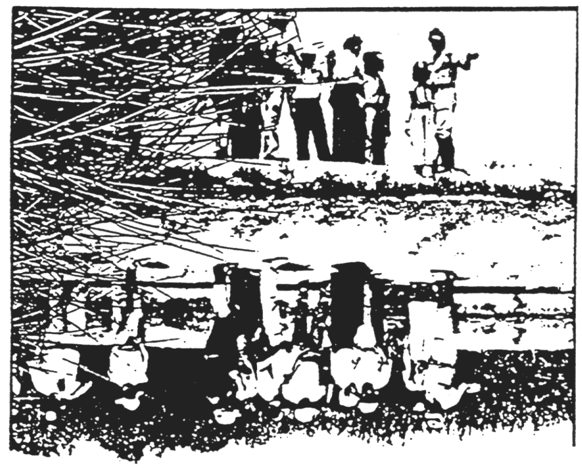
NATIONAL, STATE, and REGIONAL AWARDS for WETLANDS PROJECT

The Multipurpose Wetlands Research and Demonstration Study has received the Association of Metropolitan Sewerage Agencies (AMSA) 1994 Research and Technology Award. AMSA represents the Nation's largest publicly owned wastewater treatment facilities. Member agencies serve the majority of the sewered population in the U.S., and collectively treat and reclaim over 14 billion gallons of wastewater each day. AMSA's members are environmental practitioners dedicated to protecting and improving the quality of the Nation's waters.

The annual Research and Technology award is given to an AMSA member agency which produces a technical innovation related to wastewater treatment or sludge utilization and disposal. The winning research project or technological innovation must be directly related to basic processes of collection or treatment of wastewater or utilization or disposal of sewage sludge. The project must be conducted in-house, or by a consultant under direction of the agency, and the project must have practical application. The awards presentation will be held on May 23, 1994, in Washington, D.C., during AMSA's National Environmental Policy Forum and 24th Annual Meeting.

In 1993, the project won the Inland Empire West Resource Conservation District 1993 Conservation Partnership Award for Water Quality. The Inland Empire West Resource Conservation District is a self governed, non-profit local government agency established by conservation minded, local residents through state law. Its purpose is to help all residents within its boundaries conserve and develop their natural resources through good conservation practices.

California's Local Government Commission Award for Innovation in Water Conservation, Reclamation, and Management was awarded to the Multipurpose Wetlands Research and Demonstration Study in November 1992.



Above: Mid-east visitors reflected in the clear water of a research cell. Photo is upside-down. Flip over to see actual image. See article, back page.

HEMET/SAN JACINTO SITE WIDELY VISITED

The Wetlands Research Facility and large Multipurpose Wetlands site do not yet rival Disneyland as Southern California's top tourist attraction, but local and international interest is high just the same. The facility has been visited by two groups from Australia, a group from Taiwan, another from the Peoples Republic of China, and a delegation from eleven Mid-east countries as part of the Workshop on Appropriate Small Community Wastewater Treatment and Reuse Approaches for the Middle East, sponsored by the Agency for International Development, the US State Department, and the Environmental Protection Agency, as part of the Middle East Peace Process.

In addition, local schools utilize the wetlands as an environmental science laboratory learning about wetlands ecology, the value of reclaimed water and its reuse, and our water supply as a finite and precious resource.

The site is well known among local bird watchers and is one of the locations used by the Audubon Society for its annual Christmas Bird Count. The area around the site is not verdant, but the facility provides green space and habitat appealing to both man and wildlife.

Above: A Weed Abatement/Nuisance Deterrent Alternative or WANDA, commonly referred to as a goat.

CREATIVE SOLUTION TO WEED PROBLEM

Weed control has become a challenge at the research facility. Weeds grow rapidly on the banks of the pilot cells. Methods of removal which have been tried include using a backhoe, hand digging, and "weed whacking." Hand removal was found to be too labor-intensive, while the backhoe increased erosion and removed desirable riparian plants, such as willows, which had started to colonize naturally. Weed whacking seemed promising initially, but the result after one year was that old roots gained strength and the weeds came back larger than ever.

In April, two goats were put on site in an experiment in environmentally-friendly weed control. If successful in controlling the weeds, more goats may be purchased and they may become a permanent fixture at the wetlands during the growing season. Through persistence, and a combination of methods - some resembling a wild west rodeo, EMWD's intrepid and fearless crew consisting of Jeff Hale, Steve Shockey, and Stella Denison, have managed to control the goats and do battle with thistles and other weedy giants while allowing the selective growth of quite a few willows and natural groundcover.

CONSTRUCTION BEGINS ON LARGE WETLANDS

January 3, 1994 marked the beginning of construction of the first large-scale wetlands under this program. The Hemet/San Jacinto Multipurpose Constructed Wetlands, located at the northwest corner of the Hemet/San Jacinto Regional Water Reclamation Facility, has a design flow of 1 million gallons per day (MGD) but will be capable of treating up to 5 MGD of secondary reclaimed water. The basic wetlands occupies 25 acres of the 43.5 acre site.

The construction contract includes earthwork, grading, piping, electrical installation, and a 5 MGD effluent pump station. All pumps, motors, electrical panels, and supplies have been ordered and received. To date, the site has been cleared, grubbed, stripped and excavated, and about 250,000 cubic yards of fill earth have been moved. Wet weather in February and March caused delays. An additional 120,000 cubic yards of earth will be moved when the site dries. Construction will be completed, weather permitting, by the summer 1994.

Wetlands planting will take place under a separate contract following construction. EMWD and USBR are in the process of finalizing the planting plans and specifications and expect to advertise for bids shortly. The major planting operation will be transplanting bulrush to the wetlands from plant propagation cells at the USBR/EMWD Wetlands Research Facility. The plant propagation cells will be revegetated as part of the contract. The planting plan also calls for four specialized planting operations: (1) Islands seeded with watergrass; (2) A shallow emergent plant area planted with creeping spikerush, broadleaf water plantain, broadleaf arrowhead, and marsh smartweed; (3) Moist soil test areas will be seeded with wild millet, Pennsylvania smartweed, and red saltbush; and (4) Open pond shelves with submerged plants including sago pondweed tubers and horned pondweed clumps.

The wetlands is a three-phase integrated system consisting of five inlet marshes converging into an open water pond area, followed by a single outlet marsh. The system concept included extensive wildlife features such as islands for waterfowl nesting, a pond beach for shorebird habitat, a riparian area to enhance shoreline habitat, and moist soil test areas to act as "seasonal wetlands."

USBR/EMWD WETLANDS

MONITORING PROGRAM UPDATE

The USBR/EMWD Wetlands Research Facility is located in San Jacinto, CA. The 7.8 acre facility consists of: (1) two 0.5 acre nursery cells for wetland plant propagation; (2) eight 50' x 230' research cells; and (3) a reverse osmosis (RO) desalination unit, two saline vegetated marshes, and two evaporation ponds.

RESEARCH CELLS

Four of the eight research cells are fully vegetated with California bulrush and four have an open water pond in the middle. One of the research objectives is to measure differences in water treatment performance between the two types. Series I and IA of the research program are complete and have provided a wealth of baseline data. The period of sampling was October 20, 1992 through November 10, 1993.

Weekly Monitoring - Paired three- and one-phase cells were monitored in weekly rotation throughout Series I/IA. The typical weekly monitoring consisted of three components:

1) Inlet and outlet water temperature, pH, EC, and DO were recorded hourly.

2) Inlet and outlet ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, orthophosphate phosphorus and turbidity analyses were performed weekly; while TKN, total phosphorus, BOD, TSS, TOC, and total and fecal coliform bacteria analyses were performed every third week.

3) Two ultrasonic flowmeters were used to record total and average daily flows.

Quarterly Monitoring - Quarterly survey objectives were to evaluate vegetation condition and growth, sample the macroinvertebrate communities and document variations in water quality conditions within and among the research cells. The water quality component of the quarterly surveys consisted of taking measurements of water temperature, pH, EC, and DO in the inlet, middle, and outlet of each cell. Chlorophyll a concentrations were also measured in the inlet and outlet of each cell.

The results of Series I/IA will be presented in the Phase II Report which is expected to be available in June 1994.

Water Quality - The chemical data were analyzed by Stephen Crombie of EMWD. The data were subjected to the paired sample t-test. Preliminary findings indicate a difference between one- and three-phase cells in nitrogen removal. The baseline monitoring data show that the mean Total Nitrogen removal in the three-phase cells was 57.7%, compared to only 11% in the fully vegetated cells.

Microorganisms - A brief study of the microscopic life in the research cells was conducted by Stella Denison, EMWD. Four Divisions - Cyanochloronta, Chlorophycophyta, Euglenophycophyta, and Pyrrhophyta - were found represented by ten genera. Unicellular organisms occurred in both the one- and three-phase cells. Colonial and filamentous organisms were found only in the three-phase cells.

Above: Steve Shockey, EMWD Field Assistant, with macroinvertebrate substrate habitats or "bug buckets".

Invertebrates - Invertebrate sampling was conducted by Doug Andersen, USBR, to establish a baseline for species distribution. Sampling was conducted by placing small artificial substrates on the floor of the wetlands to which the bottom-dwelling organisms would attach themselves and subsequently be counted. In addition, "sweep net" samples were taken to determine species present in the water column. Collected organisms were preserved for later identification. Field notes

RESEARCH FACILITY

on the sampling techniques, which occurred in April, July, and November 1993, were maintained for ongoing evaluation and refinement. A total of 24 different types of invertebrates were identified; eight of these were common to all cells. No steady or consistent pattern in the abundance or diversity of invertebrate species developed within the research cells over time. To date, collected data suggest that the invertebrate community within the cells is undergoing either seasonal shifts or trending toward a steady condition yet to be attained.

Vegetation - Bulrush growth, vigor and establishment in the research cells were monitored by Joan Thullen, USBR. The purpose of the study was to determine when the newly-constructed wetland had reached a stabilization point at which it would function much like a natural system. Rapid growth in both new shoot numbers and culm height was documented, suggesting that the combination of the Hemet/San Jacinto climate and the soil and water constituents at the site created optimum conditions for bulrush propagation. By November 1993 (14 months after planting), the bulrush culms were sufficiently dense and robust, and the research cells were then considered to be completely vegetated and established.

Soil - Monitoring of bottom sediments has been conducted since initial flooding of the research cells in September 1992. Baseline sampling indicated that all trace elements in the substrate were well within acceptable limits. Therefore, it was considered unlikely that the substrate would serve as a source for any toxic constituents. Instead, it was anticipated that the substrate would act as a sink, potentially removing certain constituents from the water. The data collected indicates that most elements in the substrate have experienced minimal change in concentration thus far. However, arsenic and cadmium have shown an increase.

Research in the future will focus on hydraulic retention times, nutrient loading rates, evapotranspiration, microbial dynamics, and investigations on the feasibility of using wetlands-treated reclaimed water for groundwater recharge. A study to characterize the composition of total organic carbon (TOC) during passage through the wetlands will also be undertaken to evaluate effectiveness in meeting California's regulatory requirement for the amount of "TOC of wastewater origin" in reclaimed water.

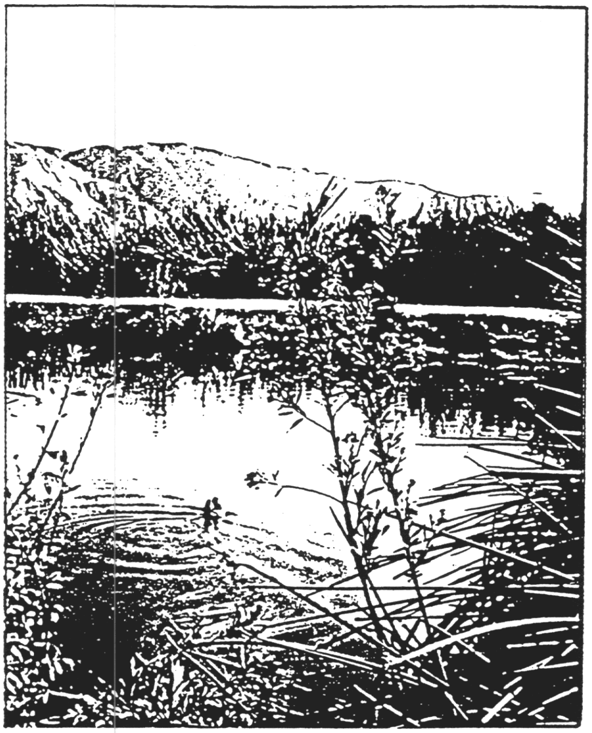
Stella Denison, EMWD Water Quality Dept., leads an enthusiastic group of students in a wetlands ecology lab.

RO/SALINE VEGETATED MARSHES

Designed, constructed, and installed by Bill Boegli, USBR, the RO unit has been in operation since April 1993. The focus of the pilot has been on the feasibility of using the reject stream of the RO desalting process in vegetated saline marshes to reduce brine volume and provide an additional use of brackish water in arid areas. Brine may be able to provide the water source necessary to sustain much-needed habitat and green belts. Stephen Crombie, EMWD, has been the operator and trouble-shooter on the RO unit during this pilot study. Stella Denison has been trained by Stephen to be the "back-up" operator for the unit.

Salt-tolerant plants were planted in the two marshes and reject brine from the RO unit was used to sustain the plants. The plants turned brown during the fall and winter. This was to be expected as many marsh plants enter into a period of senescence during the winter months. The plants started to turn green again with new growth in the spring. The plants are currently green and dense throughout both marshes.

Research is focused on the long-term ability of the reject stream to sustain saline marshes, the potential accumulation or concentration of toxic materials, and bioproductivity of the marshes.



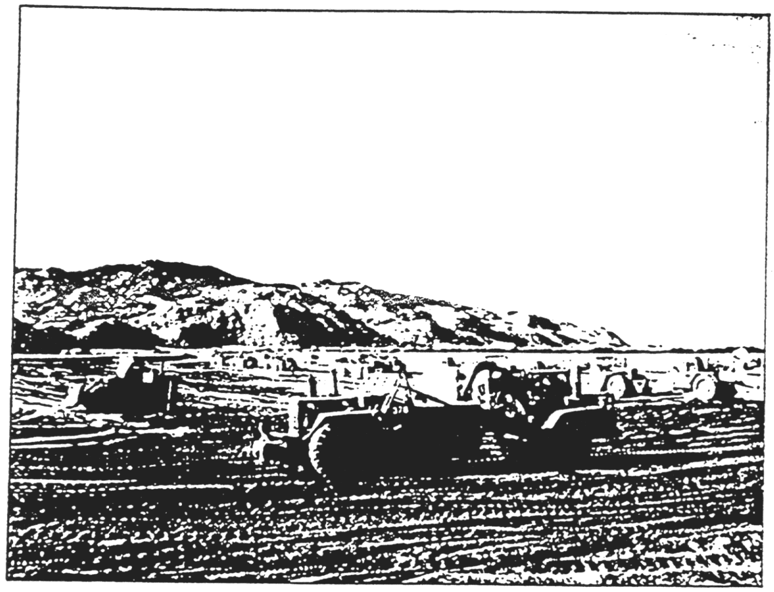
Above: Ruddy ducks in open water area of research cell.

HABITAT CREATION

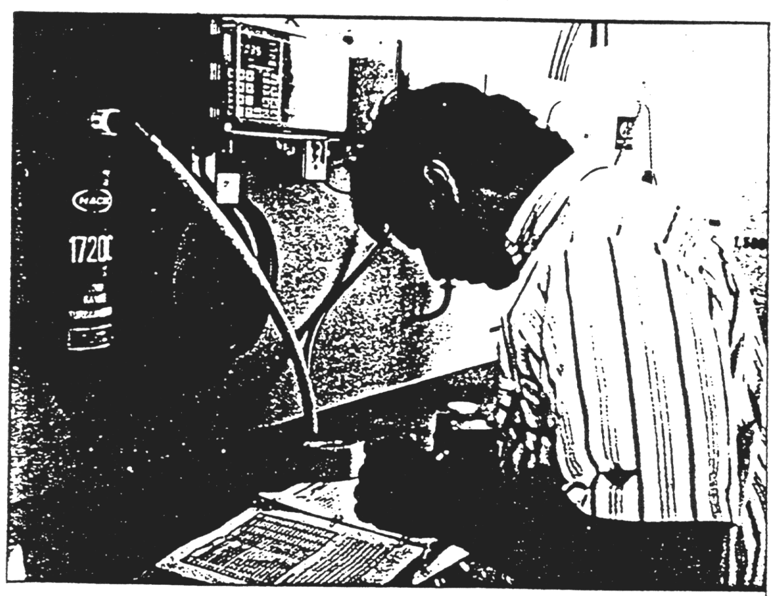
More than 92 species of birds have been identified using the ponds for resting and feeding at the Hemet/San Jacinto Regional Water Reclamation Facility, with a number using the site for breeding and the rearing of young. For example, Ruddy ducks discovered that the research cells with open water areas provide ideal habitat. These bright chestnut-colored ducks with black and white head and sky-blue bill differ from other ducks in many ways. They are deep-water divers, feeding from the bottom even as hatchlings, whereas other ducks begin by picking food from the surface. For ideal habitat, Ruddy ducks require clear, deep-water areas for feeding, but they also need tall, dense reeds for retreat and nesting. The three-phase research cells at the USBR/EMWD Wetlands Research Facility provide ideal habitat.

The H/SJ RWRF site is visited by a wide variety of birds including numerous ducks, Canada Geese, raptors such as Golden Eagles, hawks and owls, numerous shorebirds, songbirds, and herons and egrets. More exotic birds such as Snow Geese, Bald Eagles, White-faced Ibis, Double-crested Cormorants, and Peregrine and Prairie falcons have been unexpected visitors.

Right: New Wetlands logo - a black-necked stilt digitized by Mark Salcido, Engineering Technician I, EMWD Water Resource Management and Research Department, on an Integraph workstation.



Above: A herd (flock?) of large scrapers moves earth for the Multipurpose Constructed Wetlands. Construction began January 3, 1994.
Below: Stephen Crombie, Associate Chemist, EMWD Water Quality Department, records data at the reverse osmosis/saline vegetated marsh pilot study.



Above: USBR Commissioner Dan Beard and EMWD General Manager Andy Schlange tour the wetlands project following the February 10, 1994 Dedication Ceremony.

COMMISSIONER PRAISES PROJECT

USBR Commissioner Dan Beard praised the Hemet/San Jacinto Multipurpose Constructed Wetlands Project at a dedication ceremony held on February 10, 1994 at EMWD. He referred to the project as one of the "bright, shining stars" of the Reclamation program. Commissioner Beard characterized the project as a "win, win, win" solution--reaching water supply objectives, saving taxpayers' money, and adhering to environmental standards.

The Hemet/San Jacinto Multipurpose Constructed Wetlands Project is funded by a Small Reclamation Projects Act loan. The SRPA loan program was created by Congress in 1956 through Public Law 84-984 to stimulate local economies and benefit the nation through extending, reclaiming, and recycling local water supplies.

Commissioner Beard told the audience that the Hemet/San Jacinto Multipurpose Wetlands Project is an example of what the Bureau of Reclamation is trying to do on a national level: develop a balanced water resource policy that meets a variety of water needs in an economical way. He also mentioned that the Bureau of Reclamation is ending the business-as-usual approach with a leaner budget and more accountability to the taxpayer.

The Hemet/San Jacinto Multipurpose Constructed Wetlands will provide reclaimed water treatment, waterfowl habitat enhancement and wildlife diversity, and public education and recreation. It will improve the water quality of the reclaimed water supply and allow maximum utilization of local water resources, thereby reducing dependence on imported water.

MIDDLE EASTERN VISITORS SEE VALUE IN CONSTRUCTED WETLANDS

As part of the Middle East Peace Process, the Agency for International Development and the U.S. State Department brought a group of water resource experts from 11 governments to the U.S. in July 1993 for a "Workshop on Appropriate Small Community Wastewater Treatment and Reuse Approaches for the Middle East." The visitors were from several Arab countries, Israel, and Russia. They spent a day at EMWD learning about the Multipurpose Wetlands Research and Demonstration Study as well as EMWD's water resources management, reclaimed water reuse, and water harvesting programs.

Participants expressed great interest in both the reclaimed water wetlands research cells and the pilot reverse osmosis/saline marsh project. At a review session the following day, the general reaction of the participants was that constructed wetlands are definitely an approach to consider for the Middle East. They were seen as a way of improving effluent quality and providing habitat along the North African Flyway. It was also noted that constructed wetlands would be applicable along streams before discharge. Potential disadvantages that were raised were increase of total dissolved solids, buildup of salt in soil, water evaporation/loss, and dependency on cheap, available land. One representative commented that removal of salt was the number one problem in his country. It was noted that a main reason for wetlands is to help overcome psychological barriers to reclaimed water use and promote conservation of the natural environment. There was also considerable interest in the reverse osmosis/saline marsh project. In this project EMWD is desalinating brackish groundwater and using the brine to support a saline marsh wetlands. The saline wetlands serve to concentrate the brine, reducing the volume for disposal, and also potentially provide additional beneficial uses of the water for greenbelts, open space, and habitat. It was felt that this technology is transferrable in some situations. As a possible application, it was suggested that saline marshes could be used in the collection and treatment of waste from an area where several industries that demineralize are located. A possible problem with the reverse osmosis technology is the difficulty of getting spare parts and trained technicians in some countries.

EASTERN MUNICIPAL WATER DISTRICT · SERVICE · RECLAMATION · WATER CARE · RIVERSIDE COUNTY

For Information Contact:
Eastern Municipal Water District
(909) 925-7676
Christie Moon Crother,
Project Coordinator, ext. 228
LeAnne Hamilton,
Project Manager, ext.525

In the midst of the 1990 California drought, EMWD (Eastern Municipal Water District), located southeast of Los Angeles, became interested in reusing their scarce water supplies. The progres-

The goals of the Hemet wetland are to improve the quality of the wastewater to allow its use for agricultural and landscape irrigation, or for ground-water recharge, and to provide diverse wildlife habitat

Designing Wetlands to Clean Wastewater

Reclamation/Eastern Municipal Water District
Multipurpose Constructed Wetlands

JOAN S. THULLEN
Applied Sciences Branch

sive Managers and Board of Directors decided to try constructed wetlands, a cheap and relatively new biological technique, to clean their secondary treated municipal wastewater and simultaneously provide green space and wildlife habitat.

EMWD brought their idea to Reclamation. Reclamation felt that a constructed wetland research and demonstration project would be mutually beneficial, and a Memorandum of Understanding was signed.

Technical teams from EMWD and Reclamation created conceptual designs for several types of wetlands. Civil engineers, hydraulic engineers, chemical engineers, soil scientists, a geologist, a botanist, a landscape architect, and a wildlife biologist worked together to move from a wetland concept to the final design phase. Construction of the first demonstration wetland will begin in early 1994 at EMWD's Hemet/San Jacinto Regional Water Reclamation Facility, or simply, the Hemet site. The 45-acre site will include about 20 acres of treatment wetlands, some riparian areas, moist soil wetland areas, native upland grass and coastal sage shrub areas, and areas for public viewing, parking, walking, picnicking, and passive recreation.

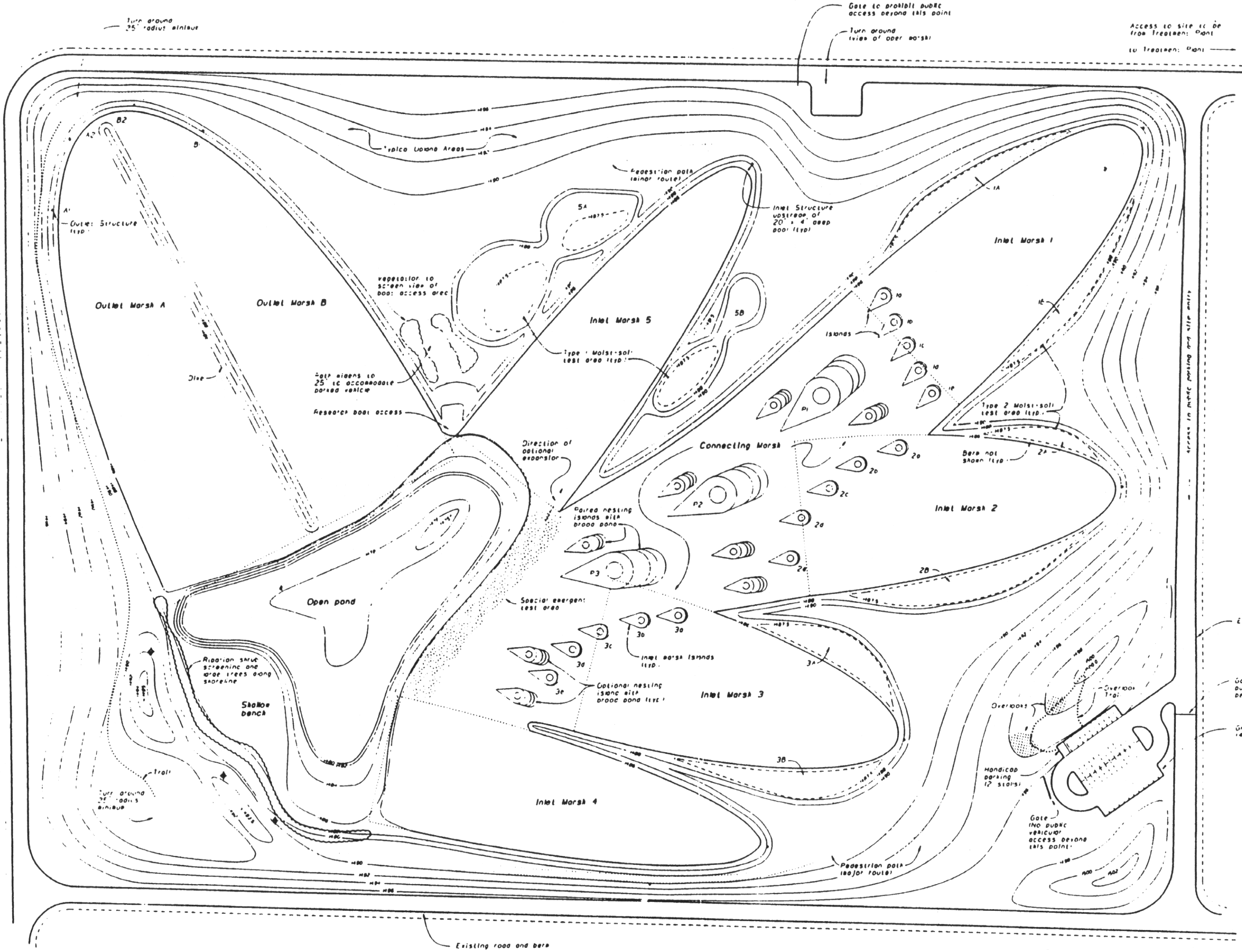
(particularly for migratory waterfowl and other wetland birds) and greenbelt aesthetic areas in a semirural, urban setting. The bottom line is to achieve these goals in a more cost-efficient manner than conventional water treatment methods and to improve the San Jacinto Valley environment at the same time.

The conceptual design for the Hemet demonstration site was developed by studying the published literature on constructed wetland design and interviewing experts in the field. The USBR/EMWD Phase 1 Report (November 1991) explains the conceptual design in detail. The design is based on a three-phase system concept. Each phase has a particular function and retention time to achieve the stated objectives. This three-phase system, developed by Dr. Robert Gearheart of Humbolt State University to treat 1 million gallons of water a day, consists of the following components:

1. A 10-acre treatment wetland, which the water moves through in 5 to 10 days.
2. A 2- to 3-acre open water pond, which the water moves through in no longer than 2 to 3 days.
3. A 6-acre "polishing" wetland, which the water moves through in 4 to 5 days.

CONCEPTUAL SITE DESIGN   HEMET/SAN JACINTO DEMONSTRATION WETLANDS

USBR/EMWD
Multipurpose Wetlands
Research & Demonstration
Study



GENERAL NOTES

1. [symbol] indicates the locations of the inlet and outlet structures
2. ◆ indicates duck viewing blinds
3. Drawings 1608-D- through 5 are being attached to the May 1993 Design Concept and Criteria Report, Multipurpose Constructed Wetlands, Hemet Site. The drawings are conceptual in nature and are not to be used for construction.
4. All bottom elevations shown are tied to the assumed base elevation 1486.0 feet used when setting the Inlet and Outlet Marshes invert. If the base elevation is changed, the features directly related to the wetlands will also have to change by a corresponding amount, while the upland features would be revised in a proportional manner.
5. Design water depth in the Inlet and Outlet marshes is 1.5 feet. The maximum water depth in the marshes is 2.25 feet.
6. Vegetation in the inlet and outlet marshes, islands, special emergent test areas and moist-soil test areas, represents an important aspect of this wetlands research project. Details related to the wetlands planting may be found in the report's attachment A. The resulting wildlife habitat is another important aspect of the wetlands research.
7. The pedestrian paths are to be gravel surfaced and able to accommodate research vehicles. Public vehicles use of the paths are prohibited.
8. Other features such as overlooks, trails, pedestrian paths, and upland or riparian areas and plantings, duck blinds, and the parking lots are public amenities to the project and are not directly involved in the project research effort.

Phase 1, planted primarily with bulrush plants, will filter out sediments and remove nutrients and organic materials by nitrification (bacteria converting ammonia to nitrite and then to nitrate) and denitrification (the addition of carbon to convert nitrate to nitrogen gas, which will escape from the system into the atmosphere). The plants or the soil sediments will also absorb additional nutrients and some metals. Phase 2 is primarily for wildlife use, which will degrade the water quality in some respects (e.g., from feces, feathers or other remains, sediment mixing, possible pathogens brought in by the wildlife, etc.). Phase 2 may also help improve the water quality by providing oxygenation of the water for further nitrification, additional nutrient removal by the submerged plants and algae, destruction of pathogens by the direct sunlight, a sink for sediments or phosphorus, and/or equalization and mixing of the water flow. Phase 3, again planted primarily with bulrush plants, will remove the nutrients and algae which may accumulate in the open water pond and will allow extra time for denitrification.

The original outline of the Hemet wetland mimicked a natural wetland configuration in which several tributaries converge into one to become an open water area. However, the original outline required some downsizing to fit all the treatment arms into the 45-acre rectangle which EMWD had available. The new configuration resembles a baseball glove. In any case, wildlife prefer a natural shape over square corners; each wetland part can still function as conceptualized.

To test the hydraulics of the proposed wetland shape and the arrangement of the wildlife features which will be built into it, Russ Dodge of the Hydraulic Structures Section tested the design with a table top model in the Hydraulics Laboratory. The model made obvious the effects of every island or deeper water area on the water flow. Russ changed the inflow configurations to obtain a more even flow across the treatment arms and, with the rest of the technical team, changed the shape and placement of the islands and associated deeper water holes to avoid large "dead" areas. No exchange of air or water takes place in dead areas, so the water becomes stagnant, or nearly so. Stagnant areas do not contribute to water quality improvement, nor will wildlife use such areas. The aquatic invertebrates that are eaten by many waterfowl and aquatic birds will not thrive, and pathogens, like *Clostridium botulinum*, the bacterium which releases a toxin that causes botulism, may flourish.

This 20-acre demonstration wetland has been designed not only to clean the water to acceptable levels and provide wildlife habitat, but also to provide a perfect opportunity to conduct research on all types of constructed wetland issues. For example, the system will be flexible enough to conduct studies on variations in the loading rates, flow rates and retention times for treatment, and determinations of treatment effectiveness in each wetland zone. Research will also be conducted to determine how the size, orientation, and placement of islands affect waterflow and use by invertebrates and wildlife. Wildlife use and the survivability of various wetland plant communities will also be studied. Many other research issues exist, and more may be addressed as time goes on. Additionally, eight pilot cells have been built near the demonstration site to test specific research issues in a more controlled environment. Questions answered in the pilot cells will enhance the effectiveness of the demonstration wetland and future operational wetlands.

Many Denver Office scientists and engineers and Lower Colorado scientists and planners worked with EMWD personnel on this project since its inception. If you would like to obtain more information, please contact Ms. Bernice Sullivan, Activity Manager, at 303-236-3171. . ■

APPENDIX I

APPENDIX I

AWARDS

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To Jan Shepherd		From Teresa Harde	
Co. Bureau		Co EMWD	
Dept.		Phone #	
Fax # 702-293-8682		Fax #	

February 22, 1994

RECEIVED FEB 25 1994 E.M.W.D.

Peter Archuleta
Assistant General Manager. Operat
Eastern Municipal Water District
2045 S. San Jacinto Avenue
P.O. Box 8300
San Jacinto, CA 92581

Dear Mr. Archuleta:

On behalf of the Association of Metropolitan Sewerage Agencies, it gives me great pleasure to advise you that AMSA's Awards Committee has selected Eastern Municipal Water District to receive the Research and Technology Award for 1994 for its "Multipurpose Wetlands Research and Demonstration Study." AMSA gives this award to a member agency which produces a technological innovation related to wastewater treatment or sludge utilization.

The AMSA Awards Banquet is scheduled for the evening of May 23 in Washington, DC in conjunction with the Association's 24th Annual Meeting. AMSA will have a display at the Meeting featuring this year's awards recipients. The National Office will provide you with details on this display as the meeting draws near.

Congratulations, and I look forward to seeing you in Washington in May.

Sincerely,

Victor Medina
Chair, Awards Committee

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Dedicated to Environmental Improvement for Over 20 Years

AMSA Monthly Report

Dedicated To Environmental Improvement For Over 20 Years

Volume 20, Issue 5 — MAY 1994

Mineta and Browner to Address AMSA's Membership

EPA Administrator Carol Browner

Chairman Norman Mineta

House Public Works and Transportation Committee Chair Norman Mineta (D-CA) and EPA Administrator Carol Browner have both confirmed plans to address AMSA's members and other attendees at the Association's upcoming National Environmental Policy Forum later this month.

Administrator Browner will join Senate Environment and Public Works Chair Max Baucus on the program on Tuesday, May 24. Browner will serve as the luncheon speaker.

Since her confirmation as EPA administrator in January 1993, Browner has actively involved herself in a number of issues of importance to AMSA, including finalization of the National Combined Sewer Overflow (CSO) Policy and a variety of Clean Water Act (CWA) reauthorization activities. She will undoubtedly have much to say regarding the administration's efforts to promote reauthorization of the Act this Congress.

Representative Mineta will provide the keynote address for the "Capitol Hill Breakfast" on Wednesday, May 25. Representative Mineta is the chief sponsor of H.R. 3948, "The Water Quality Act of 1994," the primary clean water reauthorization initiative in the House. He has been actively pursuing the completion of CWA reauthorization this year and will give an update on his committee's efforts.

Clean Water Act Reauthorization Activities Continue Roller Coaster Ride

Following a recent Democratic Caucus meeting, Rep. Norm Mineta (D-CA), chair of the House Public Works & Transportation Committee, announced plans to hold hearings on the reauthorization of the Clean Water Act. It is anticipated that two days of hearings, before the Water Resources & Environment Subcommittee, will be held prior to Congress' Memorial Day break. The additional hearings represent an effort on the part of Chairman Mineta to discuss remaining contentious issues and build a broader coalition in support of the Clean Water Act reauthorization. AMSA has requested the opportunity to testify at the upcoming hearings.

On April 21, Chairman Mineta introduced a revised substitute of H.R. 3948, The Water Quality Act of 1994, that included provisions on wetlands protection and the State Revolving Loan Fund allocation provisions. Both issues carry with them a considerable amount of controversy. Additionally, an outline of a bipartisan alternative initiative has been released by Democrats and Republicans who have not signed on to support H.R. 3948. The alternative proposal, for which legislative language is currently being drafted, adds additional issues to the Clean Water Act

continued on page three

AMSA Honors Roe, Others During National Environmental Policy Forum

In addition to major addresses from the environmental leaders in Congress and the Administration, and panel discussions on a number of key issues, AMSA's National Environmental Policy Forum will feature the presentation of the Association's 1994 Awards. AMSA's Annual Awards Program recognizes individuals from both within and outside of the Association's membership as well as the outstanding achievements of member agencies.

U.S. Rep. Robert A. Roe (D-NJ), former chair of the House Public Works and Transportation Committee, will receive the Association's Public Service Award during a May 23 Gala Awards Banquet. AMSA's Public Service Award honors elected or appointed officials who have shown a particular awareness to the challenges faced by municipal wastewater treatment agencies. Congressman Roe will be recognized for his many years of service on the House Public Works and Transportation Committee.

In 1991 Congressman Roe was elected chair of the House Public Works and Transportation Committee. Previously, he was the chair of the committee's Subcommittee on Water Resources where he wrote several environmental laws, including the Superfund Reauthorization Act of 1986, the Water Resources Development Act of 1986 and the Clean Water Act of 1987. He retired from Congress in 1992.

State, Local Officials Recognized

Allan E. Stokes, administrator of the Environmental Protection Division of the Iowa Department of Natural Resources, will receive a Public Service Award for his work as a state administrator and his dedication to environmental management. Stokes has more than 20 years of executive managerial experience with the state of Iowa, 14 of which have been with the environmental protection programs. Stokes served as the president of the Association of State and Interstate Water Pollution Control Administrators from 1991-92 and worked closely with AMSA's leadership on a number of issues of common concern to both associations.

The Hon. Jerry Abramson, mayor of Louisville, Ky., and current president of the U.S. Conference of Mayors, will be presented with the Public Service Award honoring the work of a local elected official. Abramson was first elected mayor of Louisville in 1985, and since then he has implemented a successful curbside recycling program and created an extremely popular campaign, Operation Brightside, which has beautified the community by picking up tons of trash and planting flowers. Mayor Abramson has been instrumental in many critical water pollution control programs implemented by AMSA member agency Louisville and Jefferson County Sewer District and its executive director, Gordon Garner.

Hotch to Receive Distinguished Performance Award

AMSA's Distinguished Performance Award honors individuals who formerly represented a member agency and who have shown superior dedication in the field of water pollution control. Marilyn Hotch, formerly with the Massachusetts Water Resources Authority (MWRA), is this year's honoree. As MWRA's Special Assistant for Environmental Issues, Hotch was the chair of AMSA's Pretreatment and Hazardous Waste Committee and was very active on many other Association committees. She served as AMSA's Legislative Coordinator for Region I and worked closely with the Legal Affairs Committee. Since leaving MWRA to move to Maine, Hotch has continued to work on environmental protection issues and currently serves on the National Safe Drinking Water Advisory Council and the Maine Environmental Priority Project.

President's Award Honors Association Leaders

The President's Award is given to current members and agency managers who have made significant contributions towards achieving the goals and objectives of AMSA. This year's winners are two AMSA committee chairs who have clearly made a positive contribution to the Association.

William Schatz, counsel to the Northeast Ohio Regional Sewer District, has served in committee leadership positions with AMSA for six years. As chairman of the Legal Affairs Committee, he has been instrumental in the continuous improvement and publication of AMSA's *Law Digest*. Schatz has used his committee as a forum for the continuing education of publicly owned treatment works (POTWs) managers and legal counsel through timely and well researched agendas. By inviting EPA representatives and environmental groups to attend the committee meetings, Schatz has helped to externalize AMSA's message of environmental protection.

Jon Schellpfeffer, assistant director, Madison Metropolitan Sewerage District, and chair of AMSA's Facilities Financing Committee, will be recognized for the hundreds of hours he has devoted to compiling AMSA's '90 and '93 Financial Surveys. Schellpfeffer developed much of the concept for AMSA's "Cost of Clean" report and created the Association's "Annual Service Charge Index." The surveys and reports have been an essential source of information for the Association, its members and other individuals and organizations throughout the country.

Linn Promotes Member Interests On GLI

Keith Linn, environmental specialist with the Northeast Ohio Regional Sewer

continued on page four

Combined Sewer Overflow Policy Signed

On Friday, April 8, Environmental Protection Agency (EPA) Administrator Carol M. Browner signed the Combined Sewer Overflow (CSO) Policy (see *Technical Bulletin TB 94-13*). The policy was developed through the regulatory negotiation process and the final product represents a consensus reached by EPA, municipal and environmental representatives. AMSA was instrumental in finalizing the policy and was identified by EPA as a key stakeholder.

On Monday, April 11, Bob Perciasepe, EPA assistant administrator for water, presided over a press conference to introduce the policy to the press and public. He noted that the policy will bring a consistent, nationwide approach to dealing with CSO discharges. Perciasepe stressed both the environmental and financial benefits to the policy, which contains provisions allowing site-specific requirements for controlling CSOs that overflow during wet weather conditions.

Implementation Activities Scheduled for Fall

Now that the policy has received Administration approval implementation activities are underway. A total of eight implementation guidance documents will be developed by EPA, of which five are expected to be released for external review in the near future. They will include nine minimum controls, alternative financing methods, guidance for long-term planning, guidance for permit writers and guidance for setting priorities in CSO control. The remaining guidance documents are expected to be released at the end of June or beginning of July and will cover financial capability, water quality standards and monitoring. The Association's Wet Weather Committee members will be reviewing the documents and providing EPA with comments.

EPA is planning five implementation workshops for August and September. These workshops have been scheduled for Boston, Pittsburgh, southern New Jersey, Chicago and Portland. Further information on these workshops will be forwarded through the National Office as it becomes available.

CSO Program Assessment Report Will Profile 20 Member Agencies

AMSA is in the process of drafting a CSO control strategies report. The report will discuss the new National CSO Control Policy, the scope of the CSO problem, strategies for CSO control, and chronicle water quality data documenting the effectiveness of different control programs. Twenty AMSA member programs will be profiled. The report will provide important information for all communities and individuals involved in CSO control. For this reason it will serve as the focus of a session at the upcoming implementation workshops.

Continuous Emissions Monitoring Guidance Proposed for Sludge Incinerators

In March 1994 EPA's Office of Wastewater Enforcement and Compliance (OWEC) released its final draft of the guidance document THC Continuous Emission Monitoring Guidance for Part 503 Sewage Sludge Incinerators for review and comment. This document provides guidance for Part 503 permit writers on permit terms and conditions for total hydrocarbon (THC) continuous emissions monitoring system (CEMS). The guidance also addresses specifications for the installation, calibration, operation and maintenance of THC CEMS. This document does not address carbon monoxide CEM requirements.

The original version of the guidance, which was developed by EPA Region V, incorporated provisions that were based on hazardous waste incineration regulations. Through AMSA's comments and re-evaluation by EPA headquarters, the document underwent substantial changes to more accurately reflect conditions at sewage sludge incinerators.

AMSA's Incinerator Workgroup, chaired by Bob Dominak, Northeast Ohio Regional Sewer district, reviewed and prepared comments to the final draft guidance document. The Association's comments are generally supportive of the intent and purpose behind the document; however, members identified several items in need of modification to ensure that the final permit conditions are reasonable. These clarifications are particularly important given that THC CEMS have never been used on a continuous basis at POTWs. Among the recommended revisions, AMSA has proposed that EPA extend the compliance deadline for the installation of THC CEM systems from Feb. 19, 1994, to February 19, 1995, or one year following publication of the guidance in the *Federal Register*. The original compliance date was delayed pending issuance of the permit writer guidance on CEMS.

A February 17 memorandum issued by Michael Cook, director of EPA's OPEC, stated the agency's intent to provide public notice on the availability of the final permit writer's guidance for CEMS and a new Part 503 compliance date for sludge incinerators in the *Federal Register* in late spring.

Clean Water Act

continued from page one

debate in the House of Representatives, including unfunded mandates, risk assessment and takings provisions.

The scheduling of hearings and the release of the bipartisan alternative proposal will delay markup of H.R. 3948, which was expected to take place in early May. AMSA has forwarded an analysis of the alternative proposal and other emerging news on the Clean Water Act reauthorization to their membership via *Legislative Bulletin No. 94 -13.*

AMSA Awards

continued from page two

District, will receive this year's Environment Award in recognition of his work on the Great Lakes Water Quality Initiative (GLI). Linn began work on the project in 1990 and has represented AMSA in the Initiative's Public Participation Group for more than two years. He has become an acknowledged expert on the GLI and its resulting guidance document. Linn was instrumental in developing AMSA's technical comments to the guidance document. Through his work and dedication, AMSA fully participated in the Great Lakes Water Quality Initiative.

Member Agency Projects and Programs Honored

AMSA member agencies will be honored for their achievements over the past year. The Eastern Municipal Water District's (Calif.) demonstration project, "Multi-Purpose Wetlands Research and Demonstration," is a cooperative effort between the district, other government agencies, academia and environmental groups to evaluate and expand the use of reclaimed water. The Hampton Roads Sanitation District, Va., designed and produced a training video and brochure entitled "Protecting our Pipelines: Eliminating Entrained Air" to educate employees in avoiding costly repairs caused by pipe damage from entrained air.

Several member agencies have been involved in public education and information program development. The Rock River Water Reclamation District, Ill., is part of a coordinated effort that produced a middle school curriculum on wastewater treatment called "Water Environment Education." The Metro Wastewater Reclamation District's (Col.) comprehensive program, "Varied Aspects of Public Education and Information," includes a speakers bureau, facility tours and promotional events. The Milwaukee Metropolitan Sewerage District, developed the "History of Water Pollution Abatement Program" to highlight the completion of a 16-year water pollution abatement project and to educate citizens on the significance of the project. The El Paso Water Utilities Public Service Board, Texas, produced a video in both English and Spanish entitled the "Fred Hervey Water Reclamation Plant" to show plant visitors the importance of the reclamation plant in meeting future drinking water needs. Each of these agencies will be honored with awards.

White Recognized for a Quarter Century of Service

Lee C. White will be honored for his 25 years of service to AMSA. White, who has been with the Association since its inception, has guided much of AMSA's legal activities. White retired from legal practice in April of 1994.

Future Meetings Examine Water Quality, Pretreatment

AMSA's remaining 1994 meetings will focus on water quality and pretreatment. The 1994 Summer Technical Conference, "Water Quality Criteria & Standards in a Changing Environment" will be held from July 19-22 at the Minneapolis Metrodome Hilton in Minneapolis. Technical Conference agenda items will include water quality criteria, criteria development, standards and permitting and other related issues. Look for a General Bulletin later this month with a preliminary program and registration materials for this important conference.

This year's Pretreatment Coordinators Workshop will be held November 2-4 at the Hyatt Regency Hotel in Indianapolis. This workshop will, for the first time, be jointly sponsored by AMSA and the Environmental Protection Agency (EPA). The November meeting will build on the series of successful AMSA workshops by bringing regulators and local pretreatment officials together for dialogue and technology transfer.

Association of Metropolitan Sewerage Agencies
1000 Connecticut Avenue, N.W.
Suite 410
Washington D.C. 20036

J. ANDREW SCHLANGE
GENERAL MANAGER
EASTERN MUNICIPAL WATER DISTRICT
P.O. BOX 8300
SAN JACINTO, CA 92581-8300

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MULTIPURPOSE CONSTRUCTED WETLANDS

Project Awards

- Association of Metropolitan Sewerage Agencies Research and Technology Award for 1994
- California's Local Government Commission 1992 Award for Innovation in Water Conservation, Reclamation and Management
- Inland Empire West Resource Conservation District 1993 Conservation Partnership Award - Water Quality

Eastern Municipal Water District

EMWD honored for conservation

by The Hemet News

California's Local Government Commission has recognized Eastern Municipal Water District for innovation in water conservation, reclamation and management.

EMWD was honored for its Multipurpose Wetlands Research and Demonstration Study, an approach to expanded use of reclaimed water.

The five-year project involves the use of wetlands constructed to treat wastewater and brackish groundwater in order to reuse it for agricultural and groundwater recharge purposes.

Craig A. Weaver, a member of EMWD's board of directors, accepted the award Friday on behalf of the agency during the commission's statewide conference on critical water policy issues.

Eastern is conducting the research and development study in cooperation with the U.S. Bureau of Reclamation and in consultation with other government agencies, the academic community and environmental groups.

Eastern Municipal Water District provides water and wastewater services throughout a 534-square mile area of western Riverside County with a population of about 380,000.

Water district wins kudos for conservation efforts

Eastern one of five agencies so honored

The Press-Enterprise

SAN JACINTO

Industry associations have been showering awards on Eastern Municipal Water District for leadership in preaching and practicing water conservation.

Eastern was one of five Association of California Water Agencies' member districts to receive a water management certificate recognizing its commitment to efficient water use.

The association noted several examples of Eastern's strategy, including education, programs to reduce demand and research into alternative supplies. The district also has drafted other public agencies in the campaign to conserve water.

The district serves central and southwest Riverside County.

Last month the Local Government Commission, a non-profit educational group comprised of public agency officials, honored the district for its experimental wetlands project at the San Jacinto Regional Water Reclamation Facility.

In a joint experiment with the U.S. Bureau of Reclamation, Eastern is studying how bulrush plants grown in a wetlands can improve the quality of wastewater passing through a marsh en route to re-use for irrigation.

The district received one of 14 awards given to private industry, agriculture and water agencies.

Also last month, General Manager J. Andrew Schlange received an award for innovation in addressing water supply challenges from the Valley Group, an organization of community leaders dedicated to economic advancement of western Riverside County.

News from
Eastern Municipal Water District
Community Relations Officers:

Glen Daniels
Ext. 382

Dick Heil
Ext. 383

Peter Odencrans
Ext. 219

Phone Numbers: (800) 468-6111 • (714) 925-7676 • FAX: (714) 929-0257

UNIQUE WATER RECLAMATION PROJECT HONORED

San Jacinto, CA, Nov. 23, 1992 -- California's Local Government Commission has recognized Eastern Municipal Water District for its innovative water conservation, reclamation and management programs.

The prestigious award was presented Friday evening (Nov. 20) at the Biltmore Hotel in Los Angeles during the commission's statewide conference on critical water policy issues.

EMWD was honored for its Multipurpose Wetlands Research and Demonstration Study, a far sighted and creative approach to expanded use of reclaimed water. The district is considered to be at the leading edge of reclaimed water use and research nationally. The arid nature of Eastern's service area and of the southwest, generally, makes this research into extending water resources especially important.

The five-year project involves the use of wetlands constructed to treat wastewater and brackish groundwater in order to reuse it for agricultural and groundwater recharge purposes. The process offers an attractive and economical alternative to conventional, energy-intensive physical, chemical and biological treatment facilities needed to meet water quality standards.

-more-

Mail: P.O. Box 8300 • Main Office: 2045 S. San Jacinto Avenue • San Jacinto, California 92581-8300

Craig A. Weaver, a member of EMWD's board of directors, accepted the award on behalf of the agency.

"Wetlands for wastewater treatment have received nationwide attention as communities attempt to resolve water and wastewater management problems," Weaver said. "Our project addresses not only those needs but wildlife values, public education and environmental enhancement, as well. The wetlands program shows great promise," he added.

Eastern is conducting the research and development study in cooperation with the U.S. Bureau of Reclamation and in consultation with other government agencies, the academic community and environmental groups.

"A unique aspect of our project is that we are designing in wildlife enhancement and public education from the very start," notes Christie Crother, project coordinator. "We are showing that those objectives can be made part-and-parcel of a comprehensive reclamation effort and that they benefit one another."

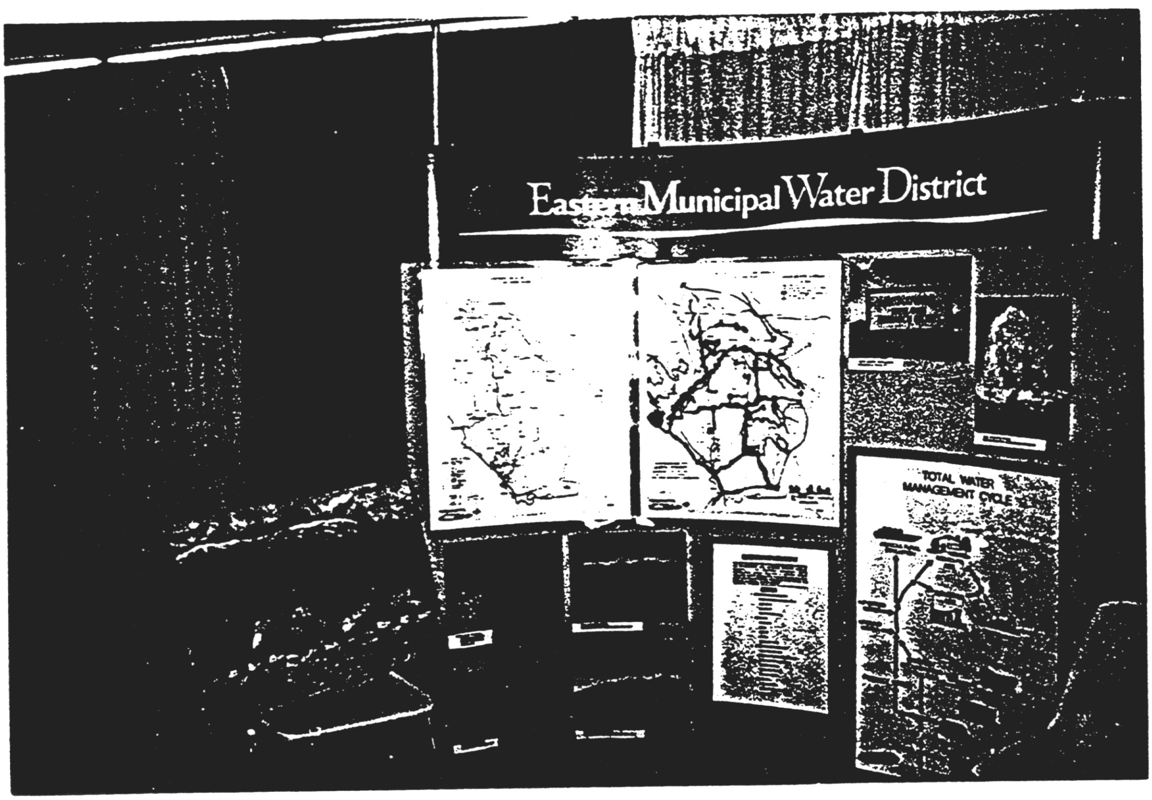
Eastern Municipal Water District provides water and wastewater services throughout a 534-square mile area of western Riverside County with a population of about 380,000.

###

November 20, 1992

California's Local Government Commission Award for Innovation in Water Conservation, Reclamation, and Management for the USBR/EMWD Multipurpose Wetlands Research and Demonstration Study.

Award accepted by Craig Weaver, Member, EMWD Board of Directors, at annual California Water Policy: Toward a New Consensus II Conference, Los Angeles, California.



RECEIVED
AUG 2 3 1993
E.M.W.D.

Inland Empire West Resource Conservation District

2816 E. Fourth St., Ontario, CA 91764-4601 *(909) 987-0622*
FAX (909) 987-1767

August 20, 1993

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MAIL DIST	EX	AD	EN	OP	RD	SF	HR	PC	BD	ADD COPY	EX	AD	EN	OP	RD	SF	HR	PC	BD
										ACT									

General Manager
Eastern Municipal Water District
P.O. Box 8300
San Jacinto, CA 92581-8300

To Whom It May Concern:

On behalf of the Inland Empire West Resource Conservation District, The Gas Company, and the Inland Empire Business Journal, we are pleased to congratulate you on being selected as a finalist in our Conservation Partnership Awards. You were selected in the category of Water Quality Protection, for your constructed wetlands demonstration project. Other finalists in the category are: South Orange County Reclamation Authority, Santa Ana Watershed Project Authority, Riverside County Flood Control and Water Conservation District.

So as to better assist our judges in selecting the eventual winner in each category, the IEWRCD/panel judges may be contacting you for further information. The winner in each category will be announced at our awards ceremony on the evening of September 17th 1993. The event will be held at The Gas Company Auditorium - 1980 Lugonia Avenue, Redlands, CA 92373. Tickets are $18.00 per person.

As we wish to have a professional looking presentation, we are asking each finalist to provide us with the following:

* Two or three slides of the project or program.
* A copy of your logo in camera ready form.

We are requesting this material to be at our offices, not later than September 7th 1993. Our address is: 2816 East Fourth St, Ontario, CA 91764.

Should you have any questions, please do not hesitate to contact me at (909) 987-0622. We look forward to seeing you on the evening of September 17th.

Sincerely,

Bill Ruh
Volunteer/Event Coordinator

Eastern Municipal Water District

October 6, 1993

TO: Board of Directors

FROM: General Manager

SUBJECT: Multipurpose Wetlands Research & Demonstration Study Award

On September 17, 1993, Eastern Municipal Water District, Multipurpose Wetlands Research and Demonstration Study, was recognized and honored as the recipient of the 1993 Conservation Partnership Award in the Water Quality Category. The first annual awards were sponsored by the Inland Empire West Resource Conservation District, The Gas Company, and the Inland Empire Business Journal. The award was presented at an evening ceremony at The Gas Company Auditorium in Redlands.

The awards were developed to recognize the conservation accomplishments of businesses, community organizations, governmental agencies, non-profit groups, and individuals. The five categories for awards were: Community Outreach, Conservation Leadership, Employee Awareness, Media Coverage, Technological Innovations, and Water Quality. There were over 120 nominations for awards in the five categories. Four finalists were selected for the Water Quality Category with EMWD announced as the winner at the ceremony.

The Inland Empire West Resource Conservation District is a self-governed, non-profit, local government agency established by conservation-minded, local residents through state law. In the shadow of the "Dust Bowl" era of the 1930's, conservation pioneers envisioned a program for the conservation of soil, water, and related resources. Funding for the district is obtained from public/private grants, memberships, corporate and individual contributions and property taxes. The district was formed in 1941. The purpose of the District is to help all residents conserve and develop their natural resources through good conservation practices.

It is with great pride and pleasure that I present this award to your Honorable Board.

Respectfully,

J. Andrew Schlange
General Manager

Prepared by,

P. Ravishanker
Assistant General Manager
Resource Development

J:\WORDPROC\WP\RES_DEV\AWARD.CMC

Mail To: Post Office Box 8300 • San Jacinto, California 92581-8300 • Telephone (909) 925-7676 • Fax (909) 929-0257
Main Office: 2045 S. San Jacinto Avenue, San Jacinto • Customer Service/Engineering Annex: 440 E. Oakland Avenue, Hemet, CA

News from
Eastern Municipal Water District
Community Involvement Officers:

Dick Heil Ext. 383
Peter Odencrans Ext. 219
Ted Haring Ext. 221

September 23, 1993

WETLANDS PROJECT EARNS
CONSERVATION PARTNERSHIP AWARD

Eastern Municipal Water District's efforts in improving water quality have been honored with the Conservation Partnership Award. It is one of only six such awards.

The presentation was held in Redlands September 17. It was sponsored by the Inland Empire West Resource Conservation District, Inland Empire Business Journal and The Gas Company. EMWD's project was selected from more than 120 nominations for outstanding conservation accomplishments in community outreach, conservation leadership, employee awareness, media coverage, technical innovations or water quality.

EMWD's Multipurpose Wetlands Demonstration and Research Study in San Jacinto treats wastewater to higher standards for wider industrial and agricultural reclaimed water use. Initial studies have proven successful in removing pollutants, such as heavy metals and nitrates, while also providing needed wetland habitat for waterfowl, fish and wildlife.

Three large-scale wetlands demonstration sites are planned, with each site to accomplish the equivalent of a one-million-gallons-per-day conventional facility.

The Inland Empire West RCD is a self-governed, non-profit local government agency established by conservation-minded, local residents through state law. Its purpose is to help all residents within its boundaries conserve and develop their natural resources through good conservation practices.

EMWD is a water resources agency that, in addition to supplying fresh water, normally treats about 25 million gallons a day of wastewater at five regional facilities, which serve some 280,000 residents.

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EMWD receives conservation award

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The Valley Times
Friday, October 15, 1993

MORENO VALLEY CHAMBER OUTLOOK
The Official Publication of the Moreno Valley Chamber of Commerce
Vol. 9, No. 9, Nov/Dec 1993

Wetlands Project Earns Conservation Partnership Award

Eastern Municipal Water District's efforts in improving water quality have been honored with the Conservation Partnership Award, it was one of six such awards.

The presentation was held in Redlands September 17. It was sponsored by the Inland Empire Business Journal and the Southern California Gas Company. EMWD's project was selected from more than 1200 nominations for outstanding conservation accomplishments in community outreach, conservation leadership, employee awareness, media coverage, technical innovation or water quality.

EMWD's Multipurpose Wetlands Demonstration and Research Study in San Jacinto treats wastewater to higher standards for wider industrial and agricultural reclaimed water use. Initial studies have proven successful in removing pollutants such as heavy metals and nitrates, while also providing needed wetland habitat for waterfowl, fish and wildlife.

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Water district earns coveted award

■ **INNOVATION:** *Eastern Municipal Water District garners honor for its project seeking to expand reclaimed water use*

The Californian

Eastern Municipal Water District has received a nationally-coveted Research and Technology Award for 1994 in recognition of its innovative "Multi-purpose Wetlands Research and Demonstration Study."

The award is sponsored by the Association of Metropolitan Sewage Agencies and honors innovation related to wastewater treatment. Eastern's project was selected from among the work of hundreds of association member agencies.

Christie M. Crother, a project coordinator in the Resource Development Branch, accepted the award on the district's behalf. Crother played a key role in the project's development.

To qualify for the honor, a project must directly relate to basic processes of wastewater collection or treatment, must be conducted in-house or under the agency's close direction, and must have practical application.

"Our wetlands project easily meets all those conditions, and, in fact, we are expanding it from 'demonstration' status to full operational capacity," Crother said. "We are showing how to reclaim wastewater in an economical, natural way while we benefit wildlife and offer educational opportunities rarely equaled in our region, and all of this is to the advantage of our ratepayers and the general public."

> "We are showing how to reclaim wastewater in an economical, natural way . . .
>
> —CHRISTIE CROTHER, coordinator

The EMWD project is cosponsored by the Bureau of Reclamation, and a number of other agencies also participate. It is designed to evaluate and expand the use of reclaimed water through the use of multipurpose constructed wetlands. Besides providing economical and natural tertiary processing of wastewater treatment plant effluent, the project provides quality habitat for migratory waterfowl and shorebirds.

The Californian

6-10-94

APPENDIX J

APPENDIX J

SPECIES LISTING

SPECIES LISTING

The following are scientific and common names of species mentioned in the text.

PLANTS

California bulrush	*(Scirpus californicus)*
hardstem bulrush	*(Scirpus acutus) or (S. acutus)*
Alkali bulrush	*(Scirpus robustus)*
rush	*(Juncus spp.)*
duckweed	*(Lemna spp.)*
marsh or water pennywort	*(Hydrocotyle umbellata)*
seepwillow	*(Baccharis glutinosa)*
creeping spikerush	*(Eleocharis palustris)*
marsh smartweed	*(Polygonum muhlenbergii)*
Pennsylvania smartweed	*(Polygonum pensylvanicum)*
smartweed	*(Polygonum spp.)*
cattail	*(Typha spp.)*
swamp timothy	*(Crypsis schoenoides)*
willow	*(Salix spp.)*
watergrass plants	*(Echinochloa crusgalli)*
quillwort	*(Isoetes spp.)*
mallow	*(Malva spp.)*
prickly lettuce	*(Lactuca Serriola)*
plastic flamingo	*(Flamingo plasticus)*

INVERTEBRATES

Scientific and common names of taxa mentioned in the text are presented in Table 4-5 on page 117.

BIRDS

Scientific and common names of birds are presented on subsequent pages.

A Sleigh
1993-94

Species List

CLARK'S GREBE (Aechmophorus clarkii)

October, 27, 1993 (1)

EARED GREBE (Podiceps nigricollis)

June 22, 1993 (20)
June 27, 1993 (18)
July 5, 1993 (22)
July 30, 1993 (6)
August 3, 1993 (8)
August 15, 1993 (4)
August 18, 1993 (2)
August 29, 1993 (3)
September 5, 1993 (2)
September 29, 1993 (2)
October 9, 1993 (1)
October 13, 1993 (3)
October 18, 1993 (4)
October 20, 1993 (3)
October 27, 1993 (4)
November 7, 1993 (2)
November 13, 1993 (2)
November 21, 1993 (4)
November 27, 1993 (2)
November 30, 1993 (3)
December 14, 1993 (1)
December 23, 1993 (2)
December 30, 1993 (1)
January 10, 1994 (1)
January 13, 1994 (2)
January 23, 1994 (1)
January 29, 1994 (1)
February 14, 1994 (5)
February 24, 1994 (2)
March 1, 1994 (24)
March 15, 1994 (12)
March 24, 1994 (8)
April 4, 1994 (18)
April 18, 1994 (47)
April 30, 1994 (25)
May 11, 1994 (23)
May 17, 1994 (29)
May 19, 1994 (30)
May 26, 1994 (3)
June 3, 1994 (11) } nesting
June 7, 1994 (27)
June 13, 1994 (18)
June 23, 1994 (16)

DOUBLE-CRESTED CORMORANT (Phalacrocorax auritus)

October 27, 1993 (3)

BLACK-CROWNED NIGHT HERON (Nycticorax nycticorax)

July 3, 1993 (1)
May 11, 1994 (1)
June 23, 1994 (1)

GREEN-BACKED HERON (Butorides striatus)

May 26, 1994 (1)

CATTLE EGRET (Bubulcus ibis)

June 27, 1993 (1)
October 13, 1993 (1)
November 27, 1993 (5)
January 29, 1994 (3)
February 14, 1994 (72)
February 24, 1994 (2)
March 1, 1994 (19)
May 26, 1994 (3) in breeding plumage
June 7, 1994 (7)
June 13, 1994 (4)
June 23, 1994 (1) ✓

SNOWY EGRET (Egretta thula)

August 12, 1993 (1)
September 5, 1993 (1)
November 7, 1993 (1)
February 24, 1994 (1)

GREAT EGRET (Casmerodius albus)

July 3, 1993 (1)
September 5, 1993 (1)
October 18, 1993 (1)
November 27, 1993 (1)
December 23, 1993 (1)
January 29, 1994 (1)
June 3, 1994 (1)

GREAT BLUE HERON (Ardea herodias)

June 23, 1994 (1)

WHITE-FACED IBIS (Plegadis chihi)

June 22, 1993 (25)
July 3, 1993 (1)
September 5, 1993 (1)

CANADA GOOSE (Branta canadensis minima)

August 18, 1993 (1)
August 29, 1993 (1)
September 5, 1993 (1)
September 29, 1993 (1)
October 13, 1993 (1)
October 18, 1993 (1)
December 4, 1993 (1)

CANADA GOOSE (Branta canadensis)

November 13, 1993 (26)
November 21, 1993 (13)
November 27, 1993 (28)
November 30, 1993 (29)
December 4, 1993 (371)
December 23, 1993 (1)
December 30, 1993 (25)
January 23, 1994 (1)
January 29, 1994 (131)
February 14, 1994 (184)
February 24, 1994 (52)

MALLARD (anas platyrhynchos)

August 12, 1993 (5)
August 15, 1993 (2)
August 18, 1993 (11)
August 29, 1993 (6)
September 5, 1993 (5)
September 29, 1993 (38)
October 9, 1993 (166)
October 13, 1993 (116)
October 18, 1993 (114)
October 20, 1993 (37)
October 24, 1993 (24)
October 27, 1993 (37)
November 7, 1993 (31)
November 13, 1993 (28)
November 21, 1993 (38)
November 27, 1993 (9)
November 30, 1993 (30)
December 4, 1993 (3)
December 14, 1993 (3)
January 10, 1994 (2)
January 29, 1994 (2)
February 14, 1994 (48)
February 24, 1994 (6)
March 1, 1994 (2)
March 15, 1994 (8)
March 24, 1994 (9)
April 4, 1994 (18)
April 18, 1994 (19) 10 are juveniles
April 30, 1994 (8)
May 11, 1994 (21)
May 17, 1994 (37) some juveniles
May 19, 1994 (20)
May 26, 1994 (39)
June 3, 1994 (32)
June 7, 1994 (26)
June 13, 1994 (23)
June 23, 1994 (21)

GADWALL (Anas strepera)

August 18, 1993 (10)
August 29, 1993 (7)
March 15, 1994 (1)

March 24, 1994 (3)
May 11, 1994 (15)
May 19, 1994 (2)

GREEN-WINGED TEAL (Anas crecca)

September 5, 1993 (2)
October 27, 1993 (3)
November 7, 1993 (8)
November 13, 1993 (3)
November 21, 1993 (2)
November 30, 1993 (3)
December 4, 1993 (35)
December 14, 1993 (17)
December 23, 1993 (32)
December 30, 1993 (38)
January 10, 1994 (65)
January 13, 1994 (49)
January 16, 1994 (56)
January 23, 1994 (52)
January 29, 1994 (13)
February 14, 1994 (21)
February 24, 1994 (9)
March 1, 1994 (2)
March 15, 1994 (33)
March 24, 1994 (13)
April 4, 1994 (8)
April 30, 1994 (2)
June 13, 1994 (1)

AMERICAN WIGEON (Anas americana)

October 9, 1993 (42)
October 13, 1993 (12)
October 18, 1993 (218)
October 20, 1993 (176)
October 24, 1993 (390)
October 27, 1993 (659)
November 7, 1993 (306)
November 13, 1993 (1102)
November 21, 1993 (2569)
November 27, 1993 (3586)
November 30, 1993 (1534)
December 4, 1993 (2405)
December 14, 1993 (2899)
December 23, 1993 (4108)
December 30, 1993 (6050)
January 10, 1994 (6632)
January 13, 1994 (2833)
January 16, 1994 (8315)
January 23, 1994 (8484)
January 29, 1994 (9107)
February 14, 1994 (1162)
February 24, 1994 (4060)
March 1, 1994 (2179)
March 15, 1994 (1091)
March 24, 1994 (1092)
April 4, 1994 (104)

EURASIAN WIGEON (Anas penelope)

November 27, 1993 (2)
November 30, 1993 (3)
December 4, 1993 (2)
December 14, 1993 (5)
December 23, 1993 (11)
December 30, 1993 (8)
January 10, 1994 (5)
January 13, 1994 (10)
January 16, 1994 (3)
January 23, 1994 (6)
January 29, 1994 (11)
February 14, 1994 (1)
February 24, 1994 (2)
March 1, 1994 (1)
March 15, 1994 (5)
March 24, 1994 (2)

NORTHERN PINTAIL (*Anas acuta*)

July 30, 1993 (7)
August 3, 1993 (3)
August 12, 1993 (4)
October 13, 1993 (1)
October 18, 1993 (9)
October 20, 1993 (7)
October 24, 1993 (4)
October 27, 1993 (32)
November 7, 1993 (2)
November 27, 1993 (22)
November 30, 1993 (5)
December 4, 1993 (3)
December 14, 1993 (24)
December 23, 1993 (32)
December 30, 1993 (2)
January 10, 1994 (48)
January 13, 1994 (42)
January 16, 1994 (111)
January 23, 1994 (53)
January 29, 1994 (55)
February 14, 1994 (297)
February 24, 1994 (77)
March 15, 1994 (5)
March 24, 1994 (1)

NORTHERN SHOVELER (*Anas clypeata*)

September 5, 1993 (2)
September 29, 1993 (3)
October 9, 1993 (8)
October 13, 1993 (34)
October 18, 1993 (23)
October 20, 1993 (59)
October 24, 1993 (64)
October 27, 1993 (68)
November 7, 1993 (25)
November 13, 1993 (30)
November 21, 1993 (165)
November 27, 1993 (41)
November 30, 1993 (29)

December 4, 1993 (60)
December 14, 1993 (82)
December 23, 1993 (109)
December 30, 1993 (330)
January 10, 1994 (1259)
January 13, 1994 (3962)
January 16, 1994 (2011)
January 23, 1994 (1028)
January 29, 1994 (1020)
February 14, 1994 (370)
February 24, 1994 (926)
March 1, 1994 (150)
March 15, 1994 (196)
March 24, 1994 (388)
April 4, 1994 (455)
April 18, 1994 (14)
April 30, 1994 (1)
May 17, 1994 (1)
May 26, 1994 (1)

BLUE-WINGED TEAL (*Anas discors*)

August 29, 1993 (3)
October 20, 1993 (2)

CINNAMON TEAL (*Anas cyanoptera*)

August 12, 1993 (6)
August 15, 1993 (5)
August 18, 1993 (20)
August 29, 1993 (8)
September 5, 1993 (42)
September 29, 1993 (1)
October 18, 1993 (3)
October 20, 1993 (19)
October 24, 1993 (20)
October 27, 1993 (72)
November 7, 1993 (65)
November 13, 1993 (32)
November 21, 1993 (21)
November 27, 1993 (8)
November 30, 1993 (3)
December 23, 1993 (28)
December 30, 1993 (4)
January 13, 1994 (19)
January 16, 1994 (1)
January 29, 1994 (10)
February 14, 1994 (41)
February 24, 1994 (29)
March 1, 1994 (60)
March 15, 1994 (89)
March 24, 1994 (52)
April 4, 1994 (61)
April 18, 1994 (27)
April 30, 1994 (8)
May 11, 1994 (4)
May 17, 1994 (10)
May 19, 1994 (20)
May 26, 1994 (13)
June 3, 1994 (15)

June 7, 1994 (22)
June 13, 1994 (18)
June 23, 1994 (33)

RUDDY DUCK (Oxyura jamaicensis)

June 22, 1993 (36)
June 27, 1993 (2)
July 3, 1993 (42)
July 14, 1993 (3)
July 30, 1993 (1)
August 3, 1993 (14)
August 12, 1993 (32)
August 15, 1993 (2)
August 18, 1993 (13)
August 29, 1993 (19)
September 5, 1993 (9)
September 29, 1993 (55)
October 9, 1993 (35)
October 13, 1993 (36)
October 18, 1993 (12)
October 20, 1993 (21)
October 24, 1993 (9)
October 27, 1993 (42)
November 7, 1993 (13)
November 13, 1993 (20)
November 21, 1993 (42)
November 27, 1993 (17)
November 30, 1993 (8)
December 4, 1993 (2)
December 14, 1993 (44)
December 23, 1993 (76)
December 30, 1993 (47)
January 10, 1994 (68)
January 13, 1994 (39)
January 16, 1994 (75)
January 23, 1994 (90)
January 29, 1994 (82)
February 14, 1994 (120)
February 24, 1994 (105)
March 1, 1994 (402)
March 15, 1994 (116)
March 24, 1994 (106)
April 4, 1994 (96)
April 18, 1994 (82)
April 30, 1994 (51)
May 11, 1994 (61)
May 17, 1994 (44) including 6 juveniles
May 19, 1994 (47)
May 26, 1994 (23)
June 3, 1994 (26)
June 7, 1994 (35)
June 13, 1994 (55)
June 23, 1994 (73)

CANVASBACK (Aythya valisineria)

February 14, 1994 (1)

REDHEAD (Aythya americana)

October 24, 1993 (15)
October 27, 1993 (4)
November 7, 1993 (1)
November 21, 1993 (13)
November 27, 1993 (16)
November 30, 1993 (4)
December 4, 1993 (2)
December 14, 1993 (37)
December 23, 1993 (20)
December 30, 1993 (3)
January 10, 1994 (4)
January 16, 1994 (5)
January 29, 1994 (4)
February 14, 1994 (26)
February 24, 1994 (13)
March 1, 1994 (1)
April 4, 1994 (5)
April 18, 1994 (18)
April 30, 1994 (4)
May 11, 1994 (1)
May 17, 1994 (1)
May 19, 1994 (5)
May 26, 1994 (5)
June 3, 1994 (11)
June 7, 1994 (21)
June 13, 1994 (16)
June 23, 1994 (11)

RING-NECKED DUCK (Aythya collaris)

October 20, 1993 (2)
November 13, 1993 (2)
November 27, 1993 (2)
December 30, 1993 (2)
January 13, 1994 (1)
January 29, 1994 (3)
February 14, 1994 (37)
February 24, 1994 (23)
April 4, 1994 (2)
June 7, 1994 (1)
June 13, 1994 (1)
June 23, 1994 (1)

GREATER SCAUP (Aythya marila)

February 14, 1994 (2)
February 24, 1994 (7)
March 15, 1994 (2)

LESSER SCAUP (Aythya affinis)

October 27, 1993 (3)
November 7, 1993 (1)
November 13, 1993 (4)
November 21, 1993 (5)
December 14, 1993 (4)
December 23, 1993 (3)
December 30, 1993 (5)
January 23, 1994 (8)

January 29, 1994 (15)
February 14, 1994 (77)
February 24, 1994 (87)
March 15, 1994 (34)
March 24, 1994 (21)
April 4, 1994 (13)
April 18, 1994 (10)
April 30, 1994 (1)
May 17, 1994 (2)
June 3, 1994 (4)
June 7, 1994 (2)

BUFFLEHEAD (Bucephala albeola)

November 7, 1993 (3)
November 13, 1993 (6)
November 21, 1993 (9)
November 27, 1993 (16)
November 30, 1993 (7)
December 4, 1993 (23)
December 14, 1993 (14)
December 23, 1993 (9)
December 30, 1993 (7)
January 10, 1994 (11)
January 13, 1994 (5)
January 16, 1994 (19)
January 24, 1994 (12)
January 29, 1994 (25)
February 14, 1994 (28)
February 24, 1994 (44)
March 1, 1994 (23)
March 15, 1994 (15)
March 24, 1994 (4)

VIRGINIA RAIL (Rallus limicola)

November 21, 1993 (1)
December 4, 1993 (1)

SORA (Porzana carolina)

October 18, 1993 (2)
October 20, 1993 (1)
October 24, 1993 (1)
October 27, 1993 (1)
November 21, 1993 (1)
November 27, 1993 (2)
November 30, 1993 (2)
December 14, 1993 (1)

COMMON MOORHEN (Gallinula chloropus)

June 22, 1993 (2)
June 27, 1993 (2)
July 3, 1993 (1)
July 14, 1993 (5)
July 30, 1993 (3)
August 3, 1993 (3)
August 12, 1993 (2)
August 15, 1993 (1)

August 18, 1993 (1)
September 5, 1993 (2)
September 29, 1993 (13)
October 9, 1993 (4)
October 13, 1993 (8)
October 18, 1993 (9)
October 20, 1993 (9)
October 24, 1993 (6)
October 27, 1993 (5)
November 7, 1993 (4)
November 13, 1993 (5)
November 21, 1993 (1)
November 27, 1993 (3)
November 30, 1993 (4)
December 4, 1993 (1)
December 23, 1993 (1)
December 30, 1993 (1)
January 10, 1994 (4)
January 13, 1994 (2)
January 16, 1994 (2)
January 23, 1994 (4)
January 29, 1994 (2)
February 14, 1994 (1)
February 24, 1994 (2)
March 1, 1994 (2)
March 15, 1994 (2)
March 24, 1994 (3)
April 18, 1994 (1)
April 30, 1994 (2)
May 11, 1994 (3) also found a nest
May 17, 1994 (3) including 2 juveniles
May 19, 1994 (3) adults
May 26, 1994 (5) 2 adults, 3 juveniles

AMERICAN COOT (Fulica americana)

June 22, 1993 (6)
June 27, 1993 (10)
July 3, 1993 (8)
July 14, 1993 (5)
August 12, 1993 (3)
August 15, 1993 (5)
August 18, 1993 (13)
August 29, 1993 (26)
September 5, 1993 (16)
September 29, 1993 (42)
October 9, 1993 (23)
October 13, 1993 (23)
October 18, 1993 (34)
October 20, 1993 (44)
October 24, 1993 (36)
October 27, 1993 (17)
November 7, 1993 (40)
November 13, 1993 (39)
November 21, 1993 (73)
November 27, 1993 (37)
November 30, 1993 (37)
December 4, 1993 (17)
December 14, 1993 (26)
December 23, 1993 (53)

December 30, 1993 (61)
January 10, 1994 (32)
January 13, 1994 (32)
January 16, 1994 (46)
January 23, 1994 (55)
January 29, 1994 (28)
February 14, 1994 (51)
February 24, 1994 (135)
March 1, 1994 (200)
March 15, 1994 (205)
March 24, 1994 (223)
April 4, 1994 (159)
April 18, 1994 (79)
April 30, 1994 (57)
May 11, 1994 (24)
May 17, 1994 (10)
May 19, 1994 (14)
May 26, 1994 (13)
June 3, 1994 (12)
June 7, 1994 (14)
June 13, 1994 (13)
June 23, 1994 (10)

AMERICAN AVOCET (*Recurvirostra americana*)

June 22, 1993 (146)
June 27, 1993 (138)
July 3, 1993 (151)
July 14, 1993 (172)
July 30, 1993 (143)
August 3, 1993 (11)
August 12, 1993 (40)
August 15, 1993 (68)
August 18, 1993 (100)
August 29, 1993 (51)
September 5, 1993 (26)
September 29, 1993 (81)
October 9, 1993 (48)
October 13, 1993 (105)
October 18, 1993 (160)
October 20, 1993 (4)
October 24, 1993 (102)
November 7, 1993 (42)
November 13, 1993 (43)
November 21, 1993 (50)
November 27, 1993 (8)
November 30, 1993 (7)
December 4, 1993 (58)
December 14, 1993 (9)
December 23, 1993 (3)
December 30, 1993 (1)
January 10, 1994 (15)
January 13, 1994 (20)
January 16, 1994 (36)
January 23, 1993 (30)
January 29, 1994 (5)
February 14, 1994 (18)
February 24, 1994 (13)
March 1, 1994 (1)
March 15, 1994 (47)

March 24, 1994 (52)
April 4, 1994 (79)
April 18, 1994 (47)
April 30, 1994 (50)
May 11, 1994 (17)
May 17, 1994 (40)
May 19, 1994 (13)
May 26, 1994 (12)
June 3, 1994 (4)
June 7, 1994 (8)
June 13, 1994 (7)

BLACK-NECKED STILT (*Himantopus mexicanus*)

June 22, 1993 (184)
June 27, 1993 (172)
July 3, 1993 (153)
July 14, 1993 (136)
July 30, 1993 (124)
August 3, 1993 (8)
August 12, 1993 (28)
August 15, 1993 (88)
August 18, 1993 (88)
August 29, 1993 (109)
September 5, 1993 (147)
September 29, 1993 (5)
October 13, 1993 (1)
October 20, 1993 (8)
October 24, 1993 (30)
October 27, 1993 (138)
November 13, 1993 (27)
November 21, 1993 (11)
November 27, 1993 (9)
November 30, 1993 (6)
December 4, 1993 (55)
December 14, 1993 (6)
December 23, 1993 (23)
December 30, 1993 (2)
January 10, 1994 (38)
January 13, 1994 (12)
January 16, 1994 (11)
January 23, 1994 (1)
January 29, 1994 (8)
February 14, 1994 (35)
February 24, 1994 (3)
March 1, 1994 (38)
March 15, 1994 (35)
March 24, 1994 (22)
April 4, 1994 (31)
April 18, 1994 (23)
April 30, 1994 (19)
May 11, 1994 (19)
May 17, 1994 (27)
May 19, 1994 (24) nesting on banks
May 26, 1994 (36)
June 3, 1994 (14)
June 7, 1994 (31) including 3 juveniles
June 13, 1994 (37)
June 23, 1994 (49) including 6 juvenile, also saw 3 eggs in nest

KILLDEER (Charadrius vociferus)

June 22, 1993 (4)
June 27, 1993 (15)
July 3, 1993 (9)
July 14, 1993 (7)
July 30, 1993 (24)
August 3, 1993 (2)
August 12, 1993 (1)
August 15, 1993 (1)
August 18, 1993 (6)
August 29, 1993 (3)
September 5, 1993 (31)
September 29, 1993 (8)
October 9, 1993 (2)
October 13, 1993 (7)
October 20, 1993 (4)
October 24, 1993 (4)
October 27, 1993 (28)
November 7, 1993 (17)
November 13, 1993 (5)
November 27, 1993 (1)
December 14, 1993 (1)
December 23, 1993 (1)
January 10, 1994 (2)
January 13, 1994 (1)
February 24, 1994 (4)
March 1, 1994 (12)
March 15, 1994 (5)
March 24, 1994 (1)
April 4, 1994 (3)
April 18, 1994 (1)
April 30, 1994 (2)
May 11, 1994 (4)
May 17, 1994 (3)
May 26, 1994 (1)
June 3, 1994 (1)
June 7, 1994 (1)
June 13, 1994 (2)

GREATER YELLOWLEGS (Tringa melanoleuca)

September 5, 1993 (1)
September 29, 1993 (1)
November 21, 1993 (1)
December 23, 1993 (4)
February 14, 1994 (2)
March 1, 1994 (9)
March 24, 1994 (9)
April 4, 1994 (3)
April 30, 1994 (1)

LESSER YELLOWLEGS (Tringa flavipes)

September 5, 1993 (2)
March 1, 1994 (1)
March 24, 1994 (2)

SPOTTED SANDPIPER (Actitis macularia)

July 3, 1993 (5)
July 14, 1993 (8)

WILSON'S PHALAROPE (Phalaropus tricolor)

August 3, 1993 (15)
August 12, 1993 (11)
August 15, 1993 (20)
August 18, 1993 (25)
August 29, 1993 (3)
September 5, 1993 (29)
May 11, 1994 (1)

LONG-BILLED DOWITCHER (Limnodromus scolopaceus)

July 3, 1993 (3)
July 30, 1993 (1)
August 3, 1993 (15)
August 12, 1993 (40)
August 15, 1993 (108)
August 18, 1993 (60)
August 29, 1993 (35)
September 5, 1993 (145)
September 29, 1993 (111)
October 9, 1993 (1)
October 13, 1993 (74)
October 18, 1993 (73)
October 20, 1993 (5)
October 24, 1993 (95)
October 27, 1993 (254)
November 7, 1993 (1)
November 13, 1993 (182)
November 27, 1993 (20)
November 30, 1993 (7)
December 4, 1993 (770)
December 14, 1993 (6)
December 23, 1993 (2)
December 30, 1993 (63)
January 10, 1994 (1)
January 13, 1994 (79)
January 16, 1994 (1)
January 29, 1994 (11)
February 14, 1994 (3)
March 1, 1994 (11)
March 15, 1994 (29)
March 24, 1994 (280)
April 18, 1994 (117)
April 30, 1994 (21)

DUNLIN (Calidris alpina)

December 23, 1993 (3)
December 30, 1993 (1)

SEMIPALMATED SANDPIPER (Calidris pusilla)

December 4, 1993 (43)

WESTERN SANDPIPER (Calidris mauri)

September 5, 1993 (4)
September 29, 1993 (22)
October 18, 1993 (142)
October 24, 1993 (76)
October 27, 1993 (32)
November 7, 1993 (9)
November 13, 1993 (7)
November 27, 1993 (31)
November 30, 1993 (5)
December 4, 1993 (203)
December 14, 1993 (51)
December 23, 1993 (7)
December 30, 1993 (8)
January 13, 1994 (100)
January 29, 1994 (9)
March 1, 1994 (38)
March 24, 1994 (4)
April 4, 1994 (43)
April 30, 1994 (15)
May 11, 1994 (2)
May 17, 1994 (1)

LEAST SANDPIPER (Calidris minutilla)

July 30, 1993 (10)
August 3, 1993 (1)
August 12, 1993 (85)
August 15, 1993 (40)
August 18, 1993 (100)
August 29, 1993 (142)
September 5, 1993 (91)
September 29, 1993 (24)
October 9, 1993 (46)
October 13, 1993 (45)
October 18, 1993 (271)
October 24, 1993 (26)
October 27, 1993 (74)
November 7, 1993 (17)
November 13, 1993 (302)
November 30, 1993 (12)
December 4, 1993 (143)
December 14, 1993 (31)
December 23, 1993 (15)
January 10, 1994 (28)
January 13, 1994 (93)
February 24, 1994 (1)
March 15, 1994 (51)
March 24, 1994 (38)
April 4, 1994 (43)
April 18, 1994 (5)
April 30, 1994 (6)

BONAPARTE'S GULLS (Larus philadelphia)

November 21, 1993 (17)
November 27, 1993 (2)
November 30, 1993 (17)
December 4, 1993 (3)
January 16, 1994 (1)

RING-BILLED GULL (*Larus delawarensis*)

March 1, 1994 (61)
March 15, 1994 (48)
March 24, 1994 (3)

CALIFORNIA GULL (*Larus californicus*)

March 15, 1994 (3)
March 24, 1994 (51)
April 4, 1994 (2)
April 18, 1994 (514)
April 30, 1994 (321)

TURKEY VULTURE (*Cathartes aura*)

August 12, 1993 (8)
August 15, 1993 (40)
August 18, 1993 (13)
August 29, 1993 (1)
May 19, 1994 (1)
May 26, 1994 (1)
June 13, 1994 (1)

GOLDEN EAGLE (*Aquila chrisaetos*)

October 13, 1993 (1)

NORTHERN HARRIER (*Circus cyaneus*)

November 13, 1993 (1)
November 21, 1993 (1)
November 27, 1993 (2)
November 30, 1993 (2)
December 14, 1993 (1)
December 23, 1993 (2)
January 16, 1994 (2)
January 23, 1994 (1)
January 29, 1994 (3)
February 14, 1994 (3)
February 24, 1994 (2)
March 24, 1994 (2)
April 4, 1994 (1)

RED-TAILED HAWK (*Buteo jamaicensis*)

August 18, 1993 (1)
September 5, 1993 (1)
October 18, 1993 (1)
October 24, 1993 (1)
November 21, 1993 (1)
November 30, 1993 (2)
December 4, 1993 (1)
December 14, 1993 (2)
December 23, 1993 (1)
December 30, 1993 (3)
February 14, 1994 (2)
February 24, 1994 (1)
June 7, 1994 (1)

June 23, 1994 (1)

FERRUGINOUS HAWK (Buteo regalis)

November 13, 1993 (1)

HARRIS' HAWK (Parabuteo unicinctus)

October 27, 1993 (immature) (1)

AMERICAN KESTREL (Falco sparverius)

August 15, 1993 (1)
August 29, 1993 (1)
September 5, 1993 (2)
September 29, 1993 (3)
October 9, 1993 (2)
October 13, 1993 (4)
October 18, 1993 (3)
October 20, 1993 (2)
October 24, 1993 (1)
October 27, 1993 (2)
November 7, 1993 (3)
November 21, 1993 (1)
November 30, 1993 (3)
December 4, 1993 (3)
December 14, 1993 (4)
December 23, 1993 (1)
December 30, 1993 (2)
January 13, 1994 (2)
January 16, 1994 (2)
January 23, 1994 (2)
January 29, 1994 (1)
February 14, 1994 (1)
February 24, 1994 (1)

PRARIE FALCON (Falco mexicanus)

October 24, 1993 (1)

MOURNING DOVE (Zenaida macroura)

January 23, 1994 (3)
March 15, 1994 (2)
June 7, 1994 (4)
June 13, 1994 (1)

BURROWING OWL (Athene cunicularia)

June 22, 1993 (1)
June 27, 1993 (3)
July 3, 1993 (4)
July 30, 1993 (1)
August 3, 1993 (1)
December 14, 1993 (1)
December 23, 1993 (2)
January 10, 1994 (1)
January 13, 1994 (1)
January 16, 1994 (1)
January 23, 1994 (1)

January 29, 1994 (1)
February 14, 1994 (1)
Februay 24, 1994 (1)
March 1, 1994 (1)
April 18, 1994 (2) One with bands
May 11, 1994 (1) bands

ANNA'S HUMMINGBIRD (Calypta anna)

October 13, 1993 (2)
October 20, 1993 (2)
October 24, 1993 (2)
October 27, 1993 (3)
November 7, 1993 (1)
November 13, 1993 (2)
November 21, 1993 (1)
November 30, 1993 (1)
December 4, 1993 (1)
December 14, 1993 (1)
December 23, 1993 (1)
June 3, 1994 (1)

BELTED KINGFISHER (Ceryle alcyin)

September 5, 1993 (1)
September 29, 1993 (1)

CASSIN'S KINGBIRD (Tyrannus vociferans)

July 3, 1993 (2)
August 18, 1993 (2)
April 18, 1994 (2)
May 17, 1994 (1)
June 13, 1994 (1)

BLACK PHOEBE (Sayornis nigricans)

July 3, 1993 (1)
August 3, 1993 (1)
August 12, 1993 (1)
August 18, 1993 (2)
August 29, 1993 (1)
September 5, 1993 (1)
September 29, 1993 (1)
October 9, 1993 (2)
October 13, 1993 (2)
October 18, 1993 (1)
October 20, 1993 (2)
October 27, 1993 (1)
November 7, 1993 (1)
November 13, 1993 (1)
November 21, 1993 (1)
November 27, 1993 (3)
November 30, 1993 (2)
December 4, 1993 (1)
December 23, 1993 (3)
December 30, 1993 (2)
January 10, 1994 (2)
January 13, 1994 (2)
January 23, 1994 (2)

January 29, 1994 (1)
February 14, 1994 (2)
March 1, 1994 (3)
April 4, 1994 (2)
April 18, 1994 (1)
April 30, 1994 (2)
May 11, 1994 (1)
June 3, 1994 (1)
June 7, 1994 (4)
June 13, 1994 (1)
June 23, 1994 (1)

SAY'S PHOEBE (Sayornis saya)

September 29, 1993 (1)
October 9, 1993 (3)
October 13, 1993 (2)
October 18, 1993 (3)
October 20, 1993 (4)
October 27, 1993 (2)
November 13, 1993 (5)
November 21, 1993 (2)
November 27, 1993 (1)
December 14, 1993 (2)
December 23, 1993 (2)
January 10, 1994 (1)
January 16, 1994 (1)
January 23, 1994 (1)

WESTERN FLYCATCHER (Empidonax flaviventris)

January 16, 1994 (1)

HORNED LARK (Eremophila alpestris)

June 27, 1993 (18)
July 3, 1993 (1)
August 18, 1993 (1)
September 29, 1993 (5)
November 13, 1993 (36)
November 21, 1993 (8)
November 27, 1993 (1)
December 14, 1993 (18)
December 23, 1993 (9)
January 13, 1994 (1)
January 16, 1994 (2)
January 23, 1994 (2)
January 29, 1994 (2)
February 14, 1994 (1)
February 24, 1994 (19)
March 15, 1994 (4)
March 24, 1994 (1)
April 4, 1994 (172)
April 18, 1994 (2)

VIOLET-GREEN SWALLOW (Tachycineta thalassina)

March 24, 1994 (45)
April 30, 1994 (8)
May 17, 1994 (many)

May 19, 1994 (many)
May 26, 1994 (many)

BANK SWALLOW (Riparia riparia)

August 15, 1993 (16)
August 29, 1993 (22)
March 24, 1994 (17)
May 26, 1994 (many)

BARN SWALLOW (Hirundo rustica)

August 15, 1993 (9)
November 13, 1993 (1)
March 24, 1994 (8)
May 11, 1994 (many)
May 17, 1994 (few)
May 19, 1994 (few)
May 26, 1994 (many)

HOUSE WREN (Trogloduites aedon)

January 13, 1994 (1)

MARSH WREN (Cistothorus palustris)

January 29, 1994 (1)

WESTERN BLUEBIRD (Sialia mexicana)
December 23, 1993 (5)
January 10, 1993 (3)
February 24, 1994 (1)

MOUNTAIN BLUEBIRD (Sialia currucoides)

December 14, 1993 (27)
December 23, 1993 (2)
December 30, 1993 (11)
January 10, 1994 (10)
January 13, 1994 (10)
January 16, 1994 (4)
January 23, 1994 (3)
February 14, 1994 (2)
February 24, 1994 (2)

LOGGERHEAD SHRIKE (Lanius ludovicianus)

June 27, 1993 (2)
July 3, 1993 (1)
August 3, 1993 (1)
August 12, 1993 (1)
August 15, 1993 (3)
August 18, 1993 (1)
August 29, 1993 (1)
September 29, 1993 (3)
October 9, 1993 (2)
October 13, 1993 (1)
October 18, 1993 (3)
October 20, 1993 (3)
October 24, 1993 (1)

October 27, 1993 (2)
November 7, 1993 (3)
November 13, 1993 (3)
November 21, 1993 (2)
November 27, 1993 (2)
November 30, 1993 (2)
December 4, 1993 (1)
December 14, 1993 (5)
December 23, 1993 (4)
December 30, 1993 (3)
January 10, 1994 (1)
January 13, 1994 (2)
January 16, 1994 (1)
January 23, 1994 (1)
January 29, 1994 (2)
February 14, 1994 (3)
February 24, 1994 (4)
March 1, 1994 (2)
March 15, 1994 (2)
March 24, 1994 (2)
April 4, 1994 (2)
June 7, 1994 (2)
June 13, 1994 (2)
June 23, 1994 (3)

NORTHERN MOCKINGBIRD (Mimus polyglottos)

December 4, 1993 (1)
January 23, 1994 (1)
February 24, 1994 (1)
April 18, 1994 (1)
June 23, 1994 (1)

AUDUBON'S WARBLER (Dendroica coronata)

October 13, 1993 (4)
October 20, 1993 (25)
October 24, 1993 (13)
October 27, 1993 (8)
November 13, 1993 (26)
November 21, 1993 (2)
November 27, 1993 (13)
November 30, 1993 (4)
December 4, 1993 (3)
December 14, 1993 (60)
December 23, 1993 (2)
December 30, 1993 (2)
January 13, 1994 (3)
January 16, 1994 (1)
January 29, 1994 (1)
February 14, 1994 (12)
February 24, 1994 (1)
March 1, 1994 (1)
April 4, 1994 (1)

COMMON YELLOWTHROAT (Geothlypis trochas)

November 13, 1993 (1)
November 21, 1993 (1)
December 14, 1993 (2)

January 10, 1994 (1)
January 13, 1994 (3)
January 16, 1994 (2)
January 23, 1994 (1)
January 29, 1994 (1)
February 14, 1994 (1)
February 24, 1994 (2)
May 17, 1994 (1)

SONG SPARROW (Melospiza melodia)

November 21, 1993 (3)
December 30, 1993 (1)
January 29, 1994 (2)
April 30, 1994 (1)
May 26, 1994 (2)
June 7, 1994 (1)
June 13, 1994 (1)

SAGE SPARROW (Amphispiza belli)

May 19, 1994 (1)

RUFOUS-CROWNED SPARROW (Aimophila ruficeps)

January 29, 1994 (1)
March 1, 1994 (2)
March 15, 1994 (1)

WHITE-CROWNED SPARROW (Zonotrichia leucophrys)

October 18, 1993 (3)
October 20, 1993 (1)
October 24, 1993 (1)
October 27, 1993 (13)
November 30, 1993 (4)
December 30, 1993 (9)
January 16, 1994 (1)
January 23, 1994 (1)
January 29, 1994 (4)
February 14, 1994 (1)
March 1, 1994 (3)
March 15, 1994 (26)
March 24, 1994 (6)
April 4, 1994 (28)

WESTERN MEADOWLARK (Sturnella neglecta)

September 29, 1993 (1)
October 9, 1993 (2)
October 20, 1993 (2)
October 24, 1993 (2)
October 27, 1993 (1)
November 13, 1993 (1)
December 4, 1993 (1)
December 14, 1993 (1)
December 23, 1993 (15)
December 30, 1993 (2)
January 23, 1994 (1)
January 29, 1994 (1)

February 24, 1994 (2)
March 1, 1994 (2)
March 15, 1994 (2)
March 24, 1994 (5)
May 11, 1994 (1)
May 26, 1994 (4)
June 3, 1994 (1)
June 7, 1994 (1)
June 13, 1994 (6)
June 23, 1994 (1)

YELLOW-HEADED BLACKBIRD (Xanthocephalus xanthocephalus)

August 18, 1993
September 5, 1993
October 24, 1993

RED-WINGED BLACKBIRD (Agelaius phoeniceus)

August 12, 1993
August 15, 1993
August 18, 1993
August 29, 1993
September 5, 1993
September 29, 1993
October 9, 1993
October 13, 1993
October 18, 1993
October 20, 1993
October 24, 1993
October 27, 1993
November 7, 1993
November 13, 1993
November 21, 1993
November 27, 1993
November 30, 1993
December 4, 1993
December 14, 1993
December 23, 1993
December 30, 1993
January 10, 1994
January 13, 1994
January 16, 1994
January 23, 1994
January 29, 1994
February 14, 1994
February 24, 1994
March 1, 1994
March 15, 1994
March 24, 1994 (few)
April 4, 1994 (few, in field, not in bulrush)
April 18, 1994 (1)
May 19, 1994 (few)
May 26, 1994 (few)
June 7, 1994 (2) not in bulrush
June 13, 1994 (few)
June 23, 1994 (look like starting to breed)

TRICOLORED BLACKBIRD (Agelaius tricolor)

June 22, 1993
June 27, 1993
July 3, 1993
August 12, 1993
March 24, 1994 (many)
April 4, 1994
April 18, 1994
April 30, 1994
May 11, 1994
May 17, 1994 (few)

BREWER'S BLACKBIRD (Euphagus cyanocephalus)

June 22, 1993
June 27, 1993
July 14, 1993
July 30, 1993
August 3, 1993
August 12, 1993
August 15, 1993
August 18, 1993
August 29, 1993
September 29, 1993
October 9, 1993
October 13, 1993
October 18, 1993
October 20, 1993
October 24, 1993
October 27, 1993
November 13, 1993
November 21, 1993
November 27, 1993
November 30, 1993
December 4, 1993
December 14, 1993
December 23, 1993
December 30, 1993
January 10, 1994
January 13, 1994
January 16, 1994
January 23, 1994
January 29, 1994
February 14, 1994
February 24, 1994
March 1, 1994
March 15, 1994
March 24, 1994
April 4, 1994
April 18, 1994
April 30, 1994
May 11, 1994
May 17, 1994
May 19, 1994
May 26, 1994
June 3, 1994
June 7, 1994
June 13, 1994
June 23, 1994

BROWN-HEADED COWBIRD (Molothrus ater)

October 18, 1993 (1)

GREAT-TAILED GRACKLE (Quiscalus mexicanus)

April 30, 1994 (2)

HOUSE FINCH (Carpodacus mexicanus)

November 21, 1993 (2)
November 27, 1993
January 10, 1994 (2)
January 13, 1994 (3)
January 16, 1994 (2)
February 24, 1994 (1)
March 1, 1994 (1)
April 4, 1994 (4)

APPENDIX K

APPENDIX K

MINUTES OF JULY 8, 1994, TECHNICAL ADVISORY COMMITTEE MEETING (INCLUDING COMMENTS ON DRAFT PHASE II/III REPORT FROM TECHNICAL ADVISORY COMMITTEE)

Eastern Municipal Water District

General Manager
J. Andrew Schlange

Legal Counsel
Redwine and Sherrill

Director of The Metropolitan Water District of Southern California
Doyle F. Boen

Treasurer
Rogers M. Cox

August 18, 1994

TO: EMWD/USBR/NBS Multipurpose Constructed Wetlands Study Technical Advisory Committee

FROM: LeAnne Hamilton
Project Manager

SUBJECT: July 8, 1994 TAC Meeting Minutes

Dear TAC Participant:

Enclosed is a summary of the July 8 TAC Meeting for the Multipurpose Wetlands Research and Demonstration Study. It was a very valuable meeting, providing a wealth of information and suggestions to help us design future research and demonstration studies. Thank you very much for your participation.

If you were unable to attend this meeting, I hope that the minutes will keep you informed and that you will be able to attend the next meeting. Any comments or suggestions that you have are always welcome.

Again, thank you for your interest, time, and support for this project.

LeAnne

Enc.

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Main Office: 2045 S. San Jacinto Avenue, San Jacinto • Customer Service/Engineering Annex: 440 E. Oakland Avenue, Hemet, CA

SUMMARY OF
THE TECHNICAL ADVISORY COMMITTEE MEETING
EMWD/USBR/NBS
MULTIPURPOSE WETLANDS RESEARCH & DEMONSTRATION STUDY
JULY 8, 1994
EMWD BOARD ROOM

ATTENDEES	REPRESENTING
Tim Ulrich	U.S. Bureau of Reclamation
April Sleigh	Cal Poly, Pomona
Andrew Haimov	Cal Poly, Pomona
Dr. Richard Gersberg	San Diego State University
Eric Stiles	U.S. Bureau of Reclamation
Lee Ischinger	NBS-Fort Collins, Colorado
Doug Andersen	NBS-Denver
Robert James	U.S. Fish & Wildlife Service
Joan Thullen	NBS-Denver, Colorado
Jim LaBounty	U.S. Bureau of Reclamation
Dick Whitson	U.S. Bureau of Reclamation
Mir S. Mulla	UC Riverside
Jim Sartoris	NBS/USBR-Denver
Jean Shepherd	USBR-Boulder City, Nevada
Amy Porter	USBR-Boulder City, Nevada
Robert Gearheart	Humboldt State University
Bob Knight	CH2M Hill
Hugh Murray	Riverside County Environmental Health
David Richardson	Riverside County Environmental Health
Linda Garcia	Santa Ana Regional Water Quality Control Board
Alfred Javier	Eastern Municipal Water District
Christie Crother	Eastern Municipal Water District
Mike Garner	Eastern Municipal Water District
LeAnne Hamilton	Eastern Municipal Water District
John Ward	Eastern Municipal Water District
Steve Crombie	Eastern Municipal Water District
Stella Denison	Eastern Municipal Water District

The group was welcomed by Jean Shepherd, USBR Project Manager, and the participants introduced themselves. Ms. Shepherd asked that comments be submitted on the draft Multipurpose Wetlands Research and Demonstration Study Phase II/III report. (Three of the technical advisors submitted written comments after the meeting. The comments are attached).

The agenda was reviewed by LeAnne Hamilton, EMWD Project Manager, and the group then loaded a bus and took a tour of the EMWD/USBR/NBS Multipurpose Wetlands Research and Demonstration Facility at the Hemet/San Jacinto Regional Water Reclamation Facility (RWRF).

The group returned from the tour and Ms. Hamilton briefly explained the program objectives, research objectives, and the issues for discussion by the TAC. The TAC was asked to focus on: 1) the lessons learned so far in the research and demonstration studies; and 2) the recommendations for future wetlands research and demonstration projects. The research objectives were separated into objectives for the pilot cells, saline marshes, and demonstration wetlands. The program objectives included both management objectives (water reuse, public involvement, multipurpose habitat, etc.) and operational objectives (erosion control, vector control, vegetation management, etc.).

Ms. Hamilton asked that the participants break into smaller groups to discuss issues:

Group 1: Water Quality and Sediment/Water Interactions
Group 2: Vector and Pathogen Issues
Group 3: Wildlife, Invertebrate, and Plant Issues.

The discussion groups met for approximately 2½ hours. At the end of the day, the whole group reconvened in one room and a representative of each discussion group gave a brief synopsis of their discussion.

VECTOR AND PATHOGEN ISSUES

Mr. Al Javier summarized the "Vector and Pathogen Group" discussion:

Vectors

Two weeks prior, the mosquito count in the research cells had been 500+ per dip. The latest count was only 100-200 per dip. The possible cause of the reduction could have been the introduction of mosquito fish (*Gambusia*) and/or the increase in temperatures in the vicinity. Twelve (12) species of mosquitoes had been identified. The counts were high enough to cause concern. The recommendation was made to set traps to monitor the mosquitoes. The Riverside County Health Department agreed to do this. The goal would be to reduce the mosquito count to 5-10 per dip.
Dr. Mir Mulla of UC Riverside commented that although treating wastewater in wetlands has many advantages and desirable attributes, establishing these systems in urban and suburban areas could potentially produce tremendous numbers of pest and disease vectoring mosquitoes and possibly other noxious and injurious insects. He emphasized the need for research.

Pest and disease vectoring mosquitoes produced in the wetlands could cause the following problems:

1. They could bite workers, researchers and others visiting the marsh.

2. Insects could fly away into surrounding areas and bite humans and horses. There are many thoroughbred horse ranches within the flight range of mosquitoes produced in the wetlands.

3. Depending on the species and epidemoiologic conditions, mosquitoes could serve as vectors of viral agents causing encephalitis in humans and horses. The epidemiologic cycle of encephalitis involves mosquito vectors, birds (which are abundant in the marsh), and humans and horses.

Dr. Mulla commented that the current status of our knowledge regarding long-range management and remedial measures is inadequate. He proposed that studies look at:

1. Faunistics of Mosquitoes: Determining the abundance and taxa of mosquitoes produced on a seasonal basis. This would include:

   a. Larval Assessment: Sampling on a weekly basis in open areas, margins and inside the ponds. Larvae would be identified to species level. Representative samples would be taken from several ponds to see if there is any variation caused by water quality, plant cover or other factors.

   b. Adult Assessment: Adult mosquitoes would be collected on a weekly or biweekly basis. Several traps would be established in critical areas inside the marsh and outside. All mosquitoes would be identified to species. Observations would be made on the landing and biting activity of adult mosquitoes on horses and other animals in the area.

II. Saline Marshes and Evaporation Cells: These saline habitats could support entirely different species or groups of species of mosquitoes. Larval assessment would be more emphasized in these habitats.

III. Impact of Larvirorus fish: A number of small fish have been shown to decimate mosquito larvae in open bodies of water. However, most predatory fish fail to penetrate the thick plant stands where most larvae are prevailing. Fish worth considering are:

Gambusia affinis (mosquito fish)
Cyprinidon maculatus (Desert Pupfish and others)
Poecilia reticulata (guppy).

IV. Evaluation of Microbials and Insect Hormones: These two (2) groups of mosquito control agents were considered to be environmentally friendly. However, their use on a continuing basis was not recommended. These could be used on an emergency basis.

There was a general question with regard to other types of management, besides biological control of mosquitoes or other insects. Dr. Mulla responded that chemicals can be used but would interfere with other forms of aquatic life. The same is true of using microorganisms. The point was raised that another predatory fish that could possibly be introduced is the Stickleback. Its ability to associate with vegetation was discussed. It is indigenous to California, unlike *Gambusia*. The Pupfish is also a native and it is adapted to high temperatures, but it may be endangered/threatened. A question was raised about possible sources of fish for stocking.

Other potential sites for future wetlands projects are: Mystic Lake, where mosquitoes would be expected to have a low impact, and Little Valley where they could have a high impact due to proximity of a residential area.

Pathogens

The types of viruses present in the influent and effluent of the wetlands research cells are unknown. The types of bacteria have not been identified; some data are available on total and fecal coliform. A study could be performed to identify and enumerate both viruses and bacteria (inlet and outlet). However, the study may not be needed unless the end product would be used for drinking. EMWD is interested in groundwater recharge for indirect potable reuse. The effluent will be chlorinated.

WILDLIFE, INVERTEBRATE, AND PLANT ISSUES

Ms. Stella Denison summarized this group's discussions. The group focused on the need to study the whole ecosystem, since every part is linked to every other part.

Important areas that need investigation are:

1. Succession of algae populations
2. Community structure
    a. Understanding the relationships between birds, mammals, invertebrates, and plants in the system.
    b. Which elements are the important ones?
       Answer: The ones linked to the operation of the system.
    c. What is a "good" system?
    d. How do we understand the structure of the system?
       Answer: Documentation. Document structure of system by:
        - Quantitative - population biology
        - Qualitative - Identification, observations, pictures
3. What do we know currently about our system?
4. What do we need to know? Why do we need to know it?
   Answer: Must be based on stated goals of project.
5. Plant (weed) management
6. Management and understanding of system

7. Management and understanding of natural systems
(Comparison of data needed between constructed and natural system).

8. Mosquito control needed

   a. Native fish are the first choice.
      - 3-Spined Stickleback
      - Pupfish (endangered)
      - Mohave Chub

   b. *Gambusia* - Second choice

9. Sand/gravel/rock areas for waterfowl provide food and grit.

The need was identified for a full-time, on-site coordinator who would coordinate the activities of the different groups and agencies using the wetlands for research at the ground level of operations. There is already coordination at the Executive Committee level.

A monitoring plan for the demonstration wetlands facility should address:

1. Access to islands
   - Markers to locate paths
   - Select particular species to follow

2. Wildlife use of emergent and submerged areas
   - Which birds use these areas?
   - What they eat (by inference) and how much?

3. Vegetation management must deal with organic buildup and sedimentation. Potential methods for removing vegetation include:
   - dredging
   - dynamite
   - mowing
   - burning.

4. General bird usage patterns by observation

5. Plant growth

6. Fish (trap, count, mark, retrap and count percentage)

7. Algae - identified through contract lab or in-house; minimum quarterly basis; limnology survey

8. Community structure
   - After collection of individual components, someone ties information together.
   - Water quality is an important issue.

- Continue to monitor wildlife - general observations.
- Nocturnal wildlife: We definitely have some. How should this be documented?
- Plant/wildlife interactions: Continue observation.

There was discussion about the practicality of maintaining open paths through the bulrush for monitoring or observation purposes by any of the methods proposed (machete, dredging, etc.). It would be a labor and cost problem, and might have been better addressed at the design stage. Access is needed into the interior of the demonstration wetlands to observe wildlife use of the islands and into the interior of the research cells to retrieve artificial substrates for invertebrate analysis. It was also commented that the bulrush grows very tall at the site and the islands are not very large, thus there is the possibility for bulrush to completely cover the islands, replacing the intended habitat. It was suggested that the demonstration wetlands have open water areas around the islands so that access can be obtained by wading.

WATER QUALITY

Mike Garner summarized the results of the Water Quality Group's discussion. The group discussed the following issues:

I) Review of Series 1 Monitoring Program

A) Objectives

B) Methodology

II) Problems with Series 1 Monitoring

A) Budget Limitations
1) Large number of parameters monitored
2) Limited sample size (number of data points)

B) Inadequate Hydraulic Controls
1) Reasons for problems
2) Impact upon data
3) Potential solutions to problems

C) Limited Flow Data
1) The need for effluent flow totals
2) Impacts upon data
3) Potential solutions to problems

D) Logistic Difficulties
1) Rain delays (operating problems)
2) Evapotranspiration problems (inadequate summer brine flow for saline marsh)
3) The loss of the Alessandro Well (feedwater for reverse osmosis)

III) Results of Continuous Monitoring (Data Sonde)

A) Types of Data Collected

B) Difficulties in Interpreting and Using Data

C) Potential Roles for Continuous Monitoring

IV) Series 1 Monitoring Results

A) Statistical Quality of Data
  1) Impacts of hydraulic problems
  2) Small size of data sets
  3) Statistical treatment of data

B) The Value of Data Replication

C) Nitrogen Kinetics
  1) Open space vs. vegetated cells
  2) Carbon availability
  3) Relationship of data to previous research
  4) Potential explanations of observed nitrogen data

D) Miscellaneous Data
  1) Pathogens
  2) Phosphorus and BOD
  3) Exogenous contaminants (bird droppings)
    a) Pathogens
    b) Phosphorus
  4. Miscellaneous field observations
  5. Saline Marsh
    a) Plant growth
    b) Impacts of logistical problems on data

V) Proposed Series 2 Monitoring

A) Nitrogen Monitoring
  1) Sampling methodology
  2) Narrower focus (statistical strength)
  3) Alternative experimental approaches

B) Vegetation Management

C) Wildlife Inputs

D) Saline Marsh

E) Demonstration Wetlands Monitoring
  1) Maturation issues

The discussion concluded with an attempt to develop consensus conclusions and recommendations on what was learned in Series 1 and what should be accomplished in Series 2. A summary of consensus conclusions/recommendations follows:

Research Cells

I) Improve hydraulic control (limit flow variations) prior to implementing Series 2 monitoring. Tracer (e.g., lithium) studies should be performed to assess hydraulic conditions.

II) Develop the ability to monitor research cell effluent flows, with a goal of developing some mass balance data.

III) Narrow the number of parameters monitored (but increase sampling of identified parameters) to develop better statistical strength of data (while observing budget limitations). The major focus of Series 2 should be on one-phase vs. three-phase cell nitrogen removal differences. Nitrogen data should be correlated with carbon (BOD or TOC) and dissolved oxygen data.

IV) Intermittent scans for chloride, iron, sulfur, and total phosphorus should be done. (Chloride in particular may be a conservative indicator useful for correlating with water loss and mass balance data).

V) Data replication is useful and should be pursued where possible. On the other hand, there is considerable value in changing the experimental design, to obtain more information on design and management of demonstration projects, by eliminating the experimental approach (use of duplicate conditions, etc.). Rather than trying to duplicate ecological systems, it may be better to change load, change depth, change the amount of open water, sample within the cells, and strategically measure the aquatic impact.

VI) Vegetation management experiments should not be pursued.

VII) Grab samples will be adequate for assessing effluent water quality. However, variation in influent water quality should be examined. If extreme variability in influent quality is found, it may be necessary too use influent composite samples.

VIII) Series 2 monitoring should develop data on the effects of changing hydraulic loading rates, once baseline data at design loading is deemed adequate. In addition, the effect of changing water depth should be determined.

IX) Mechanical bird exclusion experiments should not be pursued. Birds are unlikely to be the major reason for the nitrogen removal results which were observed. Birds could get caught in the nets. Efforts should be focused on strategic sampling.

Saline Marsh

I) The value of initial data is limited due to logistical problems in Series 1.

II) Narrow the scope of data collected to focus on the specific contaminants detected during sampling to date.

III) Try to develop a non-mobile population of vertebrates (fish) for use in assessing bioaccumulation in addition to plant data.

IV) Two years of operation and data are not enough to determine aquatic life impacts. Ten years is more realistic.

Demonstration Wetlands

I) Water quality data developed during the first two years of system operation will probably not support conclusions about overall system performance in the future. A long-range data collection program should be considered after system maturation.

The Technical Advisory Committee meeting was adjourned at 3:15 pm. A group photograph was taken by EMWD's Community Relations Department.

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FINAL
LIST OF ATTENDEES
JULY 8, 1994 TAC MEETING

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CH2M HILL
Engineers
Planners
Economists
Scientists

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Fed Ex

July 14, 1994

SCW38036.WK

Ms. LeAnne Hamilton
Research Coordinator
Eastern Municipal Water District
2045 S. San Jacinto Avenue
P.O. Box 8300
San Jacinto, CA 92581-8300

Dear LeAnne:

Subject: Hemet/San Jacinto Multipurpose Wetlands Review Comments

Thank you for the opportunity to review and comment on the draft Phase II/III Wetlands report and to participate in your Technical Advisory Committee (TAC) meeting on July 8, 1994. The attached memorandum summarizes the issues and recommendations that I raised at the TAC meeting. I have listed all of these issues even though I realize that you may not wish to take action on some because of cost considerations or lack of a consensus among the members of the TAC. If you wish to discuss the scope or rationale for any of these recommendations, please feel free to call me at (904) 331-2442.

The attached memorandum includes comments based on only a brief review of the draft report. If you wish, CH2M HILL could provide a more detailed review and analysis of the data collected during the Series 1 and 1A research efforts. This review and analysis could focus on research cell inflow/outflow water chemistry and flow data, and estimate pollutant removal/transformation rate constants that would be applicable to the design of the Little Valley Wetlands and other wetland projects EMWD may wish to implement in the future. If you wish to discuss a scope and level-of-effort for these services, please let me know.

On behalf of CH2M HILL, I would like to thank you and EMWD for including us in this important project. We look forward to a continuing relationship as you expand your program of wetlands/habitat creation and utilization.

Sincerely,

CH2M HILL

Robert L. Knight

Robert L. Knight, Ph.D.
Senior Environmental Scientist

A.W. Copy to
L Hamilton

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MAIL DIST	EX	AD	EN	OP	RD	SF	HR	PC	BD	ADD COPY	EX	AD	EN	OP	RD	SF	HR	PC	BD
										ACT									

GNV/1001629A.WP5
xc: Jag Salgaonkar/SCO
Michelle Girts/PDX

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TO: LeAnne Hamilton/EMWD

COPIES: Jag Salgaonkar/SCO
Michelle Girts/PDX

FROM: Bob Knight/GNV

DATE: July 14, 1994

SUBJECT: EMWD Multipurpose Wetlands Project Draft Phase II/III Report Technical Review

PROJECT: SCW38036.WK

This memorandum summarizes my comments concerning the above-referenced report as well as the "Water Quality and Sediment/Water Interactions" discussion items at the TAC meeting on July 8, 1994. These comments are based on a brief review of the draft Phase II/III report, on the field trip to the wetlands research/demonstration site, and on discussion with you, your staff, and other participants at the TAC meeting.

Comments on the Draft Report

The draft Phase II/III report is well organized and well-written. The authors have successfully compressed an extensive monitoring effort into an informative summary. I only have a few suggestions for enhancing the usefulness of this draft document:

- Plan and section view illustrations of the research and plant propagation cells should be provided to show cell numbering protocol, cell locations, sample stations, cell dimensions, etc.
- A table should be included that summarizes design criteria for the plant propagation and research cells including information on area, length, width, water depth, flow rates, hydraulic loading rate (HRT), design inflow concentrations and loads, etc.
- Hydraulic residence times (HRT) mentioned in the report are estimated and should be qualified as such.
- Summary tables could be provided for water quality changes, sediment chemistry, plant growth, invertebrate populations, and wildlife studies.

Recommended Changes for Series 2 Research

Some important water quality findings from the Series 1 research include:

- No significant decrease in concentrations of BOD_5 and TSS in any of the treatments;

- Significant reductions in NH_4-N concentrations in the 3 Phase (3P) wetland cells but not in the 1 Phase (1P) cells; and

- No reduction or a slight increase in TP concentrations in all cells.

A better understanding of the basis for these observations can be provided during the Series 2 monitoring effort. Continued research will provide additional information for design of future wetland systems if the following engineering/operational changes are made:

- Consistent inflow rate, accurate measurement of these inflows, and the ability to vary these flow rates with a minimum of operational effort should be provided at the research cells. An inflow splitter box is one alternative that could provide this essential control.

- Mass balance calculations are dependent on an accurate water balance for the research cells. Outflow rates should be consistently monitored to estimate this important component of the water balance. It was suggested that V-notch weir plates could be installed in the existing outlet control boxes and a water level recorder or daily staff gauge readings could be used to monitor outflows with sufficient accuracy.

- Actual HRT and wetland hydraulic characteristics can only be determined by periodic tracer studies in all research cells. A lithium or similar inert tracer is recommended for use in wetlands.

- The existing outlet skimmer design may be contributing to excessive outlet nutrient concentrations because the intake to the outlet weir box is drawn from the floor of the wetland. Several sets of nutrient samples (NH_4-N, TKN, and TP) should be carefully collected over a vertical gradient in the wetland cells just upstream of the outlet boxes to see if Series 1 and 1A samples were biased by the existing skimmer design. New skimmers should be installed that draw water from just below the water surface.

A number of other recommendations concerning the Series 2 research project are less critical but are listed below for your information:

- Chloride measurements provide an inexpensive method of documenting concentration/dilution effects related to evapotranspiration/precipitation. Inflow/outflow chloride measurements should be conducted on a biweekly or monthly basis in all research cells.

- Removal of total residual chlorine (TRC) requires addition of sodium bisulfide on a seasonal basis. This sulfide contributes to the wetlands pollutant loading and may contribute to increased hydrogen sulfide production and subsequent toxicity and odors. You may wish to conduct an experiment to look at the dissipation of TRC in the wetland when it is receiving chlorinated influent. TRC samples should be collected over a longitudinal gradient starting at the influent end and extending down flow until TRC is undetectable.

- You may wish to obtain more insight concerning the effectiveness of transverse open-water zones for enhancing treatment performance by modifying some of the research cells. I would suggest two cells with no deep zones, two with one deep zone, two with two deep zones, and two with three deep zones.

- You may wish to better quantify the effects of HLR (and conversely wetland area) on treatment performance. Two methods were discussed to provide this information. One method is to give up cell-to-cell replication and set inflow rates to give 4 HLR's for each set of 3P and 1P cells for a period of 3 to 6 months. The second method is to test the same HLR across all 8 cells for a period of 3 months, then change all 8 cells to a second HLR for 3 months, etc. I would suggest you test HLR's between about 1 cm/d and 10 cm/d.

- Metals monitoring in the saline test cells has identified As, Ba, Cd, Cu, Mo, Se, and Zn as having detectable concentrations in the RO brine water and sediments. I would suggest that you continue bioaccumulation studies and focus your sampling on two or three of these metals (for example, As, Cu, and Se) in water, sediments, algae, macrophytes, and fish.

- Bulrush harvesting is not recommended as an effective method for either nutrient removal or to improve HRT or system operation. Vegetation management with fire may be considered in the Demonstration wetland cell.

- The quantification of nutrient inputs from birds should be estimated based on routine bird counts and a literature review of nutrient content in bird feces.

Demonstration Wetlands

Construction of the demonstration wetland system is underway. It is fully realized that design changes at this time will be expensive to implement. Nevertheless EMWD and the Bureau of Reclamation may wish to consider the following changes that may improve system performance and facilitate operation:

- Two to three transverse deep zones could be provided in each inlet arm and in the two parallel outlet arms to assist with flow distribution, increase HRT, and enhance fish and waterfowl habitat. These deep zones could be from 30 to 50 feet wide with 2:1 to 3:1 slopes, and be about 4 to 5 feet deep below grade. These deep zones will also provide access to the interior of the wetland cell for monitoring and maintenance.

- Deep zones around the islands will improve their attractiveness for wildlife use.

- Boardwalks located at several key locations would greatly facilitate monitoring access and could be incorporated into the public trail system without excessive wildlife disturbance.

- Skimmers in the outlet weir boxes should be redesigned to draw water from just below the wetland water surface rather than from the wetland floor.

- Start-up monitoring should be considered and could include all parameters of research or operational interest, sampled on a routine (biweekly or monthly) basis.

Summary

The comments and recommendations provided above are based on a limited review of information provided by you about the Research/Demonstration Wetland Projects at Hemet/San Jacinto the potential cost and benefit of each recommendation should be weighed as you consider whether or not to implement these changes.

'UG - 3 1994 E.M.W.D.

SDSU

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July 20, 1994

Ms. LeAnne Hamilton
Project Manager, Multipurpose Wetlands Program
Eastern Municipal Water District
P.O. Box 8300
San Jacinto, CA 92581-8300

Dear LeAnne:

It was a pleasure meeting you, and being able to tour the construction site for the Demonstration Project. I hope that the lively discussions generated at the meeting of the Technical Advisory Committee, specifically concerning the analysis of the series 1/1A monitoring program data for the pilot research facility, was informative and helpful for your future efforts. As you had requested, in the following narrative I will detail my specific comments both regarding your 1/1A research results and my recommendations for the direction of a future research program at this pilot research facility.

One of the most surprising results for the 1/1A research cells was the lack of nitrogen removal in the 1-phase cells. Since the outlet level of N was not significantly above (although it was slightly higher than) the inlet level in these 1-phase cells, I do not necessarily agree with the conclusion that there was nutrient loading (perhaps by birds) that accounted for this higher outlet level of N. Indeed, in the 3-phase cells which showed significant N removal, there is still alot of vegetated area to support bird populations, and even so these 3-phase systems showed a marked decline in N when outflow is compared to inflow. Obviously, something is occurring in the 3-phase cells that is not happening in the 1-phase cells, and this is probably due to a conspicuous lack of nitrification in the 1-phase system. This absence of nitrification is surprising however, since the data for dissolved oxygen in both the 1 and 1A series show oxygen levels ranging from 0-90% saturation with mean values at near 50%.

On the other hand, there are several alternative explanations for the significant N removal in the 3-phase cells. The explanation proposed by both the EMWD and BuRec (NBS) staff is that the N (mostly ammonia) removal that is observed is due to nitrification in the open (pool) area, and subsequent denitrification in anoxic wetland zones. This sequential nitrification-denitrification is certainly possible, but let me now forward another alternative explanation, not just to be contrary, but in order to illustrate the type of data you need to gather in order to make definitive conclusions on the fate of N in the system. For sequential nitrification-denitrification to occur, the wetlands must supply approx. 4.5 mg/l of oxygen for each mg/l of N for nitrification to be complete. Then, since you do not find any appreciable amount of nitrate in the outlet of the 3-phase cells, all of this nitrate must be denitrified this entailing a carbon (BOD) demand of about 3 mg/l BOD for each mg/l of nitrate-N denitrified.

Possible sources of oxygen in the 3-phase cells to support the nitrification above include wind-induced mixing and algal photosynthesis. Even though algal (chlorophyll) levels were not monitored in the research cells, evidence for the growth and activity of algae in open waters of these wetlands come from some of the statement made by Jim Sartoris and Steve Crombie who noted at the TAC meeting that there was considerable diurnal fluctuation in dissolved oxygen levels observed with continuous monitors placed at outlet structures of the wetland cells (which were unvegetated). These diurnal fluctuations are best explained as reflecting algal photosynthesis, which brings me to the alternative explanation for the N removal observed--that is, algal uptake of ammonia in the unvegetated areas of the wetlands might have been responsible for a significant fraction of the total N removal observed in the 3-phase cells, and these algae are subsequently removed in the vegetated end before discharge. This is made all the more possible by other statements made by Jim Sartoris referring to the relatively long hydraulic residence times (conducive to algal growth) in the cells particularly during the summer when other demands for water were highest, and also the fact that the residence time in the pool areas of the cells accounted for about 50% of total. The main point here is that in your future monitoring of these research cells, you need to measure certain parameters carefully (e.g. DO, chlorophyll, or nitrification--using N-Serve), so that you can determine definitively the mechanisms responsible for N removal.

Since nitrate did not appear in appreciable quantities in the effluent of the 3-phase cells, in order for sequential nitrification-denitrification to have accounted for the N loss, then the nitrate would have to have been entirely removed by denitrification in anoxic environments. With a productivity of about 5 gm of carbon per m^2 per day, and a ratio of approximately 3:1 for the carbon demand of denitrification, then assuming that half of the carbon produced in the wetlands is assimilable, the carbon demand of denitrification could be satisfied. However, considering that much of the carbon produced will be used by aerobic respiration, and that the research cells were young systems with not alot of detrital build-up, my guess is that not all of the nitrate removed was in fact denitrified. Again, this is where algal assimilation might play an important role.

As for phosphorus (P) removal, although there was a significant increase in all cells from inlet to outlet, since only dissolved orthophosphate was analyzed (but not total P), this increase in dissolved P may be attributed to mineralization of TP (particulate P) in the wetlands and not really an overall increase in P. Again, from your data we cannot say for sure.

My recommendations for future research are much the same as we discussed at the TAC meeting. I believe the significant difference observed for N removal in the 3-phase and 1-phase cells certainly deserves further study. The cells must be designed with adequate replication (as you already have), with the hydraulic loading rates under much closer control. The study design should focus on showing that the open water, the 3-phase system stimulates sequential nitrification-denitrification. In this case you need to disprove the hypothesis that algal uptake is responsible for the significant N removal observed.

I agree with the conclusion of the TAC that TP, ortho P, S, and Fe should be monitored on a more infrequent basis with the focus on nitrate, nitrite, ammonia, TKN, BOD, DO, and some measure of algal activity. Since the wastewater is chlorinated and since the ultimate use of the water is for restricted, non-body contact situations, then I question the need for frequent coliform or virus/pathogen monitoring.

I hope these comments have been useful and wish you and your staff the best of luck as you scale-up to the demonstration multi-purpose system.

Sincerely,

Richard M. Gersberg, Ph.D
Professor

To: LeAnne Hamilton

From: Bob Gearheart

Date: August 4, 1994

Subject: Review of Report

Recommendations:

Pilot Mesocosms

1) Change experimental design to obtain more information on design and management of demonstration projects by eliminating the experimental approach (use of duplicate conditions, etc.). It is impossible under the best of conditions to actually have ecological similar conditions. Better to change load, change depth sample within, etc., and strategically measure the aquatic impact.

2) Reconstruct influent flow apparatus to be able to measure the influent flow and to have a reliable constant input (stilling well and weir box).

3) Re-construct the effluent weir boxes to insure the discharge volume is coming from the top of the wetland. Use a "V" notch weir with a depth measurement device (ruler) to be able to measure flow directly without the need for sophisticated electronic measuring equipment.

4) Focus on the water quality issues of concern, nitrogen forms, suspended solids, and public health significant organisms.

5) Determine the bio-mass in the pilot cells (dry weight above ground and below ground).

6) Design an intracellular sampling protocol.

Demonstration Project

1) Deepen the regions in the demo-project which are upstream from the effluent discharge area to allow submergent species to prevail. An attempt should be made to have alternating open water-closed water sections with at least 2-3 days of contact in closed water (emergent vegetation) prior to discharge.

2) Take aerial photographs (vegetation monitoring) every 3 months for the next 15 months to show community succession.

General Comments:

1) Data should be placed into loading format to allow for a kinetic analysis of water quality parameters.

2) Considering the first year was a start up condition, the report was very well done. There is a tremendous amount of data which has not been analyzed in the report. (Again, great work for a student). I'll do my part next year and parcel out some studies to undergraduate or graduate student.

3) Too much work spent doing pseudo statistics (good example is Appendix A) without any real attempt to explain what is happening and what is significant. Statistics should not be a substitute for ecological understanding!