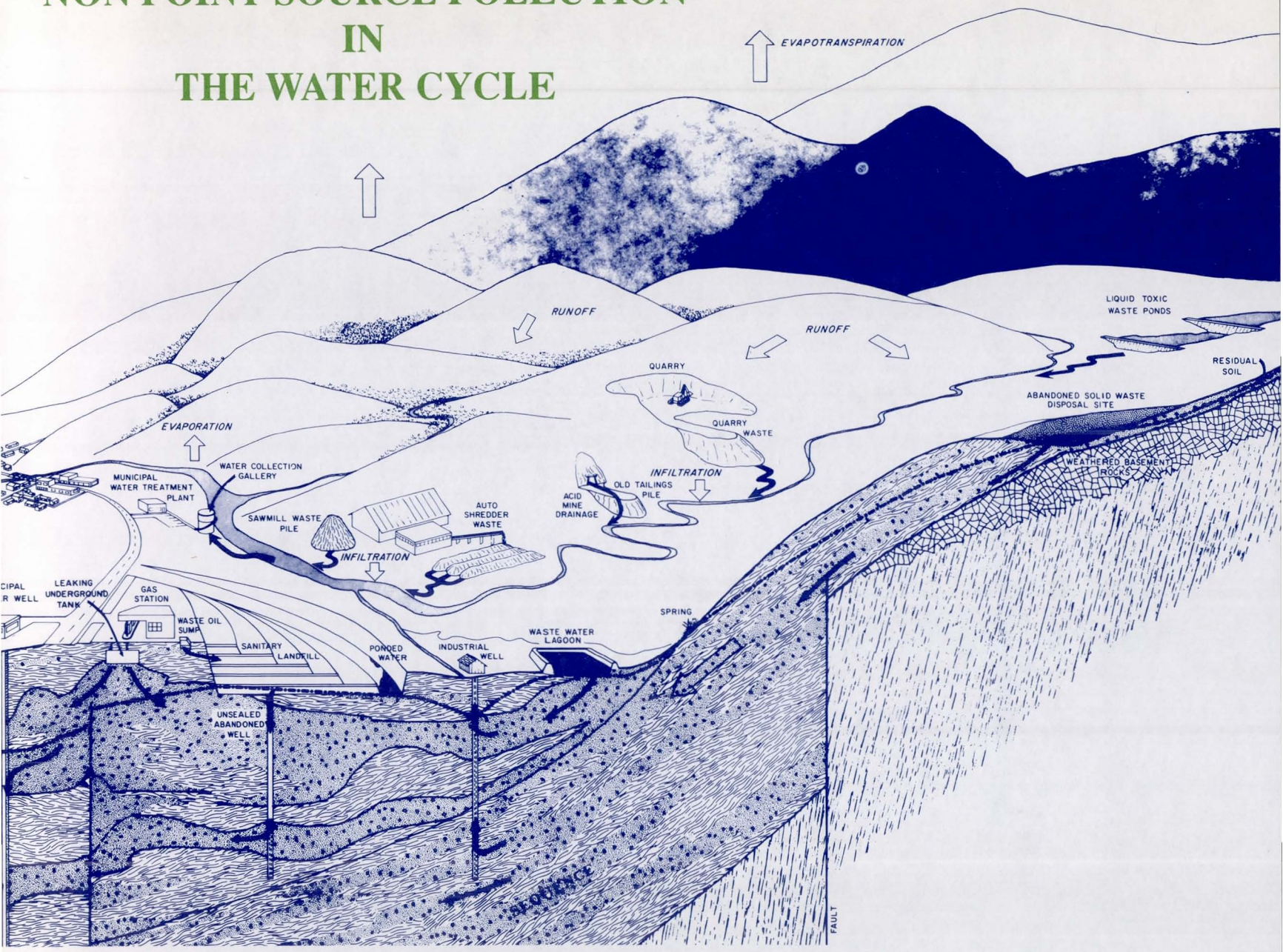
# NON POINT SOURCE POLLUTION IN THE WATER CYCLE




## WESTERN STATES WATER COUNCIL

### NON POINT SOURCE POLLUTION CONTROL WORKSHOP TECHNICAL ISSUES

**July 25-28, 1989**
**Irvine, CA 92714**

# *NONPOINT SOURCE POLLUTION CONTROL WORKSHOP TECHNICAL ISSUES*

## July 25-28, 1989

Irvine, CA

**Western States Water Council**
**Creekview Plaza, Suite A-201**
**942 East 7145 South**
**Midvale, Utah 84047**

## WORKSHOP OBJECTIVE

Each western state may have its own approach to Non Point Source (NPS) pollution control, however, technical issues are common in many of the states. An objective of the workshop is to identify NPS technical issues related to NPS pollution control and to determine their relationship to EPA's Point Source/NPS Programs and the states' water quality issues. A second objective is to monitor and report on successful western states projects, programs, and strategies aimed at mitigating NPS pollution. A third objective is to develop recommendations to WSWC to be included in future WSWC position papers or policies dealing with nonpoint sources.

### THE COVERS

**The front and back covers were adapted from the California State Water Resources Control Board's "Ground Water Contamination In The Water Cycle."**

# WESTERN STATES WATER COUNCIL

The Western Governors' Conference organized the Western States Water Council (WSWC) in 1965 to: "...accomplish effective cooperation among western states in matters relating to the planning, conservation, development, management, and protection of their water resources." The Governors also said: "The future growth and prosperity of the western states depend upon... adequate quantities of water of suitable quality."

The emphasis and focus of the WSWC has changed over the years as water policy issues have evolved. However, the Council's commitment to effective cooperation among the states has remained constant. This need for cooperation is premised on the primary authority of the states to manage water resources. Exercise of this authority leads to decisions which shape the growth and destiny of the West.

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# WESTERN STATES WATER COUNCIL (WSWC)
## NONPOINT SOURCE (NPS) POLLUTION CONTROL -- TECHNICAL ISSUES WORKSHOP
JULY 25-28, 1989
THE IRVINE HILTON AND TOWERS
IRVINE, CALIFORNIA

TUESDAY, July 25, 1989

| | |
|---|---|
| 1:00 p.m. - 4:00 p.m. | Registration - International Foyer |
| 2:00 p.m./3:00 p.m./4:00 p.m. | Tours of the Irvine Exhibit |
| 5:00 p.m. - 7:00 p.m. | WSWC Members, Session Chairs, and Speakers Meeting |
| 6:00 p.m. - 8:00 p.m. | Registration - International Foyer |

WEDNESDAY, July 26, 1989

8:00 a.m. Registration - International Foyer

8:30 a.m. **Pastries, Coffee &/or Juice** - International Foyer

9:30 a.m. Welcome - Salon A & B
D. Craig Bell, WSWC Executive Director
Opening Remarks - Salon A & B
David N. Kennedy, Director, CA Department of Water Resources and WSWC Executive Committee Member.

**SESSION I: OVERVIEW OF NPS -- TECHNICAL ISSUES**
Session Chair: Darlene Ruiz, Vice Chairwoman
CA State Water Resources Control Board (SWRCB)
and
Chairwoman, WSWC NPS Pollution Control Subcommittee

10:00 a.m. The NPS Pollution Challenge
Darlene Ruiz, Vice Chairwoman, CA SWRCB

10:20 a.m. WSWC's NPS Pollution Survey
Norman K. Johnson, Legal Counsel
Western States Water Council

10:30 a.m. Overview - Agricultural Drainage from Crop Production
Kenneth K. Tanji, Professor of Water Science,
Department of Land, Air, & Water Resources
University of California, Davis

10:40 a.m. An Overview of Session IV:NPS Pollution Impact of Agricultural Chemicals

Steve Pirner, Director, SD Division of Environment Quality

10:50 a.m. Overview - NPS Pollution from Agricultural Grazing/Feedlots/Dairies
Don Ostler, Director, UT Bureau of Water Pollution Control

11:00 a.m. Overview - Urban Runoff/Construction/Hydrologic Modification
Carol Jolly, Water Quality Program Manager, WA Department of Ecology

11:10 a.m. Overview of Silviculture Session Issues
Richard J. Nichols, Administrator, OR Water Quality Division

11:20 a.m. NPS Control - Resources Extraction & Land Disposal - Overview
Lewis Dodgion, Administrator, NV Division of Environment Protection

11:30 a.m. **ROUNDTABLE DISCUSSION & QUESTIONS**

12:00 p.m. **No-Host Deli Buffet LUNCH** - Salon C
Presiding: Eliseo M. Samaniego, Member, CA SWRCB
Speaker: Assemblyman Jim Costa, Chairman
CA Legislature, Assembly Committee on Water, Parks & Wildlife

**SESSION II: AGRICULTURAL DRAINAGE - NPS POLLUTION CONTROL -- TECHNICAL ISSUES** - Salon A & B
Session Chair: Kenneth K. Tanji, University of CA

1:30 p.m. Overview of the U.S. Department of Interior's Irrigation Drainage Studies in the Western States
Dr. Roy Schroder, Research Hydrologist
U.S. Geological Survey, San Diego

1:45 p.m. Agricultural Drainage Water-Treatment and Disposal Option
Edwin W. Lee, DE/DPA, Environmental Engineer
Retired U.S. Bureau of Reclamation - March 1989
Dr. Lee has also provided the paper "Dairy and Feedlot Waste Treatment and Disposal Alternatives for NPS Control" to support Session V.

2:00 p.m. Irrigation-Induced Water Quality Problems
Jan van Schilgaarde, PhD, Chairman, Committee on Irrigation - Induced Water Quality Problems
Water Science & Technology Board, National Research Council

2:15 p.m. NPS Pollution from Agricultural Drainage in California:Defining the Problem and Addressing the Need
Blaine Hanson, Irrigation & Drainage Specialist
Cooperative Extension, University of California, Davis
Farouk T. Ismail, Ph.D., P.E., Supervising Engineer, CA SWRCB

2:30 p.m. Agricultural Drainage Technical Issues Facing Water Agencies
Stephen K. Hall, Executive Director
Land Preservation Association, Fresno, CA
Cindy K. Tuck, Government Relations Advisor
Heron, Burchette, Ruckertt & Rothwell, Sacramento, CA

2:45 p.m. Regulation of Agricultural Subsurface & Surface Drainage in the San Joaquin Basin
William H. Crooks, Executive Officer
CA Regional Water Quality Control Board, Central Valley Region

3:00 a.m. **ROUNDTABLE DISCUSSION & QUESTIONS**

3:45 p.m. **BREAK**

**SESSION III: CASE STUDY - SANTA ANA RIVER WATERSHED**
Panel Chair: Bill B. Dendy, President
Bill B. Dendy & Associates, Davis, CA

4:00 p.m. NPS Case Study-Technical NPS Pollution Issues Affecting Water Quality Management in the Santa Ana River Watershed and their Application to the Western States
Nereus L. Richardson, Chief Engineer and Assistant Manager Orange County Water District, Fountain Valley
Donald E. Evenson, Senior Vice President
James M. Montgomery Consulting Engineers, Inc., Walnut Creek, CA

6:00 p.m. **SOCIAL HOUR-HOSTED "Hors D'Oeuvres Variees" & NO-HOST BAR**
Salon C - Sponsored by Jame M. Montgomery Consulting Engineers, Inc.

THURSDAY, July 27, 1989

7:30 a.m. **PASTRIES, COFFEE AND/OR JUICE** - International Foyer

**SESSION IV: NPS POLLUTION IMPACT OF AGRICULTURAL CHEMICALS**

Session Chair: Steven Pirner, SD

8:15 a.m. Agricultural Chemicals:NPS:A Dilemma
Eliseo M. Samaniego, Board Member, CA SWRCB

8:35 a.m. Control of Rice Herbicides in California Water Ways
Marshall Lee, Associate Environmental Harzard Scientist
CA Department of Food & Agriculture

8:50 a.m. Ground Water Quality Activities:California Pesticide Management Plan
Steven C. Monk, Ground Water Program Coordinator
CA Department of Food & Agriculture

9:05 a.m. Industry's Perspective on NPS Ground Water Issues
Dick Jackson, Ph.D., Manager, Ground Water Program
Agricultural Products Division, Dupont Company; Chair, Western Agricultural Chemicals Associations's Water Quality Task Force

9:35 a.m. **ROUNDTABLE DISCUSSION & QUESTIONS**

10:00 a.m. **BREAK**

**SESSION V: NPS POLLUTION FROM AGRICULTURAL GRAZING/FEEDLOTS/DAIRIES**

Session Chair: Don Ostler, UT

10:15 a.m. NPS Pollution from Grazing in Arizona
Carole Russell, Nonpoint Source Manager
AZ Water Quality Management Unit

10:30 a.m. Montana's NPS Pollution Monitoring Strategy
Dr. Loren Bahls, Supervisor
MT Water Quality Management Section

10:45 a.m. Idaho's Agricultural Pollution Abatement Plan
Al E. Murray, Chief, Water Quality Bureau
ID Department of Health and Welfare

11:00 a.m. New Mexico's Nonregulatory NPS Pollution Control Approach
Jim Piatt, Program Manager, Planning Section
NM, Environmental Improvement Division

11:15 a.m. Spiritwood Lake Restoration Project
Michael T. Sauer, Limnologist
ND State Department of Health

11:30 a.m. **ROUNDTABLE DISCUSSION & QUESTIONS**

12:00 p.m. **No-Host Deli Buffet LUNCH** - Salon C
Presiding: D. Craig Bell, WSWC Executive Director
Speaker: Senator Ruben Ayala, Chairman
Senate Agriculture & Water Resources Committee
CA Legislature

**SESSION VI: URBAN RUNOFF/CONSTRUCTION/HYDROLOGIC MODIFICATION**

Session Chair: Carol Jolly, WA

1:30 p.m. NPS Pollution Control Program for Puget Sound, Washington
Nancy McKay, Deputy Director
Puget Sound Water Authority

1:45 p.m. Lake Tahoe NPS Pollution Control Program
David S. Ziegler
Chief, Long Range Planning Division
Tahoe Regional Planning Agency, Zephyr Cove, NV

2:00 p.m. A Basinwide Approach to NPS Management
Lane Wyatt, Water Quality Program Manager
Northwest CO Council of Government

2:15 p.m. Sedimentation Treatment Systems for Urban Drainage in Anchorage, AK
J. Brett Jokela, Senior Engineer
James M. Montgomery, Inc., Archorage, AK
Thomas R. Bacon, Project Manager
Municipality of Anchorage, Department of Public Works, Anchorage, AK

2:30 p.m. San Francisco Bay Urban Runoff Control Program
Steve Ritchie, Executive Officer
CA Regional Water Quality Control Board, San Francisco Bay Region

2:45 p.m. ROUNDTABLE DISCUSSION & QUESTIONS

3:10 p.m. **BREAK**

**SESSION VII: SANTA ANA RIVER WATERSHED/NEWPORT BAY NPS PROGRAMS**

Session Chair: James Cornelius, Principal Engineer, CA SWRCB

3:15 p.m. Agency Partnership for Nonpoint Source Control in Newport Bay
Patricia Blodgett, Senior Environmental Specialist (Newport Bay Coordinato
CA Santa Ana Regional Water Quality Control Board

3:30 p.m. Unsatuated Zone Movement of NPS Volatile Contaminants in the Redlands, CA Area
Gary L. Guymon, Professor of Civil Engineering
University of CA, Irvine, CA

3:45 p.m. The Mitigation of NPS Development Impacts on Newport Bay
Sat Tamaribuchi, Director, Environmental Planning
The Irvine Company, Newport Beach, CA

4:00 p.m. **ROUNDTABLE DISCUSSION AND QUESTIONS**

4:15 p.m. Tours-NPS Pollution Control Facilities for Protection of Newport Bay

Tours are being developed by Professor Guymon, University of California, Irvine, with assistance from the Orange County Water District

FRIDAY, July 28, 1989

7:30 a.m. **Pastries, Coffee and/or Juice** - International Foyer

**SESSION VIII: OVERVIEW - SILVICULTURE**

Session Chair: Richard Nichols, OR

8:15 a.m. The State of Washington's Timber, Fish & Wildlife Agreement
Bob Duffy, Environmental Planner, NPS Unit, WA Department of Ecology

8:30 a.m. CA Forest Practice Rules Assessment
Dean Cromwell, Executive Officer
CA State Board of Forestry
Gaylon Lee, Forest Practice Manager
CA State Water Resources Control Board

8:45 a.m. U.S. Forestry Service Best Management Practices-An Example of Successful NPS Pollution Control through Planning & Program Development
Andy Leven, Director
Regional Watershed Management
U.S. Forest Service, San Francisco, CA
John R. Rector, Group Leader, Water Resources & Planning Group,
U.S. Forest Service, San Francisco, CA

9:00 a.m. 208 Certification-The Endless Journey
Gil Murray, Vice President
Timber Association of CA

9:15 a.m. **ROUNDTABLE DISCUSSION AND QUESTIONS**

9:45 a.m. **BREAK**

**SESSION IX: NPS POLLUTION CONTROL - RESOURCES EXTRACTION & LAND DISPOSAL**

Session Chair: Lewis Dodgion, NV

10:00 a.m. Total Mercury in Sediment, Water, and Fishes in the Carson River Drainage West-Central Nevada
James J. Cooper, Ph.D., Aquatic Biologist
NV Division of Environmental Protection

10:15 a.m. Alaska Resources Extraction NPS Issues
Jerry Brossia, Regional Manager
AK Division of Land & Water Management
Fairbanks, AK

10:30 a.m. Contamination of Ground Water from Underground Wastewater Disposal Systems, Upper Mojave River Basin, CA
Ken Carter, Senior WRC Engineer
CA Regional Water Quality Control Board, Lahontan Region
Amjad M. J. Umari, Project Director, U.S. Geological Survey, San Diego

10:45 a.m. Texas Wellhead Protection Program - A Reasonably Implementable and Cost-Effective NPS Management Tool
Brad L. Cross, Chief
Wellhead Protection Program, Ground Water Conservation Section
TX Water Commission

11:00 a.m. NPS Pollution Aspects of the U.S. Bureau of Land Management's Mineral Resources Program
Robert Anderson, Deputy State Director for Mineral Resources
U.S. Bureau of Land Management, Sacramento, CA

11:15 p.m. **ROUNDTABLE DISCUSSION AND QUESTIONS**

12:00 p.m. **No-Host Deli Buffet LUNCH** - Salon C
Presiding: Professor Charles DuMars
Speaker: Michael C. Kavanaugh, Chairman
Water Science and Technology Board
of the National Research Council
Topic: Overview of Water Science and Technology Board's Programs
Related to NPS Pollution

**SESSION X: FEDERAL AND UNIVERSITY PROGRAMS**

Session Chair: Professor Charles DuMars
University of New Mexico Law School
and WSWC Member

1:30 p.m. U.S. Department of Agriculture's Role in NPS Pollution Control
Virgil L. Backlund
Soil Conservation Service/EPA Liaison
U.S. Department of Agriculture, Davis, CA

1:45 p.m. NPS:Agenda for the Furture
Martha G. Prothro
Director, Office of Water Regulation & Standards
U.S. Environmental Protection Agency, Washington, DC

2:00 p.m. Research Role of the University of California in Understanding Technical Issues Related to WPS Pollution
Henry J. Vaux Jr., Professor of Economics
University of California, Riverside, CA
Director, University of California's Water Resources Center

2:15 p.m. **ROUNDTABLE DISCUSSION AND QUESTIONS**

**SESSION XI: SESSION CHAIR'S REPORTS ON NPS POLLUTION CONTROL -- TECHNICAL ISSUES**
Session Chair: Darlene Ruiz, CA

2:30 p.m. **ROUNDTABLE DISCUSSION AND RECOMMENDATIONS**
Kenneth Tanji, CA
Steve Pirner, SD
Carol Jolly, WA
Don Ostler, UT
Richard Nichols, OR
Lewis Dodgion, NV
Charles DuMars

3:30 p.m. **A D J O U R N M E N T**

## Wednesday Morning, July 26, 1989

| | |
|---|---|
| 8:00 a.m. | Registration – International Foyer |
| 8:30 a.m. | **Pastries, Coffee &/or Juice –** International Foyer |
| 9:30 a.m. | **Welcome and Opening Remarks –** Salon A & B<br>D. Craig Bell, WSWC Executive Director<br>David Kennedy, Director, CA Department of Water Resources, WSWC Executive Committee Member |

WESTERN STATES WATER COUNCIL

*Creekview Plaza, Suite A-201/942 East 7145 South/Midvale, Utah 84047/(801) 561-5300 / FAX (801) 255-9642*

*July 11, 1989*

*Dear Workshop Participant:*

*On behalf of the members and staff of the Western States Water Council I welcome you to the Council's Non-point Source Pollution Control Technical Issues Workshop. We have prepared these proceedings to help ensure that your workshop experience is as beneficial as possible.*

*The Council was organized in 1965 by the Western Governors' Conference to: "...accomplish effective cooperation among western states in matters relating to the planning, conservation, development, management, and protection of their water resources." The need for cooperation is premised upon the states' primary authority to manage water resources. Decisions made in the exercise of this authority help shape the destiny of the West. Over the years the Council has focused on a variety of water policy issues. The Council believes that opportunities to exchange information regarding such issues, through workshops such as this, foster the kind of constructive relationships between states which the Council was created to support.*

*Beyond this general purpose, this workshop has multiple objectives. One is to identify technical issues related to non-point source pollution control and to determine their relationship to EPA's point-source and non-point source programs and state water quality issues. A second objective is to monitor and report on successful western state projects, programs, and strategies aimed at mitigating non-point source pollution. The third objective is to develop recommendations which may be included in future Council non-point source pollution control position papers or policy statements.*

*While the workshop issues will not be new to most of you, we hope the workshop will provide you an opportunity to gain new perspectives and share fresh insights and ideas. In this regard, we would appreciate any comments you may have regarding the workshop.*

*The Council desires to acknowledge with appreciation the efforts of its Non-point Source Pollution Control Subcommittee, chaired by Darlene Ruiz, in planning the workshop and arranging for the workshop program and facilities.*

*Thank you for coming.*

Craig Bell

*D. Craig Bell*
*Executive Director*

# TECHNICAL PROGRAM

## Wednesday Morning, July 26, 1989

| | | PAGE |
|---|---|---|
| **SESSION I:** | **OVERVIEW OF NPS POLLUTION – TECHNICAL ISSUES**<br>Session Chair: Darlene Ruiz, Vice Chair CA SWRCB and Chair, WSWC NPS Pollution Control Subcommittee | |
| 10:00 a.m. | **Goals of Workshop**<br>Darlene Ruiz, Vice Chair, CA SWRCB | I-A |
| 10:20 a.m. | **WSWC's NPS Pollution Survey**<br>Norman K. Johnson, Legal Counsel Western States Water Council | I-B |
| 10:30 a.m. | **Overview - Agricultural Drainage from Crop Production**<br>Kenneth K. Tanji, Professor of Water Science, Department of Land, Air, & Water Resources, University of California, Davis | I-C |
| 10:40 a.m. | **Overview - Agricultural Chemicals**<br>Steve Pirner, Director, SD Division of Environment Quality | I-D |
| 10:50 a.m. | **Overview - Agricultural Grazing/Feedlots/ Dairies**<br>Don Ostler, Director, UT Bureau of Water Pollution Control | I-E |
| 11:00 a.m. | **Overview - Urban Runoff/Construction/ Hydrologic Modification**<br>Carol Jolly, Water Quality Program Manager, WA Department of Ecology | I-F |
| 11:10 | **Overview - Silviculture**<br>Richard J. Nichols, Administrator, OR Water Quality Division | I-G |
| 11:20 | **Overview - Resources Extraction & Land Disposal**<br>Lewis Dodgion, Administrator, NV Division of Environment Protection | I-H |
| 11:30 | **ROUNDTABLE DISCUSSION & QUESTIONS** | I-I |
| 12:00 p.m. | **No-Host Deli Buffet LUNCH** - Salon C<br>Presiding: **Eliseo M. Samaniego** Member, CA SWRCB<br>Speaker: **Assemblyman Jim Costa** Chairman, Assembly Committee on Water, Parks and Wildlife, CA Legislature | I-J |

# THE NONPOINT SOURCE POLLUTION CHALLENGE

by
Darlene E. Ruiz
Vice Chair
California State Water Resources Control Board
and
Chair Nonpoint Source Subcommittee
Western States Water Committee
July 26, 1989

The 1987 amendments to the Clean Water Act place further attention upon the control of nonpoint source pollution. As we continue to draw together our assessments of the extent and effects of nonpoint source pollution, we see a picture of a problem that challenges both our administrative and technical capabilities.

A complex and interrelated set of technical, political, economic and administrative issues must be resolved before nonpoint source programs can achieve any measurable effectiveness. Initial assessments indicate this will be the major pollution concern of the next decade. However, many states nonpoint source programs have already experienced some successes.

Though the site specific technical issues pertaining to nonpoint source control vary with the nature and general cause of the pollution, the type of water body being contaminated, and the actual contaminants present, all sites share in the fundamental technical problems. The adequacy of current monitoring systems is a critical issue for many states. By its very definition, nonpoint source pollution poses complex monitoring problems. Correlating observed water quality degradation to nonpoint source involves linking together pieces of a puzzle made of transport systems, diverse contaminants, and spatial and temporal proximity.

Controlling nonpoint source pollution poses a different, and seemingly inverse, set of technical considerations from those posed by monitoring the problem. Most

of our technology has been geared toward point source applications. We have been addressing point sources by directing contaminant or site specific approaches to control measurable and quantifiable levels of isolable pollutants. Applying this technology to nonpoint source pollution requires analyzing the component contaminants and attempting to isolate the diffuse sources. What is linked together for monitoring must be broken into component parts for application of point source treatment and management techniques.

Nonpoint source does not lend itself to site or contaminant specific technical approaches. Bioassay monitoring may lead to indications of significant water body degradation without yielding specifics on either contaminants, abatement, or cleanup. In some cases, such as where a best management practices plan has been put in place to control nonpoint source problems, there may still remain significant problems with stream turbidity or ground water contamination. Clearly in such a situation, even if we are satisfied that best management practices are the best technical approach for dealing with nonpoint source, we may still be thoroughly dissatisfied with a resultant continued degradation of the water body the best management practices were implemented to protect. There are currently no pat answers to many nonpoint source technical problems and many states feel EPA should devote more energy to remedying this situation, and less energy to setting unrealistic assessment timeframes.

Nonpoint source programs can be effective. Clearly, if we are to halt the degradation of our nations waters, nonpoint source programs must be effective. We are pushing the economic and environmental utility of our point source programs beyond the point of marginal return. Though control and monitoring of point sources will continue to remain an important water quality task, our focus must now shift to nonpoint source pollution. As we shift our attention, we realize that as complex as the technical questions may be, ultimately, the success or failure of nonpoint source programs may rest in our solutions to the economic, and consequent political, decisions we will be required to make with regard to implementing nonpoint source programs.

Though nonpoint source pollution is receiving national attention, it is presently an issue best addressed at a local level. Solutions to this problem will come from local agencies working with local interests to manage local nonpoint source

pollution. The successes at this local level, and there have already been successes, can be shared with other localities experiencing similar nonpoint source problems. The federal government can work as a clearinghouse for this information, as a facilitator, through adequate funding and as a developer of best management practices technology to the complex contaminant mixes and differing water bodies affected by nonpoint source.

The Western States Water Council in 1987 determined that nonpoint source pollution was a serious concern and formed a subcommittee of their water quality committee to provide a forum for exchange of ideas. The Council next conducted a nonpoint source pollution survey of their members. That survey was the starting point for the development of this week's nonpoint source pollution technical issues workshop.

The long term goal of the workshop is the protection of the beneficial uses of the western states ground and surface waters. Three immediate objectives of the workshop are:

1. To identify nonpoint source technical issues related to nonpoint source pollution control and to determine their relationship to EPA's point source/nonpoint source programs and the states' water quality issues;

2. To monitor and report on successful western states projects, programs, and strategies aimed at mitigating nonpoint source pollution; and

3. To develop recommendations to the Council for inclusion in future Council position papers or policies dealing with nonpoint source pollution.

A preliminary review of the prepared papers indicates that a large number of issues have been identified and programs or projects from nearly all of the member states are being presented.

Speakers will be presenting:

1. Five papers on subsurface agricultural drainage problems in the western states which present many technical challenges;

2. A nonpoint source pollution control plan for protection of a lake that includes 38 separate control measures;

3. A "bubble concept" as an effective and equitable method of controlling both point and nonpoint source pollution;

4. A stormwater management program that includes performance criteria;

5. Four questions will be presented that must be answered to prevent unacceptable ground water contamination due to application of agricultural chemicals.

6. Two alternative pesticide contamination prevention programs to protect ground water;

7. A program to protect surface water from pesticides;

8. Four technical problems that plague nonpoint source monitoring programs are provided and discussed;

9. Grazing is presented as the most pervasive source of water impairment with over grazing being the critical problem;

10. The concern that the Soil Conservation Service criteria are inadequate to protect small lakes;

11. That in spite of attention by many agencies the environmental quality of a bay continues to decline as the area is developed;

12. Speakers from three states, the United States Forest Service and the Timber Industry will discuss the use of BMPs and regulations for the control of nonpoint source pollution from silviculture operations;

13. Mercury contamination, septic tank/seepage pit systems, wellhead protection and the United States Bureau of Land Management nonpoint source program;

14. The roles, responsibilities and programs of the United States Environmental Protection Agency and the United States Department of Agricultural, including the issue as to whether the USDA will give water quality protection equal billing with control of soil erosion; and

15. The research role of the University of California System.

All of this should provide ample items for the Friday afternoon closing session.

Because this conferences is focused on the Western States, I would like to take this opportunity to shift from the general goals to the specifics of California's nonpoint source program.

California has completed an assessment and management plan consistent with Section 319 of the Clean Water Act. California's assessment meets the requirements of Section 319. It also goes a step beyond the requirements. Our assessment is a highly structured data base. In addition to including the source and the reliability of the assessment data, the report is also coded to allow separation by 28 mutually exclusive categories such as: confined animals, irrigation return flows, grazing impacts, channel erosion, construction, habitat modification, hydrologic modification, mineral extraction, and urban runoff. The assessment is also organized by contaminant parameters, such as sediments, dissolved solids, and coliform. This initial structuring of the data base provides a flexible framework for future monitoring and management planning activities.

The assessment quite plainly reveals nonpoint source pollution problems are extensive. Each of California's nine regional boards reports some form of nonpoint source pollution contributing to degradation problems within its boundaries. Fortunately, each region has also begun programs for addressing nonpoint source problems.

In our Lahontan Region, which encompasses some of the finest ski areas in the world, the regional board has worked with the ski resort operators to establish best management practices to control sediment from the ski areas. The use of best management practices has been incorporated into the regional board's basin plan for control of nonpoint source pollution from other sites, such as golf courses, campgrounds, and livestock grazing areas. The use of narrative standards in setting best management practices for the region has been tested in court and was found to be an acceptable alternative to numeric criteria.

For Lake Tahoe, control of nonpoint sources is the key to controlling degradation of water quality. For this reason, a nonpoint source consciusness is present in local land use planning. This consciousness goes beyond a mere awareness and recognition of the problem. Over the next five years, state and local agencies will be spending $68 million for control of erosion and surface water runoff from public rights-of-way; and, this is just the start of what is anticipated to be a $270 million program.

In our Central Valley Region, which includes much of the State's prime agricultural areas, the regional board has worked with rice farmers to control the amount of rice herbicides entering the Sacramento River and its tributaries. The presence of herbicide in the river had caused some fish kills and regular taste complaints from domestic water users. Through the cooperative implementation of a best management practices program, which included restriction on amount and location of herbicide applications, training of applicators, and minimum holding times for water treated by the herbicides, measurable decreases in herbicide concentrations in the receiving waters were recorded, annual fish kills reduced, and taste complaints curbed. One of the interesting sides to this program was that it led to a water quality assessment indicating toxic ambient levels even prior to the use of the herbicides. You will be hearing more on this program later.

In the Los Angeles Region, the regional board, the State Board and the Environmental Protection Agency are cooperatively working together to protect and improve the Santa Monica Bay estuary. An integral part of this project is the control and management of urban stormwater runoff.

In 1986, the San Francisco Bay Regional Board suspected nonpoint sources as a major contributor to severe water quality problems in the South Bay. The region's basin plan was amended to reflect the nonpoint source problems and the work was begun with local jurisdictions to control the problem. To date, local agencies have invested over $1 million in developing approaches to nonpoint source control. Again, you will hear more about this program later.

The State Board nonpoint source unit will be working with the regional boards to ensure nonpoint source continues to receive the attention required by Section 319. As I noted previously, all of the regions have nonpoint source success stories already. The requirements of Section 319 will allow us to review these successes and smooth the transfer of information to various projects among the regions.

The second phase of the State program will involve funding specific nonpoint source projects and monitoring results. The third phase will be the ongoing implementation of nonpoint source projects following a review and analysis of the successes and setbacks encountered in the initial program efforts. This may all sound a bit administratively and procedurally complex, and frankly it is, but nonpoint source pollution is a complex problem. By its very nature, nonpoint source does not lend itself to traditional point source treatment methodologies.

With point source, we generally know what the problem is and from where it is originating. With point source, if it looks like a duck, walks like a duck and quacks like a duck, we know it is a duck and we can respond appropriately. With nonpoint source, all we know is something from somewhere killed the duck. Our job then becomes tracing the diffuse sources of harmful contaminants and then finding a methodology that will end the degradation of the particular water body.

We feel we have made progress with our nonpoint source program in California. As our assessment indicated, however, nonpoint source is not a new problem for us, and it is not a problem that has gone unaddressed. Our mission now is to build upon past successes; to look for new, innovative, and economically feasible methods of responding to nonpoint source contamination, and to seek adequate federal funding to meet the requirements of federal mandates.

Nonpoint source pollution is the water quality challenge of the 1990s, which is why the Western States have started working on meeting it now and why the Western States Water Council is presenting this workshop.

Thank you.

*****

Norman Johnson

**PRELIMINARY SUMMARY OF FINDINGS**
**WESTERN STATES WATER COUNCIL'S**
**NONPOINT SOURCE POLLUTION SURVEY**

A nonpoint source (NPS) pollution control survey was conducted by the Western States Water Council in early 1988. The data was provided to all the member states and used as a source document for developing the agenda for this week's workshop. The questionnaire was developed with input from a number of western states. The main objective was to produce information which would be beneficial to the western states as they were developing their nonpoint source assessment and management programs as required by the Clean Water Act.

A preliminary analysis of the data has been done. Some of the concerns are that currently the primary source of funding for NPS is from the federal government, however, some states have developed "innovative" sources of funding.

Most of the states cited state regulations rather than state statutes as the basis of regulatory control. Federal requirements were a secondary method of regulatory control. Eleven states have civil and/or criminal penalties for noncompliance under the regulatory approach. Four states did not have penalties. However, during 1986, there was only limited NPS enforcement for NPS pollution by the states. In half of the states their state water quality standards for surface water applied to NPS pollution.

The data indicates that water quality, health, and environmental agencies are primarily responsible for NPS control and that most states have a combination of a regulatory/nonregulatory approach with agriculture being the main nonregulatory aspect. Within the nonregulatory approach the main reason for compliance was financial with avoidance of regulations being second. Most of the western states have recently taken actions to promote NPS control under their nonregulatory approach.

Four methods were given as the primary methods of regulatory NPS control in the western states. These are:

1. Pesticide Regulations
2. Erosion Control
3. Forest Practice Rules
4. Septic Tank Regulations

All of the states except one have identified best management practices (BMPs) as part of their NPS program. In most states, the BMPs have been officially recognized in

their water quality plans. Only three states have listed their NPS control program as being effective; six as partially effective, two as ineffective, and four as unknown.

The states were asked to rank the major NPS categories with regard to statewide impacts on water quality and beneficial uses. The state rankings are as follows with the major impacts starting at the top of the list:

1. Grazing
2. Agricultural Runoff (surface)
3. Hydrologic/Habitat Modification
4. Irrigation Return Flows
5. Land Development
6. Mining
7. Urban Runoff
8. Silviculture
9. Road Construction & Maintenance
10. Land Disposal
11. Recreation

As shown above the major impacts were related to agriculture, hydrologic modification and land development.

Six states indicated that they maintain an NPS pollution monitoring program for surface waters. Twelve states maintain an ambient monitoring program which provides information on NPS Pollution. Eight states have targeted certain waters for NPS management during the next five years.

Five states maintain a ground water quality monitoring program where as a total of 13 states have cooperative efforts with other agencies. In most of the states, their ground water protection strategies addresses NPS pollution impact. The states have legislative authority to implement their strategies.

Eight states have water quality standards that applied to ground water, and three additional states are preparing standards. In six states their standards apply to NPS pollution, and in four states standards are being proposed to apply to NPS pollution. In seven states, the standards include nondegradation provisions and in five states, they contain antidegradation provisions.

Each of the western states included a number of "success stories" in their response to the survey. A number of these "success stories" will be presented during the next few days.

# Overview - Agricultural Drainage from Crop Production

Kenneth K. Tanji
University of California, Davis

Crop production under irrigated as well as dryland conditions result in varying amounts of surface and subsurface drainage from rainfall, snowmelt waters and applied irrigation waters. In the most simplest case these drainage flow pathways consist of surface runoff, deep percolation or leaching beyond the crop root zone, and collected subsurface drainage which may include shallow ground waters intercepted by natural and man-made open channels and effluents from tile drainage systems.

Associated with these drainage flows are a number of water quality constituents of concern in both the dissolved and suspended states. The principal NPS pollutants discharged from cropland are sediments, dissolved mineral salts, nutrients (mainly nitrates and phosphorus), pesticides (insecticides, herbicides, fungicides, miticides), animal wastes (containing nutrients, salts, biochemical oxygen demand, etc.), and trace elements (including heavy metals).

The quantities of NPS pollutants discharged are typically estimated in terms of concentration (mass per unit volume of water, e.g., mg/liter) and unit mass emission rates (mass per unit area, e.g., lbs./acre) which require a knowledge of concentration of pollutant, volume of water, and surface area from which the pollutant was discharged.

The concentrations and mass emission rates of these NPS pollutants are influenced by numerous factors including hydrology and climate, soils and geology, agronomic, irrigation and drainage practices, rates and amounts of agrichemicals applied and pollutant properties (reactivity and mobility).

In order to manage and control the discharge of NPS pollutants it is necessary to understand the source(s) and processes by which they are mobilized and transported into streams, lakes, reservoirs, ground waters and estuaries.

For instance, sediment production from erodible cropland in surface runoffs are orders of magnitude higher than that of deep percolation because of filtration by the soil profile. Moreover, sediment concentration in runoffs may vary widely depending on vegetative cover, steepness of slope, rainfall intensity and duration and the like, and the amounts delivered from cropland to receiving water bodies depends on the relative amounts of sediments deposited and/or resuspended in transit. Sediments also contain various forms of nitrogen, phosphorus, and salt particles which may dissolve in the receiving water.

In contrast, the concentrations of dissolved mineral salts from salt-affected lands are typically much greater in deep percolation than in surface runoffs because of the concentrating effects of evapotranspiration by plants and chemical weathering of soil minerals. For cropland that are underdrained, the tile effluent collected is typically a mixture of subsurface drainage from the root zone as well as shallow ground waters intercepted by the drainage system. In some instances, the salinity of shallow ground waters are substantially greater than that leaching from the root zone. The principal sources of salts in drainage of croplands are irrigation water, soil salinity, rising shallow ground waters, soil and water amendments, and fertilizers and animal manures.

The two examples illustrate the technical complexities in evaluating agricultural drainage and NPS pollutants. Although site-specific conditions and processes have a strong influence on what and how much pollutants are drained from croplands, there is a growing body of alternative management options to reduce emissions of NPS pollutants, e.g., source control, drain water reuse, drain water treatment, drain water disposal as well as institutional changes.

This afternoon's session will be devoted to technical issues in regard to NPS pollution control for irrigated croplands. Papers will be presented on irrigation drainage problems in the western U.S. as well as those focused on San Joaquin Valley's salinity, drainage, and toxic element problems.

# AN OVERVIEW OF SESSION IV:

# NPS POLLUTION IMPACT OF AGRICULTURAL CHEMICALS

by

Steven M. Pirner, Director
Division of Land & Water Quality
South Dakota Department of Water & Natural Resources

The NPS pollution impact of agricultural chemicals has been a subject of great public concern. This concern has ranged from having any physical contact with the chemicals during application, ingesting chemicals that have been applied to edible products, having chemicals carried in runoff or drainage into surface waters, and most recently, having chemicals leach into ground waters. It is this last concern that has created both a public and political reaction to the NPS agricultural chemical issue. This is a concern that is shared by the citizens of this country on a national scale, and you will note that four of the five papers to be presented on the topic of NPS impacts of agricultural chemicals deal with ground-water issues.

In illustration of the national concern, I recently received a letter from the Environmental and Energy Study Institute in Washington, D.C., which states the following statistics: "A recent Environmental Protection Agency (EPA) report confirmed findings of a total of 46 different pesticides in 26 states. In many areas, particularly the Midwestern states, groundwater is contaminated by nitrates from fertilizer. For example, in Minnesota, about 25 percent of rural private wells exceed EPA's drinking water standard for nitrates. In Iowa, 40 percent exceed this standard, and, in Nebraska, as many as 70 percent of rural wells exceed the standard."

In order to set the stage for our session on Thursday, which is going to focus on approaches to solve the problem of NPS impact of agricultural chemicals, I would like to relate some of our experiences in the State of South Dakota in simply defining the problem. First, the relationship between our ground-water resources and agriculture must be understood.

Ground water is indeed a precious resource to our State, just as it is in many of the western states. Ground water constitutes by far our most commonly used water supply source. For example, approximately 95 percent of our public water supply systems rely upon ground water as their source. In many cases, the utilized ground water is being stored in shallow surficial aquifers, which of course have been judged to be the most susceptible to pollution from surface activities.

Just as ground water is one of our most important natural resources, agriculture is one of our most important economic bases. The

business of agriculture is our primary economic industry and our dominant land use within the State. In order to survive in agriculture, operators must constantly find new more efficient methods of farming, and this has lead to increased use of agricultural chemicals to economically maximize production. Therefore, the facts of shallow ground-water supplies underlying vast expanses of agricultural lands has lead the public to be very concerned about potential NPS inputs of agricultural chemicals into our water supplies

In South Dakota, we have taken a pragmatic approach towards attempting to investigate these public concerns regarding ground-water quality, not because of a lack of concern, but rather because of all the unknowns. Indeed, there have been and still are many technical problems associated with attempting to address the NPS agricultural chemical issues in a scientifically valid manner. For example, the sampling methodologies, analytical methods, and data interpretation methods have all been developed only relatively recently, and, in fact, are still in the age of development. The cost to perform ground-water studies, especially when pesticide analyses are involved, are extremely costly, and this too has been a major hindrance to developing our knowledge. However, we have been able to perform a number of studies, and valuable information has been collected which will ultimately lead to effective control and management methodologies.

The statistics quoted above compare fairly well with the situation found in South Dakota. The eastern half of our State is a glaciated region which contains extensive shallow surficial aquifers. After completing several studies in this region of rural wells that are used for either household use or stockwatering, it has consistently been found that approximately 30 percent of these wells do not meet either bacteria and/or nitrate standards for drinking water. However, it has been found that the type of well construction has an influence on the water quality of the sample, with shallow large diameter wells that are typically not grouted producing poor quality water most frequently. Based on these findings, and simply our own observations of the extremely poor locations and construction practices used for many rural wells, it was initially concluded that the nitrate problems were related more to poor well location and construction rather than nonpoint source contributions.

Additional studies were proposed to further define the problem. We began a long-term, multi-agency project funded under the U.S. Department of Agriculture Rural Clean Water Program in which the relationship between ground-water quality and different management practices of using agricultural chemicals on dryland farms could be studied. A major component of this study is to determine both water and chemical pathways and transport mechanisms in the vadose zone. We have also completed more cursory studies designed to indicate the presence or absence of agricultural chemicals in ground water under both dryland and heavily irrigated sites.

To date, the results of these studies have provided some fairly common results. Nitrates are being detected very frequently in the ground water stored in shallow surficial aquifers under farmed areas. However, there is correlation between both the presence and the concentrations of nitrates versus the sample depth of the aquifer. In other words, our studies show that the highest frequency of occurrence and the highest concentrations of nitrates generally appear in the top ten to twenty feet of saturated thickness. Conversely, nitrates are seldom found in the lower portions of the aquifer and, if detected, are at relatively low concentrations. This stratification phenomena which is being observed raises many practical and philosophical issues. For example, if the quality near the water table exceeds the state ground-water quality standards, but samples representative of the deeper portions of the aquifer do not, at what point should it be decided that the beneficial uses of the ground water are being adversely impacted?

In terms of pesticides, our studies in South Dakota have generally shown less than ten percent of the sample data from any one study containing any detectable concentrations. Nearly all concentrations have been less than any known drinking water standard or health advisory, with few detections ever found in following samples from the same well. However, we have not seen the stratification of pesticides within the saturated thickness such as is the case with nitrates. Instead, one study actually found pesticide concentrations most frequently in wells screened greater than ten feet below the water table. The implications of this finding are still unclear.

While there are still many unknowns, the data collected thus far has lead to the conclusion that agricultural chemicals are indeed reaching the ground water from NPS. In an agriculturally dominated state such as South Dakota, this conclusion could have major implications. New legislation mandating continued study and management of agricultural chemicals was proposed this year and included in the South Dakota Centennial Environmental Protection Act of 1989, which was introduced on behalf of Governor Mickelson. A provision of the Act reads "... the state shall formulate and revise as necessary state management plans for the use of fertilizers and pesticides that are based on protecting water quality and preventing ground water pollution. These management plans will be based on use practices within the state as a whole or in specific areas within the state depending on hydrogeological differences, and shall be used by the state in regulating fertilizers and pesticides pursuant to (specified existing legislation) in developing future contingency plans, and in performing public education."

The authors of the Bill certainly realized that not all of the answers to fully implement these provisions are known at this time. Therefore, a ground-water research fund was also established, a portion of which is directed to "identify and assess environmental and socioeconomic impacts of agricultural practices, develop alternative practices that support productive and efficient

agriculture and provide information through education and published materials to assure agriculture in the state of South Dakota that is economically, ecologically and socially maintainable over an extended period of time and that optimizes long-term profitably, prevents soil erosion and groundwater contamination and supports rural communities." As related to agricultural chemicals, this legislative mandate can be summarized by simply stating that research must be carried out to refine chemical use practices while sustaining productive agriculture.

Research is critical to successfully managing agricultural chemicals for the long-term protection of our water resources. While a great deal has already been learned concerning practices that can be used to minimize water pollution, such as performing soil testing to reduce over application, the proper timing of applications, and proper chemical handling, there are still a great many unanswered questions and probably many more questions that have yet to be asked. The subject of impacts of agricultural chemicals on human health and the quality of water resources is terribly complex. Simply consider the many different sciences involved in the issue, such as botany, chemistry, climatology, geology, hydrology, microbiology, soil science, toxicology, and all the interactions that must be understood.

The same ground-water quality concerns which we have been experiencing at the state level have already forced several changes in Federal legislation and programs. For example, in the 1970's and early 1980's there was a major effort to implement Best Management Practices in agriculture that were designed to abate surface water pollution, mostly from excessive soil erosion. However, many of these practices actually may concentrate agriculture chemicals in localized areas and thus increase the potential for leaching into the ground water. This led to questions being raised concerning whether a net environmental benefit was actually being achieved. As a result, the United States Department of Agriculture refocused their agency emphasis and developed their Water Quality Action Plan to incorporate both surface and ground-water quality concerns in their conservation planning assistance to farmers.

The United States Environmental Protection Agency (EPA) has also attempted to address the issue, partially as a result of the NPS provisions of the Clean Water Act Amendments of 1987. A result of their efforts is the Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy.

I believe that the papers to be presented during Session IV of this workshop are excellent examples of the possible components of a comprehensive program dealing with agricultural chemicals on a NPS basis. The first two abstracts that were reviewed for this session are titled "Control of Rice Herbicides in California Water Ways" by Marshall Lee, Associate Environmental Hazard Scientist, California Department of Food & Agriculture; and "Ground Water Quality Activities - California Department of Food & Agriculture" by Steven Monk, Ground Water Program Coordinator, also from the California

Department of Food & Agriculture. Both Mr. Lee and Mr. Monk will be describing how they have effectively used NPS control methodologies in a regulatory role. Meanwhile, Dr. Dick Jackson, Manager of Groundwater Programs for Dupont, will describe solutions that are economically attractive to the farmer, and solutions that emphasize education in his paper entitled "Industry's Perspective on NPS Ground Water Issues".

In summary, the papers in Session IV will present the scope and complexity of the NPS agricultural chemical problem. Experiences will be discussed in implementing solutions to the agricultural chemical issue that encompass the range of NPS controls; namely, regulatory controls, financial incentives, and education/ information. For many comprehensive NPS control programs dealing with agricultural chemicals to be successful, it is likely that a mix of these various strategies will be required. Thus, while it is absolutely essential to continue performing research to improve our knowledge of chemical use alternatives, chemical fate and transport phenomena, and human health consequences, the papers will also illustrate that the time for the development and implementation of positive prevention and control programs has arrived.

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Western States Water Council
Nonpoint Source Control Workshop
Session V

# Overview - Nonpoint Source Pollution from Agricultural Grazing/Feedlots/Dairies

by Don Ostler, Director
UT Bureau of Water Pollution Control

## Background

Nonpoint sources of water pollution were recognized by Congress as a major contributor of pollution to waters of the nation. The 1987 Federal Clean Water Act established provisions, through Section 319 to control nonpoint sources. Nonpoint source pollution is caused by sources that are not regulated as point sources and is associated with agricultural, construction, mining, urban, and silvicultural activities. Nonpoint source pollution results in the human made or human induced alteration of the chemical, physical, biological, and radiological integrity of water quality. Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, or percolation. Pollution from nonpoint sources occurs when the rate at which pollutant materials entering waterbodies or ground water exceeds natural levels.

In Utah, water quality data indicate that nonpoint source pollution problems consist primarily of sediment, nutrients, and salinity. The human caused nonpoint sources vary from watershed to wateshed, however, on a statewide average 70% of the nonpoint source impairments are due to agricultural activities, 13% by resource extraction, 8% by urban runoff, 5% by construction, 2% by waste disposal and 2% by hydrologic modification. The largest source of nonpoint source pollution in Utah is natural or background, however it is not practical to expect much control from these sources.

## Program Development

Utah has conducted a variety of activities to control pollution from nonpoint sources. These activities include local zoning and building regulations aimed at reducing urban runoff, incentive programs promoting the voluntary adoption of soil conservation practices, education on the proper use of pesticides and a wide variety of related programs. In some cases, the direct goal of these programs was to control NPS pollution. More often, however, the goal was to control soil erosion or conserve water. The result provided indirect benefits to water quality.

Utah's nonpoint source pollution management program is attempting to consolidate diverse resources and to coordinate an approach to control nonpoint source (NPS) pollution. This approach means building a strategy that not only addresses nonpoint source problems, but also coordinates and complements the activities of other agencies through the best use of available resources.

Resources allocated to NPS efforts have been scarce. However, due to this resource scarcity, those involved in NPS control have been forced to rely on others to achieve their goals. The resources of soil and water conservation organizations, enforcement agencies, land management agencies and other groups have been used to achieve NPS goals. Often NPS control was an afterthought or small additional benefit. This background has supplied NPS managers with valuable knowledge and abilities. They know how other agencies and organizations work and they know they must work cooperatively to accomplish their difficult task.

Early NPS control efforts in Utah were instigated with working agreements among the Utah Departments of Health and Agriculture, local associations of government and local soil conservation districts. These agencies forged an alliance through existing authorities and concern for natural resource protection to combat nonpoint source pollution. While the primary focus was on agriculture, programs and projects also included urban erosion control, mining, construction and hydrologic modification. These agencies also worked with federal and state land management agencies to control NPS pollution on their lands.

The Department of Health has official representation on the Utah Soil Conservation Commission (SCC). The SCC is the governing policy board for local SCDs and administers the Agriculture Resource Development Loan (ARDL) program which provides low interest loans to farmers for soil and water conservation and NPS control projects. The Department of Health has provided funds to the Department of Agriculture to assist in NPS project development and the implementation of best management practices (BMPs).

At the local level, Soil Conservation Districts, Areawide Water Quality Management Agencies and others have worked together to control NPS pollution. These agencies have combined resources in efforts to encourage the voluntary adoption of BMPs. Most notable of these local projects is the Snake Creek Rural Clean Water Project (RCWP) which among other accomplishments provided a model for local cooperation on an NPS project.

Best Management Practices

Best management practices (BMPs) may be defined as methods, measures or combinations of measures that are determined by an agency after problem assessment to meet its nonpoint source (NPS) pollution control needs. They include, but are not limited to, structural and nonstructural controls, and operation and maintenance procedures.

The diffuse nature of nonpoint sources complicates the issue of control. Apparent solutions are not necessarily effective and the implementation of a control measure at one point may create a more serious problem at another. BMPs must be flexible and suited to the specific location at which they are to be implemented. Each site has different characteristics of soil, slope, vegetative cover, precipitation and other variables that must be considered before control practices may be prescribed.

It is also not practical to expect 100% control of NPS pollution. The goal is to restore beneficial uses and achieve a cost-effective control level. In many cases the cost to control NPS pollution may exceed the benefits of the project. However, a large measure of control may often be gained at small cost by not adhering to rigid practices, or by using common-sense solutions. In simpler terms, the goal is not to implement a set of BMPs across the state, but rather to effect improvements in water quality. Measures that accomplish this goal in a cost-effective manner should be emphasized.

Best management practices cannot be viewed in isolation. They must be seen as a management strategy, an approach, or a system. Seldom is one practice sufficient to resolve a nonpoint source problem. A combination of practices is usually required along with a management philosophy of commitment to reducing nonpoint pollution. It is rarely sufficient to install a practice and forget it. BMPs and systems require an ongoing maintenance and management effort that must be recognized at the onset.

The best management practices are intended for use on state and private lands within priority watershed areas and in antidegradation segments. These practices are not intended to supercede the judgment of public land managers. Public land management agencies will be expected to continue to operate through the established procedures in the Memoranda of Agreement with the State Planning Coordinator and the Department of Health.

Many BMPs are already in use by agencies and legal subdivisions of the State of Utah. The practices of those agencies are generally considered adequate, however, they are routinely evaluated by the Bureau of Water Pollution Control.

Local, state and federal agencies have formal BMPs for control of nonpoint source pollution. These agencies also have formal working relationships with the state which provide for periodic review of BMPs.

BMPs fall into three categories for implementation. Those the state intends to encourage, those which will be assisted through financial cost-share or loans and those which will be enforced through regulations. It is not the intent of the state to develop new regulations, however communities and counties in the state will be encouraged to adopt regulations to control urban construction and development activities to include road construction. All agriculture and grazing practices are eligible for cost-sharing through the Agriculture Conservation Program or the Agriculture Resource Development Loan Program. Technical assistance and education will be provided to the maximum extent feasible on practices for all nonpoint sources.

The following lists the BMP's available for NPS control in Utah for grazing management on rangeland and animal waste control. The BMP's are defined and the purpose or goal is dicussed. Then the conditions where the practice applies is discussed and then further refinement is detailed as specific management guides.

## GRAZING MANAGEMENT ON RANGELAND

Definition:

Grazing at an intensity that will maintain enough cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation.

Purpose:

To: (1) increase the vigor and reproduction of key plants; (2) accumulate litter and mulch necessary to reduce erosion and sedimentation and improve water quality; (3) improve or maintain the condition of vegetation; (4) increase forage production; (5) maintain natural beauty; and (6) reduce the hazard of wildfire; and (7) improve wildlife habitat.

Conditions Where Practice Applies:

On all rangeland, native pasture and grazed wildlife land.

Specification Guide:

Management specification includes but is not limited to:

Livestock Water Development
Grazing Land Mechanical Treatment
Heavy Use Area Protection
Proper Grazing Use
Fencing and Water Development

# ANIMAL WASTE CON  OL

Definition:

Minimizing the transport of nutrients from confined animal feeding operations to surface and ground water through vegetative and structural practices.

Purpose:

To prevent surface and subsurface water pollution from animal wastes.

Conditions Where Practices Applies:

On feedlots, dairies, hog farms, poultry farms and other concentrated animal feedlots.

Specification Guide:

Management specification includes but is not limited to:

Animal Confinement Areas
Animal Confinements Cleaning
Animal Waste Storage
Filter Strips
Manure Disposal
Restricting Stream Access
Stream Embankment Protection
Pasture and Range Establishment
Controlled Grazing
Waste Management System
Waste Storage Structure
Waste Utilization

The five papers to be presented in Session V of this workshop represent excellent examples of nonpoint source management, monitoring and BMP implementation. Larry Stephenson with the Arizona Department of Environmental Quality will discuss the regulation of Agricultural NPS pollution in Arizona and how that program fulfills the goal for protecting water quality in addition to maintaining on-site flexibility for Arizona's diverse crops, cropping patterns, soil and irrigation technologies. Mr. Loren Bahls with the Montana Department of Health and Environmental Sciences will discuss the goals of Montana's NPS pollution monitoring strategy and some technical problems associated with NPS monitoring program. Al Murrey with the Idaho Department of Health and Welfare will discuss Idaho's agricultural pollution abatement plan and how that plan is being expanded to reflect the requirements of Section 319 of the Clean Water Act. Mr. Jim Piatt of the New Mexico Environmental Improvement Division will discuss New Mexico's nonregulatory NPS pollution control approach to water quality. Michael T. Saver of the North Dakota State Department of Health will discuss the Spirit Lake restoration project through utilization of a comprehensive approach to lake management.

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# URBAN RUNOFF
# CONSTRUCTION AND
# HYDROLOGIC MODIFICATION

by: Carol Jolly
Assistant Director
Water and Shorelands
Department of Ecology
State of Washington

Moderator for Western States Water Council
Nonpoint Source Pollution Control Workshop:
Technical Issues

July 25-28, 1989
Irvine, California

Stormwater runoff is an increasing source of concern to water quality managers throughout the western states. This is true for heavily urbanized areas such as San Francisco Bay as well as less populous--but rapidly growing--regions such as the Dillon Reservoir Watershed in Northwest Colorado.

When ASIWPCA did their nonpoint source survey a few years ago, they found that almost all states had some regulations dealing directly or indirectly with the effects of stormwater discharges; these controls included construction/land use restrictions, erosion and sediment controls, flood control plans, urban runoff controls, and permits. Most states do use some kind of performance standard to regulate activities contributing to stormwater runoff.

The literature on state regulation of storm runoff in addition to presenting a picture of regulatory diversity also shows variation in the extent to which the states take an active role in implementation and enforcement. Some states maintain central control over their programs while others rely on local or regional government entities.

We will be hearing tomorrow on urban runoff and construction controls from representative of five diverse regions. Their approaches to stormwater management are as varied as their communities: from NPDES permits to protected stream environment zones, from sedimentation basins to phosphorus allocations under a bubble concept.

As with most water quality problems, the specifics vary by site. In exceptionally clean Lake Tahoe, the planning agency is dealing with increasing algal productivity from nutrients and with sediments from streams, highways, storm drains, and erosion. San Francisco Bay's Regional Water Quality Board has identified suspended solids, bacteria, heavy metals, and petroleum hydrocarbons from residential, commercial, and industrial sources. Anchorage's Public Works Department focuses its efforts on protecting the area's salmonid fisheries from urban sediments and associated trace metals and from oil and grease. In Summit County, in the heart of Colorado's ski country, the impact of phosphorus contained in urban runoff as well as municipal treatment plants was a serious concern for a water supply reservoir.

In Washington State, the major developments in the control of stormwater pollution are happening in the Puget Sound region. Puget Sound has been designated by EPA as an estuary of national significance; to protect this valuable water body, the Department of Ecology has substantially increased its pollution control commitment.

Ecology formed a Stormwater Unit early in 1988 to focus on local and highway runoff. The six member staff are working on a technical manual, model ordinances and technical guidance to local government, and on a regulation requiring the Department of Transportation to manage stormwater by adopting a Best Management Practices Manual, regulating deicing chemicals and pesticides preparing biennial reports, preparing a capital improvement program, requiring target dates for completion of BMPs for traffic, and requiring certain BMP maintenance practices and monitoring.

Stormwater is also being addressed on a watershed basis through local nonpoint source pollution plans. Counties, cities, and conservation districts are developing management frameworks to facilitate nonpoint source pollution management.

At the local level, the trend toward improved surface water control has continued. Two dozen cities and counties have already enacted ordinances establishing surface water utilities; many other cities and counties are considering formation of utilities or reviewing and revising management policies, programs, or ordinances.

The goal of these programs is to protect shellfish beds, fish habitat and other resources, to prevent the discharge of contaminated sediments, and to achieve water quality standards by reducing (to the maximum extent practicable) pollutant discharges from stormwater and CSOs.

The strategy for achieving this goal is to develop stormwater programs in urbanized areas of Puget Sound in a phased program starting with the largest cities; to require that all cities and counties develop operation and maintenance programs, adopt ordinances for new development, and develop stormwater education programs; and to require all cities with CSOs in the Puget Sound basin to develop and implement plans providing for the greatest reasonable reduction of CSO events in the shortest possible time.

Tomorrow you will hear many creative approaches for tackling these problems. But there are some elements that will emerge from essentially all the presentations:

- The importance of data about sources and effects.
- The value of flexibility.
- The need in many cases for enforcement tools in targeting solutions to local circumstances - whether permits or construction approval requirements; and
- The value of cooperative efforts among local agencies and regional boards, among private developers, and among state and local governments.

As Lane Wyatt phrases it so thoughtfully in his paper: "when all parties are confronted with a common problem such as avoiding a development moratorium or protecting drinking water supplies, coordination problems can be simply addressed . . . Economic and environmental benefits of a collaborative approach--such as reduced disruption, reduced need for bond issues and improved water quality - may be enough to drive such coordination."

Stormwater and construction runoff are recognized as causes of that "common problem" in more and more communities. Tomorrow we will be hearing some innovative and effective ideas, based on real-world experiences, about coordinated solutions.

# OVERVIEW OF SILVICULTURE SESSION ISSUES

Richard J. Nichols
Oregon Department of Environmental Quality
July 26, 1989

As will be evidenced by the presentations given at the Silviculture Session, many states and the U.S. Forest Service have spent much time and resources developing and implementing effective nonpoint source pollution programs for silvicultural activities. The task has not been easy nor noncontroversial.

A state-wide Forest Practices Act has been in effect in Oregon since the early 1970s. While this has resulted in obvious reduced impacts on water quality, not everyone is convinced that water quality is being adequately protected. Unfortunately, little water quality monitoring has been conducted to verify that water quality standards are being maintained.

As a result of Section 319 of the Water Quality Act of 1987, the Oregon Department of Environmental Quality is revising its approach to reviewing nonpoint source control programs such as the Oregon Forest Practices Act. In addition to a list of best management practices, the Department will consider monitoring as an essential component of a nonpoint source management program.

Where water quality monitoring indicates that water quality standards are not being met, the nonpoint source programs would provide for a mechanism to review and upgrade a best management practice. The Department views this as an iterative process concluding in a best management practice that is protective.

Institution of monitoring programs for silviculture and other nonpoint source activities will create questions that will need further investigation and resolution:

1. How can effective and efficient monitoring programs be designed to deal with the intermittent nature of nonpoint source pollution from silvicultural practices?

2. In Oregon, water quality standards were adopted when the major, and perhaps single, concern was the control of point source pollution. Should the water quality standards be reviewed and modified to better address the potential impacts of nonpoint source pollution and to assure adequate protection of beneficial uses?

3. A related question to number 2 above would be: Are there other pollutant parameters that would better indicate the impact or lack of impact on beneficial uses from nonpoint source pollution?

4. What if best management practices necessary to meet water quality standards are not economically practicable? Does this preclude further resource development?

BOB MILLER, *Acting Governor*

Administration 702/885-4670
Air Quality 885-5065
Construction Grants 885-5870

STATE OF NEVADA

Groundwater 702/885-4670
Waste Management 885-5872
Water Pollution 885-4670

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

**DIVISION OF ENVIRONMENTAL PROTECTION**

**201 South Fall Street**
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June 29, 1989

Jim Cornelius
Chief Program Support Unit
State Water Resources Control Board
Division of Loans and Grants
Post Office Box 944212
Sacramento, CA 94244-2120

Dear Jim:

My overview for Session IX of the Western States Water Council Non Point Source Workshop is attached.

If you have any questions please let me know.

Sincerely,

L. H. Dodgion, P.E.
Administrator

LHD/srb:6

(O)-4837

**Western States Water Council**
**NPS Pollution Control Workshop**
**Session IX**
**NPS Control - Resource Extraction and Land Disposal**
**Overview**

The workshop committee has done a commendable job in bringing together a distinguished panel of resource professionals to share their expertise and experiences in program development as well as discuss technical aspects of NPS pollution control of resource extraction and land disposal activities. Speakers representing state and federal management and regulatory agencies will address a variety of topics ranging from state programs and policies aimed at protecting water quality in Alaska's pristine wilderness areas from the effects of resource exploration and development to the evaluation of potential groundwater impairments from septic tank/seepage pit systems in a rapidly urbanizing area near Los Angeles.

The topics scheduled for this session are particularly pertinent to western states. The history of development and settlement patterns in the west are intimately linked to mineral resource exploration and extraction. Today, mining of precious metals, production of oil and gas and development of geothermal resources are vital elements in the economies of our states. California, for example, leads the world in production of geothermal energy and leads the nation in production of non-energy minerals. In 1988, Nevada, the fifth largest gold producer in the world, generated over 3.5 million ounces valued at 1.5 billion dollars.

managed

Much of the mineral resource development in the west occurs on public land administered by federal agencies. In the states of Alaska and Nevada, for instance, over 85% of total land area is owned by the federal government. Because of the significant portion of federal ownership and multiple use policies for these lands, it is imperative that state and federal resource management agencies establish cooperative working relationships in order to develop effective NPS pollution control programs which are consistent with both state and federal regulations and management plan goals. Mr. Robert Anderson, Deputy State Director for Mineral Resources with the U.S. Bureau of Land Management will present BLM's nonpoint source pollution control policy and its application to mineral extraction on public lands. From a state's perspective, Mr. Jerry Brossia of Alaska's Division of Land and Water Management will discuss Alaska's laws, regulations and water use programs designed to protect in-stream flows and prevent water quality degradation by logging and hydrocarbon development in Alaska's extensive wilderness areas.

Proposed and currently active operations are not the only resource-extraction related NPS pollution concerns. Mr. Jim Cooper of the Nevada Division of Environmental Protection will report on the results of studies which indicate that existing high levels of mercury in water sediment and aquatic biota of the Carson River in western Nevada can be traced to the Comstock Lode silver and gold milling operations during the late 1800's. Tons of elemental mercury used to process the ore were lost during milling. Elevated levels of mercury are found throughout the Carson River downstream of the historic milling sites near Carson City. Spring runoff is the primary factor controlling transport of sediment-bound mercury. Lahontan Reservoir, completed in 1915 to store Carson River water for irrigation in the Newlands Project area, is now a sink for mercury-laden sediment. Studies suggest that mercury was transported past the reservoir location prior to its construction and entered the Carson River wetlands and Stillwater Wildlife Management Area. Mercury in fish and aquatic birds have been detected at levels of concern.

In an attempt to control water pollution from resource extraction activities, the Nevada Division of Environmental Protection developed and the state recently adopted what are believed to be effective and innovative water pollution control regulations governing mining operations. These regulations allow the state to classify components of mining operations traditionally considered nonpoint sources, such as waste-rock piles, tailing impoundments, and the mined pit, as point sources thereby empowering the state to mandate containment levels that control pollution migration to ground and surface waters. As opposed to most regulations which are reclamation-oriented, becoming effective only after environmental contamination has occurred, Nevada's regulations address the control and prevention of pollution from mining activities. Furthermore, these regulations not only prescribe minimum protection standards and criteria, but also take into account site specific conditions. Well documented site characteristics can be used to assist in defining levels of concern and establishing design requirements, hence providing industry with economic incentives to seek environmentally less sensitive areas for location of ore-processing operations. In addition, the Nevada legislature recently adopted a bill requiring the reclamation of land subject to certain mining operations and exploration projects. The bill gives administration/enforcement authorities and responsibilities to NDEP. Persons wishing to engage in mining activities on state, private or federal lands are required to apply for a permit from the Division. The applicant must submit a detailed, comprehensive reclamation-plan for NDEP approval and provide a bond or surety prior to initiation of operations. Finally, the bill establishes civil penalties for violations of its provisions.

In the west, the demand for use of relatively easily developed and inexpensive surface water resources by agriculture, municipal, industrial and private interests far exceeds supply; placing a hardship, particularly during drought years, on all involved parties. The alternative, though more costly, is the development of groundwater resources. States and the federal government have recognized the need and responsibility to protect groundwater supplies from NPS pollution. Two papers presented during this session focus on the protection and contamination of groundwater from NPS pollution. Mr. Brad Cross, Wellhead Protection Program Chief with the Texas Water Commission, will share his experiences in developing an extremely successful wellhead protection program encompassing over 6,000 public water supplies supported by nearly 15,000 water wells. Elements of the program provide for state assistance and encourage every community to take an active role in designating wellhead protection areas and maintaining groundwater quality. The Texas program is a example of an implementable and cost-effective NPS pollution management tool.

Mr. Ken Carter representing the California Regional Water Quality Control Board will report on the results of a study conducted in cooperation with U.S.G.S. in response to concern over potential groundwater contamination from wastewater disposal to septic tank/seepage pits in a rapidly developing area near Los Angeles. The investigation evaluates groundwater quality impacts through the application of neutron-log moisture-content profiles, soil cores, and suction-cup-lysimeter analyses in determining vertical migration rates of wastewater in the unsaturated zone and changes in concentrations of fecal coliform and nitrogen in the wastewater.

In summary, the papers which will be presented highlight management tools and current technologies available to resource management professionals in controlling the diverse and complex resource extraction and land disposal-related NPS pollution problems threatening water quality in the west.

LHD/wpr
6/29/89

# Wed. Afternoon, July 26, 1989

| | | PAGE |
|---|---|---|
| **SESSION II:** | **AGRICULTURAL DRAINAGE - NPS POLLUTION CONTROL TECHNICAL ISSUES -**<br>Salon A & B<br>Session Chair: Kenneth K. Tanji,<br>University of CA | |
| 1:30 p.m. | **Overview of the U.S. Department of Interior's Irrigation Drainage Studies in the Western States**<br>Dr. Roy Schroder, Research Hydrologist<br>U.S. Geological Survey, San Diego | II-A |
| 1:45 p.m. | **Agricultural Drainage Water Treatment Technology**<br>Edwin W. Lee, DE/DPA, Environmental Engineer, U.S. Bureau of Reclamation (Ret. 3/89) | II-B |
| 2:00 p.m. | **Irrigation – Induced Water Quality Problems**<br>Jan van Schilgaarde, PhD, Chairman, Committee on Irrigation – Induced Water Quality Problems<br>Water Science & Technology Board,<br>National Research Council | II-C |
| 2:15 p.m. | **Status of Agricultural Drainage in CA**<br>Blaine Hanson, Irrigation & Drainage Specialist,<br>Cooperative Extension,<br>University of California, Davis<br>Farouk T. Ismail, Ph.D., P.E., Supervising Engineer, CA SWRCB | II-D |
| 2:30 p.m. | **Agricultural Drainage Technical Issues Facing Water Agencies**<br>Stephen K. Hall, Executive Director<br>Land Preservation Association, Fresno, CA<br>Cindy K. Tuck, Government Relations Advisor - Heron, Burchette, Ruckertt & Rothwell,<br>Sacramento, CA | II-E |
| 2:45 p.m. | **Regulation of Agricultural Subsurface & Surface Drainage in the San Joaquin Basin**<br>William H. Crooks, Executive Officer<br>CA Regional Water Quality Control Board,<br>Central Valley Region | II-F |
| 3:00 p.m. | **ROUNDTABLE DISCUSSION & QUESTIONS** | II-G |

# United States Department of the Interior

GEOLOGICAL SURVEY
Water Resources Division
5735 Kearny Villa Road, Suite O
San Diego, CA 92123
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May 10, 1989

James Cornelius, Principle Engineer
Division of Loans and Grants
Wastewater Resources Control Board
P.O. Box 944212
Sacramento, CA 94244-2120


DIVISION OF LOANS & GRANTS


Dear Mr. Cornelius:

In respone to your request, I will present a talk titled "Overview of the U.S. Department of Interior's Irrigation Drainage Studies in the Western States" at the Western States Water Council meeting in Irivine on July 26-28, 1989. Enclosed are reprints from two presentations at a recent American Society of Civil Engineer's symposium that can be reproduced and distributed. Each page is numbered with light blue pencil on the lower right corner.

Sincerely,

Roy A. Schroeder

Dr. Roy A. Schroeder
Research Hydrologist

Enclosure

cc: Marc Sylvester

*Reprinted from Proceedings on*
*Planning Now for Irrigation & Drainage*
*IR Div/ASCE, Lincoln, NE, July 18-21, 1988*

# Preliminary Results of the Department of the Interior's Irrigation Drainage Studies

Marc A. Sylvester[1], Jonathan P. Deason[2],
Herman R. Feltz[3], and Richard A. Engberg[4]

## ABSTRACT

Responding to increasing concern about the quality of irrigation drainage and its potential effects on human health, fish, and wildlife, the Department of the Interior, in 1986, began irrigation drainage studies in nine areas in seven Western States. These studies were done to determine whether irrigation drainage has caused or has the potential to cause harmful effects on human health, fish, and wildlife, or might reduce the suitability of water for beneficial uses. Results of the seven studies completed in 1987 are presented and are compared to baselines, standards, criteria, and other guidelines helpful for assessing the potential of observed constituent concentrations in water, bottom sediment, and biota to result in physiological harm to fish, wildlife, or humans. Selenium is the constituent most commonly found at elevated concentrations in water, bottom sediment, and biota in the study areas. Yearly variation in precipitation and streamflow, geologic sources of trace elements, arid to semi-arid climate, internal drainage basins, irrigation drainage, and pesticide usage were the factors that affected concentrations of constituents in water, bottom sediment, and biota in the study areas.

## INTRODUCTION

Responding to increasing concern about the quality of irrigation drainage and its potential effects on human health, fish, and wildlife, the Department of the Interior, in 1986, began irrigation drainage studies in nine areas in seven Western States. These studies were done to determine whether irrigation drainage has caused or has the potential to cause harmful effects on human health, fish, and wildlife or, might reduce the suitability of water for beneficial uses.

Seven of the studies were completed during 1987 and the remaining two (Salton Sea area in California and Stillwater Wildlife Management Area in Nevada) will be completed in 1988. Studies at ten additional areas were started in 1988. More detailed studies in four of the areas studied in 1986 and 1987 also were started in 1988. These four

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studies are being done because results of the 1986-1987 studies in these areas indicate that irrigation drainage might be causing harmful effects on human health, fish and wildlife, or beneficial uses of water.

## SUMMARY OF RESULTS

A brief summary of the most significant results from each of the reconnaissance investigations completed in 1987 is presented below. The page limitations of this paper preclude anything more than an overview of the most significant findings. Readers should refer to the referenced reports to obtain a full discussion of the results of each investigation and to Deason (in press) for a description of the sampling and analysis protocol.

### Lower Colorado River, Arizona and California

The lower Colorado River study area (Radtke et al., 1988) included the mainstream Colorado River and adjacent land from Davis Dam, just north of the Arizona-California border, downstream to Imperial Dam just north of the Mexican border.

With the exception of one water sample having a cadmium concentration of 69 ppb, no trace elements were found in concentrations exceeding State of Arizona maximum allowable limits for protected uses of surface water. In addition, the only organic pesticides detected in water were the short-lived organophosphorus compounds diazinon, methylparathion, parathion, and chlorpyrifos.

Concentrations of barium, molybdenum, vanadium, and zinc in water were substantially greater at stations directly receiving irrigation drainage but were not found to be at elevated levels. Selenium concentrations, conversely, were lower at stations directly receiving agricultural discharges and did not increase from Davis Dam to Imperial Dam. Thus, selenium concentrations in water appear to be derived from sources upstream of Davis Dam and are not enriched by agricultural activities in the lower Colorado River valley.

Selenium concentrations in bottom sediment at mainstream stations equaled or exceeded the 95-percent baseline (1.4 ppm dry weight) for soils in the Western United States (R. C. Severson, U.S. Geological Survey, written communication, 1987). Selenium concentrations in bottom sediment at stations directly receiving agricultural discharges were lower than at mainstream stations and did not exceed the 95-percent baseline for soils in the Western United States. The largest concentrations of selenium in bottom sediment (up to 7.1 ppm dry weight) were found in backwater areas of the mainstream of the Colorado River. Thus, bottom sediment in the mainstream of the lower Colorado River appears to be acting as a sink for selenium. Organochlorine pesticides and other synthetic organic compounds were detected in bottom sediment in the study area. DDE was found at all stations and ranged from 0.1 to 7.5 ppb, dry weight.

Except for selenium, no inorganic constituents exceeded guidelines for the protection of fish and wildlife resources. Mean selenium concentrations in carp ranged from 0.62 to 4.0 ppm wet weight, generally exceeding the 85-percent national baseline of 0.71 ppm, wet

weight for fish collected in the National Contaminant Biomonitoring Program from 1978 to 1981 (Lowe et al., 1985). Selenium concentrations in fish of 2 ppm, wet weight or greater, can result in reproductive impairment or lack of recruitment in fishes (Baumann and May, 1984). Carp having concentrations equal to or greater than 2 ppm, wet weight, were collected from backwater or oxbow lakes that receive inflow from the main river.

Organic compounds do not appear to present environmental problems for fish in the lower Colorado River. Organochlorine pesticide concentrations in biota generally were less than 1.0 ppm, wet weight.

## Tulare Lake Area, California

The Tulare Lake study (Schroeder et al., 1988) was conducted in the southern portion of the dry Tulare Lake Bed, which is located at the southern end of the Central Valley in California. Specific sites included in the study were the Kern and Pixley National Wildlife Refuges and the Westfarmers evaporation pond system, which is about five miles west of the Kern Refuge.

Trace-element concentrations in water, bottom sediment, and biota were found to be comparatively low at Kern and Pixley National Wildlife Refuges and high at Westfarmers evaporation ponds. Concentrations of trace elements at Kern and Pixley National Wildlife Refuges did not exceed baselines, drinking-water standards, or criteria for protection of aquatic life. Concentrations of several trace elements did exceed such guidelines at Westfarmers evaporation ponds. For example, concentrations of selenium, the constituent of greatest concern in the study area, ranged from 110-360 ppb in water from the Westfarmers evaporation ponds, far exceeding the U. S. Environmental Protection Agency (1986) criterion of 35 ppb for protection of aquatic life. In contrast, selenium concentrations in water at Kern and Pixley National Wildlife Refuges were less than 1 ppb.

Few pesticides were detected in water, bottom sediment, or biota, and where found, their concentrations were much less than those at which adverse effects would be apparent.

Low concentrations of trace elements and pesticides at Kern and Pixley National Wildlife Refuges indicate that these constituents pose little threat to wildlife there. Much higher concentrations of trace elements (particularly selenium) in water, bottom sediment, and biota at Westfarmers evaporation ponds suggest that health and reproduction of wildlife there could be threatened. Preliminary results of bird censuses and nesting and brooding surveys in 1987 indicate that there are adverse physiological effects on shorebirds nesting at Westfarmers evaporation ponds.

## Sun River Project, Montana

The Sun River study area (Knapton et al., 1987) was composed of three areas in Teton and Cascade counties of west-central Montana: (1) the Greenfield-Fort Shaw Irrigation Districts, (2) Freezeout Lake Game Management Area (including Priest Butte Lake) and (3) Benton Lake National Wildlife Refuge (NWR). Each of these areas is directly affected by irrigation practices and return flows.

Based on a comparison with baselines, criteria, and standards, concentrations of constituents in water, bottom sediment, and biota within the Greenfields-Fort Shaw Irrigation Districts do not indicate a threat to human health, fish, or wildlife. Both the Freezeout Lake Game Management Area and the Benton Lake NWR, however were found to contain elevated levels of several constituents in water, bottom sediment, and biota.

The highest concentrations of trace elements in water and bottom sediment were associated with saline seeps, which are common throughout the Northern Great Plains. For example, concentrations in water as high as 580 ppb selenium, 660 ppb cadmium, 7,000 ppb nickel, 2500 ppb boron, and 19,000 ppb zinc were detected in saline seeps in the Benton Lake NWR. These concentrations far exceed Montana standards or criteria for the protection of human health, aquatic life, or agricultural crops. However, flow volumes from such seeps were very small relative to total inflows. The highest selenium concentration in bottom sediment was 6.7 ppm, which is greater than the 95-percent baseline of 1.4 ppm for soils in Western United States.

Boron concentrations in sago pondweed from Freezeout Lake and Benton Lake were at levels (230-990 ppm, dry weight) which might be toxic to consumer organisms limited to an aquatic vascular plant diet for an extended period of time (Knapton et al., 1987). Several bird livers and eggs contained boron concentrations at or approaching levels (6 to 89 ppm and 26 to 31 ppm, dry weight, respectively) found in diet studies to reduce hatching success and decrease survival of mallard ducklings (Patuxent Wildlife Research Center, 1987), while other bird livers and eggs were below such levels.

Selenium was found in the majority of biological samples. The highest levels of fish were found in Priest Butte Lake. Selenium concentrations (dry weight) in fish (up to 48 ppm in yellow perch and 35 ppm in white sucker), invertebrates (up to 32 ppm in insects), bird livers (up to 32 ppm in avocets, 28 ppm in coots, and 46 ppm in eared grebes), and bird eggs (up to 68 ppm in avocet eggs, 7.8 ppm in coot eggs, and 18.0 ppm in eared grebe eggs) indicate that levels are present that could have toxic effects on fish (Gillespie and Baumann, 1986 and Goettl and Davies, 1978) and birds (Heinz, et al., 1987). Other trace elements and pesticides either were not detected or generally were at low concentrations.

## Milk River, Montana

The Milk River study area (Lambing et al., 1987) is centered around the Bowdoin NWR in northeastern Montana, about seven miles east of the town of Matta.

In general, concentrations of trace elements, radiochemicals, and pesticides in the refuge lakes were not found to be greatly elevated compared to upstream water supplies. Very few exceedances of water quality guidelines were detected and none were prevalent at any particular site. High streamflows in the study area in 1986 probably resulted in lower than normal concentrations of dissolved constituents.

In bottom sediment, trace element concentrations were generally similar to background concentrations found in soils, and pesticides were not detected. Concentrations of trace elements and pesticides in biological organisms generally were less than values known to adversely affect growth or reproduction. Maximum concentrations of several trace elements were considered elevated, but the occurrences generally were random among sites. Arsenic was found in all biological samples analyzed except for bird eggs, walleyes, and hemipterans, and was highest in plants and net plankton. The highest arsenic concentration measured was 21 ppm dry weight in net plankton. Boron was found in all organisms sampled but one, and generally was found in higher concentrations in sago pondweed and filamentous algae than in other trophic levels sampled. The highest boron concentration (810 ppm dry weight) was detected in sago pondweed. Mercury was below detectable levels in plants and invertebrates and was found at relatively low concentrations in bird eggs, bird livers, and fish. The highest mercury concentration (1.6 ppm dry weight) was in an avocet egg. Selenium was found in all classes of organisms sampled, with the highest concentrations (2.6-13 ppm dry weight) occurring in net plankton.

## Laguna Atascosa National Wildlife Refuge, Texas

The Laguna Atascosa study (Wells et al., 1987) was conducted in the lower Rio Grande Valley, which is located principally in the four southernmost counties of Texas: Starr, Hidalgo, Cameron, and Willacy. It includes the Laguna Atascosa NWR along the Gulf of Mexico in Cameron and Willacy Counties.

Results of sampling in the lower Rio Grande Valley and Laguna Atacosa NWR indicate that concentrations of dissolved trace elements in water generally are not elevated. The most significant trace element appears to be boron, the concentrations of which increase significantly from west to east. Concentrations of boron ranged from 220 ppb to 5,300 ppb at all sampling locations except for Athel Pond, a lake in the refuge that receives little freshwater inflow, where concentrations of dissolved boron as high as 11,000 ppb were detected. No chlorophenoxy herbicides or carbamate insecticides were detected. Low concentrations were detected of triazine herbicides (less than 0.1 to 1.7 ppb), organophosphorus insecticides (less than 0.01 to 0.75 ppb), and organochlorine insecticides (DDE only, from less than 0.01 to 0.01 ppb).

Concentrations of trace elements in bottom sediment were less than the 95-percent baselines for soils in the western United States, except for manganese (maximum concentration exceeded the 95-percent baseline of 1,500 ppm). The only pesticides detected in bottom sediment were chlordane, DDT, DDE, DDD, and dieldrin. Concentrations ranged from 0.1 to 34 ppb, dry weight.

Concentrations of trace elements in fish were low. Only maximum concentrations of arsenic, mercury, selenium, copper, and zinc exceeded the 85-percent baselines for fish in the United States (Lowe et al., 1985). No concentrations were at levels known to be harmful to fish. The only pesticides detected were toxaphene, DDT, DDE, and DDD concentrations ranging from less than detection to 9.9 ppm, wet

weight. Some concentrations exceeded baselines for fish in the United States (Schmitt et al., 1985).

Concentrations of trace elements in birds also were low. For example, the selenium concentration in a composite of five black-necked stilts was only 0.47 ppm, wet weight. No concentrations were at levels known to be harmful to birds. Concentrations of DDT, DDD, and DDE in the black-necked stilt composite were 0.036, 0.053, and 3.3 ppm wet weight, respectively.

## Middle Green River, Utah

The Middle Green River Basin area consists of about 25,500 square miles along the mainstream of the Green River and its tributaries south of Flaming Gorge Reservoir and north of the town of Green River, Utah. The study (Stephens et al., 1988) focused on the Ouray National Wildlife Refuge and the Stewart Lake Waterfowl Management Area within the middle Green River Basin.

Generally, concentrations of all constituents except boron, selenium, zinc, and gross alpha radiation were less than guideline values in water, sediment, and biological tissues. Of these, selenium appeared to be the principal constituent of concern. Concentrations of selenium entering Stewart Lake from subsurface drain pipes ranged from 14 to 140 ppb. Selenium concentrations in bottom sediment in the alluvial areas where the drains enter Stewart Lake ranged from 10 to 85 ppm. Liver tissue collected from coots at Stewart Lake contained from 4.9 to 26 ppm selenium, dry weight. These concentrations are similar to those in coots from Kesterson NWR (Ohlendorf et al., 1986) and indicate that adverse effects on wildlife reproduction and growth from selenium may be occurring.

At the Ouray NWR, concentrations of selenium in water ranged from less than 1 to 93 ppb, with the higher values occurring in the North Roadside Pond, which receives only irrigation drainage water. Liver tissue from coots on the North Roadside Pond contained a geometric mean concentration of 32 ppm selenium, dry weight, whereas liver tissue from coots collected in areas of the refuge that receive water from the Green River contained less than 5 ppm selenium, dry weight. Several embryonic deformities also were found in the North Roadside Pond.

At a few sites, concentrations of boron and zinc exceeded Utah standards for agriculture and wildlife protection, respectively. Gross alpha radiation in drain water samples generally exceeded the Utah standard of 15 picocuries per liter for protection of aquatic life and domestic water supplies.

## Kendrick Project, Wyoming

The Kendrick study area (Peterson et al., 1987) was defined as the Kendrick Reclamation Project service area, just west of Casper, Wyoming. The study area is bounded on the east by the North Platte River and Casper Creek, and on the west by the Casper Canal.

Analyses of water, bottom material, and biological samples for trace elements, pesticides and radiochemicals indicated that the main

constituent of concern is selenium. Concentrations of dissolved selenium in water ranged from less than 1 ppb to 300 ppb, with a medium concentration of 7.5 ppb. The higher selenium concentrations were found in creeks, a drain, a well, and a lake. Concentrations of dissolved selenium in the North Platte River, which supplies drinking water for several municipalities, ranged from less than 1 to 4 ppb.

Bottom material samples contained selenium concentrations of 0.9 to 25 ppm, with the highest levels found in the places that contained the higher concentrations of dissolved selenium in water.

Selenium concentrations in fish and invertebrate samples taken at some lakes were at levels (greater than 8 ppm, dry weight) that could cause adverse physiological effects to birds (Heinz et al., 1987 and Patuxent Wildlife Research Center, 1987). Most bird liver and egg samples from lakes contained selenium concentrations that could have toxic effects. For example, selenium concentrations ranged from 51 to 170 ppm (dry weight) in avocet livers from Rasmus Lee Lake and were 43 to 56 ppm (dry weight) in two mallards from Illco Pond.

Other than selenium, the only constituent that might be of concern is boron. Boron concentrations in rooted aquatic plants were found at levels (390-630 ppm, dry weight in sago pondweed) that might be toxic to birds limited to a diet of aquatic vascular plants for an extended period of time.

## FACTORS AFFECTING RESULTS

Several factors appear to be involved in determining the concentration of constituents associated with irrigation drainage that were found in water, bottom sediment, and biota during the 1986-87 reconnaissance studies of irrigation drainage areas conducted by the Department of Interior.

One of the factors is the yearly variation in precipitation and streamflow. The Milk River, Colorado River, and Green River basins had greater than normal precipitation prior to or during the studies, which resulted in greater than normal streamflows. Generally, constituent concentrations were not elevated, or were not at levels known to produce harmful effects on growth or reproduction of organisms in the Milk River or Lower Colorado River study areas. However, in the Middle Green River study area, a few trace elements, principally selenium, occurred at elevated concentrations in water, bottom sediment, and biota. Deformed coot embryos were found, and selenium concentrations in biota were at levels that can result in adverse effects on wildlife reproduction. Larger than normal flows in the Milk and Colorado Rivers raised refuge water levels and helped flush accumulated salts from the wetlands. The flushing of Stewart Lake WMA due to large flows in the Green River since 1982 probably has diluted concentrations of trace elements in the lake. Thus, greater than normal precipitation and streamflow decreased constituent concentrations, but elevated concentrations of trace elements in water, bottom sediment, and biota still were observed in the Middle Green River study area.

Geologic sources of trace elements is another factor. Kendrick Reclamation Project area, Middle Green River basin, and west side of

the Tulare Lake basin contain geologic formations known to be sources of trace elements, particularly selenium. In each case, the source rocks are pervasive, and soils in the area are primarily derived from such rocks. In the Kendrick Reclamation Project area, soils are derived from Cretaceous formations of marine origin, several of which are known to be seleniferous (Crist, 1974; Rosenfeld and Beath, 1964, p. 23). Soils in the area are known to be high in selenium (3.7 to 37 ppm, Rosenfeld and Beath 1964, p. 45). Irrigated lands in the Middle Green River basin are located on soils that overlie the Mancos Shale. This shale is known to contain high concentrations of selenium (140 ppm at a site in Colorado) (Coleman and Delevaux, 1957, p. 519) and is the formation in which the Green River flows in much of the study area. Soils in the western part of the Tulare Lake basin are derived from Cretaceous and Tertiary marine rocks that contain selenium. Soils on the west side of the basin are high in selenium (Tidball et al., 1986). As mentioned previously, Kendrick Reclamation Project area, Middle Green River, and Westfarmers ponds in the western part of the Tulare Lake basin have elevated concentrations of trace elements, principally selenium, in water, bottom sediment, and biota. Concentrations are at levels that could result in harmful effects to wildlife.

Although geologic formations that contain selenium and other trace elements do occur in the other study areas, elevated selenium concentrations in bottom sediment occur only in the Lower Colorado River basin. The source of these elevated concentrations appears to be upstream of Davis Dam, which is outside of the study area. Elevated selenium concentrations in soils have not been documented in any of these areas. Except in a few localized places, selenium concentrations in water and biota also were not elevated at any of these other study areas. Thus, geologic sources of trace elements (particularly selenium) appear to be directly related to elevated concentrations of these elements in the study areas, especially and perhaps only, if such sources are pervasive and substantial enough to have a primary effect on concentrations of trace elements in soils and bottom sediments.

A third factor is an arid to semi-arid climate where precipitation is low (i. e. less than or equal to 12 inches per year) and evaporation or evapotranspiration is high (several times precipitation). These conditions apply to all the study areas except Laguna Atascosa, where the average annual precipitation is between 22 and 30 inches, depending on location in the study area. Evaporation of water in streams, ponds, and wetlands in the study areas no doubt increased salt concentration in water and soil. Nevertheless, evaporation or evapotranspiration do not appear to be the primary factors controlling trace-element concentrations in the study areas, because some areas had relatively low concentrations and others relatively high concentrations despite similar precipitation and evaporation conditions.

Another factor is internal drainage basins or sinks. Indeed, the greatest trace element and dissolved solids concentrations in the Milk and Sun River study areas generally were found in terminal drainages with no outlet (Dry Lake Unit and Benton Lake, respectively). Also, selenium concentrations in biota were greatest in Westfarmers Ponds (evaporation ponds with no outlet) in the Tulare Lake study area, and

in the shallow ponds and reservoirs with little or no flow through or surface water release in the Kendrick Reclamation Project area. These areas had elevated selenium concentrations that could result in adverse effects on wildlife reproduction and growth. In the Middle Green River study area, Stewart Lake and ponds and wetlands in the Ouray NWR are managed water bodies with inlets and outlets; they do not function as internal drainages. Wetlands and ponds along the Lower Colorado River are not internal drainages either. However, the only elevated selenium concentrations detected (> 2 ppm, wet weight) were from backwater or oxbow lakes that receive inflow from the main river. Despite some nonconforming situations, most of the information from the reconnaissance studies shows that internal drainages with terminal ponds and wetlands (especially shallow ones) and backwater or oxbow lakes (in the case of the Lower Colorado River study) are related to elevated trace-element and dissolved-solids concentrations. This is not unexpected, as effects of evaporation and evapotranspiration would be greatest in such areas under arid or semi-arid climatic conditions.

The amount and proportional contribution of irrigation drainage to wetlands, ponds, and refuges in the study areas is another factor. Irrigated agriculture occurs in all of the study areas. The amount of irrigation drainage and the proportion it contributes to the water supply of refuges and wetlands varies considerably among the study areas.

In study areas where concentrations of selenium were elevated and at levels that could adversely affect wildlife reproduction and growth (Kendrick Reclamation Project, Middle Green River, and Tulare Lake study areas) extensive irrigation and drainage do occur. The contribution of irrigation drainage to receiving waters in these areas ranged from none at Goose Lake in the Kendrick Reclamation Project area to all at Westfarmers Ponds in the Tulare Lake area. Except for Goose Lake, the amount of irrigation drainage received by wetlands, ponds, and reservoirs in the Kendrick Reclamation Project area is not well documented. North Roadside Pond, where elevated selenium concentrations in water and biota were noticed at Ouray NWR in the Middle Green River study area, receives irrigation tailwater and likely some shallow ground water. Except during periods of overflow from the Green River, the source of water to Stewart Lake primarily is irrigation drainage from the lands within the service area of the Jensen Unit of the U.S. Bureau of Reclamation's Central Utah Project.

In other study areas where concentrations of selenium generally were not elevated (Milk River, Sun River, Laguna Atascosa, and Lower Colorado River areas), a consistent pattern is not apparent. Irrigation and drainage generally are not extensive in the Milk and Sun River study areas, but are in the Lower Colorado and Laguna Atascosa study areas. Irrigation drainage comprises 15-40 percent of the water supply to Bowdoin NWR in the Milk River study area. It is a minor source of water to Freezeout Lake Game Management Area and a major source of water to the Benton Lake NWR in the Sun River study area. Major sources of irrigation drainage contribute water to the Laguna Atascosa NWR and wetlands and refuges in the Lower Colorado River study area, although the proportion it contributes to the total supply is undetermined. A clear relation cannot be determined between elevated trace-element concentrations and the amount and proportional

contribution of irrigation drainage to receiving waters in the study areas because of the paucity of quantitative information and the apparent lack of consistent patterns among study areas.

The last factor considered is pesticide application. Little or no quantitative information on pesticide application was obtained during the reconnaissance studies. Thus, no quantitative relations can be determined between usage and occurrence in water, bottom sediment, or biota. Nevertheless, some qualitative statements can be made. Organochlorine pesticides generally were detected only in study areas where applications have been large (Lower Colorado River and Laguna Atascosa). DDE was the principal compound detected. Concentrations were low in water and sediment (< 0.01 ppb and generally less than 10 ppb, dry weight, respectively). Concentrations in biota also were low (generally less than 1.0 ppm, wet weight). The occurrence of DDE is indicative of the persistence of this breakdown product of DDT, which was widely used from the 1940's to the early 1970's (when it was banned in the United States). Other pesticides either were not detected or their occurrence was localized.

## GENERAL OBSERVATIONS AND RELATIONS

Although the evaluation process described above has not yet been completed, several observations about the nature of irrigation-induced contamination problems can be made.

First, it appears that selenium is the constituent most commonly found at elevated concentrations. Although selenium was not detected at elevated concentrations in all areas, nor was it found to be the constituent of greatest concern in all areas with elevated concentrations, it clearly was the constituent most frequently detected at elevated levels.

Another significant observation concerns the variability of concentrations found within the study areas. Concentrations of analytes were found to vary widely on a spatial basis in all environmental media sampled. This observation leads to the conclusion that, at least in some cases, irrigation-induced contamination problems are likely to be site specific. Thus, problems can be severe on a localized basis while having a low level of relative significance on a regional basis.

Other inferences can be made from the results of the reconnaissance investigations that may enhance our ability to predict where irrigation-induced contamination problems will occur from planned or existing irrigation developments. For example, irrigated areas in internal drainage basins appear to have high concentrations of trace elements in water, bottom sediment, and biota. The Tulare Lake, Milk River, Kendrick, and Sun River study areas all contain internal drainage basins or bodies of water having no surface-water outlets. In each case, the closed bodies of water contained some of the highest concentrations of constituents within the study areas.

Other hydrologic and geochemical characteristics also can serve as indicators of possible problems. The presence of alkaline, seleniferous soils in arid or semi-arid environments (low precipitation with high evaporation rates) is an example.

One fairly consistent pattern that should be of interest to scientists and resource managers alike is the apparent inverse relation between selenium and arsenic concentrations. The inverse relation appears to be consistent among study areas and within the various media analyzed (water, bottom sediment, and biota). This apparent relation is being investigated further.

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# TRACE ELEMENTS AND PESTICIDES IN SALTON SEA AREA, CALIFORNIA

**By Roy A. Schroeder[1], James G. Setmire[2], and John C. Wolfe[3]**

**ABSTRACT:** Concentrations of numerous potentially toxic trace elements and pesticides were determined in water, sediment, and biota from the Salton Sea area in southeastern California. Comparison of results with data from other studies in this area and from other areas, and with various water-quality standards or criteria, indicate that selenium probably is the principal contaminant of concern in the Salton Sea basin and that it probably is related to agricultural practices. Selenium is mobilized in the subsurface drainwater produced by agricultural irrigation and transported in ditches and rivers, some of which pass through or near the Salton Sea National Wildlife Refuge before entering the Salton Sea. Some selenium apparently is incorporated into the food chain. In response to the finding of elevated selenium residues in fish from the area by State agencies, the Imperial County Health Department has issued a health advisory restricting or prohibiting human consumption of fish from the Salton Sea and drains.

## INTRODUCTION

In 1986-87, the U.S. Geological Survey, U.S. Fish and Wildlife Service, and U.S. Bureau of Reclamation measured concentrations of numerous potentially toxic trace elements and pesticides in water, sediment, and biota from the Imperial and Coachella Valleys in the Salton Sea area of southeastern California (Fig. 1). This reconnaissance, one of several similar studies in the Western United States, was conducted in response to documented evidence of selenium toxicity to wildlife caused by agricultural-irrigation drainwater at Kesterson NWR (National Wildlife Refuge), in the northern San Joaquin Valley, and because of the potential for similar problems at other facilities managed by the Department of the Interior or receiving water from Interior-funded projects. Of particular concern to this study is the Salton Sea NWR at the northern end of the Imperial Valley.

The Salton Sea basin is a structural and topographic trough filled with several thousand meters of mostly alluvial and lacustrine deposits and some material from weathering of nearby mountains (Loeltz and others, 1975). The pseudo-marine Salton Sea now occupies almost 1,000 km² of the basin up to an altitude of -70 m (below sea level) and has a maximum depth of about 15 m. The present Salton Sea was formed when a temporary diversion of the Colorado River failed on October 11, 1905, causing the entire discharge of the Colorado River to flow into the Imperial Valley.

The Federal Government placed all low-lying lands in a public reserve by Executive Orders issued in 1924 and 1928. In 1930, the Salton Sea NWR was established for the preservation of wintering habitat for waterfowl and other migratory bird species. The refuge includes about 140 km², most of which is currently submerged beneath the Salton Sea. About 20 km² is contained in two units, about 15 km apart, at the southeastern tip of the Salton Sea (Fig. 1). The New River enters the Salton Sea near the southern unit and the Alamo River

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enters it at the northern unit. The combined flow of the New and Alamo Rivers is the major source of water replenishment to the Salton Sea. About half the total discharge of the New River originates in Mexico, where it acquires industrial and municipal wastes from the city of Mexicali (Setmire, 1979, 1984) in addition to agricultural chemicals from the Mexicali Valley, which is contiguous with the Imperial Valley. Virtually all the water in the Alamo River is derived from recharge or

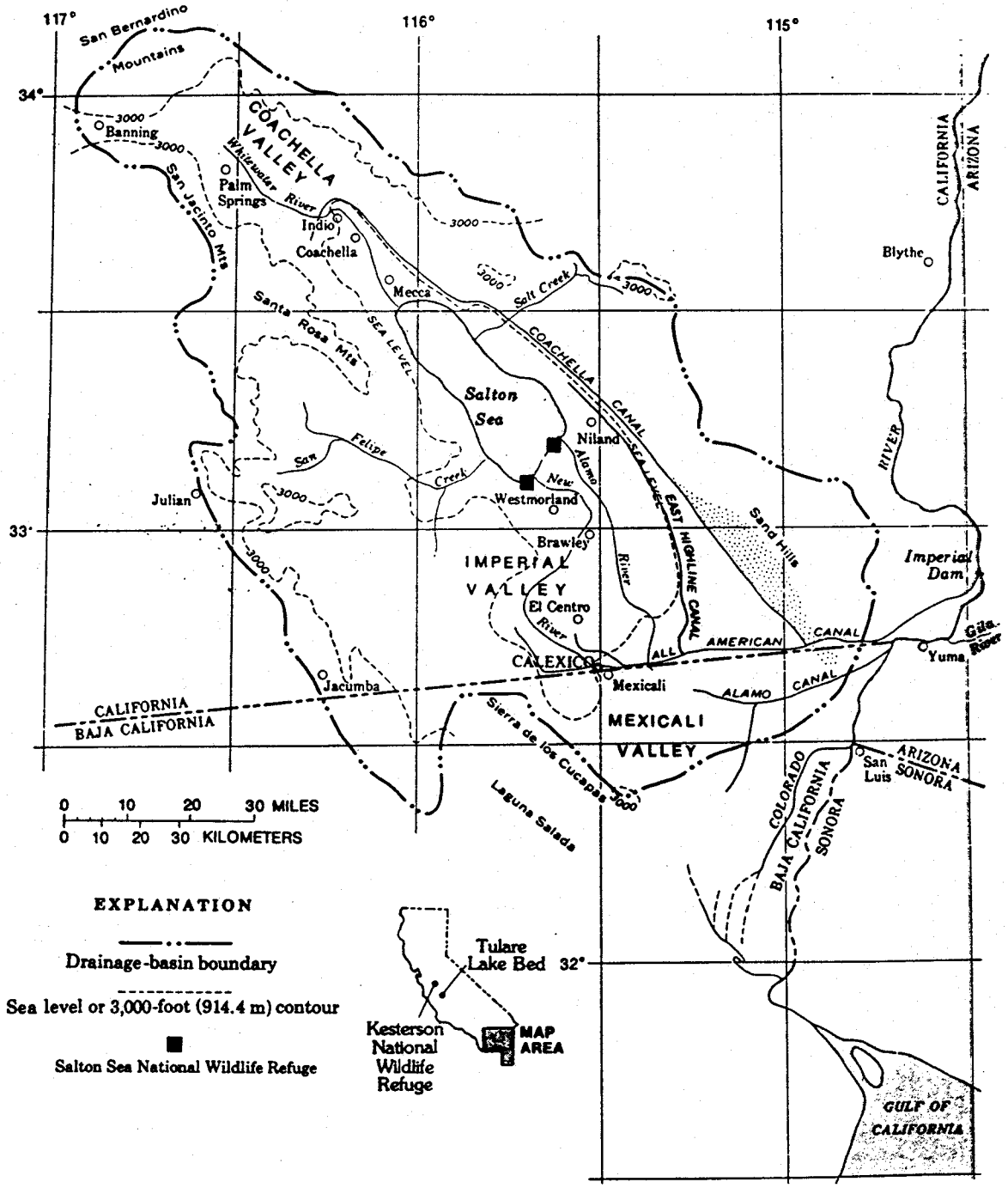


FIG. 1-- Map of Salton Sea basin.

runoff in the Imperial Valley, and it contains residues of pesticides and fertilizers from agricultural sources in the valley (Irwin, 1971; and Eccles, 1979).

Irrigated agriculture has been extensive in the Imperial Valley since early in the 20th century. Since 1942, irrigation water has been supplied entirely by the All-American Canal, which diverts Colorado River water at the Imperial Dam (Fig. 1). The first underground tile drains were installed in 1929, and drains now form an extensive network that carries subsurface irrigation drainwater to collector sumps from which it is pumped into ditches that convey it to the New and Alamo Rivers or directly to the Salton Sea. The quality of this drainwater, and especially its selenium content, was an important focus of this reconnaissance. Documented evidence (for example, White and others, 1987) of high selenium concentrations in fish inhabiting the Salton Sea and area drains has caused the Imperial County Department of Health to issue an advisory restricting the quantity of fish consumed by humans and prohibiting consumption by children and pregnant or nursing mothers.

## RESULTS AND DISCUSSION

Chemical constituents analyzed for this reconnaissance include major ions, macronutrients, trace elements, common radiochemicals, purgeable (volatile) organic compounds, organochlorine compounds, carbamate and organophosphorus insecticides, and chlorophenoxy-acid and triazine herbicides. Selected data are summarized and compared to results obtained from other areas in Tables 1 and 2. Water samples from 12 sites, including 8 drainwater sumps, and sediment samples from 17 sites were analyzed. Location of sampling sites, not shown on Fig. 1 because of scale limitations, can be obtained from the authors. The sampled drainwater sumps are scattered throughout the Imperial Valley.

Comparison of trace-element concentrations in sediment from the Salton Sea area with concentrations at other areas (Table 1) indicates that median concentrations in the Salton Sea area are not unusually high, although some high values exist at individual sites. Highest concentrations for most of the trace elements listed in Table 1 were measured in sediment from the Whitewater River in the Coachella Valley. Notable exceptions are arsenic, for which the highest concentration of 11 µg/g was measured in the New River, and selenium, measured at 3.3 µg/g (Fig. 2) in a composite sample of surface sediment from several locations beneath the Salton Sea.

The highest trace-element concentrations found in water (Table 2) occurred in drainwater samples for most elements--usually from a different sump for each element. Exceptions are arsenic and boron, for which highest concentrations measured were in the Salton Sea. Although trace-element concentrations were somewhat high in drainwater from the Salton Sea area, they are approximately the same as concentrations in samples from farm drain sumps and shallow ground water in the western San Joaquin Valley area, and they are much lower than concentrations in impounded drainwater from the western San Joaquin Valley. (See selected comparisons in Table 2.)

Selenium is the only trace element for which concentrations in drainwater frequently exceeded criteria established for protection of aquatic life (Fig. 2 and Table 2). Selenium criteria recently were revised from 35 µg/L to 5 µg/L for freshwater and 71 µg/L for

saltwater, on the basis of four-day average acid-soluble concentrations (U.S. Environmental Protection Agency, 1988). The median selenium concentration for the eight drainwater sumps sampled in this reconnaissance was 26 µg/L and the maximum was 300 µg/L; these concentrations are about the same as the median of 25 µg/L and maximum of 267 µg/L found in 119 drainwater samples recently collected throughout the Imperial and Coachella Valleys (P. Gruenberg, California Regional Water Quality Control Board, written commun., 1987).

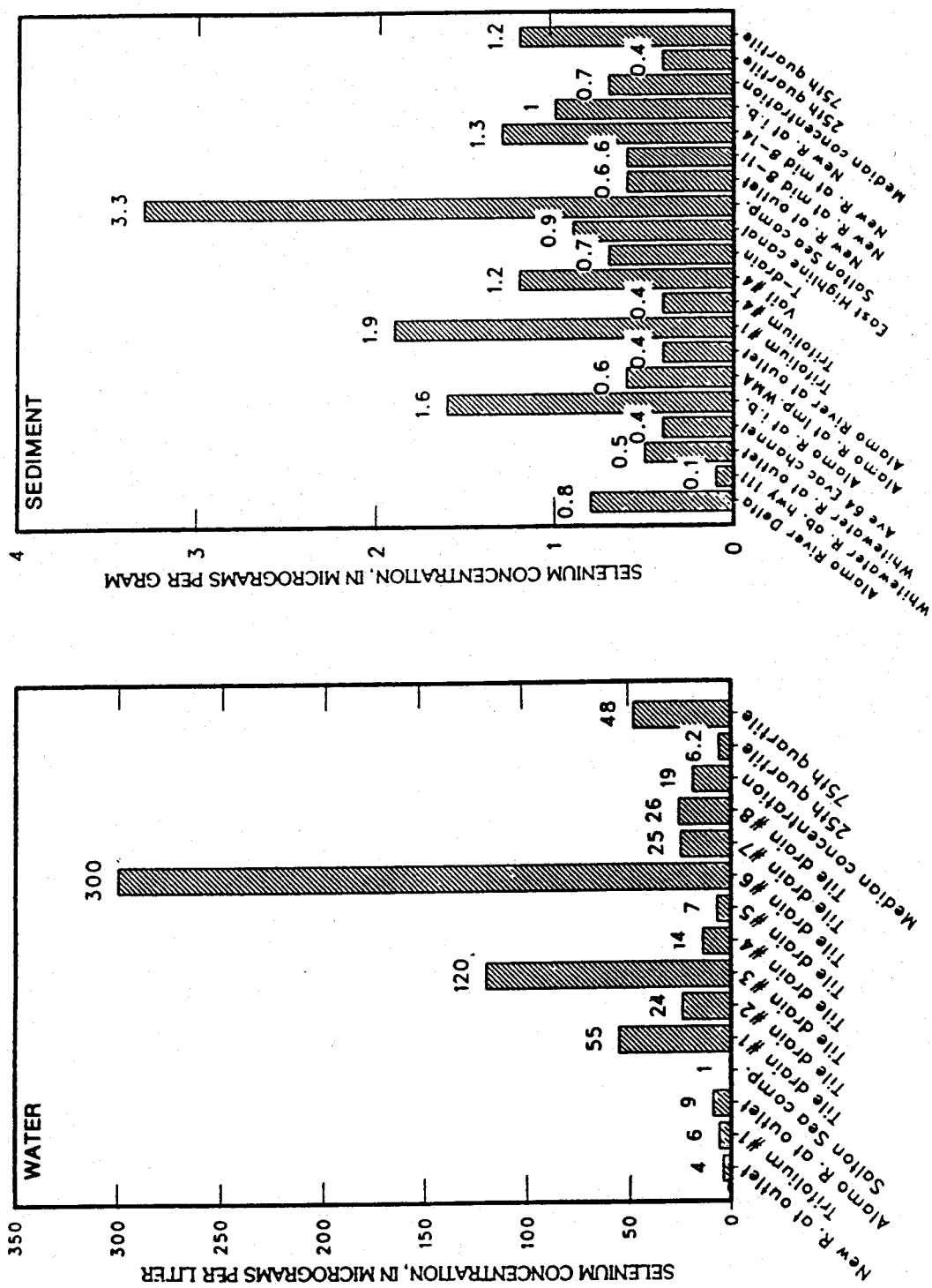


FIG. 2-- Selenium concentrations in water and sediment from Salton Sea basin.

TABLE 1. Comparison of selected trace-element and organochlorine concentrations in 17 samples from bottom material from the Salton Sea study area with concentrations in samples from other areas

[Elements from Severson and others (1987) in µg/g and organochlorines in µg/kg on dry-weight of silt plus clay. Geometric-mean concentrations in B-horizon soils of the Western United States are from Shacklette and Boerngen (1984), world-average shale concentrations are from Rose and others (1979), and silt-plus-clay size concentrations in Tulare Lake Bed area are from Schroeder and others (1988) and are arithmetic means for trace elements and highest value measured for organochlorines. NWR, National Wildlife Refuge; <, less than; ≅, approximate; --, no data]

| Constituent | Salton Sea area | | Western U.S. soils | World-average shale | Tulare Lake Bed area | |
|---|---|---|---|---|---|---|
| | Median | Range | | | Westfarmers | Kern NWR |
| As | 5.6 | 2.4-11 | 5.5 | 12 | 7.1 | 8.8 |
| Ba | 550 | 480-780 | 580 | 550 | 480 | 610 |
| B | 2.4 | 0.8-19 | 23 | 100 | 160 | 4.4 |
| Cd | <2 | <2 | -- | .3 | <2 | <2 |
| Cr | 58 | 50-210 | 41 | 90 | 120 | 59 |
| Cu | 28 | 21-64 | 21 | 42 | 39 | 26 |
| Pb | 21 | 17-52 | 17 | 25 | 12 | 16 |
| Hg | .03 | 0.02-0.11 | .046 | 0.02-0.4 | ≅.02 | .04 |
| Mo | <2 | <2-4 | -- | 2.6 | 14 | <2 |
| Ni | 25 | 22-170 | 15 | 68 | 72 | 30 |
| Se | .7 | 0.1-3.3 | .23 | .6 | 7.2 | ≅.1 |
| Ag | <2 | <2 | -- | .19 | <2 | <2 |
| Th | 10.5 | 9.0-56 | 9.1 | 12 | 8.4 | 16 |
| U | 4.9 | 3.5-15 | 2.5 | 3.7 | 6.6 | 5.3 |
| V | 77 | 63-140 | 70 | 130 | 110 | 92 |
| Zn | 78 | 67-530 | 55 | 100 | 107 | 88 |
| DDE | 18 | 0.6-64 | -- | -- | .6 | 8.5 |
| DDD | 3.5 | <0.1-24 | -- | -- | .2 | 2.0 |
| Dieldrin | .3 | <0.1-2.2 | -- | -- | .1 | 1.1 |
| Chlordane | <1 | <1-20 | -- | -- | <1 | <1 |
| PCB | <1 | <1-24 | -- | -- | <1 | <1 |

An unknown mechanism apparently is removing selenium as it moves from the drains to the Salton Sea because its concentration is reduced to about 10 µg/L in the Alamo River, 5 µg/L in the New River, and 1 µg/L in the Salton Sea. The observation that highest selenium concentrations in sediment samples collected for this reconnaissance occur in the Salton Sea suggests that incorporation in anaerobic sediments may be an important sink for selenium. This hypothesis receives further support from the recent finding that selenium in waters of the Salton Sea exists predominantly in reduced oxidation states, even in oxic surface waters (Cooke and Bruland, 1987).

Low to moderate concentrations of pesticides in water and sediment from the Salton Sea area (Table 1), similar to levels reported at the same locations 10 years earlier by Eccles (1979), were detected. The highest concentrations found generally occurred in bottom material from the New River at the international boundary. DDE was the organochlorine detected most frequently and at highest concentration in both bottom-material (Table 1) and biological samples. DDE concentrations on wet-weight basis ranged from 0.13 to 0.35 µg/g in freshwater clams (*Corbicula fluminea*), 0.11 to 0.61 µg/g in mosquitofish (*Gambusia*), and 0.17 to 4.8 µg/g in muscle tissue from waterbirds (coots, stilts, and shoveler ducks) taken on or near the Salton Sea NWR. The DDE residues found in mosquitofish are close to the mean value of 0.20 µg/g for fish collected during the 1980-81 nationwide NCBP (National Contaminant Biomonitoring Program) survey (Schmitt and others, 1985). The DDE residues in waterbirds from the Salton Sea area are much lower than levels documented to cause adverse reproductive effects during laboratory studies on birds (Longcore and others, 1971).

TABLE 2. Comparison of selected aqueous trace-element concentrations in 12 samples from the Salton Sea study area with concentrations in other areas and with criteria or standards

[All concentrations in µg/L. World-average freshwater concentrations are from Rose and others (1979), shallow ground-water plus farm-drain-sump concentrations from San Luis Unit in western San Joaquin Valley are from Deverel and others (1984), concentrations from Westfarmers ponds in Tulare Lake Bed area are from Schroeder and others (1988), and criteria or standards for protection of freshwater aquatic life from acute effects are from U.S. Environmental Protection Agency (1986b) except as indicated in footnotes. <, less than; --, no data]

| Element | Salton Sea area | | World average freshwater | San Luis Unit | Westfarmers | Criteria or standards |
|---|---|---|---|---|---|---|
| | Median | Range | | Median | Range | |
| As | 2 | 1-9 | 2 | 2 | 2-5 | 360 |
| Ba | 100 | <100-300 | 20 | -- | 100-300 | [1]1,000 |
| B | 1,800 | 680-11,000 | 10 | 3,100 | 86,000-140,000 | [2]750 |
| Cd | 1 | <1-2 | .03 | <1 | <1-1 | 3.9 |
| Cr | <1 | <1-5 | 1 | 10 | 30-50 | 16 |
| Cu | 5 | 1-11 | 3 | 2 | 70-140 | 18 |
| Fe | 50 | 30-160 | 100 | 50 | 150-330 | [3]1,000 |
| Pb | <5 | <5 | 3 | <1 | <5 | 82 |
| Mn | 50 | <10-2,900 | 15 | 30 | 30-90 | [4]1,500 |
| Hg | <.1 | <0.1-0.3 | .07 | <.1 | <0.1 | 2.4 |
| Mo | 24 | 4-58 | 1.5 | 17 | 1,300-1,700 | -- |
| Ni | 3 | <1-11 | 1.5 | -- | 5-10 | 1,400 |
| Se | 19 | 1-300 | .4 | 6 | 110-360 | [3]35 |
| Ag | <1 | <1-28 | .3 | -- | <1-1 | 4.1 |
| U | 27 | 9-55 | .5 | -- | 250-360 | [5]500 |
| V | 26 | 15-500 | 2 | 14 | 150-300 | -- |
| Zn | 30 | 20-70 | 20 | 11 | 70-90 | 120 |

[1]Maximum allowable level for protection of drinking water (U.S. Environmental Protection Agency, 1986a).
[2]Maximum allowable level for protection of boron-sensitive agricultural crops.
[3]Maximum allowable level for protection of freshwater aquatic life from chronic effects.
[4]Minimum value for aquatic biota (McKee and Wolf, 1971).
[5]Maximum allowable level for protection of saltwater fish and wildlife (Environment Canada, 1979).

During the 1975-76 winter period, Koranda and others (1979) measured increasing residues of bromine (also selenium) in wintering waterfowl at the Imperial Wildlife Management Area's Wister Unit about 10 km north of the northern unit of the Salton Sea NWR. They attributed the accumulation of this nonessential element to use of brominated pesticides. Volatile nematicides, such as DBCP (dibromochloropropane) and EDB (ethylene dibromide), were used extensively at the time in California. Although DBCP was banned in 1979 and EDB was banned in 1983, evidence exists that compounds such as EDB can persist in soil for many years (Steinberg and others, 1987). This reconnaissance did not detect (<0.2 µg/L) any volatile organic compounds in the eight drainwater samples.

Partial analyses obtained to the present of trace-element concentrations in biological samples collected from on or near the Salton Sea NWR are summarized in Table 3. Comparison with 85th-percentile values for fish from the 1980-81 NCBP survey indicate that selenium is elevated in mosquitofish from drains on or near the refuge. Selenium concentrations also were found to be high in waterbird livers, although concentrations are less than those from two areas of the western San Joaquin Valley where high values have been reported (Table 3). It is noted that Table 3 should be used only as a very general indication of comparative contaminant levels, because data from each area are for different species of waterbirds.

TABLE 3. Comparison of selected trace-element concentrations in fish and waterbirds from on or near the Salton Sea NWR (National Wildlife Refuge) with concentrations in other areas

[All concentrations in µg/g on dry-weight basis. NCBP (National Contaminant Biomonitoring Program) 85th-percentile values for fish are from the 1980-81 nationwide survey (Schmitt and others, 1985) and assume an average water content of 75 percent (Schroeder and others, 1988). Residues in waterbird livers at Kesterson NWR are from Ohlendorf and others (1986) and Ohlendorf (in press) and at Westfarmers ponds in Tulare Lake Bed area are from Schroeder and others (1988). ND, not detected; --, no data]

| Element | Fish | | Waterbirds | | |
|---|---|---|---|---|---|
| | Salton Sea | NCBP | Salton Sea | Kesterson | Westfarmers |
| As | ND-2.6 | 0.88 | ND-1.0 | -- | <0.2 |
| Cd | ND | -- | ND-3.4 | 0.12-.96 | 3.7-38 |
| Cr | ND-0.77 | -- | ND-3.4 | -- | <0.4 |
| Cu | ND-10 | 3.6 | 7.5-150 | -- | 18-78 |
| Hg | ND | 0.72 | 0.14-49 | 0.35-10 | 1.3-4.6 |
| Ni | ND-3.4 | -- | ND-2.4 | -- | 0.31-4.3 |
| Se | 3.5-17 | 2.8 | 7.0-27 | 25-37 | 26-120 |
| Zn | 8.7-120 | 160 | 41-220 | 55-170 | 120-180 |

## CONCLUSIONS

Evidence obtained during this reconnaissance, and from other studies, indicates that selenium occurs at elevated concentrations in the Salton Sea area and that subsurface irrigation drainwater from the Imperial Valley is the principal source of selenium delivered to the Salton Sea and the Salton Sea NWR. Additional studies will be needed to assess the threat from selenium and to follow its incorporation through the food chain at the Salton Sea NWR.

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26 June 1989

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Dear Mr. ~~Cornelius~~, Jim

Attached are the abstracts for my two presentations at the Western States Water Council Non-point Source Pollution Control Technical Issues Workshop, July 26-28, Irvine, CA.

The first one is from the front sheet of the ASCE paper on Treatment and Disposal Options. You have a copy of this paper already, which will be presented in Session II.

The second abstract is also from the front sheet of the paper on Dairy and Feedlot Waste Treatment and Disposal Alternatives for Non-Point Source Control. The final manuscript of this last paper will be sent to you by 30th June. This document is to support Session V, NPS Pollution from Agricultural Grazing/Feedlots/Dairies.

Sincerely yours,

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Attchs: a/s

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# Treatment and Disposal Options[1]

by Edwin W. Lee*, M. ASCE

Abstract: Treatment and disposal of agricultural subsurface drainage water present unique technical challenges. The traditional cause for concern from irrigated agriculture drainage was salinity, but recent emphasis has shifted to environmental impacts of residual pesticides, herbicides, fungicides, fertilizers, and toxic trace elements. Viable treatment and disposal alternatives which can meet stringent environmental regulations and at affordable cost to the agricultural economy present formidable problems. Treatment options include the use of anaerobic bacteria, microalgal-bacteria, physical-chemical methods, and in-situ processes. Disposal alternatives include discharge to surface waters and evaporation ponds, deep-well injection and reclamation for reuse. Irrigation on salt-tolerant crops and power plant cooling are potential reuses. Brine recovery for solar gradient ponds and salt recovery are also possibilities for reclamation.

## INTRODUCTION

The treatment and disposal of agricultural subsurface drainage water presents unique technical challenges. A review of the technical literature reveals only limited experiences in the management of large volumes of subsurface drainage from irrigated agricultural lands. The challenge is made more difficult by the complex chemical characteristics of most drainage water. Drainage usually contains a heavy salt load, which has been the traditional cause for concern for agricultural irrigation. However, recently emphasis has shifted to

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residual pesticides, herbicides, fungicides, fertilizers, and toxic trace elements. This recent focus has been mainly a public health and environmental concern. While salt emission and residuals from agricultural crop chemicals can be controlled to some degree by field management practices and conventional treatment processes, the control of toxic trace elements in drainage requires the development of innovative treatment and disposal technologies.

## TREATMENT OPTIONS

### Technology Available

Current technical literature indicates that numerous wastewater treatment technology processes may be applicable for agricultural drainage water. Jenkins (1987) and Lee (1988) completed literature reviews of conventional wastewater treatment technology for application to subsurface drainage water of the San Joaquin Valley in California.

Although many processes have potentials for treatment of drainage, only a relatively few have been selected for study or development. While desalination technology is the most advanced and has been applied in practice around the world, many other processes have been screened from further consideration for trace element reduction because of reported low capability for removal or high costs. The complex chemical characteristics of most agricultural drainage water do not lend to easy application of conventional treatment technology.

The California State Water Resources Control Board (1987) prepared a plan for regulating agricultural drainage in the San Joaquin Valley. The priority water-quality objectives have been determine as follows:

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|---|---|
| Selenium | 5 ppb |
| Electroconductivity | 1.0 mmhos |
| Boron | 700 ppb |
| Molybdenum | 10 ppb |

Lee (1988) completed a technical review of studies on treatment technologies for application to drainage water in the San Joaquin Valley. In the following paragraphs, the state-of-the-art on selected treatment methods are discussed. This overview can provide guidance for application to other areas with similar problems.

## Desalination

Of the many desalting processes, reverse osmosis (RO) is considered to have the most promise for agricultural drainage. This technology has been well advanced (Culp/Wesner/Culp, 1979; PRC Toups, 1982) and has had world wide application. The technology uses a semipermeable membrane to separate water from dissolved salts and suspended materials. Pressure is applied to the saline feedwater and water is forced through the membrane, leaving the salts behind in a brine stream.

A RO technology assessment for drainage water by CH2M Hill (1986), was completed to evaluate the process with off-the-shelf technology. The CH2M Hill study was a conceptual-level study for a 10 MGD reverse osmosis desalting plant to treat water from the San Luis Drain which collects agricultural subsurface drainage from about 40,000 acres in the San Joaquin Valley. Other experiences with desalting drainage water have been reported by the U.S. Bureau of Reclamation Desalting Test Facility at Yuma, Arizona (1985) and the California Department of Water Resources at Los Banos, California (DWR, 1986.)

The RO process studied by CH2M Hill, would have a TDS concentration of 550 to 650 mg/L in the product water, while the brine would have a TDS concentration of 55,000 to 67,000 mg/L. Selenium concentration would be about 10 to 20 ug/L, while other trace metal levels were expected to be reduced to very low levels. Boron would be only partially removed; 7 to 8 mg/L would remain in the product water. However, desalting of drainage water will be expensive. CH2M Hill estimated in its study that treatment alone would cost $1,090/AF of drainage water from the San Joaquin Valley. This does not include brine disposal costs.

## Trace Element Treatment

While the reverse osmosis process can remove dissolved solids and trace elements, it is costly. Alternative and less costly methods are being developed to meet the needs of agricultural developments. These processes fall into three main categories of: (1) Biological, (2) chemical, and (3) physical methods. The more promising of these processes and the present state-of-the-art are:

## Biological Processes

An anaerobic bacteria process has been under investigation since 1985 in the San Joaquin Valley, California. The process consists of biological reactors

for bacteria-mediated reduction, microfilter for removing of fine solids, and ion exchangers for polishing of the effluent stream. A carbon source is injected into drainage water entering the biological reactors and provides the energy for the bacteria-cellular buildup to drive the process. Methanol is the usual feed to the reactors but other carbon sources can also be used. The reaction time in the biological reactors is less than 1 hour.

Biological reactors (EPOC, 1987 and Binnie, California, 1988) can reduce selenium from a drainage inflow containing about 330-550 ug/L to about 16-50 ug/L and after microfiltration to 10-40 ug/L. After polishing in the ion exchange resin or soil column, the selenium in the processed water can be reduced to less than 10 ug/L. In the ion exchange process, boron was also reduced from about 10 mg/L to less than 1 mg/L. It is estimated that treatment costs would range from $224 per acre-foot for a 1 MGD plant down to $145 to $163 per acre-foot for a 10 MGD plant. These include capital, maintenance, and operation costs but not drainage collection or disposal costs.

very effective!

A microalgal bacteria process has been under development for the reduction of selenium in agricultural drainage in the San Joaquin Valley of California. In this process, (Oswald 1985, 1987, 1988a, 1988b) microalgae and bacteria are cultured in open ponds under high rate growth conditions and harvested by a low cost bioflocculation process for fermentation in digestors for methane generation. The digested algal material is recovered and used to reduce the oxidation state of selenium contained in drainage water. In a reactor, selenium in drainage water is reduced by the digested algal material to an insoluble state and then is separated from the water column. Methane gas is used to power the plant operation and combustion gases are fed back as a supplemental carbon source to the high rate algal pond. The effluent from the reactor is clarified in a dissolved air flotation chamber and then discharged.

In laboratory experiments the digested algal material reduced soluble selenium concentration in drainage water from 367 ug/L to 20 ug/L, about 95 percent removal. Part of the remaining selenium may be colloidal and some can be removed by a solids separation system to achieve higher removal rates.

Preliminary studies indicate that treatment costs by the microalgal bacterial process would range from $102/acre-ft in a 10 MGD plant to $68/acre-ft in a 100 MGD plant. These include capital, maintenance, and

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operation costs, but not drainage collection and disposal costs of effluent and residuals.

Chemical Treatment

Selenium in the selenate form can be reduced to elemental selenium and removed from the aqueous phase with ferrous hydroxide (Murphy, 1988 and Moody, 1988).

In preliminary laboratory tests, ferrous hydroxide was able to reduce and precipitate selenium by 99 percent within 30 minutes of contact time. However, field tests indicated that the reaction is slower but reduction down to 1 ug/L still could be achieved with a longer contact time. The process is pH dependent, but dissolved oxygen and nitrates appear to exert an inhibiting factor on the reaction rate. Progress reports (USBR, 1987 and 1988) provided data and information on development of the process. Preliminary estimates for treatment is about $70/acre-ft for a 50 MGD plant but can rise to over $150, if nitrates and oxygen in the drainage are excessively high. These include capital, maintenance, and operational costs but not collection and disposal costs.

Physical Treatment

The physical treatment of wastewater involves adsorption of ions on natural and synthetic surface active materials, including ion exchange resins. While many natural materials and synthetic substances exhibit ion adsorptive potentials, the capability to adsorb specific trace elements narrows the range of materials to highly selective ones.

Iron filings was used as an adsorption material for heavy metals in a minipilot plant at the Panoche Drainage District near Firebaugh, California in 1985 using a process patented by Mayenkar (1986). It was claimed that the surface of the iron filings could be activated by oxygenation and that selenium was adsorbed on the activated surface (Harza, 1986).

A major problem encountered in the columns used in the studies was the cementation of the iron filings. The cause for the clogging of the columns was not explained but possibly could be due to precipitation, coagulation, or occlusion of drainwater constituents in the iron filing beds. This can have effect on the bed life and, hence operating costs. Preliminary studies indicated that a wide range of costs ($70 to $285/acre-foot) can be expected, depending on bed life and removal expectancies.

## In-situ Biological Process

In-situ biological process involves selenium volatilization by microbial action (Frankenberger, 1988a). The natural process of volatilization can be significantly accelerated by microbial methylation of selenium.

Studies provide support to the potential application of the process for the detoxification of seleniferous soils, sediments, and water. In the laboratory, it was shown that fungi could take up selenium salts and biologically convert them into methylated species, primarily dimethylselenide. Methylated gas forms are naturally volatilized into the atmosphere and dispersed.

The process is biologically stimulated by carbon sources, moisture, aeration, and activators. Zinc, nickel, and cobalt appear to be good activators, but high nitrogen applications inhibit the reaction. Adequate aeration and moisture are needed to sustain the obligate aerobic fungi. Studies in soil system with isolates of selenium methylating fungi, including *Acremonium folciforme*, *Penicillium citrinum*, and *Ulocladium tuberclatum* showed enhanced evolution.

Field studies were initiated in 1987 on soils at Kesterson Reservoir in the San Joaquin Valley, which has been contaminated. Field level selenium volatilization was made with a dome capture device. The highest rate of emission was recorded during the summer, at more than 800 $ug/m^2/hour$ (Frankenberger, 1988b). Citrus pulp enhanced volatilization to the best level, compared to other organic sources. Temperature and moisture levels greatly influenced the process and emission rate. Estimates indicate that it will take more than 2 years to detoxify the selenium contamination in Kesterson Reservoir to an acceptable level by this process.

The microbial methylation of selenium from water has been reported by Frankenberger (1988c). Studies in the laboratory and field indicate that selenium can be volatilized from open water and thus can be a method to detoxify contaminated ponds.

# DISPOSAL, RECLAMATION, AND REUSE OPTIONS

## Technical Options

The treatment of drainage water for dissolved solids removal and reduction of trace elements still leave a problem with residuals composed of brines and salts. Disposal, reclamation, and reuse are options to be considered. A review of these options was completed by

Nishimura (1988) for the drainage problems in the San Joaquin Valley of California and can provide an overview for application to other areas with similar needs.

Disposal

There are three general methods for the disposal of drainage water: (1) Discharge to surface waters, (2) evaporation in ponds, and (3) deep-well injections.

Discharge to surface waters. This is the most widely used practice today for the disposal of drainage water. Potential receiving waters can be oceans, bays, deltas, rivers, and streams. Water quality standards may exist for all receiving waters for the protection of beneficial uses. These will determine the engineering design, the dilution factors, and the installation of conveyance and disposal facilities for the specific location. Special consideration must be given to the protection of the aquatic environment and to evaluate impacts.

Evaporation ponds. The disposal of drainage water to evaporation ponds has been a practice where physical factors preclude discharge to surface waters or regulatory agencies foreclose other options. However, evaporation ponds pose a risk to ground water supplies and the environment.

In California, like many other locations, wastes in ponds are classified according to toxic constituents. For example, any waste exceeding predetermined toxic limits can be classified as hazardous. Under these conditions, special construction is required for containment, including double linings, leachate collection and removal systems and precipitation and drainage control facilities. In addition, a monitoring plan for toxic ponds must be implemented with the approval of regulatory agencies.

The ecological impacts of evaporation ponds are equally important and may determine design, construction, and operation. Fish and wildlife experts are concerned that evaporation ponds can create hazardous habitats. Selenium in impounded water can bioaccumulate in the aquatic food chain by more than 2000 times and, therefore, can threaten any fish and wildlife inhabiting these ponds (USFWS, 1987).

Drainage water may be treated to remove toxic constituents before discharging into evaporation ponds but this can be costly. Moreover, the increasing concentration of toxic substances during evaporation stages may nullify any treatment benefits. An

alternative to treatment may involve special construction and operational requirements, which can incur extra costs. For example, in California, the construction cost estimate for toxic ponds can exceed $200,000 per acre as compared to an ordinary evaporation pond for about $20,000 per acre. The monitoring of ponds can incur added annual costs.

In evaluating evaporation ponds for the management of drainage water, consideration must be given to land requirements, siting, and eventually disposal of accumulated salts. The land requirement for evaporation pond is largely determined by local climatical factors and geology. Ponds must be designed for the specific site under evaluation.

Brown and Caldwell (1987) reported that the U.S. Soil Conservation Service (SCS) estimates for a sequential four-cell pond design in the semiarid San Joaquin Valley, California that 0.265 acre of pond surface would be required to contain each acre-foot of drainage water produced per year. Allowing for an additional 20 percent of land area for levees, buffer zones etc., SCS estimates about 0.32 acre of land is required per acre foot of drainage water to be disposed.

Deep-Well Injection

The technology of deep-well injection has been used in the oil industry to enhance production and to dispose of waste brine. There is potential for the application of this technology for the disposal of agricultural drainage (URS, 1986).

Institutional constraints such as the Underground Injection Control (UIC) Program of the U.S. Environmental Protection Agency can rigidly control deep-well injection systems. Injection of hazardous wastes has in recent years been receiving considerable attention of Federal, State, and local regulators because of failures of some injection efforts. Also, the public may perceive that underground aquifers do not allow adequate control for the disposal of hazardous materials.

If waters to be injected are deemed hazardous under Federal and State definitions, several provisions of the U.S. Resources Conservation and Recovery Act (RCRA) will apply. The UIC program specifies which of the RCRA regulations are applicable to deep-well injection of hazardous wastes.

There are numerous regulatory procedures to attain deep-well injections approval, and there are also

potential liabilities that should be considered. Leakage from pipes and confining zones bear liability risks. EPA will require that certain financial responsibilities be maintained, but there are also other complex, uncertain liability issues such as those that relate to adjoining property rights.

Geohydrological conditions must be considered in the selection of injection sites. Existing well drilling data can be a useful source of information. Protection of fresh ground water must be considered. Geologic formations with low permeability must isolate the injection zones from fresh water formations.

Consideration must be given to potentials of seismicity induced by the injection process. In addition, the compatibility of chemistry of the drainage water with the geochemistry of the geologic formation must be evaluated. The biochemistry of the injecting fluids must not induce biological clogging of the formation and cause premature failures.

Injection facilities are specially constructed to inject hazardous or nonhazardous wastes. Construction requires drilling a hole to a depth that meets UIC requirements and below the lowermost formation that contains (within a quarter of a mile) a well used for drinking water and into a formation capable of receiving the wastes. Porous, saline water-bearing sands confined above and below by impermeable rock strata are the most desirable receiving formations.

The service life of the injection well or, in this case the amortization period, is governed largely by the aquifer pressure buildup. Pressure buildup in the receiving formation is a function of both the volume injected and the rate of injection. The life expectancy of injection wells in the oil industry has been observed to extend to about 35 years. A conservative estimate of service life would be about 25 years.

Pretreatment of drainage water prior to injection may be needed to minimize clogging or fouling of the well. Clogging of the well or the receiving formation could result from one or a combination of several reasons.

Physical blinding by the accumulation of particulate matter can clog wells. Chemical precipitation of the injection face or formation can also clog wells. Biological activity and resultant fouling of the injection horizon appear to be more serious concerns.

The unit cost for deep-well injection for various pretreatment of drainage in the San Joaquin Valley can range from $164 to $213 per acre-foot, depending on pretreatment needs (URS, 1986).

## Reclamation And Reuse Options

Reclamation and reuse of agricultural drainage water is consistent with good management of natural resources. There are many opportunities and options.

An agroforestry program for the management of saline drainage water was demonstrated in the San Joaquin Valley by the California Department of Food and Agriculture, (1987 and 1988). Almost 180 acres were planted in 1985 with eucalyptus, casuarina, poplar, mesquite and elderica pines. Freshwater was used to irrigate the seeding during the first year to establish the trees. Then saline drainage water was used to irrigate the trees, which also draw from the ground water system. Findings to date indicate that drainage water could be used to irrigate trees. Once established, trees can draw water from the ground water system for growth and evapotranspiration. An added incentive is the uptake and disposal of trace elements. Harvesting of trees can provide biomass to fuel power plants for the generation of electricity and for pulp production.

Drainage water can be used for power plant cooling. However, the chemical characteristics of most drainage water would require pretreatment for corrosion and scale control.

A test program in California used water from a tile drainage system for power plant cooling (DWR, 1978). The study was based on a plant to treat 11.5 million gallons per day as makeup water for a 1,000 MW powerplant. Treatment processes were used to soften water by ion-exchange resins and to regenerate the resin, using concentrated cooling tower blowdown without adding new chemicals. The estimated cost of treating drainage water would be about $163 per acre-foot (adjusted to 1984 costs), not including the disposal of any wastewater. Additional costs for brine disposal in evaporation ponds would add $108/acre-foot. Therefore, the sum of treatment and evaporation pond disposal costs totaled about $271 per acre-foot. However, if selenium or other basic contaminant levels in the waste brine should reach hazardous levels, the disposal costs may be substantially higher because special ponds may be required.

Laughlin (1986) studied the use of drainage water from the Palo Verde Irrigation Outfall Drain in the Colorado

River basin for a hypothetical power generating station near Las Vegas, Nevada. The study was part of the Colorado River Water Quality Improvement Program of the U.S. Bureau of Reclamation. Several treatment options were studied for the drainage water. It was concluded that drainage was a viable source of cooling water and use would contribute to the lowering of salt loads in the basin.

Treated drainage water can be reclaimed for reuse for municipal, industrial, and agricultural purposes, provided that water quality can meet standards for reuse. There could be serious limitations on reuse, depending on the desalination process and the chemical composition for the drainage water. It is not sufficient to reduce the total dissolved solids, but substances such as boron and toxic trace elements must also meet standards for beneficial uses. For example, in reuse for agricultural irrigation, TDS, boron, and molybdenum levels are particularly important. For natural habitat and human consumption, toxic trace elements are important factors to be evaluated.

To date, the desalination of drainage water for reuse has not been widely practiced. Although studies have been made on the potentials for reuse, the large volume of drainage and related high costs have not favored the installation of large facilities and related financing.

Solar gradient pond technology offers the possibility of using the waste products, brine or salt, for the production of electrical energy.

Ormat Turbines, Ltd., (1981), reported from its experience with solar ponds in Israel that about 20 to 25 percent of the incident irradiation can be collected and extracted at about 180 °F to 200 °F. Using specially designed turbines and generators, Ormat has demonstrated that the low-temperature energy can be effectively converted into electrical energy.

The Ormat technology was studied by the U.S. Bureau of Reclamation for salinity control (1982) and has been demonstrated by the USBR at El Paso, Texas (Hightower, 1987). This technology was extensively reviewed by the Massachusetts Institute of Technology (1985) for the Electrical Power Institute of Palo Alto, California.

Energy extraction is accomplished by two methods. One is to place the heat exchangers in the heat storage zone; the other, more frequently mentioned method, is to

extract hot brine from the pond, pass it through an external heat exchange, and return the cooled brine to the pond.

Solar ponds are not expected to be a component of immediate drainage water treatment solutions, but the technology may advance to make the concept feasible. Technology advancement, in turn, will be largely governed by the supply and demand for energy.

The recovery of salts or minerals from agricultural drainage water from evaporation ponds may be an ultimate solution to the difficult salt disposal problem. The products could be sold and repayment could possibly cover some or all of the disposal costs. The U.S. Bureau of Reclamation (IDP-1979) studied the possibility for salt recovery. The trends in worldwide markets and proximity to markets are important factors in the recovery of salt. Unless these are favorable to a specific location, the marketing of recovered salt from drainage water on a commercial basis would be limited.

A novel approach which integrates several of the reclamation and reuse options is the concept of cogeneration-desalination. This concept was explored by URS Corporation (1987) for the Westlands Water District, California (1988). The concept involves the use of gas turbines for the generation of electrical power with the bypass heat used for the desalination of drainage water. Salt is crystallized from the brine stream while the water from the desalination process is made available for reuse. Electrical power that is surplus to plant operation is sold for cost recovery. Although the technology of each process is well developed, their integration into an economical system is yet to be proven. Basic economic consideration will be whether the surplus electrical energy and the salt products can cover process costs.

Other reuse options include ocean salinity repulsion, wetlands, and aquaculture. Although innovative, they have not been evaluated beyond the conceptual phase. A major problem is associated with the trace elements in drainage water, which can create technical and institutional barriers.

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Key Words

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Trace element

Toxic waste

30 June 1989

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Dear Mr. ~~Cornelius~~ Jim

Attached for your further action is a final copy of the paper, Dairy and Feedlot Waste Treatment and Disposal Alternatives for Non-Point Source Control, for the forthcoming NPS Pollution Control Technical Issue Workshop, July 26-28, Irvine, CA.

If you have any queries on the paper, please feel free to call me -(415) 769-9927.

Sincerely yours,

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DIVISION OF LOANS & GRANTS

# Dairy and Feedlot Waster Treatment and Disposal Alternatives for Non-Point Source Control

Abstract: Present waste management practices in the dairy and feedlot industry are primarily directed to good housekeeping around animal confinement areas and easy handling and disposal of solids and liquids on land. Animal wastes are potential source of organic pollution, nitrogen overload and salt contamination of land and water resources. Control of Non-Point Source of pollution will require evaluation of present practices. A review of present practices, potential problems and suggestions for management alternatives are presented. Innovative low-cost alternatives for treatment and reduction of pollution are discussed for consideration as part of NPS control programs.

## INTRODUCTION

Current waste management systems in dairies and feedlots with high animal concentration are designed simply for the easy collection and separation of solids and wastewater. The objective of present practices is to facilitate handling of wastes for on-site disposal and to depend on minimal housekeeping. In rural settings, this has been acceptable. However, with the growing concern for the control of non-point sources (NPS) of pollution, there is need to evaluate present management practices to determine if alternative approaches are needed to comply with current programs. The purpose of this paper is to review briefly present practices, to address basic issues related to NPS control and to offer suggestions for alternative management practices for the cattle dairy and feedlot industry. Alternatives are directed to low cost but effective technologies for NPS control.

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Edwin W. Lee, Alameda, CA

BACKGROUND

Dairy and feedlot wastes management practices have evolved rapidly over the past 25 years, with the growth of environmental regulations imposed on the industry. Prior to this period of environmental awareness traditional pasture dairies and open cattle ranges were usually located in rural areas where relative isolation permitted simple and low cost management practices.

With the growth of environmental legislations and the increase of animal densities in dairies and confined feedlots, management practices have incorporated elementary control facilities. Review of these practices have been documented in overviews by the US Federal Water Pollution Control Administration (1968) (1969), the Canadians (1972) Loehr (1969) and Azevedo (1974). While present methods, described in these reports have improved upon earlier unrestricted management practices, there is awareness now that present systems may not meet enlightened environmental goals, particularly as envisaged in the control of non-point pollution sources.

A recent study by the Soil Conservation Service (1988) gave emphasis to these concerns in a review of the dairy industry in the Chino Basin in Southern California. The study recommended revisions to current management practices to control degradation of land and water resources of the basin. In another recent study, the California State Water Resources Control Board (1988), reviewed nitrate pollution in ground waters and identified feedlots and dairies located throughout the State as sources for degradation of local drinking water supplies. This study confirmed findings of an earlier study on nitrate pollution in the Upper Santa Ana Basin in Southern California by the Soil Conservation Service (1973). In the intervening 15 years, the control of nitrate pollution has not progressed in any significant degree in the basin, despite the public health implications of nitrates. Thus a review of current practices at this time in the context of NPS control and evaluation of alternatives methods would promote discussions to address the various issues facing the industry.

CURRENT MANAGEMENT PRACTICES

The primary focus of present management practices is to dispose of solids and liquids in ways to eliminate breeding places for flies, gnats and mosquitos and to control odors, dust, and nuisance. Reference is made to the University of California Cooperative Extension guidelines on the design of systems (1977) (1980) (1984). Earlier, Lamb (1972) prepared guidelines for livestock waste

management and there are numerous other guidelines from the literature for the industry. Regulations basically require that animal wastes be kept on-site, surface and ground water be protected and nuisances be controlled. Present practices are directed to install the most facilitative and least costly means for the disposal of solids and wastewaters. The reduction of the pollution potentials of solids and liquids is only a secondary consideration.

Structural facilities in dairies and feedlots incorporate systems to collect and to separate solids from manure and wastewater for easy disposal of the separated materials on-site. Solids are applied on land or are transported for off-site disposal. The handling of wastewater involves storage ponds for temporary holding of liquids before land application. Treatment for reduction of pollutants is not a primary goal in holding ponds and any removal is coincidental to most operations.

Regulatory authorities usually require on-site containment which may be difficult to achieve in most locations, particularly in high animal density operations during the wet seasons. The long-term outcome of these operations is the persistent non-point emission of nutrients, biodegradable organics and salt loads to soil systems and surface and ground water resources.

ALTERNATIVE PRACTICES

Programs for the regulation of non-point sources present challenges and call for alternative management schemes particularly where high concentrations of confined animals in dairy and feedlots are located. Alternative approaches with emphasis on treatment technologies would need to be considered to control organics, salts and nutrient emissions from these sites. These approaches will require application of advanced state-of-the-art treatment technologies.

For the purpose of this paper, management alternatives will address solids and liquids separately, since these are the distinctive waste forms of NPS from dairies and feedlots.

## Waste characteristics

To provide a measure of the pollution potentials, typical ranges of cattle waste characteristics are shown in Table 1. There are several characteristics of animal waste that can have implications for control strategies. These are the biodegradable organics (BOD), nutrients (N/P) and total solids. Strategies for control should be directed

## CATTLE WASTE CHARACTERISTICS[1/]

Table 1

| | |
|---|---|
| Animal Size, pounds | 1000 |
| Wet Manure, ppd | 38-74 |
| Total Solids, ppd | 9.5 - 11.4 |
| BOD[2/], ppd | 2.5 |
| Nitrogen, ppd | 0.35 - 0.44 |
| $P_2O_5$, ppd | 0.11 - 0.12 |
| $K_2O$, ppd | 0.27 - 0.34 |

[1/] Loehr, R.C. (1969)

[2/] Canadian Animal Waste Mangement Guide Committee (1972)

ppd - pounds per day

primarily at these potential pollutants since they are significant factors in environmental protection programs and their relatively high concentrations in animal wastes give cause for concern.

Solid wastes

Solid wastes are composed mainly of manures, spilled feedstock and yard sediments. Dissolved minerals fractions from solid wastes comprise the salt loads. In dry dairies and feedlots, solid wastes can be easily collected and disposed on land. The benefits of the present disposal practice include the fertilization values of manures for crop utilization and the amendment properties of solids in improving soil condition. The disadvantages of long-term solid waste applications on land include the gradual salt build up in the soil system, nitrate overdose on crops and off-site discharges, leading to eutrophication of receiving waters and the transmission of animal borne diseases. The control of NPS would need to address the overall pollution potentials arising from present practices and the following paragraphs contain some suggestions.

Alternatives for solid waste management can be considered within the present state of practice, with emphasis on resource recovery. However the application of existing technologies would require selective application, since technologies must be both technically effective and cost affordable. It should be recognized that the dairy and cattle industry is under economic strains and affordable cost is a major consideration. Trade-offs in cost and environmental goals may determined the ultimate choice of technologies in any specific situation.

Under present practice, manures can be dried and sold for off-site disposal and this practice should continue wherever possible for dry dairies and feedlots, since it is the most cost effective means. However, alternative to this practice is to compost the manure, provided that the solids do not contain excessive moisture, which can hinder the process. The cost of composting facilities can be off-set by the sale of the by-products but the economics remains fragile and at best, can be considered only for partial cost recovery. The long-term benefits are related to the conservation of natural resources, and in this respect, composting may be viewed with favor for the environment.

Another alternatives include the use as manures a food additive for feeding animals. Most studies have been experimental (Azevedo, 1974) since animal feed regulations need to be considered. At this time, this cannot be

considered a viable alternative. Other alternatives include the use of manure to manufacture composition building materials and to burn as fuel in power co-generation systems. Although innovative, all of these and others have not been advanced to a stage for practical applications and must be excluded from further consideration at this time.

However an energy conservation approach which deserved evaluation is the generation of methane from biogas systems. The process requires solids to contain sufficient moisture for proper digestion and generation of methane. Since liquids in the process will generate wastewater, biogas systems will be considered in the following section, covering the management of wastewater.

Wastewater

Liquid wastes from dairy and feedlot operations are usually derive from the washdown of equipment and stalls, and from drainage of local runoffs. The mixing of water with manure creates a greater burden in management schemes, since this increases the volume and weight of waste products which must be handled. Local runoffs during the wet season add to this overall arrangement problem. However, the addition of water eases transport and handling of solid waste products.

Most dairies and feedlots wastes contain high moisture. In operations where slotted or flushed floors are installed for easy drainage of stalls, water is used for washdown and conveyance of wastes for easy housekeeping. In these situations, waste management must address both solid and liquid forms. Usually sediments and other easily settleable solids are separated in pre-treatment facilities. The settleable solids are composed mostly of inorganic substances, which can be easily disposed on land. With emphasis on a treatment strategy to meet NPS control, the reduction of pollution in the wastewater is a desired goal.

A treatment strategy is considered necessary since present land application practices, over prolonged periods lead to degradation of land and water resources. The present practice of using temporary holding ponds for follow-on land application is tolerable only if large land areas or great dilution capacity were available in receiving waters. Even if large areas are available, the gradual accumulation of salts and nutrients present a long-term environmental degradation problem. Thus wastewater treatment must be considered in alternative approaches, for any NSP control program. This will present challenges to the industry from both technical and economic perspectives.

Treatment technologies for reducing organics, nitrogen forms and dissolved solids have been developed for municipal and industrial applications. Most technologies require intensive capital investments, and demanding operation and maintenance schedules, which can be costly to the economies of dairy and feedlot operations. Therefore selection of treatment technologies must be aware of cost implications on the industry. An approach that encompasses low cost but yet effective pollution reduction is most pragmatic for NPS control programs.

A process that could meet the criteria for both low cost and technical effectiveness may be possible with lagoon treatment systems. These systems have been reported by Loehr (1969), Taiganides (1978), the Canadians (1972) and others for the treatment of animal wastes. However, lagoons have not been used extensively for dairy and feedlot waste treatment since the present practice of holding ponds and easy land application have been acceptable to most regulatory authorities. However, with the present programs for NPS control, there is need to review lagoon technology for organics reduction and possibly for the control of nitrogen and dissolved solids.

Most studies on lagoon technology have focused on either anaerobic or aerobic processes with emphasis on organic reduction. Significant reduction of nitrogen and dissolved solids (salts) cannot be expected in these lagoon systems.

There is need to review the state-of-the-art in lagoon technology in an integrated process for meeting goals for the reduction of organics, nitrogen and dissolved solids. An integrated approach should investigate the use of facultative pond systems for the reduction of organics and nitrogen and the use of evaporation ponds for the removal of dissolved solids. This integrated system involves technologies which have been developed and employed in engineering practices and therefore will not require any new developments. The innovation is suggested in the integration of these pond systems. Integrated pond systems have been used by Prof W. J. Oswald, University of California-Berkeley (1988a). These systems are composed of a deep facultative pond with anaerobic and aerobic zones in a single earth lined structure, followed by a high rate algal pond for oxygen production and algal biomass reclamation. Biomass removal will reduce nitrogen emission.

A facultative pond is a deep pond which combines an anaerobic process in the deep lower portion, and an aerobic process in the upper layers. The design of a facultative pond permits high organic loadings in the

lower section, which also serves as an organic solids digester. The anaerobic environment permits the stabilization of organic solids and the denitrification and evolution of nitrogen to the atmosphere above. The upper aerobic layers allow for the further reduction of organics in an algal-bacterial process. The liquid effluent contains residual organics, nitrogen forms and a stable algal biomass, which can be applied on land for disposal. The digester part of the facultative pond can degrade and stabilize over time the settleable organic solids to a low volume. Although facultative ponds may appear simple in design, successful application requires careful analysis and design, using engineering parameters which have been gathered through years of practice.

Although facultative ponds will remove settleable solids, they will not remove dissolved solids to any significant degree. Minimal dissolved solids can be removed with the settleable solids in the pre-treatment process and with the digester sludge but most dissolved salts will be carried over from the facultative ponds. As dissolved solids containing salts have been implicated in the degradation of surface and ground water, they should be controlled by removal or reduction. But this is not an easy task.

Process treatment for dissolved solids reduction requires costly state-of-the-art technologies. This includes desalination with permeable membranes, exchange resins and thermal distillation processes, which would not be cost effective to the dairy and feedlot industry. A possible approach would be the use of simple evaporation ponds. This technology would be most effective in arid and semi-arid areas.

If dissolved solids control is necessary, evaporation ponds could be integrated in the process. Drainage from land on which effluent from the facultative ponds have been applied could be collected by underdrains and processed in evaporation ponds. Underdrains could be installed in irrigated pastures to intercept percolating water before reaching the underlying ground water. Design for ponds would include a progressive concentration process, until mineral solidification is achieved. Then solid salts can be recovered from terminal ponds for off-site disposal.

If conservation practices were to be an added objective for the management of wastes, consideration should be given to several recovery processes in integrated pond systems and these possibilities should include the following processes:

Biogas: The anaerobic processes in the facultative ponds contains digesting organics which will generate methane. Biogas production from manure has been proposed Azevedo (1974) but, although a few digesters have been installed, they have not been used in large numbers. Guidelines have been produced by the University of California Extension Service (1982) for consideration.

Normally the gas would evolve from the surface of ponds. However, gas can be collected for an energy source and this can be possible with a low cost underwater plastic cone. The use of facultative ponds with internal digesters can be an innovative low cost approach. There are good indications that this can be an economical and effective method to recover methane.

Algal Recovery: By growing and harvesting algae from the effluent of the facultative pond, it would be possible to increase biogas production or to reclaim algal biomass for resource recovery. This would require algae to be grown in a high-rate pond to high concentrations. Oswald (1988b) has reported on high-rate ponds in which algae can be harvested by a simple bio-flocculation process, without the addition of chemicals. This process has been demonstrated as a low cost algal harvesting process by Shelef (1983) and Benemann (1980). The algal biomass can be feed to the digester of the facultative pond to increase methane generation or can be dried for animal and poultry feedstock. Nitrogen removal is further enhanced by removal of biomass from the process.

SUMMARY AND CONCLUSIONS

1. Present management practices for dairy and feedlot wastes need to be evaluated for meeting NPS control. Present systems are primarily directed to facilitate the handling of solids and liquids for easy on-site disposal. The need for treatment and reduction of potential pollutants is not a recognized goal.

2. Animal wastes are potential sources of organic pollution, nitrogen overload and salt contamination of land and water resources. Their treatment and removal present challenges to existing technologies.

3. Low cost alternative technologies should be developed from existing state-of-the-art. These could be basically developed around integrated ponds treatment systems to include anaerobic,aerobic and evaporation ponds.

4. Facultative ponds combine the features of an anaerobic deep pond and an aerobic shallow pond in a single structure to stabilize organics and to denitrify materials.

5. Evaporation ponds can concentrate saline water collected from drainage water from irrigated pasture so that salts can be intercepted from deep percolation to ground water systems. Recovered salts can be sold for cost recovery.

6. Innovative alternatives to the integrated pond systems can include recovery of biogas from the anaerobic digester in the facultative pond and the recovery of biomass from high-rate algal ponds in the further treating the effluent from facultative ponds. Recovered biomass can off-set the costs of treatment.

7. Although suggested alternatives have been identified, there is need to demonstrate these several processes in a project to integrate the system to determine their overall effectiveness.

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# IRRIGATION INDUCED WATER QUALITY PROBLEMS

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In 1982, an unexpected discovery was made at Kesterson National Wildlife Refuge in California's San Joaquin Valley. Reproductive failures and deaths were noted in some species of aquatic organisms and waterfowl, and investigation showed that levels of selenium were elevated in these biological specimens and in the refuge's water.

These discoveries, together with some assumptions on cause and effect, led the State of California's Resources Agency and the U.S. Department of Interior to sponsor the Committee on Irrigation Induced Water Quality Problems in 1985. This Committee operates under the auspices of the Water Science and Technology Board, a scientific advisory unit of the National Academies' National Research Council.

Today's presentation reflects the deliberations of the Committee and, in large part, is a condensation of a report to be published by the National Academy Press this fall.*

The Committee's charge was not to find and advocate a solution to the water quality problems in the San Joaquin Valley, but to provide advice to the relevant parties in their search for an equitable and technically sound solution, and to reflect on the broader questions associated with water quality degradation from irrigation in arid and semi-arid environments.

Irrigation-induced water quality problems are hardly new. The renowned E. W. Hilgard, for example, eloquently addressed the "evil, besetting California's irrigation districts" as early as 1886; referring to salinity problems, then painfully apparent, he cautioned that one

should not "...hope that natural laws will be waived in favor of California".** The history of salination in irrigated areas, with associated drainage problems, goes back thousands of years. Neither is there anything new in the observation that, even though specialists (drainage engineers, soil scientists or irrigation specialists) have long recognized the need for drainage if irrigation is to be maintained, substantial institutional barriers exist to accomplish such drainage.

What was new in 1982 was the discovery of significant harm to fish and waterfowl from exposure to selenium. Also, the rapidity with which this problem built up was unprecedented. The Kesterson wildlife ponds were constructed in 1971 and their water supply was exclusively fresh water through 1978. By 1981, they were fed exclusively with irrigation drainage water. Barely two years later, in 1982, the first problems were noted.

These events galvanized various groups into action. The problem of drainage need and drainage disposal for the San Joaquin Valley, studied ad nauseam for at least half a century, took on new life, new urgency and totally new dimensions.

What brought on the Kesterson phenomenon? A series of natural and human factors combined: failure for decades to provide adequate drainage for the rapidly expanding irrigated area, high levels of selenium (and other trace elements) in the irrigated soils of the region, and the attempt to use small regulatory reservoirs--the very shallow Kesterson ponds covered less than 1200 acres--as terminal evaporation ponds must be mentioned. But possibly even more important was the pressure on migratory birds caused by a drastic reduction in wetlands; over the last century, over 90% of the once abundant wetlands in California have been

drained, forcing the birds using the Pacific Flyway to depend on ever fewer and smaller sites.

Had the San Luis drain, designed to provide an outlet for drainage water to the San Joaquin-Sacramento Bay, been constructed as planned--and then the Kesterson ponds been used only as regulatory reservoirs--it is unlikely that the problem of selenium toxicity would have been discovered, at least in the 1980's. One should not conclude, however, that the northern San Joaquin Valley represents an isolated situation. The hydrogeology of the arid west is such that one can expect similar problems elsewhere. In fact, as discussed earlier on this program, the Department of Interior has initiated a National Irrigation Water Quality Program and, to date, has identified at least four other refuge sites that warrant detailed investigation for similar water quality problems.***

In the early history of the Western United States, the overriding objective was economic development. The Reclamation Act of 1902 provided an impetus for water development, presumably to encourage family farms by providing irrigation water. Little consideration was given to environmental issues, or to the inevitable reduction in wildlife habitat associated with such development. The situation has changed. We now see severe pressure on water resources from expanding cities and industry, an expanding demand for recreation in the form of sport fishing, white water rafting and simply enjoyment, and an increasingly intense concern with water quality. Irrigation, once seen as the life blood of the West and the engine driving development, now has to compete with many other uses. The days are past when those in agriculture could take for granted that they will be given special consideration in this competition for natural resources and in the concern for environmental protection.

In a sense, the developments at Kesterson can be seen as a useful warning. Problems associated with irrigation agriculture may be more far reaching than many of us thought. These problems must be recognized and addressed.

A resolution of alleged or real problems with irrigation drainage requires, first of all, an understanding of the natural processes. Then, due consideration must be given to an assessment of institutional constraints and opportunities. No resource problem is purely technical or simply political; all require a mix for understanding and for resolution. In the view of our committee, it is essential in working towards solutions to recognize and explicitly employ a logical series of study elements: problem recognition, problem definition, data collection and assessment, identification and display of alternative solutions, and evaluation of these alternatives. In a democratic society, these processes must take place openly and, to the extent possible, with public participation. What follows is an elaboration on these statements.

## Is irrigation agriculture sustainable?

Irrigation relentlessly and unavoidably increases the salt concentration in return flows, or drainage waters, compared to the irrigation water. Plants use pure water and leave behind whatever salt was contained in the soil water. It is necessary to flush these salts downward to avoid building up salt concentrations in the root zone that exceed the tolerance of the crop to be grown; in the process, this leaching water often dissolves additional salts from the soil, or displaces saline subsurface water. Whatever the detailed mechanisms that

occur on a specific site, after irrigation there will be less water to carry as much salt or more.

To be accurate, this picture needs modification and refinement. For today's purpose, however, it suffices to generalize that irrigation agriculture cannot be maintained over time unless there is provision for drainage to carry away accumulated salts. This drainage water needs to go someplace, and the natural place is the ocean. The salts in the ocean, typically 35,000 mg/L, were derived from the soils and rocks on the continent and transported to the ocean by rivers. Irrigation speeds up this natural process somewhat.

Not all irrigated regions have an outlet to the sea. The Dead Sea between Jordan and Israel, the Great Salt Lake in Utah and the Salton Sea in Southern California are examples of sinks, of bodies of water that accumulate salts as the water evaporates. When first formed, these inland seas have substantial biological value as lakes for fish, birds and other animals, and as an oasis for the growth of vegetation. As they gradually become more saline, they lose some of their value, eventually becoming "dead".

Whether one transports drainage water via water courses to the ocean, or disposes of it into sinks, it is clear that there is a cost associated in values foregone. Thus, the question of sustainability has a two-fold answer. We can manage irrigation enterprises in a sustainable manner; however, we must be willing to pay a price in other values foregone. We might reword the question: Do we choose to sustain irrigated agriculture?

The discovery of selenium at Kesterson--and the recognition since of the presence of other trace elements at toxic concentrations there and

elsewhere--does not change the above scenario philosophically. It does make it more complicated in detail and it also makes the question posed more pressing: Do we choose to pay the cost of irrigation?

Structuring the problem solving process.

An important function of the Committee was to provide guidance (or possibly moral support) to the officials responsible for the San Joaquin Valley Interagency Drainage Program, so that their investigations would be scientifically sound, comprehensive yet focused, relatively efficient and, above all, defensible and creditable. It is not often that five (or more) agencies, each with different missions, and different clienteles and different institutional memories are asked to work together as one in a tight time frame. It would be easy, but not constructive, to point to actions that could have been taken earlier, better or should have been avoided. It is worth noting that, working under difficult circumstances, the program managers and their staffs responded creditably and responsibly to the challenge they faced.

Some of the advice provided, and some of the thoughts presented here, may seem obvious and even trite. Many of us might agree with that perception, were it not that experience taught us differently.

The starting point in tackling complex environmental issues is problem definition. As a problem is first recognized, it is crucial that substantial effort be devoted to this phase. To illustrate, during the Committee's first meeting, the recurring question was: What is the problem? Providing a safe haven for birds on the Kesterson ponds? Saving irrigation agriculture in the area draining to Kesterson? Defining the geochemical processes that led to the situation? Meeting the letter of the law? Resolving the drainage problems for Southern California?

Avoiding adverse effects on wildlife from selenium? Why selenium? Why not boron, arsenic, molybdenum?

There are several obvious reasons for wanting to define the problem, even though one often tends to search for a solution without knowing what the solution is to solve. A most important reason for insisting on explicit problem definition is the need for all parties, all vested interests, to communicate--if all can agree on a problem definition, much progress has been made. Another is that one cannot devise a data gathering protocol without specifying an objective.

One next needs to develop a protocol for information gathering and data assessment. Here we like to stress three separate points. First, it is recommended that a formal systems analysis framework be established up front. One needs to know what information is needed and how it will be put to use; furthermore, it is easier for civil engineers, agronomists, fish and wildlife specialists and economists to communicate if the framework for all communication is clearly established. Second, physical and biological data must be gathered and evaluated within a clearly established quality assurance, quality control protocol; only then will data be readily exchangeable and collectable, and only then will the results stand up to scientific scrutiny. Early in the present case, for example, it was evident that analytical techniques used by various groups for selenium determination were inconsistent and, obviously, in some cases, incorrect. Third, there needs to be a protocol for monitoring. As the project study develops, there is need for baseline data, but when one arrives at the stage of implementing solutions, one needs to know whether they are as effective as anticipated. The monitoring issue goes far beyond these two points and raises interesting dilemmas. It is difficult

to routinely monitor for problems that have not been identified; yet one needs to establish a system for collecting timeline data that can at least help alert knowledgeable specialists to potential problems.

An extremely important step is the identification and display of a wide range of potential options that can contribute to a solution. One is tempted to state that all options must be displayed and evaluated, but such completeness may be impractical. To illustrate, one possible solution to resolving irrigation-induced water quality problems might be to stop irrigating. It is inappropriate, in fact devastating to the process, to make an a priori determination that the U.S. Bureau of Reclamation (or the Soil Conservation Service, or...) is in the business of supporting irrigation and hence stopping irrigation is unacceptable. It is constructive to investigate the consequences of a stop to irrigation (or a reduction in irrigated area) and to determine the costs, as well as the benefits, of such an action. Similarly, one should not dismiss ocean disposal of drainage water because it is counter to State law; it may be appropriate to change the law. Again, the costs and benefits of ocean disposal should be determined.

All through the process described, it is important to maintain open communication, not only among program participants, but also with the affected public, broadly defined. One appropriate and necessary (but not sufficient) mechanisms for such communication is the establishment of a Public Advisory Committee, made up of representatives of various groups in society. Such a committee can be organized under State law or Federal law. It not only serves to avoid big surprises; it also is an excellent feedback mechanism to alert program managers to the interests of their clientele.

Institutional considerations

There is a tendency, in tackling problems such as irrigation drainage disposal, to search diligently for technical solutions while the institutions are considered fixed and unalterable. This is particularly true of managers of Federal and State agencies who are used to working within the constraints imposed on them by their agencies.

Our committee felt strongly that such an attitude cannot be defended. We argued that at least as much time and effort should be expended on potential institutional solutions as on technical solutions. Here, I define the word institution very broadly, to include organizations, laws, regulations, contracts and conventions.

For example, it does not seem rational to consider chemical treatment of drainage effluent, with or without additional subsidy, without also considering the impact of agricultural (crop price support) subsidies and water (Reclamation contract) subsidies. It seems appropriate to investigate both the local economic effect of discontinuing irrigation on a portion of the land contributing drainage and the regional and national economic effect of such an action. Such consideration, of necessity, would address questions of equity. One would expect a study of pricing of irrigation water, and of the possibility of water transfers to higher value uses. The issue of competing uses--instream values, duck clubs, water fowl habitat and certainly municipal use--with irrigation clearly must be addressed. To a significant extent, such comparisons and trade offs cannot be expressed readily in economic terms. Just the same, they cannot be ignored. Whether the approach used parallels the procedures of the Principles and Standard developed by the now defunct Water Resources Council is not important. That the issues be addressed expressly, is important.

Westwide studies

When the committee was organized, its task was focused on the immediate problem of water management in the San Joaquin Valley as it related to Kesterson Reservoir. From its beginning, however, the committee pondered the broader questions of irrigation induced drainage in arid regions, especially in closed basins. Thus, when the Department of Interior initiated its westwide reconnaissance survey referred to earlier, it was natural that the committee be asked to address questions of study design and implementation for this program as well. Indeed, in response to requests from Interior, committee members have spent substantial time and effort, both collectively and individually, in advising program managers in the development and execution of proposals for the 20-some studies initiated under this program.

For present purposes, it suffices to note that, in part because of experience gained in the San Joaquin Valley, numerous pitfalls were avoided. The three agencies primarily involved--Bureau of Reclamation, Fish and Wildlife Service, and Geological Survey--developed effective cooperative study teams in a short time frame that used comparable and defensible study proposals under guidance of a national, joint leadership team.

The conclusions reached by the committee as a result of the San Joaquin experience were not so much modified as reinforced by this broader--and still preliminary--look at other wildlife refuges fed by drainage water from federal projects.

Conclusions

Irrigation agriculture cannot avoid causing some adverse effects on the environment. The manner in and extent to which society wishes to sustain irrigation agriculture must be determined in an open forum. It is technically relatively easy to sustain irrigation indefinitely, if society so decides.

The discoveries at Kesterson have made this issue far more acute than it was previously. Besides the well understood issues of salinity, we now must recognize the potential problems related to trace elements that may, and in some cases will, reach concentrations toxic to biota. Kesterson should not be seen as an isolated incident, but as a harbinger of similar problems elsewhere.

Because of expanded populations, greater wealth and increased concern with natural values, agriculture can no longer take for granted that it will be given special status. Exemption from environmental regulation is (and should be) a thing of the past. Thus, irrigation in the future must complete on equal footing with other competitive uses for our water resources.

Resolving the complex issues that will arise, and in some cases have arisen already, requires organizational and technical skills that go beyond the experience of most existing institutions and agencies. The experience gained in the San Joaquin Valley should provide a number of useful lessons for the future.

These lessons include the need for strong program management, using a team representing diverse disciplinary expertise as well as often conflicting institutional interests; the need for scientific

credibility, which can be enhanced by a carefully developed QA/QC protocol; the need for a systems framework to facilitate communication among parties not often in close contact, as well as inclusions of disparate data sets; and the need for public participation in a formal manner.

In addition, it should be stressed that the widest possible range of potential solutions need be displayed and evaluated for careful comparison and that this range clearly must include institutional and market adjustments as well as technical fixes.

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# NONPOINT SOURCE POLLUTION FROM AGRICULTURAL DRAINAGE IN CALIFORNIA: DEFINING THE PROBLEM AND ADDRESSING THE NEED

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## INTRODUCTION

California has traditionally provided world leadership in agricultural and environmental resource management. However, the ability to manage this state's resources is being severely challenged by the mounting problems related to agricultural drainage. Pollution of surface and groundwater by residuals from agricultural production is occurring throughout California, with potentially serious effects on irrigated crops, aquatic life, and human health. Nonpoint source pollution from agricultural drainage in California is a complex issue with many dimensions. This paper provides an overview of the more significant aspects of this problem, and describes the role of the state's Agricultural Drainage Water Management Loan Program (Loan Program) in addressing the problem.

## I. DEFINING THE PROBLEM - NONPOINT SOURCE POLLUTION FROM AGRICULTURAL DRAINAGE WATER

The nonpoint source pollutants causing water quality degradation include both naturally-occurring substances, such as sediments, salts, and trace elements, and man-made chemicals, such as fertilizers and pesticides. The salinity problem has existed in California for more than 100 years. Problems with fertilizers and pesticides have developed more recently. The pesticide problem became widely recognized only in the 1960's and 1970's when DDT and other pesticides were found to cause death and reproductive failure in birds and fish. Problems with trace elements, other than boron, became more widely known only in the early 1980's when waterfowl deaths and deformities were discovered at Kesterson Reservoir and traced to selenium in agricultural drainage water.

### NONPOINT SOURCE POLLUTION FROM AGRICULTURAL DRAINAGE WATER

Today, California farmers irrigate 9.5 million acres using surface water and groundwater resources. A significant part of the applied water, however, is not utilized by the crop and becomes drainage water. It is discharged to streams, percolates to groundwater aquifers, or becomes perched near the surface above shallow confining layers. The water quality impacts of this drainage water are felt in three major areas: irrigated agriculture, aquatic life and the environment, and human health.

## Pollution Problems Affecting Irrigated Agriculture

The major pollution problems affecting irrigated crops are the drainage and salinity problems in the San Joaquin Valley and Colorado River Basin. By 1984, approximately 2.2 million of the 5.6 million irrigated acres in the San Joaquin Valley had been affected by salinity (Backlund and Hoppes, 1984). Beck (1987) estimated that, without changes in drainage water management, agricultural production could be reduced as much as 80 percent in some parts of the valley. Approximately 200,000 of the 500,000 irrigated acres in the Imperial Valley have also been affected by salinity.

### *San Joaquin Valley*

Drainage in the San Joaquin Valley has been a continuing problem since irrigation became widely practiced there. With the construction of the Central Valley Project in the 1950's and the State Water Project in the 1960's, increased water deliveries to the western San Joaquin Valley accelerated the drainage and salinity problem. The San Luis Drain, originally planned to export salts out of the basin, was never completed due to environmental concerns and financing problems, and farmers were forced to look for other solutions to the drainage problem.

In much of the valley, particularly on the west side, drainage and salinity problems are associated with perched water tables where downward movement of water is restricted by a clay layer. Table 1 shows the acreages on the west side of the San Joaquin Valley affected by shallow water tables (Department of Water Resources, 1988). Over three-quarters of a million acres have water tables less than 5 feet below the surface.

Table 1. Acreages with Shallow Water Tables in the San Joaquin Valley

| | Water Table Depth | | | |
|---|---|---|---|---|
| Area | 0-5 Ft. | 5-10 Ft. | 10-20 Ft. | Total |
| Northern San Joaquin | 34,000 | 31,000 | 33,000 | 98,000 |
| Delta-Mendota | 309,000 | 78,000 | 42,000 | 429,000 |
| San Luis | 111,000 | 137,000 | 86,000 | 334,000 |
| Tulare Lake | 322,000 | 135,000 | 92,000 | 549,000 |
| Kern County | 65,000 | 108,000 | 173,000 | 346,000 |
| Total | 841,000 | 489,000 | 426,000 | 1,756,000 |

Subsurface, or "tile" drainage is widely used in an attempt to lower shallow water tables, and the drainage effluent is high in salts. Johnston (1977) reported drainage effluent from the northern part of the Delta-Mendota service area ranges from about 1,500 to 2,500 ppm TDS. TDS concentrations can range much higher in some areas, particularly where reuse is practiced.

In the Tulare Basin, more than 400,000 acres are salt-affected and over one million acres are threatened by rising water tables (Coppock, 1984). The Kern County Water Agency has predicted that annual damage from the high water table and salinity could exceed $45 million by the year 2005 (Johnston, 1977).

The Tulare Lake Basin is closed, with no outlet to the San Joaquin River except during exceptionally high flood periods. As a result, many water users constructed evaporation ponds for disposal of drainage water. There are currently 27 evaporation ponds in the San Joaquin and Tulare Lake Basins. They range in size from 10 to 1,800 acres and cover a total area of 7,160 acres. The ponds can be attractive to waterfowl and other wildlife. These impacts are discussed in the next section.

*Colorado River Basin*

Irrigation of the Colorado River Basin in southeastern California began in 1901 when Colorado River water was diverted to the region. Salinity problems developed in the Imperial and Palo Verde Valleys soon afterward, and by 1918, salinity had forced 50,000 acres out of production (Kelley and Nye, 1984). The problem worsened until tile drains were installed in the 1940's.

Drainage from the Imperial Valley is discharged to the Salton Sea. The Salton Sea was formed in 1905 by a breach in diversion works on the Colorado River. The Salton Sea has since been used as a drainage sump for agricultural, municipal and industrial waste waters, some from Mexico. Now, due to salinization from surface evaporation and a continuing influx of drainage water, it is developing serious salinity and toxicity problems, as well as a rising water level. Though not a natural water body, it has over the years developed extensive biota, which are now threatened by the increasing salinity and pollution. In addition, salt concentrations in the Colorado River water used for irrigation are increasing and it is projected that reduced yields and high operating costs could lead to serious economic damage for Imperial Valley farmers by the year 2000 (Kelley and Nye, 1984).

## Pollution Problems Affecting Aquatic Life and the Environment

*Salinity and Aquatic Life*

Drainage water adds 5 million tons of salt to the Salton Sea each year (Kelley and Nye, 1984), and the TDS concentration in the Salton Sea is now around 40,000 ppm, higher than the 35,000 ppm of seawater (Letey et al., 1986). The concentration is predicted to increase to 59,000 ppm by the year 2012. The high salinity threatens to kill the fish and end the Salton Sea sport fishing industry. If proposed water conservation measures (canal lining, reservoir regulation, and water reuse) are carried out, the salt concentration may increase due to lack of dilution to 96,000 ppm by 2012 (Black, 1983).

*Trace Elements and Aquatic Life*

The most significant trace element from agricultural drainage affecting aquatic life is selenium. We became acutely aware of the impacts of selenium on wildlife in 1983 when waterfowl deaths and deformities were observed at Kesterson Reservoir and traced to selenium in agricultural drainage water.

San Joaquin Valley. Kesterson Reservoir has since been the focus of much research and debate. In one study, the U.S. Department of Interior (1985) found 40 percent of the bird nests had at least one dead embryo, and 20 percent of the chicks were deformed. Many other studies have documented similar findings. As a result, importation of drainage water to Kesterson terminated in 1986.

The average selenium concentration in the San Luis Drain used to supply Kesterson Reservoir was about 300 parts per billion (ppb). However, fish and wildlife have been found to bioaccumulate selenium to much higher levels than that found in their environment. Concentrations up to 283,000 ppb in fish and 110,000 ppb in eggs of aquatic birds have been reported.

The soils of the west side of the San Joaquin Valley are of marine origin and contain significant amounts of selenium. Drainage waters from the west side are generally quite high in selenium with respect to regulatory criteria. Concentrations of selenium in shallow groundwaters have been observed as high as 4,400 ppb (Deveral et al., 1984).

Concerns over trace elements in the Central Valley are not limited to Kesterson Reservoir. Other wildlife refuges and wetlands exist in the region. Monitoring in the Grasslands Water District, Volta Wildlife Area, Kern Wildlife Refuge, and other areas is continuing in an effort to identify the regional scope of the problem. These areas represent crucial habitat for migratory birds in the Pacific Flyway.

Evaporation ponds used for disposal of agricultural drainage water may also be harmful to wildlife. Selenium, arsenic, molybdenum and other trace elements are being concentrated to very high levels in the ponds, and problems similar to those at Kesterson Reservoir are beginning to occur. The U.S. Fish and Wildlife Service (1988) recently found deformed embryos of 5 waterfowl species near Tulare Basin evaporation ponds. Near one pond, the frequency of deformities in ducks was much higher than at Kesterson Reservoir. The cause of the deformities is not yet clear.

Various methods are being tried to make evaporation ponds unattractive to wildlife. However, in view of the sequence of problems encountered so far in identifying suitable means for disposal of drainage water, the Central Valley Regional Water Quality Control Board (Regional Board) and the Department of Fish and Game are taking a measured approach in responding to the situation. The Regional Board is currently undertaking an environmental impact analysis to address the cumulative effects of evaporation basins.

Other elements besides selenium are of concern too. Arsenic, cadmium, chromium, manganese, and molybdenum have been found in concentrations above

levels known to be toxic to aquatic life, or are being biomagnified in the food chain (Letey et al.,1986, and California Department of Water Resources, 1986).

Recent sampling by the California Central Valley Regional Board revealed elevated concentrations of uranium in agricultural drainage water, up to 1,200 ppb (Westcot et al., 1988). The maximum concentration in evaporation ponds was 11,000 ppb. About 45 percent of the samples from the ponds exceeded 1,000 ppb. The Regional Board cautioned that the presence of uranium in such high concentrations might indicate the presence of the more hazardous radium isotope and that radium concentrations should be evaluated.

Colorado River Basin. In the Salton Sea National Wildlife Refuge, selenium appears to be accumulating in tissues of wintering waterfowl. However, there have been no reports of bird deaths or abnormalities that can be linked directly to selenium. In 1985, selenium levels in Salton Sea fish were the highest in the state at 6,200 ppb (State Board, 1987).

*Pesticides and Aquatic Life*

The use of inorganic chemicals for control of agricultural pests began in California in the 1880's (Smith, 1946). These substances include: arsenic, copper, sulfur, and mercury, and compounds produced by certain plants, such as pyrethrum and nicotine. The use of man-made organic chemicals began in 1922 when paradichlorobenzene was applied as a soil fumigant. However, the major development of organic pesticides began in the 1940's.

In the 1960's and 1970's it was found that some chlorinated hydrocarbon insecticides were persistent in the environment and were causing death and reproductive failure among birds and other wildlife. Some of the problems occurred through direct contact with the insecticides or contamination of food sources. Later it was found that agricultural pesticides could be carried in the surface runoff from irrigated fields, either dissolved in the water (typical for organophosphates) or adsorbed on soil sediments (typical for chlorinated hydrocarbons). The pesticide residues, in some instances, killed fish and also birds that ate the fish. For example, studies of the effects of pesticides on fish-eating birds at wildlife refuges in the Klamath Basin area began in 1960 when a die-off of birds was observed (Pillmore, 1961). The deaths were found to be caused by agricultural drainage containing toxaphene and endrin (Godsill and Johnson, 1968, and Kieth, 1966).

Very large quantities of pesticides are used in California. Contamination of surface waters by various pesticides is found in virtually every area of the state. The California Department of Food and Agriculture (CDFA) Pesticide Use Report for 1986 lists over 440 distinct pesticides applied in California, with a total use in that year of 86 million pounds of active ingredients (CDFA, 1986). Mandatory pesticide use reporting is limited to licensed applicators, and it has been estimated by CDFA that the actual total use of pesticides in the state may be three times higher than the reported use figures, i.e. around 250 million pounds in 1986. Reports by various state and federal regulatory agencies indicate that findings of pesticide contamination in state waters are increasing.

The best-known insecticide is DDT. Its use has been banned nationwide since 1972, yet the State Board's Toxic Substances Monitoring Program (TSMP) has detected DDT and related compounds in an increasing number of locations in recent years.

## Pollution Problems Affecting Human Health

Potential health hazards from the use of groundwater for domestic purposes occur because of high concentrations of nitrates and pesticides in many wells throughout the state.

### *Nitrates and Human Health*

Nitrogen occurs in a variety of forms in agricultural fields: elemental nitrogen and nitrogen oxide gases, nitrate, nitrite, ammonia, cyanide, and organic nitrogen. The main form of nitrogen in chemical fertilizers is nitrate, which is readily soluble in water. Decomposition of animal wastes produces nitrate as well as smaller amounts of nitrite and ammonia. Nitrite and ammonia are less stable in the soil, however, and do not tend to move very far below the surface. Therefore, the main groundwater nitrogen pollutant related to agriculture is nitrate.

In the early days of California agriculture, soils were very fertile and yields were exceptionally high. After about 1900, however, yields began to drop off and farmers began to apply commercial fertilizers and animal manures. The use of fertilizer increased dramatically between 1900 and 1940, although the actual amounts used were still small.

Since the 1940's, the use of inorganic nitrogen fertilizer on crops has increased greatly and crop yields have increased dramatically as a result. However, an estimated 35 percent of the applied nitrogen runs off to surface water or leaches into groundwater (Anton et al., 1988). In recent years it has been recognized that high nitrogen use has resulted in a serious problem of nitrogen pollution of groundwater in many areas.

Nitrate itself is relatively nontoxic to humans. The health hazard from nitrate occurs when ingested nitrate is converted to nitrite in the body. Nitrite can react with other substances to produce carcinogenic compounds (nitrosamines). Although several studies have shown correlations between incidence of cancer and exposure to nitrite (in food), no biological evidence exists to directly prove nitrite causes cancer in humans. Nitrates in water have also been implicated in birth defects but, again, direct linkage has not been proven.

The most notable effect on human health of nitrates in drinking water is infant methemoglobinemia (blue-baby syndrome), which occurs when nitrite is formed from nitrate in the stomach and combines with hemoglobin, reducing the oxygen-carrying capacity of the blood. Infants up to three months of age are especially susceptible. Adults are not normally affected.

Based on the relationship between nitrate in drinking water and infant methemoglobinemia, the water quality standard for drinking water supplies has been set by the U.S. Public Health Service at 45 ppm nitrate or 10 ppm nitrate-nitrogen. Some private wells on farms in California have been found to contain several hundred ppm (Coordinating Committee for Scientific and Technical Assessments of Environmental Pollutants, 1978).

In terms of the quantity of water affected, nitrate contamination (from both fertilizers and animal wastes) may pose a greater threat to drinking water than pesticides and other toxic organic compounds. For example, the Metropolitan Water District of Southern California (1987) estimates that it is losing 4 percent of its drinking water supply annually to nitrates and total dissolved solids (primarily nitrate) compared with less than 0.5 percent lost because of toxic organics. Because it may take up to 60 years for changes in nitrogen applications to affect groundwater nitrogen levels, the problem may get much worse. Nitrate contamination occurs statewide.

*Pesticides and Human Health*

A recent State Board assessment cites over 2,900 verified incidents of groundwater contamination by pesticides in 28 counties, including over 50 distinct pesticide compounds (Cohen and Bowes, 1984). About one-half of the contamination incidents were caused by point sources such as leaks and spills.

Table 2 is a summary of a 1986 CDFA pesticide contamination survey of over 8000 wells throughout the state (Ames et al., 1987, and Brown et al., 1986). Based on the survey, 14 counties were identified as having 5 or more wells contaminated by pesticide residues.

Table 2. California Department of Food and Agriculture 1986 inventory of wells with pesticide contamination.

| County | Number of Wells | Major Contaminants |
|---|---|---|
| Del Norte | 41 | Aldicarb, 1,2-D |
| Fresno | 1,375 | DBCP |
| Glenn | 46 | Atrazine, Prometon, Simazine |
| Kern | 70 | DBCP, EDB, 1,2-D |
| Kings | 6 | DBCP |
| Los Angeles | 38 | Atrazine, Simazine |
| Madera | 5 | DBCP |
| Merced | 282 | DBCP, EDB, 1,2-D |
| Riverside | 35 | DBCP, Simazine |
| San Bernardino | 64 | DBCP |
| San Joaquin | 93 | DBCP, 1,2-D |
| Stanislaus | 115 | DBCP |
| Sutter | 14 | DBCP |
| Tulare | 108 | DBCP |

While numerous pesticides have been detected in groundwater, CDFA has concluded that there is only enough evidence to associate 10 pesticides or related compounds (i.e. metabolites) found in groundwater samples with general nonpoint source agricultural applications. The compounds implicated are aldicarb, aldicarb sulfone, atrazine, bromacil, dibromochloropropane (DBCP), diuron, EDB, prometon, simazine, and 1,2-D. Of these compounds, aldicarb, atrazine, bromacil, diuron, prometon, and simazine are currently licensed for use as active pesticide ingredients. Other compounds may be present (alachlor, carbofuran, dimethoate, molinate and its metabolite molinate sulfoxide, and others), but insufficient information is available to link these to general agricultural applications (versus improper disposal, etc.). The contaminant of greatest concern from general agricultural applications is DBCP.

DBCP is a nematicide applied as a soil fumigant. In a recent State Board study (Cohen and Bowes, 1984), nearly 2,500 drinking water wells (nearly one-third of those tested), were contaminated with DBCP. As a result, about 700,000 people may have been exposed to DBCP. The number of contamination incidents has continued to increase as more aggressive monitoring activities are implemented in an attempt to define the scope of the problem.

DBCP has been identified as a potent animal carcinogen and is therefore a suspected human carcinogen. Evidence indicates that it also causes sterility in human males, as well as birth defects. The California Department of Health Services (DHS) has concluded (1980) that it is unlikely DBCP can be used as a soil fumigant without contaminating groundwater, and that the related compounds dichloropropane, dichloropropene, EDB, and methyl bromide might cause similar problems.

The San Joaquin Valley is now recognized to possess the most widespread groundwater contamination problem from pesticides in the nation, primarily from DBCP (Russell et al., 1987). For example, DBCP has been found in 23.8 percent of the wells tested in Tulare County, 15.9 percent of the wells in Kern County, and 43.4 percent of the wells in Fresno County (Fischer and Reid, 1986). It has been estimated that the total groundwater contaminated by DBCP in the San Joaquin Valley is about 30 million acre feet, or approximately 25 percent of the total usable groundwater in the entire valley.

DBCP concentrations regularly exceed the DHS action level of 1 part per billion (ppb) in Fresno and Kern Counties. DHS adopted its current action level of 1 ppb in 1978, before information on the carcinogenicity of DBCP was available. EPA has since estimated the lifetime cancer risk of consuming water with 1 ppb DBCP as 150 cases per million people. This risk is unacceptably high. DHS policy is that carcinogens in drinking water should not exceed a level causing a cancer risk of one case per million people. DHS is currently in the process of adopting an action level of 0.2 ppb for DBCP.

DBCP contamination also affects large quantities of groundwater in Orange, Riverside, and San Bernardino Counties.

The use of DBCP was suspended in 1977, yet new incidents of well contamination are being identified. Cohen (1986) estimated the cumulative use of DBCP in California from 1955 to 1977 to be in excess of 50 million pounds. In light of the high use rates, direct soil injection as a means of application, and an estimated soil half-life in excess of 100 years, groundwater contamination problems may persist for decades to come.

## II. ADDRESSING THE NEED - THE AGRICULTURAL DRAINAGE WATER MANAGEMENT LOAN PROGRAM

### BACKGROUND

The Agricultural Drainage Water Management Loan Program (Loan Program) was authorized by the Water Conservation and Water Quality Bond Law of 1986 (Bond Law) for the purpose of mitigating the adverse impacts of agricultural drainage. The Bond Law authorizes a total of $75 million for low-interest loans to public agencies for agricultural drainage water management projects. Loans may be up to $20 million with an interest rate set at fifty percent of the interest rate paid by the state on the most recent sale of state general obligation bonds. The current interest rate for loans is approximately 3.5 percent. Loans of up to $100,000 may also be issued for feasibility studies of projects potentially eligible for funding. The repayment term may extend up to twenty years.

The primary eligibility criterion for participation in the Loan Program is that there must be pollution or a threat to pollution of the waters of the state from agricultural drainage. Treatment, storage, or disposal facilities for agricultural drainage water may be purchased or constructed. Engineering costs for design and construction, as will as land purchase and right-of-way costs are eligible for reimbursement. Some specific facilities identified in the Bond Law are surface impoundments (including evaporation ponds), conveyance facilities, treatment works (including ion-exchange and desalting facilities), and injection wells.

### TYPES OF PROJECTS

The Loan Program is administered by the California State Water Resources Control Board (State Board). To date, twenty applications have been received for construction of facilities, and five applications for feasibility studies. The twenty-five projects can be broadly classified into five categories as follows:

1. Disposal projects - These include evaporation ponds and deepwell injection facilities. Loan applications have been received for twelve disposal projects, including three inactive projects which may be developed as either disposal or selenium removal projects.

2. Selenium removal projects - These may involve physical/chemical processes or biological processes. Loan applications have been received for two selenium removal projects.

3. Groundwater cleanup projects - These may involve desalting technology, nitrate removal, or treatment for DBCP. There are five active projects in this category. All will produce potable quality water.

4. Drainage management projects - These may achieve pollution control through means other than the construction of treatment or disposal facilities. Water quality objectives may be achieved by primarily operational or managerial procedures. There is one project in this category.

5. Feasibility studies - These may include studies of projects potentially eligible for funding in any category discussed above, or may be investigations of drainage problems without fixed solutions. There are five projects in this category.

Table 3 is a summary of the twenty-five projects in the Loan Program.

## Disposal Projects - Lost Hills Water District and Westlands Water District

Disposal projects include evaporation ponds and deepwell injection facilities. An example of the former is the Lost Hills Water District project in the Tulare Lake Basin. This project consists of the acquisition and construction of approximately 683 acres of evaporation ponds for the disposal of subsurface drainage water. Because of the environmentally sensitive nature of this project, the State Board imposed a number of loan conditions upon the district to reduce any potential adverse environmental impacts of the ponds. These include monitoring and data collection requirements, wildlife control measures, mitigation and closure plans, and a detailed water balance and water conservation program. The primary focus of these requirements is to assure that toxic constituents in the drainage water (especially selenium) will not reach hazardous levels as specified by the Toxic Pits Cleanup Act of 1984. Loan funding is being withheld from the district until these items have been completed to the satisfaction of the State Board.

Another type of disposal project is Westlands Water District's one mgd pilot deepwell injection project. This project is located in the San Joaquin Valley approximately thirty-five miles west of Fresno. Subsurface agricultural drainage water, formerly discharged to Kesterson Reservoir via the San Luis Drain, will be injected into deep saline aquifers approximately a mile and a half below the surface. This depth is well below any usable source of drinking water and should pose no threat to beneficial uses. If successful, the district plans to develop a larger scale facility with several injection wells. They currently have a loan application with the State Board for a nine mgd project. Several other agencies in the San Joaquin Valley are monitoring the progress of the Westlands' facility prior to developing disposal projects of their own.

Table 3. Summary of projects in the Agricultural Drainage Water Management Loan Program.

| Agency | Category[1] | Loan Request $1000[2] | Project Description | Project Status[3] |
|---|---|---|---|---|
| Lost Hills Water District | 1 | 2,670 | Phase 1 construction and aquisition of 683 acres of of evaporation ponds in the Tulare Lake Basin. | Board approval obtained with conditions. Loan contract pending fulfillment of loan conditions. |
| Imperial Irrigation District | 1 | 250 | Design and construction of a pilot ten-acre evaporation pond to evaluate the feasibility of a large scale evaporation pond system for Salton Sea water. | Board approved 8/88, Legislature approved 8/88. |
| Westlands Water District | 1 | 1,498 | Design and construction of a prototype one mgd deepwell injection facility for disposal of agricultural drain water. | Board approved 8/88, Legislature approved 8/88. |
| Tulare Lake Drainage District | 1 | 1,000 | Design and construction of a 715-acre evaporation pond facility for disposal of agricultural drain water. | Board approved 8/88 with loan condition, Legislature approved 8/88, loan contract pending. |
| Westlands Water District | 1 | 16,522 | Phase 2 design and construction of a nine mgd deepwell injection facility for disposal of agricultural drain water. | Inactive |
| Reclamation District No. 999 | 1 | 500 | Design and construction of drainage improvement facilities for control of shallow water table and water quality. | Board approved 8/88, Legislature approved 8/88, loan funds disbursed 6/89. |
| Broadview Water District | 1,2[4] | 5,000 | Design and construction of a 3.9 mgd selenium removal or deepwell injection facility for disposal of agricultural drain water. | Inactive |
| Charleston Drainage District | 1,2[4] | 1,000 | Design and construction of a 0.9 mgd selenium removal or deepwell injection facility for disposal of agricultural drain water. | Inactive |

Table 3. (continued)

| Agency | Category[1] | Loan Request $1000[2] | Project Description | Project Status[3] |
|---|---|---|---|---|
| Pacheco Water District | 1,2[4] | 2,000 | Design and construction of a 1.9 mgd selenium removal or deepwell injection facility for disposal of agricultural drain water. | Inactive |
| Lost Hills Water District | 1 | 3,049 | Phase 2 design and construction of an expanded evaporation pond and drainage system for disposal of 4.1 mgd of agricultural drainage. | Inactive |
| Dudley Ridge Water District South | 1 | 900 | Design and construction of a 0.6 mgd drainage and evaporation pond system for disposal of agricultural drain water. | Inactive |
| Dudley Ridge Water District North | 1 | 1,128 | Design and construction of a 1.25 mgd drainage and evaporation pond system for disposal of agricultural drain water. | Inactive |
| Westlands Water District | 2 | 1,198 | Design and construction of a 0.5 mgd prototype selenium removal facility using a biological process. | Inactive |
| Panoche Drainage District | 2 | 500 | Phase 2 design and construction of a 0.27 mgd selenium removal facility using an iron filings process. | Inactive |
| Santa Ana Watershed Project Authority | 3 | 15,051 | Design and construction of a desalting and DBCP removal facility for groundwater in the Arlington Basin. | Loan funds disbursed 11/88, project under construction. |
| City of Redlands | 3 | 2,750 | Design and construction of a six mgd activated carbon wellhead treatment facility for the removal of DBCP from groundwater. | Board approved 8/88, Legislature approved 8/88, loan contract signed. |
| Orange County Water District | 3 | 18,008 | Design and construction of salinity and nitrate removal facilities for contaminated groundwater in the Irvine area. | Project is in the planning stage. |

Table 3. (continued)

| Agency | Category[1] | Loan Request $1000[2] | Project Description | Project Status[3] |
|---|---|---|---|---|
| City of Riverside | 3 | 14,400 | Design and construction of wellhead treatment facilities for removal of DBCP. | Project is in the planning stage. |
| Santa Ana Watershed Project Authority | 3 | 15,200 | Design and construction of a 5.3 mgd salinity and nitrate removal facility for groundwater in the lower Chino Basin. | Project is in the planning stage. |
| Panoche Drainage District | 4 | 2,000 | Development of a drainage water by-pass system around the Grasslands Water District using the San Luis Drain for a portion of the facilities | Project is in the planning stage. |
| Panoche Drainage District | 5 | 100 | Feasibility study of an iron filings process for removal of selenium from drain water. | Loan funds disbursed 5/89, project is under construction. |
| United Water Conservation District | 5 | 75 | Feasibility study to determine the source of, and solutions to, a high-nitrate groundwater problem. | Board approved 8/88, Legislature approved 8/88, loan contract signed. |
| Buena Vista Water Storage District | 5 | 100 | Groundwater monitoring and feasibility study. | Planning is complete, Board approval pending. |
| Gustine Drainage District | 5 | 100 | Groundwater monitoring and feasibility study. | Loan funds disbursed 4/89, monitoring program in progress. |
| Colusa County Zone of Benefit 2 | 5 | 100 | Feasibility study to identify a drainage plan for groundwater containing high concentrations of trace elements. | Inactive |

[1] Category 1 - Disposal projects, 2 - Selenium removal projects, 3 - Groundwater cleanup projects, 4 - Drainage management projects, 5 - Feasibility studies

[2] Capital cost of project may exceed loan amount.

[3] Inactive projects are not likely to proceed in 1989-90.

[4] Project may be developed as a disposal or selenium removal facility.

## Selenium Removal Projects - Panoche Drainage District

The only active selenium removal project in the Loan Program is Panoche Drainage District's pilot iron filings plant. While this project is technically on the record as a feasibility study, it is conducted as a small demonstration facility and is a good example of this type of project. Laboratory and bench-scale testing have shown that iron filings can remove a large percentage of the selenium in agricultural drainage water. Panoche is conducting a field study of a process developed by Harza Engineering using this principle. The process hasn't been proven on a large scale and so is not ready for widespread application. The district has an application in to the State Board for an expanded facility when the results of their pilot study are known. As with the Westlands' project, other agencies in the San Joaquin Valley are monitoring the Panoche project prior to developing treatment and/or disposal projects of their own.

## Groundwater Cleanup Projects - Santa Ana Watershed Project Authority

There are currently five active projects in the Loan Program in the groundwater cleanup and reclamation category. The use of loan funds for this purpose was not envisioned when the Bond Law was originally conceived, however the language of the Bond Law seems to accommodate them where the source of pollution can be traced to agricultural drainage. Primary contaminants include salinity, nitrates and DBCP.

An example of this type of project is the desalting and DBCP removal facility currently being built by the Santa Ana Watershed Project Authority in Riverside County. Groundwater in the Arlington Sub-basin has been polluted from a long history of agricultural practices in this area, and is unusable as a source of domestic supply. The project will pump approximately six mgd from the aquifer through a series of five extraction wells. Desalting will take place in a nearby reverse osmosis facility. DBCP removal will be accomplished with treatment by granular activated carbon. Waste brines will be discharged to the ocean via the Santa Ana Regional Interceptor, and product water will be sold to the Metropolitan Water District of Southern California.

## Drainage Water Management Projects - United Water Conservation District

Drainage water management projects may achieve pollution control and water quality objectives through operational or non-structural approaches to drainage problems. An example of this type of project is United Water Conservation District's groundwater nitrate study in Ventura County. The Montalvo Forebay Groundwater Basin has been polluted by nitrates in excess of the drinking water standard of 45 mg/l. The study is examining a number of alternatives for pollution control, including blending, exchanges, etc.

## Feasibility Studies - Gustine Drainage District

The last category is feasibility studies. These may include studies of projects in any category discussed previously, or may be investigations of

drainage problems without an identified solution. An example of the latter is Gustine Drainage District in the western San Joaquin Valley which is conducting an intensive groundwater monitoring program to determine the sources of, and solutions to, a shallow water table within the district.

## CONCLUSIONS AND RECOMMENDATIONS

1. Reduction in the volume of drainage water is generally considered to be the most feasible near-term solution to the drainage problem in the Central Valley and the Imperial and Coachella Valleys. A number of recent studies have pointed out the need for better water management to achieve drainage reduction (California Regional Water Quality Control Board, 1988). Many obstacles exist, however, to improving water management including relatively abundant water supplies at low cost, lack of information and skills, and farm/institutional constraints.

2. The disposal problem for poor quality tile drainage water has raised some difficult legal and policy questions. For example, in some areas there is considerable lateral movement of shallow groundwater from higher to lower elevations. Should the farmers at lower elevations with tile drainage systems be held responsible for poor quality drainage water originating from up-slope farms? In one case, the tile system under a 640 acre area continued to produce drainage water during a season in which the land was neither planted nor irrigated. In another example, the selenium in one farm evaporation pond has become concentrated to the point that the pond now faces regulation under the California Toxic Pits Cleanup Act of 1984. Cleaning of the pond would cost 30-50 times the value of the farm. In recognition of the possible consequences of applying the Toxic Pits Cleanup Act to agricultural evaporation ponds, the California Legislature passed Assembly Bill 2875 in 1988 which provides exemptions for agricultural evaporation ponds meeting certain conditions.

3. The persistent nature of some pesticides in the environment, such as DBCP, is likely to cause new cases of contamination for years to come, even though the use of such compounds has been banned for many years.

4. It is too early to assess the effectiveness of the Loan Program in the control of agricultural drainage problems. It presently takes from one to two years for an agency to receive loan funds from the date of first application. At this time loan funds have been disbursed for four of the twenty-five projects, and none of these have completed construction. Preliminary indications are, however, that these will be successful projects. Delays in project funding can be attributed to four causes:

   * A lengthy application process.

   * Caution about taking on debt, even at low interest rates, without proven tangible benefit.

   * Unproven technology. Pilot-scale projects may need to be completed prior to development of full-scale facilities.

* Uncertainty about government regulations. Agencies may be reluctant to design and construct projects when regulatory standards are in flux. Examples include the pending adoption of new discharge standards for the San Joaquin River, and the uncertainty over allowable selenium concentrations in the invertebrate food chain in evaporation ponds.

5. Table 4 is a fiscal summary of the fifteen active projects in the Loan Program. There are insufficient funds for the inactive projects which are waiting for the results of feasibility studies or pilot-scale projects before implementing larger scale facilities.

6. The Loan Program is limited in the type of projects it can fund. "Drainage water management units," as the term is used in the authorizing legislation, means land and facilities for the treatment, storage, or disposal of agricultural drainage water. A new definition of this term is needed to include projects which achieve water quality objectives through control of drainage water at the source, and through non-traditional and innovative technologies.

7. Institutional requirements and regulatory standards will play a major role in the demand for loans for drainage improvement projects. Many agencies are reluctant to implement costly drainage improvement projects without a regulatory incentive or mandate to do so. Examples include the Maximum Contaminant Level (MCL) for DBCP in public drinking water supplies of 1.0 ppb (a reduction in the MCL to 0.2 ppb is pending), the primary drinking water standards for other contaminants such as nitrates, and various water quality objectives.

Production of food and fiber provides a strong base for California's economy. However, if we are to maintain the agricultural industry and, at the same time, continue to provide the quality of life to which California's citizens are accustomed, we must minimize the long-term problems that are developing from high-production agriculture. Since irrigated agriculture claims 83 percent of the total state water use, the objective of maintaining state water quality is no small or localized task. We are now beginning to recognize that continued intensive agricultural production will require much more careful management of soil and water resources than in the past. We also need to develop long-term solutions to the problems rather than "quick-fixes" that, in some cases, are not effective or have the potential of creating new problems. Long-term solutions will require a sustained effort in the areas of research, farm management, and government regulation.

Table 4. Summary of the Agricultural Drainage Water Account, June 1, 1989

| | DEBIT | BALANCE |
|---|---|---|
| Total Authorization | | $75,000,000 |
| Administrative Allowance | $3,750,000 | |
| Total Available for Loans | | $71,250,000 |
| Total Loans Approved by Board | $23,994,000 | |
| Uncommitted Funds | | $47,256,000 |
| Remaining 1988 Priority List Projects[1] | $15,200,000[2] | |
| Loan Requests Received in Response to 1989 Solicitation of Proposals | $35,508,000 | |

[1] Placed on Priority List 1/21/88

[2] Does not include nine inactive projects requesting $27,179,000

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WESTERN STATES WATER COUNCIL
NONPOINT SOURCE POLLUTION CONTROL WORKSHOP
TECHNICAL WORKSHOP: July 25-28, 1989

Wednesday, July 26, 1989, Afternoon

# AGRICULTURAL DRAINAGE TECHNICAL ISSUES FACING WATER AGENCIES

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## I. INTRODUCTION

Irrigated agriculture has become an indispensable part of the California economy. Inherent with the benefits of irrigated agriculture is the problem of managing the resulting saline drainage water that is generated in many irrigated areas. Clearly an economically feasible solution to the drainage problem that adequately protects the environment is imperative. In the process of seeking that solution, water agencies are confronting several technical agricultural drainage issues to ensure the future of irrigated agriculture. This paper serves to present an overview of these issues and the steps water agencies in the western San Joaquin Valley are taking to address them.

## II. BACKGROUND: THE PROBLEM

Without adequate drainage, economic losses for irrigated agriculture are inevitable. The problem is that in irrigated areas, saline ground water rises into the root zone of growing crops, resulting in reduced crop yields (soil productivity). In the western San Joaquin Valley, much of the soil is underlain with stratified clay layers that do not allow rapid, natural drainage of applied water. The water table throughout large areas of the Valley contains levels of dissolved salts and other common elements which may be toxic to agricultural crops and must be drained from the crop root zone. Today over 100,000 acres of land are drained in the Valley's west side. Additional land now needs drainage and more land will need it in the future. However, little additional land will be drained until an economically-sound and environmentally-safe management and disposal plan is developed.

## III. RELATED TECHNICAL ISSUES FACING WATER AGENCIES

As discussed above, continued viable farming of irrigated lands depends on adequate sub-surface drainage. The goal of maintaining adequate drainage in a practical way, while at the same time protecting the public health and the environment, presents four technical issues for water agencies: (1) the development of means of encouraging water conservation; (2) the development of adequate drainage water management strategies; (3) compliance with water quality requirements; and (4) the authority of water agencies to manage drainage water.

### A. DEVELOPMENT OF MEANS OF ENCOURAGING WATER CONSERVATION

Farmers and local water agencies in the San Joaquin Valley's west side recognize that the first step in solving the drainage problem is to reduce the amount of water that needs to be managed. The best way to reduce that volume is through on-farm water conservation. Water agencies are taking the following steps to encourage water conservation at both the on-farm and district levels.

(1) Westlands Water District is implementing an aggressive water conservation program designed to optimize water use and minimize contributions to the shallow ground water table.

(2) Westlands Water District and the Westside Resource Conservation District are cooperating in a grower assistance program to encourage investments in improved irrigation.

(3) Broadview, Firebaugh Canal, Pacheco and San Luis Water Districts and Panoche Drainage District have hired a water conservation coordinator to develop district-level water conservation plans.

(4) Broadview Water District is involved in a trial tiered-water-pricing program that will give growers financial incentives to reduce their drainage volumes.

(5) Panoche Drainage District and Broadview, Pacheco, San Luis and Firebaugh Canal Water Districts are developing drainage water management plans to control their drainage discharges.

### B. DEVELOPMENT OF ADEQUATE DRAINAGE WATER MANAGEMENT STRATEGIES

Although on-farm water conservation is an important step in reducing the volume of drainage water, conservation

alone will not solve the drainage problem. Measures need to be taken to treat and dispose of the drainage water that will still be generated. Water agencies in the western San Joaquin Valley alone have spent millions of dollars in the development of adequate drainage water management strategies. Examples of efforts in this area include:

(1) Westlands Water District is participating with Fresno State University, the State of California and other agencies in developing a field research center on the west side of the San Joaquin Valley. That center will provide a location for qualified researchers to investigate promising methods for drainage water treatment and disposal.

(2) Several water districts are looking into electrical cogeneration as a means of treating and disposing of drainage water. One process being explored involves using excess heat from natural gas turbine generators to consolidate and remove dissolved salts from the drainage water.

(3) Panoche Drainage District is involved in a pilot-level study to assess the use of iron filings to remove selenium from drainage water.

(4) Westlands Water District plans to construct a well into very deep saline strata for the disposal of drainage water.

## C. COMPLIANCE WITH WATER QUALITY REQUIREMENTS

Of course, strategies to manage agricultural drainage water must "fit" within the programs for water quality protection at all levels of government. The water quality concern in question is whether the discharge of agricultural drainage water to a receiving water body (such as a river) will cause an exceedance of a water quality objective or standard in the receiving water body.

Agricultural drainage is a classic example of a "nonpoint" source discharge (i.e., nondiscreet discharges from multiple sources). Since, to a large degree, the regulation of nonpoint sources is a new area of water quality regulation, one of the technical issues facing water agencies is the development of nonpoint source regulatory programs. Following is an overview of three nonpoint source policy areas which will have an impact on water agencies in California.

### 1. California's Nonpoint Source Management Plan

In 1988, the California Water Resources Control Board (the "State Board") developed and adopted its "Nonpoint Source Management Plan" (the "Plan") pursuant to Section 319 of the Federal Clean Water Act. In brief, the Plan calls for the State Board and the Regional Water Quality Control Boards (the

"Regional Boards") to address nonpoint source management concerns by using the following three management options:

a. voluntary implementation of Best Management Practices (BMPs);

b. regulatory-based encouragement of BMPs; and

c. effluent limitations.

The plan calls for the use of the least stringent option that successfully protects or restores water quality, with more stringent measures considered if timely improvements in beneficial use protection are not achieved. This plan is consistent with the U.S. Congress decision to move toward encouraging the use of BMPs as opposed to issuing individual discharge permits for water agencies and growers. This policy makes sense in light of the fact that nonpoint sources typically result from the action of several or numerous sources which are difficult to identify or quantify.

As the State and Regional Boards begin implementation of the Plan, water agencies in California can expect to see more State involvement in the already ongoing efforts to improve farm water management practices in order to reduce pollutant loadings to receiving water bodies.

2. Assessment and Ranking of Impacted Water Bodies

Also in 1988, the State Board developed two documents pursuant to Section 319 of the Federal Clean Water Act entitled the Nonpoint Source Problem Inventory (the "Inventory") and the Nonpoint Source Problem Assessment (the "Assessment"). The Inventory serves as a database of currently known nonpoint source problems in California. The Assessment presents an overview of nonpoint source problems in California as documented in the Inventory. The State Board plans to use this information in developing its "Clean Water Strategy".

The current version of the Inventory and Assessment are based on the best information that the State Board has at this time, and the State Board will be updating these documents on an ongoing basis. Local water agencies have commented to the State Board that, in future revisions to these documents, it would be appropriate to give further attention to the degree of risk posed by the water quality problems identified in the Inventory. The current version of the Inventory focuses on the number of exceedances of water quality standards as opposed to the degree of an exceedance or the basis of a standard (e.g., health protection). Thereby, the current version could equate a location posing a significant human health risk with a location posing a slight risk to wildlife or vegetation. The State Board has agreed with this comment. Providing such input into the State Board's ongoing development of its Clean Water

Strategy is another technical issue facing California water agencies.

3. Point of Application of Water Quality Objectives

Since the Spring of 1988, the State Board has been developing a Water Quality Control Policy to define the "Point of Application of Water Quality Objectives". The premise of the policy is that, if appropriate conditions are set forth, a mixing zone (i.e., a three-dimensional volume) should be granted between the location of the discharge and the "point" where water quality objectives and standards will be applied. The State Board plans to adopt the final version of this policy in February of 1990.

In the ongoing discussions regarding this policy, one of the fundamental questions has been how this policy should relate to nonpoint sources, including agricultural drainage. The final version of this policy, to the extent it applies to nonpoint sources, could have a significant impact on the regulation of agricultural drainage. Providing constructive input into the development of this policy is one of the technical issues now facing water agencies in California.

D. LOCAL AGENCY AUTHORITY TO MANAGE DRAINAGE WATER

A final issue facing local agencies in managing agricultural drainage waters is the question of whether water agencies have the authority to: (1) implement drainage water management programs; and (2) regulate the generation, collection, and disposition of drainage water with their own boundaries. Often, the authorizing statutes which created the districts in which drainage problems arise do not establish such specific authority.

For example, many water districts were created to purchase water from a state or federal project and deliver that water to growers within the districts. It is questionable whether those districts can force growers to comply with provisions of a drainage water management plan that the districts may create.

While there a few districts which have specific drainage management authority, the majority of the water districts do not have such authority. In situations where the districts do not have authority to enforce drainage management plans, cooperation between districts and individual growers is essential to the implementation of a drainage plan. Without such voluntary cooperation, it is unlikely that a successful drainage management plan will be developed or implemented.

It is important for state and federal regulatory agencies to recognize the important role of water agencies in developing successful Best Management Practices. It is also

important for the regulatory agencies to recognize the legal limitations which the districts face. Given these limitations, the cooperation of all involved groups is essential. Without extensive coordination, solutions are liable to be fragmented and incomplete. Moreover, for practical solutions to be implemented, the framework of laws and policies regulating the disposal of agricultural drainage water must incorporate sufficient flexibility to allow fiscally- and environmentally-sound programs developed by cooperative efforts to be implemented.

## IV. CONCLUSION

Irrigated agriculture has become an indispensable part of the California economy. Inherent with the benefits of irrigated agriculture is the problem of how to manage the resulting drainage water. Clearly a solution to the drainage problem that adequately protects the environment is imperative. Water agencies and growers in California are meeting this challenge by: (1) supporting research, improved water conservation and innovative drainage management programs; and (2) participating in the development and implementation of the State's Nonpoint Source Management Program and related policies.

# REGULATION OF AGRICULTURAL SUBSURFACE AND SURFACE DRAINAGE IN THE SAN JOAQUIN BASIN

William H. Crooks and Dennis W. Westcot[1]

Today we would like to share with you the types of problems that have been encountered from agricultural drainage water, both surface and subsurface, in the San Joaquin River Basin of California. These problems, although specific to this basin, are likely to be encountered in similar forms in other intensively irrigated basins. There are a number of options being implemented or considered to solve or minimize these problems.

## THE BASIN

The San Joaquin River Basin makes up a portion of the southern end of the Great Central Valley of California (Figure 1). It stretches southward from the Sacramento-San Joaquin Delta to the drainage divide between the San Joaquin and Kings Rivers near Fresno. The basin encompasses over 11,000 square miles between the crest of the Sierra Nevada and the crest of the Coast Range. The Sierra Nevada, where elevation often reaches 10,000 feet or above, is a major source of excellent quality surface water which originates from snowmelt. In addition to the San Joaquin River, three major tributaries, the Stanislaus, Tuolumne and Merced Rivers, flow into the San Joaquin River as it flows north into the Sacramento-San Joaquin Delta, one of the most productive estuaries in the world. Total annual runoff averages about 6,062,000 acre-feet. Water is also imported to the basin from the Sacramento River by means of the Delta-Mendota Canal. Water is also exported from the basin from the Stanislaus, Tuolumne and San Joaquin Rivers.

The valley floor portion of the basin has undergone extensive land development in the past 50 to 75 years. Irrigated agriculture constitutes the largest and most important use of land in the valley. Total irrigated acreage is 1,760,000; however, increasing urbanization of these lands is occurring.

## INTRODUCTION

The emphasis in water supply and water supply development in the San Joaquin River Basin is taking a major turn. Good quality supplies, which previously were plentiful and readily available, are becoming fully developed. Intense competition for the remaining finite supply is beginning to emerge. Because the remaining surface water supply is limited, there is increased attention on protecting this limited supply from any type of degradation which might reduce its usability or limit its development. Irrigated agriculture, being the largest user of water in the San Joaquin River Basin does have a significant impact on water quality and its usability for other purposes. The main causes of the impacts that result from irrigated agriculture appear to be fourfold:

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[1]Executive Officer and Chief, Agricultural Unit, respectively. California Regional Water Quality Control Board, Central Valley Region, Sacramento, California

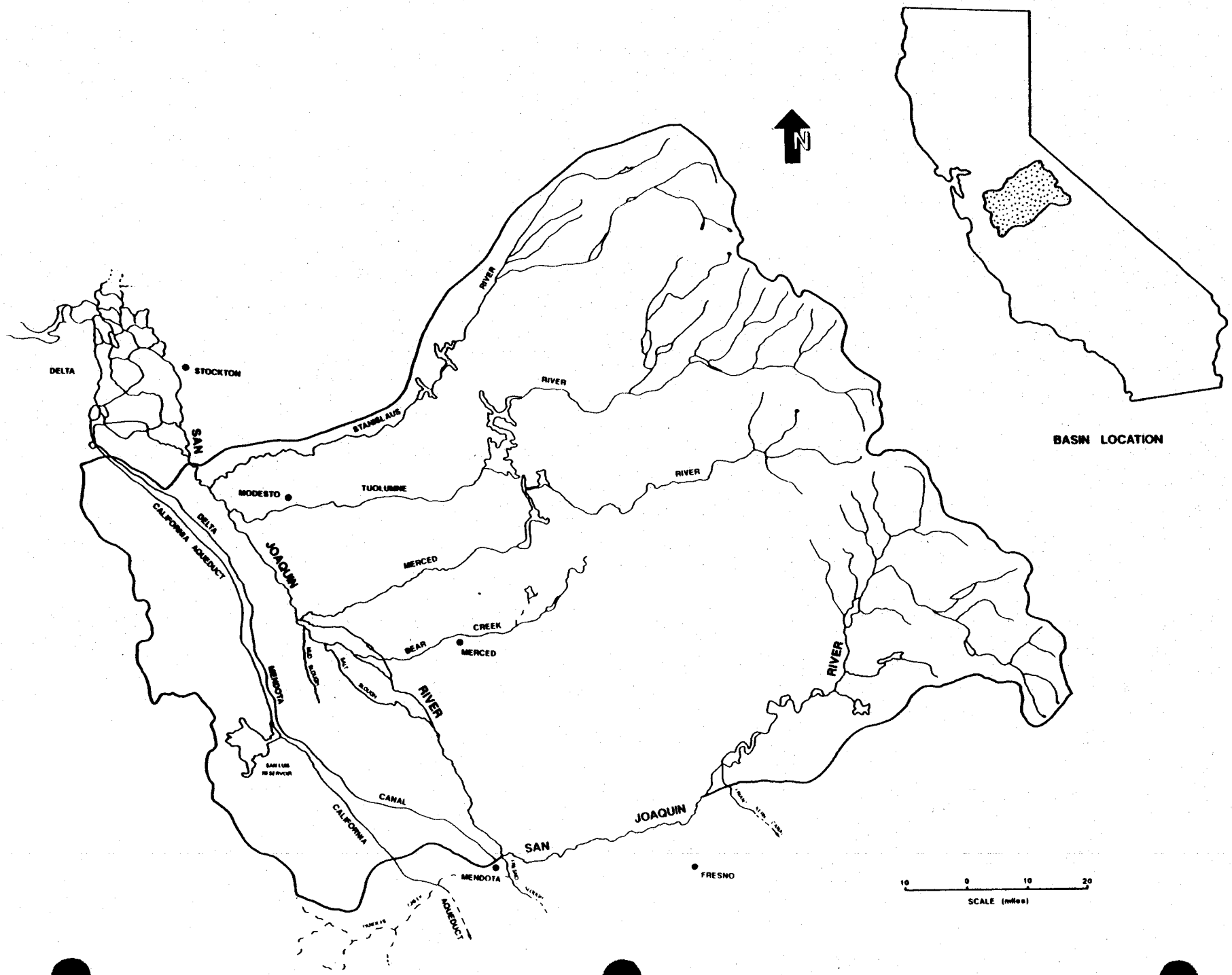


Figure 1 San Joaquin River Basin in the Central Valley of California

a. upstream diversions have reduced river flows and thus reduced the dilution capacity of the river for the remaining salts and other contaminants including those returning from irrigated agriculture;

b. water development has imported outside water supplies into new areas carrying with it significant new quantities of salt;

c. expanded irrigation development has resulted in more concentrated salt loads returning to the river from normal evapotranspirational processes as well as increased salt loads and other contaminants from subsurface drainage projects on new and existing irrigated land; and

d. surface water runoff from irrigated fields has carried toxics and other materials used on the fields into the surface water supplies.

Because the discharge of surface tailwater and subsurface drainage water are creating the greatest impact, initial efforts on controlling or reducing pollutant loads will be directed at these discharges.

We have found that both surface return water (tail water) and subsurface drainage may contain toxic constituents that require proper management to protect the beneficial uses of receiving waters. Pesticides and fertilizer materials are too often carried away from target fields in tail water while subsurface drainage, in addition to high salts, has been found to contain heavy metals and, occasionally, pesticides.

The regulation of agricultural surface and subsurface drainage water is more a resource management problem than the regulation of the classical waste stream from a city or industry. In developing controls, an important distinction is the waste source. Pesticide and fertilizer wastes, that are discharged to surface water, are produced at an identifiable location. When the regulation and control of pesticides and fertilizer runoff has not been effective, the option is still available to remove the source by restricting use of that material. The regulation of agricultural subsurface drainage water discharges is different. The water is a blend of naturally occurring elements from a wide area, sometimes covering several hundred square miles. The exact sources and controls are difficult to determine. Restricting discharge of subsurface drainage water may mean the elimination of irrigation.

The remainder of this paper will briefly describe the approaches being taken to begin regulation of both subsurface and surface drainage water from irrigated land in the San Joaquin River Basin. Although each will be described here separately, they are closely linked.

## SUBSURFACE DRAINAGE WATER DISCHARGES

High water tables and subsurface drainage water problems are not new to the San Joaquin River Basin. The first tile drains to control the high ground water were installed in the 1950s soon after the importation of water through the Delta-Mendota Canal. The drainage problems are principally centered on lands west of the San Joaquin River whose soils were derived from the Coast Range. As the drainage problems increased, more lands were tiled and the drainage water discharged to the San Joaquin River. Plans were being laid for the construction

of a main drain that would carry this water to the San Francisco Bay and ocean. In 1968, construction commenced on the first 82 miles of the San Luis Drain from near Five Points, California to Kesterson Reservoir in Merced County. Construction of the remainder of the drain was halted, however, due to funding shortages. The Regional Board stated in its San Joaquin Basin Plan (SWRCB, 1975) that the drain was a necessity in order to protect beneficial uses in the San Joaquin River but also recognized that impacts would continue until the drain was completed.

The earliest concerns with the drainage water and its disposal in the San Joaquin River were centered on salinity and especially its impact on irrigated agricultural beneficial use in the southern San Joaquin Delta. Boron, because of its impact on irrigated agriculture was the only trace element of concern. Recent findings in the Central Valley of California and in the San Joaquin River Basin, however, have shown that other trace or minor elements, some that may be potentially toxic, are also found in drainage problem areas (Deveral et al., 1984 and Chilcott et al., 1988). A recent survey by the Central Valley Regional Board of 314 tile drainage sites that discharge into the San Joaquin River showed elevated concentrations of certain trace elements (Chilcott et al., 1988). The survey also showed that there was considerable variability in trace element concentration depending upon the location of the discharge site within the basin. Table 1 shows the subsurface drain water characteristics for three areas within the San Joaquin River Basin. Table 1 also shows characteristics for drainage water from San Joaquin and Contra Costa Counties that also contribute salt and trace elements to the river and Delta but downstream of where the river enters the San Joaquin Delta.

Table 1 Subsurface Drainage Areas and Median Drain Water Characteristics For Areas Discharging Into the San Joaquin River[a]

| Location | Area (acres) | EC (μmhos/cm) | Representative Concentrations μg/L[b] B | Se | Mo | Cr | As |
|---|---|---|---|---|---|---|---|
| Merced & Part of Fresno County (Panoche Fan) | 51,000 | 6,100 | 7,900 | 120 | 30 | 16 | 1 |
| Merced County (River Trough) | 1,000 | 1,500 | 600 | <1 | 15 | <5 | 4 |
| Stanislaus County | 8,400 | 2,100 | 1,200 | 2 | <5 | 6 | 1 |
| San Joaquin and Contra Costa Counties | 25,000 | 2,500 | 3,000 | 2 | <5 | <5 | 2 |

[a]Only includes areas draining into the San Joaquin River and Delta
[b]Representative of subsurface drainage only, not blended discharges

The trace elements in the subsurface drainage water are of natural geochemical origin. There is no evidence to date to indicate that they were brought in as a result of irrigated agriculture (Tidball et al., 1986). These trace elements, most especially the trace element selenium, were responsible for the waterfowl impacts, including deaths and birth deformities, that occurred at Kesterson Reservoir (Ohlendorf et al., 1986). As a result of these findings, regulatory steps were taken to close the site. The result has been that the first 65 miles of the valley-wide drain have been taken out of service and there is now a question about whether the drain will ever be completed.

The absence of a drain has resulted in continued discharge of subsurface drainage water to the river. As expected, the high salinity of this drainage water is having an impact on the quality and usability of the San Joaquin River. Figure 2 illustrates the progressive increase in salinity as you move downstream on the San Joaquin River. Extensive water diversions and return subsurface drainage water entering through Mud and Salt Sloughs, upstream of the Merced River inflow, are significantly impacting river water quality. For the year 1985, return flows to the river through Mud and Salt Sloughs accounted for 57% of the salt and 80% of the boron but only 12% of the flow that entered the Delta from the San Joaquin River (SWRCB, 1987). Clifton and Gilliom, 1989 showed that these sloughs accounted for the greatest percentage during the low flow (irrigation season) periods when greater than 70% of the salt load discharged by these sloughs occurred.

The finding of trace elements in this drainage water also raised the concern that potential downstream impacts were occurring on waterfowl, fish, wildlife, public health and irrigated agriculture. Figure 3 shows the average total selenium concentrations in the San Joaquin River for water years 1986-1989 at a site immediately downstream of the Merced River inflow.

For Figure 3, the 1986 water year was considered a wet year while water years 1987-89 are considered either dry or critical water years. Monitoring to date shows that (James et al., 1988 and Westcot et al., 1989):

a) highest total salinity and selenium concentrations occur just downstream of Mud and Salt Sloughs (Figure 2);

b) concentrations are highly dependent upon the streamflow available for dilution; and

c) the highest concentrations occur in the nonirrigation season when the better quality surface tailwater from irrigated agriculture makes up a smaller portion of the river flow.

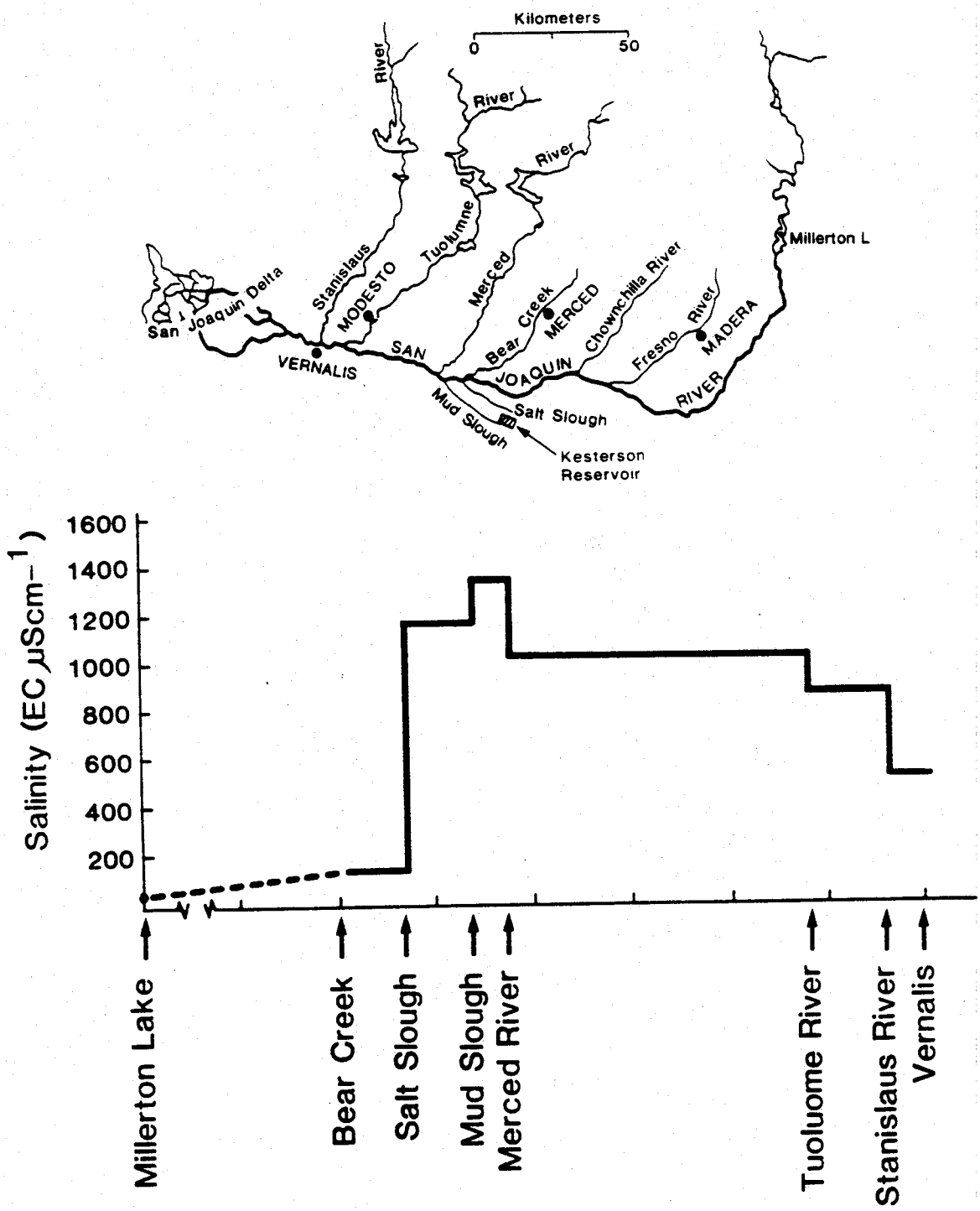


Figure 2 Median salinity for June - September 1985 at various points along the San Joaquin River (Westcot, 1988)

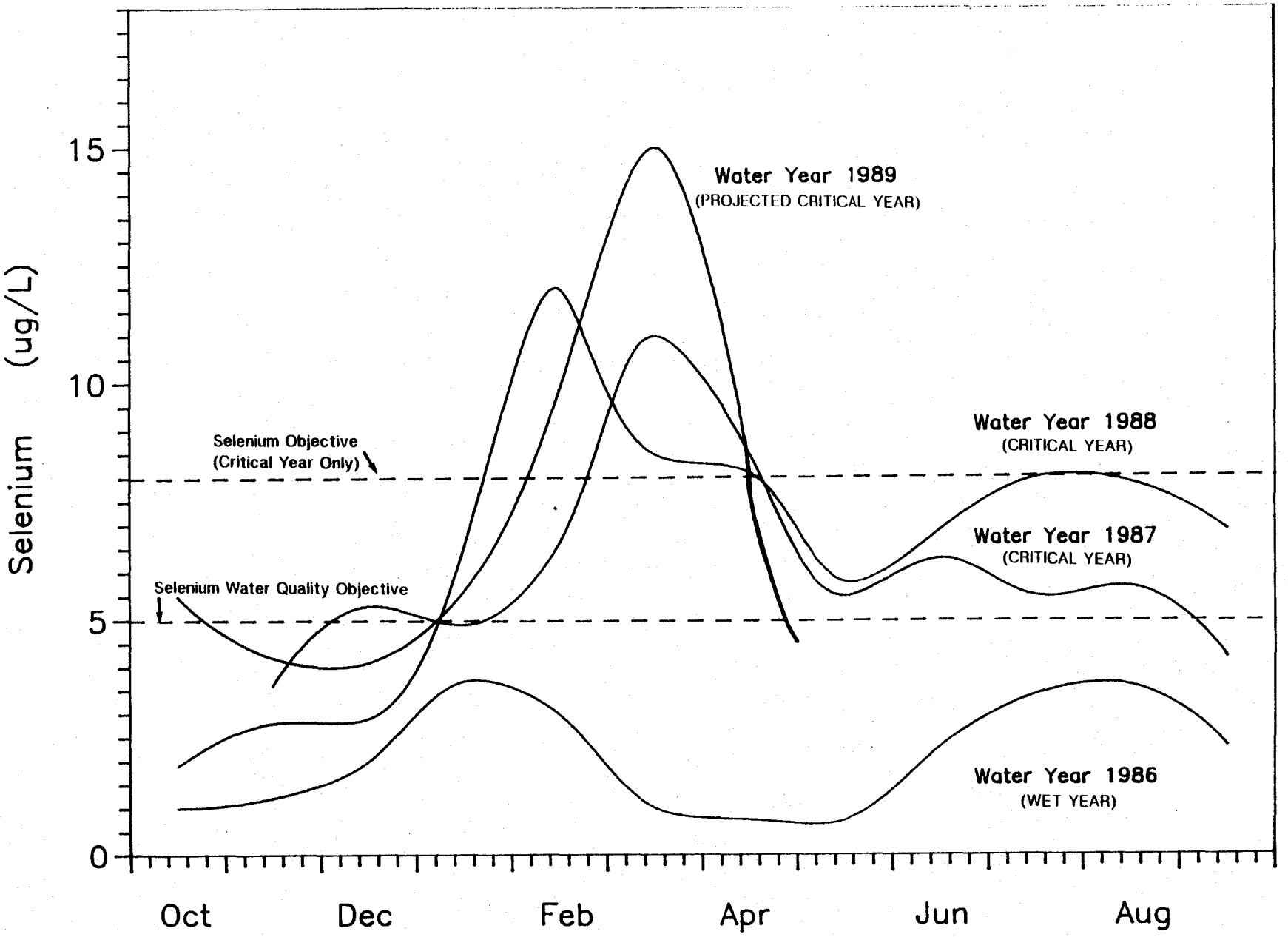


Figure 3 Average Total Selenium Concentrations in the San Joaquin River at Crows Landing Bridge During Various Water Year Types

## OPTIONS FOR DEALING WITH THE SUBSURFACE DRAINAGE WATER

In the 1975 San Joaquin Basin Plan the Regional Board proposed several implementation actions. These, however, concerned primarily salinity and were predicated on the assumption of salt export from the Basin through a valley-wide drainage facility. Because of the absence of that facility, greater emphasis must be placed on regional and local solutions including the control of nonpoint source activities that generate agricultural subsurface drainage. The Regional Board recently completed its efforts to amend the San Joaquin Basin Plan (5C) which is to form the basis for the regulation of agricultural subsurface drainage water discharges (RWQCB, 1988a, 1988b and 1988c). The amendment consisted of four main areas: modifications to the beneficial use designations for affected water bodies within the San Joaquin River Basin; water quality objectives for those water bodies to ensure those uses are protected; policies to be carried out by the Regional Board and other parties in solving the drainage water impact problem; and a proposed program of implementation needed to meet the water quality objectives.

The beneficial use designations consisted of adding specific designations for Mud Slough (north) and Salt Slough, the two principal sloughs that carry the drainage water to the San Joaquin River. Those uses designated were consistent with the findings that these sloughs carry principally agricultural return flow, including the subsurface drainage water.

The principal constituents of concern in agricultural subsurface drainage water in the San Joaquin River Basin are selenium, boron, molybdenum and salinity. The most sensitive beneficial uses to these constituents are aquatic life, wildlife and agricultural supply. Agricultural subsurface drainage contains other trace elements; however, data indicate they are present in less toxic concentrations. By focusing on the four main constituents of concern, efforts to control them and reduce their concentration in surface waters will likely lead to reductions in the other trace elements.

The water quality objectives adopted by the Board are shown in Table 2. The proposed selenium objectives for the San Joaquin River at Crows Landing are also shown in Figure 3. The proposed objectives provide reasonable protection to beneficial uses based on present knowledge and the objectives appear to be economically and technically achievable by the compliance date. The proposed objectives are in general agreement with the fresh water aquatic life criteria promulgated by EPA (USEPA, 1987). The Regional Board plans to reconsider these selenium objectives in three years.

The policies and implementation plan adopted by the Regional Board will be utilized to regulate the discharges. There are specific principles that underlie the proposed program. The most important being that the problem is created by regional water and land use and that water quality and water quantity are interdependent and thus the control of water supply and use practices can be as effective as the control of discharges in achieving water quality objectives. The policies adopted illustrate the philosophy behind the program. The key policies are:

- The export of salt out of the basin is still favored over in-basin storage in the San Joaquin Basin (5C) and the river may continue to be used to remove these salts from the basin provided water quality objectives are met;

- Reuse of drainage water will be encouraged but activities that increase the discharge of poor quality water will be prohibited; and

- The control of agricultural subsurface drainage will be pursued on a regional basis with the control of selenium and other toxic elements being of highest priority.

The contribution of upslope irrigators to subsurface drainage flows is one of the most difficult issues in regulation. The regulatory agency tends to focus on the fellow with the discharge--the farmer with the subsurface drainage system. Yet we know that the irrigated land upslope of him contributes to his drainage flow. However, before we can effectively deal with this issue, there are two questions which we need answered. First, we need a scientific method of measuring flows from upslope irrigated lands that will stand up in technical evidence proceedings. Second, we may need to establish legal mechanisms for regulating upslope irrigators. We intend to pursue both of these areas as part of our regulatory program for the San Joaquin Basin. But a more effective approach to resolution of this problem would be for the drainage agencies, water districts, and farmers to come to an agreement on responsibilities and distribution of costs. This likely will require a new institutional arrangement encompassing all the responsible parties.

In line with this approach, the Regional Board has emphasized "source-control" in the Basin Plan update. This involves encouraging improved on-farm water management to reduce drainage flows. Reducing drainage water volumes makes the choice of other reuse, treatment and disposal alternatives easier. The approach chosen here is based on a mass of research work that shows that reducing flow through a deeper salty zone is likely to result in a reduction in flow and mass emission of salts found in subsurface drainage water. The influence of the drain discharge on trace element loading is less clear. Recent data from Westlands Water District showed no relationship between selenium and discharge rate but further data collection is needed (Westcot, 1988). This may be related to the length of time the field has had a subsurface drainage system (Fujii et al., 1987).

Because of interactions between trace elements, ground water and geological substrate, there is insufficient data available to conclude that reducing deep percolation will help reduce the concentration or mass emission of trace elements. Research on load-flow relationships for trace elements is underway especially dealing with field trials where improved on-farm water management is being evaluated against drainage flow reductions. It is this research data that will form the basis for a long-term management plan in the area.

Because of the need to remain flexible in the regulatory program, a key element of the Regional Board's implementation program is the development of drainage operations plans (DOPs). Specific best management practices have not been established in the Basin Plan as these are evolving as the research and field trials are completed. Best management practices will be defined in the DOPs. A DOP will be required to be submitted and approved annually. The DOP will be

developed by the local agencies. It will identify actions to be taken to comply with the Basin Plan objectives. These actions may consist of any of a wide variety of point source discharge and nonpoint source discharge control techniques.

Table 2 Water Quality Objectives as Adopted by the Central Valley Regional Board for the San Joaquin Basin (5C)

| Constituent | Water Quality Objectives | | Compliance Date |
|---|---|---|---|
| **San Joaquin River, mouth of the Merced River to Vernalis (Delta Inflow)** | | | |
| Selenium | 5 μg/l monthly mean | 12 μg/l maximum | 1991 |
| | 8 μg/l monthly mean (critical year only) | | 1991 |
| Molybdenum | 10 μg/l monthly mean | 15 μg/l maximum | 1991 |
| Boron | 0.8 mg/l monthly mean (15 March-15 September) | 2.0 mg/l maximum | 1991 |
| | 1.0 mg/l monthly mean (16 September-14 March) | 2.6 mg/l maximum | 1991 |
| | 1.3 mg/l monthly mean (critical year only) | | 1991 |
| **Salt Slough, Mud Slough (north), San Joaquin River, Sack Dam to mouth of the Merced River*** | | | |
| Selenium | 10 μg/l monthly mean | 26 μg/l maximum | 1993 |
| Molybdenum | 19 μg/l monthly mean | 50 μg/l maximum | 1993 |
| Boron | 2.0 mg/l monthly mean (15 March-15 September) | 5.8 mg/l maximum | 1993 |
| **Grassland Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Area (Measured in any water used by subject areas for waterfowl habitat.)** | | | |
| Selenium | 2 μg/l monthly mean | | 1989 |

* An alternate set of objectives is proposed to go into effect, if the plan to use the San Luis Drain is implemented. The alternate set of objectives provide for better water quality in Salt Slough and the San Joaquin River, Sack Dam to the mouth of Mud Slough (north) and a longer compliance period for Mud Slough (north) and the San Joaquin River, mouth of Mud Slough (north) to mouth of the Merced River.

At the end of each year, an assessment will be made of the actions specified in the DOP and their efficacy in complying with the Basin Plan and in achieving water quality objectives. The succeeding year's DOP will be developed and approved on the basis of the knowledge gained from preceding DOPs.

We will work closely with the dischargers in implementing the regulatory program. We will encourage them to form into regional groups or agencies as this simplifies the regulatory process and provides more flexibility for them. We will also solicit their assistance in refining what will be a relatively new type of regulatory program.

Until recently, the Central Valley Regional Board had assumed, like many other agencies, that a long-term valley-wide solution to the San Joaquin Valley drainage water disposal problem would be developed and would be in the form of a discharge to a salt sink like the ocean. This solution does not appear to be a viable option at the present time and it appears that we will need to consider regional solutions. Therefore, we are looking at controlled discharge of salts and trace elements to the river while at the same time trying to minimize these at their source.

SURFACE WATER (TAILWATER) DISCHARGES TO THE SAN JOAQUIN RIVER

Subsurface drainage water discharges through Mud and Salt Sloughs make up only 10-15% of the total river flow as the San Joaquin River enters the Delta. The largest portion of the river as it enters the Delta is made up of agricultural surface return flows especially during the irrigation season when it may represent 90% or greater. These return flows are primarily surface runoff from irrigated fields. James et al., 1989a found that there were nearly 200 surface drainage discharge points into the San Joaquin River downstream of the Mendota Pool with nearly half of them occurring in the 48-mile section of river immediately downstream of Mud and Salt Slough to the point where the water enters the Delta from the San Joaquin River. Greater than 95% of these drains are being used on a continuous basis for the discharge of surface runoff water. The majority of these drains enter from the western side of the San Joaquin River. In addition to the direct discharges, 40 discharge points enter the Stanislaus, Tuolumne and Merced Rivers in the reaches from the Highway 99 Bridges to their inflows to the San Joaquin River (James and Westcot, 1989a and 1989b, James et al., 1989b). Each of these discharge points represents a potential site where chemicals and other materials used in the fields can find their way into the San Joaquin River.

Pesticide and other chemical discharges to surface water are the result of the chemicals' characteristics and agriculture's poor management of them and their irrigation water. Pesticides, such as toxaphene and endosulfan, have caused the loss of hundreds of thousands of fish (Table 3). Pesticide use in the San Joaquin Valley is heavy; for example, in 1982 about 46 million pounds of active ingredients were applied in the entire San Joaquin Valley, of which about one-half is applied in the San Joaquin River drainage (Gilliom and Clifton, 1987). These pesticides pose a threat to water quality and especially aquatic life as they are discharged through surface tailwater runoff. Recent testing by Regional Board staff shows that aquatic life toxicity is occurring but the pattern of occurrence is erratic indicating pulses of material moving into the river system likely from field runoff from recently treated fields. Testing will continue

to define the sources of these toxic slugs that are entering the river and the need for regulation.

Table 3 Reported Fish Kills in California Involving Toxaphene and Endosulfan (California Department of Fish and Game)

| | Year | Number of Episodes | Fish Killed |
|---|---|---|---|
| | 1963-69 | 18 | 97,010 |
| | 1970-74 | 14 | 48,585 |
| | 1975-79 | 24 | 65,030 |
| | 1980-83 | 8 | 7,200 |
| Totals | | 64 | 217,825 |

Of equal concern in the San Joaquin River Basin is that many of the pesticides being found are organochlorine compounds such as chlordane, DDT and toxaphene. Many of these chemicals are no longer in use. The California State Water Resources Control Board's Toxic Substances Monitoring Program has documented the accumulation of toxaphene, chlordane, dieldrin, and even continuing accumulation of DDT in fish and other aquatic organisms within the San Joaquin River. Many fish in the San Joaquin River have levels of toxaphene, DDT and other materials that exceed the National Academy of Sciences' Guidelines for Fish and Wildlife. In addition, striped bass eggs from the San Joaquin River contained relatively high levels (1400 ppb fresh weight) of toxaphene (Cohen et al., 1982). DDT continues to this day to be at high levels or increasing in fish tissue in the San Joaquin River. The continued presence of high organochlorine residues in the fish tissue indicates that the organochlorine residues that persist in bed sediments of the river are being replenished by new sediment eroded from irrigated fields and carried to the river via tailwater runoff and discharge. A recent USGS study has pinpointed this as the source and mass balance calculations show that most of the loading to the river is via drains entering from the west side of the river. In addition, the USGS estimated water concentrations exceeded the aquatic-life criterion for DDT (the sum of DDD, DDE, and DDT) (Gilliom and Clifton, 1987). A recent survey by the Regional Board confirmed this finding except that chlordane was not found in the agricultural drains sediments but was found extensively in urban area drain sediments (Chilcott, 1989). A recent two-year sampling by the Regional Board has shown suspended sediments concentrations exceeding 5,000 mg/L entering the San Joaquin River from drains serving areas to the west of the San Joaquin River. The concentrations vary widely throughout the season but tend to be highest in the spring during pre or first irrigations.

## OPTIONS FOR DEALING WITH THE SURFACE (TAILWATER) DISCHARGES

Due to the concern for the tailwater from the west side of the river and the organochlorine laden sediment it might carry, the Regional Board funded a nonpoint source pollution control study of this area (Bailey et at., 1989). This study looked closer into the sources of sediment and their causes including irrigation methods, soils, slopes, cropping patterns and erosion potential

scales. This study was the preparatory work to an expanded effort to look at the feasibility of implementing erosion control practices within the farming network in the west side of the San Joaquin River, principally in western Stanislaus County. The second study is proposed now for EPA funding under Section 319 which is to look at nonpoint source impacts and solutions. This feasibility study is to only look at whether sediment control works can be implemented, within what costs and financing structure, where priorities should be to get the greatest return for the investment, and to outline the mechanisms needed for implementation. This report will then serve as the means of starting an area-wide nonpoint source program.

To gain the experience and data needed on successful erosion control techniques in the western Stanislaus County, the State Water Resources Control Board and the Central Valley Regional Water Quality Control Board participated in a pilot scale sediment reduction program in the Spanish Grant and Crow Creek Drainage Districts in the problem area. This program, financed through the State Assistance Program was successful in implementing 16 projects covering 1,500 acres. This project allowed the local Resource Conservation District to evaluate the effectiveness of the implemented techniques. The results showed a significant reduction in sediment discharge as well as a positive return on investments were experienced by each project. In addition to direct cost benefits, a reduction in water use was also accomplished (Souza and Bailey, 1987). The key mechanism in the success of this project was a proactive stance by the farming groups and local control of the project implementation. Because of the success of the local control of this project, the Resource Conservation District in the area is now forming a local advisory group to assist them in developing the implementation plan for the Section 319 evaluation. This local advisory group would then be in place to continue the implementation phase.

The surface discharges of toxics, including fertilizers and pesticides must be controlled. The regulatory mechanisms are available. Regulation or enforcement can be conducted through the provisions of California's Porter-Cologne Water Quality Control Act, Proposition 65 Regulations and the pesticide use and enforcement provisions of the California Department of Food and Agriculture. These actions, however, would require a tremendous outlay of staff and resources. A better approach and the key to control lies in improved tail water management at the farm and water district level. This demands a strong active role by local agencies and farming organizations. It is through a spirit of cooperation that we will solve these problems.

Agriculture in the San Joaquin River Basin uses the majority of the water in the basin and we cannot assume that this level of use can continue without proper controls on the impacts it causes. We all need to work together to solve or at least minimize the problems while at the same time maintain a viable agricultural economy in the basin. Farmers, water purveyors, drainage entities, public agencies, chemical suppliers, the University of California and the regulatory agencies need to communicate their problems and concerns to each other and learn to work together in a spirit of cooperation. The main element of success in controlling nonpoint source impacts must be local initiative to develop solutions.

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**SESSION III: ROUNDTABLE DISCUSSION**

Panel Chair: Bill B. Dendy, President
Bill B. Dendy & Associates, Davis, CA

4:00 p.m. **NPS Pollution Case Study, Technical Issues Affecting Water Quality Management in the Santa Ana River Watershed and their Application to the Western States**

William R. Mills, Jr. General Manager Orange County Water District, Fountain Valley, CA
Donald E. Evenson, Senior Vice President James M. Montgomery Consulting Engineers, Inc., Walnut Creek, CA

# NPS POLLUTION CASE STUDY: TECHNICAL ISSUES AFFECTING WATER QUALITY MANAGEMENT IN THE SANTA ANA RIVER WATERSHED AND THEIR APPLICATION TO THE WESTERN STATES

This panel discussion will focus on several aspects of water quality management in the Santa Ana River Watershed of Southern California, with emphasis on plans and projects for controlling non-point sources of pollution. The first paper, by Bill Dendy, will give an overview of water management in the watershed and how control of non-point sources is being incorporated into water management. The second paper, by Don Evenson, will describe how non-point pollution impacts are assessed using hydrologic and water quality models in a structured Basin Planning Procedure. The third paper, by Nick Richardson, will focus on one specific project designed to correct a non-point source problem.

# APPROACHES TO CONTROLLING NON-POINT SOURCES OF WATER POLLUTION IN THE SANTA ANA RIVER WATERSHED

By Bill B. Dendy

The purpose of this paper is to describe how five water supply agencies have joined together to combat a common problem - the threat to water supplies of non-point sources of water pollution. By taking a watershed-wide view of the problem the agencies expect to implement solutions to the problem in a more cost-effective manner than if they were to deal individually with the problem only in their own jurisdictions. The five agencies created a joint powers authority, the Santa Ana Watershed Project Authority (SAWPA), in 1969 to define and develop solutions. Comprehensive control plans have been developed and are being implemented in conjunction with the Santa Ana Regional Water Quality Control Board.

The water supply system in the Santa Ana Watershed is complex. The historical use of water for irrigated agriculture, prior to modern urban development, caused pollutants to migrate into the unsaturated zone. These pollutants are showing up in water supplies as they reach the water table. There is going to be a delayed water quality impact of serious proportions that water supply agencies will have to cope with.

It is probably the case that the salts, nitrates, pesticides and other pollutants already in place in the saturated and unsaturated zones of the groundwater basins of the watershed are the single largest non-point source of pollution, although a degraded supplemental water supply might challenge that ranking. These in-place pollutants are not there as the result of nefarious activity. They are simply the predictable product of extended intensive normal agricultural practices. There is nobody to regulate or sue to clean up the problem.

Returning these valuable basins to full use for water storage requires a great deal more thought and creativity than some simplistic regulatory concept. SAWPA is on the right track to success, but has a long way to go.

**SAN JACINTO WATERSHED**

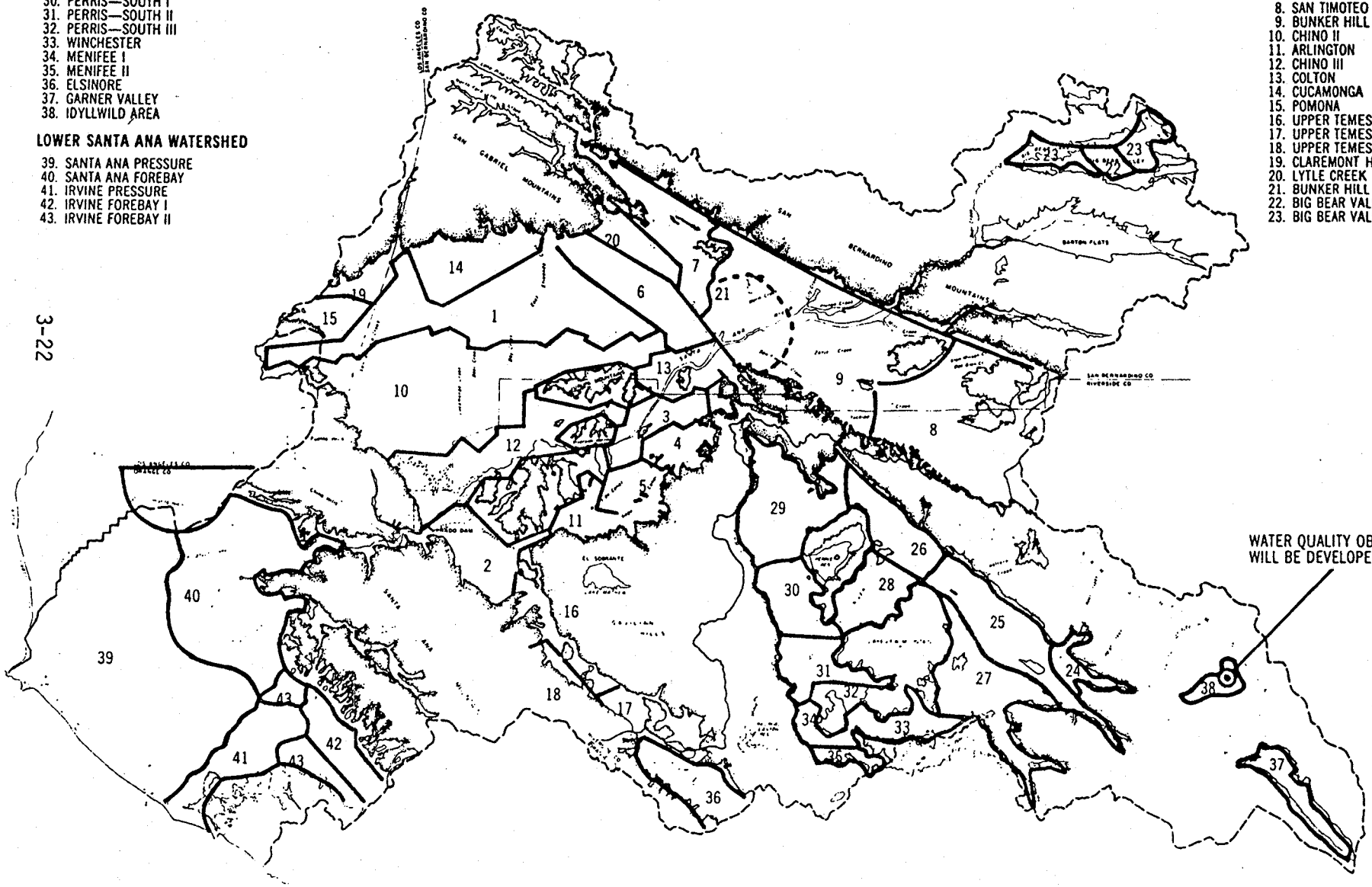
24. SAN JACINTO—CANYON
25. SAN JACINTO—INTAKE AND UPPER PRESSURE
26. SAN JACINTO—LOWER PRESSURE
27. HEMET
28. LAKEVIEW
29. PERRIS—NORTH
30. PERRIS—SOUTH I
31. PERRIS—SOUTH II
32. PERRIS—SOUTH III
33. WINCHESTER
34. MENIFEE I
35. MENIFEE II
36. ELSINORE
37. GARNER VALLEY
38. IDYLLWILD AREA

**LOWER SANTA ANA WATERSHED**

39. SANTA ANA PRESSURE
40. SANTA ANA FOREBAY
41. IRVINE PRESSURE
42. IRVINE FOREBAY I
43. IRVINE FOREBAY II

**UPPER SANTA ANA WATERSHED**

1. CHINO I
2. TEMESCAL
3. RIVERSIDE I
4. RIVERSIDE II
5. RIVERSIDE III
6. RIALTO
7. BUNKER HILL I
8. SAN TIMOTEO
9. BUNKER HILL II
10. CHINO II
11. ARLINGTON
12. CHINO III
13. COLTON
14. CUCAMONGA
15. POMONA
16. UPPER TEMESCAL I
17. UPPER TEMESCAL II
18. UPPER TEMESCAL III
19. CLAREMONT HEIGHTS
20. LYTLE CREEK
21. BUNKER HILL PRESSURE
22. BIG BEAR VALLEY I
23. BIG BEAR VALLEY II




GROUND WATER SUBBASINS
SANTA ANA REGION

FIGURE 3-1

# ASSESSING NON-POINT POLLUTION IMPACTS USING COMPUTERIZED BASIN PLANNING PROCEDURES

by
Donald E. Evenson
James M. Montgomery, Consulting Engineers, Inc.

**The Santa Ana Watershed Project Authority** has invested in the development and application of a computerized set of planning procedures that includes 1) a data management system to predict water requirements and waste loads, 2) a groundwater/surface water flow model that predicts groundwater levels and movement, as well as base flow in the Santa Ana River, and 3) a water quality model that predicts total dissolved solids (TDS) and nitrate levels in the groundwaters and surface waters of the Santa Ana Watershed.

The Santa Ana Watershed has a drainage area of approximately 1,500 square miles and about a third of this area (356,000 acres) overlies a group of interconnected groundwater basins. These basins are the principal source of water supply for the area's agricultural, municipal and industrial uses. In 1988, these uses required approximately one million acre-feet of water. Historically, the major water user in the watershed was irrigated agriculture. For example, in 1951 irrigated agriculture consumed about 78 percent of the total water use. Today, it uses less than 25 percent. This change in water use and attendant pollutant loadings has created some unique water pollution problems and is challenging the regulatory and financial institutions to find equitable solutions.

A key element in dealing with this challenge are the computerized planning procedures that have been developed and improved under the direction of the Santa Ana Watershed Project Authority. The Data Management System uses land use and population data to predict water requirements and waste loads for every agency in the watershed and for all overlying land uses. It also uses basic facilities planning data to predict where the water supplies will come from and where the wastewater returns will be discharged. Since all land uses are included, the DMS includes all point sources of pollution, all

non-point sources of pollution such as irrigated agriculture, dairies, feedlots, and urban and rural runoff, as well as natural sources of recharge and runoff. The results of the DMS allow planners an opportunity to compare waste loadings from all sources. A recent application of the DMS to evaluate the impacts of nitrate loadings in the watershed revealed that in 1988 over 75 percent of the nitrate loadings in the Chino Basin (a major groundwater basin in the watershed) were from dairies and feedlots. Thirty-five years ago, in 1951, the primary nitrate source was irrigated agriculture. In other words, the dominant source of nitrate loadings to the groundwater basin has shifted from one type of non-point source to another. This use of the DMS shows the effective use of the DMS to isolate the primary sources of pollution - both point and non-point sources - and to clearly identify the regulatory challenge to deal with non-point sources of pollution.

The groundwater and surface water models are used to predict the impacts of these pollution sources and the effectiveness of regulatory programs designed or proposed to reduce waste loadings. The interesting part of the application of these procedures to the Santa Ana Watershed is the long memory of the watershed. Over the last eighty years, groundwater levels in the watershed have been drawn down by over-pumping and, as a result, the water table is now very deep in most of the watershed. Consequently, both point and non-point sources of pollution that have been discharged over the last 80 years are just now being observed in groundwater production wells. A recent study for the Metropolitan Water District of Southern California revealed that nitrate levels in the watershed will continue to rise for the next 50 years, even though the major pollution loads, which were non-point sources, have been virtually stopped for many years.

Recent model predictions show a continued decline in groundwater and surface water quality. This ability to assess the impacts of both point and non-point sources of pollution is a significant benefit to the regulatory agencies. It provides them an opportunity to look at an entire watershed and to include all sources of pollution. If used with perspective, it can help evaluate and formulate regulatory programs that are cost-effective and that will provide tax payers and rate payers with the most efficient use of their money to control and manage pollution.

**Groundwater Renovation With The Irvine Desalter Project**

The groundwater in the Irvine sub-area of the Orange County groundwater basin has been degraded by agricultural activities (TDS and Nitrates) and military activities (dissolved organics). Currently, the groundwater in this area is utilized strictly for irrigation. However, poor quality groundwater migrating westward threatens nearby potable groundwater supplies for IRWD and the cities of Tustin and Santa Ana. The proposed Irvine Desalter Project would restore the groundwater basin for use as a reservoir for domestic supplies, and insulate domestic supplies from further degradation.

The project treats poor quality water so that it may be used as a municipal supply. In time, the groundwater basin quality will improve. The Irvine Desalter Project reclaims approximately 6.6 million gallons per day (mgd) of poor quality groundwater containing high concentrations of both total dissolved solids (TDS), Nitrates and trichloroethylene (TCE). The groundwater from the Irvine area will be pumped from a field of six wells and transferred to the treatment facility which would incorporate processes effective in removing salts, Nitrates, and trace organic contaminants. At the treatment plant, the concentrations of TDS and Nitrates will be significantly reduced such that the plant's effluent (of approximately 5.40 mgd) will be pumped directly into the nearby municipal water distribution system. Dissolved organics present in the groundwater must also be reduced to concentrations below State Drinking Water Standard. The plant's brine byproduct is anticipated to be directed to neighboring sewer facilities for ocean disposal. Because brine disposal costs are significant, desalting systems that generate reduced values of waste streams are favored.

# Thursday Morning, July 27, 1989

| | | PAGE |
|---|---|---|
| **7:30 a.m.** | **Pastries, coffee and/or juice –** International Foyer | |
| **SESSION IV:** | **NPS POLLUTION IMPACT OF AGRICULTURAL CHEMICALS** Session Chair: Steven Pirner, SD | |
| 8:15 a.m. | **Agricultural Chemicals: A NonPoint Source: A Dilemma** Eliseo M. Samaniego, Member, CA SWRCB | IV-A |
| 8:35 a.m. | **Control of Rice Herbicides in California Water Ways** Marshall Lee, Associate Environmental Hazard Scientist, CA Department of Food & Agriculture | IV-B |
| 8:50 a.m. | **Ground Water Quality Activities - CA Department of Food & Agriculture** Steven Monk, Ground Water Program Coordinator, CA Dept. of Food & Agriculture | IV-C |
| 9:05 a.m. | **Industry's Perspective on NPS Ground Water Issues** Dick Jackson, Ph.D. Manager, Ground Water Program, Agricultural Products Division, Dupont Company; Chair, Western Agricultural Chemicals Association's Water Quality Task Force | IV-D |
| 9:30 a.m. | **ROUNDTABLE DISCUSSION & QUESTIONS** | IV-E |
| 10:00 a.m. | **BREAK** | |

# AGRICULTURAL CHEMICALS: A NONPOINT SOURCE: A DILEMMA

By

Eliseo M. Samaniego, Member

California State Water Resources Control Board

Despite all the hype and glamour one associates with California--the land of movie stars and sunshine and high-tech industry, California is first and foremost the land of agriculture. Agriculture is California's number one industry. It produces over $15 billion annually. We produce 250 different crops including 94 percent of this country's wine grapes and 87 percent of its garlic. Every olive, fig, artichoke, and kiwi fruit you eat is grown in California. And along with crop production goes the accompanying labor force. One out of every three persons employed in California works in agriculture or a related industry. Agriculture is truly the heart beat of this state.

So what's the problem? One part of the problem is water: where it's located, how it gets to where it's needed and how it gets disposed of after it's used. With an arid and semi-arid climate, most of the state's water supply falls as rain and snow in the north, in the wintertime. Most of the demand occurs in the south, in the summer. That was the initial dilemma. But with typical California initiative and creative thinking, that part of the problem was solved with the construction of the federal Central Valley Project in the 1930s and the State Water Project in the 1960s. California has done well in capturing water for redistribution. Reservoirs and water transport systems now lace together north and south.

**Agricultural Chemicals - Samaniego**

Farm life was good in the Golden State. Agriculture has grown and prospered. But water transported to the southern San Joaquin Valley, one of the most highly productive agricultural regions in the world, has brought another piece of the problem. The southern San Joaquin is essentially a closed basin. When federal and state water projects were designed, farmers were promised construction of a drain to transport the wastewater to a discharge point in the Sacramento-San Joaquin Delta. Construction on the San Luis Drain began in 1968, but by 1975 money had run out with only 85 miles of the drain built. Its terminus became the Kesterson Wildlife Refuge in Merced County. The salts, trace elements, such as selenium, pesticides, herbicides and metals leached from the soils during irrigation and transported through the San Luis Drain then ran off into the ponds of this wildlife refuge.

Options for a drainage system were reevaluated and State and federal agencies began working together to resolve the drainage problem. Possible discharge points considered were Morro Bay and Suisun Marsh in the Delta. In 1980 the Bureau of Reclamation began gathering data needed to obtain a State permit to discharge the drainage water into the Delta. In gathering this data, U.S. Fish and Wildlife Service made a discovery that would elevate the problem of agricultural drainage disposal to front-page news.

Selenium, a natural trace element, was found in Kesterson ponds at levels sufficient to cause deformity and death of the waterfowl using Kesterson as a stopping point on the Pacific Flyway.

Another threat to wildlife came with the discovery that the San Joaquin kit fox population was being depleted due to farm practices which disrupted its normal habitation practices. The kit fox is now an endangered species.

It seemed the life-giving water pumped south to bring abundant crops to the western San Joaquin had become a disposal problem through a combination of natural and man-made actions. And so the dilemma: Would some of the most productive agricultural land in the world be put out of production because there was no apparent way to dispose of its drainage water? Draining the water to Monterey Bay is prohibited under a local ordinance. Legislation was proposed last year to ban dumping of Valley drain water anywhere along the coast from Monterey Bay to Morro Bay. A similar bill was defeated this year, but undoubtedly such legislation will continue to be introduced at each new legislative session.

We at the California Water Board and the Central Valley Regional Board, the agency directly responsible for water quality in the San Joaquin Valley, are grappling with this dilemma. The answer is coming slowly, and in many pieces. It won't happen overnight and it probably won't happen with the construction of a pipe to the ocean.

The answer will be found in best management practices for irrigation use. These are most commonly physical hands-on measures, but, in a larger framework, require a series of institutional and individual choices before actually

implementing a specific control measure. To borrow a definition from a John Muir Institute report: "...BMPs do not simply spring from the side of technical manuals. BMPs reflect the background and missions of agencies, preferences of technical advisors, and receptiveness of landowners and managers and they should be selected and applied with the particular physical features of a site uppermost in mind."

It's relatively easy to regulate point source pollution. It comes from the end of a pipe. Someone is responsible for the pipe. With nonpoint source pollution you have to get inventive. Often there is no one specific cause for the pollution and it becomes impossible to pinpoint the parties responsible. For example, there is a continuing problem with unacceptable levels of DDT, endosulfan and toxaphene being found in sediment and fish tissue taken from the San Joaquin River. These chemicals were banned years ago. So where are they coming from? They're coming from thousands of acres of irrigated land where these chemicals were applied years ago and there is little possibility of ever determining responsibility for its application.

When the Water Board reviewed the Kesterson situation in 1984 they saw the need for a technical committee to examine the complete picture of agricultural drainage throughout the half million acres of western San Joaquin Valley farmland.

That committee came up with several recommendations, including consideration of BMPs by the Central Valley Regional Board to reduce pollutant loads. The idea is that reducing subsurface drainage volume and pollutant loads through an aggressive water conservation and management program could reduce dramatically not only selenium concentrations, but also salts, boron and other consitutents of concern. Under Porter-Cologne, the legal authority under which State and Regional Boards administer their water quality duties, the Regional Board cannot specify how water quality standards are to be met, but there are two ways they can use their regulatory authority to encourage BMPs. First, they can waive waste discharge requirements on condition dischargers comply with BMPs or they can enforce BMPs indirectly by entering into agreements with other agencies who do have the authority to enforce BMPs. The State and Regional Board have cooperated with the Department of Food and Agriculture to develop this type of agreement to establish BMPs.

The State and Regional Board view BMPs as a reasonable approach to a difficult problem, although we know that control measures dealing with irrigation practices can bring sizeable costs with them.

The State Board has estimated the cost of moderately improving both water use and drain flow at about $16 an acre. These better water management techniques are readily workable. More aggressive techniques, significantly more efficient than the furrow irrigation presently practiced, could reduce drainage volume 50 to 70 percent. Costs associated with the more aggressive technology are

estimated at about $60 an acre. These cost estimates came from a Technical Committee Report the Water Board issued on Regulation of Agricultural Drainage to the San Joaquin River. These costs are similar to those being developed by the San Joaquin Interagency Drainage Program. We recognize the heavy costs involved. We also recognize that an investment will have to be made for farming to survive in the San Joaquin Valley.

To this end some $1 million in state bond funds has been earmarked for two programs aimed at getting a better handle on irrigation and drainage flow management.

The first program is a mobile agriculture water conservation laboratory which visits individual farms, evaluating irrigation systems on site to help growers improve irrigation practices. To date, 1,500 evaluations have been completed Mobile laboratories are now operating in Fresno, Kings, Tulare, Kern, Ventura, Riverside, Imperial and San Diego Counties.

The second program involves projects to demonstrate the impact of on-farm irrigation management in the western San Joaquin Valley. Yesterday Bill Crooks, the Executive Officer of the Central Valley Regional Board, spoke to you about the work the Regional Board is doing with Valley farmers on drainage operations plans to be included in the Regional Board's Basin Plan. The farmer has no control over the quality of the water in subsurface drains which comes from ground water. Because this, Valley farmers have taken the initiative and told

the Regional Board they will present the Board with plans on how best to manage this water and control its problems. Board staff will then offer its expertise and together a plan will be devised. It will be tested, revised and re-worked until the desired results are achieved. In setting up experimental irrigation practices, it's important to note that these new and innovative irrigation practices are being tested within the farmer's own system and not on a segregated square of experimental farmland.

Through the efforts of the growers and the Department of Water Resources, this program is expanding to include more growers and more acreage. With the original seed money local farming communities have been able to build effective cost-sharing programs and also establish better working relationships with state and federal agencies interested in similiar goals of good water managing in agriculture. To date, that original $1 million in seed money has grown to $1.5 million per year since the projects became cost-sharing projects using State, federal and local money. It is anticipated the combined program will last for the next several years.

The Central Valley Regional Board is also developing BMPs for dairy waste disposal practices. The Chino Basin, east of Los Angeles, has long been a vast dairy center. With increasing urbanization, dairy farmers are moving north to Kings and Tulare Counties. Because of their close ethnic ties, these farmers congregate and the resultant accumulation of dairy waste causes serious salt and nitrate loading to the ground water. These problems have already been experienced in the Chino Basin, and they are expected in the Tulare Basin.

## Agricultural Chemicals - Samaniego

The problem of nitrate was discussed at length in a recent Water Board report to the Legislature (Nitrate in Drinking Water). In preparing this report, our staff took data from state and federal agencies, county environmental health officers, and public and private water suppliers. The data showed the close relationship of nitrate contamination problems with dairy waste and agricultural activities, in particular those which utilize application of nitrogen fertilizers in one form or another.

The dilemma here is that public health concerns would best be served with little or no nitrogen in the drinking water source (of which the largest perecentage is ground water), and that the farmer is best served by applying an adequate supply of nitrogen to his growing crops with some unavoidable leachate percolation carrying nitrogen as nitrate to the ground water. At the same time, these waters are drinking water sources in the municipal domain, but they can't meet state drinking water standards because of the nitrate. Nearly all ground water basins in the central and coastal regions of California are now in this dilemma.

In an effort to mitigate this problem the Department of Food and Agriculture organized a Nitrate Working Group which produced guidelines to help provide best management practices for maximum crop production with minimum fertilizer use. Research staff from UC Davis and UC Riverside, staff from the Water Board and Food and Ag, and representatives from the California Fertilizer Association all participated in this Working Group and are themselves involved in producing guidelines to help the farmer to use BMPs to improve his irrigation and fertilizer practices.

**Agricultural Chemicals - Samaniego**

A few months ago, I talked to the California Fertilizer Association regarding what I see as a need for an outreach program from the fertilizer manufacturer to the farmer, letting the farmer know that if his fertilizer use is not judicious, everyone stands to lose. Overuse will invite increased regulation such as has happened in parts of the Midwest. But most of all fertilizer overuse could cause serious degradation of the ground water and that is where we all lose. I might add I think this same outreach program concept applies to the pesticide manufacturer as well.

I know there is a common tendency to think that more is better than less. In my professional practice as a pharmacist, I have discovered there is a dangerous attitude in many of us to think that if one pill is good, two pills must be better. Not true. This same mentality applies to fertilizer and pesticide use. Twice as much fertilizer and pesticide will not produce twice as large a crop.

With pharmacists, the drug companies come to the pharmacists with a "utilization review process" where they discuss the proper use of a new drug on the market. I see the need for farmers to receive this same type of judicious review of how fertilizer and pesticide products are applied. There is no excuse for today's farmer to simply say: "That's what my Dad always used on his fields. That's how much he used. What's good enough for Dad is good enough for me."

One example of <u>best management practices</u> that have been in effect for several years and are successful are the Regional Board's efforts to control releases of rice herbicides into the Sacramento River. Marshall Lee from California's Department of Food and Agriculture will give you a complete description of this particular BMP, but the cooperative implementation of measures to control the

application and location of herbicide application, training of applicators and minimum holding times for water treated by the herbicides has shown measurable descreases in herbicide concentrations in receiving waters. Fish kills previously recorded from the herbicide discharges and the taste complaints from the City of Sacramento who take their drinking water from the Sacramento River have been eliminated.

The Clean Water Act requires that each state identify best management practices to address that state's nonpoint source problems, taking into account the impact of the practices on ground water quality. The Water Resources Control Board is following this mandate strictly. We feel there should be a dynamic relationship between the State and Regional Boards and the discharger. (And I refer here to any discharge: salts, dairy wastes, fertilizers, etc.) If the discharger cooperates there is no need that he be driven to the regulatory arena. Should the discharger fail to work with the Regional Board to establish this necessary rapport, and should the discharger violate his BMP, he knows his actions could lead to serious actions by the Regional Boards.

Agriculture in California has reached a crossroads. No longer will the farmer be given the free hand to produce crops using practices with the potential to harm the environment. Resolving ag drainage problems, resolving nitrate problems and resolving pesticide problems will be long-term processes. The actual or probable sources of these problems include established agricultural and waste disposal practices that have long been a part of our society's lifestyle. To solve these problems, to answer these dilemmas, changes must occur. Everyone involved will need time, patience and persistence to ensure that the future of agriculture in California is safe, healthy and productive.

## Control of Rice Herbicides in California Waterways

J. Marshall Lee
California Department of Food and Agriculture

Water discharged from rice fields in California's Sacramento Valley flows into a complex of surface drains and ultimately into the Sacramento River. The character of this drainage water influences the quality of water downstream. Specific water quality problems can be linked to rice field discharges and the pesticide residues that they contain. The California Department of Food and Agriculture, as lead agency for regulating pesticide use in California, has regulated use of rice pesticides in order to eliminate any water quality problems associated with their use.

In the early 1980's two important herbicides used in rice production, molinate (Ordram®) and thiobencarb (Bolero®), were linked with two types of water quality problems in the agricultural drains and the Sacramento River. Molinate had been identified as the cause of fish kills that were prevalent each May and June in the agricultural drains. Thiobencarb, when it occurred in river water chlorinated for municipal purposes, caused an offensive taste in drinking water. In 1986 another rice herbicide, bentazon (Basagran®), was found in the Sacramento River. Bentazon, unlike molinate and thiobencarb, is not broken down during chlorination at water treatment plants, and was therefore found in tap water samples.

By the beginning of the molinate and thiobencarb use season in 1984, the California Department of Fish and Game and the California Department of Health Services developed guidelines and action levels that were based on assessments of the toxicology of these products and their impact on beneficial uses of water. The Department of Fish and Game recommended that molinate and thiobencarb concentrations in the agricultural drains and Sacramento River not exceed 90 parts per billion (ppb) and 24 ppb, respectively, in guidelines designed to protect the aquatic environment. The Department of Health Services developed primary action levels of 20 ppb and 10 ppb for molinate and thiobencarb, respectively, to protect consumers of water that may contain these compounds or their breakdown products. They later stated that concentrations in raw, untreated river water could be used to indicate compliance with these action levels. They also determined that thiobencarb, when it occurs at concentrations of 1 ppb or more in the Sacramento River, contributes to an offensive taste in finished, chlorinated drinking water. This was the basis for a recommendation that 1 ppb be used as a secondary action level for thiobencarb. The Department of Food and Agriculture and the Central Valley Regional Water Quality Control Board stated that they would use these guidelines and action levels to guide future regulatory efforts directed at molinate and thiobencarb. In subsequent years, these regulatory guidelines were amended as knowledge of the behavior and toxicology of rice pesticides were updated. In 1986 DHS developed a primary action level for bentazon of 8 ppb. In 1987 the Department of Fish and Game determined that the toxicity of molinate and thiobencarb on aquatic organisms were additive and the department presented their guidelines, still 90 ppb for molinate and 24 ppb for thiobencarb, in

that context. And in 1989, after considering updated toxicological information, DHS established maximum contaminant levels (MCLs) for molinate (20 ppb), thiobencarb (70 ppb), and bentazon (18 ppb) in California regulations.

The programs developed for reducing discharges of molinate, thiobencarb, and bentazon into water of the Sacramento Valley were attempts to maintain concentrations below recommended action levels and guidelines by using what was known about the environmental behavior of the two compounds. Molinate is a relatively short-lived material in rice field water, where it dissipates readily primarily due to volatilization. Programs have required molinate users to retain treated field water for a specified time, allowing the compound to dissipate to low levels before being released into state waterways. Thiobencarb is more persistent in rice fields, where it readily adsorbs to soil but is available to repartition into field water. Because of the relative persistence of thiobencarb, the duration of a holding time long enough to protect the secondary action level of 1 ppb would be impractical for most rice growers. Therefore, reduced use was believed to the best way to reduce thiobencarb concentrations in the drains and the river. In addition, certain water management practices such as recirculating systems and ponding apparently facilitate the dissipation of thiobencarb. Programs evolved that used sales limitations, but included incentives for using approved water management practices. By 1987 thiobencarb could only be used by growers who used these practices. Bentazon also dissipates slowly from field water. However, bentazon is applied about three weeks later than molinate and thiobencarb so the rice plants are more tolerant of the long holding times necessary to dissipate bentazon.

In 1989 most molinate users were required to hold treated water on their property for 14 days following application to allow for on-site dissipation. The program provided for shorter holding times if molinate was incorporated into the soil before fields were flooded or if it was applied to fields in areas known to have very low discharge potential. Users of thiobencarb in the Sacramento Valley were subject to a sales limitation voluntarily imposed by the manufacturer: no more than 4.4 million pounds, enough to treat 110,000 acres, could be sold. In addition, thiobencarb could only be used on properties with approved water management systems. These included those with tailwater recovery systems, fallow land available for ponding, and those included in water districts that use practices that prevent thiobencarb-laden water from entering state waters. In 1989 bentazon users were to have prevented discharge of all field water from the time of application, usually in early June, until fields were drained for harvest in late summer, as had been the case in 1987 and 1988. Prior to the 1989 use season, however, bentazon use was suspended in California because it was detected in 61 of the 178 wells surveyed in California rice growing regions.

In order to access the effects of the regulatory programs, water samples were collected from major agricultural drains and the Sacramento River and analyzed for the presence of molinate, thiobencarb, bentazon, and other potential contaminants. In May 1987, concentrations of molinate and thiobencarb in the Colusa Basin Drain, historically the most significant contributor of rice pesticides to the Sacramento River, peaked

at 67 ppb parts per billion (ppb) and 4.5 ppb, respectively, near its outfall on the river. No fish kills attributable to pesticide toxicity were observed, as had been the case since 1983. In 1982, prior to control efforts, tens of thousands of fish were killed in the Colusa Basin Drain and molinate and thiobencarb concentrations peaked at 204 ppb and 59 ppb, respectively. The 1988 monitoring program also indicated that bentazon discharges had been controlled. Peak concentrations in the Sacramento River at the intake to Sacramento's water treatment facility were 0.52 ppb, compared to 16 ppb in 1986 under similar river flow conditions.

The total mass of molinate and thiobencarb transported in the Sacramento River past Sacramento each year provides a better basis for year-to-year comparisons because the dilution effects of the Sacramento River are standardized. In 1988, 5595 lbs of molinate and 104 lbs of thiobencarb were transported in the Sacramento River past Sacramento. This represents a 86% reduction in annual molinate transport since 1982 when an estimated 40,000 lbs were transported. The amount of thiobencarb transported was reduced by over 95% since 1985, the last year before the program began phasing out use on acreages without approved water management systems.

A monitoring program similar to those used in the Sacramento Valley in previous years was in place again in 1989. Major agricultural drains and the Sacramento River were monitored for molinate, thiobencarb, bensulfuron methyl (Londax®, a newly registered rice herbicide) and carbofuran (Furadan®, an insecticide) during the application and during periods of anticipated discharge.

Efforts will continue to identify potential adverse effects associated with the use of agricultural chemicals used in rice concurrent with efforts to further reduce contamination of Sacramento Valley waterways. A report which presents rice pesticide use in 1989, water quality monitoring results, and presents a program proposed for implementation in 1990 will be available in the fall by contacting:

Department of Food and Agriculture
Environmental Monitoring and Pest Management
1220 N Street, P.O. Box 942871
Sacramento, CA 94271-0001
(916) 322-2395

## Ground Water Quality Activities: California's Pesticide Management Plan

**Steven C. Monk**
Ground Water Program Coordinator
California Department of Food and Agriculture

The **California Department of Food and Agriculture** (CDFA), as the lead State agency for pesticide regulation, is developing **The California Pesticide Management Plan for Ground Water Protection** (the Plan). This Plan will serve two purposes. First of all, the Plan will provide a complete description of CDFA's Ground Water Protection Program. Secondly, the Plan will be submitted to the U.S. Environmental Protection Agency (EPA) for acceptance as a state pesticide management plan in compliance with EPA's Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy.

In its strategy, EPA noted that the potential vulnerability of ground water to pesticide contamination is determined by a complex set of factors which vary significantly from area to area and are not fully understood at this time. The area-specific nature of the pesticide contamination concern suggests the need for a localized protection approach. Therefore, the EPA strategy provides each interested and qualified state with the opportunity to take the lead role by designing and implementing plans to manage pesticides in order to prevent ground water contamination by emphasizing area-specific determinations.

CDFA, in coordination with other State agencies concerned with water quality protection, has constructed the **Ground Water Protection Program** to address the potential for pesticide contamination of the State's ground water resources. The cornerstone of the Program is the **Pesticide Contamination Prevention Act of 1985** (the Act), one of the first and most complex state laws to deal with this issue.

The Act directs CDFA to:

* Collect and analyze environmental fate data on all pesticides registered for agricultural use in California, and to identify and monitor potential ground water contaminants. This activity is referred to as **The Data Collection and Management Process.**

* Review any pesticide found in ground water or in soil under certain conditions to determine if it pollutes or threatens to pollute ground water as a result of legal, agricultural use, and to take appropriate corrective action when necessary. This activity is called **The Pesticide Detection Response Process.**

* Compile and maintain a statewide database of wells sampled for pesticide active ingredients. This final area of activity is known as **The Well Water Quality Data Collection Process.**

As comprehensive as the Act is, the Ground Water Protection Program is much more. The Program is, in large measure, a synthesis of both the Act's mandates and earlier administrative plans to utilize the results of laboratory studies, well sampling, soil coring, and computer modeling to develop risk ratings to indicate a particular pesticide's potential to reach ground water when used in specific areas under specific conditions. These latter efforts provide the tools for focusing Program management on localized protection needs.

The **goal** of the Program is to protect ground waters from pesticide contamination through the enhancement of regulatory efforts, preventive planning, and corrective actions. Immediate **objectives** for the Program include:

* To coordinate various authorities and projects into a unified and effective regulatory structure

* To satisfy legislative mandates in the Act in a timely and efficient manner

* To serve as the state pesticide management plan called for in EPA's strategy.

The Program has **five primary components** which correspond to the five chapters in the Plan:

* **Chapter 1 - Goals and Policies**
* **Chapter 2 - Authorities and Institutions**
* **Chapter 3 - Prevention Elements**
* **Chapter 4 - Response Elements**
* **Chapter 5 - Workplan**

In the first chapter, the policies, objectives, and rationale of CDFA's Program and other related water quality protection efforts will be presented. In the second chapter, applicable federal and State statutes and programs will be discussed. The third chapter presents the Program components for preventing pesticide contamination, while the fourth chapter presents the components for responding to pesticide contamination that has already occurred. The final chapter presents a detailed plan of implementation, including pesticide-specific control plans.

**Three key constituents** of the Program, which serve as some of the previously mentioned regulatory tools for focusing management efforts on localized protection, are:

* the **Ground Water Protection List**, focusing program efforts on specific pesticides of ground water concern

* **Special Protection Areas or Pesticide Management Zones,** focusing program efforts on specific geographical areas which are designated as sensitive to ground water contamination from pesticide use

* **Best Management Practices,** both a voluntary and regulatory-based means of modifying specific pesticide use in specific areas where the potential for pesticide contamination of ground water is evident.

To understand the integration of these concepts, the examination must begin with the Ground Water Protection List. This List is required by the Act which describes it as a list of pesticides that have a potential to pollute ground water. CDFA has split the List into tiers which reflect the ways in which a pesticide may be identified for listing. At present, there are two tiers.

**Tier One** of the Ground Water Protection List include the "response chemicals" which have the potential to pollute by virtue of their identification as known leachers as a result of the Pesticide Detection Response Process. This Process has three phases:

* **Phase One - Investigation** to determine if a detected pesticide has been found as a result of legal, agricultural use 120 days

* **Phase Two - Evaluation** of the detected pesticide in a registrant's report and hearing before a special advisory subcommittee

* **Phase Three - Mitigation** decisions concerning appropriate corrective actions, when necessary, including the listing of the pesticide on Tier One of the Ground Water Protection List.

**Tier Two** of the List include the "prevention chemicals" which have the potential to pollute by virtue of their identification as suspected leachers as a result of the Data Collection and Management Process. This Process follows five progressive steps:

* **Step One** is the development of specific information concerning the chemical properties and environmental fate characteristics of pesticides through a data call-in as part of the State registration and renewal process.

* **Step Two** is the setting and refining of Specific Numerical Values as parameters for that data which serve to segregate the suspected leachers from the non-leaching pesticides.

* **Step Three** is the comparison of sets of chemical values for specific pesticides to the Specific Numerical Values to identify those pesticides which exceed the parameters.

* **Step Four** is to further screen those pesticides identified in Step Three by an examination of the label to sort out

suspected leachers based upon recommended application methods.

* **Step Five** is the listing of the pesticide on Tier Two of the Ground Water Protection List.

CDFA's Ground Water Protection Program prescribes two general **regulatory activities** for the pesticides identified in Tier One of the Ground Water Protection List. The first activity is to implement the mitigation decision of the CDFA Director. This activity usually entails the identification of Special Protection Areas or Pesticide Management Zones and the initiation of regulatory-based Best Management Practices. A **Pesticide Management Zone** (PMZ) is a geographical area of approximately one square mile which is sensitive to ground water contamination from pesticide use. A PMZ is the regulatory building block demarcating special protection areas. A PMZ corresponds to a section as defined by base meridian, township, range and section, or which is defined by latitude and longitude or some other generally acceptable geographical coordinates. At present, the only criteria available for regulatory designation of PMZs is the detection of a pesticide as the result of legal, agricultural use. However, additional criteria will be developed for designating PMZs based upon the identification of actual pathways in the area which may be related to soil types and hydrogeology, among other potential factors.

The second regulatory activity in support of Tier One of the Ground Water Protection List is compliance monitoring to ensure enforcement of instituted Best Management Practices and to test their effectiveness in preventing ground water contamination.

CDFA's Ground Water Protection Program also prescribes two regulatory activities to support the listing of a pesticide on Tier Two of the Ground Water Protection List. The first activity is the development of a Pesticide Profile (literature search; use and sales reporting) leading to safe use determinations or voluntary Best Management Practices to mitigate potential adverse impacts on ground water from further unmodified uses. This activity, of necessity, involves regulatory research and educational programs to reach the user and the public.

The second regulatory activity in support of Tier Two of the List is investigative monitoring through sampling of both soil and well water to confirm or refute the leaching potential of each Tier Two pesticide in areas of the State where use is most significant. This monitoring provides information which not only bears on the listing of a pesticide, but also characterizes its environmental presence after use in such a way that safe use decisions can be made or modifications of use projected.

This extensive Program development has been achieved through the cooperative efforts of the California Legislature, State and federal agencies, the agricultural industry, and the public. While progress has been significant, as the previous details will attest, The

California Pesticide Management Plan for Ground Water Protection is intended to be a dynamic document which will change to reflect Program improvements as technical knowledge is increased and capabilities are enlarged. Therefore, the Plan, as it describes California's strategy to prevent pesticide contamination of ground water, should be viewed as a snapshot in time and not as the endpoint of regulatory efforts. To obtain further information on the evolution of this Plan, direct any inquiry to:

California Department of Food and Agriculture - designated as lead agency
Environmental Monitoring and Pest Management Branch
P.O. Box 942871
Sacramento, CA 94271-0001
(916) 324-8916

# INDUSTRY'S PERSPECTIVE ON NPS GROUNDWATER ISSUES

R. A. Jackson, Ph.D.

The groundwater issue is one of the most important issues facing the agricultural industry today. It has been described as the environmental issue of the 1980s and will likely continue as the environmental issue of the 1990s. It's important to recognize that this is a highly emotional issue and we have to deal with that, but we have to learn to deal with it on a rational basis, using the best scientific information available. The issue must be addressed in a way that protects human health but does not unnecessarily restrict the use of agricultural chemicals.

Today, I'll discuss some aspects of the groundwater issue from the industry's perspective - and talk about some of the facts versus perceptions. I'll discuss the significance of some of the reported detections and some of the things that should be done to prevent unacceptable concentrations of agricultural chemicals from getting to groundwater.

Crop protection products are vital production tools for America's farmers. Without them, yields -- and profitability -- would significantly drop.

Nobody has a greater stake in groundwater protection than America's farmers. If groundwater is contaminated by unsafe concentrations of crop protection chemicals, their families are the first to be put at risk.

Crop protection products can be used safely and effectively in most settings without endangering groundwater quality.

The public's perception is that any chemical detected in groundwater is bad no matter what the concentration. The fact is that trace quantities of chemicals can sometimes be detected in groundwater using highly sensitive analytical technology. Several agricultural chemicals have been detected in some ground or well water samples, but usually at extremely minute concentrations. The actual risk to public health depends on the concentration of the chemical in groundwater... not on its mere detection.

EPA's 1986 summary indicated that 17 agricultural chemicals had been detected in 23 states and the number of detections reported has increased since then. Does that mean that the "problem" is getting worse or does it simply mean that more monitoring is occurring and detection limits are getting lower?

It's necessary to closely examine the results of groundwater studies in comparison to standards or health advisory levels in order to understand the significance of the reported detections.

Recent Minnesota results are typical of what's being found in the mid-west. One hundred wells were sampled by the Department of Agriculture in the most vulnerable agricultural areas and 400 public wells were sampled in vulnerable areas of the state by the Health Department. Pesticides were reportedly detected in 51% of the ag wells and 28.5% of the public wells tested. However, most concentrations were less than 1 ppb.

Atrazine was reportedly detected more frequently than other pesticides in that survey. However, it was not detected at the 0.01 ppb detection limit in 293 of the 400 public wells; 69 Wells had concentrations between 0.01 and 0.1 ppb; 31 between 0.1 and 1 ppb, 4 wells between 1 and 3 ppb and only 3 wells exceeded Minnesota's 3 ppb recommended allowable limit (RAL).

These results indicate that the real contamination problem is not as significant as it seems based only on the frequency of detections. The real problem is fairly limited but it needs to be addressed to prevent concentrations from exceeding acceptable drinking water standards.

Other surveys show similar results. Most samples analyzed show no detectable residues at all unless studies are conducted in highly vulnerable areas. Positive results, when detected at all, are usually less than one part per billion. When positive results exceed a few parts per billion, they're typically associated with highly vulnerable hydrogeology such as sandy, Long Island soils or are likely the result of "quasi-point" sources such as spills or direct entry to the water table.

Most groundwater detections resulting from normal agricultural applications are less than one-part-per-billion. A person would have to live to be 685 years old to consume 500 mg of a chemical if he drinks 2 liters of water per day containing 1 ppb of that chemical. Five hundred mg is the weight of one extra-strength aspirin tablet.

All significant sources of contamination need to be identified and addressed to prevent unacceptable concentrations from getting into groundwater. This includes contamination resulting from point sources, "quasi-point" sources or from normal applications in highly vulnerable areas. These sources need to be addressed separately since their potential impact on groundwater and the appropriate approach to prevention of unacceptable groundwater concentrations is different.

This is a non-point source workshop so I won't talk about point sources but I will talk about "Quasi-point" sources since they occur widely and are responsible for many, if not most, of the higher concentrations reported.

"Quasi-point" sources are caused by high localized soil concentrations or direct entry into the water table. As an example, 1/4 lb of chemical spilled in a 100 sq. ft. area around a well-head is equivalent to application of 100 lbs./acre to the soil surface. This can cause groundwater concentrations that are 50 times higher than those that result from application of a chemical to the same area at 2 lbs. per acre. "Quasi-point" sources also result from direct entry of a chemical into the water table. No chance exists for degradation or binding to occur in the soil since the soil column is by-passed in those situations. This can happen because of back-siphoning into a well or entry of runoff water into a well with a poor seal or into dry wells installed to carry irrigation tail-waters directly from the soil surface to the water table.

"Quasi-point" source contamination can be prevented without restricting the availability of agricultural chemicals to farmers. Education is key to addressing this part of the problem and needs to cover every aspect of pesticide handling and use that can cause significant contamination as well as ways to prevent direct entry of contaminants into the water table.

Four basic questions have to be answered to prevent unacceptable groundwater contamination due to normal application of agricultural chemicals in highly vulnerable areas. What concentrations are unacceptable? Which areas are susceptible to unacceptable groundwater contamination? Which chemicals that are used in those areas, if any, can get to groundwater at unacceptable concentrations? How can agricultural chemicals be managed in those situations to prevent unacceptable contamination from occurring?

We believe that unacceptable contamination should be defined using MCLs established under the safe Drinking Water Act. EPA's life-time health advisory levels should be used on an interim basis until MCLs are established since they are based on the results of the most sensitive chronic studies and include large safety margins to insure protection of people's health.

Where the chemical is used and how much is used is also an important consideration. As an example, pesticides that are applied to foliage have little chance of getting into groundwater since little reaches the soil surface.

Hydrogeological vulnerability is a function of the interactions between soil and water that determine how much water moves through the soil to the water table and how rapidly it gets there. Irrigation is one of the factors that can be managed to help prevent groundwater contamination. If crops are irrigated with only the amount of water necessary, water will not move beyond the root zone and the chemical will not be carried to the water table. DRASTIC was developed by EPA to set priorities for EPA's nation-wide survey. It identifies some of the factors that are important to hydrogeological vulnerability but should not be

Depth to Groundwater
- Net Recharge
Aquifer media
Soil type
Topograph

Impact of unsat zone
Hydraulic Conductivity

used blindly since it has not been validated as a predictor of unacceptable groundwater contamination.

Key chemical properties include soil binding and degradation, which are functions of both the pesticide and the soils to which they are applied. Chemicals that are tightly bound to soil will not move to groundwater. Likewise, little groundwater contamination will occur if most of the chemical degrades in the time that it takes for water to transport it from the soil surface to the water table.

EPA's nation-wide well water survey will help answer some of the questions that I posed. Health advisory levels were developed for 62 pesticides including essentially all those that have been detected or are likely to be detected in groundwater. These health advisory levels incorporate large safety margins to protect people's health and should be used to determine the significance of detections. This survey will help determine the extent and limits of the problem and it will help define the types of areas where unacceptable contamination can occur.

Once this survey is completed, we can better relate agriultural chemical use, chemical properties and hydrogeological vulnerability with detected concentrations. We can then focus our attention and resources on managing the use of pesticides in the specific highly vulnerable situations where it's necessary to prevent unacceptable concentrations from getting into groundwater.

Much of the environmental research done to register our products is done to help answer the groundwater questions that I raised. This includes soil mobility, soil degradation and terrestrial dissipation studies. Results from these studies can be used in computer models to predict the likelihood of migration of significant concentrations to groundwater and additional monitoring studies can be conducted when necessary. Du Pont and several other companies are currently actively involved in monitoring efforts.

We believe that a cooperative effort is necessary to address the groundwater issue which involves the chemical industry, regulators, academia and most importantly, farmers. Solutions to these problems will only be useful if they can be implemented economically by farmers.

Today I have addressed facts versus perceptions. I've indicated that the concentration of the chemical in groundwater is important, not its mere detection and I've indicated the need to use reasonable standards to protect people's health without unnecessarily restricting the use of these important chemicals.

# Thursday Morning, July 27, 1989

| | | PAGE |
|---|---|---|
| **SESSION V:** | **NPS POLLUTION FROM AGRICULTURAL GRAZING/FEEDLOTS/DAIRIES**<br>Session Chair: Don Ostler, UT | |
| 10:15 a.m. | **NPS Pollution from Grazing in Arizona**<br>Larry W. Stephenson, Environmental Program Specialist<br>Water Quality Assessment Section<br>AZ Department of Environmental Quality | V-A |
| 10:30 a.m. | **Montana's NPS Pollution Monitoring Strategy**<br>Dr. Loren Bahls, Supervisor<br>MT Water Quality Management Section | V-B |
| 10:45 a.m. | **Idaho's Agricultural Pollution Abatement Plan**<br>Al Murray, Chief, Water Quality Bureau<br>ID Department of Health and Welfare | V-C |
| 11:00 a.m. | **New Mexico's Nonregulatory NPS Pollution Control Approach**<br>Jim Piatt, Program Manager, Planning Section<br>NM Environmental Improvement Division | V-D |
| 11:15 a.m. | **Spiritwood Lake Restoration Project**<br>Michael T. Sauer, Limnologist<br>ND State Department of Health | V-E |
| 11:30 a.m. | **ROUNDTABLE DISCUSSION & QUESTIONS** | V-F |
| 12:00 p.m. | **No-Host Deli Buffet LUNCH** - Salon C<br>Presiding: **D. Craig Bell,**<br>WSWC Executive Director<br>Speaker: **Senator Ruben Ayala**<br>Chairman, Senate Agriculture and Water Resources Committee , CA Legislature | V-G |

# Regulation Of Agricultural NPS Pollution In Arizona

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**ABSTRACT**

The 1986 Arizona Environmental Quality Act (EQA) established by statute three programs to regulate agricultural nonpoint source pollutants. These include:

1. a general permit program consisting of best management practices for the application of nitrogen fertilizers and concentrated animal feeding operations

2. a program intended to prevent groundwater contamination due to the use of agricultural pesticides; and

3. rangeland planning and management agency delegation for grazing activities.

## Introduction

The 1986 Arizona Environmental Quality Act (EQA) was the legislative result of a response to a 1985 initiative petition produced on water quality issues. The initiative, if approved, would have required that water quality issues be placed upon the November 1986 general election ballot. In mid 1985, Arizona water users requested that Governor Bruce Babbitt appoint a Blue Ribbon Commission consisting of knowledgeable experts, concerned citizens water users and state legislators to draft legislation to address the apparent concerns regarding water quality issues. Early in their proceedings, the Commission resolved that nitrogen and pesticide pollutants be addressed separately. As a result, the legislative mandates and subsequent programs for regulating agricultural Nonpoint Source (NPS) pollutants in Arizona have few similarities.

In January 1986, the Commission released a draft copy of legislation entitled "Arizona Water Quality Protection and Restoration Act." The Act, which was commonly referred to as Hawke I, was introduced into the 1986 legislative session as House Bill 2518. After being extensively amended, House Bill 2518 was passed as the Arizona Environmental Quality Act.

Although Hawke I was initially limited in scope specifically to water quality, the resulting House Bill 2518 was significantly expanded to include provisions for the following:

- establishment of the Arizona Department of Environmental Quality (ADEQ);
- Water Quality Control;
- Air Quality
- Noise Abatement
- Solid Waste Management; and
- Hazardous Waste Management.

## Management of Nitrogen Pollutants

The 1986 Arizona Environmental Quality Act (EQA) mandated that the Department of Environmental Quality adopt by rule a program consisting of Best Management Practices (BMPs) to control the discharge of pollutants from the agricultural NPS activities of (1) the application of nitrogen fertilizers and (2) concentrated animal feeding operations. By Arizona Statute, the application of nitrogen fertilizers and concentrated animal feeding operations are defined as regulated agricultural activities.

The Governor appointed Blue Ribbon Commission initially recommended that nitrogen pollutants be regulated by way of individual aquifer protection permits. However, after evaluating the cost requirements for implementing an individual permit program for regulated agricultural activities, a general permit program was developed. In addition, the Commission also included in their recommendations provisions for using BMPs for regulated agricultural activities. The BMP concept, which was adopted from the federal Clean Water Act as found in the USEPA rules and regulations, was judged to be well suited for regulating agricultural activities because of the following:

- BMPs are a fact driven approach to pollution control;
- BMPs provide the regulated sector with a high degree of participation and self governance; and
- BMPs allow for site to site or farm to farm flexibility.

The Arizona EQA mandated that the Director of ADEQ adopt by rule agricultural general permits consisting of BMPs for the application of nitrogen fertilizers and concentrated animal feeding operations. However, the vesting of highly specific engineering type BMPs in rule would have resulted in the loss of site by site or farm by farm flexibility. This constraint was overcome when the BMPs were redefined as general goal statements in rule. The generalized BMPs provide direction, purpose and incorporate the necessary elements of flexibility into the program. Thus, the regulatory program fulfills the goal of protecting water quality while maintaining on-site flexibility for Arizona's diverse crops, cropping patterns, soils and irrigation technologies. To assist the regulated community in complying with the law, the Department in association with the Governor appointed advisory committees assembled a handbook of specific guidance practices (GPs). By definition, guidance practices are the methods which an operator can use to implement the general BMPs. Since guidance practices are not incorporated into rule, they can be easily modified to reflect the current understandings of nitrogen management and developing technologies for control of nitrogen pollution. In addition, the establishment of guidance practices outside of rule facilitates the process of modification, since those modifications are not subject to the lengthy rule making process.

For purposes of managing pollutant discharges from a regulated agricultural activity the owner/operator must assure compliance with BMPs contained in rule. Discharges shall be managed through the use of guidance practices or some other measure designed to assure compliance with the BMPs. Guidance practices are therefore specific examples of techniques which can be used to reduce to the greatest practical degree discharge of nitrogen pollutants.

The BMPs, GPs and other methods contained in an owner/operator strategy may be assembled into a total resource management plan. Thus an owner/operator strategy for managing discharges from cropland could include specific guidance practices and other methods for the following:

- the management of soil;
- the management of water;
- the management of crops;
- the amount of fertilizer applied; and
- the timing of fertilizer application.

In contrast an owner/operator strategy for managing discharges from a concentrated animal feeding operation could include specific guidance practices and other methods for the following:

- the location of the facility;
- the management of solid and liquid wastes;
- the management of runoff; and
- land disposal of wastes.

Arizona's generalized BMPs as adopted into rule to prevent or minimize the discharge of nitrogen pollutants to groundwater for regulated agricultural activities are indicated as follows:

- <u>Application of Nitrogen Fertilizers</u>

  1. Application of nitrogen fertilizer shall be limited to the amount necessary to meet projected crop plant needs.

  2. Application of nitrogen fertilizer shall be timed to coincide as closely as possible to the periods of maximum crop plant uptake.

  3. Application of nitrogen fertilizer shall be by a method designed to deliver nitrogen to the area of maximum crop plant uptake.

  4. Application of irrigation water shall be limited to that amount necessary to supply crop needs to minimize nitrogen loss by leaching and runoff.

  6. The operator shall use tillage practices that maximize water and nitrogen uptake by crop plants.

- <u>Concentrated Animal Feeding Operations</u>

  1. The operator shall harvest, stockpile and dispose of manure from feedlot confinement areas in a manner which will minimize nitrogen pollution by leaching or runoff.

2. The operator shall control and dispose of nitrogen contaminated water resulting from activities associated with a concentrated animal feeding operation in a manner which will minimize discharge of nitrogen pollutants.

3. The operator shall close or abandon facilities in a manner which will minimize the discharges of nitrogen pollutants.

**Pesticide Contamination Prevention Program**

The 1986 Arizona EQA mandated that ADEQ adopt a program of Pesticide Contamination Prevention (PCP) for agricultural use pesticides. In contrast to the mandated Nitrogen Pollutant Management Program, the PCP program is (1) not a permit program and (2) does not utilize or rely upon the implementation of BMPs. This difference in conceptualization is directly attributable to the fact that (1) different subcommittees of the Blue Ribbon Commission developed the Nitrogen Pollutant and Pesticide Contamination Prevention statutes and (2) regulation of the use of agricultural pesticides in Arizona is vested in the Arizona Commission of Agriculture and Horticulture.

Nonpoint Source impacts of agricultural use pesticides upon groundwater are regulated by the ADEQ through the Pesticide Contamination Prevention (PCP) program. The PCP program integrates 6 regulatory mechanisms as defined in statute in the Arizona EQA to accomplish the goal of protecting Arizona groundwater from NPS agricultural use pesticide contamination. These regulatory mechanism consist of the following:

- information submittal by pesticide registrants;
- establishment of numeric values;
- development of a groundwater protection list;
- reporting on the use and sales of pesticides on the groundwater protection list by users and dealer;
- monitoring and testing of groundwater and soil for agricultural use pesticide contamination;
- upon detection, review of circumstances surrounding contamination to determine whether use of the pesticide should be modified or discontinued.

## Information Submittal

By Statute, the registrant of an agricultural use pesticide for use in Arizona must submit to the ADEQ specific criteria for each active ingredient for evaluation for groundwater pollution potential. These criteria are listed as follows:

- Water Solubility,
- Vapor Pressure,
- Henry's Law Constant,
- Octanol Water Partition Coefficient,
- Soil Absorption Coefficient
- Hydrolysis Half-life,
- Photolysis Half-life,
- Soil Aerobic Metabolic Half-life,
- Soil Anaerobic Metabolic Half-life,
- Field Dissipation Half-life.

## Establishment of Numeric Values

The ADEQ has established by rule specific numeric criteria for water solubility, soil absorption coefficient, hydrolysis, anaerobic and aerobic soil metabolism and field dissipation. By rule, an active ingredient of an agricultural use pesticide which has a water solubility greater than 30 ppm or a soil absorption coefficient (Kd) of less than 5 and any dissipation half-life greater than 3 weeks is indicated as having a capacity of leaching to groundwater. An agricultural use pesticide is therefore categorized as a "suspect leacher" if the chemical and physical criteria indicate that it is both mobil (water solubility or soil absorption value) and persistent (dissipation half-life).

## Development of Groundwater Protection List

The ADEQ shall establish by rule a groundwater protection list consisting of active ingredients for agricultural use pesticides which have the potential to pollute groundwater. Agricultural use pesticides which are identified as both mobile and persistent are placed on the groundwater protection list.

Reporting

By Statute, dealers shall make quarterly reports to the Director of ADEQ of all pesticide sales.

Monitoring and Testing of Groundwater and Soil

By Statute, agricultural use pesticides which are placed upon the groundwater protection list shall be included in statewide groundwater monitoring and soil testing programs. The Department shall monitor both soil and groundwater in those areas of the state where agricultural use pesticides have been used and where a reasonable probability exists that a specific active ingredient may leach to pollute groundwater.

Detection of a Pesticide in Soil or Groundwater

A registrant of an agricultural use pesticide shall be notified when an active ingredient or degradation product of an agricultural use pesticide is detected:

- 8 feet below the soil surface or below the root zone of a crop where the active ingredient was used;
- below the soil microbial zone;
- in the groundwater of the state.

Upon notification that an active ingredient or a degradation product which has an identified potential to pose a threat to public health has been detected in the soil or groundwater of the State, a registrant may modify the label use instructions in such a manner that the active ingredient can not pollute groundwater. If the label cannot be modified in manner which will ensure that the active ingredient will not pollute groundwater in the state the registration of the pesticide shall be cancelled. If an agricultural use pesticide is found to be carcinogenic, mutagenic, teratogenic or toxic to humans, the registration shall be immediately cancelled.

**Rangeland Planning and Management Delegation for NPS Grazing Activities**

The 1986 Arizona EQA mandated that the Department of Environmental Quality adopt by rule, a program to control NPS discharges of any pollutant or combination of pollutants into navigable water. Unlike the BMP program for Nitrogen Pollutants and the Pesticide Contamination Prevention program, grazing activities were not specifically detailed in the EQA.

The 1988 draft Arizona NPS Assessment Report has identified rangeland activities as a major contributor of NPS pollution in the State. The ADEQ is currently developing a program in rule for the agricultural NPS activity of grazing. This program is conceptualized as a cooperative effort between ADEQ and specific private, state and federal land managers. The NPS Management Program for grazing activities consists of the following components:

- planning,
- implementation by rule,
- implementation by other means, and
- compliance

Planning

By Federal and State Law, the Arizona Department of Environmental Quality has the lead responsibility for planning and development of the NPS Management Program for grazing activities. However, the Department has established a technical advisory group to assist in the planning process. This advisory group consists of distinguished representatives from the following:

- Governor's Rangeland Advisory Council,
- Arizona Cattle Growers Association,
- Arizona Wool Growers Association,
- University of Arizona
- Arizona State Senate
- Arizona House of Representatives,
- Bureau of Land Management,
- National Forest Service,
- Arizona State Land Department,
- USDA - Soil Conservation Service,
- Commission on Arizona and the Environment, and
- The Nature Conservancy.

## Implementation by Rule

The Department is currently negotiating with identified public resource management agencies for the purpose of designating and delegating NPS implementation responsibility. Delegation of implementation authority is subject to the condition that an agency meets the following criteria:

- legal authority to administer the delegated authority;
- financial solvency and the necessary resources to manage delegated responsibilities;
- administrative competence, organizational resources and personnel resources to manage the delegated responsibilities;
- technical competence to manage the delegated responsibilities;
- public acceptability to manage the delegated responsibility, and
- agency accountability to ensure that the Management Agency is accountable to the public that is served.

The technical advisory group, detailed in the planning discussion above, is currently assisting the Department in identifying BMPs for grazing activities to be adopted into rule.

## Implementation by Other Means

The Department is negotiating with several land management agencies and the University of Arizona to establish education and technical transfer components of the program to assist the regulated community in complying with the law. In addition, demonstration research projects are being developed in conjunction with the USDA-Soil Conservation Service and the National Resource Conservation Districts (NRDCs).

## Compliance

The Department has retained the option to delegate the monitoring and program oversight components of the NPS Management Program for grazing activities. Enforcement activities, however, are maintained by the Department.

DRAFT

# MONTANA'S NPS POLLUTION MONITORING STRATEGY

by

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for

Nonpoint Source Pollution Control Technical Issues Workshop
Western States Water Council
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## SUMMARY

Montana is a large, varied state with few people. Agriculture, forest products and mining are the principal land-based industries. About one-third of Montana's streams suffer moderate to severe use impairment. Nonpoint source pollution is the cause of impairment in 95 percent of these waters. Agriculture is by far the largest source of use impairment. Major causes of impairment in the Agricultural source category are sediment, salinity, nutrients, streamflow depletion and stream channel alterations. Montana has an approved Section 319 Agricultural NPS Management Program. The Program is intended to be a coordinated, comprehensive, multi-agency approach to NPS control with the Department of Health and Environmental Sciences as the lead agency.

Montana's NPS Monitoring Strategy has three goals: (1) Develop a record of current conditions on all streams; (2) rank impaired streams according to pollution severity as a basis for cleanup priority; and (3) verify the application of BMPs and document their effectiveness. Goal #1 will be addressed by surveying existing data bases and transferring assessment information to a customized version of the EPA Waterbody System. Goal #2 will be achieved by applying a uniform stream reach NPS pollution assessment procedure to impaired streams. Standardized assessment ratings obtained in this manner will be stored in a computerized data base called the Montana Reach Tracking System. Goal #3 will be accomplished by conducting BMP audits and in-depth, project-specific monitoring programs.

A number of technical problems plague NPS monitoring programs. Four of these are identified and discussed briefly. However difficult these technical issues may be to overcome, monitoring and assessment will remain essential elements of any NPS pollution control program.

Background

Montana is the fourth largest state but has only 800,000 people. The western third of the state is forested mountains; the eastern two-thirds are grassland plains. Agriculture, forest products and mining are the principal land-based industries.

Montana has over 20,000 miles of fishable streams, some of them nationally acclaimed trout streams. The state has approximately 4,000 lakes and reservoirs and an estimated 2 million acres of wetlands. Natural water quality varies considerably from west to east.

About one-third of Montana's streams suffer moderate to severe use impairment. NPS pollution is the cause of impairment in 95 percent of these waters. Agriculture (46%) and hydromodification (26%) are the largest sources of use impairment, followed by land disposal, mining, and forest practices. Major causes of impairment in the Agricultural source category are sediment, salinity, nutrients, streamflow depletion and stream channel alterations.

Montana submitted its Section 319 NPS Assessment Report and Management Plan to EPA on August 2, 1988. Stream assessments in the Assessment Report are based largely on the judgement of local resource managers. No attempt was made to rank or prioritize streams for rehabilitation other than making a distinction between streams moderately impaired (uses partially supported) and streams severely impaired (uses not supported).

The Montana NPS Management Program is intended to be a coordinated, comprehensive, multi-agency approach to NPS control with the Department of Health and Environmental Sciences as the lead agency. Coordination is accomplished through a NPS Interagency Task Force and MOUs with key agencies. The goal is

to achieve, through demonstration projects, financial incentives, education and existing regulatory controls, universal application of BMPs for those source categories that substantially impair or threaten to impair beneficial uses of Montana waters. For agricultural BMPs, Montana has adopted the standard conservation practices and specifications of the Soil Conservation Service.

Montana received EPA approval of its Section 319 Assessment Report on April 12, 1989 and of the General Management and Agriculture portions of its Management Program on June 7, 1989. The Department is applying for a portion of the Governor's 20% set aside from the state's Construction Grants allocation [Section 201(g)(1)(B)] to implement the program, using funds from the State's Resource Indemnity Trust as match.

Monitoring Strategy

Montana's NPS Monitoring Strategy has three goals:

1. Develop a record of current conditions on all streams -- impaired and unimpaired;

2. Rank impaired streams according to pollution severity as a basis for cleanup priority; and

3. Verify the application of BMPs and document the effectiveness of BMPs.

Goal #1: Develop Baseline. Numerous agencies in Montana engage in water quality monitoring and assessment. Information exists in many different data bases in both the electronic and printed media.

Representatives of these agencies were assembled in Helena in February 1989 as the Monitoring Committee of the NPS Interagency

Task Force. The Committee decided it would pursue four recommendations made in the NPS Assessment Report: 1) improve coordination; 2) inventory existing data bases and prepare a directory to those data bases; 3) prioritize types and location of future monitoring; and 4) explore sources of funding for monitoring.

As required under Section 305(b) of the CWA, the state will take the lead in developing statewide assessments of water quality conditions using the information at hand. The Department of Health and Environmental Sciences will use a customized version of the EPA Waterbody System as a repository of assessments (but not of water quality data) and as a tool to generate water quality assessment reports.

The Natural Resources Information System (NRIS) headquartered in the Montana State Library has volunteered to inventory the monitoring programs and data bases of other agencies. NRIS will then prepare a directory of these monitoring programs and data bases. This directory will be used by the Department as a source book of information which may be consulted in developing a record of current conditions statewide. It will also help the Monitoring Committee to prioritize the types and locations of future monitoring.

Goal #2: Rank Impaired Streams. In Montana's approved NPS Management Program, the Department outlined a system for ranking and selecting watershed projects for implementation. Forty percent of the weighting in this system will be based on the severity and extent of impairment to beneficial uses. [The other 60% will be based on technical and financial feasibility (40%) and demonstration value for transfer to other areas (20%).]

This system has required that the Department develop a uniform stream reach NPS pollution assessment form to standardize the

rating of use impairment in Montana streams. The form is accompanied by an evaluation key to describe the different levels of impairment (e.g., excellent, good, fair, poor) in each assessment category (e.g., bank stability, vegetative condition, embeddedness). Numerical values are assigned to each level of impairment, which may be combined to yield an aggregate score for that reach. The form is intended to be usable by individuals with varying backgrounds and applicable to a broad spectrum of streams, including mountain and prairie streams.

Assessment scores obtained in this uniform manner will reside in a computerized data base called the Montana Reach Tracking System. A comparison of aggregate scores for the different streams will provide the needed ranking of impaired streams.

Streams with the highest impairment ratings would be slated for a more intensive assessment by an interdisciplinary and (or) inter-agency review team. The type of intensive assessment would depend on the nature of impairment and may include BMP audits, bioassessment, collection of water or sediment samples, and a streambank physical features inventory. These more detailed assessments would be required prior to project implementation, both to pinpoint problem areas for BMP application and to serve as a benchmark against which to gauge the effectiveness of controls (Goal #3). All levels of assessment would help to develop a record of current conditions (Goal #1).

<u>Goal #3: Verify BMP Implementation and Effectiveness</u>. It is generally accepted if not well documented that most water quality problems can be avoided if BMPs are in place. (However, extensive activity in a watershed may result in cumulative effects even though BMPs have been applied throughout.) The first "monitoring" priority then should be to determine whether BMPs have actually been applied.

Montana has adopted the forest practices BMP audit procedure developed by the State of Idaho. This procedure takes into account both the application and, at least superficially, the apparent effectiveness of the BMP or BMP system. The Department believes that BMP audits are a very useful first-line tool in assessing real or potential water quality impacts and should be developed for the agriculture and mining source categories as well. BMP audits can also serve to measure the degree of participation in a voluntary NPS control program and as an enforcement tool in a regulatory program.

For individual watershed implementation or demonstration projects, a water quality monitoring program is needed to evaluate the effectiveness of BMPs or BMP systems. Such a program may involve one or more of the in-depth assessment techniques described above and would be tailored to the specific nature of the problem, e.g., organic wastes vs. inorganic sediment.

Two of the demonstration projects included in the Agricultural portion of Montana's NPS Management Program are Godfrey Creek and Otter Creek. Godfrey Creek is polluted primarily by manure from animal confinement areas associated with dairies. In Otter Creek, the cause of impairment is primarily sediment from poor grazing and irrigation practices. "Before and After" monitoring programs for these two projects will be very different. The Godfrey Creek program will rely primarily on measurements of nutrients and bacteria in the water column; in Otter Creek, improvement will be gauged by changes in fish and macroinvertebrate populations.

Monitoring and the application of BMPs may need to be repeated because water quality managers don't always "get it right" the first time. If monitoring shows that impairment still occurs after BMPs are in place, then the activity causing the impairment

needs to be modified even further (better than "best" management practices applied) and the monitoring repeated. In effect, this becomes a continuous process in watersheds with ongoing resource development activities. Such monitoring may also help to validate models used to predict the cumulative effects of multiple activities in a watershed. In some cases monitoring or modelling may show that activities should be deferred, as they have been in the Lolo and Buck Creek watersheds near Missoula.

The iterative process just described is known as an "adaptive management" approach. This approach involves cooperative research, monitoring, and evaluation to better understand land use/water quality interactions and to adapt specific management practices as needed in specific situations. Montana's Flathead Basin Commission has initiated an adaptive management program addressing forested lands in the Flathead River Drainage upstream from Flathead Lake.

Technical Issues

Aside from resource limitations, there's a host of technical problems that plague NPS monitoring programs.

One of these is the diffuse nature of the sources and causes of water quality impairment. It's not always possible to identify the source of a pollutant in a stream or to measure the effectiveness of a single BMP.

Natural variation in streams, longitudinally and over time, often make it difficult to detect anything but gross changes in water quality. Water quality effects of land use activities may be delayed and continue long after the activity has ceased.

Another technical issue specific to sediment and nutrients is the lack of useful criteria by which to judge the level of use

impairment in running waters. Threshold values from the literature are seldom transferable to streams with different physical and biological features.

Finally, cause-and-effect relationships between pollutants and use impairment are often implied but rarely proven. Deposited sediment in spawning and rearing areas may appear to be holding down trout populations when the limiting factor is actually depleted stream flow, angling pressure, or stream infertility.

Monitoring the water quality effects of land use activities is much more difficult than monitoring the effects of point source discharges. However difficult these technical issues may be to overcome, monitoring and assessment will remain essential elements of any NPS management program.

# WESTERN STATES WATER COUNCIL
# NONPOINT SOURCE POLLUTION CONTROL
# TECHNICAL ISSUES WORKSHOP

## IDAHO'S AGRICULTURAL POLLUTION ABATEMENT PLAN

Al E. Murrey, P.E.
Idaho Department of Health and Welfare, Division of Environmental Quality

OUTLINE OF THE AG PLAN

The State Agricultural Water Quality Program (Program) has been in operation since 1979. The Idaho Agricultural Pollution Abatement Plan (Ag Plan) is the foundation for the state's program. Grants are funded from the Division of Environmental Quality (Division) and jointly administered by the Soil Conservation Commission (Commission). Planning grants are used for identifying agricultural acreage contributing to water quality pollution. From the planning projects, implementation grants are selected for cost-sharing on voluntary installation of best management practices (BMPs).

### Agency Responsibility

The Division's objective is to assure that water quality is protected from impacts resulting from agriculture through the implementation of the Ag Plan in the Program. This is accomplished through close cooperation with the Commission, technical agencies, primarily the Soil Conservation Service (Service), and local agencies such as the Soil Conservation Districts (District). The Commission is responsible for overall District administration. The Service is responsible for the technical aspect of the Ag Plan and the Program. The Division's role is to administer funds for project planning and implementation, and evaluate effectiveness of the Program in protecting beneficial uses of water. These roles are being fine-tuned through the current revision of the Program, Ag Plan, Program Procedures Manual and rules and regulations.

**The Basis for State Agricultural Water Quality Program**

The Ag Plan emphasized three factors essential to the success of the Program:

1. Technical assistance to farmers identifying problems and solutions to agricultural pollution;

2. Informational and educational activities raising awareness of the pollution problems and solutions available ; and

3. Incentives for BMP implementation offsetting the costs of BMP installation. The BMP benefits are generally long-term, and affect the farmer as well as the downstream public.

A five-year trial period was established (with EPA approval) to determine the effectiveness of the voluntary nature of the program. The Ag Plan is entering its ninth year of implementation. Evaluations and results have shown the Program is working very well. The state has received acclaim, regionally and nationally for its outstanding efforts in voluntarily reducing agricultural pollution.

IMPLEMENTATION OF THE AG PLAN

As of fiscal year 1990, 21 planning grants and 25 implementation grants will have been made to 18 local Soil Conservation Districts to solve water quality problems from approximately one-half million acres of agricultural land. About 15.8 million dollars in state funds have been allocated to these projects. It is estimated that the land-owner's cost-share will match the amount of grant funds invested by the end of their ten-year contracts.

**Legislative Action in 1980**

As a means of achieving the Clean Water Act of 1972 (Public Law 92-500), area waste treatment management processes have been developed and implemented. The Ag Plan was developed under Section 208 of the Clean Water Act.

When the waste treatment management process was developed to address agricultural nonpoint source pollution, the DEQ contracted with the Commission to assist in the process. Section 208 grant funds fron the EPA were used to develop the Ag Plan. The plan was certified by Governor Evans and approved by EPA in 1979. The plan was updated in 1982.

**General Process for Projects**

Districts apply for planning projects based on stream segments of concern listed in the Ag Plan. Planning projects are then selected by the Division, Commission and the Service based on criteria including water quality benefits, technical assistance availability, district readiness to proceed, project water quality studies and funding. The length of planning projects is from a year to 18 months. A final report is developed from the planning project and submitted with an application for implementation. Selection of the implementation projects are based on criteria similar to the planning project selection process. Implementation projects are conducted over a ten to 15 year period. The Soil Conservation Commission and the Board of Health and Welfare must approve all projects before a grant is offered.

**Information and Education**

Each District with an active Program devotes a certain portion of their project budget to information and education programs. Programs include project tours, conservation tillage tours, classroom presentations, slide shows, poster contests and picnics. The goal is to foster community awareness of ag-related water quality problems and to generate community project support.

**Funding**

Grant funds spent to date by each project, and money contributed by contracting farmers into the matching portion of the program are monitored on a quarterly basis. Funding for all Program projects comes from the Idaho Water Pollution Control Account. The state revenues are derived from a combination of cigarette, tobacco, inheritance, and sales taxes.

**Technical Assistance**
The quality control of BMPs is provided by the Service or the Commission to assist the farmers in their conservation plan. Technical assistance is essential to the effectiveness of the improvement to water quality.

**Problems Encountered**
One problem the Division continually encounters is the Water Pollution Control Account (WPCA) funding level. The legislature has borrowed from the WPCA from time to time causing decreases in the account's funding levels.

Another problem in the program is the increasing monitoring demand for new planning projects and post-monitoring for ongoing projects. Additional administrative oversight is needed in the Division's Central Office. Currently the Division cannot keep up with the ever-increasing demand for lab analysis and staff to conduct the necessary water quality monitoring. The Division is looking into some alternative data sources and streamlining approaches to the monitoring demand problem.

The third problem is the rapid growth of the Program. The popularity of the program has created an expanded workload for all cooperating agencies' staff. The agencies are finding it difficult to keep up with maintenance of existing projects while reviewing an increasing amount of applications every year. Last year, we had 22 applications. During the previous years we rarely received more than 12.

PROGRAM EFFECTIVENESS

The effectiveness of BMPs and of the Ag Plan is conducted through pre- and post-water quality monitoring, project reviews, plan reviews, and agency meetings. Currently the DEQ is conducting nine water quality studies and has published an additional 35 water quality reports involving agricultural projects.

Public involvement has provided a strong foundation for the program. The emphasis on information and education has lead to wide-spread acceptance of the Ag Plan by farmers, ranchers, cooperating agencies, state legislators, and the public.

The soil conservation districts and the landusers are strongly committed to the program. Progress to date demonstrates that the voluntary program is well received by all groups involved and is effective through a viable information and education program, adequate technical assistance and financial incentives.

**Program Coordination**

The success of the Program depends to a large degree on open communication and coordination among land managers, regulatory agencies, resource managers, the regulated industry and the public. Listed below are documents aiding in the essential coordination among these groups.

Idaho Agricultural Pollution Abatement Plan

Outlines the BMPs, agency responsibilities/authorities, and identifies action items for program improvement. Certified by Governor Cecil Andrus and approved by EPA.

Agricultural Water Quality Program Rules and Regulations, Title 1, Chapter 14

Defines and outlines the foundation of the State Agricultural Water Quality Program, the Idaho Agricultural Pollution Abatement Plan, and the plan's Procedural Manual.

Idaho Agricultural Pollution Abatement Plan Procedures Manual

Provides the practical application of the Agricultural Water Quality Program Rules and Regulations as well as the Idaho Agricultural Pollution Abatement Plan.

Idaho Water Quality Status Report and Nonpoint Source Assessment

Addresses impacts by agrichemicals in surface water and groundwater, livestock grazing on riparian areas, and livestock confinement areas not recognized as point sources.

Memoranda of Agreement (MOA) & Memoranda of Understanding (MOU)

Contractual agreements have been completed between the Division, Commission, Service, and Idaho Association of Soil Conservation Districts.

## NEW DIRECTIONS

The Ag Plan and Program are being expanded and revised to reflect requirements of Section319 of the Clean Water Act. The additions will include livestock grazing on riparian areas, the state antidegradation agreement, impacts by agrichemicals in surface water and groundwater, and livestock confinement areas not recognized as point sources. Other issues to be addressed during the Plan and Program revision process include clarification of agency responsibilities; BMP establishment and approach; the voluntary aspect of the Program; post-implementation monitoring; technical assistance, financial assistance, and program streamlining.

## AGENCY CONTACTS

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# New Mexico's Nonregulatory NPS Pollution Control Approach

Jim Piatt

New Mexico Environmental Improvement Division

## Historical Perspective

Statewide nonpoint source management in New Mexico began on a systematic basis during the section 208 planning process. Section 208(b)(2)(F-K) of the federal Clean Water Act required the states to identify processes, procedures and methods to identify and control, to the extent feasible, nonpoint sources of water pollution. Sources to be included in the plan were identified in the Act as agriculture, silviculture, mining, construction, waste disposal and man-induced salt water intrusion into fresh waters.

At the time the 208 management plan was prepared, water pollution resulting from point source discharges was deemed to be of greater concern and higher priority. While attention and limited resources were focused on the high priority issue of point source control, educational programs, incentives and technical assistance were chosen as methods of promoting a voluntary approach to nonpoint source control. The plan which was developed and adopted by the New Mexico Water Quality Control Commission stated (1): "It is the consensus of the Commission that mandatory BMPs

shall not be adopted until such time as water quality problems ... have been adequately documented."

Until recently, monitoring activities performed by the State, federal agencies and others have not been aimed at identifying nonpoint source water pollution problems. Monitoring nonpoint source pollution events is difficult at best because of the largely stochastic nature of their occurrence. The results of available water quality monitoring are often difficult to interpret because of the large number of activities in any given area which may be contributing to the perceived results. However, the states **must** now attempt such monitoring and interpretation because of a change in the federal statute.

On February 4, 1987, the U.S. Congress passed, over President Reagan's veto, the Water Quality Act of 1987 (PL 100-4). The Water Quality Act amended the Goals and Policy section of the federal Clean Water Act (PL 92-500) by adding a new subsection explicitly stating that nonpoint source control is the national policy. The Water Quality Act further amended the Clean Water Act by adding a new section entitled "Sec. 319 Nonpoint Source Management Programs." This section mandated an assessment of the nonpoint source effects on the states' waters and development of a management program to control such effects. New Mexico completed its assessment report and transmitted that report to the U.S. Environmental Protection Agency (EPA) in October 1988. The EPA formally rejected this submittal on January 31, 1989 as not fully meeting the requirements of the Act. The report was updated and resubmitted to EPA in May 1989. To date, EPA has not acted on the resubmittal.

## Grazing Impacts

The New Mexico Nonpoint Source Assessment (2) identified water quality concerns due to nonpoint source pollution in 104 river reaches and 55 lakes. Feedlots and dairies have not been shown to adversely affect surface water quality in New Mexico although the amount of water quality monitoring aimed at making such a determination is minimal. The Assessment did show that grazing activities contribute to partial use impairment of 1,016 of the 1,276 affected river miles and 90 of the 104 identified reaches. Of the 102,800 lake acres reported as partially impaired, grazing contributed to the impairment of 102,083 and 52 of the 55 affected lakes. While grazing is the most pervasive source of water quality impairment in New Mexico, in almost every case there were other nonpoint sources contributing to the water quality impairment. The effects of grazing on water quality were judged to be of low or moderate severity in most of the cases. In the few remaining cases, where the effects were severe, the ongoing impacts were due to the historical overgrazing of areas with highly erodible soils. The identified water quality concerns related to grazing are predominantly due to sediment input and associated turbidities. Other effects are due to sediment-borne heavy metals and plant nutrients. Virtually every one of the State's designated uses, including irrigation, have been affected by these pollutants.

The discovery of adverse water quality effects from grazing activities is not particularly surprising. Grazing removes the vegetative cover which

is the single most important variable affecting soil erosion (3). In the uplands, grazing also accelerates erosion through soil compaction which reduces infiltration, increases runoff and results in gully formation. Compounding the concerns is the tendency of domestic stock to congregate in the riparian areas due to the amount and kinds of available forage, presence of shade and access to water (4). Streamside vegetation acts as a filter strip and prevents erosion by shielding the banks during storm-flows. Roots bind the streambanks together and help prevent sloughing of soil materials into the water. However, streamside activities by livestock may result in the destruction of the streambanks by trampling. This bank destruction results in direct sediment input to the system further altering the aquatic habitat. The consumption of the riparian vegetation also allows overland flows to enter the system. Decreased shading will result in increased water temperatures and the lack of vegetation will further destabilize the streambanks. These potential water quality impacts are of significant concern to New Mexico because grazing is the most extensive of all land uses in the State; between 82 and 84 percent of the land surface is used for livestock production (5,3). However, among the impacts is the not-insignificant benefit that residents receive from this activity. Total livestock receipts for 1985 totaled 717.5 million dollars (6).

Seventeen percent of the State's native grasslands are reportedly in "poor" condition while 57 percent are in "fair" condition (3). Soil erosion from privately owned range-lands in New Mexico is estimated to average 8.3 tons/acre/year, the highest in the country (7). The U.S. Department of Agriculture (8) reported that only 28 percent of the

nonfederal rangeland was adequately managed. Central to the idea of good range management is controlling livestock grazing at an intensity that leaves sufficient vegetative cover to protect the soil. Yet, the most recent USDA (8) review found that 7 million acres in New Mexico need grazing management strategies developed specifically to address current overgrazing.

**New Mexico's Nonregulatory Approach to NPS Management**

Water quality management in New Mexico is changing. Mandated assessment activities have shown that livestock production has, and is, affecting water quality in a significant portion of the State's rivers and lakes. These facts are already leading to change "on the ground". Voluntary management activities by the State's ranching community have been accelerating. The Soil Conservation Service (SCS) is emphasizing improved grazing management in its assistance programs and has over 400 operating grazing systems in the State covering almost 6 million acres of rangelands (9). These plans go beyond the structural "band-aids" applied in the past and deal on the ecosystem level with all of the environmental concerns, including water quality. The trend toward intensive management is expected to continue, with 1.6 million acres expected to be under new management activities this year. Water quality concerns are being specifically addressed in these plans.

## Institutional Changes

The "system" itself is changing due to the Congressional mandate and the new awareness of the effects of nonpoint source pollution. The SCS is involved in a crash program of training its own staff in techniques of preventing as well as identifying and correcting nonpoint source water pollution concerns. The Bureau of Land Management is emphasizing riparian management in its grazing management plans, largely due to water quality concerns (10). Region III of the U.S. Forest Service, which includes those national forests in Arizona and New Mexico, is in the process of finalizing a Best Management Practices Handbook which deals with all of its land management activities.

As a state employee it's an interesting, and challenging time to be working in the nonpoint source area. Our citizens are better informed, more active and vocal about their water quality concerns than at any time in the past. Awareness of nonpoint source water quality concerns, and a new sensitivity to these concerns, is increasing in the State bureaucracies. Water demands for agriculture, recreation and municipal and industrial water supplies are increasing. We are learning that water polluted by large scale land activities is just as useless as that polluted by point source discharges.

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# FINAL REPORT

## Spiritwood Lake Restoration Project
## From 1980 to 1988

Submitted by

Michael T. Sauer
North Dakota State Department of Health
and Consolidated Laboratories

## Introduction

Spiritwood Lake, located in the east-central part of North Dakota, is approximately 15 miles northeast of Jamestown. The lake is unique among natural lakes in the prairie pothole region. Salient features include: (1) a maximum depth of 16 meters, exceeding all other natural lakes in the state which are capable of supporting a sport fishery; (2) it exhibits thermal stratification; (3) a densely forested shoreline; (4) ample public ownership of adjacent lands; and (5) site of the only state-owned fish hatchery.

The Spiritwood Lake project was the state's first attempt to evaluate and subsequently restore a lake by utilizing a comprehensive approach to lake management.

A diagnostic study was initiated in 1980 and completed in 1982 to determine the trophic state of the lake and delineate the major sources of nutrients responsible for its eutrophication. A nutrient budget was developed during the study which identified nonpoint nutrient loading from the watershed and internal loading from sediments during anoxic periods as major sources. During periods of moderate to high runoff, the watershed was a major contributor, whereas during years when low runoff occurred, the sediments provided the greatest nutrient load.

Subsequent to the diagnostic study, the feasibility of restoring the lake was reduced to five alternatives. The hypolimnetic withdrawal was the selected alternative because it had the best probability of being effective, a relatively low cost, and had broad public support.

Public participation/education was an integral part of the planning process as well as an essential component during the implementation phase. Local support for the project came from the Stutsman County Water Management Board, the Stutsman County Soil Conservation District, the city of Spiritwood Lake, and the Spiritwood Lake Improvement Association. State and federal assistance on the project came from the North Dakota Department of Health and Consolidated Laboratories, the North Dakota State Water Commission, the North Dakota State Game and

Fish Department, the U. S. Environmental Protection Agency, and the U. S. Soil Conservation Service.

Ultimately, the one group which is often overlooked but perhaps the most important of all are the individual landowners/farmers in the watershed. These individuals gave an enthusiastic response, voluntarily reducing soil erosion and modifying their farming practices.

## Implementation

Construction of the pipeline and pump house began in July 1982 and was completed in early September of that year. The underwater portion consisted of 1,370 meters (4,500 feet) of 40.6-centimeter (16-inch) diameter high density polyethylene pipe which was perforated with 500 2.5-centimeter (1-inch) holes near the end of the pipe which laid in the deepest water. The pump has an electric 3-phase, 25-horsepower capable of moving 7,200 liters (1,900 gallons) per minute. The discharge pipe to Schock wetland is 1,125 meters (3,700 feet) of 30.5-centimeter (12-inch) diameter PVC pipe.

Implementation of agricultural Best Management Practices (BMPs) and other measures to control erosion began in 1981 and was essentially completed by the end of 1983. A conservationist working for the Stutsman County Soil Conservation District had the primary responsibility of developing conservation plans in the watershed. This individual, working in concert with funding from the Soil Conservation Service, Agricultural Stabilization and Conservation Service, and the North Dakota Game and Fish Interest Fund, was able to provide nearly all of the costs associated with conservation practices.

The watershed size of 6,018 hectares (14,860 acres) has approximately 3,840 hectares (9,480 acres) directly contributing due to the nonintegrated drainage pattern typical of the Northern Great Plains. Wind erosion was also addressed outside the drainage area due to the high probability soil deposition on the lake surface. The following is a

list of the type and amount of BMPs implemented for the project:

| | |
|---|---|
| Tree Planting | 58 miles |
| Grassed Waterways | 8 miles |
| No Till | 1,296 acres |
| Crop Residue Use | 14,944 acres |
| Protected Fallow | 3,300 acres |
| North Dakota Wildlife Habitat Feeding | 349 acres |
| North Dakota Set Aside for Wildlife | 502 acres |
| Water Bank | 287 acres |
| Terraces | 9,860 feet |
| Animal Waste Storage | 1 |
| Stock Ponds | 6 |
| Water Development for Wildlife | 19 |
| Wildlife Dam | 1 |
| Desilting Pond | 1 |
| Critical Area Seeding | 19 acres |

The costs for the land treatment from 1981 through 1983 were $46,000, $72,000, and $44,000, respectively.

## Discussion

The elevation of Spiritwood Lake has been a concern throughout the project. An agreement was reached in May 1981 among all concerned parties which identifies specific pumping criteria. The complete operating plan (Appendix A) delineates that at an elevation above 1443.5 msl, pumping can occur for water quality and quantity purposes. From an elevation of 1443.5 to 1440 msl, pumping can occur for water quality purposes only, and below 1440 msl, no pumping will be allowed.

The lake's elevation to surface area from 1440 to 1444 msl is 527.1 and 588.5 acres, respectively. During the project period, the lake's elevation ranged from a high of 1444.3 msl during April 1982, to a low of 1440.1 msl during April 1986. Generally, most of the runoff occurs during the spring period (Figure 1). Pumping occurs one to two months

SPIRITWOOD LAKE

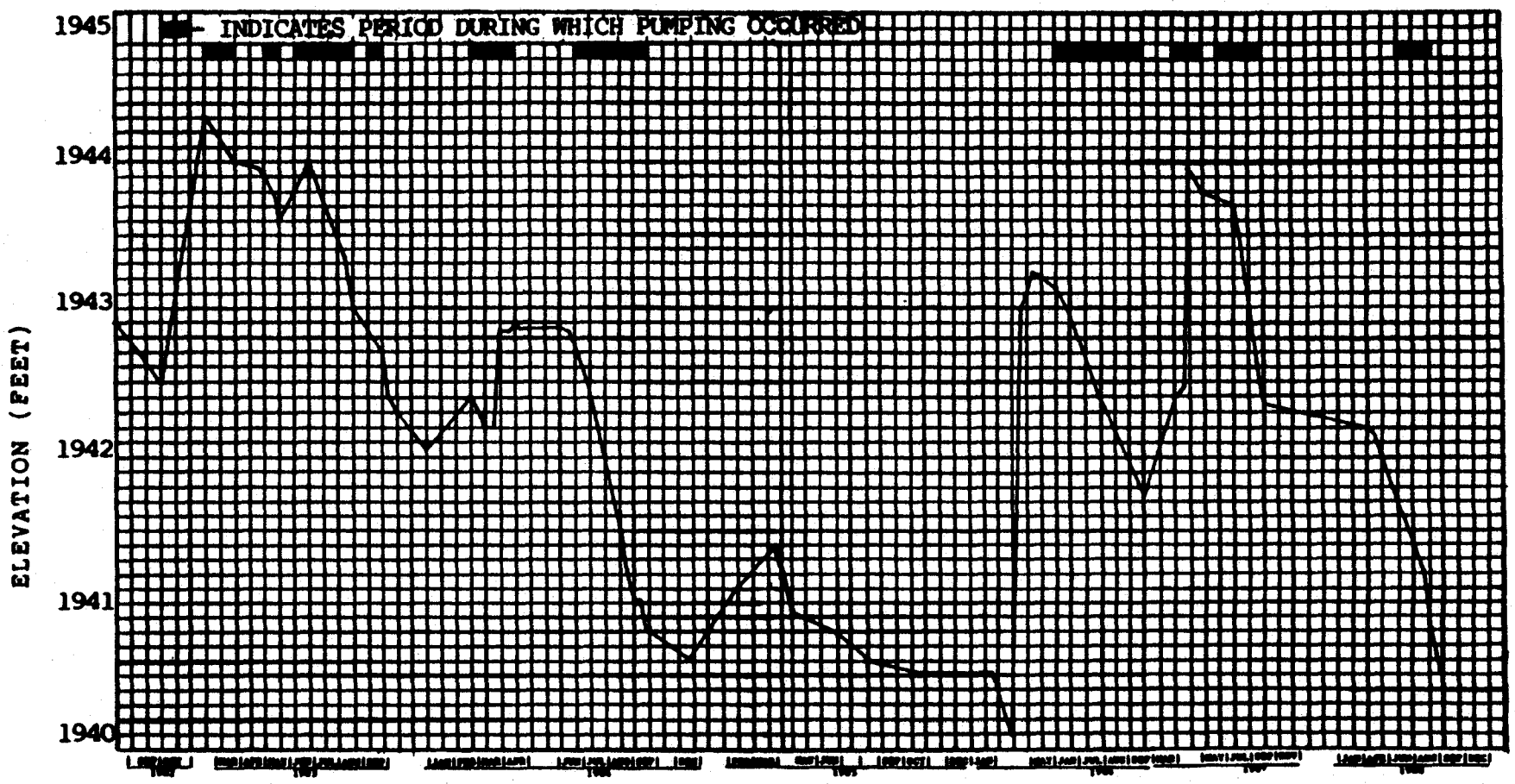



Figure 1.

Lake elevation (msl) and pumping intervals from 1982 to 1988.

prior to the ice-out or spring overturn and again after the first algal bloom die off through fall overturn, which occurs from mid-June through mid-September.

During summer stratification and as the period of ice cover progresses, the hypolimnion becomes anoxic due to the decomposition of materials which have settled from the photic one as well as sediment oxygen demand. Substantial quantities of nitrogen and phosphorus can be removed during this period with a relatively minor impact on lake elevation (Table 1). Each year, it is necessary to decide a pumping schedule which considers lake elevation, anticipated spring runoff, and nutrient concentration in the hypolimnion. Based upon these criteria, no pumping occurred during the spring/summer of 1985 or the spring of 1986. From 1982 through 1985, significantly more nitrogen and phosphorus were removed from the lake than entered it from nonpoint sources. The exception was 1986, when extreme loading from runoff occurred. On May 11 of that year, a five-inch rainfall occurred in a two-hour period of time. On some parts of the watershed, the soil was vulnerable to erosion considering the magnitude of the rainfall. Most fields were planted during the pervious weeks, and subsequently, vegetative cover was minimal. Fields with minimum tillage and crop residue management were not sufficient to retard erosion. Nearly nine tons of nitrogen and two tons of phosphorus entered the lake as a result of this storm. Total Kjeldahl nitrogen, nitrate, ammonia, and total phosphorus levels in the runoff reached 7.53 mg/l, 0.562 mg/l, 0.352 mg/l and 1.42 mg/l, respectively.

An algal assay bottle test performed during the diagnostic study indicated that nitrogen was the nutrient which limited algal growth. Nitrogen loading to the lake has been gradually reduced until the 1986 storm event. Controlling nitrogen input has been shown to be very difficult due to its solubility, input from atmospheric deposition, and presence of algal species capable of nitrogen fixation. This was recognized from the onset of the project. The emphasis was shifted accordingly to control phosphorus; the intention of the implementation program was to reduce phosphorus loading to the extent that it became the limiting nutrient. This was a more practical approach because phosphorus can be absorbed on soil particles; therefore, if erosion is reduced, the commensurate decrease in phosphorus loading would occur.

TABLE 1

° Total Kjeldahl Nitrogen (TKN)
° Total Phosphorus (TP)
° Water Quality Additions/Removal
1982-1988

| | TKN (lbs.) | TP (lbs.) | Quantity (acre-feet) |
|---|---|---|---|
| **1982** | | | |
| Pumping | 1,045* | 153 | 92 |
| **1983** | | | |
| Pumping | 11,100 | 950 | 1,041 |
| Runoff | 5,012 | 773 | 1,010 |
| **1984** | | | |
| Pumping | 17,963 | 1,512 | 1,008 |
| Runoff | 3,718 | 472 | 740 |
| **1985** | | | |
| Pumping | | (no pumping occurred) | |
| Runoff | 2,270 | 225 | 420 |
| **1986** | | | |
| Pumping | 14,031 | 867 | 747 |
| Runoff | 18,900 | 4,600 | 1,670 |
| **1987** | | | |
| Pumping | 25,600 | 1,600 | 1,196 |
| Runoff | 4,000 | 915 | 980 |
| **1988** | | | |
| Pumping | 6,550 | 930 | 246 |
| Runoff | 930 | 60 | 50 |

lbs. - Pounds per year.
*1982 - 1,045 pounds was Ammonia as N.

The concentration of total phosphorus at 0.5 meters in the photic zone (Figure 2) indicates a gradual reduction. This decrease was not limited to the spring overturn period but also shows declining peaks during the periods of summer stratification. The concentration of total phosphorus at 15.5 meters (Figure 3) followed classical changes resulting from stratification and overturn. There are no decreasing trends apparent in phosphorus concentration, even though the amount of organic material settling from the photic zone has been reduced. The release of phosphorus from sediments during anaerobic periods is apparent from late July through early September.

The concentration of nitrate nitrogen at 0.5 meters (Figure 4) demonstrates nitrogen continued to be the limiting nutrient for primary productivity. Nitrate-nitrogen decreases during stratified periods and approaches trace concentrations by mid-summer, when phytoplankton reach their maximum biomass.

The nitrate-nitrogen concentration at 15.5 meters (Figure 5) decreases following spring overturn as nitrate is reduced to ammonia. This was caused by the decomposition of organic material settling from the photic zone as well as sediment oxygen demand.

Total Kjeldahl nitrogen (TKN) shows significant variability in concentration at both the 0.5- and 15.5-meter depths (Figure 6). It ranges from a high of 10.0 milligrams per liter during September 1983 at 15.5 meters just prior to fall overturn to a low of 1.2 milligrams per liter at the end of May 1983 at 0.5 meters. Relatively low concentrations of TKN at 15.5 meters occurred during the summer stratification in 1982 and 1985. This coincides with years of low nutrient loading from the watershed.

The secchi disk transparency (Figure 7) shows typical seasonal variations for the project period. The maximum transparency was 12.5 meters during November 1982, and the minimum was 0.9 meters during August 1980. A secchi disk transparency has generally increased with significant improvements during the spring following late winter pumping, during most of the summer following reduced spring loading, and in the autumn following fall overturn in years that summer pumping occurs.

SPIRITWOOD LAKE - CENTER, DEPTH 0.5 METERS, TOTAL PHOSPHATE (P)

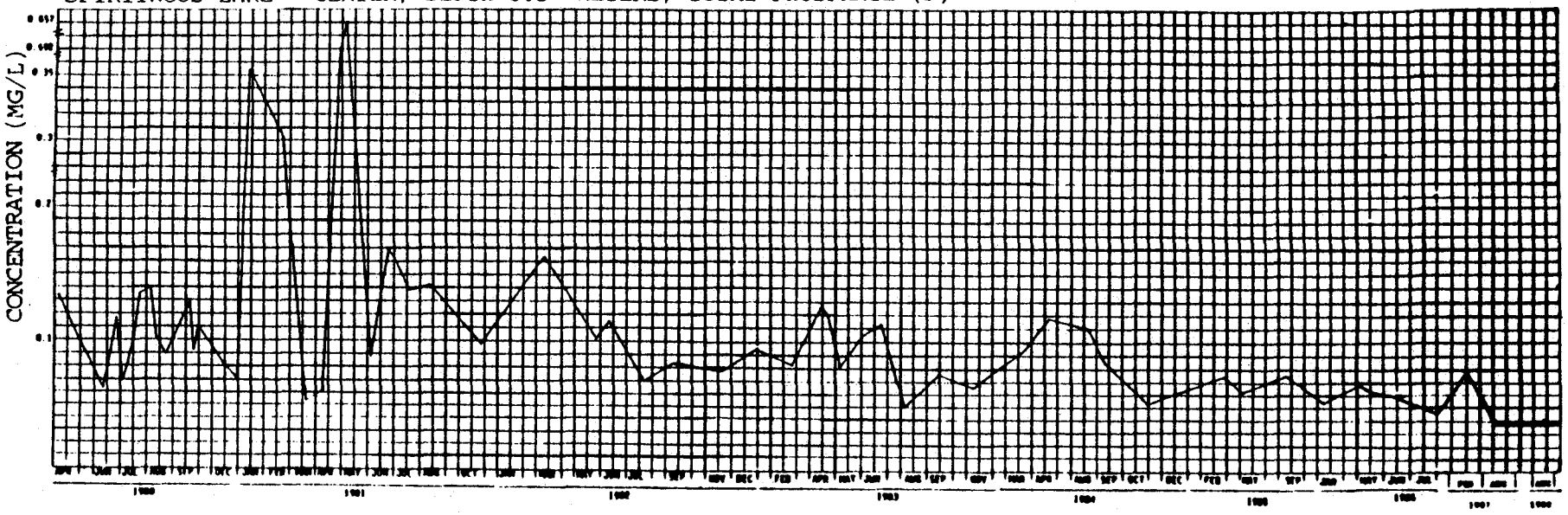



Figure 2. Total Phosphate - P concentration at 0.5M from 1980 to 1988

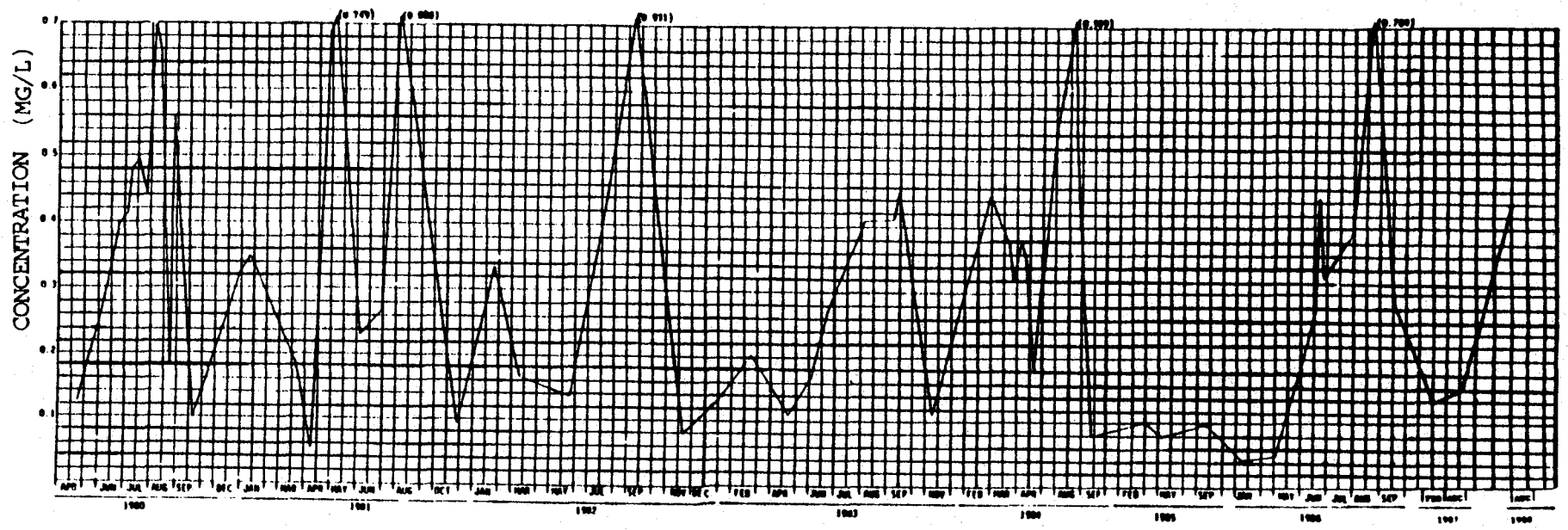



Figure 3. Total Phosphate - P concentration at 15.5M from 1980 to 1988

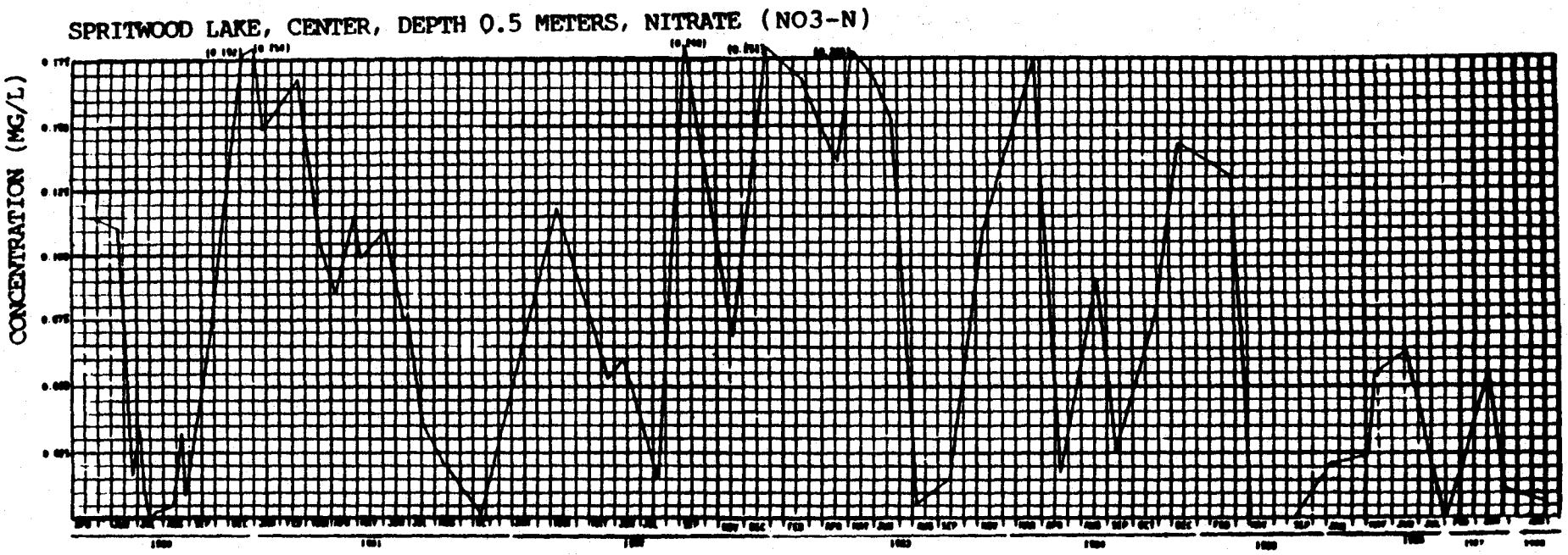



Figure 4. Nitrate-N concentration at 0.5M from 1980 to 1988

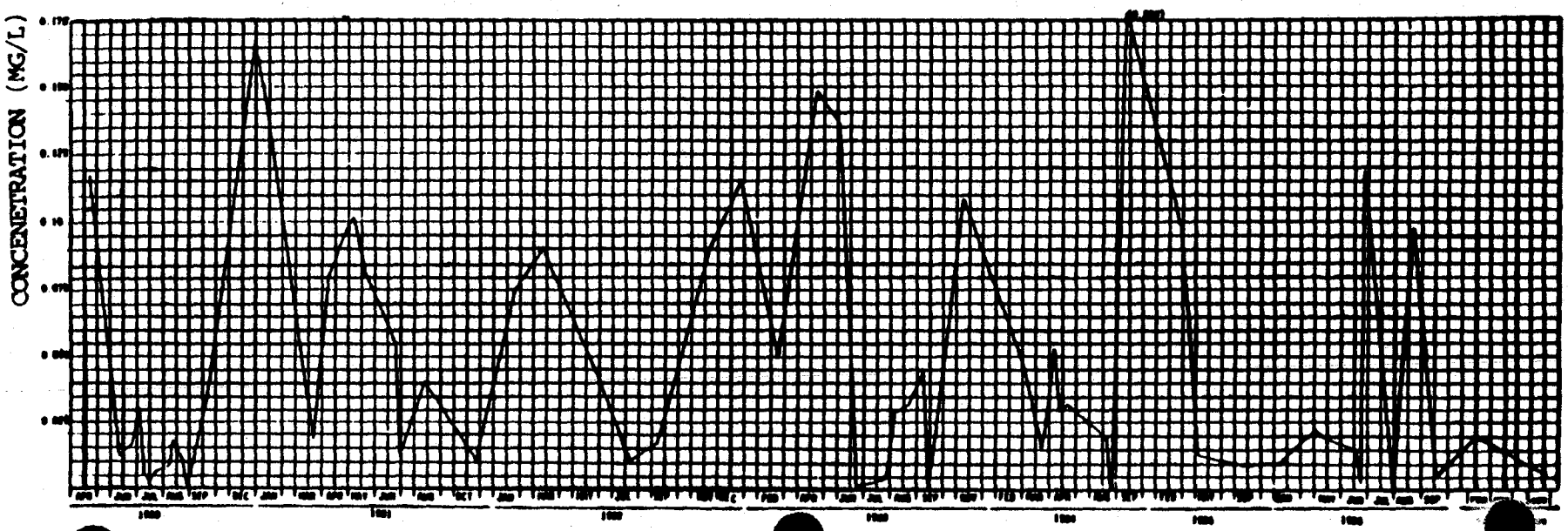
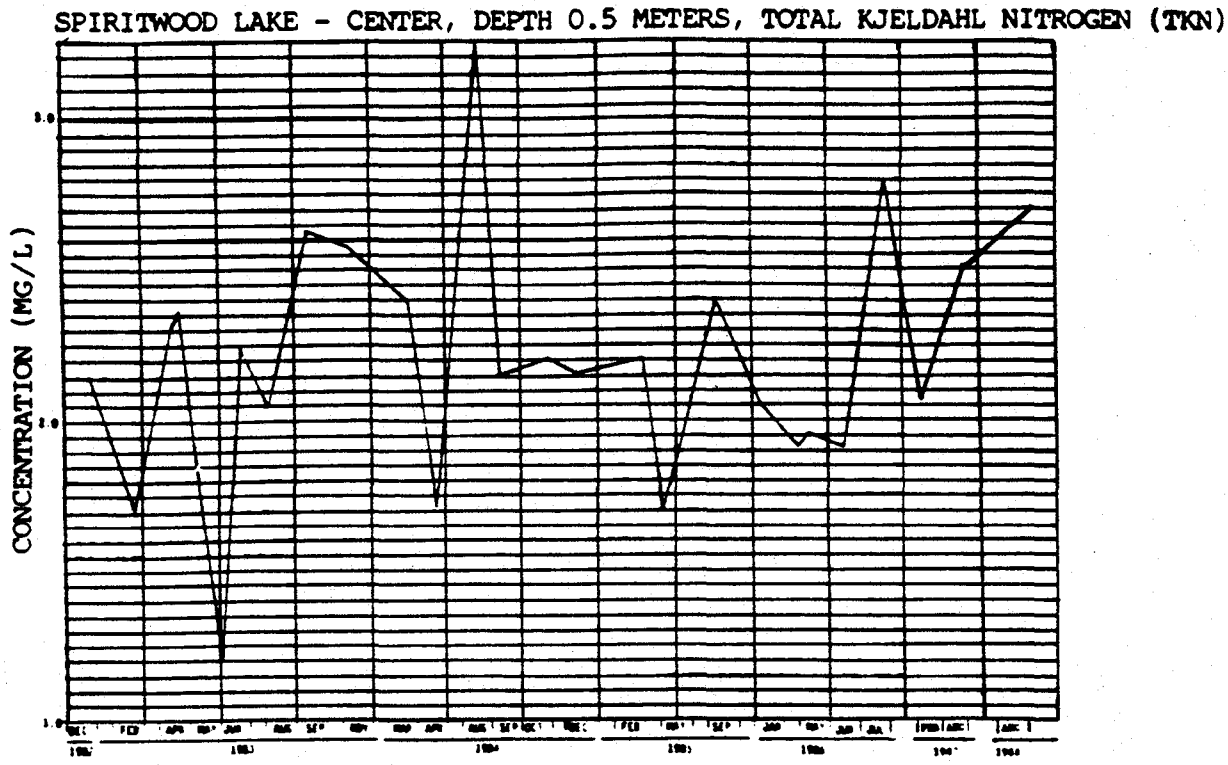



Figure 5. Nitrate-N concentration a[illegible].5M from 1980 to 1988



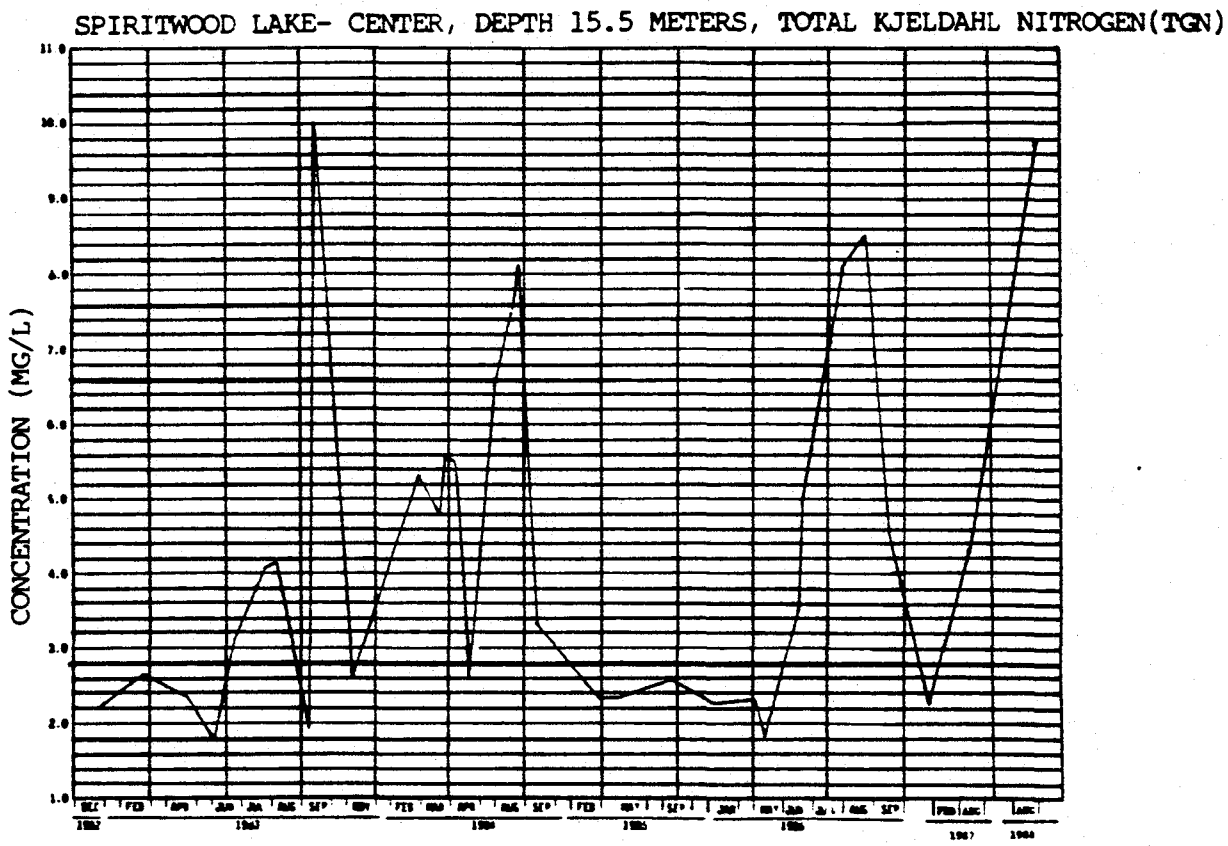




Figure 6.

Total Kjeldahl Nitrogen concentration at 0.5M (top) and 15.5M (bottom) from 1982 to 1988

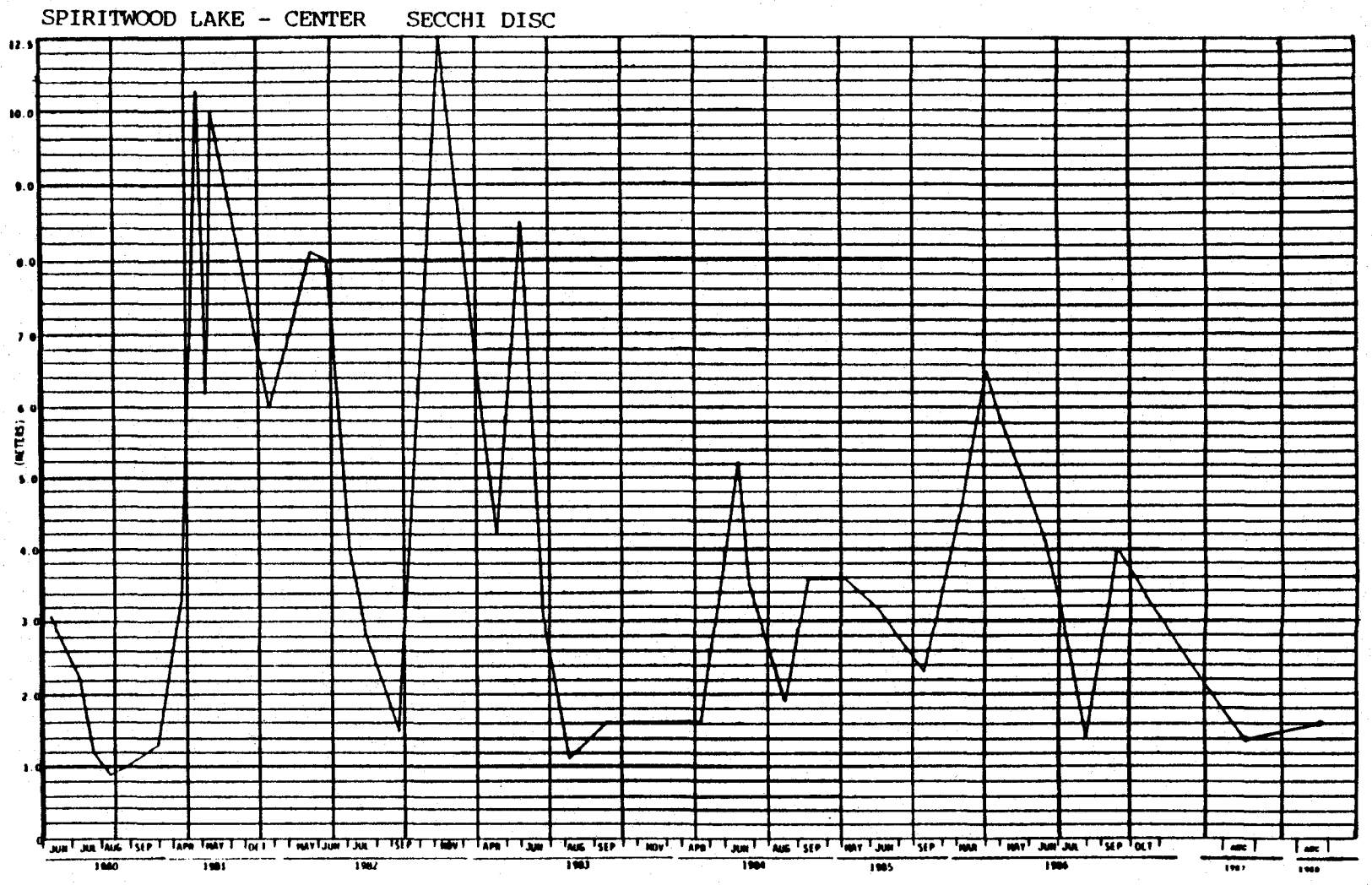



Figure 7.

Secchi Disc transparency from 1980 to 1988

The total dissolved solids (TDS) at 0.5 meters (Figure 8) showed seasonal fluctuations with a gradual decrease. TDS decreases with spring runoff and then gradually increases as evaporation occurs throughout the summer and fall and peaks during the winter as salts increase when ice cover occurs. The TDS of spring runoff averages 300 milligrams per liter, and the effects of dilution are apparent when high spring runoff occurred during 1983, 1984, 1986 and 1987.

The phytoplankton community was dominated by cyanophyta during the summer seasons prior to the project implementation. The three genera representing 85 percent of the biomass in decreasing order were Microcystis aeruginosa, Lyngbya sp and Oscillatoria sp.

A significant change in community structure began in 1983. Although cyanophyta continued to dominate during the summer with Lyngbya sp representing up to 60 percent of the biomass, Microcystis aeruginosa and Oscillatoria sp have been reduced to trace concentrations. A substantial increase in chlorophytes; Scenedesmus sp, Pedeastrum sp, and Chlorella sp, have increased species diversity. A spring bloom of Bacillareophytes have been delayed a few weeks and are less intense.

## Summary

The restoration of Spiritwood Lake was intended from the outset to be a long-term project. The emphasis on reducing nutrient transport from the watershed was paramount throughout the implementation process. However, due to a number of factors, the reduction in quantities has not reached expectations. The design and implementation of BMPs were based upon Soil Conservation Service criteria. These criteria allow the loss of up to five tons of soil per acre. This is apparently justified when long-term soil productivity is the only concern; however, it is woefully inadequate when a lake the size of Spiritwood Lake is a receiving waters. There has also been a return to agricultural practices, which were common in the watershed prior to the project. This has been confined to increased tillage and less crop residue use. Two unusually heavy rainfalls occurred during the project period, which resulted in serious setbacks from a nutrient reduction perspective, one in particular occurring in May 1986, when fields were particularly vulnerable to

SPIRITWOOD LAKE - CENTER, DEPTH 15.5 METERS, TOTAL DISSOLVED SOLIDS (TDS)

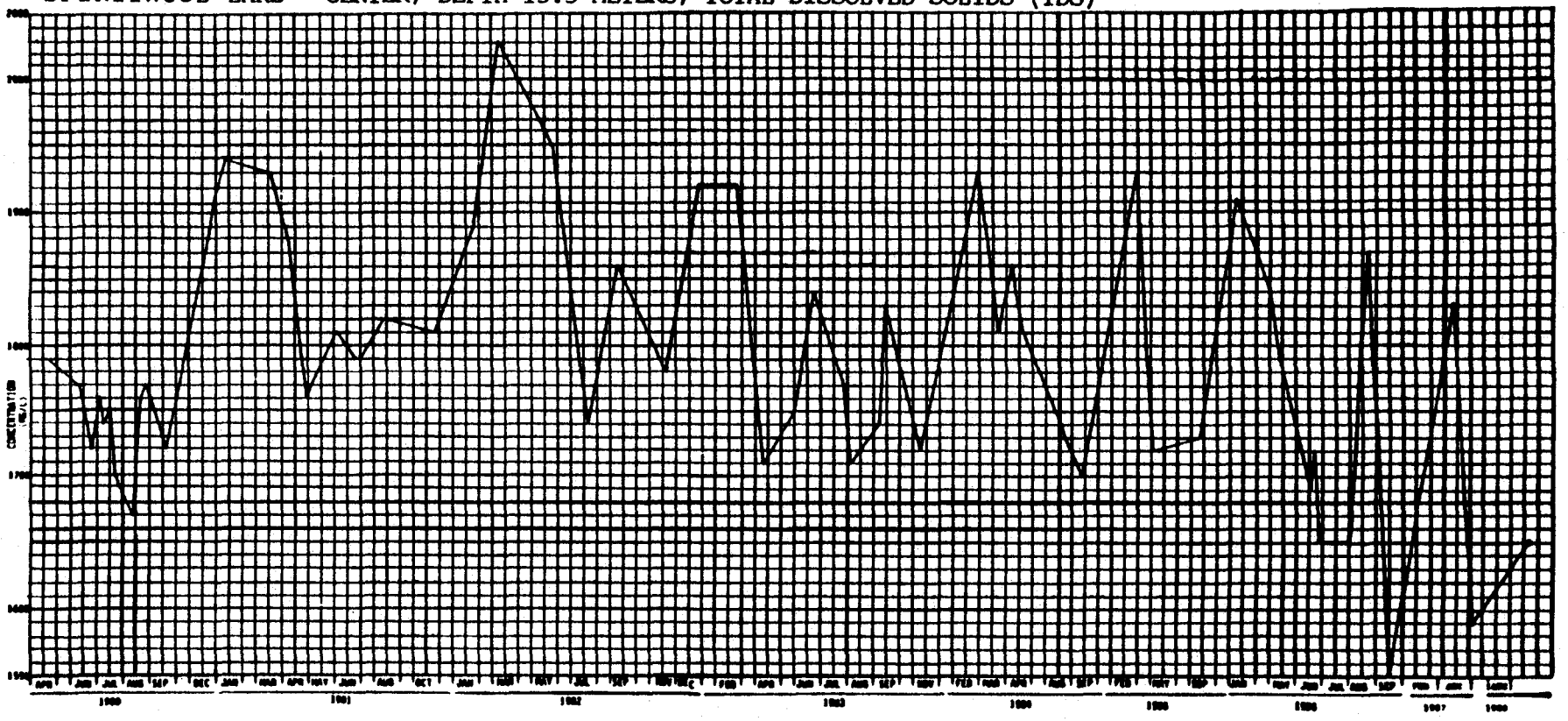


Figure 8.

Total Dissolved Solids concentration at 0.5M from 1980 to 1988

erosion. The greater-than-25-year rain event presents a new challenge for designing effective BMPs. Another aspect of nutrient enrichment which remains unquantified are contributions from waterfowl. Spring and fall migrations can result in up to 2,000 ducks using the lake for periods of up to one month.

The nutrient removal aspects of the project have exceeded expectations. Over 76,000 pounds of nitrogen and nearly 6,000 pounds of phosphorus have been removed through 1988. This removal, along with reducing oxygen demand in the hypolimnion, has resulted in dissolved oxygen being present to deeper levels. This improved dissolved oxygen to greater depths may be responsible for improved water clarity in spite of nutrient concentrations remaining above eutrophication threshold levels. Large body Daphnia were frequently found in high concentrations to a depth of 11 meters during daylight hours from late spring through mid-summer. Their grazing activity could be responsible for reduced/delayed peaks in biomass during this period as well as the shift in speciation.

This project will continue with efforts to evaluate existing BMPs, renew crop residue management use in areas where these practices are no longer being used, and to further define the role of biomanipulation in improving water clarity and expanding species diversity.

APPENDIX A

AGREEMENT

Spiritwood Lake Operating Plan

I. Parties

This Agreement is between the North Dakota State Department of Health and Consolidated Laboratories, hereinafter referred to as the Health Department; the North Dakota State Water Commission, hereinafter referred to as the Commission; the Stutsman County Water Management District, hereinafter referred to as the Board; and the North Dakota State Game and Fish Department, hereinafter referred to as the Game and Fish Department.

II. Intent and Purpose

The Spiritwood Lake pumping facilities will be installed to remove nutrient-rich water from the hypolimnion of Spiritwood Lake and pump that water to Alkali or Shock Lake. The objective is to reduce the primary productivity of Spiritwood Lake to a level which will manifest itself in an aerobic hypolimnion.

The purpose of this Agreement is to establish a management plan for operation of the pumping facilities. Execution of this Agreement will constitute approval of the management plan for operation and maintenance as established herein.

III. Plan of Operation

The Spiritwood Lake pumping project shall be operated in the following manner:

1. The Health Department, based on water quality information and lake elevations, will determine when pumping from Spiritwood Lake will be allowed. Other parties to this Agreement will be kept informed of all pumping activities.

2. The relationship between the water levels in Spiritwood Lake and in Shock or Alkali Lake will be considered before and during all pumping activities. These relationships are as follows:

   A. Spiritwood Lake above elevation 1,443.5. Pump to lower to 1,443.5 for water quality and water level control purposes.

   B. Spiritwood Lake elevation 1,443,5 to 1,440. Pumping will occur only when necessary for water quality purposes.

   C. Spiritwood Lake elevation 1,440 or below. No pumping will occur.

D. Shock Lake elevation below 1,440. Pumping can occur any time for water quality or water level control purposes.

E. Shock Lake elevation 1,440 to 1,442. Pump for water quality purposes only.

F. Shock Lake level above 1,442. No pumping will occur.

G. Flood easements will be obtained to elevation 1,446 on Shock Lake.

3. Pumping may occur outside of the above-mentioned conditions if unusual circumstances arise. Concurrence to operate the pumps under unusual circumstances will be obtained from the Health Department, the Commission and the Board.

4. The Health Department will provide an annual summary of pumping activities to the Commission and the Board.

5. The Game and Fish Department will provide an annual summary of their activities regarding Spiritwood Lake to the Health Department.

6. The Game and Fish Department in conjunction with the Health Department will operate the pumping facilities on Spiritwood Lake.

IV. Modification of Management Plan for Operation and Maintenance

Changes to any provision of this Agreement shall not be effective unless such changes are made in writing, signed by the parties, and attached hereto.

| | |
|---|---|
| Gene A. Christianson, Chief<br>Environmental Health Section<br>North Dakota State Department of Health<br>and Consolidated Laboratories | Date |
| Vernon Fahy, State Engineer<br>North Dakota State Water Commission | Date |
| Van Amundson, Chairman<br>Stutsman County Water Management District | Date |
| Dale L. Henegar, Commissioner<br>North Dakota State Game and Fish Department | Date |

# Thursday Afternoon, July 27, 1989

| | | PAGE |
|---|---|---|
| **SESSION VI:** | **URBAN RUNOFF/CONSTRUCTION/ HYDROLOGIC MODIFICATION**<br>Session Chair: **Carol Jolly,** WA | |
| 1:30 p.m. | **NPS Pollution Control Program for Puget Sound, Washington**<br>~~New speaker~~ | VI-A |
| 1:45 p.m. | **Lake Tahoe NPS Pollution Control Program**<br>David S. Ziegler<br>Chief, Long Range Planning Division<br>Tahoe Regional Planning Agency | VI-B |
| 2:00 p.m. | **NPS Pollution Control Program for Northwest, Colorado**<br>Lane Wyatt, Water Quality Program Manager,<br>Northwest Colorado Council of Government | VI-C |
| 2:15 p.m. | **Anchorage Stormwater Treatment System**<br>J. Brett Jokela, Senior Engineer<br>James M. Montgomery, Inc., Anchorage AK | VI-D |
| 2:30 p.m. | **San Francisco Bay Urban Runoff Control Program**<br>Steve Ritchie, Executive Officer<br>CA Regional Water Quality Control Board, San Francisco Bay Region | VI-E |
| 2:45 p.m. | **ROUNDTABLE DISCUSSION & QUESTIONS** | VI-F |
| 3:10 p.m. | **BREAK** | |

# NONPOINT SOURCE POLLUTION

## Goal

To reduce and ultimately eliminate harm from nonpoint sources of pollution to Puget Sound, including pathogens, toxic contaminants and sediment.

## Problem

The most common sources of nonpoint pollution in Puget Sound include failing on-site septic systems, improper agricultural practices, stormwater runoff, illegal discharges of sewage from boats, and improper forest practices. Nonpoint pollution from these sources carries pathogens, sediment and toxic contaminants to streams, rivers and eventually Puget Sound. Some of the adverse effects from nonpoint pollution include closure of commercial shellfish beds, damage to fisheries habitat and impairment of water used for drinking and recreation.

## Key Features

- Local watershed management programs. The plan calls for selection of 12 "early action" priority watersheds for early development of watershed action plans. Committees in each county are to rank all watersheds within the county to determine priorities for future action plans. Committees will prepare action plans for each watershed in descending order of priority. The Authority is to adopt regulations to provide guidelines for local watershed management.
- Countywide prevention of nonpoint pollution. By July 1989 Puget Sound cities and counties will evaluate their plans, programs and policies for effectiveness in addressing water quality concerns. Countywide education about nonpoint pollution is coordinated with the long-range education strategy.
- State government programs to augment local efforts. A boaters task force is addressing pollution from boats through an educational program and proposals for additional pumpout facilities. The Department of Social and Health Services (DSHS) is reviewing the effectiveness of existing statewide standards for on-site septic systems and is developing a program for certification of on-site professionals. A legislative proposal for addressing the need for owner education and on-site system inspection and maintenance is being developed. Continued funding for the Dairy Waste Management Program is supported, and a study for the establishment of a cost-sharing program is conducted.

## Progress to Date

- Committees in 12 "early action" watersheds are developing plans to correct and prevent nonpoint pollution.
- Each Puget Sound county will complete its ranking of watersheds by January 1989.
- The Authority adopted Chapter 400-12 WAC, "Local Planning and Management of Nonpoint Source Pollution," in February 1988.
- The Department of Ecology and the USDA Puget Sound Cooperative River Basin Team are providing technical assistance to watershed planning and ranking activities.
- DSHS established a committee to study the effectiveness of current statewide standards for on-site systems. The Authority submitted legislation on on-site system inspection and maintenance to the 1987 and 1988 legislatures.
- The State Parks and Recreation Commission worked with the Boaters Task Force to develop a boater education program and a legislative proposal for siting pumpout stations in Puget Sound. One pumpout was installed at Mystery Bay State Park.
- DSHS will complete a model ordinance by January 1989 addressing methods of sewage disposal for liveaboards at public and private marinas for voluntary adoption by local governments.
- The Authority participated on the administrative committee of the Timber/Fish/Wildlife Project.

## Activities for the 1990-91 Biennium

Counties will continue submitting proposals to develop watershed action plans in top-ranked watersheds; implementation of approved watershed action plans will begin. Counties and cities will submit their water quality evaluations to the Authority by July 1989. The State Board of Health will adopt amendments to the state on-site septic system regulations by July 1989.
Ecology will revise guidelines for local shoreline master programs to include standards relating to marinas. State Parks will continue implementing the Boater Education Program, will install additional pumpout stations at up to four state parks, and will develop a strategy to ensure compliance with federal marine sanitation device (MSD) installation and use. DSHS will continue its water quality monitoring in boating areas.

Summary of a program in the 1989 Puget Sound Water Quality Management Plan. For a copy of the plan or other summaries, contact:
Puget Sound Water Quality Authority • 217 Pine St., Suite 1100 • Seattle, Washington 98101 • 206-464-7320 or 800-54-SOUND

## Program Benefits

Implementation of the nonpoint pollution program will result in control of a wide variety of pollutants currently entering Puget Sound and its watersheds. Areas with commercial and recreational shellfish resources will benefit directly from control of sources such as failing septic systems and poor agricultural practices. Other beneficial uses, such as fish habitat and drinking water, will also benefit from control of nonpoint pollution.

## Estimated Program Cost

FY 1990-91 $13.6 million
FY 1992-93 $18.3 million

Funding sources: Local governments are anticipated to request $6.4 million from the Centennial Clean Water Fund in 1990-91 and $8.4 million in 1992-93. Local government revenue sources are expected to provide $2.5 million in 1990-91 and $2.9 million in 1992-93. The general fund would provide about $4.3 million in 1990-91 and $6.5 million in 1992-93.

June 30, 1989

Western States Water Council
Nonpoint Source Pollution Control Workshop
Session VI: Urban Runoff/Construction/Hydrologic Modification

# Lake Tahoe Nonpoint Source Pollution Control Program

David S. Ziegler, Chief
Long Range Planning Division
Tahoe Regional Planning Agency

Introduction. In 1969, California and Nevada created the Tahoe Regional Planning Compact (P.L. 91-148; 83 Stat. 360), which named the Tahoe Regional Planning Agency (TRPA) the regional land use and environmental resource planning and regulatory agency for the Tahoe Region. In 1974, the governors of California and Nevada designated TRPA an areawide planning agency under section 208 of the federal Clean Water Act. TRPA adopted a 208 plan in 1978, but although Nevada certified the plan, California did not.

In 1981, subsequent to amendments Compact (P.L. 96-551; 94 Stat. 3233) which required TRPA to approve all activities in the Region which might have a significant environmental impact, TRPA adopted a revised 208 plan. California and Nevada conditionally certified the 1981 plan, and EPA Region IX conditionally approved the 1981 plan. Because sewage has been exported from the Tahoe Region since about 1970, the 1981 208 plan was almost exclusively a nonpoint source control plan.

The amended Compact called for TRPA to adopt environmental threshold carrying capacities ("thresholds") to protect the scenic, recreational, educational, scientific, natural, and public health and safety values of the Tahoe Region. TRPA adopted a comprehensive set of thresholds in 1982. They established standards in the areas of water quality, soil conservation, air quality, vegetation preservation, wildlife, fisheries, noise, recreation, and scenic resources.

maintain

In April, 1984, TRPA amended its Regional Plan so that it would attain the threshold standards. Immediately, the League to Save Lake Tahoe and the California Attorney General brought suits against TRPA, alleging that the TRPA plan was incomplete and did not meet the requirements of the Compact; that the EIS was inadequate; and that TRPA would approve projects without making the findings required in the Compact.

In June, 1984, the U.S. District Court, Eastern District of California, ruled in favor of the plaintiffs and enjoined TRPA from accepting, reviewing, or approving project applications, except those the Court specifically exempted. Upon appeal, the Ninth Circuit Court of Appeals affirmed the lower court's order in July, 1985.

In August, 1985, TRPA organized a Consensus Building Workshop to recommend resolutions to the key issues surrounding the Regional Plan. The Workshop included TRPA, the plaintiffs, the intervenors in the litigation, and many other groups whose interests should be represented in any agreement on the Regional Plan. These additional groups represented conservation and property rights interests, governmental units, utilities, and other community interests. The Workshop met regularly for 15 months, consuming over 16,000 hours of TRPA staff and participant time.

The Workshop proposed consensus solutions to the key issues and, in 1986 and 1987, TRPA adopted elements of the Regional Plan, including a Code of Ordinances, reflecting the recommendations of the workshop. These actions led to settlement of the litigation and the lifting of the injunction in July, 1987. (For more information on the Consensus Building Workshop, see Ingrum and TRPA, 1987.)

In November, 1988, TRPA amended the 1981 208 plan to make it consistent with the Regional Plan. Nevada and California certified the 1988 amendments, and EPA Region IX approved the amended 208 plan, with conditions, in June, 1989. Like the 1981 208 plan, the 1988 plan addresses primarily nonpoint source pollution. It continues many of the concepts of the 1981 208 plan, but includes a new system for determining eligibility for construction of single-family homes on vacant parcels; new policies for the regulation of land coverage, including the concept of land coverage transfers; and new policies for protection and restoration of stream environment zones (SEZs).

Setting. The Lake Tahoe Basin is located between two mountain ranges, the Carson Range on the East and the Sierra Nevada on the west. Approximately one-third of the Basin is in Nevada and two-thirds is in California. Portions of six counties lie within the Tahoe Region, but the Region contains only one incorporated city, the City of South Lake Tahoe, California. The total land area includes over 207,000 acres, of which over 70 percent is publicly owned.

Fed owns 70%

Lake Tahoe, renowned for its crystal clear water and beautiful setting, is about 12 miles wide and 22 miles long, with a maximum elevation of 6,229 feet, a surface area of 192 square miles, 71 miles of shoreline, and an average depth of 1,027 feet. Mountain peaks around Lake Tahoe create a bowl-shaped watershed, with a single outlet, the Truckee River, at Tahoe City on the northwest shoreline. Lake Tahoe occupies about 38 percent of the total area of the Basin.

residence time 600-700 yrs.

The climate of the Tahoe Region is characterized by long, relatively mild winters with short, dry summers. Precipitation normally falls as snow during the winter, with infrequent thunderstorms in the summer. Western portions of the Basin receive between 35 and 80 inches of precipitation per year, while the east receives between 20 and 35 inches. The average growing season is short, extending from mid-June to the end of August, making revegetation difficult.

Geologically, the Tahoe Basin is young and has relatively shallow, somewhat sterile soils. Bailey (1974) evaluated soil characteristics and geomorphological hazards to develop a land capability rating system for the Tahoe Region. The rating system assigns mapped soil units to one of seven land capability districts. For each district, Bailey's system establishes a maximum percentage of any area that can be converted to impervious coverage and still maintain its environmental balance. These percentages range from 1 to 30 percent. In 1982, TRPA adopted the Bailey system as a threshold standard for the Tahoe Region.

Vegetation of the Region is dominated by a mixed conifer association which occupies about 85 percent of the land area. The balance of the area is composed of five other associations: the cushion plant, shrub, sagebrush, meadow, and deciduous riparian associations.

Development and urbanization of the Tahoe Region generally occurred following the 1960 Squaw Valley Olympics. Since that time, the population of the Region has increased over five times. 80 percent of the population lives in California. Development is predominantly in the area adjacent to Lake Tahoe and in the wide, gently sloping valleys in the south. Existing development includes over 24,000 single-family homes, 14,000 multi-family units, 12,000 tourist units, 2,000 campground units, and 4 million square feet of commercial floor area. Land uses include casino gaming, an airport, and numerous outdoor recreational uses. Seven highways provide access to the Region; the dominant form of transportation is the private automobile.

The undeveloped areas of the Region are predominantly publicly owned, with the U.S. Forest Service managing over 70 percent of the land area. The Forest Service, California, and Nevada are actively purchasing environmentally sensitive lands and other lands. Thus, the extent of public ownership is increasing.

Hydrology and Water Quality. Lake Tahoe is ultra-oligotrophic. It has very low concentrations of nutrients, high oxygen content, and exceptional clarity. The University of California-Davis has measured algal productivity and clarity since 1968. The euphotic zone has a depth of about 105 meters.

Since 1968, primary productivity (PPR) has increased about 150 percent. A high degree of year-to-year variability in PPR appears to be largely influenced by annual precipitation and the degree of vertical mixing. Clarity of Lake Tahoe shows an overall decreasing trend with similar variability. Since 1968, clarity has declined by about 20 percent.

Several entities collect tributary and other water quality data. The main agencies involved are the United States Geological Survey, the Forest Service, the University of California-Davis, and TRPA. Presently, 10 tributaries receive intensive year-round monitoring.

A Systems Model. Although the agencies who work with water quality and land use planning in the Tahoe Region have desired for many years to have a predictive model of the watershed-airshed-Lake system, no such model exists. Development of a predictive model is ongoing. In the meantime, identification of appropriate management techniques to control changes in water quality and attain water quality standards must start with a firm understanding of the mechanisms at work in this complex ecological system. The following points summarize TRPA's systems model:

-- Lake Tahoe is suffering from cultural eutrophication from an inbalanced nutrient budget. The algae are nutrient-starved, with the limiting nutrient fluctuating between nitrogen, phosphorus, iron, or a combination. The nitrogen and phosphorus budgets are both out of balance; the phosphorus budget may be easier to balance.

-- Increasing algal productivity is a function of increasing storage of dissolved nutrients in Lake Tahoe. As algal productivity increases, clarity decreases.

-- In the Tahoe Region, sources of stream sediments are largely within the channels themselves. Sediments build up in channels until large-enough flows occur to move them. Increased sediment production affects fish spawning, turbidity and clarity of receiving waters, channel stability, aesthetics, fish habitat, and nutrient loading to Lake Tahoe.

-- Storm or snowmelt runoff accounts for rapid rises in streamflows and peak discharges. Groundwater accounts for base flow.

-- If rainfall or snowmelt exceed a soil's infiltration rate, water will flow overland, creating the potential for erosion. Vegetation removal, soil compaction, and soil removal decrease infiltration capacity. Overland runoff is extremely rare in the natural areas of the Tahoe Region.

-- Areas of seasonally saturated soils, known as "variable source areas," provide a direct pathway for precipitation and snowmelt (and their nutrients) to reach streams. Runoff from these areas can be substantial. To avoid damage to water quality, these areas must be protected from disturbance.

-- Increases in drainage density, a measure of watershed dissection, are associated with increased yields of sediment and dissolved nutrients. In developed areas, man-made conduits and drainageways increase drainage density and short-circuit the treatment normally provided by the soil and vegetation complex.

-- Stream environment zones (SEZs) are capable of rapid uptake and incorporation of nutrients, are conducive to denitrification, and have many other benefits to water quality. However, when SEZs are disturbed, they can actually be a source of sediments and dissolved nutrients. SEZs must be protected for these reasons.

-- In some parts of the Tahoe Region, contributions of dissolved nutrients from groundwater to Lake Tahoe are as high as contributions from surface water. Groundwaters have higher nutrient concentrations close to Lake Tahoe, where development is concentrated.

-- Natural undisturbed watersheds are very efficient and conservative in the treatment of nutrients. Studies have found extremely low concentrations of inorganic nitrogen in runoff from natural areas, often below the level of detection. Average concentrations of inorganic nitrogen in precipitation are 20 to 50 times higher than in Lake Tahoe itself; this demonstrates the importance of nutrient removal in the watershed.

-- Development of the watershed increases yields of sediments and dissolved nutrients by providing new sources of both, and by interfering with the natural delivery and removal mechanisms. Typically, development increases sediment sources; increases peak flows; increases stream energy and the ability of streams to transport sediments; decreases hydrologic lag time; decreases hydrologic flow time; and short-circuits the ability of the watershed to remove sediments and dissolved nutrients from runoff.

-- Development also adds other new sources of dissolved nutrients: fertilizer, sewage system exfiltration, and airborne nutrient emissions.

-- Local and distant sources of airborne nitrogen and phosphorus contribute nutrients to Lake Tahoe. Short-range transport (less than 300 miles) involves large urbanized areas of California.

Based on the systems model, TRPA has identified six needs for water quality management:

-- the need to preserve the soil's capacity to infiltrate runoff waters,

-- the need to protect variable source areas, stream environment zones, and natural areas in general,

-- the need to avoid adding new conduits and channels to the watershed, and to infiltrate runoff wherever possible,

-- the need to control nutrients reaching Lake Tahoe from fertilizer use and sewage spills and leaks,

-- the need to be aware of atmospheric nutrient loads, and to control them where possible, and

-- the need to control erosion, to avoid exposing new sources of sediments and dissolved nutrients to runoff waters.

Problem Assessment and Control Needs. The systems model sets the stage for the problem assessment and determination of control needs. The main conclusions of TRPA's water quality problem assessment are as follows:

-- Streets, roads, and highways represent a major source of water quality problems. Because Best Management Practices (BMPs) which minimize water quality impacts were not incorporated into the transportation network when it was built, retroactive application of BMPs and other controls is expensive.

-- BMPs are needed and can be effective at reducing yields of sediment and dissolved nutrients from existing development, when properly conceived, designed, installed, and maintained. Effectiveness of BMPs on sediments is generally higher than effectiveness on dissolved nutrients. In intensively developed areas, community-wide approaches to BMP implementation may be necessary.

-- Effluent limits on discharges of urban runoff, administered and enforced by state regulatory agencies, are an essential tool for controlling loads of sediment and dissolved nutrients to the surface and groundwaters of the Region.

-- Compared to the existing backlog of problems, contributions of future development to water quality problems will be smaller, since BMPs and other controls can be incorporated into project design and implementation. There is a need to focus attention on the backlog of water quality problems.

-- Protection and restoration of SEZs and native vegetation are crucial to water quality management.

-- Nutrient loads to receiving waters from fertilizer use could be easily controlled. Management of this source of nutrients is a cost-effective control practice.

-- Upwind reductions in emissions of oxides of nitrogen (NOx) over the next two decades will help control atmospheric deposition of airborne nutrients on Lake Tahoe, but local controls on NOx emissions are needed as well.

-- All of the sewage collection and treatment entities in the Region should strive to eliminate sewage spills and chronic leaks from their systems.

-- Management practices and other controls to minimize the impacts of outdoor recreation activities and other activities in the natural areas of the Region on water quality are important.

-- Construction and dredging within the waters of Lake Tahoe represent potential water quality problems. Care should be taken to avoid interruption of the natural processes of beach formation and littoral drift, to avoid the unfortunate consequences of altering this important natural system.

Overview of the NPS Control Program. TRPA's nonpoint source pollution control program includes 38 separate control measures covering the areas of urban runoff and erosion, airborne nutrients, waste management, natural area management, and water quality problems in Lake Tahoe and the shorezone. The control measures include BMP requirements for new development; existing development; fertilizer application; snow and ice control; timber harvest; livestock confinement and grazing; pesticide use; and dredging and construction in Lake Tahoe.

The control measures also include: a capital improvements program for erosion and runoff control; limitations on new subdivisions; land use planning and controls; water quality impact mitigation programs; protection of native vegetation; requirements to utilize native and adapted plants; fertilizer reporting requirements; effluent limits and discharge permits; improved mass transit; redevelopment and redirection of land use; air emission controls; prohibitions on solid waste disposal; compliance schedules for marina sewage pump-out facilities; controls on anti-fouling coatings on boats; and other measures.

TRPA also regulates the rate and timing of growth within the Tahoe Region. Under the Code of Ordinances, TRPA issues allocations for additional development to distribute development within the constraints established by the threshold standards. No person may construct a project which requires an allocation unless they obtain an allocation, the parcel is eligible to use the allocation, and TRPA approves the project. Under Chapter 33 of the Code, TRPA allocates additional residential units, commercial floor area, and tourist accommodation units.

If the control measures produce the expected benefits to the environment more slowly than anticipated, TRPA has committed to make adjustments to its Regional Plan. A comprehensive evaluation will be prepared by September, 1991, and every five years thereafter. TRPA will evaluate the results of its monitoring programs and measure the effectiveness of control measures against predetermined benchmarks. A large number of supplemental control measures and contingency measures have been identified, and TRPA will implement them as necessary to ensure attainment of its environmental goals.

The Individual Parcel Evaluation System (IPES). IPES is a new system in TRPA's nonpoint source control program for determining eligibility for construction on vacant single-family parcels. As of the late 1970's, approximately 18,000 vacant residential parcels existed in the Tahoe Region, representing a large potential for additional single-family home construction and associated water quality impacts.

The 1981 208 plan attempted to control the potential water quality impacts of developing these parcels. It determined eligibility for development of single-family homes by limiting new impervious coverage to the less-sensitive Bailey land capability districts 4, 5, 6 and 7. These regulations were extremely controversial, for several reasons. First, the soils maps which form the basis of the land capability maps did not have sufficient resolution to consistently identify soils on parcels which are typically 1/3 acre or less in size. This led to misunderstandings about the building potential of individual parcels. Second, about a third of the vacant parcels in the Region are mapped in the more-sensitive land capability districts 1, 2 and 3, making it impossible for owners of those parcels to pursue building permits, even though they pay sewer and street assessments and local taxes.

Based on recommendations from the Consensus Building Workshop, TRPA developed new principles to apply to vacant residential parcels. The Workshop recommended a new system for determining eligibility for construction which: (1) was credible and understandable by the public, (2) was accurate, objective, and scientific, (3) was compatible with other systems applicable to other land uses, (4) included a transfer-of-development program, (5) included incentives for remedial erosion control, and (6) included a technically-based appeal process.

The resulting system, IPES, was developed by TRPA in consultation with a technical steering committee. Under IPES, TRPA evaluates and assigns a numerical score to each vacant single-family parcel based on: (1) relative erosion hazard, (2) runoff potential, (3) degree of difficulty to access the building site, (4) water influence areas, (5) condition of the watershed, (6) ability to revegetate, and (7) the need for water quality improvements in the vicinity of the parcel. IPES includes an element,

separate from the criteria used to rate parcels, which encourages mitigation of existing water quality problems by property owners. The rating of a parcel may be increased to a limited degree, by the property owner constructing off-site water quality improvements.

Under IPES, a team of experts evaluates each vacant parcel in the field using a standardized approach. To date, TRPA has evaluated over 13,000 parcels. TRPA has rated the parcels numerically, and ranked them from most suitable to least suitable, by jurisdiction. According to a process established in the Code of Ordinances, TRPA established a level in the ranking separating the less-sensitive parcels from the more-sensitive parcels. Only parcels above this level, as it may subsequently be adjusted, comprise the "top rank" and may pursue a building permit.

TRPA may annually lower the numerical level (or "IPES score") defining the top rank for any jurisdiction by the number of building allocations utilized in that jurisdiction the previous year, provided certain conditions are met. These conditions have to do with requirements that monitoring programs be in place; that progress is being made on capital improvements for erosion and runoff control; that reductions are occurring in the inventory of vacant parcels; and that compliance with conditions of project approval is satisfactory.

With EPA's approval of the 1988 208 plan in June, 1989, TRPA is now fully implementing IPES. All development allocations issued for single-family homes after July 1, 1989, must be processed under IPES. TRPA continues to use the seven land capability classifications of the Bailey system, and their associated levels of allowed land coverage, to regulate other types of development.

Transfer of Development. To provide both TRPA and property owners more flexibility to plan new development and, at the same time, mitigate existing land use and water quality problems, TRPA encourages consolidation of development through transfer. There are four types of transfer programs: transfers of residential development; transfers of units of use; transfers of land coverage; and transfers of residential allocation.

Transfers of residential development rights are permitted from vacant parcels to eligible receiving parcels. Each vacant parcel is assigned one development right which, along with a residential allocation, is needed to construct a residential unit. Multi-residential development thus requires the transfer of development rights unless the developer earns "bonus units" in relation to public benefits provided by the project. Upon transfer of a development right, sensitive parcels are no longer eligible for future residential development.

Transfers of units of use (i.e., existing tourist accommodations, residential units, commercial floor area) may also be permitted. When transfers are approved, structures on the donor site must be removed or modified to eliminate the transferred units. Upon transfer of units of use, sensitive parcels are permanently restricted from receiving new development and, insofar as possible, are restored and maintained in a natural state.

Within limits established in the Code of Ordinances and the 208 plan, land coverage may also be transferred. The intent of the land coverage transfer provisions is to allow greater flexibility in the placement of land coverage, utilizing land banks, lot consolidations, land coverage restoration, and transfers. The exact details of the land coverage transfer requirements vary depending upon the type of use involved, such as commercial, tourist, residential, outdoor recreation, or public service.

To the extent possible, TRPA will utilize a land coverage banking system to facilitate elimination of excess coverage and to provide transfer mechanisms. In 1988, TRPA and the California Tahoe Conservancy, a state agency, entered into an MOU establishing a California-side land bank. An MOU to establish a Nevada-side land bank is under development. Private transactions are also allowed in both states.

Land coverage transfers are subject to certain constraints, including the requirement that all transfers shall be at a ratio of 1:1 or greater, and that transfers must generally occur from more sensitive to less sensitive parcels. When a land coverage transfer is approved, the donor lot must be restricted to open space and restored.

Transfers of residential allocations are permitted from parcels located on sensitive lands to more suitable parcels. (An allocation, in addition to a residential development right, is required before any person can commence construction of an additional residential unit, except for affordable housing units. Although TRPA issues the allocations, local units of government distribute them according to their own rules, which include "first-come-first-served" and "random allocation" programs.) When an allocation is transferred, the donor parcel must be permanently retired.

Stream Environment Zone (SEZ) Protection and Restoration. As discussed above, stream environment zones (SEZs) are very important to water quality in the Tahoe Region. No new land coverage or other permanent disturbance is permitted in SEZs, with certain limited exceptions for public outdoor recreation facilities, public service facilities, and projects which require access across SEZs to otherwise suitable sites. All exceptions require complete mitigation of impacts, including offsetting restoration in an amount 1.5 times the area of SEZ disturbed.

SEZs are determined to be present through the use of a system of key indicators (e.g., surface water flow, primary riparian vegetation) and secondary indicators (e.g., certain soils and certain groundwater conditions).

TRPA's threshold standards also require the restoration of all disturbed SEZs in undeveloped areas of the Region, and the restoration of 25 percent of the disturbed SEZs in the developed areas. TRPA estimates there are about 17,700 acres of SEZ in the Region, with about 9,200 acres on private land. About 4,400 acres have been disturbed, developed, or subdivided. Thus, the threshold standard establishes a goal of 1,100 acres of restoration work in these areas.

Development of a detailed restoration program is ongoing, and an updated program will be published in 1990. However, 65 acres of disturbed SEZs had already been restored as of 1988, and TRPA has identified another 450 acres of potential restoration projects. To refine the SEZ Restoration Program and keep it current, TRPA has agreed to:

-- classify and map stream reaches according to their stability classification, and match restoration methods with disturbed reaches based on their stability classification,

-- identify major problems areas and project sites for use in community planning, public works planning, and other programs,

-- develop guidelines for planning and designing SEZ restoration projects,

-- establish a scientific and technical advisory committee to guide the SEZ restoration program.

Summary. Under the Tahoe Regional Planning Compact, TRPA is the regional land use and resource planning and regulatory agency for the Tahoe Region. TRPA's 1988 208 plan, which was derived from its Regional Plan, is primarily a nonpoint source pollution control plan. Lake Tahoe is suffering from cultural eutrophication resulting from an inbalanced nutrient budget. Development of the Tahoe Region increases yields of sediments and nutrients through several mechanisms, and provides new sources of nutrients. In response to a detailed problem assessment, TRPA's nonpoint source control program includes 38 separate control measures. Some of the more unusual control measures are: (1) the Individual Parcel Evaluation System (IPES), a system for determining eligibility for construction on vacant single-family parcels, (2) transfer of development programs to give TRPA and property owners more flexibility, and (3) stream environment zone protection and restoration programs, which will result in the restoration of 1100 acres of disturbed SEZs.

## REFERENCES

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DIVISION OF LOANS & GRANTS

# A BASINWIDE APPROACH TO NPS MANAGEMENT

By Lane Wyatt, Northwest Colorado Council of Governments

## INTRODUCTION

The Northwest Colorado Council of Governments (NWCCOG) region includes the northern Rocky Mountains of Colorado. It is an area of notable beauty and is renowned for the concentration of world-class recreational sites: Aspen, Breckenridge, Copper Mountain, Steamboat Springs, Winter Park, Vail and others. It also forms the majority of the headwaters for the Colorado River. In the past, transmountain diversions have transported huge portions of precious clean water from the region to Denver, Colorado Springs and other cities on the Front Range. In recent years the NWCCOG region has come under considerable pressure to further divert these headwater streams. This loss of water has begun to severely affect the regions ability to grow and therefore develop economically. Reduced flows aggravate in-stream metals concentrations which result from numerous abandoned 19th century mines as well as the natural geology rich in metal ores. Wastewater treatment facilities are forced to expand treatment levels as low flow levels change and ambient stream concentrations increase. It becomes increasingly evident that cooperation among dischargers, diverters and local entities is a necessity for the survival of this region.

One example of how effective cooperation can work is Dillon Reservoir in Summit County. Summit County is located 70 miles west of Denver. It is situated on the west side of the continental divide at an average elevation of over 9000 feet. It is in the heart of Colorado's ski county and was the fastest growing county in the nation between 1970 and 1980. During the ski season the County's population jumps from 12,000 to over 70,000 and summer activities are rapidly approaching the draw of winter skiing. It is the play ground for the Denver metropolitan area.

Dillon Reservoir is located in the middle of Summit County. It was constructed in 1964 as the major water supply for Denver. Lake Dillon stores 254,000 acre-feet of water behind a 231 foot dam.

## PHOSPHORUS MANAGEMENT FOR DILLON RESERVOIR

The Dillon Reservoir hydrology is dominated by spring snowmelt. The basin's steep slopes and rocky soil result in high-energy streams carrying large sediment loads and high

natural levels of nutrients. In addition, extensive land use changes and the growing population in the basin have increased the nutrient loading of the reservoir. By the late 1970's the combination of high natural, or background loads, and increased loading due to human activities had resulted in reduced transparency, changes in color and diminished oxygen levels, all caused by summer algal blooms.

In 1982, an EPA funded Clean Lakes study identified Dillon Reservoir as mesotrophic and phosphorus as the limiting nutrient in this growing eutrophication problem. About one half of the total load was attributable to human activities, and of this, more than one half was the result of urban NPSs - runoff from parking lots, golf courses, construction sites, septic systems and other diffuse sources. Discharges from four municipal treatment facilities were attributed with the remaining phosphorus load from human sources. A very important finding of the Clean Lakes Study was that controlling the point sources alone would not be adequate to prevent future algal blooms, even if phosphorus discharges from municipal sources were reduced to zero, NPS loads from new developments would cause eventual eutrophication of the reservoir.

In Colorado, stream water quality standards and NPDES permits are the responsibility of the Colorado Water Quality Control Commission (WQCC). In 1984, following the completion of the Clean Lakes Study, the WQCC directed local entities to address the phosphorus problem in Dillon Reservoir. It also suggested that Summit County should consider a moratorium on new development. In response to this direction, the Summit Water Quality Committee (SWQC) was formed. This group consisted of the Towns, County, and the sanitation districts and was formalized by an intergovernmental agreement. For six months the SWQC met weekly with representatives from NWCCOG, EPA, the ski resorts, and major developers in an attempt to resolve the phosphorus dilemma, maintain a high level of water quality in the reservoir, and still accommodate future growth. The resultant strategy focused on controlling NPS pollution and included provisions for point/nonpoint trading as a means of implementing NPS controls.

The "bubble concept" was employed in this trading strategy. It was considered an effective and equitable method of controlling both point and nonpoint source pollution. This approach had been used in air pollution control but had never been applied to water pollution problems. It involves controlling the collective impact of a given pollutant rather than dealing with the discrete sources independently. In other words, discrete sources would be allowed to vary as long as the total load remained within some limits. Central to the success of this trading strategy was the availability of effective, low-cost NPS controls. EPA funded a pilot NPS

demonstration project consisting of a sedimentation pond followed by an infiltration pit. This project removed 68% of the incoming phosphorus. NWCCOG estimated that if similar controls were employed basinwide it would be over 50% more cost effective (a savings of more than $750,000 per year) than stringent point source controls.

## POLLUTION REDUCTION TRADING

Based on the Clean Lakes Study, the SWQC determined that limiting basinwide phosphorus loading to 10,162 pounds per year was environmentally acceptable and reasonable to meet. This level of loading should be adequate to meet the WQCC's in-reservoir phosphorus standard for Dillon Reservoir of 0.0074 mg/l. Because the actual loading is a result of independent variables, such as rainfall and runoff, the determination of loading will be indexed to the 1982 water yield of 212,000 acre-feet. The allocation of this critical load is shown in Table 1.

TABLE 1. Phosphorus Allocation for Dillon Watershed (lbs./year)

| POTWs | Industrial | Nonpoint source | Precipitation & groundwater | Background | TOTAL |
|---|---|---|---|---|---|
| 1,510 | 504 | 1,990 | 1,527 | 4,631 | 10,162 |

However, this phosphorus allocation was predicted to be exceeded by 1990. The "bubble concept" would permit phosphorus allocations to municipal treatment facilities to increase, thus allowing local development to continue, while still meeting the loading limit for the reservoir. This was accomplished by allowing credits to be received for controlling nonpoint sources that existed prior to 1984. In this manner entities with phosphorus allocations could receive a one pound credit for every two pounds of NPS phosphorus that existed prior to 1984 that they removed. The 2:1 ratio was established to account for some uncertainty in NPS control methods and the likely increase in NPS loading associated with continued growth. The WQCC agreed to this phosphorus management program and, through its issuance of NPDES permits, assigned appropriate phosphorus allocation to the treatment facilities. The WQCC also stipulated that no credits for NPS phosphorus control would be granted until the local governments adopted land use ordinances requiring runoff and erosion controls and streamside setbacks.

The issue of operating, maintaining and monitoring NPS controls for which credits were received is handled through the NPDES permit system. Failure of a NPDES permit holder

who has received credits to meet these responsibilities can result in enforcement, including the requirement to undertake more stringent point source controls to meet the additional credits which were included in the NPDES effluent limits.

The SWQC has continued to meet monthly and oversees the trading program and monitors Dillon Reservoir and its tributaries for water quality trends. The Committee recently approved a point/nonpoint trade which involved the sewering of a subdivision previously serviced by septic systems. Additional projects being implemented for trading include routing storm sewers through a series of underground holding tanks connected by perforated pipe, a large detention basin, and further sewering of septic systems where feasible. The SWQC has also become very involved in public education/awareness on local water pollution issues.

## LESSONS FROM THE DILLON RESERVOIR EXPERIENCE

NWCCOG has found that, in general, cooperation and collaboration among various affected parties is the most direct and effective approach to dealing with water quality problems. Although it sounds elementary, parties which have previously found it difficult to reach consensus among themselves can provide a considerable hurdle to the implementation of this approach. However, our situation suggests that when all parties are confronted with a common problem, such as avoiding a development moratorium or protecting a drinking water supplies, coordination problems can be simply addressed. Because pollution reduction trading will most likely occur in a large area, such as an entire watershed, there is a need for interjurisdictional coordination. Economic and environmental benefits of a collaborative approach-such as reduced disruption, reduced need for bond issues, and improved water quality-may be enough to drive such coordination. In addition to this general need for cooperation, a recent study by the EPA identified a number of specific conditions that must be present for pollution reduction trading to be successful, and these seem to hold true for the Dillon Reservoir situation. Among the important findings of the study Reservoir are:

- -Water quality problems must result from both point and nonpoint sources.
- -Point sources must meet technology-based treatment requirements, and low-cost nonpoint source controls must be available.
- -There must be sufficient water quality data, loading data, and an understanding of pollutant effects to evaluate various nonpoint source control strategies.
- -A specified organization, recognized by regulatory agencies, should be responsible for authorizing trades, monitoring the program, and providing long term water quality management.

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# SEDIMENTATION TREATMENT SYSTEMS FOR URBAN DRAINAGE IN ANCHORAGE, ALASKA

By ~~J.Brett Jokela~~ David Black, P.E.[1], and Thomas R. Bacon[2]

**ABSTRACT**

Stormwater management has become an increasingly integral component of management of nonpoint source pollution (NPS) of water resources. The Municipality of Anchorage Department of Public Works (DPW) has been active in developing and implementing sedimentation treatment systems for stormwater drainage. The criteria were developed by collaboration among state and local water quality officials and the professional design community, led by James M. Montgomery, Consulting Engineers, Inc. (JMM).

Performance criteria for ponds are based on site specific storm drain modelling and 60% removal of total suspended sediment (TSS) prior to discharge into the local salmon-bearing stream network. Oil and grease and trace metals from roadway runoff will be removed from the discharge as they are associated with suspended sediment. The ponds have been designed with public safety and aesthetics as important considerations, due to the potential multiple use aspects of the lowland park areas adjacent to the site. Other design features were required to allow for subarctic conditions. Cost data are presented in comparison to other localities.

## PERFORMANCE CRITERIA

The establishment of design criteria for sedimentation basins requires consideration of three factors:

- Identification of the pollutants to be removed;
- Verification of the design criteria in the actual operation of the facility; and
- Transferability of the design criteria from one drainage basin to another.

### Pollutant Identification

The effect of pollutants on aquatic life depends on local water chemistry. Existing water quality data is not ade-

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quate for the prediction of long term impacts for many pollutants. These cause and effect relationships are not well understood and likely vary from area to area. Although time is required for research efforts to provide the necessary data, there is a current need to provide water quality control facilities.

Anchorage area streams support salmon and trout and the water quality discussion centers around protection of the existing salmonid fisheries. Unless controlled, urban sediments can accumulate in streams, covering the gravel redds needed for a productive fishery. Sediments also smother other aquatic life needed to maintain an adequate food chain. Fish eggs and alevin are susceptible to toxic trace metals and organic compounds associated with suspended sediment found in the urban runoff.

By focusing on sediment and oil and grease as primary pollutants, design calculations are possible for construction of treatment facilities. Secondary pollutants adsorbed on sediment particles are also removed by these facilities. The relationship of the secondary pollutants with respect to local aquatic life lacks a quantitative definition, but significant removals can be expected in association with the sedimentation process.

Design Criteria Verification and Transfer

If the operational performance of a sedimentation basin cannot be predicted from the design procedure, there is no reliable basis for the treatment of runoff. In such a case specifying a design to meet water quality goals is problematical and modifications of operating facilities to correct deficiencies becomes a matter of chance.

The focus of early attempts at stormwater quality management was on the water quality treatment derived from retention and detention basins constructed for flood control purposes. The detention basin outflow hydrograph, was often set as a regulation standard to limit the development of flood peaks in developed watersheds.

In an effort to establish a best management practice for sedimentation basin design, the United States Environmental Protection Agency (EPA) coordinated nationwide performance testing of existing facilities as a part of NURP. The NURP data were analyzed by a number of authors to identify appropriate design approaches empirically. These were reviewed and summarized by EPA(1986). Several such facilities have recently been constructed. These analyses offer a significant improvement over previous design approaches. Driscoll (1986) presented percent removal of total suspended solids (TSS)

from urban stormwater as a function of the ratio of basin surface area to catchment area.

Walker(1986) established rates of pollutant removal based on a function of permanent pool size of the basin. This relationship includes explicit consideration of local hydrologic variables, as the permanent pool size is expressed as a ratio of basin volume to mean storm runoff volume. The Maryland Water Resources Administration(1986) compared EPA data using both approaches. The trend is clear that with increasing basin size relative to contributing area and contributing storm volume, better treatment performance should be expected.

Methods discussed above assume that data relationships collected at one location can be transferred to other locations. The variation of the existing data shows the risk in applying this assumption to perform design computations for any given outfall. There are additional problems with generalizing a methodology and applying it to northern climates. Snow can remain on the ground for the extended winter season thereby mass pollutant load increases with the length of the winter. In Anchorage, and other western communities, snowmelt can account for a significant fraction of the annual NPS pollutant loading.

The design approach taken for Anchorage is to calculate the required overflow rate based on the complete removal of a target particle size based on the sediment basin input hydrograph. A 208 planning study(Municipality of Anchorage, 1979) specified a goal of removing 60 percent of the sediment from storm water runoff. The goal was based on an evaluation of the existing surface water quality and on the projected increase of pollutants to be expected as areas were developed. Particle size data from Anchorage storm runoff reported by JMM(1986) indicate that removal of 20-micron and larger particles will meet the goal of 60% removal for the Anchorage area.

## PRECIPITATION AND RUNOFF

### Design Storm Selection

The Municipality of Anchorage met with the State Department of Environmental Conservation and a group of private engineering consultants who had experience in the treatment of surface runoff to discuss and establish design parameters for construction of sedimentation basins. From these meetings a set of best management design criteria for the community was established. A 6-hour duration, 2-year recurrence rainfall event was selected as the design storm for water quality treatment facilities.

Storm drains in the Anchorage area are designed to accommodate the 10-year design storm. Predicted peak flows for the 2-year event generally range between 60 and 70 percent of the predicted peak flows for the 10-year event. A bypass for excess flows is included in the design of a basin, substantial treatment of the total flow can be expected.

Modeling Catchment Response

Sedimentation basin design requires the prediction of an inflow hydrograph for a given design storm. The accuracy of the prediction depends an several variables. The availability of rainfall data, allowances for orographic effects, and the amount and intensity of the design rainfall are important factors. Also important is the availability of information about surficial geology and the accuracy of land use planning for developing drainage areas.

Several methods and computer models exist for prediction of surface runoff. There has been considerable discussion about what method or model produces the best results. The Municipality of Anchorage uses the Illinois Urban Drainage Area Simulator (ILLUDAS) for storm drainage design.

The accuracy of computations, however, will never exceed the accuracy of the available input data and verification data. If data is limited, the rational method may be the quickest and least expensive way to compute the required design flow. If more data is available or alternatives must be considered for more complex situations, computer models offer advantages. For accurate results data collection and calibration to local conditions is essential.

Baseflow Considerations

Subsurface flows generally represent minor contributions to predicted design flows for surface runoff. Infiltration from pipe buried below the water table, or in some cases, perforated drain pipe is common in urban areas dominated by boreal wetland environments. Observed base flows in a recent study for Anchorage (Bacon & Billman, in press) show that values may range as high as 3.9 percent of the predicted 10-year peak flow with most of the data falling between 0.1 and 1.5 percent. The practice in Anchorage has been to use a value of 0.65 percent of the predicted 10-year peak flow for design purposes when measured values could not be obtained.

**BASIN GEOMETRY**

The sedimentation process demands that certain attention be paid to the configuration of the basin in order to maximize its performance. Of special concern are the surface area, volume, depth and cross sectional area of the basin.

Aesthetic considerations are important as well, as the basin shape can determine its acceptance by the public as a landscape amenity.

Relation to Water Table

Unless the basin is constructed with an impervious earth soil liner or a manufactured flexible membrane, it will be necessary to insure that infiltration into the basin, or exfiltration from the basin are minimized by locating the basin such that the normal pool elevation is close to the natural water table. The site for basin development and the hydraulic gradient between the influent drainage and receiving water surface must be evaluated to determine the most appropriate position for the basin. Peak stages in the receiving water must also be considered.

In Anchorage, the sites for sedimentation basin development have been ordained by the history of the area's development. This means, for the most part, that sedimentation basin sites are left to lowland undeveloped tracts at the mouths of drainage systems which are to be retrofitted with stormwater treatment systems. The high groundwater levels on the proposed development sites requires that the basins be constructed as wet ponds, with relatively large standing pools of water to accommodate treatment of the inflow.

Surface Area

Traditional sedimentation theory has been the basis of design criteria for sedimentation treatment of water and wastewater since it was first proposed. Design of sedimentation unit processes depends on the idea that the terminal settling velocity of a particle in a fluid will control the rate at which the particle is removed from the influent stream in the reactor. This is approximated in design of the reactor by establishing an hydraulic loading rate criterion, which is equivalent to, the settling velocity of the target particle. Settling velocity is usually calculated using Stoke's Law:

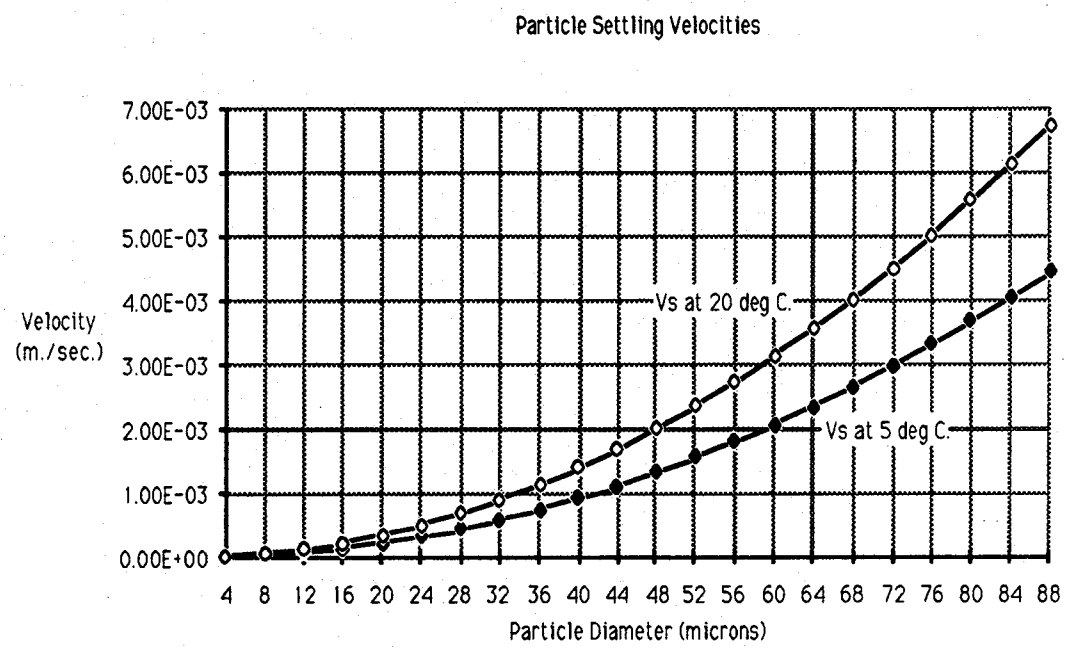
$$V=D^2(\gamma_S-\gamma)g/18\mu$$

where V is particle settling velocity, D is particle diameter, $\gamma_S$ and $\gamma$ are specific gravity of the sphere and the fluid, g is gravitational acceleration, and $\mu$ is dynamic viscosity.

The hydraulic loading rate is defined as the ratio of reactor surface area to influent flow rate. For example, a discharge of 10 cfs through a pond of 20,000 cu. ft. would have a loading rate of 0.0005 cfs/cu.ft., equivalent to

0.0005 ft/sec. This process is temperature dependent. This loading rate would be sufficient for 100% settling of 11 micron diameter particles at 20° C, but would allow settling of only 20 microns particles at 5° C, a temperature common in Anchorage. As can be seen from the figure, the allowable settling velocity or loading rate for a given size particle should be decreased by approximately 40% if the particles are suspended in cold water. One can expect therefore, that required surface areas for equivalent sedimentation in cold climates would be somewhat larger than in temperate areas. When viewed in economic terms, this may affect the choice of treatment efficiencies.

FIGURE 1




## Volume

The volume of a sedimentation basin has been used as a criterion in conjunction with residence time for treatment (Hartigan, 1986). Residence time may be important if reaction processes within the basin are time dependant, such as the biological and chemical reaction rates. Bacteria growth and decay, for instance, can be affected by the residence time within a sedimentation basin. In temperate regions, concerns about oxygen depletion and algal production may encourage consideration of maximum residence time criteria for stormwater sedimentation treatment.

The basin volume also must consider space for accumulated sediment storage and ice growth. A minimum pool volume

is recommended by various authors (Schueler,1987) to insure that some hydraulic retention takes place even at very low flows.

Depth

Depth of the sediment basin is constrained by the economy of excavation and by the desire to maximize the volume of the basin in the smallest land area. If emergent vegetation is to be used as a part of the treatment process, then the depth of the pond should allow for establishment of flora such as water lilies and sedges. Sediment will accrue in the deepest portion of the pond, so the ultimate means of dredging deposited sediment must be able to accommodate the depths involved. The Anchorage design guidelines suggest an 8 foot maximum depth from the base pool elevation to the top of the accumulated sediment.

Cross Section

Given an adequate surface area to accommodate a given hydraulic surface loading, rapid horizontal flow through the sedimentation basin is likely to re-entrain sediments if the discharge velocity through the basin exceeds a critical threshold value. Hence a minimum cross section area is recommended. Anchorage uses 0.04 feet per second as a maximum allowable horizontal velocity.

Plug Flow versus Short-circuiting

Much of the basin surface area and volume will be wasted if the path of least resistance for influent untreated water is direct to the outflow point. To achieve maximum sedimentation, a "plug-flow" through the system is desired. The careful location of the inflow and outflow points and the longitudinal orientation of flow through the basin is required. Depending on site considerations, a length to width ratio of 2:1 as a minimum is necessary. Some references(JMM, others) suggest a 5:1 ratio to ensure the flow conditions do not encourage short-circuiting.

Side Slopes

If a sedimentation facility for a storm drain outfall is used in conjunction with park or greenbelt development, or is otherwise accessible to the public, safety is a genuine concern. While an open pond for stormwater treatment is no more of a hazard than a stream bank or public lakeshore, consideration must be given to the use of the site surrounding the basin as a play area. In order to minimize risks of accidents near the basin, a shallow side slope (5 horizontal to 1 vertical) is recommended. This will also allow for access by maintenance equipment.

Shallow side slopes have other benefits as well. For surcharge conditions in the pond during storm peaks, a shallow side slope will entail an enlarged surface area, thus effectively reducing the surface loading rate. This reduction in surface loading rate will allow for more material to be settled out of the basin during peak flows.

**DESIGN PROCEDURE**

A method for applying the design considerations is illustrated in Figure 2. The prescribed procedure puts major emphasis on meeting the hydraulic loading criterion as the initial standard, with adjustments to the configuration required to meet other criteria. The design procedure has evolved in practice over the past two years, and reflects the approach outlined in the Municipality Of Anchorage Design Criteria for Public Facilities (1988).

**MAINTENANCE CONSIDERATIONS**

Design of sedimentation basins must include maintenance considerations. In most cases the long term operation costs will be more significant than the short term capital construction cost. Everything else being equal low maintenance design elements should be selected over higher maintenance options.

Sediment Dredging

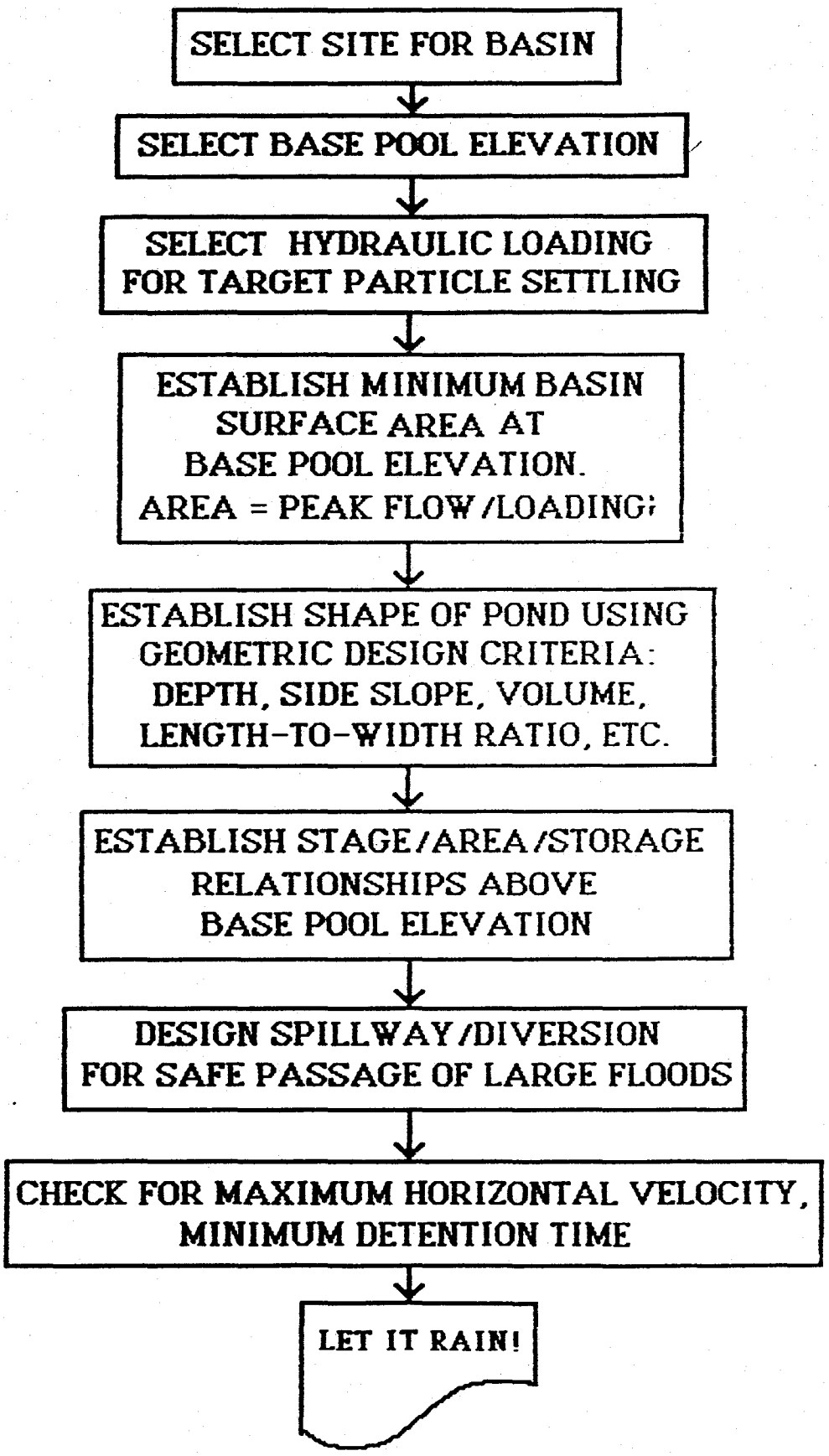
A design must provide access for heavy maintenance equipment. This provision includes access to the site and access around the sedimentation basin. Landscaping should be placed so it does not block cleaning equipment activity. Slopes in and around the sedimentation basin should be designed to conform with maintenance equipment requirements.

The design should include a bypass structure that will allow routing runoff flows around the sedimentation basin for maintenance purposes. Depending on the groundwater elevation and the site hydraulic characteristics, two sediment removal techniques appear to be likely.

If the site can be dewatered, the sediments can be removed by conventional excavating equipment. An Anchorage basin was recently cleaned using this technique. If the basin cannot be dewatered, the use of a small hydraulic dredge appears to be appropriate. In both cases isolation of the basin from the runoff flows will reduce the maintenance effort.

FIGURE 2

# DESIGN METHODOLOGY



The design should incorporate an area that can be used to dewater removed sediments. This is particularly important for the use of a hydraulic dredge. The area should be graded so any water from the sediment flows back into the basin. Designing basins as two or more ponds allows treatment of fluids from removed sediments without risking degradation of the receiving water.

Sediment Disposal

If possible land should be included for sediment disposal. This eliminates the cost of hauling the material to an offsite disposal area. Environmental considerations for disposal of dredged sediment include the impact of the sediment deposition and the potential for contaminant leachate migration from the disposal site. Grading and capping the disposed solids can mitigate the potential for water to leach substances from the disposal. The oil and grease content and the trace metals adsorbed to dredged sediment are potential contaminants that must be considered.

Tests performed by Montgomery Laboratories on sediment exhumed from a sedimentation pond after seven years of deposition show a marked increase in trace metals concentrations among the finer particulates in the downstream end of the basin. Tests utilizing the EP Toxicity extraction procedure, however, show that the trace metals are not leachable and are not likely to migrate from a disposal area.

Landscape Maintenance

Selection of landscape items should include considerations of their maintenance costs. Selection of native plant varieties can substantially reduce the maintenance effort while providing the necessary esthetic and slope stabilization improvements.

Ice

In northern climates ice formation must be considered when selecting each design elements. The issue is not whether ice will form in a cold climate; the issue is whether the ice formation will create problems requiring extensive maintenance activity. Flow into the basin, flow between basin cells and flow out of the basin are critical icing points. Appropriate icing control is critical to economical treatment of runoff resulting from the spring snowmelt.

In some cases control of the hydraulic grade line and flow transitions can reduce the icing potential of a design. Where necessary the design should include thaw pipes or electric heat tape systems to control ice buildup.

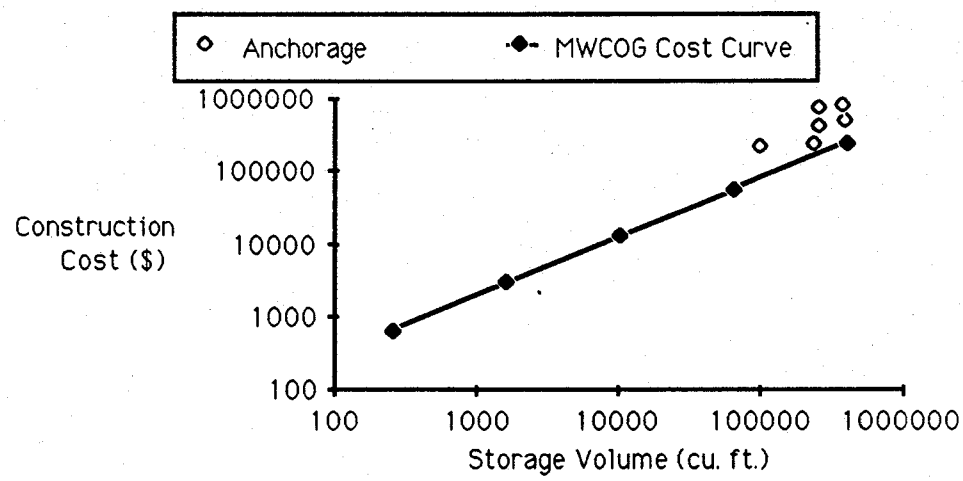
**ANCHORAGE COST EXPERIENCE**

Costs of the facilities which have been constructed or designed for the Municipality of Anchorage have varied considerably because of the site specific design features and the variable cost for acquisition of the land. In two cases, the basins were constructed on real property already in the public domain. Hence, no money was required to purchase the property. This cost savings is substantial, as sites for some basins have high value as creekside commercial or residential property.

Construction costs were variable among the Anchorage sites, but comparable on a per unit area drainage basis. Cost curves for temperate zone stormwater sedimentation facilities were presented by Wiegand(1986). His results are plotted in Figure 3, along with data taken from the six ongoing Anchorage projects. The figure demonstrates that total costs for these facilities in Anchorage is as much as one order of magnitude higher than Wiegand's estimates.

FIGURE 3

SEDIMENTATION BASIN COST DATA




Selecting a worst case condition of high land costs and high construction costs might lead to as much as $6300 per acre of watershed area treated. This is equivalent to nearly $4 Million per square mile of drainage area. Nearly half of this cost is attributable to land acquisition. Thus it behooves urban water resource planners to identify locations for these kinds of developments through systematic drainage planning and to obtain those parcels as early as possible in the land development process.

## CONCLUSIONS

Design criteria for sedimentation treatment of stormwater were established by the Municipality of Anchorage. These criteria consider site specific hydrologic conditions. Theoretical performance calls for 60% removal of suspended sediments, or 100% removal of sediments larger than 20 microns in effective diameter. Construction costs are high for these facilities in comparison to previously reported cost data, and are very much dependant on costs for land acquisition for the facilities.

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STATE OF CALIFORNIA

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July 11, 1989

Ms. Carol Jolly, Water Quality
Program Manager
Department of Ecology
St. Martins College, Mail Stop PV-11
Olympia, WA 98504-8711

Dear Ms. Jolly:

Enclosed is a copy of my paper for the Nonpoint Source Pollution Control Workshop in Irvine. If you have any questions regarding it before the workshop, don't hesitate to call me at (415) 464-0516.

Sincerely,

Steven R. Ritchie
Executive Officer

cc: Jim Cornelius, SWRCB

# SAN FRANCISCO BAY URBAN RUNOFF CONTROL PROGRAM

PRESENTED AT THE
NON POINT SOURCE POLLUTION CONTROL WORKSHOP
JULY 27, 1989
IRVINE, CALIFORNIA

BY

STEVEN R. RITCHIE
EXECUTIVE OFFICER
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION

The San Francisco Bay Regional Water Quality Control Board (Regional Board) is the State water pollution control agency responsible for protection of the beneficial uses of San Francisco Bay and its tributaries up to and including a small portion of the Delta (Figure 1). In carrying out its responsibility, the Regional Board has made major strides in pollution control. Municipal and industrial point sources of pollution have been controlled to an increasing degree under the NPDES permit program for the last two decades. The load of BOD and suspended solids from these point sources has been decreased by roughly ninety percent while the population of the Bay Area has doubled. However, stormwater has been only partly controlled as a contributor of pollutants to the Bay system. While estimates vary, everyone agrees that stormwater contributes a significant portion of the pollutant load to waters of the Region. The most significant of these pollutants are suspended solids, heavy metals, petroleum hydrocarbons, and bacterial contaminants. The Regional Board has recognized this problem and has approached the control of stormwater in various ways around the Region.

The most complete control of stormwater in the Region occurs in the City and County of San Francisco with its combined sewer system. During dry weather, the City provides full secondary treatment to all of the Bayside flow. During wet weather, the picture is somewhat different, but still quite good. The series of underground moats that rings most of the City depicted in Figure 2 captures a large percentage of the City's runoff combined with sewage such that at least primary treatment is provided for about 95% of all wastewater and stormwater generated in the City. Full secondary treatment is provided for 61% of it now on an annual basis. Overall water pollution control efforts in San Francisco have been painful and expensive, but the water quality benefits have been great. They are not appropriate everywhere, but the underground moat concept that San Francisco has been forced to use should not be neglected when evaluating stormwater control alternatives for selected areas.

Another area of stormwater control has been via NPDES permit requirements on oil and grease from the six petroleum refineries and thirty three bulk oil terminals around the Bay. While we believe that more effective controls are likely to be required, some headway has been made via contaminated stormwater segregation and oil-water separator usage at these facilities.

The Regional Board's main concern now is the control of stormwater from the rest of the urbanized part of the Region. To do this, the Regional Board developed a general program concept and outline in its 1986 review of the Water Quality Control Plan for the San Francisco Bay Basin, more commonly known as the Basin Plan. The program elements include identifying stormwater sources, developing land use and drainage maps, collecting data on stormwater, and assessing existing and potential stormwater control measures. These elements provide the framework for the development of stormwater management plans in specific drainage basins.

Before going further, it is important to note that the term stormwater is a misleading one that is only used for lack of a better word to describe both wet and dry weather runoff. By stormwater we mean literally everything that flows out of a storm drain or storm drainage way into waters of the State. In practice this sometimes has very little to do with storm events, and it is apparent that significant pollution events such as spills or illegal dumping occur independent of storms. Therefore, we all need to understand that stormwater is intended to apply more to the conveyance than the quality or type of the discharge.

The Regional Board's new program has initially focused on Santa Clara County which drains to South San Francisco Bay, a Bay segment that appears on the 304(l) "short" list. Santa Clara County has a population of 1.2 million and encompasses the renowned Silicon Valley. Institutionally, Santa Clara County (Figure 3) is comprised of the county government, thirteen cities, and the Santa Clara Valley Water District which is an independent agency with flood control responsibility in the county.

The local agencies and the Water District have responded in a pro-active manner to the Regional Board's proposal, which is really a combination of carrot and stick. The stick is, of course, the threat of enforcement action if they fail to cooperate. The carrot is that they have been able to help write the rules as they go along which we all agree is more desirable than having a bureaucrat in Sacramento or Washington write them for you in a vacuum.

The Santa Clara program began in January 1987 and has been quite successful to date. The efforts there provide a clear example of the evolution of a stormwater management plan. In addition to the basic information described above, the local agencies and the Water District have coordinated and implemented a comprehensive study to characterize stormwater and to identify and evaluate control measures. Key developments of the study include the coordination of efforts between the Water District and the local agencies and the design of the monitoring program to obtain meaningful data. The annual cost of the program so far has been about $1 million, or roughly a dollar per person in the County per year.

The Santa Clara studies include the monitoring of conventional and toxic pollutants and flow at locations representative of specific land use types (residential, commercial, industrial, etc.) during both wet and dry weather. There are 12 sampling locations in the study. Four of these are lower reach stations which are intended to characterize general urban areas. The remaining eight stations were selected to characterize specific land use types. These were rather difficult to select because of the criteria that they represent a land use type that effectively coincided with a watershed. The data collected from the 12 stations as well as land use data will be incorporated into a stormwater management model (SWM 5) to assess the overall pollutant loads. The model will also allow for the evaluation of control measures, both structural and non-structural. Other study elements include sediment monitoring and acute and chronic toxicity monitoring. Completion of the study is expected by the end of 1989.

While the data and final conclusions of the study have not been released, it is appropriate to discuss some of the preliminary results. The main conclusions that can be drawn now are:

- There are not that many differences between the stormwater characteristics among most land use types. The differences appear to occur between three basic types: undeveloped, traditional manufacturing, and others (commercial, residential, and light industrial).

- The first flush concept generally holds true for real good storms. The concentration and load of pollutants are distinctly greater in the first good-sized storm after a few weeks of pollutant build up.

- o Wet weather runoff is clearly toxic using various bioassay measures (ceriodaphnia, green algae, and fathead minnow) while dry weather runoff shows mixed results. The mechanism of toxicity is not clear based on inspection of the chemical-specific data that have been collected at the same time.

- o Coliform contamination in wet weather is consistently high and may not be controllable. However, this may not be a real problem relative to beneficial use protection. After all, do people swim in the Bay during storms?

- o Dissolved oxygen concentrations are not a problem due to stormwater pollution.

With these results in hand, the next step is an important one. Between June and December 1989, Regional Board staff will be working with representatives of the Santa Clara agencies to develop a stormwater management plan. This plan will be developed as a draft NPDES permit. Adoption of a final NPDES permit for the county is expected near the end of 1989. We view NPDES permit development as a critical step in the stormwater pollution control process. While the locals have been pro-active in the program to date, it is helpful to have a clear enforceable agreement to ensure progress. The key aspects of the permit will be:

- o **Naming the dischargers** - We anticipate having one permit with all 13 cities, the county, and the Water District named as dischargers. The advantage of a single permit is that it sends a strong clear message that the Regional Board expects the entire County to work cooperatively to achieve the program goals. Additionally, it seems downright silly to divide up such a distinct drainage area along municipal lines for regulatory purposes. A downside could be how to deal with a single recalcitrant city if and when that time comes. However, the permit should be severably enforceable, and peer pressure among cities may obviate the need for Regional Board enforcement action anyway.

- o **Phased implementation of control measures** - It makes sense to require implementation of some obvious control measures right away with others to be evaluated and implemented later. "Right away" measures include identification and elimination of illicit discharges to storm drains and establishment of oil recycling centers. Other control measures may take years to develop and implement. These include those kinds of measures that obviously are needed, but consist of capital improvements that will require significant planning, design, and construction such as detention basins.

- o **Development of new control measures** - It is essential that the permit obligate active research and development of new control measures. We all need to understand that this is essentially a new area of pollution control, and much remains to be done before we can start patting ourselves on the back. Obviously, with some effort we will be able to develop more cost-effective pollution control techniques.

- o **Continuation of monitoring** - This needs little explanation. It is important to measure the gains that we make and to be aware of changes that indicate the need for revisions in our approach.

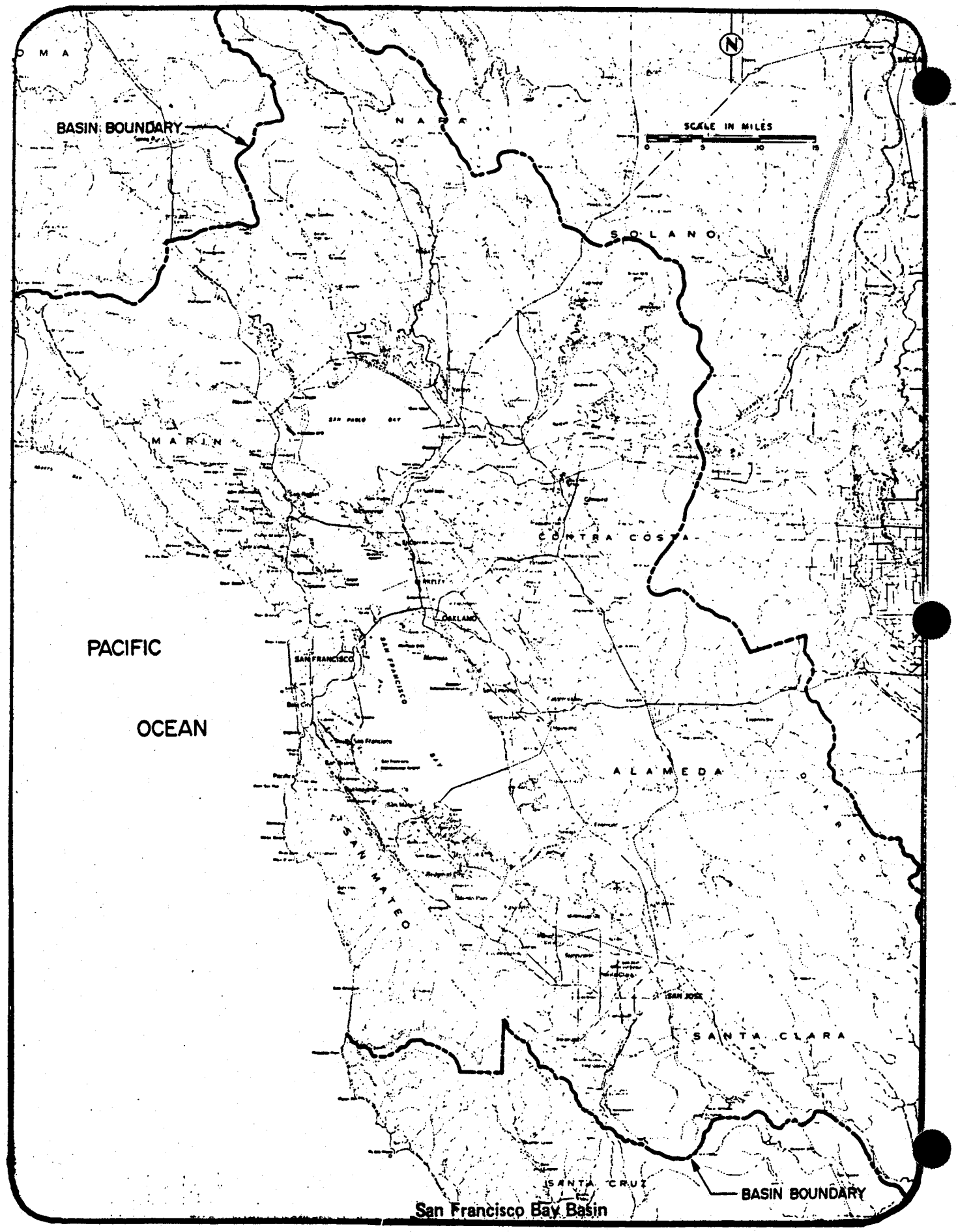
Beyond Santa Clara County, other efforts have started or will soon be underway. Neighboring Alameda County has formed a stormwater task force similar to Santa Clara County. The Alameda County Flood Control and Water Conservation District has taken the lead in this program. They are about a year behind Santa Clara County in their assessment of stormwater. However, the City of Hayward in Alameda County is involved in a unique project.

They are being used as the guinea pig in filling out EPA's NPDES permit application package for stormwater. The consultant on the project has indicated that it is turning out to be extremely difficult. Certain definitions appear to be subject to widely varying interpretation, such as what constitutes a storm drain discharge point and what is a "representative" sampling point. In our experience, the regulators and regulatees experienced the same kind of difficulties in establishing ground water monitoring programs for RCRA land disposal facilities. To their credit, Hayward is putting significant staff time into working on the project without getting any direct benefit. But it does show once again the general attitude in the Bay Area of being pro-active to help make sure that we all build a good program without simply waiting for regulators to produce a lemon.

The next phase in our program will be to begin program development for the remainder of the Bay Area south of the Bay/Delta system. We have had preliminary discussions with the city/county public works directors of the remaining two counties there, San Mateo and Contra Costa. These counties are slated for program development in the upcoming review of our Basin Plan. This will effectively mean that a stormwater assessment and control program will be in place for the major urbanized portions of the Region by 1992 or 1993. Future years will see us moving into the less urbanized North Bay counties of Marin, Sonoma, Napa, and Solano.

In conclusion, much progress has been made in the San Francisco Bay Region. In large part the reason has been the cooperativeness of the local agencies to take on the responsibility of working with the regulators to develop sound, cost-effective approaches to dealing with stormwater pollution.

FIGURE 1




San Francisco Bay Basin

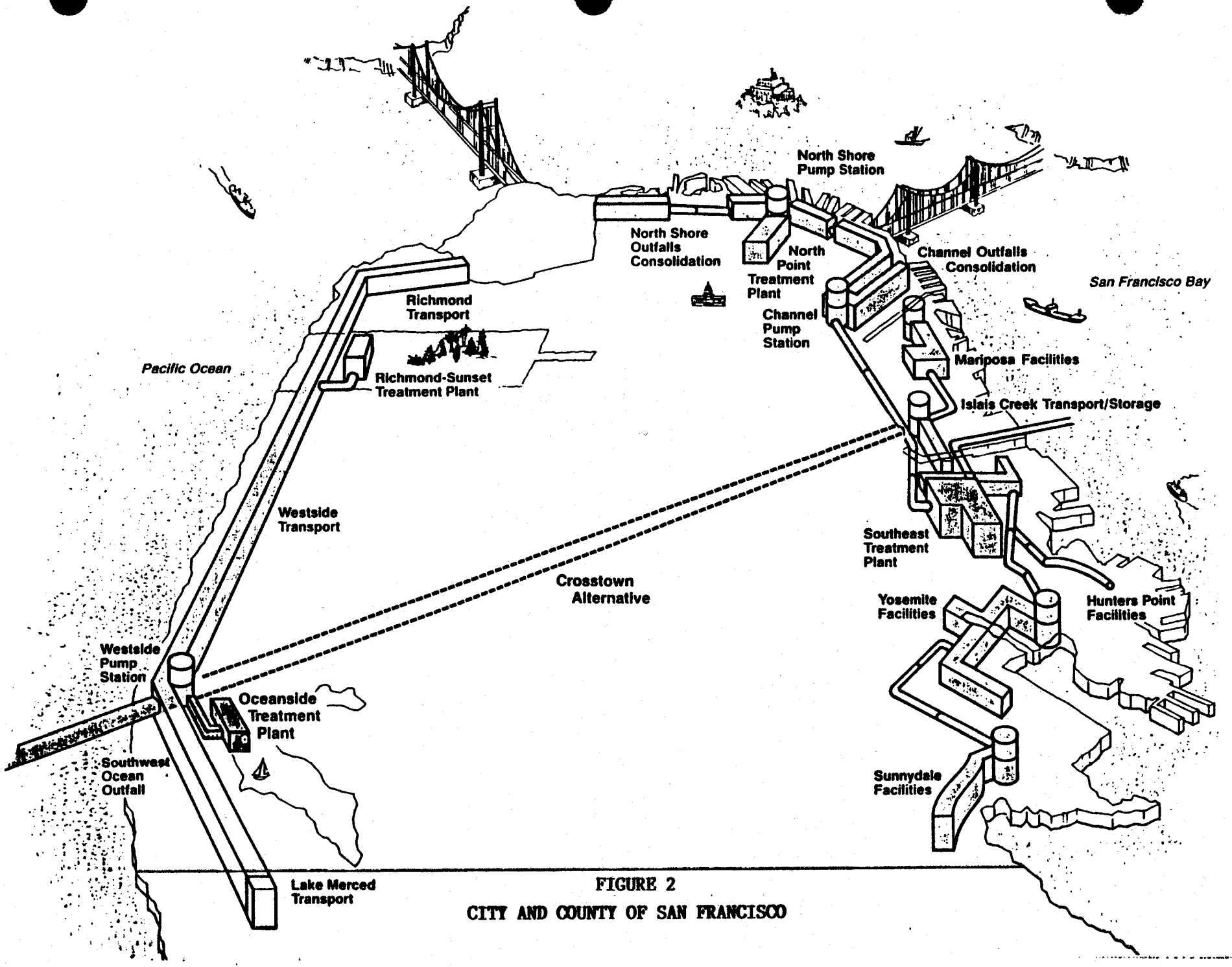



FIGURE 2

CITY AND COUNTY OF SAN FRANCISCO

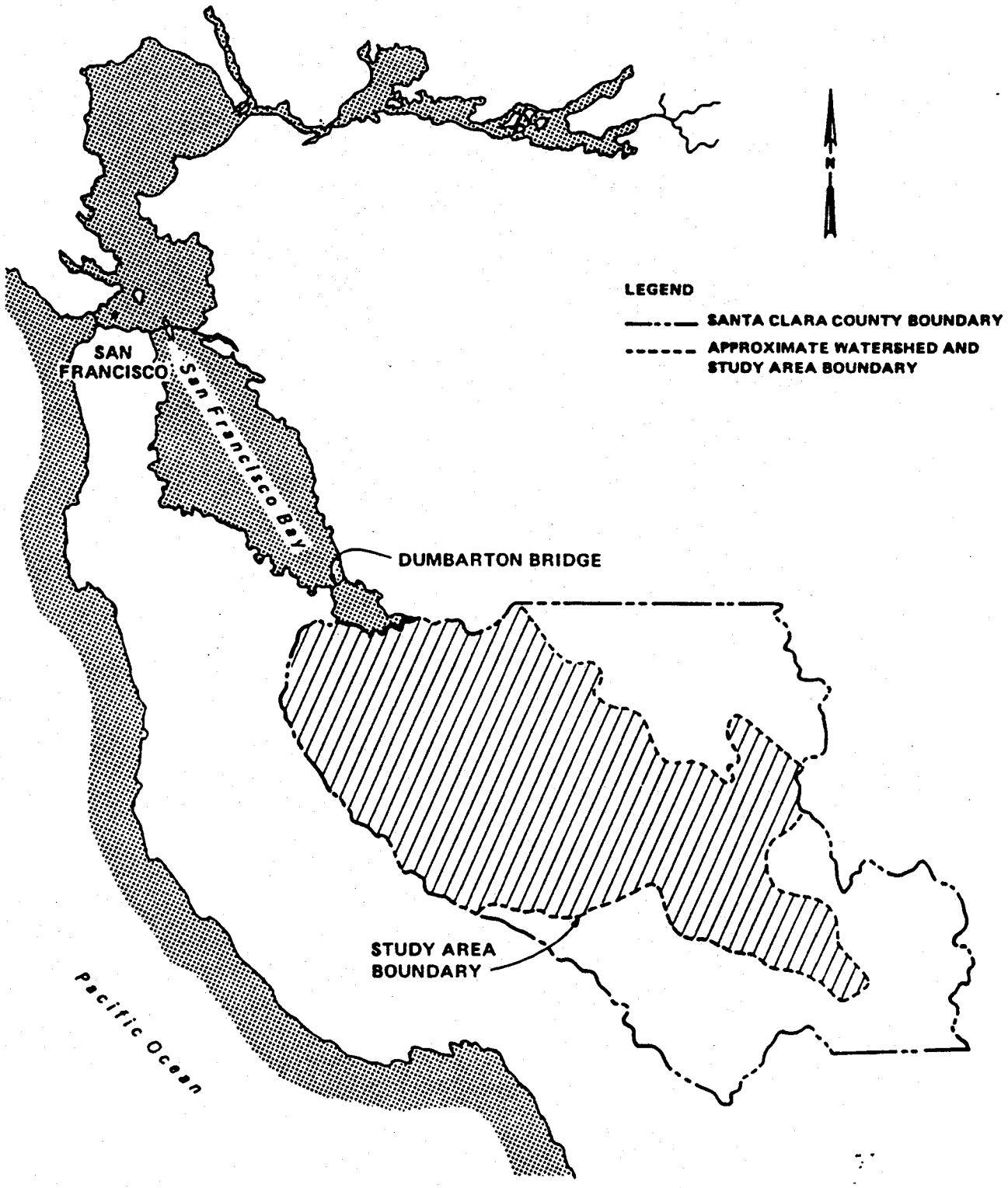



**FIGURE 3**

**SANTA CLARA COUNTY**

# Thursday Afternoon, July 27, 1989

| | | PAGE |
|---|---|---|
| **SESSION VII:** | **SANTA ANA RIVER WATERSHED – NEWPORT BAY NPS POLLUTION CONTROL PROGRAMS**<br>Session Chair: **James Cornelius**<br>**Principal Engineer, CA SWRCB** | |
| 3:30 p.m. | **Agency Partnership for Nonpoint Source Pollution Control in Newport Bay**<br>Pat Blodgett, Senior Environmental Specialist, Newport Bay Coordinator, CA Regional Water Quality Control Board, Santa Ana Region | VII-A |
| 3:45 p.m. | **Unsaturated Zone Movement of NPS Volatile Contaminants in the Redlands Area**<br>Gary L. Guymon, Professor of Civil Engineering, University of CA, Irvine, CA | VII-B |
| 4:00 p.m. | **The Mitigation of NPS Pollution Impacts on Newport Bay**<br>Sat Tamarabuchi, Director, Environmental Planning, The Irvine Company, Newport Beach, CA | VII-C |
| 4:15 p.m. | **Tours–NPS Pollution Control Facilities for Protection of Newport Bay** | VII-D |

NONPOINT SOURCE TALK
JUNE 23, 1989

# AGENCY PARTNERSHIP FOR NONPOINT SOURCE POLLUTION CONTROL IN NEWPORT BAY

Patricia Blodgett, Newport Coordinator, California Regional Water Quality Control Board-Santa Ana Region

The Water Quality Control Plan for the California Regional Water Quality Control Board -- Santa Ana Region, identifies a variety of beneficial uses of the waters of Newport Bay. These include contact and noncontact water recreation, commercial and sport fishing, and collection of shellfish for bait or personal consumption. Newport Bay provides valuable habitat for a diverse array of plants and animals, including several endangered species. Upper Newport Bay Ecological Reserve is an important coastal wetlands for birds migrating north and south along the Pacific Flyway, and its waters provide spawning, nursery and foraging habitat important to the preservation of marine fisheries.

Newport Bay is also a recreational and commercial center for Orange County. 2.1 million Orange County residents rely on Newport for beach, boating and other water related activities. One statistic that illustrates the heavy use of Newport Bay is that 10,000 vessels in the Newport area are registered with the State of California. Furthermore, the dramatic growth that the Newport area has experienced in the past 30 years is expected to continue into the 21st Century. The public agencies that are charged with the

protection and management of this vital resource face a challenging array of problems.

Numerous public agencies have some responsibilities related to the management and protection of water quality in Newport Bay. The U.S. Coast Guard (USCG) maintains a station in Newport, and is responsible for the enforcement of federal marine regulations in the area. The Orange County Sheriff's Department maintains a Harbormaster's headquarters in Newport, and is responsible for enforcement of water safety regulations. The Orange County Environmental Management Agency (OCEMA) monitors water quality in Newport Bay and the inflows of materials from County maintained flood control channels to the Bay. The Orange County Health Care Agency (OCHCA) regularly monitors bacterial quality in Newport and has the authority to close beaches and restrict water contact recreation if necessary in order to protect public health. The City of Newport Beach regulates commercial activities and maintains most of the beaches in Newport Bay. The California Department of Fish and Game (DFG) is responsible for the protection of fisheries and wildlife in Newport. The Santa Ana Regional Water Quality Control Board is responsible for protecting water quality and the beneficial uses of Newport Bay and its watershed. The Regional Board coordinates the other involved agencies to assure that water

quality is enhanced and protected. The Regional Board also regulates discharges of wastes to Newport Bay and its tributaries and has the authority to take enforcement actions if necessary to protect water quality.

In spite of attention from these many agencies, the environmental quality of the Bay continued to decline as the area developed. It became apparent that each agency could magnify the impact of their own work by working cooperatively with other involved agencies. In 1985, Senator Marian Bergeson reaffirmed that the activities of the various state and local agencies involved with Newport be coordinated by the Regional Water Quality Control Board, as specified by the Porter-Cologne Water Quality Control Act, and that a staff position be assigned exclusively to this coordination effort. Since 1986, the Regional Board has received supplemental funds from the State Water Resources Control Board for Newport Coordination. It has been the objective of this program to encourage the development of effective partnerships among agencies, the business community, and the public, to address the pollution problems of Newport Bay. The rationale for the partnership approach is simple: it is often a more effective and efficient strategy to implement a program through cooperative action among parties than through the adversarial process of direct regulation.

Furthermore, it was apparent that many of the pollution problems of the Bay were nonpoint source in nature, where "control" requires far more than simply issuing a permit and enforcing its conditions.

A Newport Water Quality Council was organized by the Regional Board to advise and share information about the various water quality programs that are carried out in Newport Bay and to provide a forum for the development of long term goals and objectives for the Bay. The council is made up of representatives of the agencies that have responsibilities in Newport.

In November of 1985, the Regional Board produced the report - "Newport Bay: Water Quality Issues and Recommendations", which was prepared in response to Senate Concurrent Resolution No. 38 sponsored by Senator Marian Bergeson. This report addressed three major areas of concern in the Newport Bay watershed:

Erosion/Siltation

Toxics

Bacterial Contamination

Another problem, nutrient inflows to Newport Bay, particularly from the San Diego Creek watershed, has been added to the list of problems impacting the Newport Bay since the publication of the SCR 38 document. In the upper part of the watershed, major problems

are urban and agricultural runoff, spills, groundwater inflows, and changing land use patterns. In the Upper Bay, the problems included inflows of toxics and siltation - problems which are complicated by the rapid urbanization of the area, and the need to maintain the ecological preserve characteristics of the Upper Bay. In the Lower Bay, problems included excessive algal blooms, vessel sanitation, commercial activities (especially boatyards), and inflows of toxic materials from nonpoint sources.

The coordinated agency-partnership approach has been an effective mechanism to identify and prioritize the pollution problems of Newport Bay, and then bring about appropriate corrective actions. Twenty-one specific recommendations were made in the SCR 38 document. Nine of those recommendations were directed to various city governments, three to county agencies, four to the regional board, and five to other state agencies. To date 17 of those recommendations have been fully adopted by the designated implementing agencies. In addition, other recommendations have been partially implemented by the various designated entities. Many of the coordinated interagency programs now in place in Newport were implemented in response to the directives of SCR 38.

For example, one of the recommendations of SCR 38 was to encourage the construction of more public pumpout facilities in Newport Harbor. Senate Bill 2562, passed in 1986, gave regional boards the authority to require pumpouts at specific vessel terminals. The Santa Ana Regional Water Quality Control Board, working with the Newport Bay Harbormaster, the City of Newport Beach, and Orange County Health Care Agency, has implemented a vessel pumpout program in Newport Bay. In addition, the City of Newport Beach passed ordinances to control vessel sanitation of live-aboards and to require pumpout facilities for the sailboat and charter boat marinas in Newport. Several agencies and private concerns are contributing to public education and boater awareness campaigns.

Another recommendation of SCR 38 was to continue implementing the "San Diego Creek Comprehensive Stormwater Sedimentation Control Plan" which was developed in 1982 as part of an areawide planning (Sec. 208) initiative. Local costs for these projects have totalled $13.8 million. Projects include extensive dredging to create an 85-acre sedimentation basin in the Upper Bay, together with side and center channels for restoration purposes, and three sedimentation basins in San Diego Creek, upstream from its outlet to Upper Newport Bay. The impact of these changes is that the

tidal prism in the Upper Bay has been greatly enlarged. It is believed that the capacity of the sedimentation basins is sufficient so that maintenance removals will only be required every five years or more on average. The California Department of Fish & Game; the Cities of Irvine, Newport Beach, and Tustin; Orange County; and the Irvine Company have an agreement to assure ongoing evaluation and local funding for the cost of perpetual maintenance of these sediment control facilities.

In addition to these sediment control projects, the Santa Ana Regional Board has worked with the Cities of Irvine and Newport Beach, and Orange County, to help them develop construction ordinances that control grading practices which minimize the erosion of and transport of sediments in the Newport watershed.

Also, in accord with recommendations of the SCR 38 Report, more monitoring has been done to identify the presence and possible sources of toxic materials to Newport Bay. The Santa Ana Regional Board, cooperating with the California Department of Fish & Game, is continuing to collect information about toxics which bioaccumulate in the Bay and upstream watershed, through the State Mussel Watch and Toxic Substance Monitoring Programs. These program results have consistently shown high levels of a variety

Also 6 wkns due to nutrient loading by San Diego Creek

3 my Nurseries now implementing recycling ~~[illegible]~~ System drip irrigation

of organics and trace metals in Newport Bay and San Diego Creek relative to other waters in the State. Nonpoint inputs appear to be the primary source of the identified contaminants. Currently the Regional Board has contracted Dr. Jan Scherfig of the Department of Civil Engineering at the University of California at Irvine to identify selected toxics in sediments at various locations in the San Diego Creek watershed.

The partnership approach has been quite successful in marshalling a variety of resources to address Newport Bay problems, and this process is continuing. One of the present activities of the Newport Water Quality Council members, coordinated by the Regional Water Quality Control Board, is a sequel to the SCR 38 Report. This is being done in response to another resolution (Senate Concurrent Resolution 88) by Senator Marian Bergeson, which asks for an update on the progress that has been made since 1985, and for any additional recommendations for future actions. Since all of the point sources of pollution in the watershed are being controlled, clearly the emphasis for the SCR 88 report is expected to be on the correction and control of nonpoint source problems which impact Newport Bay.

In summary, while interagency coordination is not a new idea, we can speak from experience that it can be flexible, effective, and efficient and it is particularly suited to dealing with nonpoint source problems.

UPPER NEWPORT BAY

SEDIMENTATION CONTROL AND RESTORATION

Sat Tamarabuchi

Restoration work and control of sedimentation within Upper Newport Bay is nearing completion, thanks to tne cooperative efforts of the State Department of Fish and Game; the Cities of Irvine, Newport Beach and Tustin; the County of Orange; and The Irvine Company.

This most recent effort began in 1980 with the Cities of Irvine and Newport Beach, together with the Southern California Association of Governments sponsoring a 208 Study. The recommendations contained in the Study have been implemented. Projects directly affecting the Bay and totalling $13.8 million have either been completed or are under construction.

Early Action Plan

This project, completed in the fall of 1982 at a cost of $3.7 million, included two sedimentation basins upstream of the Bay and a 50-acre basin within the Bay. 500,000 cubic yards of previously deposited sediment was removed from the Bay.

The project proved its effectiveness during the major storms of early 1983 by trapping in excess of 300,000 cubic yards of sediment.

Unit I

This $4.1 million project, completed in November 1985, enlarged the "Early Action" basin to 85 acres, deepened the basin, and created a 300-foot-wide and 3200-foot-long outlet channel. 890,000 cubic yards of sediment was removed from the Bay.

Unit II

A contract awarded for this project, costing $5.2, is nearing completion. This project involves the excavation of another basin within the Bay at the southerly end of the Unit I outlet channel, together with side channels for restoration purposes and a 100-foot-wide access channel extending from the basin to lower Newport Bay. Approximately 1,100,000 cubic yards of previously deposited sediment is being removed from the Bay. Excavation is being accomplished with a clamshell dredge and the spoils hauled with barges to the ocean disposal site four miles off the harbor entrance.

Third Sedimentation Basin

A contract has been awarded for the construction of a third sedimentation basin in San Diego Creek immediately upstream of the two basins constructed as part of the Early Action Plan. The cost of this basin is $800,000. The additional basin will add to the trapping efficiency of sediment that is transported during large storms, thus reducing the amount of sediment that reaches Upper Newport Bay.

Upon completion of Unit II, 2.4 million cubic yards of previously deposited sediment will have been removed from the Bay since 1982 at a cost of $11.9 million which has been funded by State and local entities. The tidal prism will be essentially restored to the condition existing prior to 1930 which was the beginning of significant changes in the Bay. In addition, basins will exist

which will localize the deposit of incoming sediments that cannot be trapped upstream. The capacity of the in-Bay basins will be sufficient so that maintenance removals only will be required every five years or more on average. The Agreement between tne parties funding the initial construction also provides for funding the cost of perpetual maintenance. Completion of Unit II concludes the planned in-Bay sediment control facilities.

A cooperative agreement has been entered into between the State Department of Fish & Game; the County of Orange; the Cities of Irvine, Tustin, Newport Beach; and The Irvine Company. The stated purpose of the agreement is to provide a forum to evaluate and assess progress toward implementing the Comprehensive Storm Water Sedimentation Plan, to formulate project-implementing agreements for the elements of the plan, and to evaluate and assess the effectiveness of the various elements of the Plan.

Current members of the Executive Committee created in the agreement are:

County of Orange--Supervisor Thomas Riley
State Department of Fish & Game--Fred Worthley
City of Irvine--Councilman Ed Dornan
City of Tustin--Mayor Richard Edgar
City of Newport Beach--Mayor John Cox
The Irvine Company--Thomas Nielsen

Participants in funding tne Upper Newport Bay restoration work and sedimentation control facilities are:

State of California, Department of Fish & Game
State of California Clean Water Bond Act Grant
California Coastal Conservancy Grant
Port of Long Beach
County of Orange
Orange County Harbors, Beaches and parks District
City of Irvine
City of Tustin
City of Newport Beach
The Irvine Company

Project Costs:

| | |
|---|---|
| Early Action Plan | $ 3.7 M |
| Unit I Bay Basin | 4.1 M |
| Unit II Channel & Basins | 5.2 M |
| Third Sedimentation Basin | 0.8 M |
| Total | $13.8 M |

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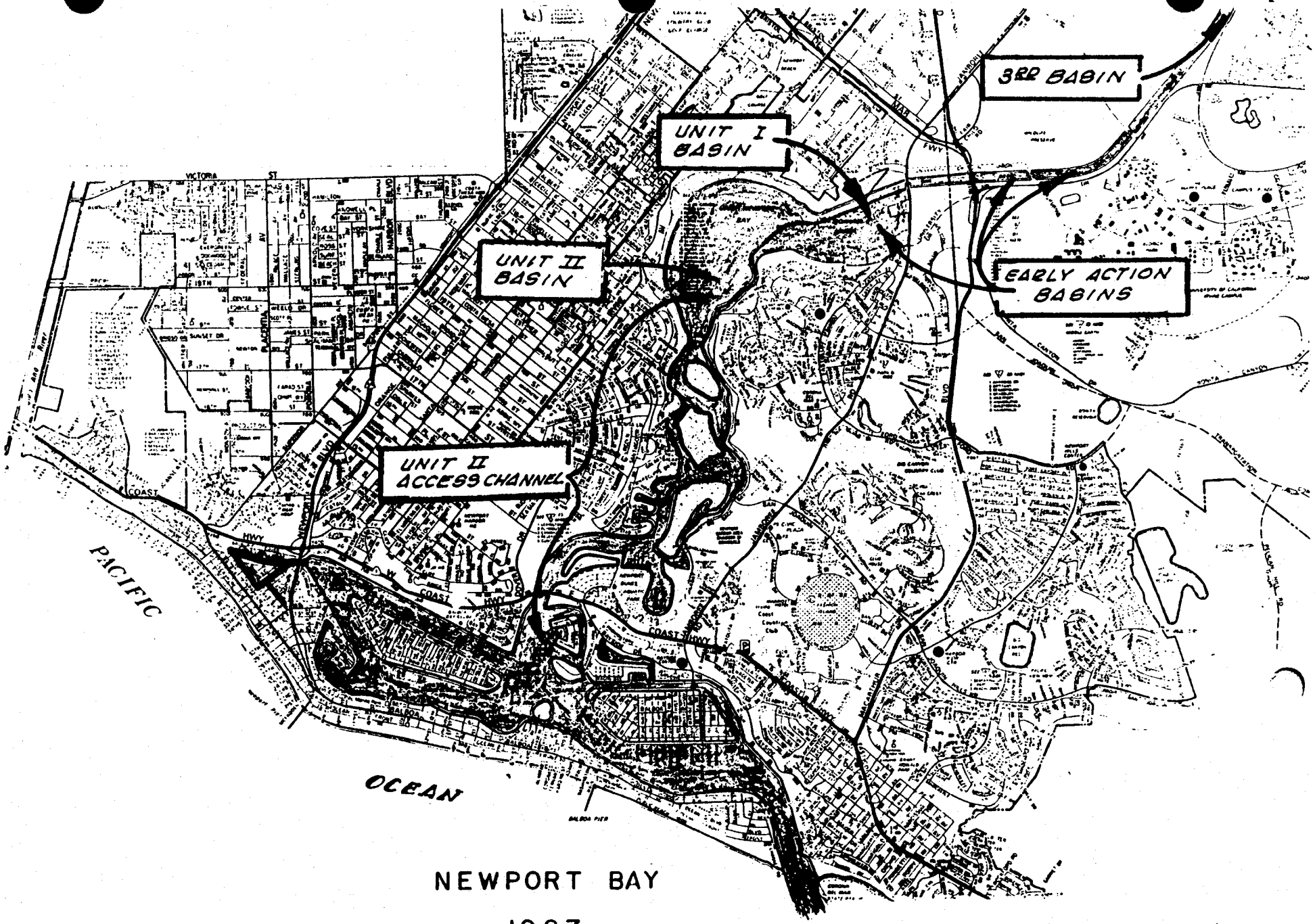


NEWPORT BAY

1987

# Friday Morning, July 28, 1989

| | | PAGE |
|---|---|---|
| **7:30 a.m.** | **Pastries, Coffee and/or Juice**<br>International Foyer | |
| **SESSION VIII: OVERVIEW–SILVICULTURE**<br>Session Chair: Richard Nichols, OR | | |
| 8:15 a.m. | **The State of Washington's Timber, Fish & Wildlife Agreement**<br>Bob Duffy, Environmental Planner, NPS Unit<br>WA Department of Ecology | VIII-A |
| 8:30 a.m. | **CA Forest Practice Rules Assessment**<br>Dean Cromwell, Executive Officer<br>CA State Board of Forestry<br>Gaylon Lee, Forest Practice Manager<br>CA State Water Resources Control Board | VIII-B |
| 8:45 a.m. | **U.S. Forest Service Best Management Practice**<br>Andy Leven, Director<br>Regional Watershed Management<br>US Forest Service, San Francisco, CA | VIII-C |
| 9:00 a.m. | **Perspective of the Timber Industry**<br>Gil Murray, Vice President<br>Timber Association of CA | VIII-D |
| 9:15 a.m. | **ROUNDTABLE DISCUSSION & QUESTIONS** | VIII-E |
| 9:45 a.m. | **BREAK** | |

A Presentation for the Western States Water Council Nonpoint Source Pollution Control Workshop at Irvine

Dick Wallace

# THE STATE OF WASHINGTON'S TIMBER, FISH AND WILDLIFE AGREEMENT

The history of protecting water quality during forest practices activities in Washington is a long and not always pleasant one. The program has been a regulatory approach with timber landowners required to obtain a permit for most activities and follow a comprehensive set of rules laid out in the Washington Administrative Code. Adoption and revision of these rules always seemed to lead to major battles of your expert versus my expert.

In the summer of 1986, leaders of the Indian tribes, timber industry, environmental groups, and state resource agencies discussed the possibility of resolving forest practices conflicts in a more constructive fashion than through litigation and battles over the rules. That started nearly six

months of intense meetings at both the technical and policy levels, over one hundred in all. The culmination of all this effort was the Timber Fish and Wildlife Agreement. The TFW Agreement was crafted to assure the protection of fish, wildlife, water quality and tribal cultural and archeological resources while providing for a healthy timber industry in Washington state.

There were a few critical steps that made the agreement possible. First, it had full support from the highest policy levels. Next, everyone agreed to a set of ground rules including "leave your weapons at the door" and "work as hard on other's problems as your own" and "listen to understand" and "everyone's issues will be addressed." Anyone could have left the table at any time but only after explaining their problem and allowing the group the chance to solve it. No one left. Another important factor was time. The Forest Practices Board set a six month deadline to complete the work. Finally, all agreed that the forest lands of the northwest and all the resources they contain were special and needed to be protected.

Each TFW cooperator recognized that the goals of the other participants are equally legitimate and important. The following five goals were developed and form the cornerstone of the agreement.

* Wildlife- " to provide the greatest diversity of habitats (particularly riparian, wetlands and old growth), and to assure the greatest diversity of species within those habitats for the survival and reproduction of enough individuals to maintain the native wildlife of Washington forest lands."

*Fisheries- " long-term habitat productivity for natural and wild fish and the protection of hatchery water supplies."

*Water quality and quantity- " protection of water needs of people, fish and wildlife."

Archeological and cultural- " to develop a process to inventory archeological and cultural spaces in managed forests; and to inventory, evaluate,

preserve, and protect traditional cultural and archeological spaces and assure tribal access."

*Timber- "the continued growth and development of the state's forest products industry which has a vital stake in the long term productivity of both the public and private forest land base."

Starting with these goals, the participants began tackling specific issues such as riparian management, roads, temperature, unstable slopes, old growth, and cumulative effects. The first step was to find areas of agreement then begin resolving differences. As it turned out their were not nearly as many areas of disagreement as people had perceived.

The agreement is by its very nature a compromise or more accurately a series of intelligent accommodations of the various goals and needs. It is also a product that reflects the best thinking of some of the persons most knowledgeable about our natural resources and the forest products industry. Anyone familiar with natural resource management will

be impressed with how far we have come and we are continually impressed with how much we have yet to learn.

The TFW Agreement is a "living" document to reshape the way we manage our natural resources. It is not a legal agreement and was never intended to be signed. It represents a commitment by all parties to work together to reach consensus both in the field and at the policy level. And it's working. Implementation has not been easy but there have been many successes.

Once the agreement was reached the TFW cooperators took it to the Forest Practices Board where it was accepted. The Forest Practices Board was established by the Forest Practices Act of 1974 to adopt rules and oversee the program. The state Department of Ecology jointly adopts rules for water quality protection. The next step was to the legislature where the state Department's of Natural Resources, Fisheries, Wildlife, and Ecology received a total of $4.5 million dollars to begin implementation. The Indian tribes went to Congress and the Washington

Environmental Council and Audubon went to private foundations, and the industry went to it's members. All were successful in obtaining funding.

The TFW Agreement is over forty pages long. It is complex, detailed and often technical. The three main components are regulation changes, voluntary/cooperative efforts, and the concept of adaptive management.

A series of specific regulatory changes were recommended to and made by the Forest Practices Board and the Department of Ecology. These fall into four main categories. Protection of riparian zones through equipment and chemical limitations and certain numbers of "leave trees" to provide large organic debris for fish and wildlife habitat and stream stability. Improved review of forest practices applications to assure site-specific plans and the use of interdisciplinary teams to evaluate conditions and prevent problems. Improved road design, construction, maintenance, and abandonment. Other rule changes addressed unstable slopes,

silvicultural activities, and application of forest chemicals.

Just as important as regulatory changes were the cooperative efforts. Major forest land owners agreed to initiate annual discussions of their harvest plans with TFW cooperators to explore ways to protect everyone's resource. They also agreed to provide "upland management areas" for the benefit of wildlife. A goal of 2 acres for every 160 acres harvested was set and a report card on performance was agreed to. The parties agreed to work together on strategies to protect old growth timber. Three pilot resource management plans are being developed similar to watershed plans that look at an entire basin. Potentially hazardous abandoned or "orphaned" roads would be identified and repaired.

In addition to regulatory and voluntary efforts, a concept of adaptive management was adopted. This is the process of updating and refining management and regulation as we improve our understanding of the dynamics of forest practices and resource management.

At the center of this is a firm commitment to cooperative monitoring, evaluation, and research. We agree on the questions to be asked, how we will go about answering them, and to "go where the truth leads us." The second element of adaptive management is an agreement to annually evaluate our progress. The annual reviews will be followed by more comprehensive reviews and an opening up of the agreement at the third and eighth years.

What are the benefits to water quality? The forest practices that have the greatest potential impact on water quality include road construction, maintenance and use, and timber harvest activities adjacent to streams. The water quality parameters affected most are turbidity, suspended and deposited sediment, and temperature.

Through the regulations, site specific inspections and evaluations, and adaptive management the TFW system will provide improved protection of water quality. Entire watershed areas will be covered through resource management plans. Interdisciplinary

teams will prevent sediment impacts from roads and unstable slopes. Riparian management zones will provide increased protection for streams, lakes, and wetlands. Required leave trees will provide shade and large organic debris for fish habitat and greater stream stability. Operational constraints will minimize soil disturbance and erosion and riparian buffers and requirements for drift control will reduce the possibility of pesticides and other forest chemicals entering the water.

Possibly the greatest benefit to water quality will come from the commitment to monitor and evaluate the effectiveness of forest practices best management practices. This new information will allow fine tuning and will enable those involved to better deal with difficult issues such as the cumulative effects of forest practices on the environment.

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# CALIFORNIA'S FOREST PRACTICE RULES ASSESSMENT

Dean Cromwell and Gaylon Lee

## BACKGROUND

For over 40 years California has used a regulatory approach to deal with silviculture as a nonpoint source of water pollution. In 1947 the State Legislature passed the first Forest Practice Act. The years that followed saw forestry embroiled in bitter debate over timber harvesting practices on private lands and in 1973 the current Forest Practice Act was passed. This Act requires much stronger protection of water quality and other aspects of the environment. Under the Act, the Board of Forestry (BOF), a nine member Board appointed by the Governor, has developed one of the more stringent sets of Forest Practice Rules (Rules) in the country. Among other things, the Rules cover choice of silvicultural systems, harvesting and erosion control practices, operations near watercourses and lakes, and construction of roads and landings.

BOF has also tried to meld the Forest Practice Act with a number of other state environmental laws which affect timber harvesting, most notably the California Environmental Quality Act. A complex regulatory structure for implementing the Rules has emerged. Timber of commercial species cannot be harvested until a plan, called a Timber Harvesting Plan (THP), has been submitted and approved by the California Department of Forestry and Fire Protection (CDF). The THP must be written and signed by a Registered Professional Forester (RPF). California requires anyone practicing forestry in the state to be licensed, which means meeting experience requirements and passing a written examination. THPs must also be reviewed by an interdisciplinary team composed of State agencies with an interest in water, primarily the California Regional Water Quality Control Boards and the Department of Fish and Game (DFG). Other experts participate as needed in THP review. There has sometimes been argument between CDF and other review team agencies. After

review, THP's can only be approved by CDF, which is the lead agency, if they conform to BOF rules.

The evolution of this structure has been the product of much political and legal debate. Part of this debate has been over how to respond to the requirements of the State's basic water quality act, the Porter-Cologne Act, and to Section 208 of the federal Clean Water Act. The attempt to incorporate the Rules and the related implementation process (process) into a nonpoint source management program which is recognized by the State Water Resources Control Board (SWRCB) and the U.S. Environmental Protection Agency (EPA) began more than a decade ago. This effort was extremely difficult due to strong mutual distrust, frequent intense conflict, and seemingly irreconcilable differences. In 1977, BOF and SWRCB agreed to review the adequacy of the Rules and the process as Best Management Practice (BMPs) pursuant to Section 208. In 1983, BOF adopted significant changes in the Rules and process to better protect water quality. BOF requested that the SWRCB certify the Rules and process as BMPs pursuant to Section 208. Strong conflicting opinions about the adequacy of the new Rules and process were expressed in SWRCB's certification hearings, but little substantive evidence was brought forward. In 1984, SWRCB agreed to certify the Rules and process conditioned on development and implementation of a four-year monitoring and assessment program and of a management agency agreement (MAA) with CDF. However, upon attempting to develop this program, the agencies found that the cost of the monitoring and assessment program would have exceeded their available resources. Also, no agreement could be reached due to strong differences between state agencies. Therefore, certification remained in abeyance.

To break the stalemate, high-level representatives of SWRCB, CDF/BOF, and the timber industry entered into intense negotiations which resulted in signing of an agreement to implement a one-year assessment of the Rules and process using a multi-disciplinary team comprising one representative from each of the signatory parties and from DFG. In 1988, SWRCB, BOF, and

CDF finally entered into a water quality management plan, which included BMPs certified under Section 208, and signed a joint management agency agreement. Key to this development were the assessment and the negotiations that followed publication of the assessment report.

The paper which follows is an attempt to capture some of the more technical issues of the assessment and negotiations experience, as well as other interrelated problems. These may be of some use to others in looking at possible institutional approaches to dealing with nonpoint sources of pollution. A word of caution, the authors are not necessarily recommending a regulatory approach. Further, it is critical to remember that the circumstances which have led to the development of California's framework for dealing with silviculture are somewhat unique to this state.

## CONDUCT OF ASSESSMENT

Several of the technical problems faced by the 208 assessment resulted from operational and environmental factors. Private-land logging in California involves many types of owners, management approaches, and harvesting methods. It is conducted on parcels varying from three acres to several thousand acres in size and in a wide variety of environmental conditions. Many logging operations are conducted in areas where there is very little threat to the quality and beneficial uses of water, while others pose significant threats to these resources. Sediment discharges from sheet and rill erosion of harvested areas are generally greatest during the first year or two following operations, but diminish considerably thereafter. On the other hand, very large sediment discharges from mass wasting events can occur during large storms which take place five to ten years after completion of operations.

The variability in site conditions, management approaches and forest practices is reflected in the Rules. In general, the prescriptive standards for forest practices which were adopted in

1983 address the most common and most critical operating practices and environmental conditions and allow considerable flexibility on a site-specific basis. Thus, many of the 227 Rules which are related to protection of water quality will not apply at a given harvest site. Also, the implementation process, including preparation and review of a THP before commencement of any timber operation, the use of nonstandard practices, and compliance with applicable requirements during conduct of operations, are at least as important as the Rule standards themselves. For these reasons, it was decided that the process should be assessed and that as many sites as possible should be visited during field assessment to help ensure a statistically significant test for each of the 227 Rules.

Institutional and political factors also resulted in technical problems. As already mentioned, implementing a statewide assessment program which included detailed monitoring would have exceeded the available budget and personnel resources of the participating agencies, and agreement regarding appropriate goals and monitoring procedures was exceedingly difficult to achieve. Due to past conflicts and mutual distrust, there was intense concern that the results of the assessment would or could be used by regulatory agencies against parties who allowed visits to timber harvesting sites on their land. There was also fear of attack by third parties, courts, or the legislature against the timber industry in general or against CDF.

Given the preceeding background, it is not surprising that the most fundamental planning issue was the anticipated use of the results of the assessment. This issue affected determination of the appropriate scope, detail and reliability of the assessment. The stated purpose of the assessment was to provide SWRCB with data, conclusions, and recommendations which it could use in deciding whether to proceed with implementation of a four-year monitoring and assessment program or to take appropriate alternative courses of action regarding certification. Because the assessment was to produce evidence for making informed

management decisions, it was decided that the assessment procedures need not be as rigorous as those used to produce scientific or legal evidence. Considering institutional and political constraints, it was decided that: (1) the field studies should last no more than one year, (2) the field assessment should not include repeated site visits or quantitative monitoring, (3) the results would not be used in enforcement actions, and (4) no party to the agreement would have any editorial rights over the assessment report.

All of the foregoing contributed to the most fundamental technical problem: how to obtain information and data which were adequately accurate and reliable for making management decisions within the constraints on time, budget and personnel. This problem was addressed through composition of the assessment team, site selection, field assessment, and data storage.

The assessment team consisted of a geomorphologist/engineering geologist from SWRCB, a biologist from the DFG, and an RPF from both the timber industry and from CDF. Each team member was selected for professional competence and attitude, as well as general familiarity with forestry. Development of mutual respect and understanding between the team members was a critical ingredient in the success of the assessment process.

A stratified random selection process was used to ensure that site selection was as unbiased as feasible. Out of a randomized field of 2528 THPs, about 260 had to be screened to yield a group of 100 sites which would: (1) be representative of the State's timber-producing areas, silvicultural systems and yarding systems and (2) facilitate efficient assessment of the effects of modern timber operations on beneficial uses of water. To accomplish the second of these goals, each randomly selected candidate site had to meet the following criteria to be selected for a site visit: (1) the THP must be filed and the operation conducted under the 1983 Rules, (2) operations must include a timber harvest area of at least ten acres, (3) the harvested area must have been through

at least one winter season, and (4) water bodies supporting beneficial uses must be present within or adjacent to the harvested area. Focusing the assessment on sites where beneficial uses of water were present led some parties to believe that the selection process was improperly biased; this perception has caused continued trouble in the political arena.

The owners of selected sites were notified of anticipated site visits. Due to the cooperation and encouragement of the timber industry and professional forestry associations, no request for a site visit was denied.

At each site visited during field assessment, the team first identified the types of forest practices actually conducted, the benefical uses of water which were potentially threatened by the operation, and the sensitive field conditions (such as erodible or unstable slopes and flood-prone areas) which could contribute to deleterious effects on beneficial uses if disturbed by timber operations.

Semiquantitative procedures were used to facilitate field assessment. These procedures could be performed rapidly and economically, were consistent between sites and team members, and provided reasonable accuracy. The team evaluated the sensitivity of each identified beneficial use and sensitive condition. Onsite assessment of erosion potential incorporated the semiquantitative erosion hazard rating system set forth in the Rules, but also considered factors (such as mass wasting and plasticity index) not included in the Rules' system. Assessment of the physical condition of stream channels and banks was based on a semiquantitative stream reach inventory methodology, while assessment of biological conditions was based on a modified habitat suitability index model.

The team identified the potential effects of each timber operation given the types of forest practices actually conducted and the type and sensitivity of at-risk beneficial uses and

sensitive conditions. The severe winter weather of early 1986 generally provided a good test of the effectiveness of forest practices in protecting water quality. To evaluate the significance of observed effects on beneficial uses and sensitive conditions, the team used a semiquantitative approach in which a numerical value represented a qualitatively described category of effect. The team members used their individual and collective professional judgement to decide which category best described the effects observed in the field. A similar semiquantitative approach was used in assessing whether the beneficial uses and sensitive site conditions, and actual or potential effects thereto, had been adequately recognized and documented during planning, review and conduct of the timber operation and in assessing the degree to which compliance with the Rules and any other applicable requirements had been achieved.

The assessment generated more than 50,000 pieces of data. To handle this information, a customized relational database was established on a personal computer. A person with considerable computer expertize was needed to develop the database so that it could be used to maximum advantage for analysis of the data. Data entry was performed by student assistants.

The assessment had certain inherent limitations. It could not effectively evaluate offsite, cumulative, or long-term effects, nor effects other than those produced by sediment. Due to combinations of effects at some sites, the team was occasionally unable to determine the relative effects of individual forest practices, or, where other land use activities had a significant effect, of a timber operation. At some sites, noncompliance with applicable requirements masked the effectiveness of the Rules themselves.

RESULTS OF ASSESSMENT

The Final Report of the Forest Practice Rule Assessment Team to the State Water Resources Control Board (report), was released in

April, 1987. The report found that there has been major improvement in the effectiveness of forest practices in protecting beneficial uses since the later 1970s, but that there is still room for improvement. The potential effects of a timber operation on beneficial uses were adequately recognized during THP preparation and review at 54% of the sites visited. The best feasible protection measures were used at 58% of the sites visited. The beneficial uses and sensitive conditions were adequately protected at 61% of the sites visited. Where adverse effects did occur, the great majority appeared to be minor. However, at several sites they were moderate to major and at a very few sites they were severe. The most commonly observed problems were caused by sedimentation.

Where applicable Rules and THP requirements were followed and sensitive conditions were not present, the standard practices for felling, yarding, erosion control installation, and watercourse and lake protection generally provided adequate protection. Operations in sensitive areas sometimes resulted in significant adverse effects. Standard practices for road and landing construction and maintenance were not always adequate where such facilities were located near watercourses. Nonstandard practices sometimes did not provide an adequate level of protection. THP information did not always allow adequate review of the potential effects of a timber operation or the adequacy of protection measures. Site preparation, which is unregulated, was found to sometimes cause problems equivalent to those of timber harvesting. Noncompliance with Rules and THP requirements was found to be the single most important impediment to adequate protection of beneficial uses and sensitive conditions. The next most important impediment was lack of recognition of the potential effects of a timber operation on beneficial uses or sensitive conditions.

Despite these flaws, the report concluded that the framework established by the Rules and implementation process could provide the best feasible protection on a consistent basis if some

adjustments are made and if all parties begin taking advantage of the opportunities within the framework. The team made a number of recommendations which they believed would ensure that the Rules qualify as BMPs, including more than 30 recommendations for Rule changes to address the deficiencies identified above. In addition, the team indicated that the Rules should incorporate more enforceable performance standards (supplemented by technical guidance documents) rather than add numerous prescriptive standards.

The report indicated that better recognition of potential effects should be achieved through: (1) development and adoption of guidance documents regarding evaluation and protection of beneficial used and sensitive conditions, (2) related training of foresters, timber operators, and agency personnel, (3) consultation by foresters with appropriate experts, (4) monitoring of the actual effects of operations, (5) planning of timber operations on a watershed level, and (6) development of related natural resource databases which are accessible to the private and public sectors.

The report addressed more effective Rule implementation. It indicated that interagency conflicts which develop in the THP review process should be addressed through a Memorandum of Understanding which recognizes the legitimate roles and responsibilities of the involved agencies, establishes a conflict resolution procedure, and provides for statewide consistency. Rule implementation should also be improved through: (1) requiring an examination for a timber operator license, (2) requiring direct communication between the RPF who prepares a THP and the timber operator who will implement it, (3) improved THP documentation and related training and education, and (4) improved inspection of operations and enforcement of requirements.

## DEVELOPMENT OF THE MANAGEMENT AGENCY AGREEMENT

Publication of the report renewed the debate over the adequacy of the Rules and implementation process. The report was widely discussed in the forestry community. Advocates from both the timber industry and environmental community found material to like and dislike. In May 1987, SWRCB held a hearing to receive evidence regarding the report and regarding its own future courses of action under Section 208. In general, the report was accepted as a starting point which raised issues that needed to be resolved. There was less agreement with the suggested solutions offered by the report, but there was still some acceptance of what needed to be done.

The testimony revealed continuing profound differences between the timber industry, foresters, environmental protection advocates, fishermen, and other concerned citizens. The most devisive issues were: (1) whether the Rules protect the quality and beneficial uses of water well enough to be certified as BMPs, (2) what criteria should be used to identify BMPs, (3) whether CDF and BOF would voluntarily make the needed changes in the Rules and implement the Rules to effectively protect water quality, and (4) who should be in control of making the needed changes to the Rules and process?

SWRCB, BOF, and CDF commenced negotiations on a joint MAA to address issues raised by the report and the hearing record. The most difficult problems were: (1) development of mutually agreeable goals, (2) ways to describe success or failure in meeting those goals, (3) appropriate time lines, and (4) the choice of language to be used. Ultimately, the MAA defined specific issues to be resolved by BOF based on points raised in the report and hearing.

About 40 specific items for resolution were identified; some of these were relatively minor, others would involve major efforts. Examples include site preparation, maintenance of erosion control facilities, culvert sizing, cumulative watershed impacts, better

implementation procedures, and conflict resolution between agencies. For each item, a target date for completion was defined, subject to a procedure by which the date could be changed. Explicit procedures to be followed in the review of the issues were delineated. Both rule and non-rule approaches were to be considered. These procedures followed normal BOF rule-making procedures with the additional step of preliminary public review of proposed changes and closer review by a BOF committee. Several opportunities for public input in this review have been provided. Finally, a liaison committee of SWRCB and BOF members and the CDF Director was established to oversee the process. By mutual agreement, the Director of DFG was also invited to serve.

Many drafts of the MAA were required and seemingly minor changes in language were extensively debated. This reflected the continuing problem of overcoming mutual distrust between the agencies, borne of a decade of bickering, as well as the issues made evident by the SWRCB hearing.

Gradually, the agencies developed some mutual understanding of each other's mandate and duties. An MAA was concluded and brought before both boards for ratification. As part of this effort, it was deemed vital to obtain the understanding and acceptance of foresters, the timber industry, the environmental community. A series of meetings were held with these groups to discuss the report and MAA.

In January, 1988, SWRCB held a meeting to consider taking action pursuant to Section 208 on a water quality management plan for timber operations on nonfederal lands. This plan consisted of those Rules selected as BMPs, the implementation process, and the MAA. Many segments of the environmental community believed that the improvements for which the MAA provided should be implemented before certification by SWRCB. BOF and the timber industry believed that certification was needed to ratify the important changes already made and to provide a satisfactory conclusion to a decade of effort. After considering its options, SWRCB decided that the proposed plan complied with applicable federal

requirements and that certification offered the best means for ensuring continued improvement in water quality protection. SWRCB therefore certified the plan, designated CDF and BOF as joint management agencies, executed the MAA with CDF and BOF, and requested EPA approval. Due to a variety of factors, EPA endorsed the framework of the plan, but declined to take action on it. EPA did accept designation of CDF and BOF as management agencies. Lack of EPA approval nearly upset the still fragile agreement.

IMPLEMENTATION OF THE MANAGEMENT AGENCY AGREEMENT

Despite the lack of EPA approval, BOF and CDF have proceeded with implementation deliberately. Their philosophy has been to encourage detailed discussion of each problem by a BOF committee and by BOF's District Technical Advisory Committees which are established by law to review proposed rules. In some cases, this has required SWRCB to extent target dates.

In two areas new legislation was required. With the support of the industry and the environmentalists, BOF sought and obtained new legislation to give it explicit authority over site preparation activities and to require maintenance of erosion control facilities. Rules now have been adopted in these areas.

A variety of initiatives are now in progress to address each task which has a target date attached. Some issues require different approaches. In some cases, BOF has relied on its committee to develop approaches to issues, often with technical input from the timber industry environmentalists, CDF, DFG, and water quality agencies. This approach has been used to deal with cumulative effects. For a number of matters related to roads and landings and watercourse and lake protection, BOF has appointed special task forces to examine issues in detail. The reports of these task forces are rather detailed and offer both rule and non-rule recommendations.

In still other cases, BOF has relied on segments of the forestry

community to develop solutions. The Associated Loggers of California, for example, have worked with CDF to develop a training course for loggers. The California Licensed Foresters Association has developed training courses and handbooks, as well as commenting extensively on rule and non-rule approaches. The Timber Association of California, which mostly represents the industrial forestry concerns within the State, has also supported training programs and participated in numerous discussions. Representatives of the environmental community and State agencies have also contributed extensively to task force discussions and at BOF meetings.

For its part, CDF has instituted a compliance monitoring program, developed a detailed cumulative effects assessment methodology, and provided substantial staff support on almost every issue. Both DFG and SWRCB have also been involved in discussions over each issue. SWRCB staff support, funded primarily through a grant from the EPA, has been critical to steady progress.

Most of these efforts are scheduled to be finished, at least as far as proposed rule changes by the end of 1989. Non-rule approaches, watershed analysis, and conflict resolution procedures between agencies may take longer. Work is now underway to develop a continuing monitoring program for forest practices.

## CONCLUSION

It is necessary to repeat the earlier caveats of this paper that California's regulatory approach to silviculture as a nonpoint source reflects the peculiarities of the State. Regulation may or may not be the best choice. In fact, much of the work done under the MAA has focused on non-rule techniques such as better guidance documents and educational programs. Rules for an activity as diverse and complex as forestry simply will not work as BMPs without broad understanding of their site specific application. How to get this understanding, and how to keep it current, remain pivotal questions.

Communications between the agencies and the timber industry are continuing. Understanding is better, though there is still the undercurrent of fear and suspicion between agencies themselves and sometimes with industry. The environmental community is also skeptical of real results and awaits the outcome of the entire process, as does EPA. Hence effective communication remains difficult. Beneath it all is the argument over how California's forestlands are to be harvested and who is in control of this decision, though there is a much better understanding that review is a joint effort.

The authors believe that we have seen, and will continue to find, much improvement in forest practices as they protect the beneficial uses of water. Recognition of potential risks is getting better, as is compliance with the Rules. The implementation of an ongoing monitoring program which is now being developed will be the key to judging the success of this nonpoint source management program, as well as fashioning ways to resolve agency conflict. At best, the road will be bumpy, but the journey is clearly worth it, or at least the agencies and the timber industry think so.

# U.S. FOREST SERVICE BEST MANAGEMENT PRACTICES
# AN EXAMPLE OF SUCCESSFUL
# NONPOINT SOURCE POLLUTION CONTROL THROUGH PLANNING AND PROGRAM DEVELOPMENT

Andrew A. Leven John R. Rector *

## ABSTRACT

The Environmental Protection Agency (EPA) has noted that Nonpoint Source (NPS) Pollution is unique. It is not amenable to control through force fitting old point source pollution control mechanisms and strategies (EPA 1989). New means of control and new physical and biological standards must be developed. The Federal Clean Water Act (CWA) provides the dynamics and flexibility to accommodate development of nonpoint source pollution controls. In the late 1970's the USDA, Forest Service participated in the State of California's Areawide Waste Treatment Management Planning program. As a result of the participation, a plan and program were developed for the control of NPS pollution on the 20 million acres of National Forest Land in the State (USFS 1979). The water quality management program and practices were certified by the State of California and approved by the EPA. The practices are acknowledged as the agency's Best Management Practices (BMP) for NPS control on National Forest System lands. The practices are extremely effective as they are tailor made to fit the Forest Service organizational framework and institutional structure and, hence, are technically, economically and practically feasible to implement.

The planning and program development opportunities of Section 208 "Areawide Waste Treatment Management Plans" and Section 319 "Nonpoint Source Management Programs" open the door for multiple agency/group involvement and innovative practice and procedure development. NPS dischargers have the opportunity to become self regulating; developing and implementing their own NPS controls.

## HISTORIC PERSPECTIVE

### NPS Pollution Control Planning

In the late 1970's the California State Water Resources Control Board (SWRCB) was involved in the initiation of CWA Section 208 mandated "Areawide Waste Treatment Management Planning." It was a formidable task to undertake a planning and program development effort that encompassed both point and nonpoint sources of water pollution. The SWRCB began the process by

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identifying and selecting 'planning agencies' for various geographic portions of the state. The Forest Service volunteered to formulate a plan, program and practices for NPS pollution control and management on the 20 million acres of National Forest System land in California. Through a cooperative agreement with the SWRCB the Forest Service was designated as a planning agency. An interdisciplinary cadre of Forest Service specialists was assembled to complete the task. Personnel representing Hydrology, Soil Science, Engineering, Fisheries and Wildlife , and Timber management disciplines were members of the team.

The charter of the team was to identify the NPS control mechanisms the agency had at its disposal (its management practices) and document its water quality management program. A systematic search was made of the agency's manuals, handbooks, specifications and policies, Federal laws, Departmental policies and Presidential orders to extract from them the existing mandates, processes, procedures and direction that constituted NPS controls. There were 98 management practices documented. They are process oriented practices that relate to a desired end state or condition not to specific methods and techniques of application. For example, practice # 2.7 is entitled "Control of Road Drainage". It has a stated objective of dispersing runoff from disturbances within the road clearing limits to minimize concentration of water and, hence, associated erosion and sedimentation. The orientation of the practice being that one of the best NPS protection measures the Forest Service applies is to properly drain road surfaces. The implicit result being that properly drained roads do not erode and create sedimentation of streams. The method or technique for draining the road, e.g., in slope the road surface and construct a ditch with culverts, water bar the road surface, French drain it, outslope it, and so forth, are the methods and techniques for attaining proper road drainage, i.e., applying the practice. The applicable method for draining the road is selected after site specific evaluation and consideration of the surrounding physical and biological environment.

The Forest Service program involved; training of its personnel in water quality requirements and responsibilities, continuous implementation of its practices, monitoring and evaluation of practice effectiveness, and updating/developing practices as needed to attain protection of beneficial uses of water.

State and Regional Board open workshops and hearings throughout the State were employed as the mechanism for obtaining public participation and involvement. Draft documents were also mailed to numerous interest groups, industry representatives, other state agencies, local agencies and the public at large for review and comment. As a result, extensive input was received. Six generations of the plan were reviewed in draft form before the final version was written.

Management Agency Agreement

In accordance with CWA Section 208 (b) (1) (B) stipulations, the Forest Service's plan was submitted to the State for certification as the program and practices the Forest Service was expected to implement to control NPS of pollution. Following certification by the State, the plan was forwarded to and approved by the Administrator of the EPA. Subsequently the Forest was formally designated as the 'Water Quality Management Agency' for National Forest lands in California and the 98 management practices became the agency's Best

Management Practices (BMP) for NPS control. This designation was formalized in 1981 with the signing of a Management Agency Agreement (MAA) between the State and the Forest Service. The MAA was the instrument that firmly established what the expected performance criteria for the Forest Service were to be. The following excerpts from the MAA document the performance expectations:

> (a) The practices and procedures set forth in the Forest Service 208 Report constitute sound water quality protection and improvement on NFS lands,...
>
> (b) It is contemplated by this agreement that the Forest Service reasonable implementation of those practices and procedures... will constitute compliance with Section 13260, subdivision (a) of Section 13263, and subdivision (b) of Section 13264, Water Code. It is further contemplated that these provisions requiring a report of waste discharge requirements for nonpont source discharges will be waived by the Regional Board pursuant to Section 13269, Water Code..."

Water Quality Management Charter

As a result of aggressive participation in developing a part of the State's water quality management program, the Forest Service was designated as a management agency, responsible for self regulation and the implementation and quality control of its own program and practices. The existing procedural prerequisites mandated in state statute for compliance with NPS control requirements, i.e., filing of waste discharge reports, and obtaining and implementing waste discharge requirements (permits), had been waived. For the Forest Service, procedural requirements had changed. The MAA does not, however, alter the regulatory authorities and responsibilities of the State and the EPA. The State quality controls the Forest Service water quality program through the conduct of inspections and reviews. The EPA continues to serve in a guidance and oversight review capacity for all water quality programs developed and/or administered by the State.

## CURRENT PROGRAM

Since the signing of the MAA in 1981, the Forest Service water quality management program has run smoothly. Over 3,000 Forest Service employees have received water quality management - BMP implementation training. Three levels of training are offered with the most intensive level being provided to the field level employee responsible for the conduct of management activities that can impact water quality. The development of missing and improvement of the weaker management practices has steadily progressed. Since the signing of the MAA in 1981, BMP have been developed for; closure and obliteration of roads, control of side-casting of earthen materials during road construction, stabilization of road prisms and spoil disposal areas, and control of locatable minerals mining activities. The most recent and perhaps most notable effort, has been the development of a Cumulative Watershed Effects management practice. The Forest Service's NPS water quality management program centers on and iterative process of practice identification, implementation, monitoring/evaluation and feedback correction/adjustment (Solomon 1988).

The methods and techniques to implement a BMP are identified on a case by case basis and are contingent upon on-site evaluation of the project area. Based on the physical and biological environment circumstances in the project area, custom-fitted water quality protection methods and techniques of BMP application are identified. The practices are implemented and monitored against attainment of water quality objectives. Where objectives are met, no further action is warranted. Where objectives are not met, the project activity is stopped if needed, and corrective action is taken. Where the practice is found to be non-effective, the practice and/or method(s) of application are improved. Evaluations of the implemented BMP in a Northern California Watershed study on the Six Rivers National Forest found the practices to be very effective in controlling the occurrence of mass land failures and erosion processes (Knopp, 1986).

A standardized process for evaluating the effectiveness of all Forest Service BMP was developed in 1988. It is currently being refined through field application and testing. When finalized, the process will assist the State and the Forest Service in tracking the progress of water quality protection and improvement on National Forest lands.

The Forest Service has been designated the water quality management agency for National Forest lands, but the State has not abdicated its CWA responsibilities. Regional Water Quality Control Boards review and provide input to Forest Plans and review proposals for Forest Service projects. On a selective basis, the Regional Boards review project Environmental Assessment reports and Environmental Impact Statements that describe the BMP to be used in controlling non point source water pollution. Regional Boards also periodically inspect project site location to observe BMP implementation. Annual meetings are held between the State Board and the Forest Service to coordinate the non point source pollution control program, BMP implementation, development or improvement, and monitoring results. These various reviews provide the State opportunity to give guidance and to quality control the Forest Service water quality management program.

## OPPORTUNITIES

### Program Development

Fundamental to controlling nonpoint source pollution is the establishment of workable programs. Programs must be able to be implemented by a cross-section of nonpoint source dischargers with varying organizational compositions and capabilities. Hence, multiple kinds of programs and types of practices may coexist at the same time in a given state's NPS control plan. The Federal Clean Water Act nonpoint source planning and program development provisions enables the development of such programs. Nonpoint source dischargers have the opportunity to be pro-active in the evolution of the State's plans, programs and practices that meet Clean Water Act mandates and regulatory authority requirements and are feasible to implement. As a result of the 1987 amendments to the CWA, planning and program development has been centered in Section 319. This Section affords the opportunity for innovative formulation of control strategies and implementation methodologies. For example, the Act

does not identify the processes to be applied to control NPS pollution nor the program to be implemented. It does not specify the categories of NPS pollution that must be controlled nor which water bodies are to be cleaned up. Finally and perhaps most significantly, it does not mandate the BMP that must be applied for prevention or elimination of NPS. The Act directs that all of these must be identified and developed through the state nonpoint source management program development.

The Practices

The latitude given by the CWA to identify BMP as part of the program and process development affords yet another opportunity for innovation. The EPA has defined BMP as follows (EPA 1987):

> "Best Management Practices (BMPs) are methods, measures or practices to prevent or reduce water pollution, including but not limited to, structural and non-structural controls, operation and maintenance procedures, other requirements and scheduling and distribution of activities. Usually BMPs are applied as a system of practices rather than as a single practice. BMPs are selected on the basis of site specific conditions that reflect natural background conditions and political, social, economic, and technical feasibility."

It is evident from this definition that the composition of a BMP is constrained primarily by organizational limitations. They can be curative or preventative, improving already deteriorated water or controlling new NPS discharges. They can be measures, methods or techniques which are structural or non-structural, spatially or temporally distributive, or a function of operation and maintenance. They are to take into account implementation feasibility and background conditions.

The State Program

In responding to the CWA Section 319 requirements, the State Water Resources Control Board developed, and on November 15, 1988, approved, a Nonpoint Source Problem Assessment and Nonpoint Source Management Plan for California. In its documents the State formalized the role of BMP and established the merits of BMP as the mechanisms that are to be implemented to control and prevent NPS pollution (State of California 1988). In addition to reaffirming BMP as NPS controls, the State program has recognized three approaches to implementing BMP; voluntary, regulatory - based on encouragement, and regulatory - based on imposition of discharge requirements (permits). The trend is toward the recognition of varying institutional frameworks in Federal, State, and local agencies and that each has its own institutional structure, authorities, and capabilities to respond to NPS abatement and control.

## CONCLUSION - RECOMMENDATIONS

Even though Section 319 of the CWA stipulates that the Governor (state) is responsible for program planning and development activities; it also stipulates

public participation and inter-governmental coordination will be an integral part of the State effort. Hence, the door is open for parties to assume an active rather than passive or reactive role in structuring programs, process and practices that will establish state NPS compliance mandates. The opportunity is afforded to develop NPS controls that are compatible with personal and/or organizational capabilities; practices that are technically and economically feasible for their institutional circumstances to implement. Viable programs that meet regulatory agency requirements and institutional capabilities can be developed that aggressively resolve NPS challenges and meet discharger NPS obligations.

It is recommended to the Western States Water Council that the participating states take advantage of the opportunity afforded by Section 319 of the CWA to develop their own unique NPS control programs. Each should consider pursuing the effort in a manner similar to that employed by the State of California which:

* Actively solicits and encourages the participation of NPS dischargers in the development of the NPS program and process.
* Recognizes institutional constraints to program development and therefore recognizes the necessity of multiple program and process coexistence within a state plan.
* Offers and supports alternative approaches to NPS control program implementation such as voluntary, regulatory and/or negotiated and agreed to mixes of both voluntary and regulatory approaches.
* Encourages generating formal agreements with NPS dischargers that;
    - establishes the water quality management responsibilities of the discharger
    - defines NPS compliance obligations of the discharger as being the implementation and quality control of their own practices and procedures
    - waives substantive and procedural requirements of state statute in lieu of individual program implementation as incentives for NPS discharger participation and performance
* Takes the burden of NPS regulation and enforcement off the state and places the burden on the discharger.

It is also recommended that potential NPS dischargers seize the opportunity to develop personalized NPS control programs/practices and assume a self regulatory posture. Dischargers should closely evaluate involvement in the state NPS program development and planning activities as a viable means of meeting their NPS compliance obligations. NPS dischargers must recognize however, that to gain authority as a designated water quality management agency, they must be ready to demonstrate through performance, that the goals and objectives of the CWA and State are being met.

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# 208 Certification-The Endless Journey

Gil Murray, Vice President
Timber Association of California

Since 1978, the state of California has been working relentlessly to have its Forest Practice Rules certified as best management practices under section 208 of the Clean Water Act.

Several state agencies and the forest products industry have devoted years of effort toward developing the most comprehensive, complex and costly set of rules anywhere in the nation. Yet, California has never been certified by E.P.A. Two questions that naturally arise from this situation are: why can't California win certification? And, when will we be certified in the future?

To answer these questions we must look at the political nature of the state, and development of the rules to date and the direction that the entire process seems to be headed.

Hopefully this will give us a better understanding of how technical issues developed in the field relate to the overall objectives of the 208 program.

Here in California you cannot separate technical issues from political concerns because the final result of any technical debate will be tempered with political influence that weighs heavily on everything we do. So, let me briefly describe for you the political situation in California.

California, as you know, is the most populous state in the nation. We are also at a state of extremes in terms of population. You are here in Orange County, the most densely populated area in the state and politically the most influential. Compare that with where I come from in Plumas County which is an area roughly the size of Orange County with only 18,000 people and not a single stoplight in the county. Our representation in Sacramento is very small to say the least. California also enjoys the widest variety of political views of any state in the nation. On the one hand are the traditional conservatives such as the Timber Industry, the Range Industry, and Agriculture who believe in private property and very little government involvement. On the other hand there are groups in the bay area and Los Angeles who believe in lots of government control and no private property rights. The political representation of the timber industry is composed of only a handful of legislators while most of the political power is represented by legislators from southern California and the bay area, who know very little about our industry.

We are a state of affluent and intelligent people who are very capable of pursuing their political agendas using any means that is available, be it the courts, the legislature, or the

administration. At times our state's legislature has been very ineffective in developing policy, so, the people have taken to ballot initiative process to solve major policy issues in the state. We in California are a very litigate society. We sue each other all the time and a lot of what goes on here is done through the courts. If you look at the history of the Forest Practices Act you will see that a lot of the policy changes that have come about have been the result of legislation and legal action through the courts.

Against that backdrop of the political situation, let me briefly describe the development of forest practices rules including BMPs for water quality. The current Forest Practices Act began in 1971 when the courts declared the Forest Practices Act of 1945 to be unconstitutional. Under the old act, the industry was basically self-regulated. We had a Board of Forestry that was made up of members of the industry. However, all that changed by 1973, the Board is now comprised mostly of public members (5) while industry now has only 3 representatives on the Board.

So we had a new Forest Practices Act and at that time our BMPs were very simple. We identified the streams, or what we thought were the streams, on a map that included the blue lines on a USGS quad map. It turns out that the blue lines were nothing more than aesthetically pleasing lines drawn on the map to contrast with the green back ground. They did not necessarily bear any resemblance with reality so they may or may not have been a major stream. When section 208 of the Clean Water Act was first passed, California undertook a major re-evaluation of the forest practices rules from a BMP standpoint and over the years we developed the current forest practices rules which took affect in 1982. Except for a few minor changes, those same rules are still in force today.

We have come along in developing the rules over the last twelve years. We refined the identification of our streams, by breaking them into three classes of watercourse, we developed protection zones, and within those zones we developed standards of protection or mitigation. We improved the road construction standards and erosion control facilities placement.

Industry has always participated in the development of the rules and we believe a lot of progress has been made. However in the certification process for 208 we ran into a few problems but they weren't technical in nature. That's the strong point I want to make here today; you have to consider the political realities when talking about technical issues. No matter how good your technical answers are, if they don't pass the political review they won't stand up and they won't be what's finally adopted. Timber harvesting is very political in this state and those groups who do not want to harvest or want to limit harvesting are very good at using technical details for stopping something that is really politically motivated and BMPs are no exception.

We have developed a set of BMPs that are very workable and very reasonable and yet we were not able to get them certified. So we had the 208 review team that you heard the previous speakers talk about. The resulting 208 report said that basically the rules work but there were a few things we could do to fine tune the rules and that the Board of Forestry should undertake those changes. The Board of Forestry and the State Water Quality Control Board signed an agreement that said they would review the changes recommended by the 208 report.

Industry was a part of the review team; we encouraged the signing of the agreement and we still support that agreement today. But just because we agree with the principles of the agreement and what is trying to be achieved, we in no way agree with all of the technical changes suggested in the report. Part of the problem for industry is, given the political scenario in California, we are on our guard that a technical issue will not be turned into a political issue to achieve someone's political goal. For that reason, industry looks with a jaundice eye at all the technical proposals that come up for discussion. We not only have to ask is this feasible, can we do it, is it cost effective and will it achieve what it's intended to do on the ground, but we have to look beyond that and say how will someone use this to obtain their political goal. It may sound a little callus but that, in fact, is what we must do.

Let me go through some of the technical issues that we're dealing with now in this latest revision of the rules.

The first one that came up was which management activities would be subject to regulation and would be included as part of the BMPs. Under the 1982 rules, we had expanded the classification of the streams and instituted larger protection zones around the stream courses. What we are doing now, and the Board has just passed rules to do this, is expanded the time frame and the activities of BMPs for water quality. Under the forest practices rules a Timber Harvest Plan goes for 3 years and there may be two one-year extensions for a total of 5 years. With the old rules, that is when the BMPs stopped. We have now expanded the rules to cover two more activities that were not subject to regulation previously and we extended the time frames involved. The rules now cover site preparation work done after the completion of timber operations and maintenance of erosion controls. The Board rules now require that there be one year and in some cases three years of additional maintenance of erosion controls. If you were to have a Timber Harvest Plan that ran for three years and you had two one-year extensions and then the Department of Forestry was to impose the maximum three-year maintenance requirement, you would be maintaining the water bars and other erosion control facilities for a total of eight years. That is an extremely long time to be maintaining water bars and other facilities.

Another area that we have had some discussions about (this will demonstrate how the technical and political issues merge) is to what standards will the quality of water be judged?

Mr. Lee and I had some discussions before the Board of Forestry on just what those standards were to be. Everybody wants clean water, that's agreeable, but how clean does it have to be? The state has certain language they have used about the amount of material that can put into the stream but industry's concern is that language could be construed to be zero discharge. If the standard is to be zero discharge then we will not be able to operate, it would be impracticable. While Mr. Lee has a very valid, technical reason for wanting the language he did, but I had to question it from the political aspect that somebody could take this into court and say this is a zero discharge and therefore we would not be allowed to operate. I have been assured that the rule is not a zero discharge.

Right now the Board is considering the rules to expand the protection zones around streams and lakes and the activities within those zones. That will be an ongoing debate. How big should the zones be for protection and then once you have established those zones, what, if any, activities will be allowed inside of those areas? I understand that in Washington one of the main motivating factors for the Timber, Fish and Wildlife Agreement was this very question. The industry looked at the losses they would suffer through the proposed stream management zones and they were motivated to sit down at the bargaining table. Here in California this is going to be a big issue. It is a technical issue, but it is also a political issue in that you start talking about a large amount of land, a lot of dollars and a lot of productive potential. If industry is going to be asked to give those lands up, then the question is how much will they be willing to give up before they are forced to do something else.

Another technical aspect that is being debated right now is beneficial uses of water. Just what are they and how will they be protected. The proposed rules would expand or as some people would say clarify the beneficial use for wildlife and wildlife habitat. That beneficial use has been in the rules, but has not been as clearly defined and in fact some of the new rules are going to have to address more wildlife habitat. Another use is flood protection. The basin plans that the Regional Water Quality Control Boards have, do not include flood protection as one of the beneficial uses but the Forest Practices Rules are going to be expanded to include flood protection in some instances.

A big issue that everyone is aware of is cumulative impacts. This is a wonderful buzz word for attorneys, in that it is such an open-ended statement it's easy to prove to a court that someone has been deficient in addressing cumulative impacts. The problem is how do

we come up with a legitimate process for evaluating cumulative impacts and yet put sideboards on the system so that industry can expect to be able to do an adequate job and not be challenged in court every time they have neglected some minute detail or they haven't looked out into the future far enough or they did not consider something that may have happened back in the dark ages. That is an ongoing debate, and there are many facets to it. One of the major difficulties is mixed ownerships in a watershed, where you have both private and federal lands or private and state lands. How do those different ownerships address cumulative impacts and once they are addressed, how do they deal with timing of activities, i.e. harvesting schedules. The Forest Service in California is very much interested in this issue. Industry is interested in it but we have some major concerns such as proprietary information. Industry must also avoid anti-trust violations such as restrain of trade. If two private owners were to start exchanging harvesting schedules or volumes to be removed in a given area, we are afraid that the federal government would take a very dim view of these types of activity. If you look at the draft regulations on cumulative impacts in the Forest Practice Rules they are one of the most comprehensive if not the most comprehensive systems developed anywhere in the U.S.

That is a brief overview of the technical issues we are faced with here in California and I hope I have given you some sense that when discussing technical issues you should keep an eye on the political winds because ultimately that is what is going to influence the final outcome.

So where do we go from here? Once all of these rules are implemented and in place. Will we be certified under 208? I really don't know and quite frankly I really don't think it matters. The certification is a political issue that the federal government and EPA may be concerned about. Regardless, the intent of the Clean Water Act will be fulfilled here in California, whether or not we have certification. Certainly the activities we're undertaking now address the concerns of section 319. The Board of Forestry and the State Water Quality Control Board are committed to fulfilling their agreement. Industry is going to continue to work with them to fulfill the agreement, in fact, we encourage them to do so. Whether EPA blesses it or not is really a political decision and hopefully it will not have an impact on the technical aspects of the BMP process, which we believe are technically sound.

Once again I would like to thank the program committee for inviting me here today and letting me having this opportunity to talk to you. It is always interesting to come to southern California. It is a kind of reality check because this is a political strongpoint in California and sometimes we lose sight of that fact by not being here very often.

# Friday Morning, July 28, 1989


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| **SESSION IX:** | **NPS POLLUTION CONTROL – RESOURCES EXTRACTION & LAND DISPOSAL**<br>Session Chair: Lewis Dodgion, NV | |
| 10:00 a.m. | **Mercury in Sediment, Water, and Fishes in the Carson River Drainage and the Stillwater Wildlife Area**<br>James J. Cooper, Aquatic Biologist<br>NV Division of Environmental Protection | IX-A |
| 10:15 a.m. | **Alaska Resources Extraction NPS Pollution Control Issues**<br>Jerry Brossia, Regional Manager<br>AK Division of Land & Water Management, Fairbanks, AK | IX-B |
| 10:30 a.m. | **Contamination of Ground Water from Underground Wastewater Disposal Systems, Upper Mojave River Basin, CA**<br>Ken Carter, Senior WRC Engineer<br>CA Regional Water Quality Control Board, Lahontan Region,<br>Amjad M.J. Umari, Project Director,<br>U.S. Geological Survey, San Diego | IX-C |
| 10:45 a.m. | **Wellhead Protection Program – A Reasonably Implementable and Cost-Effective NPS Pollution Management Tool**<br>Brad L. Cross, Chief, Wellhead Protection Program, Ground Water Conservation Section<br>TX Water Commission | IX-D |
| 11:00 a.m. | **NPS Pollution Aspects of the U.S. Bureau of Land Management's Mineral Resources Program**<br>Robert Anderson, Deputy State Director for Mineral Resources, U.S. Bureau of Land Management, Sacramento, CA | IX-E |
| 11:15 p.m. | **ROUNDTABLE DISCUSSION AND QUESTIONS** | IX-F |
| 12:00 p.m. | **No Host Deli Buffet LUNCH** - Salon C<br>Presiding: **Professor Charles DuMars**<br>Speaker: **Michael C. Kavanaugh,**<br>Chairman, Water Science and Technology Board of the National Research Council<br>Topic: **Overview of Water Science and Technology Board's Programs Related to NPS Pollution Control** | IX-G |

# Total Mercury In Sediment, Water, and Fishes in the Carson River Drainage, West-Central Nevada

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## Introduction

The use of mercury compounds by man date back to Roman times. Mercury has been used for many years for industrial, agricultural and medicinal purposes (D'Itri 1972). Recent discoveries have demonstrated the undesirable effects mercury may have on the aquatic environment. In the 1950's and 1960's Japanese and Swedish researchers found that fish accumulated a higher concentration of mercury than their environment and the consequences of human exposure to these concentrations were unveiled (Irukayama 1966; Borg et al. 1966). Marine and freshwater sport and commercial fisheries have been contaminated within the United States rendering fish unsafe for consumption.

Mercury was introduced into the Carson River of northern Nevada during the mining of gold and silver in the Comstock Lode, near Virginia City. After railroad lines connected Virginia City with 12 millsites along the Carson River from Empire to Dayton in 1869, nearly all the processing of Comstock ore was carried out at these sites because of the availability of water power (Smith 1943).

Large amounts of liquid mercury were imported and used in the amalgamation of the precious metals known as the "Washoe Process" in the ratio of 1:10, quicksilver:ore (Smith 1943). The average loss of quicksilver was 0.68 kg for each ton of ore milled. During the 30 year peak of the Comstock (1865 - 1895) it is estimated that 200,000 flasks of mercury or $6.75 \times 10^6$ kg (7,500 tons) were lost in the milling process (Bailey & Phoenix 1944); about 0.5% of that amount was later recovered.

In 1973 the U.S. Geological Survey reported that background mercury levels in the upper 7 cm of sediment upstream from pre 1900 milling sites on the Carson River were less than 0.1 mg/kg (Van Denburgh 1973). Downstream concentrations were measured up to 200 times background (20 ug/kg). The highest concentrations were found just upstream from Lahontan Reservoir. Concurrent with this study was one undertaken by the College of Agriculture Extension Service, University of Nevada, Reno, which focused on the accumulation of mercury by crop plants and domestic livestock raised in the area.

Richins (1973) was the first to document that aquatic organisms in the Carson River, including Lahontan Reservoir, contained levels of mercury in the muscle tissue which exceeded concentrations considered safe by the U.S. Food and Drug Administration (FDA). The U.S. Environmental Protection Agency (EPA) and Nevada Division of Environmental Protection (NDEP) had also collected data suggesting bioaccumulation of mercury within the system.

In a study conducted in 1981, 68% of the fish collected from Lahontan Reservoir exceeded the 1.0 ug/g FDA action level (Cooper 1983).

The NDEP initiated this study in May 1983, in response to concerns over impacts of mining/dredging in the Carson River and over public health. The final report was completed in 1985. The objectives of the study were as follows:

1. Definition of the areal extent and relative magnitude of mercury contamination within the drainage basin;

2. Identification of major sources, sinks and movement of mercury through the system;

3. Development of a data base from which to judge future conditions;

4. Development of a data base to assess the potential hazard to human health; and

5. Determine if a restoration plan is necessary and/or feasible.

Conclusions:

Surficial sediment mercury concentrations were below detection (<0.25 ug/g) between the California state line and Cradlebaugh Bridge. Levels increased slightly from New Empire to Dayton. Maximum surficial sediment concentrations occurred between Dayton and the mouth of Lahontan Reservoir, within Lahontan Reservoir, and at indiscriminate locations in Lahontan Valley. Mercury that entered the river at the Brunswick Canyon mills has apparently been carried and deposited in areas downstream that have less velocity.

Sediment contamination is well distributed throughout the lower Carson River Basin and within the canal network of Newlands Irrigation Project, Indian Lakes Complex, and Carson Sink. It appears that a significant quantity of mercury was transported past Lahontan Reservoir before damming in 1915.

High mercury concentrations were found in a river bank stratum located above and lateral to the bottom of the river channel downstream of Dayton. We speculate that this stratum is a remnant of active milling activity on the river. This layer is likely a source of mercury during the scouring spring flows.

Maximum sediment mercury concentrations and loading occur in the reach of river between Dayton and Lahontan Reservoir. Reservoir sediments annually receive a mercury-rich coating that is dependent on the magnitude of the spring runoff.

Lahontan Reservoir is a sedimentation basin and retained over 95% of its total mercury load from May 1983 through April 1984.

There is a close relationship between the abiotic distribution and the biotic accumulation in fish. Fish captured at Harvey's Ranch upstream from pre - 1900 milling sites showed no evidence of mercury contamination. Total mercury levels showed a slight increase in fish captured from Mexican Dam, 5th Street Bridge, Santiago Ruins, and Dayton. However, no fish captured from these sites had concentrations in excess of 1.0 ug/g. Following the abiotic trend, mercury bioaccumulation by fish significantly increased by Fort Churchill gage. Downstream from Dayton 45% of the fish sampled were over 1.0 ug/g.

Bioaccumulation was significant in Lahontan Reservoir, the most important fishery on the Carson River drainage. The high productivity of the reservoir and large size of some of the gamefish it supports contributes to this problem. The mean total mercury concentration in five gamefish and one commercial species were over 1.0 ug/g.

Mercury concentration was found to be dependent on the degree of habitat contamination, fish size, and fish species. However, this was highly variable from one station to another. In general, the larger the fish, regardless of the species, the greater was the mercury concentration. Large gamefish and carp had the highest mercury levels with small gamefish and non-gamefish the lowest. The degree of trophic level magnification varied between stations.

Recommendations

Carson River sediments upstream from Dayton should not be disturbed in any way. The load of mercury passing Dayton is relatively low and the reach is not a downstream source of mercury. Disturbance of sediments in this reach would probably result in mercury resuspension, transport, and recontamination of relatively clean surficial material.

Sediment within the reach between Dayton and Lahontan Reservoir have a high degree of mercury contamination and represent the major source of mercury to the impoundment. Further sampling will be required to better determine the nature and location of mercury sources in this reach. Consideration should then be given to the feasibility of mitigation.

Preliminary findings suggest that due to the widespread distribution of mercury below Lahontan Reservoir, mitigation may not be possible. However, further data should be collected in both the canals and regulatory reservoirs of the Newlands Irrigation Project and Stillwater-Indian Lakes complex to substantiate these preliminary findings.

Many gamefish in Lahontan Reservoir exceed the 1.0 ug/g FDA action level for total mercury. The human health risk associated with consumption of these fish should be evaluated by the Nevada Division of Health and a health advisory considered. (Today the Nevada Division of Health has a fish consumption advisory for the lower Carson River and Lahontan Reservoir). The continued commercial sale of carp should be evaluated since over 70% of this species captured from the reservoir exceeded the FDA action level.

The study described a significant relationship between size and mercury level in many of the Lahontan Reservoir gamefish; the larger the fish the higher the concentration. This information suggests that future management of the fishery should consider the selection of a mid-trophic level species with a relatively short life span that would not attain a large size. White bass appear to meet this objective; walleye and largemouth bass do not.

Fish from Lahontan Reservoir should annually be collected and analyzed for mercury. White bass and carp are recommended as the indicator species. Sample size should be large enough to make adequate comparisons to past years, roughly 10-15 specimens per species. Size range within species should represent all age classes and be adequate to predict mercury concentration from fish size.

For futher information on this study see Cooper et al. (1985). The report can be ordered through the Nevada Division of Environmental Protection, Carson City, Nevada.

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# CONTAMINATION OF GROUND WATER FROM UNDERGROUND WASTEWATER DISPOSAL SYSTEMS, UPPER MOJAVE RIVER BASIN, CA

BY

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## SUMMARY OF FINDINGS

The Lahontan Regional Water Quality Control Board is the Regulatory Agency responsible for water quality protection in the upper Mojave River Basin located about 130 kilometers North East of Los Angeles. Due to the explosive growth and development in the area the Regional Board became concerned over the potential for ground water contamination resulting from the increased quantity of domestic and commercial wastewater being disposed to septic tank/seepage pit systems. The Regional Board implemented development density criteria for developments utilizing these systems and initiated this cooperative study with the U.S. Geological Survey in an effort to determine appropriate future regulatory approaches.

The objectives of this study are to investigate the movement of the wastewater through the unsaturated zone and changes in concentration of fecal coliforms and nitrogen in the wastewater as it moves through the unsaturated zone to the water table. The study consists of investigating the transport of septic-tank wastewater through the unsaturated zone at eight sites (private residences) chosen to represent a range in geohydrologic conditions, number of years the seepage pit has been in operation, and loading (single vs multiple-family dwelling).

Moisture-content profiles from neutron logs were collected periodically at sites with recently installed seepage pits. The profiles were used to define the progress of the wetting front with time and to estimate rates of vertical movement of wastewater. Vertical-movement rates ranged from 0.02 meters per day in fine-grained soils to 0.17 meters per day in sandy soils.

Soil cores from all depths and septic-tank water were analyzed for fecal coliforms. These analyses showed fecal coliform counts to drop from 105 colony-forming units per 100 milliliters in septic tanks to nondetectable levels in the soil cores within a few feet from the seepage pits, indicating complete removal by the unsaturated zone.

Analyses of soil-core and suction-cup-lysimeter samples indicate that, starting from a few feet below the bottom of the seepage pits and down, virtually all the nitrogen is in the form of nitrate. Initial results indicate that nitrate-nitrogen concentrations decrease from as high as 63 mg/L (milligrams per liter) within the first 30 meters below the seepage pit bottoms to 3 mg/L near the water table.

The observed decrease in nitrate-nitrogen concentrations near the water table may be the result of anaerobic microbial reduction of nitrate-nitrogen. Further study is in progress to substantiate these preliminary findings.

This summary of findings along with the attached excerpts from the project proposal serve as an interim project report for the purpose of this workshop.

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# TRANSPORT OF CONTAMINANTS FROM UNDERGROUND WASTEWATER DISPOSAL SYSTEMS, UPPER MOJAVE RIVER BASIN, CALIFORNIA

## PROBLEM

The growing number of people moving into suburbs and rural areas has produced a dramatic increase in the quantity of untreated sewage discharged to underground septic systems. Sewage from septic systems is the largest potential source of ground-water contamination in the United States. The sewage contains contaminants, such as nitrogen, bacteria, and a number of organic chemicals, that may degrade the quality of ground water and render it unsuitable for use. Current knowledge of the transport of contaminants through the unsaturated zone does not allow prudent regulation of septic systems and protection of ground-water resources.

For example, in the upper Mojave River basin of California (fig. 1), wastewater from domestic and industrial septic tanks drain into seepage pits that in turn allow the wastewater to readily percolate into the unsaturated zone. Because the area is on the fringe of the Los Angeles megalopolis, there currently is a population and industrial boom that is likely to continue for many years. Contamination of ground water resulting from the increasing quantity of wastewater discharge into the unsaturated zone is a major concern, because the underlying alluvial aquifer is the source of public water supply and alternate sources of water are not available.

## STUDY OBJECTIVES

Objectives of this study in the upper Mojave River basin are:

1. To investigate the role of the unsaturated zone in changing concentration and speciation of nitrogen from septic-tank wastewater.

2. To investigate the role of the unsaturated zone in the attenuation of dissolved-organic contaminants from septic-tank wastewater.
3. To investigate the role of the unsaturated zone in the transport of fecal bacteria from septic-tank wastewater.
4. To determine the potential for ground-water contamination from septic-tank wastewater.

## BENEFITS OF STUDY

The problem of ground-water contamination from septic-tank systems has been documented in many areas: Long Island, New York (Ku and Sulam, 1976); Delaware (Miller, 1975); southern Florida (Pitt and others, 1975); Fresno, California (Schmidt, 1972); and Tucson, Arizona (Martin, 1980). However, in most of these previous studies the problem of quantifying the impact of contamination from septic-tank systems was complicated by other current or historical sources of contamination, such as agricultural practices and/or the presence of improperly constructed wells that allow the contamination to "short circuit" the unsaturated zone.

Unlike many of the previous study areas, wastewater from septic tanks is essentially the only current or historical source of ground-water contamination in most of the upper Mojave River area, and there are few existing wells that could "short circuit" the unsaturated zone. Therefore, the upper Mojave River area will provide an excellent opportunity to study the role of the unsaturated zone in the transport of contaminants from septic-tank systems.

This study will determine if contaminants from septic-tank systems have the potential to affect the future use of the water-supply aquifer in the upper Mojave River basin. The information will be used by the California Regional Water Quality Control Board to manage disposal practices. As such,

the questions addressed by this study are the same as those being considered by communities throughout the Nation. The recent trend toward decreased Federal funding for expensive installation of sewers and sewage-treatment plants makes it imperative that the answers to these questions be based on the technical evidence that a study such as this one can provide.

## DESCRIPTION OF STUDY AREA

The Mojave River basin is in the Mojave Desert region of southern California. The upper part of the basin (including the communities of Victorville, Adalanto, Apple Valley, and Hesperia) is proposed for study because it has experienced dramatic population growth during the past 5 years. During 1983-87, the population of the upper Mojave River basin doubled to about 140,000 people; the population is expected to again double by 1990. Most of the area is unsewered (fig. 2) and about 100,000 people currently are using underground wastewater disposal systems. The subsurface discharge of untreated liquid sewage from the 25,000 underground wastewater disposal systems currently in use is estimated at about 12 million gallons per day.

Because of impermeable caliche layers in the upper few feet of the soil in much of the area, the use of shallow leach fields to dissipate the liquid discharge from septic tanks is not possible. Instead, the liquids from septic tanks are discharged into deep seepage pits. The seepage pits are typically about 5 feet in diameter, about 30 feet deep, and lined with bricks or blocks with unmortared joints that allow rapid percolation of the wastewater into the unsaturated zone (fig. 3).

The sewage contains many contaminants that may impair ground-water quality. These contaminants include pathogens (bacteria and viruses), phosphorus, detergents, nitrogen, and a variety of organic compounds in

pharmaceuticals, disinfectants, deodorants, polishing agents, solvents, degreasers, cosmetics, paints, and pesticides. The quantity of contaminants reaching the water table is unknown.

The alluvial aquifer, which underlies much of the study area, is mainly comprised of unconsolidated sand and gravel deposits (fig. 4) (Hardt, 1971). The aquifer is as much as 1,000 feet thick and is tapped by both large-producing municipal wells and small-production wells for individual households. Depth to the water table in the study area generally ranges from about 50 to 400 feet below land surface (fig. 4). The aquifer receives most of its recharge from infiltration of streamflow during periods of storm runoff; little of the 5 inches of mean annual precipitation directly recharges the aquifer. The California Regional Water Quality Control Board estimates about 15 percent of the aquifer recharge is from the seepage pits.

## APPROACH

The objectives of this study will be met by intensively investigating the transport of septic-tank wastewater at nine sites chosen to represent a range in geohydrologic conditions and septic-tank densities in the upper Mojave River basin. The rate of wastewater movement, and the changes in concentration of selected contaminants with depth in the unsaturated zone, will be investigated at each site. Actual impact of the septic-tank wastewater on ground-water quality will be determined directly at one of the sites. Data collected at these nine sites can then be used in other areas of the upper Mojave River basin with similar geohydrologic conditions and septic-tank densities to estimate the impact of the septic-tank wastewater on ground-water quality.

## Methods of Data Collection

Drill-Site Selection--The nine sites selected for investigation will be divided into three groups of three sites. Groups will be chosen based on the length of time the seepage pits have been in operation. The first group will include seepage pits that are considered to be some of the original installations (greater than 10 years of operation), the second group will include seepage pits that have been in existence for about 5 years, and the third group will include seepage pits that are relatively new. Sites in each group will be chosen based on depth to ground water, geology, and seepage-pit density.

Although the amount of drilling and sampling will vary, some drilling will be done at all nine sites. At each site, an auger hole will be drilled as close as possible to the seepage pit. At three of the nine sites, neutron-access tubes will be installed adjacent to the seepage pit in order to measure changes in the moisture-content profile with time. At one site in the first group, where wastewater is likely to have reached the ground water, multi-depth monitor wells will be installed upgradient and downgradient of the seepage pit in order to determine the importance of dilution by vertical mixing in the saturated zone.

Collection of Drill-Core Samples--Core samples that are as nearly undisturbed as possible will be obtained; techniques will follow recommended guidelines (Scalf and others, 1981). Drilling will be done with 5-foot sections of hollow-stem auger; samples will be collected with an 18-inch drive-core sampler without removing the auger from the hole. Core samples will be collected continuously from land surface to a depth of 10 feet beneath the seepage pit and then at 5- to 10-foot intervals for the remainder of the unsaturated zone or to a depth of 150 feet (approximate maximum limit for a hollow-stem auger).

Core will be obtained in three sections of 6-inch hollow tubing. A sub-sample from each section will be analyzed for moisture content and grain size using standard soil-classification and analytical procedures (Morris and Johnson, 1967). A second sub-sample from the middle section will be submitted to a biological analysis. The remaining material from each section will be immediately sealed in glass jars, labeled, and frozen to protect against microbial activity.

Chemical and Biological Analyses of Core Samples--Samples for the analysis of dissolved nitrate, nitrite, chloride, and organic carbon and nitrogen will be extracted with deionized water from the frozen sub-samples. For each extraction, 20 grams of core material will be mixed with 100 milliliters of deionized water, shaken for 1 hour on a wrist-action shaker, and then centrifuged for 15 minutes (Klein and Bradford, 1979). About 10 milliliters of the extract will be used for field measurement of specific conductance, and the remainder will be shipped to the Survey's National Water Quality Laboratory for chemical analysis.

Selected nonextracted soil samples will also be sent to the Survey laboratory for determination of total ammonium, organic nitrogen, and total organic carbon. Several samples from selected sites will be analyzed for purgeable organic compounds.

The soil cores will be analyzed in the field laboratory for fecal coliform and fecal streptococcal bacteria. These bacteria will be eluted from the soil and their number determined by the membrane-filtration technique using specialized agar preparations described by Scheraga and others (1979).

Moisture Content--Moisture content will be determined in the field using methods described by Gardner (1965). Neutron-access tubes will be installed adjacent to the seepage pit at three of the sites so that moisture-content

profiles can be followed with time. Moisture-content measurements of the soil cores will be used to calibrate data from the neutron-access tubes.

Suction Lysimeters--The movement and quality of water in the unsaturated zone will be monitored in situ with suction lysimeters. Three to four suction lysimeters will be installed at various depths in the bore hole adjacent to the seepage pit at each site.

## Monitoring Wastewater Movement in the Unsaturated Zone

In order to establish the impact of septic-tank wastewater, it is important to determine how fast the wastewater is moving from the seepage pits to the water table. This is difficult to determine because the nature of flow in the unsaturated zone is complex. Several indirect methods, including moisture-content profiles, suction lysimeters, and unsaturated hydraulic-conductivity measurements, will be used to estimate the rate of wastewater movement.

Moisture-Content Profiles--Moisture-content profiles will be determined from field analyses of the core samples. The moisture content in the part of the unsaturated zone that is unaffected by wastewater should be low because of the arid climate. Therefore, an abrupt and major change in the moisture content will indicate the probable location and geometry of the wastewater plume. The rate of movement of this plume will be estimated by dividing the depth of the front by the length of time that the seepage pit has been in operation. At several sites, moisture-content profiles will be determined from cores collected about 25 feet from the seepage pit in order to estimate rate of lateral wastewater migration. Neutron-access tubes will be installed adjacent to three seepage pits for the purpose of monitoring changes in the water-content profiles.

Suction Lysimeters--Three to four suction lysimeters will be installed at various depths in the bore hole adjacent to seepage pits. This will allow periodic sampling to detect moisture in the unsaturated zone and to assess changes in pore-water chemistry. Very little, if any, water is expected from suction lysimeters in the unsaturated zone below the wetting front. Abrupt changes in the hydraulic (and chemical) response of the suction lysimeters can indicate the vertical rate of wastewater movement.

At one of the sites, suction lysimeters will be installed at depths of 1, 5, 10, and 20 feet beneath the seepage pit before the seepage pit is put into operation. Periodic sampling of the suction lysimeters will be used to determine the rate of wastewater movement and to monitor changes in nitrogen concentration, both with time and depth, immediately beneath the seepage pit.

Unsaturated Hydraulic Conductivity--The hydraulic conductivity of the unsaturated zone is equal to the Darcy velocity of the wastewater flow if the wastewater flow has become steady. The assumption that the wastewater flow is essentially steady is probably reasonable at depths of about 50 feet, especially at sites that have been in existence for many years. Several core samples will be tested for unsaturated hydraulic conductivity. The macroscopic downward velocity of the wastewater will be calculated by dividing the unsaturated hydraulic conductivity by the volumetric moisture content.

## Monitoring Changes in Wastewater Quality in the Unsaturated Zone

Constituents in septic-tank wastewater that will be monitored are nitrogen species, chloride, fecal bacteria, and chlorinated hydrocarbons.

Nitrogen--Septic-tank wastewater contains relatively high concentrations of nitrogen (40 to 80 milligrams per liter), mostly in the form of ammonium ($NH_4^+$) (Bouwer, 1978). Nitrogen also occurs in the form of ammonia ($NH_3$),

nitrate ($NO_3^-$), nitrite ($NO_2^-$), molecular nitrogen ($N_2$), nitrous oxide ($N_2O$), and organic nitrogen. These nitrogen species are interrelated by a complicated series of reactions that collectively comprise the nitrogen cycle (National Research Council, 1978). As wastewater moves through the unsaturated zone, both the concentration and chemical forms (speciation) of nitrogen change.

The total nitrogen load discharged through the pits will be determined by periodically analyzing samples of wastewater for concentrations of various nitrogen species. Changes that occur in the unsaturated zone will be documented by determining the concentration of each nitrogen species in soil and soil-water extracts from core samples collected adjacent to and beneath the seepage pits. In addition, water samples periodically collected from suction lysimeters will be analyzed for the complete nitrogen series. Moisture-content data obtained from the cores and the neutron-access tubes will be used to compute the total nitrogen load as a function of depth and time in the unsaturated zone. Because bacterial growth and nitrogen transformations require a source of organic carbon, concentrations of organic carbon will be determined for selected core and suction-lysimeter samples.

Chloride--Chloride is known to be present in septic-tank wastewater and is physically conservative and biologically unreactive, which makes it a useful tracer of the wastewater wetting front. Concentrations of chloride will be determined in all of the core extracts and in samples from suction lysimeters for which nitrogen is analyzed. Comparison of chloride to nitrogen profiles will document the effect of nitrogen attenuation in the unsaturated zone.

Fecal Bacteria--Sewage contains high numbers of fecal-coliform and fecal-steptococcal bacteria. Many studies have reported either complete absence or very low numbers of fecal bacteria in sewage water after it has

moved 5 to 10 feet through the unsaturated zone (Bouwer, 1978). The attenuation of fecal bacteria by the unsaturated zone will be determined by measuring the concentrations of fecal coliform and fecal strepotococcal bacteria in core samples collected from between the bottom of the seepage pits and the water table.

Chlorinated Hydrocarbons--Chlorinated hydrocarbon compounds that are commonly used in households as degreasers and solvents may contaminate underlying ground water. Their presence or absence will be determined by analysis of about 20 samples for purgeable organic priority pollutants. Samples will be taken from water in the seepage pits, from soil immediately below the seepage pits, and from water retrieved from suction lysimeters.

## Impact of Septic-Tank Wastewater on Ground-Water Quality

The impact of septic-tank wastewater on shallow ground-water quality will be documented at sites in which the unsaturated zone is relatively thin (between 50 and 100 feet) and the wastewater has reached the water table. At these sites drilling will continue, with a screened auger on the bottom, to 25 feet below the water table if possible. The screened auger will make it possible to collect point samples of the shallow ground water during drilling.

A permanent gas-drive point sampler will be installed about 5 feet below the water table in the auger hole to allow periodic sampling of the shallow ground water. Vibrating-wire strain-gage transducers will be placed above each of the point samplers to monitor piezometric pressure. Samples collected from the gas-drive point samplers will be analyzed for the complete nitrogen series, chloride, and fecal bacteria.

At one of the sites where wastewater has reached the water table, multi-depth monitor wells will be installed upgradient and downgradient of the site in order to determine the importance of dilution by mixing in the

saturated zone. Separate monitor wells will be constructed upgradient and downgradient of this site so as to sample 10, 50, and 100 feet below the water table. Samples from all of these wells will be analyzed for the complete nitrogen series, major cations and anions, purgeable organic compounds, and fecal bacteria.

## REPORTS

It is anticipated that the research will lead to one or more journal articles, which will serve as an important means of distributing the information to the scientific and regulatory communities. In addition, methods of investigation and complete results of the study will be described in a Water-Supply Paper.

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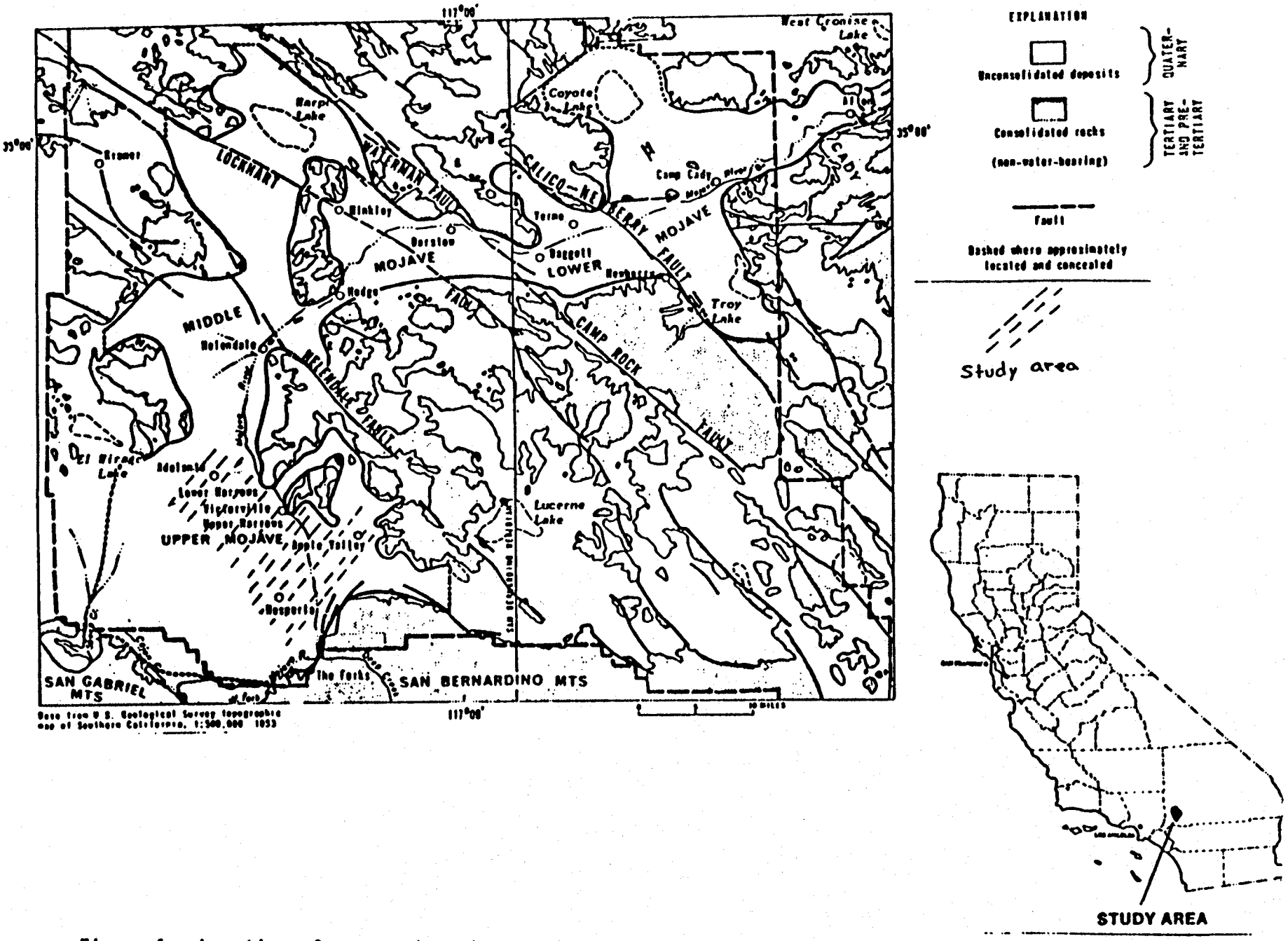


Figure 1.--Location of proposed study area in the upper Mojave River basin.

EXPLANATION

Approximate boundary of study area

Sewered areas

Unsewered areas

A——A' Line of Geohydrologic section

Scale 1 inch = 2.5 miles

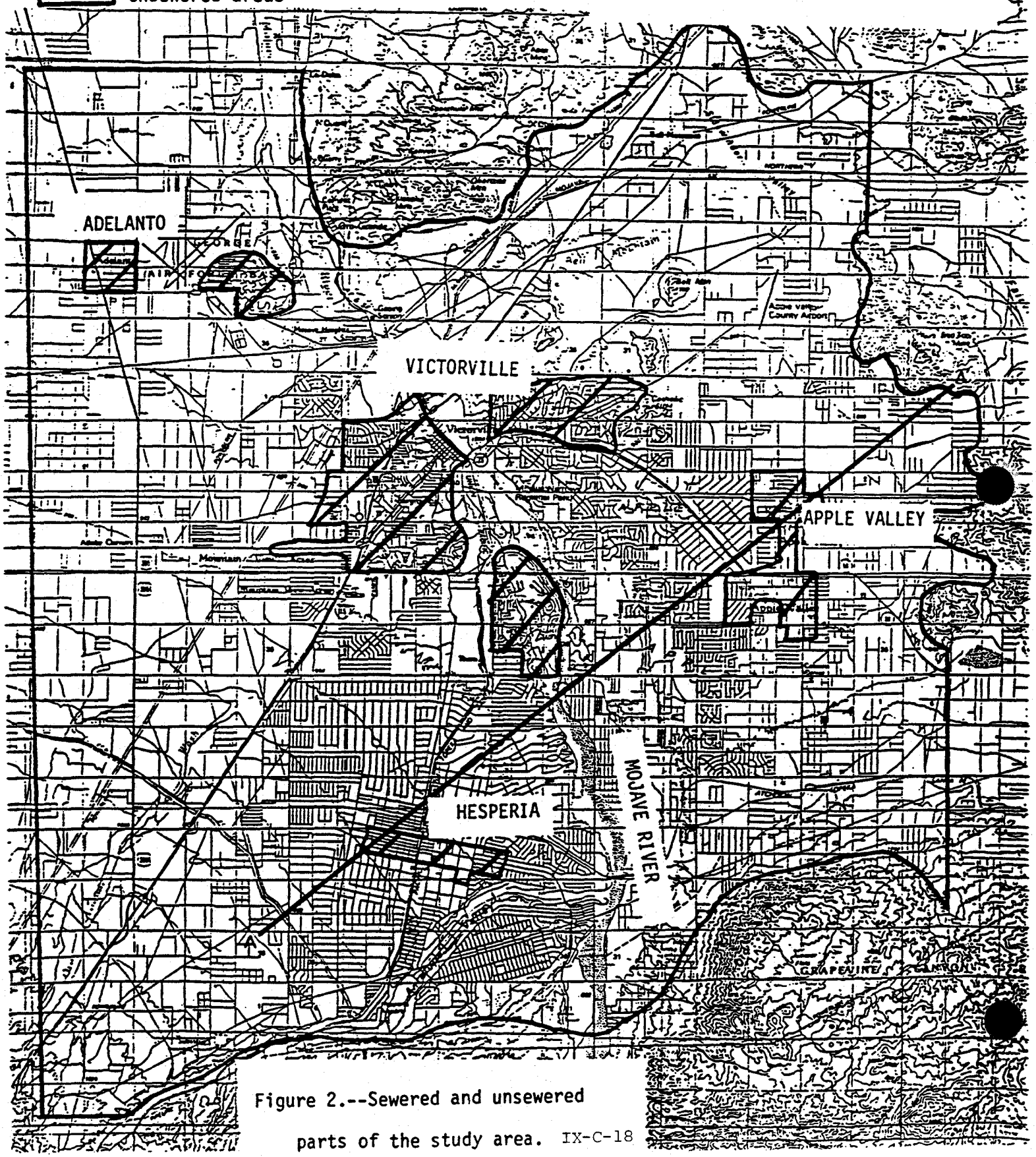


Figure 2.--Sewered and unsewered parts of the study area.

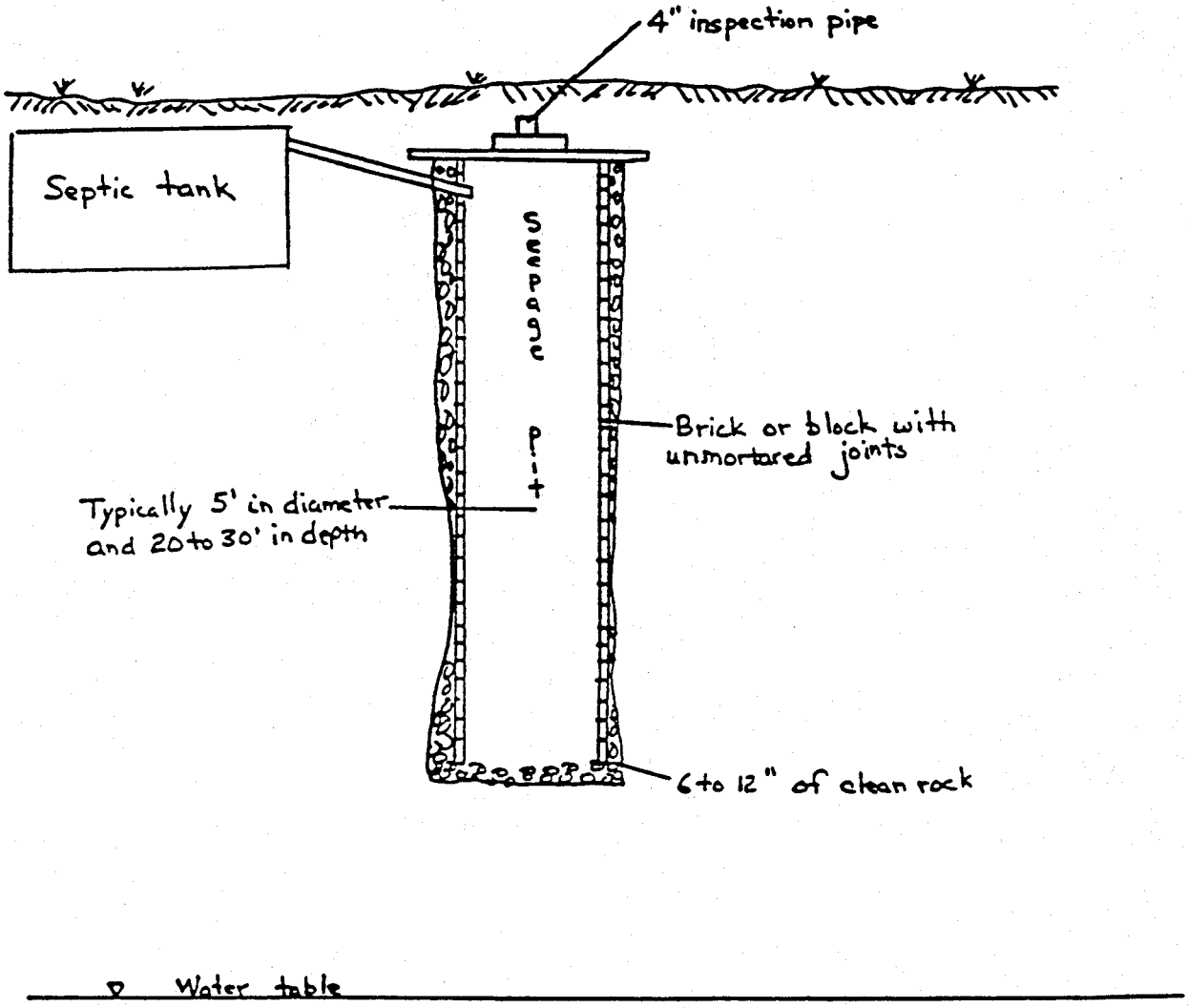


Figure 3.--Typical underground wastewater disposal system in the Upper Mojave River basin.

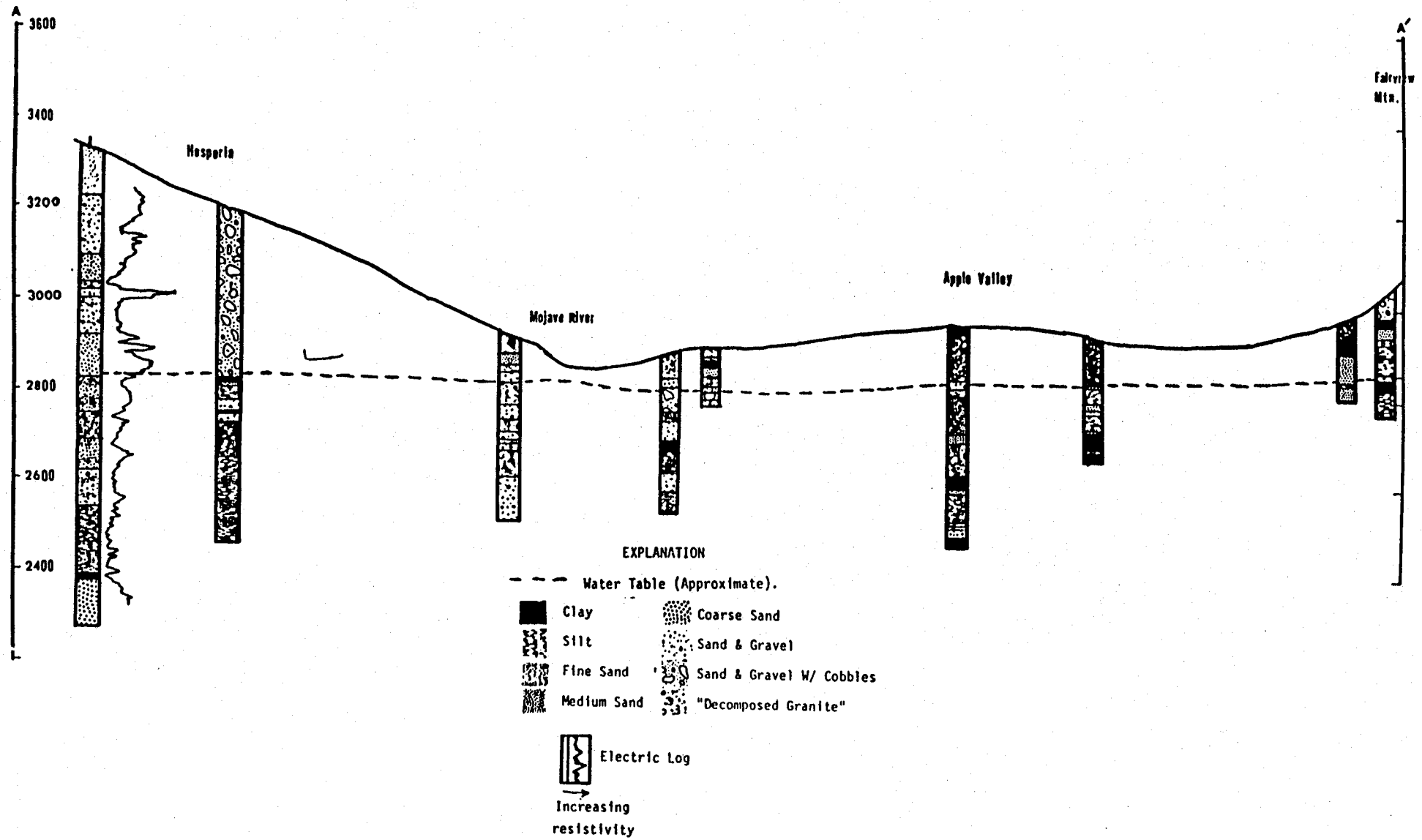


Figure 4.--Geohydrologic section of the study area.

# TEXAS' WELLHEAD PROTECTION PROGRAM

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## BACKGROUND

Ground water is an important resource in Texas. A total of seven major and seventeen minor aquifers have been delineated within Texas (Figures 1 and 2). The major and minor aquifers furnish about 57 percent of the total state water requirements. These aquifers crop out or underlie approximately 76 percent of the state's surface area of about 267,300 square miles.

The quality of ground water in the state is generally good; however, localized areas have been impacted by nonpoint sources (NPSs) of contamination or by noncompliant point source waste disposal activities. This has caused pockets of pollution immediately around the source, but no resulting aquifer-wide quality problems. The susceptibility of a facility site to ground water contamination depends in part on the hydrogeologic setting (Figure 3). If ground water does

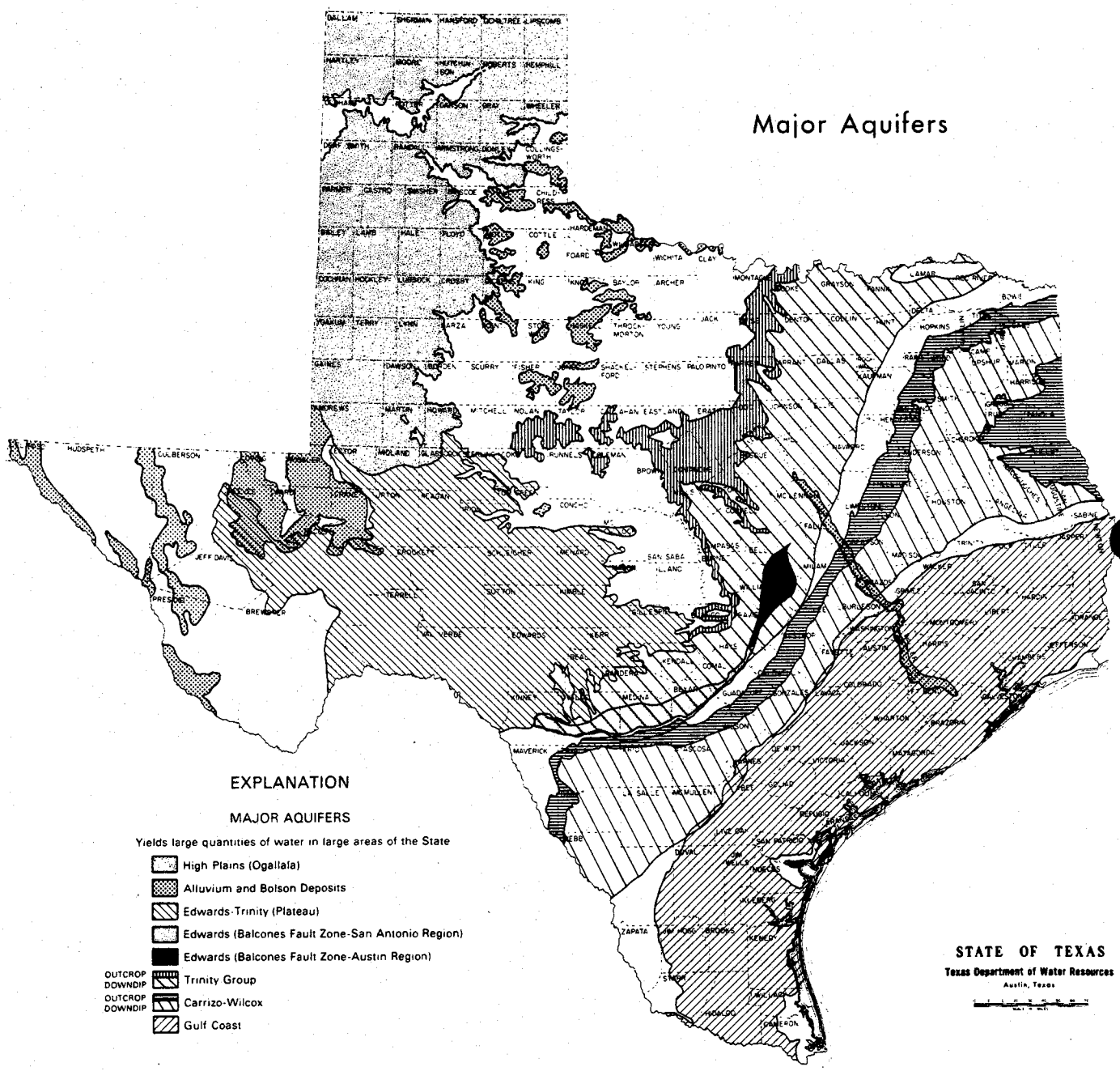
Major Aquifers
EXPLANATION
MAJOR AQUIFERS
Yields large quantities of water in large areas of the State
High Plains (Ogallala)
Alluvium and Bolson Deposits
Edwards-Trinity (Plateau)
Edwards (Balcones Fault Zone-San Antonio Region)
Edwards (Balcones Fault Zone-Austin Region)
OUTCROP
DOWNDIP
Trinity Group
OUTCROP
DOWNDIP
Carrizo-Wilcox
Gulf Coast
STATE OF TEXAS
Texas Department of Water Resources
Austin, Texas

Figure 1

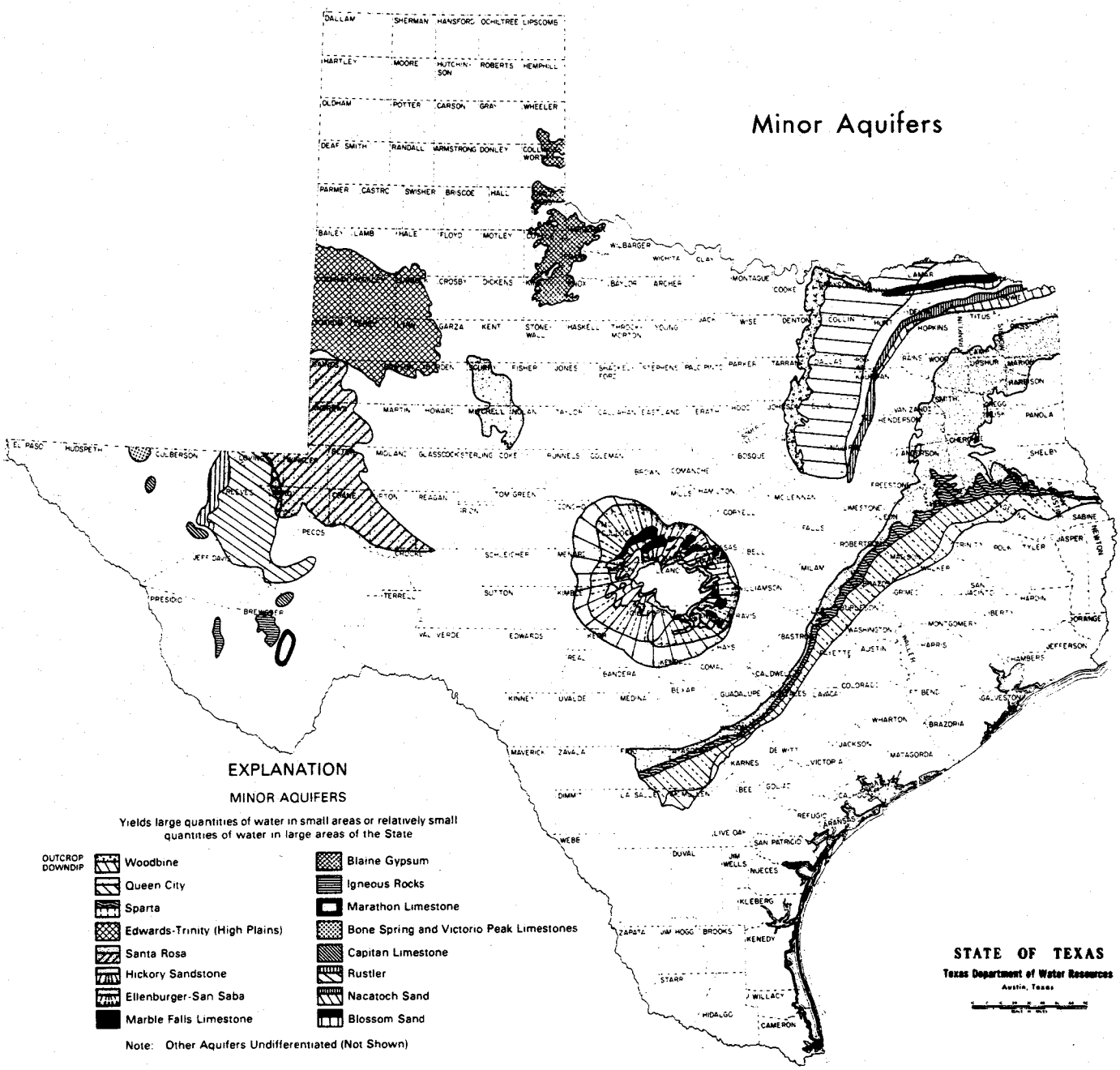
Minor Aquifers
EXPLANATION
MINOR AQUIFERS
Yields large quantities of water in small areas or relatively small quantities of water in large areas of the State
OUTCROP
DOWNDIP
Woodbine
Queen City
Sparta
Edwards-Trinity (High Plains)
Santa Rosa
Hickory Sandstone
Ellenburger-San Saba
Marble Falls Limestone
Blaine Gypsum
Igneous Rocks
Marathon Limestone
Bone Spring and Victorio Peak Limestones
Capitan Limestone
Rustler
Nacatoch Sand
Blossom Sand
Note: Other Aquifers Undifferentiated (Not Shown)
STATE OF TEXAS
Texas Department of Water Resources
Austin, Texas

Figure 2

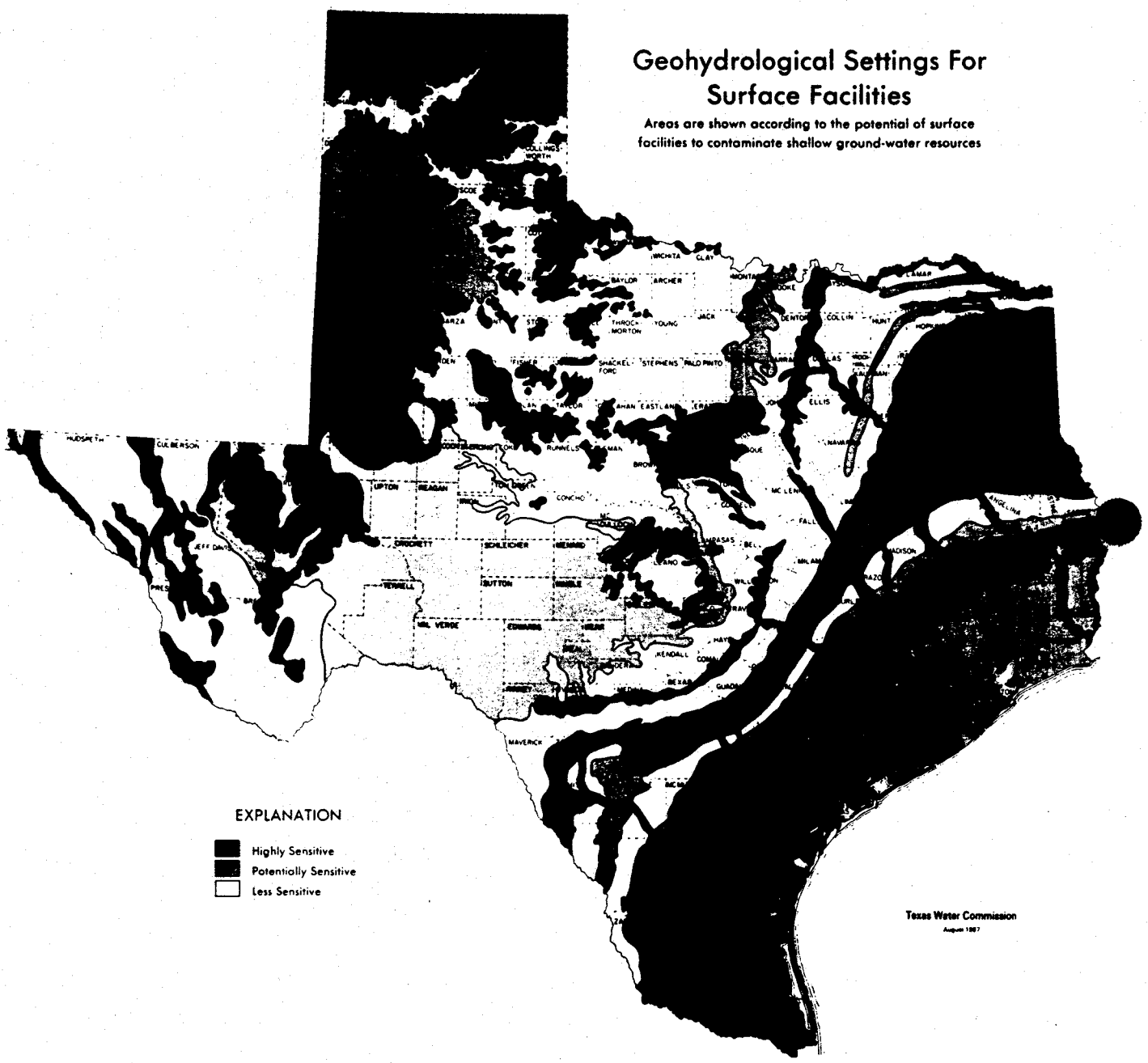
Geohydrological Settings For Surface Facilities
Areas are shown according to the potential of surface facilities to contaminate shallow ground-water resources
EXPLANATION
Highly Sensitive
Potentially Sensitive
Less Sensitive
Texas Water Commission

Figure 3

become contaminated, it is extremely difficult to clean up. Therefore, the state's regulatory philosophy is to prevent contamination from occurring in the first place.

At present, there are an estimated 6000 public ground water supply systems with approximately 14,700 public supply wells being utilized within the state. All potential sources of ground water pollution should be addressed in the immediate vicinity of these individual wells. Texas' wellhead protection strategy encourages the implementation of best management practices within specified areas surrounding these wells to prevent contamination of these public water supplies by potential nonpoint and point sources.

## INTRODUCTION

Designation of a restricted use area around a public drinking water well is one way of protecting ground water supplies. This area is referred to as a wellhead protection (WHP) area and it is defined as the surface and subsurface area surrounding a public water well or well field through which contaminants could likely pass and eventually reach the ground water supply. The Texas Water Commission (TWC) and Texas Department of Health (TDH) jointly administer the WHP program.

The TWC and TDH provide technical assistance and public education to local government to protect ground water within designated WHP areas surrounding the

state's public supply wells. This voluntary WHP program is designed to allow every community to take an active role in maintaining the quality of its municipal ground water supply.

The basic concept of the program is the minimization of land use restrictions while maximizing ground water protection. To accomplish this, the TWC delineates WHP areas based on aquifer parameters, a five-year travel time for potential contaminants, and best professional judgement to prevent ground water contamination. The TDH develops contingency plans for the provision of alternate water supplies in the event of contamination of the existing source. Local governments provide an inventory of all potential sources of contaminants within their WHP areas, then they implement the program. Guidance to local governments with respect to the inventory of potential contaminant sources, and other required technical assistance as needed, is provided by the TWC and TDH.

In addition to the primary goal of ground water protection, another goal is to provide sufficient incentives for voluntary participation of local entities in the establishment and management of individual WHP areas. This is encouraged by the holding of at least one large annual seminar in Austin and two or three mini-seminars conducted at various locations around the state. Other state agencies and/or local entities present data in their area of expertise at these seminars. Best management practices and WHP case histories are presented at these meetings. Applicable literature is disseminated through these seminars and technical assistance is provided to participants upon request.

## ROLES AND DUTIES OF STATE AND LOCAL GOVERNMENT

It is believed that state and local governments should be responsible for the protection of ground water quality despite an increasing federal role in recommending specific regulatory approaches for the protection of this resource. This is based on the following observations: a) legal authority for the control of ground water which has evolved at the state level because of the nature of the problems; b) the role states and local governments have in land use decisions; and finally, c) the fact that state and local governments are responsible for the health and welfare of their citizens.

Coordination with local entities such as cities and local governments, councils of government, underground water conservation districts, and/or river authorities, is an integral part of the state's ground water protection activities. Since the state advocates the use of WHP activities for the control of nonpoint sources of pollution, the WHP program becomes a key element in the abatement of ground water contamination in the vicinity of public water supply wells. The establishment of these wellhead protection areas provides an opportunity for local government to become involved immediately in the inventory of potential sources of contamination and to directly enact and/or administer regulatory functions which may be appropriate.

## DELINEATION OF WELLHEAD PROTECTION AREAS

As a guide, TWC staff employs the calculated fixed radius method, the Konikow and Bredehoeft numerical program, and other methods deemed necessary to delineate WHP

area boundaries. Additionally, best professional judgement plays an important role in the establishment of these areas.

Each wellhead delineation area is based upon a five-year time of travel using a city's maximum anticipated future well pumpage. It is felt that five years is an adequate response time for communities to react to a contamination event should one occur outside of the protection area.

## INVENTORY OF POTENTIAL CONTAMINATION SOURCES

Table 1 illustrates that man-influenced ground water quality problems are most commonly related to the following: a) water-soluble products that are placed on the land surface and in streams; b) substances which are deposited or stored in the ground above the water table; and c) material that is stored, disposed of, or extracted from below the water table (U.S. Environmental Protection Agency, 1985).

The field inventory of all potential anthropogenic sources of contaminants which could have an adverse effect on public health, found within the delineated WHP areas, is the responsibility of the participating cities, towns, or entities. The inventory is supervised by the TWC and TDH.

Underground water conservation districts, councils of government, and/or counties serve as a coordinator between the state agencies and the cities, towns, or entities. They provide excellent supervision of the inventory and can assist in the inventory process where necessary. Previous experience has proven that when

Table 1
Sources of Ground Water Quality Degradation

Ground Water Quality Problems that Originate on the Land Surface

1. Infiltration of polluted surface water
2. Land disposal of either solid or liquid wastes
3. Stockpiles
4. Dumps
5. Disposal of sewage and water-treatment plant sludge
6. De-icing salt usage and storage
7. Animal feedlots
8. Fertilizers and pesticides
9. Accidental spills
10. Particulate matter from airborne sources

Ground Water Quality Problems that Originate in the Ground Above the Water Table

1. Septic tanks, cesspools, and privies
2. Holding ponds and lagoons
3. Sanitary landfills
4. Waste disposal in excavations
5. Leakage from underground storage tanks
6. Leakage from underground pipelines
7. Artificial recharge
8. Sumps and dry wells
9. Graveyards

Ground Water Quality Problems that Originate in the Ground Below the Water Table

1. Waste disposal in well excavations
2. Drainage wells and canals
3. Well disposal of wastes
4. Underground storage
5. Secondary recovery
6. Mines
7. Exploratory wells
8. Abandoned wells
9. Water supply wells
10. Ground-water development

state supervised activities included districts and county government to coordinate work at the community level that the following is observed: a) sources inventoried and WHP areas established were exponentially increased; and b) their participation was effective in reducing the expenditure of state resources.

The TWC and TDH highly encourage entities to involve local service organizations (Lions Club, Rotary Club, Boy Scouts, and the American Association of Retired Persons) in the inventory process. This involvement not only reduces the workload and financial burden on the municipality, but allow communities or entities to work closely with the general public as well as the media, by informing the public of exactly what cities are doing. By doing so, WHP information may be disseminated more accurately and to a greater extent and this will help build a more cooperative working relationship.

Persons designated to perform the inventory are supplied with the following: a) a list of possible contamination sources (Table 1); b) a suggested inventory form (Figure 4); and c) U.S. Geological Survey 7 1/2 minute topographic maps showing delineated WHP areas. The designated inventory personnel are then instructed on the proper completion of WHP inventory forms and the plotting of the potential contamination sources on the maps. The inventory will then be conducted by completing a door-to-door survey of all landowners within the wellhead protection areas and locating the listed potential sources of contamination.

Inventories of potential contamination sources for each WHP area are then submitted to the TWC and TDH for review. The information for each possible contaminant source includes the following: a) landowner's name, address, and

Number _____

Figure 4

SUGGESTED INVENTORY FORM

A. Landowners Name _____

B. Address _____

C. Phone: (  ) _____

D. City: _____ Zip Code _____

E. County: _____

See Attached Map No. _____

Description of Location: _____

_____

Nature of Property

Residential _____ Commercial _____ Agricultural _____

Industrial _____ City Government Offices _____

Potential Sources of Contamination

1. Abandoned Water Well: Yes _____ No _____
   If yes, how many? _____
2. Producing Water Well: Yes _____ No _____
   If yes, how many? _____
3. Cistern: Yes _____ No _____
4. Septic Tank: Yes _____ No _____
   If yes, how many? _____
5. Cesspool: Yes _____ No _____
6. Underground Storage Tank: Yes _____ No _____
   If yes, how many? _____
7. Above Ground Storage Tank: Yes _____ No _____
   If yes, how many? _____
8. Heat Pump/Sir Conditioning Return
   Flow Well: Yes _____ No _____
9. Automobile Service Station Disposal Well: Yes _____ No _____
   If yes, how many? _____

Other related potential sources or Class V Wells: _____

10. Notes:

phone number; b) county; and c) longitude and latitude. This information is then stored on the TWC's mainframe computer. Either the TWC or the TDH will then conduct a drive or walk through inspection of each WHP area to verify the inventory of participating cities and towns.

For those entities participating in the WHP program, each WHP area will be re-inventoried and an entity's pumpage re-evaluated every two to five years depending upon the density of new urban or agricultural development within the protection areas. This requirement is stressed through public education and is included as a recommendation in each WHP report. Notices to re-inventory will be issued when appropriate. The new inventory is then submitted to the state for review and updating.

Communities or entities are encouraged to advise the TWC and TDH when new potential sources of contamination are sited within a designated WHP area. The state's inventory data base may be updated at any time.

## PILOT PROJECTS

Since the state covers an extremely large area and has an estimated 14,700 public water supply wells, implementation of any statewide WHP strategy requires the coordinated efforts of both state and local resources.

To test the coordination efforts between cities, regional entities, and the state, WHP demonstration projects were conducted utilizing cities located within two Ground Water Conservation Districts and one Texas Gulf Coast County (Figure 5). The following participated in the project: a) the cities of Dumas and Perryton (located within the North Plains Ground Water Conservation District No. 2); b) the cities of White Deer, Groom, Panhandle, and McLean (located within the Panhandle Ground Water Conservation District No. 3); and c) the cities of Katy and Rosenberg as well as the Lamar Consolidated Independent School District, located within Fort Bend County.

More specifically, the objectives of this project included the following: a) securing the participation of local governments; b) comparing different methods for determining protection areas around public water supply wells on a site specific basis; c) conducting a field inventory of all possible contamination sources within the project's protection areas; d) assessing the contamination potential of all categories of possible contamination sources found; e) reviewing the authorities of both state and local government to regulate sources of contamination; and f) preparing reports which provide recommendations to local governments regarding contamination sources found and possible courses of action.

Project control was well coordinated and consisted of the following: a) at the state level, the TWC and TDH provided general project control and oversight, and in some cases, field inventory assistance; (b) the underground water conservation districts and Fort Bend County Engineer's Office coordinated the field inventory of all potential ground water contamination sources and interfaced with city

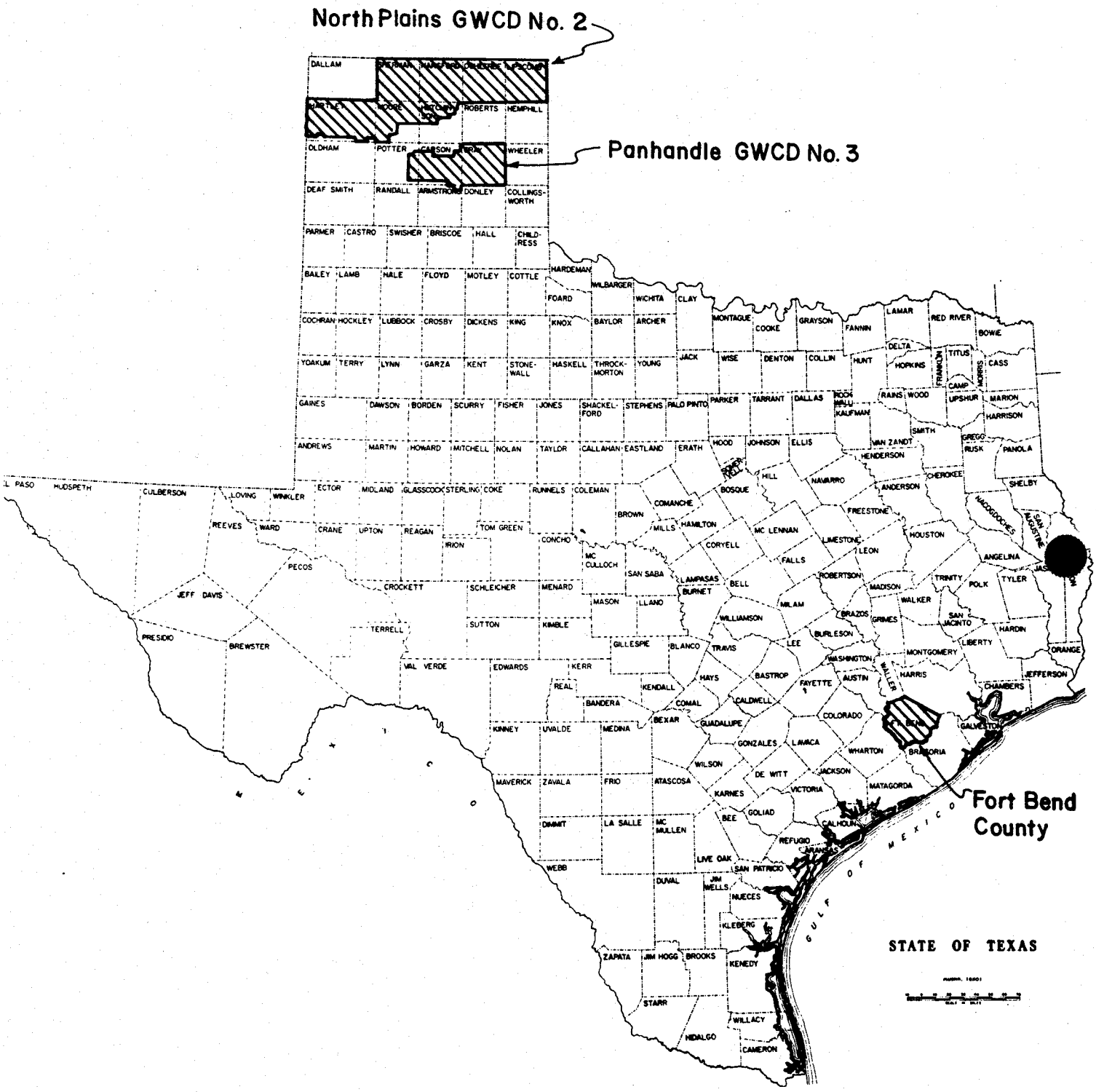


Figure 5

Location Map

government to affect the state's ground water protection recommendations; and (c) inventory and implementation of ground water protection activities were performed at the community level. Project control is illustrated in Figure 6.

The successful completion of the above projects provides the basis for the state's WHP programs in terms of project control (Figure 6). The interaction of state and local government in WHP activities are illustrated on Figure 7. Figures 6 and 7 depict the major components of the state's WHP program.

## CONCLUSIONS

Wellhead protection is an important activity with regard to implementing a nonpint source program. Public education should be viewed as very important to the successful implementation of best management practices which have been developed to mitigate designated nonpoint source ground water pollution categories and in the implementation of a wellhead protection program at a local level.

The state's role in wellhead protection should be public education and technical assistance. Finally, implementation of the wellhead protection program must be at the local level because of the state's area and the number of public water supply wells.

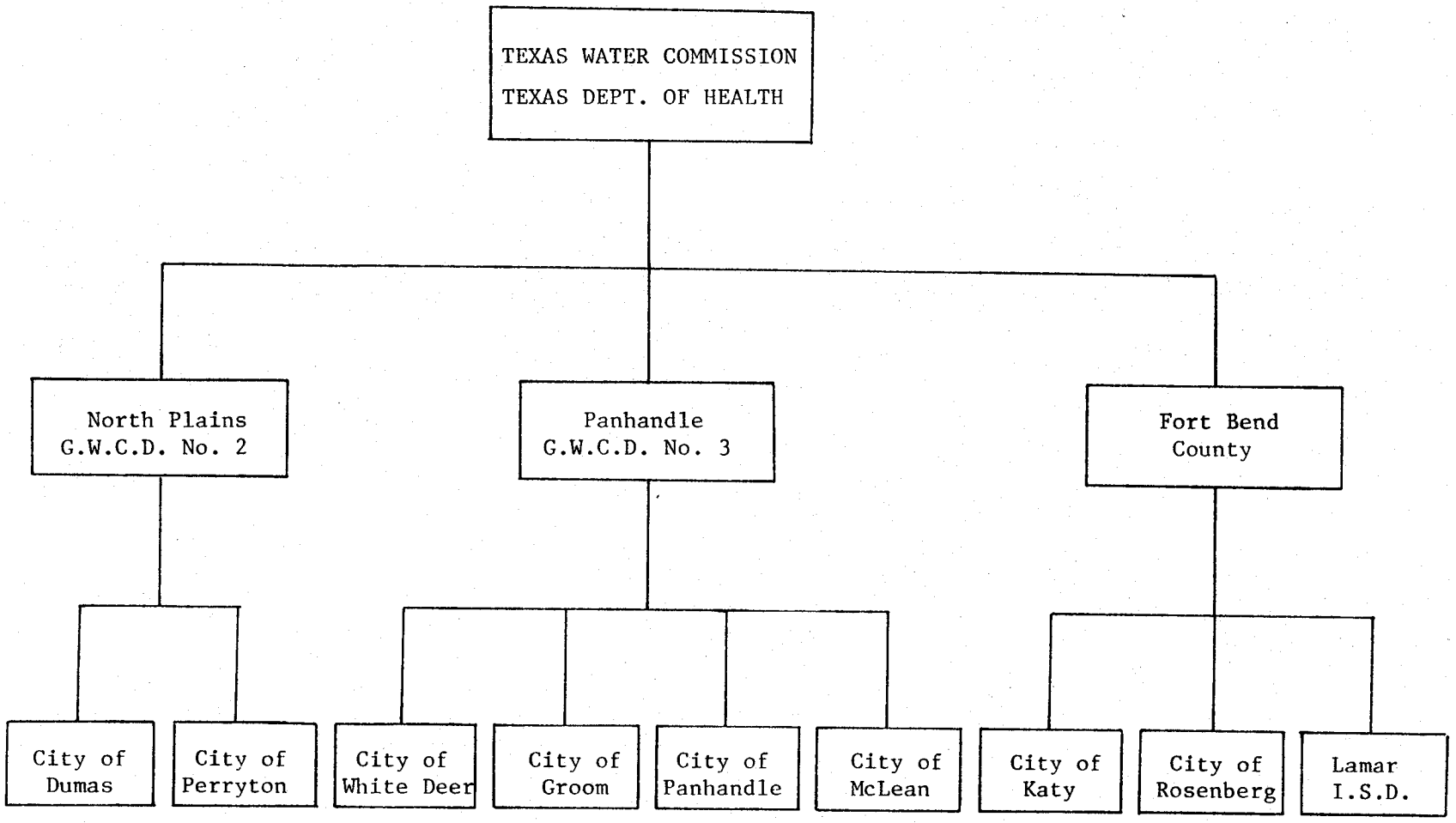


Figure 6

Project Control

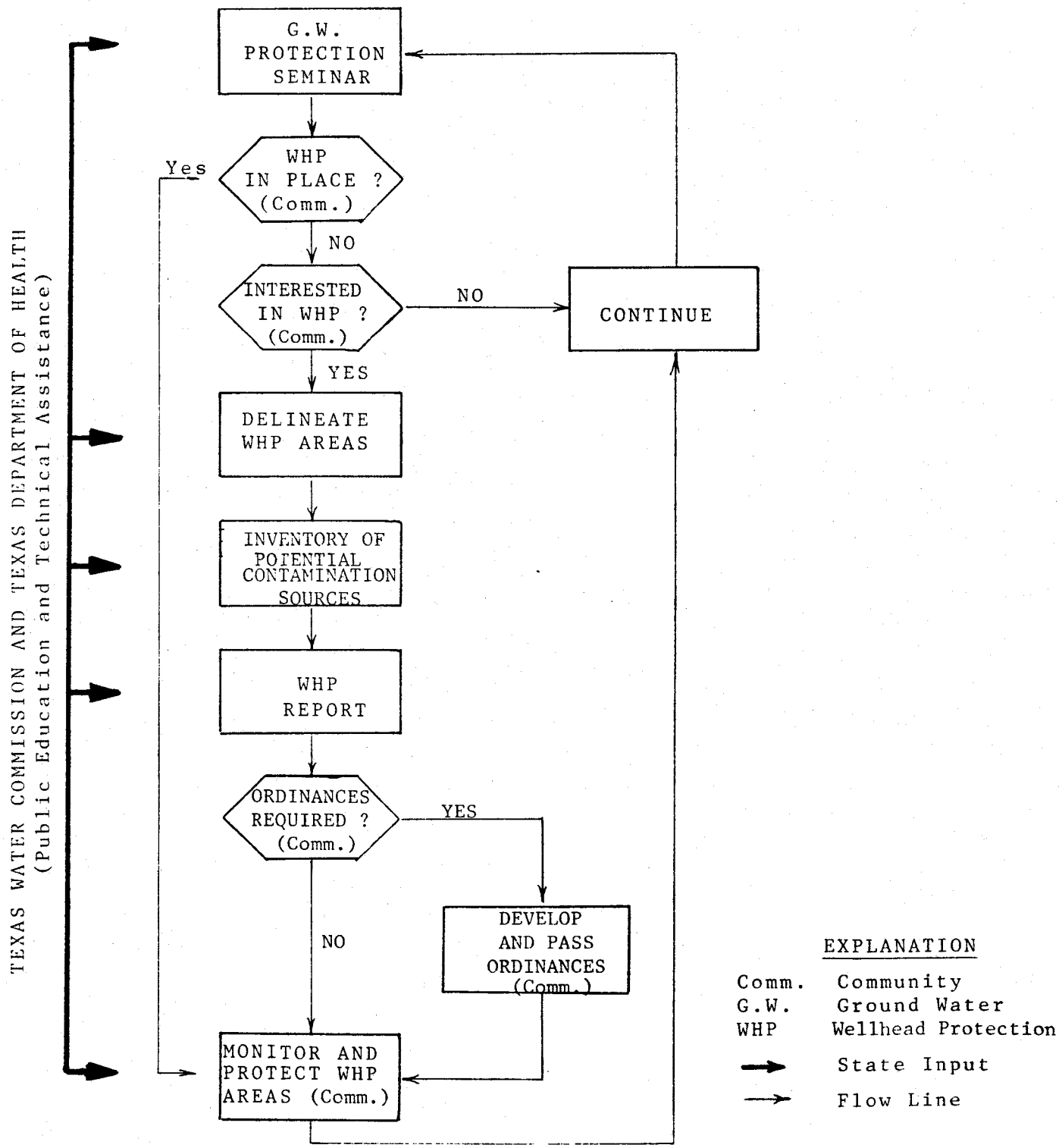


Figure 7
Flow Chart of Principle
Wellhead Protection Activities

NONPOINT SOURCE POLLUTION ASPECTS OF THE U.S. BUREAU OF LAND MANAGEMENT'S MINERAL RESOURCES PROGRAM

Robert M. Anderson
Deputy State Director - Mineral Resources
Bureau of Land Management - Sacramento, California

17 mil in Calif.

The Bureau of Land Management (BLM) is responsible for achieving balanced and effective multiple-use management on 270 million acres of publicly owned land, in 11 Western states and Alaska. In addition, BLM manages federally owned subsurface mineral rights throughout the nation underlying lands that are administered by other agencies or are privately owned. These lands contain a vast and rich array of resources. BLM is charged with managing these resources to provide for the needs of America's people for self-sufficiency in energy, mineral, agricultural and forestry products, for recreational opportunities, and preservation of historic and cultural resources.

$2.9 billion

California leads the nation in the production of non-energy minerals. It leads the world in the production of geothermal ~~energy~~. In the United States, California is the only producer of borax, and ranks third in gold and fourth in oil production.

Many of these mines and facilities are on Public Land administered by BLM. BLM administers over 17 million acres of Public Land in California plus another three (3) million acres of land in private ownership where the mineral estate is reserved to the United States government. An additional 33 million acres are under control by other federal agencies and the remaining 50 million acres in California are non-federal.

In the last ten (10) years, it is estimated that 3500 mineral exploration and development proposals from industry and citizens have been reviewed by California BLM for environmental considerations. This is a significant amount of mineral activity and underscores the highly mineralized values that exist beneath California's Public Lands.

Today, mineral exploration and extraction are made available on these lands through four Public Land Laws:

1. 1872 Mining Law -- The rights to metallic minerals such as gold, silver, zinc, lead, and copper and some non-metallic minerals such as gypsum and calcium chloride may be obtained by staking a claim.

2. 1920 Mineral Leasing Act -- BLM leases oil and gas, coal, sodium, phosphate and potassium, generally through competitive sales.

3. 1947 Materials Act -- BLM sells sand, gravel, decorative stone and other common rock at market value.

4. 1970 Geothermal Steam Act -- BLM leases known geothermal steam and hot water areas through competitive and noncompetitive sales for electrical generation and direct use.

Prior to 1980 some mining operations authorized under the 1872 Mining Law were abandoned without proper reclamation. Some of these abandoned operations may contribute to the general Nonpoint Source (NPS) pollution of certain areas within California. The most serious pollutant arising from mining activities is mine drainage generated by oxidation of pyritic materials with air in the presence of water. Waste rock and tailings may also create NPS pollution. Some of this refuse may also contain pyritic or other metallic material which may oxidize to acidic substances. The resultant concentration may remain in or near these areas until storms occur, potentially flushing the material into nearby water courses.

Significant oil and geothermal steam/hot water extraction activities take place on the Public Lands in California. Pollution from oil spills and oil field operations usually result from the movement and deposition of oil laden soil particles or crude oil in surface runoff. Oil may also contaminate groundwater if it penetrates through the soil to the free water level. Geothermal fluids, depending on their source, may carry significant dissolved salts and metals such as boron, arsenic, sulfur, etc. BLM requires re-injection of these fluids.

Mine, milling or other facility construction, as well as access roads, may also contribute to NPS pollution because of the disturbance of sediments. However, with present siting and planning requirements and erosion control practices and stipulations, NPS pollution attributed to mining has been minimized.

Of the four laws mentioned earlier, only the Geothermal Steam Act specifically provides for protection of clean water during the extraction of geothermal resources. However, starting with the National Environmental Policy Act of 1969, there have been many federal laws passed to promote and provide for a healthy environment, including clean water. None of the four mineral laws are exempt from meeting the requirements of these environmental laws when the mineral industry desires to explore for and develop the mineral resources from the Public Lands. Operators must also comply with state and county environmental laws if they are consistent with federal laws.

Formal environmental processing and mitigation of Leasing Act and Material Act mineral applications did not occur until after the passage of the National Environmental Policy Act of 1969. Likewise, environmental requirements when developing the locatable minerals under the 1872 Mining Law were not mandatory until 1980 when regulations were issued as a result of the Federal Land Policy and Management Act. Since then, BLM's policies have evolved to ensure that all mining or mineral extraction activities which may affect water quality through NPS pollution are undertaken with consideration for the issues and requirements contained within the California Regional Water Quality Control Plans. The policies also ensure that the Regional Water Quality Control Boards are fully involved in the process.

NPS related issues are usually covered through actions such as Best Management Practices (BMPs) which minimize the likelihood of introducing pollutants into streams through indirect runoff to water sources. Most actions affecting water quality through NPS do not require discharge permits, but they may involve notification of the RWQCB to allow their comment on mitigation and practices which would be incorporated into BMPs, conditions or stipulations required by BLM.

The NPS pollution program in BLM is relatively new. The headquarters office of BLM in Washington, D. C. recognizes the importance of controlling NPS pollution and thus has established the strategy for field offices to implement as follows:

- Provide cooperation and assistance to state agencies in the management of the Public Lands to reduce nonpoint source pollution.

- Incorporate water quality impacts including nonpoint sources, into land management actions planned and implemented by the BLM, including BMP's.

- Identify and address nonpoint source water quality issues in BLM activity plans, including grazing allotment management plans, timber plans, watershed activity plans, mineral development permits, and environmental documents.

- Provide personnel and resources to identify nonpoint source pollution and control techniques through coordinated research efforts and the implementation of BMP's.

- Implement program practices in conducting land use and land management activities to avoid or reduce water quality impacts and to improve water quality as necessary to meet management objectives and regulatory requirements.

In summary, The Bureau of Land Management takes seriously its efforts to ensure that clean water on the Public Lands is not affected by mining or mineral operations.

| | | PAGE |
|---|---|---|
| **SESSION X:** | **FEDERAL AND UNIVERSITY PROGRAMS**<br>Session Chair: **Professor Charles DuMars**<br>University of New Mexico Law School and WSWC Member | X-A |
| 1:30 p.m. | **US Soil Conservation Service's Program for NPS Pollution Control**<br>Eugene Andreuccetti, State Conservationist<br>Soil Conservation Service, Davis, CA<br>U.S. Department of Agriculture | X-B |
| 1:45 p.m. | **US Environmental Protection Agency's Agenda for NPS Pollution Control**<br>Martha Prothro, Director Office of Water Regulations, US EPA, Washington DC | X-C |
| 2:00 p.m. | **Research Role of the University of California in Understanding Technical Issues Related to NPS Pollution**<br>Henry J. Vaux Jr., Professor of Economics<br>University of California, Riverside, CA<br>Director, University of California Water Resources Center | X-D |
| 2:15 p.m. | **ROUNDTABLE DISCUSSION AND QUESTIONS** | X-F |

# USDA'S ROLE IN NONPOINT SOURCE POLLUTION CONTROL

Western State's Water Council Workshop
July, 28, 1989

EUGENE E. ANDREUCCETTI
State Conservationist
Soil Conservation Service
Davis, California

The SOIL AND WATER RESOURCES CONSERVATION ACT OF 1977 requires the Department of Agriculture to conduct a continuing appraisal of the soil, water, and related resources on the nonfederal land of the Nation.

The federal lands are likewise evaluated under the FOREST AND RANGELAND RENEWABLE RESOURCES PLANNING ACT OF 1974.

The conclusions reached by these evaluations are that WATER QUALITY in an increasingly important problem on all of the Nation's lands.

The report to the Congress by the Secretary of Agriculture in the NATIONAL PROGRAM FOR CONSERVATION OF SOIL AND WATER: THE 1988-97 UPDATE gives top priority to the solution of soil erosion on agricultural land and to "protection of the quality of surface and ground water from harmful contamination from nonpoint sources."

The PURPOSE then, is to address nonpoint pollution problems, including those on rural lands and many of those associated with urban use.

A USDA WATER QUALITY INITIATIVE was developed with the objective to: REDUCE LEVELS OF SURFACE AND GROUND WATER POLLUTION LOADS RESULTING FROM AGRICULTURAL PRODUCTION.
The components of the initiative are:

TARGETED RESEARCH AND EDUCATION PROGRAMS..for both technical and economic research needs have been identified and are being addressed by the Agricultural Research Service and the Economic Research Service.

IMPROVED TECHNICAL SUPPORT CAPABILITIES..are utilizing existing technology as well as new technologies developed as a result of the new research efforts

TARGETED TECHNICAL AND FINANCIAL ASSISTANCE..is being developed by the Soil Conservation Service (SCS), Cooperative Extension, Agricultural Stabilization and Conservation Service (ASCS) and Farmers Home Administration (FmHA).

IMPROVED DATA BASES..are being developed by the SCS in cooperation with the State Water Quality agencies and others.

STRENGTHEN ONGOING EFFORTS..of USDA agencies that have several decades of experience.

A USDA Water quality policy was formulated placing emphasis on NONPOINT source control for surface waters and GROUND WATER.

The POLICY spelled out the Department's role concerning:

BENEFICIAL USES..the identification and protection of these designated uses is an important opportunity for USDA involvement in NPS pollution prevention.

PUBLIC INVOLVEMENT..is required in the development of water quality goals and in the development of the strategies needed to reach the goals.

VOLUNTARY ACTIONS..are the first strategy with regulation and enforcement used only if voluntary actions fail to achieve the water quality goals.

BEST MANAGEMENT PRACTICES (BMP's)..are those groups of management practices needed to be applied by the land managers to meet the water quality goals

TECHNICAL ASSISTANCE..will continue to be made available for both watershed-wide and on-farm individual assistance in assessing the need for and the application of BMP's.

OUTREACH PROGRAMS..will be key to contacting those land managers who need to become involved in the establishment of the water quality goals, the development of BMP's and their application.

STATE NPS MANAGEMENT PLAN..development included assistance from SCS and Cooperative Extension in many states. Their continued cooperation will be key to the successful implementation of those plans.

PRIORITY WATERSHEDS..will be identified so that work on worst problems first can take place. Emphasis by USDA agencies will be on the cooperative development of solutions without regard to whose agency's programs will be used for implementation.

RESEARCH, MONITORING AND DATA GATHERING..efforts are already being stepped-up to better define the location, extent and severity of the problems. Monitoring and additional data gathering will also be needed to evaluate the effectiveness of the BMP's in meeting the water quality objectives.

MANAGEMENT OF AG CHEMICALS..is regulated in most States.The USDA agencies roles will be that of assisting in the assessment of the potential for water quality impairment and suggesting management strategies that will reduce the impact of the use of both pesticides and fertilizers.

The bottom line of USDA's WATER QUALITY POLICY IS TO "INCLUDE WATER QUALITY IN OUR DAILY WORK"

WATER QUALITY IN SCS follows the Department's lead.

Improving WATER QUALITY leads to increased WATER QUANTITY available for beneficial uses.

The WATER QUALITY priority is not a new program, but rather an emphasis that will impact all of SCS's programs, projects and activities.

To guide our efforts, WATER QUALITY ACTION PLANS have been developed by the SCS in each State. These Plans establish a development and implementation schedule for specific procedures to account for water quality in all SCS programs and activities.

These Plans include cooperation with other agencies in the design of a comprehensive system to evaluate the impacts of soil and water conservation practices (BMP's) on water quality: the formulation of up-to-date technical guidance in the form of our Field Office Technical Guides: and the training of all SCS personnel in their new roles in improving water quality.

SCS is committed to working cooperatively with those federal and state agencies who are charged with water quality leadership responsibilities. MOU's have been signed with Cooperative Extension and the Environmental Protection Agency.

The assignment of senior SCS staff members to each of the ten EPA Regional Offices to provide key technical assistance on agricultural issues is an example of this commitment.

Cooperative Extension in California and the SCS are jointly developing videotaped water quality training modules. They have agreed to train their staffs at joint county and state level water quality training sessions .

The SCS assigned a senior staff member to the California State Water Resources Control Board during the development of the State Management Plan. The technical assistance provided on practical agricultural issues enhanced the Plan.

The Department is utilizing eight Demonstration Projects nationwide to demonstrate the utility of the Best Management Practices approach to water quality improvement.

California's 400,000 acre rice growing region in the Sacramento Valley was chosen as one of these eight Demonstration Projects. The Project is in cooperation with the rice growers, Cooperative Extension, Resource Conservation Districts, State and Regional Water Quality and Agricultural agencies. It will include the cooperative development of needed changes in irrigation system design and operation including tailwater return system design. Accelerated technical assistance to these rice growers will aid them in meeting the adopted water quality standards.

There are also about thirty Water Quality Pilot Projects about to be approved. These too, will be aimed at the use of developing Best Management Practices and assisting landowners in their application. These will likely include the reduction of erosion, salinity, nutrients and pesticide residue from both agricultural and urban lands.

In summary, the SCS along with other USDA agencies is committed to assisting land managers and the state and federal agencies in the identification and solution of NPS water quality problems. Water quality will not become a PROGRAM but rather an objective to be included in each of the appropriate programs of the Department.

Water quality has often been a secondary effect of soil and water conservation practice application. Added emphasis will now be place on the design of Best Management Practices that will deal with both the off-site and cumulative impacts of soil and water conservation practices on water quality.

The SCS is strengthening its partnership with conservation districts, local, state and federal groups to aid land managers solve nonpoint source pollution problems.

Emphasis will be placed on improving the management of existing conservation programs that will be used in helping to meet the water quality goals.

The SCS will work cooperatively with others to be sure that its assistance will be provided to top priority problem areas.

Presented by:
Virgil L. Backlund
SCS/EPA LIAISON

TALKING POINTS

MARTHA G. PROTHRO

DIRECTOR, OFFICE OF WATER REGULATIONS AND STANDARDS

U.S. ENVIRONMENTAL PROTECTION AGENCY

NONPOINT SOURCES: AGENDA FOR THE FUTURE

- Over the last two years you have heard much about the States' assessment of the scope of the NPS water quality problem as reported in the 1986 National Water Quality Inventory (305(b) Report); for waters not supporting their uses, NPS pollution was reported to be the leading cause in:

  - 65% of U.S. rivers and streams

  - 76% of U.S. lakes; and

  - 45% of U.S. estuaries.

- While we don't have the equivalent numbers for the '88 Report, preliminary data are available from the draft 1988 National Water Quality Inventory. (These data have not yet undergone State review and may change.) They show that:

  - The most extensive causes of use impairment in the Nations rivers and lakes are siltation and nutrients, traditional NPS pollutants.

    - Siltation affects about 44 percent of impaired stream miles and about 42 percent of impaired lake acres

    - Nutrients affect about 21 percent of impaired river miles and about 57 percent of impaired lake acres

  - Agricultural runoff is by far the most extensive source of pollution in rivers and lakes, affecting nearly half of impaired river miles and two fifths of impaired lake acres.

  - While we are still verifying these 1988 figures, NPS pollution clearly continues to be the major remaining source of impairment in waters not fully supporting their designated uses.

- Simply put, NPS pollution is now and will continue to be the spoiler for some time to come, preventing us from collecting an appropriate return on 17 years of major public and private investment in point-source controls.

- What this means for you and me is that we've signed on for an extended tour in this battle to prevent and control NPS pollution - - -

no simple, crash program will suffice!

- Recognizing this fact of life, EPA last summer developed a draft five-year framework for the national NPS program and, through the fall, in a series of regional workshops, fine-tuned it with the help of States, localities,

  other Federal agencies and a broad spectrum of public and private groups.

- The basic assumption underlying the NPS "Agenda for the Future" is that the NPS Management Programs now being completed by the States form the cornerstone of the national NPS program: the energies, resources and activities of all the NPS "players" - EPA, Federal agencies, States, localities, public and private groups, landowners and land managers - should be primarily focused on assisting State and local governments to make those management programs work effectively and produce measurable environmental results.

- After much discussion and analysis, needed actions were grouped under five major themes:
  - public awareness
  - successful solutions
  - financial forces and incentives
  - regulatory programs
  - good science.

- In the area of public awareness, we need to do far more to raise everyone's consciousness about how they contribute to NPS pollution and how they can become part of the solution to NPS pollution. From elected decisionmaker to private citizen, there is a general lack of understanding about how NPS pollution affects water quality and their daily lives. People need to be convinced that there is a direct connection between everyday activities, land use practices and water quality and, more importantly, that taking certain actions will, in fact, make a difference in water quality. Proposed actions in this area include:

  - generation by EPA at a national level of materials and tools which States and local governments can use to reach the public-at-large

  - collaboration between EPA and other Federal agencies to take advantage of their experience/expertise in communications and delivery systems

  - EPA support and assistance to State and local grassroots efforts to develop outreach materials keyed to local issues and needs

  - assistance to States and local governments in developing coalitions and action programs organized around protection/cleanup of particular water resources such as river corridors, lakes and estuaries.



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- In the area of successful solutions, EPA will solicit the help of others (both public and private) to set up a variety of information networks to provide States and local governments with up-to-date information on practical, feasible solutions to existing problems. The fact of the matter is that States, localities and private parties are constantly coming up with innovative, workable and effective solutions. This conference itself is the best evidence of the availability of such solutions. However, we need faster, more reliable ways to communicate all of this information to a wide audience of users as it's needed. The actions now underway or planned in this area include:

  - work with the public and private sectors to create new clearinghouses or information systems, build upon/enlarge existing ones and actively market the availability of existing information to a wide range of potential users; this information includes successful approaches to outreach/public awareness, innovative financial and institutional arrangements and successful regulatory schemes as well as reliable technical tools and techniques

  - delivery of high-quality technology transfer and training through national conferences such as this one as well as regional workshops focusing on credible citizen monitoring programs, use of state-of-the-art models and decision aids such as EXPERT systems to design site-specific NPS controls and sound targeting and watershed management methodologies

  - refinement of the use of wetlands to buffer NPS pollutants and promotion of land conservancy, especially at the State and local levels, as an effective NPS BMP.

- In the area of financial forces and incentives, we need to work on two fronts at the same time: on the one hand, we need to ensure full use of the limited existing funding for NPS controls which is available and to encourage continued development of increased State and local funding sources; on the other, we need to work for modification of current policies which actually create incentives for doing business in ways that increase rather than decrease NPS pollution. Specifically, we will:

  - support and encourage States to make full use of the several sources of Clean Water Act funding authorized by the 1987 amendments for developing and/or implementing State NPS management programs, i.e., the two construction grant set-asides and State Revolving Funds

  - assist States and localities to make maximum use of funds available through other Federal agencies, e.g., Agricultural Conservation Program (ACP) Special Project funds and P.L. 566 Small Watershed Project funds

  - work with States and local governments to expand and increase the impressive number and variety of creative State/local funding mechanisms and/or taps into traditional revenue sources, e.g., cost-share programs, special taxes such as Puget Sound's cigarette tax, user fee systems, utility districts and permit/development fees

- on the side of modifying current public policy, a prime candidate is cooperation between the U.S. Department of Agriculture and EPA through the latter's Agricultural Policy Committee in developing proposals for reauthorization of the Food Security Act (Farm Bill) in 1990; this event represents an opportunity to remove and/or reduce government incentives that encourage continuous cropping practices and farming of marginal (and other) lands that produce NPS pollution while still providing for the production of food and fiber sufficient to meet the nation's needs.

o In the area of regulatory programs, work must also proceed on several fronts. There is a need both to establish more clearly the linkages between existing Federal regulatory authorities affecting nonpoint sources and to assist and support States and local governments in selecting or developing the right regulatory solutions in cases where they determine the need for them. Examples in these two areas include:

- with respect to Federal regulatory authorities: (1) networking EPA's stormwater permit requirements under section 402(p) of the CWA with State NPS management program requirements under section 319 of the CWA and (2) coordination of State NPS management programs with State pesticide management plans required under the authority of FIFRA

- with respect to State and local regulatory schemes, providing for information transfer between and among the States through newsletters, workshops and fact sheets on such topics as land-use ordinances and practices, Wisconsin's "bad actors" law and California's permit system for agricultural runoff.

o In the area of good science, the Agenda highlights a number of scientific tools, techniques and methodologies which must either be developed or refined to enable us to characterize, control and evaluate NPS impacts on water quality in a way that will lead to demonstrable environmental improvements. Some examples here include:

- development of biological criteria and physical habitat characteristics to use both in defining NPS impacts on water quality and in evaluating the effectiveness of NPS controls

- development and refinement of monitoring procedures and protocols needed to characterize NPS impacts, evaluate improvements in water quality and determine the need for additional controls

- refinement of the ecoregion approach to define attainable water quality and of the AgNPS model to help target control resources in small watersheds

- development of tools and techniques for apportioning NPS loads among dischargers and in general making the wasteload allocation process more workable for nonpoint sources.

- In a nutshell, these are the directions we believe the national NPS program must take over the next five years and beyond to enable States and local governments to achieve measurable environmental results in our efforts to prevent and abate NPS pollution. At the same time as we move forward on all these fronts, I have asked my staff at EPA to concentrate over the next six to nine months on a subset of these:

  - First, to ensure that there is a strong, viable framework for the program:

    - the most immediate task here is to complete the submission and approval/disapproval of State assessments and management programs; the latest information we have is that 36 final assessments have been submitted and 23 final management programs have been submitted; we simply must bring this phase of the 319 program to closure by August of this year and concentrate our efforts and limited resources on the programs which are ready to move ahead with implementation at that time

    - we must begin shifting into an implementation mode: this means putting more of our effort and resources into technology transfer and activities which will directly support State and local implementation actions: one example of this is this national conference; we are also moving forward with the establishment of a national NPS clearinghouse and the scheduling of regional tech transfer workshops, to be designed with the help of State and local representatives; we have also begun development of some basic outreach/public awareness materials for national distribution and are continuing the cross-program EPA task force that initiated the "Agenda for the Future" to ensure that NPS concerns will continue to receive high priority attention in all relevant EPA programs

  - Second, to achieve full use of available resources:

    - a major key to effective implementation of the management programs is funding; while Federal funding is limited, it's clear that at present the funding that is available is not being fully utilized; we shall work harder to: 1) ensure that Title I, II and VI funds are made available to the States to the maximum extent possible; and 2) assist States to fully and promptly utilize the funds which are available

    - Federal funding will not do the whole job and we will make information transfer on State and local funding initiatives, of which there are many, a high priority in our tech transfer efforts



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- Third, to lay the groundwork for showing environmental results:

  - in our development of technical guidance and "good science" materials, we shall give clear priority to the tools and techniques which will improve our ability to set clear baselines on current water quality as it relates to NPS pollution and to monitoring procedures and protocols which will enable us to evaluate the effectiveness of BMP systems and demonstrate environmental results.

# RESEARCH ROLE OF THE UNIVERSITY OF CALIFORNIA IN UNDERSTANDING TECHNICAL ISSUES RELATED TO NON-POINT SOURCE POLLUTION

Henry J. Vaux, Jr.
Professor of Economics
Director, UC Water Resources Center

The research role of the University differs in several fundamental ways from that of government or the private sector. Freedom of inquiry generally means that University researchers are given wide latitude to pursue research questions that are of interest. The research mission of the University is directed at making additions to the fundamental stock of knowledge, a task that virtually always requires a sustained effort over some significant period of time. Thus, there is no a priori expectation that University research agendas will be directly tied to short term operational problems or to problems of crisis management.

The type of research which is typically carried out in Universities has strengths which complement the short-term, more problem-oriented research undertaken by government and private research organizations. First, the University is uniquely equipped to address questions which cannot be answered in the short-term. In-house, long-term research is rarely done by operational agencies because long-term problems are difficult to foresee and because long-term research is not always an appealing response to immediate operational problems. University research, when it is far-sighted, may yield results which can solve the problems when they arise or provide the basis for effective short-term research aimed at solving immediate problems. A second strength of University research stems from the fact that it is inherently uncoupled from operational problems. Answers to operational problems are sometimes found serendipitously through efforts or projects which have no apparent relationship to the problem in question. Managers faced with an immediate and serious problem obviously have neither the time nor the resources to find solutions serendipitously.

This is not to say that University research is inherently unfocused or unrelated to problems of the real world. A substantial proportion of University research is organized broadly by topic area and supported with organized research funds. Thus, for example, within the University of California organized research efforts ranging from water to AIDS to Pacific Rim studies to interplanetary physics receive considerable support. Organized research efforts are designed to develop and enhance pertinent expertise and apply that expertise to problems confronting society. Organized research often fosters substantial synergies among investigators who would not work collaboratively on such problems without the funding and organizational support. The existence of organized research in no way diminishes the importance of contributions made by individual researchers. It is merely one means of directing and focusing the attention of groups of investigators on substantial problems of current interest.

At the University of California, research aimed at understanding and managing non-point source emissions has been on-going for over 20 years. Although many problems remain to be solved, much has already been learned. The behavior of nitrates in the soil and water environment is far better understood now than it was twenty years ago. The same is true of many classes of agricultural chemicals and their residues. Progress has been made in developing new technologies which can contribute to 'best management practices.' Some progress has also been made in devising new and potentially effective institutions for managing non-point source emissions.

Today, approximately $6 million is being spent annually within the University of California to support research on all aspects of non-point source pollution. A majority of these funds originates with organized research programs that, while not focused directly on non-point source pollution problems, are making substantial contributions toward understanding and solving those problems. A brief description of several of these organized research programs is illustrative:

## ORGANIZED RESEARCH ON NON-POINT SOURCE POLLUTION

There are four major organized research programs within the University that support a significant amount of research focused on understanding and managing non-point source pollution.

### 1. Water Resources Center

The Water Resources Center supports and coordinates research on all aspects of water resources on the nine campuses of the University of California. The research is divided into five programmatic categories: 1) Hydrology, Climatology and Hydraulics; 2) Aquatic Environments; 3) Water Quality; 4) Water Development and Management Alternatives; and 5) Institutional Arrangements. Although Center supported research encompasses a broad array of water and water related problems, nearly a third of the $800,000 annual research budget is devoted to projects that focus on understanding and managing non-point source emissions.

### 2. UC Salinity & Drainage Task Force

The UC Salinity and Drainage Task Force is charged with developing, interpreting and disseminating research knowledge which addresses critical agricultural and environmental problems related to salinity, drainage and toxic trace elements. A vast majority of the problems which fall under the purview of the Task Force are non-point source pollution problems. During the last three years, most research supported by the Task Force has focused on understanding and managing selenium emissions from irrigated agriculture. Almost two-thirds of the Task Force's

$550,000 annual budget is devoted to the support of investigations of the behavior of selenium in the soil and water environment, technical methods of reducing selenium emissions and the economics of selenium management. Many of the results of Task Force sponsored research are readily transferable to other types of non-point source emission problems and will be especially helpful if selenium problems emerge throughout the West, as some have suggested.

3. UC Toxic Substances Research and Teaching Program

The UC Toxic Substances Research and Teaching Program supports long-term research and graduate education in toxics-related fields. The mission of the program is to provide new concepts and the scientific talent necessary to solve the growing problems of toxic chemicals in the environment. The majority of the research budget of this program (approximately 70%) supports research on the health effects of toxic chemicals and engineering studies focused on the control of toxic wastes. The remaining 30% supports investigations of the fate of toxic chemicals in the environment. Most of the research in this latter category is devoted to studies of how toxic chemicals, many of which emanate from non-point sources, behave in the environment and on ways of controlling them.

4. The Agricultural Experiment Station

The Agricultural Experiment Station is the largest organized research unit in the UC System. Approximately 250 faculty members from the Berkeley, Davis and Riverside campuses hold appointments in the Experiment Station and are active in research related to all phases of agriculture. Within the Experiment Station, increasing emphasis is being placed on research related to the impact of agriculture on environmental quality and natural resources.

The Station sponsors approximately three dozen projects on the management of agricultural drain waters. It sponsors over 50 investigations focused on the management of agricultural chemicals and the development of cultural practices that do not rely on agricultural chemicals. Thus, for example, researchers supported by the Integrated Pest Management program are devising ways of controlling insect infestation with biological techniques. When such techniques are substituted for pesticides, non-point source emissions are reduced. Genetic research seeks to develop crops which are insect resistant or can survive on minimum inputs of water and fertilizer, for example. Much of the research supported in the Experiment Station focuses only indirectly on non-point source emissions but the ultimate impact of this research on non-point source pollution is likely to be substantial.

Projects supported by these programs frequently generate much larger and more ambitious efforts which are funded independently by agencies such as the National Science Foundation and the Environmental Protection Agency. Thus, in a recent year, the Toxic Substances Research and Teaching Program generated almost $9 million in external funding, of which approximately 20% was devoted to studies of non-point source contaminants. Organized research programs, then, provide both a means of focusing the considerable research expertise of the University on important societal problems and a means of enabling University investigators to attract substantial external support to work on these problems.

## CURRENT UNIVERSITY RESEARCH ON NON-POINT SOURCE POLLUTION

A brief summary of research on non-point source pollution that is currently underway at the University of California illustrates the breadth of the research effort. It also serves to identify aspects of the non-point source pollution problem to which the University may be expected to contribute solutions and reveal areas which may need more attention.

### 1. Identification of non-point source pollutants

Detecting and monitoring non-point source pollutants are often problematical since emissions are frequently diffuse and rarely concentrated. There is a particular need for low cost methods for detecting and monitoring non-point source pollutants. Two projects underway at UC Davis show promise of developing such methods. The first focuses on the development of enzyme linked immunosorbent assays to detect pesticides and pesticide residues in water. This method, which can detect concentrations as low as one ppb in the field, is being developed for a variety of pesticides used in lowland rice culture in California. Ultimately, the method may prove to be superior to gas chromatography which is somewhat cumbersome and costly. Immunosorbent assays must be developed on a pollutant-by-pollutant basis and the technique thus has limited potential as a screening test.

A second project, also underway at UC Davis, shows promise as an inexpensive broad-based screening test. This project is designed to adapt a well-known air pollution detection technique, aerosolization and PIXE analysis, to water samples. If successfully developed, this test could provide a fast and inexpensive means of assaying the elemental content of ground and surface waters and detecting the presence of chemical contamination. Taken together, these projects hold considerable promise for the development of techniques that will make contaminant detection and monitoring considerably less expensive and easier to carry out.

## 2. Understanding the Behavior of Pollutants in the Environment

Effective management of non-point source pollutants requires an understanding of how the pollutants behave in the environment. Currently, many investigators are analyzing and modeling the transport of contaminants in surface water, in the vadose zone, and in ground water. Much of this work focuses on organic chemicals. Researchers at UC Berkeley and UC Riverside, for example, are modeling the movement of organic solvents through aquitards and the vadose zone. The results of these projects will yield new insights into the speed with which non-point source contaminants move toward ground water and the extent to which they may be transformed in the soil environment. Several projects at UC Davis focus on the movement of selenium and nitrates through the vadose zone. These projects are likely to further illuminate the possibilities for managing irrigation water and agricultural chemicals to minimize the impact of non-point source emissions from agricultural lands.

Although deterministic work on the movement of contaminants in the environment is useful in understanding the rates of movement, chemical transformations and the extent to which soil may immobilize pollutants, such work does not provide comprehensive guidance about how pollutants actually behave in the field. Previous research has established that it is not feasible to predict with certainty the movement of non-point source pollutants in heterogeneous soil and water environments. Thus, future non-point source pollution management policies are likely to rest heavily on statistical analyses which characterize potential impacts in terms of probabilities.

There is a major research thrust to characterize the uncertainties surrounding the transport of non-point source pollutants in the water environment. A project at UC Davis focuses on the development of a stochastic model describing both overland and subsurface flows of drain waters arising from excess application of irrigation water. Another stochastic modeling effort at UC Berkeley focuses on the transport of organic contaminants in ground water. A recently completed project at UC Riverside has identified several important sources of heterogeneity in the field and concluded that non-point source pollutants may move to ground water at much faster rates than previously thought.

All of this work is essential in developing the capacity to predict the environmental consequences of widespread use of chemicals of all types. This information will ultimately be helpful in deciding which chemicals must be banned and which may be susceptible to management in the environment.

3. Identification of Treatment Technologies

It is often argued that the most cost effective way to manage non-point source pollution is likely to be through controls at the source. The validity of this principle depends, in part, on the fact that treatment of waters polluted by non-point source emissions is enormously expensive. The development of inexpensive treatment technologies might ultimately make it cheaper to treat polluted water rather than engaging in source management. Past non-point source emissions are now beyond source control and cost-effective treatment technologies are needed to deal with the consequences of these emissions. New and promising technologies are being developed and evaluated by a number of researchers.

Investigators at UC San Diego are attempting to understand the chemical bases of new ways for removing phosphorous and nitrogen from receiving waters. Although this research is still very preliminary in nature, it has led to federal support of an ambitious development effort. This work could ultimately have very important applications to the management of nitrate contamination of ground and surface waters. At UCLA and UC Berkeley, projects are underway to investigate further the use of biologically activated carbon in removing organics. Research at UC Berkeley examines potential new means of regenerating activated carbon and managing the wastes which are associated with the use of activated carbon treatment technologies. Investigators at UC Davis and at Humboldt State University are assessing the promise of using artificial wetlands to treat waste water. Artificial wetlands are being field tested in coastal regions as well as at a high altitude setting in the Lake Tahoe Basin. The initial results are quite promising.

Finally several projects are underway to evaluate the use of evaporation ponds in managing agricultural drainage waters. Although the use of drainage ponds does not represent a long-term solution to non-point source emissions from agriculture, successful development of design and management criteria for such ponds would buy time while other ways are found to deal with non-point source emissions from agriculture.

4. Identifying New Management Practices

Research aimed at identifying the effective and inexpensive ways of managing non-point source emissions at the source continues. Much of this work will contribute to the establishment of Best Management Practices in the future. Several projects are underway at UC Davis focused on devising better ways to manage furrow irrigation systems so as to reduce run-off and deep percolation. Previous University research identified the non-uniformity of water infiltration in irrigation as a major cause of excessive deep percolation and run-off. One of the current projects assesses the extent to which surface irrigation systems

can be managed in the face of non-uniform infiltration to optimize crop yields while reducing both the volume of drain water and aggregate chemical emissions from agricultural lands.

While there is much work focused on the development of techniques for minimizing or eliminating non-point source emissions, too little attention has been given to the development of incentives which would cause water users to reduce emissions voluntarily. Projects sponsored by both the Water Resources Center and the Salinity and Drainage Task Force focus explicitly on the issues of incentives. The Task Force has sponsored a number of investigations of decentralized incentives, such as pricing rules, that could be employed to reduce emissions.

A project currently underway at UC Riverside is designed to demonstrate that foliar application of urea to citrus has no adverse impacts on costs or yields. It has already been demonstrated that foliar application of urea leads to a substantial reduction in nitrate loadings in ground water. If it can be demonstrated that foliar application is just as profitable as surface application, follow-up education programs may induce citrus growers to reduce nitrogen emissions voluntarily.

This brief overview of current research suggests that the University is actively involved with a broad range of problems related to the causes, effects and resolution of non-point source pollution problems. The emphasis of much of this work is on non-point source emissions from irrigated agriculture. This overview also suggests that there are areas which are relatively neglected. The management of watershed lands to preserve water quality and the contribution of urban run-off to water quality degradation are two such areas. Additional efforts are also needed to develop institutions and incentives for the management of non-point source emissions.

University of California researchers will continue to address a broad range of problems related to non-point source emissions. The results of conferences such as this will be helpful in identifying priority topics for organized research and ensuring the University research continues to complement its counterparts in government and private sectors.

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**SESSION XI: SESSION CHAIRS' REPORTS ON NPS POLLUTION–TECHNICAL ISSUES**
Session Chair: **Darlene Ruiz, CA**

2:30 p.m. **ROUNDTABLE DISCUSSION AND RECOMMENDATIONS** XI-A
Kenneth Tanji, CA
Steve Pirner, SD
Carol Jolly, WA
Don Ostler, UT
Richard Nichols, OR
Charles DuMars, NM

3:30 p.m. **A D J O U R N M E N T**

Information on Speakers XI-B

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July 25-28, 1989

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Craig Bell:
1965 West. Gov Conference established W.S.W.C.
11 + 5 states
1st Water planning + development
mid 70's Water Quality State Cooperation

David Kennedy P.E. head of legal committee
Welcoming remarks

Darlene Ruiz chair Overview NPS technical Issues
Nonpt Pollution Challenge
(1) Nonpt S ≠ Agriculture
(2) Nonpt S very complex, need to select most critical impacts sources and aim to control these.
→ Need to improve monitoring $ need to id sources
Control? treatment, management
Objectives
(1) Technical issues + determine how interact w/ Fed Non + Point Source
(2) Monitor + Report Succ. Prog
(3) Develop direct for Council

Conclusions on Nonpt Source Pollution Survey
(1) Legal
(2) Water Qual Nonpt source (subcom.) Committees of WSWC
(3) Water Resources

Sect 319 Clean Water Act Nonpt Source Poll Control
State concerns: Funding inadeq + also fed!
Most controls based on state regs.
Fed regs 2nd any
Four Methods regulatory
(1) Pest reg
(2) Erosion Cont
(3) Forest Practice
(4) Septic Tank

States ranked impacts
(1) Grazing
(2) Ag
(3) Hyd/Hab Mod
(4) Irrig Return Flow
(5) Land devel
etc.

Kenneth Tanji Nonpt Source from Croplands
Ag mj of poll in Lakes 57% Hydro Mod 13%
Rivers 64% Urban Run.
What are poll salts, sed metals, Nutrients

Watershed maps for Surface
(1) Salts Rocky Mtn States → Texas
+ San Joaquin Valley
(2) Pest Resid - East US, San Joaquin
+ mid west
higher rainfall runoff
(3) Nutrient (N Phos)
Az S. Central Mid Tex Mid West Lake States
Fert + Sed loads

3 Animal Wastes BOD COD South Atlantic

4 Erosion/Sed Prod irrig. West States
small areas throughout 11

~~Effects based~~ factors affecting
1 Hyd / Clim
2 Soils / Geology

Man & Control
Sources & how get into

Sediment Production from Cropland
Erosion — surface
eg. KSLP — subsurface
— deep Groundwater

Salts
Ferts
Soil Weather
Irig Water

dissolved
Water → Surface runoff → Surface Waters
most → subsurface → Surface Waters

ppt out pick up more

Source Control
Drainage Water Reuse

Steve Pinner  Impact of Ag Chems

S. Dakota -
extensive Shallow aquafir
95% of drink water source

Ag Grazing Feedlots Dairies
Don Cotter -
Utah Program
Sediment, Nutrient, Salts
Ag 75% cause / Most is natural
Mineral / plus soils
Urban
Utah non reg approach
building permits

Clean Lakes Program success

Good efforts w/ other State + Fed Agencies
IAAs - (save $)
Work w/ Ag. Depart

Some BMPs cause other probs must be flexible + site specific. Continued maintenance of BMP critical

- Carol Jolly Overview Urban Runoff/Contract/Hyd Mod.
  Nonpt Source Survey
  ↳ all states have some reg on Stormwater
  Most "Performance Standards"
  Varied Management Programs

Washington /Puget Sound
  EPA des as Estuary of mj significance
  Stormwater runoff
    ordinances
    State DOT reg. deicing, Pest Control
    storm BMPs

- Start w/ large cities → small
all agencies cities, counties – reduce poll back
BMPs etc.
Monitoring data import
flexibility in solutions
Need for enforcement tools
Cooperative efforts
  Richard Nichols
    Silva Culture Issues
Related issues: Riparian, wetlands
  Protect roadless areas + old grove timber
Oregon Npt Source local controls
  Forest Practices Act

- Technology based stand + no follow-up monitoring
  Need to measure impacts on beneficial uses
  Cumulative effect,

- Monitoring Problems
  $ for nonpt.
  Monitor to check BMPs correct BMPs
  monitor more spend $ effectively

Lewis Dodgion Resource Extract + Land Disposal
Mining

Ag Drainage Control Technology Issues
USDI Overview Irrigation Studies
- Roy Schroder

Irrig Drainage Program
Purpose: Are there Irrig induced Problems in USDI areas?
Pot areas were reduced to Recon. investigations
+ then to 5 detailed study areas
Maps used to pick sites selenium, water quality
Recon Invest has irrig caused or will it
Cause damage to human fish
Sample sites, analysis for trace + Pest.
Detail Study
Cont Sources hydrology USDI food chain Fish Wildlife Contain Effects

- Then evaluate Mit. Alternatives

Drop + Maintain then long term mont.

Selenium most common pollutant
So focus on it
Imperial Valley Arri + Drinky

Sampled farm drain sumps
hi correlation between '86 + '88 results hi then, hi now. No simple pattern in Imp. Valley
In San Joquin simple patt evident

Edwin Lee Treatment + Disposal Options for Ag. Drainage
① Salt
② Nutrient
③ Toxic Trace Se, Boron etc
Treatment alternatives
Biolog Bacteria Fungal — Adsorption — Desalination (Reverse Osmos
Chemical ppt — Electrochemical
Pa

Irrig Induced Water Qual Problems
Jan Van Schilgaarde

Blain Hansen NPS from Ag in Calif.
Ag drain ① Subsurface tapping more water than need
② Surface Water in > absorption

- Effect on Irrig Ag.
  - Salinity
  - high water tables or poor irr water
  - Boron
    - affects crop yeild
  - Selenium & other toxics
- Trad use subsurface drain but need disposal!
- Use Evap ponds for disposal
  - Prob ponds attrack wildlife!
- Pest in ag drainge
- Surface runoff - carried in sediment to stream channels
- DDT + Toxaphene (old source now soil)

Humans
- Nitrate + Pesticides Grnd Water

Mitigating Problems

Farouk Ismail
- Bonds to provide low interest loans to farmers
- Program complicated

- Eucalyptus trees - disposal ???
  - Vashie Salinka

William Crooks

Drain continuous mon. under NPDES permit - remove toxics.

Bill Dendy SAWPA Santa Ana Watershed Project Authority
Santa Ana Regional Interceptor
intercepts salty water carries it to a waste water treatment plant then to Ocean.

Woodcrest Pipeline to improve applied water - replaces Col. River water w/ State Treated water

Arlington Desalter Pumps Groundwater (Carbon treatment) sell it to Met. Water Dis they sell it. Brine goes to SARI

2nd Desalter - intercept poor quality in Chino Basin treat salt, dump Brine into SARI

RIF Rapid Infil Denitrify water

WRRP West Reg Riverside Treat Plant
SFTP Stringfellow Treat at Leaky Dump Recovery Wells to treated then into SARI

Inplace Pollution. high Water table salty —
Need groundwater Basin for storage
But raise G.W + woops.

TDS in Unsaturated zone?

Program to increase Ground Water w/ State Project Water
Recharge in Wet years
Shortage years take out water
Or Earthquake

Irvine Desalter 6 mil gal/day
Past 4g.

Colored Water?

How do you remove Nitrate from vadose zone?
Only way now leach N to Sat zone
pump + treat.

Use imported water - Pcr source

Ag. Chemicals 7/27/89

Marshall Lee Control of Rice Herbicides in Calif Waterway
Sacramento River recieves ~~runoff~~ excess water from
Rice fields -
Sacramento - "taste" problems
specifically Balaro - used to control water grass

2 Chemicals ① Very volitle so leave on field longer
② Soil acts as reservoir, persistant very absorptive
↳ hold limited sale, nondischarge district, 30day

levels have decreased since these actions taken
'83 → 89

1986 ③ Pesticide soluable photoactive + by microbio - used for sedge control.
all water retained from applic → harvest
Emergency release 10 days.

Steven Mark Ground Water Quality Activities - Calif Pest. Management Plan.
1985 Pest. Contain Prevention Act.
AZ has it 3 components
① Data Collect + Management Prevention approach
set values in study catagories

which pest are likely to leach to Ground water.

(2) Response Mode
Report Pest. detection in Soil or Grnd Water
(3) Well water Quality - data collection process (Annual reporting to Legislature

Pesticide Management Zones
Use BMPs to modify Pest. uses
Groundwater protection plan
Tier #1 Response Chemical
Potential to Pollute
Known Leachers - have found them
Tier #2
Potential to Pollute
Suspected leachers

Tier 1
Modify use
Designate Pest Man Zone
" as Calif Restricted
Use requires - Permits require in Zones
- RA Advisor written rec.
Prohibit where necessary
Compliance Monitoring

- * Man. Zone 1 mi$^2$ unit

R.A. Jackson Industry Perspective on NPS Groundwater Issues
(Dupont)

8/18 PCA - liability ?

- Don Ostler U.T.

Carol Russell
→ Ag 1° Impact Nonpt Source
+ grazing

1986
Navigable waters
Grnd Waters - pt + nonpt

Loren Bahls
Montana's NPS Pollution Monitoring Strategy

- 2 more citrus > dwarf 24" box 1000
2 beds
① geraniums - $100
② Margaret daisy 50
③ Sansevieria + annuals 100
Tree 250

1250 drill dive + plant w/ spec. soaker hose?

Al Murray Idaho's Ag Poll Abatement Plan
Irrig + dryland farming

as long as progress is made (reflected by monitoring)
reviewed every 5 years
Nonregulatory
Developed target Watersheds
Farmers need help to ~~assist on~~ id solutions
educ of farmers
Incentive for BMP implementation
Farmer must be involved as = partner
in develop implementation

Michael Sauer North Dakota
Spirtwood Lake Restoration (1980-1988

IV Carol Jolly

Stormwater + Npt Source Pollution in Puget Sound
Nancy Hansen Puget Sound Water Quality Authority
Estuary - 10 mj River systems drain into
closure of shellfish beds - bacteria
SW controls 8 Mar stormwater collect system
More Urban = More agress Source invest Emerg Resp
Public Ed local #
Combined Sewer Overflow (CSO)

Nonpt Source

On watershed basis
Ea County ID watershed & Rank
then develop Action Plans for hi rank WS.
Gov + Pub + Priv have to address all NPS
in Watershed. Voluntary → Reg approach depend
on what is effect & appropriate Plans approved
by Dept of Ecology.

Puget Sound nonpt, Plan! Green

David Ziegler Lake Tahoe NPS Control Program
Tahoe Regional Planning Compact
(Bistate Calif/Nev 1969)
Plan developed (NPS)
Algal productively increase 150% since 1968
Clarity ↓ since 1968
Nutrient balance off
Under natural conditions little erosion
Watershed acts to cleanse runoff
Prob Develop ↑ erosion ↓ watershed ability to clean
Preserve nat. areas" control devel
Limits on impervious land cover
BMP for new develop
Vol + Reg retrofit BMPs
Wetlands Protect + Restoration

Dave Wyatt Northwest Colorado
Basinwide Approach to NPS
Hydrologic Modifications
Politics
Dillon Reservoir

1982 Clean Lake Study

"bubble concept"
control collective impact of pollut - fluct
places but meet overall load.
pollution credits

David Black Anchorage
Sediment Treatment Systems for Urban Drainage

1977 Section 208 studies
Past
Water Quality Enhancement
Structural
Nonstruct - zoning ordinance for Erosion
- Street sweep altered
Oil + Grease separator
Present
Sedimentation Basins being constructed
Design Manual for Sedimentation Basins
100% removal of 20 μ

Sus solids
① Sediments clog salmon beds
② Food chain messed up
③ Toxic Trace Metals

Bacteria Problems
Sedimentation Basins typically don't affect
~~do remove some~~.

Steven Richie San Fran Bay
L Calif Regional Water Quality Board
Reduced pt source Poll 80-90%
avg past 10 yrs.
But Stormwater control.
Drainage from Petroleum Refineries

Dry weather Runoff
+ Wet Weather runoff!

Marshy Area to clean-up
~~Detention Basins~~
Wetlands
bioaccumulation - flush by big flood!

Need good flow data for good monitoring
program

TDC
- grassed 4 miles + "wetland"
  - → Restoration after my floods
  - → Engineer for min damage for 5, 10, 20 yr storm
  - → Restoration after 100 yr flood event?

Algae in Channel bottom

EMF Sedimentation basin
- → Queen Creek! Heavy metals

ID monitoring
- Proactive
  - Education + "Passive" Controls
- Group into seasons Wet Summer
- Comparison Urban Rural

North Carolina State University Water Quality

Workplans | Item | due | comp

(9)

- Pat Blodgett — agency Partnership for NPS Poll. Control

Contact Noncontact Recreat
Shellfish

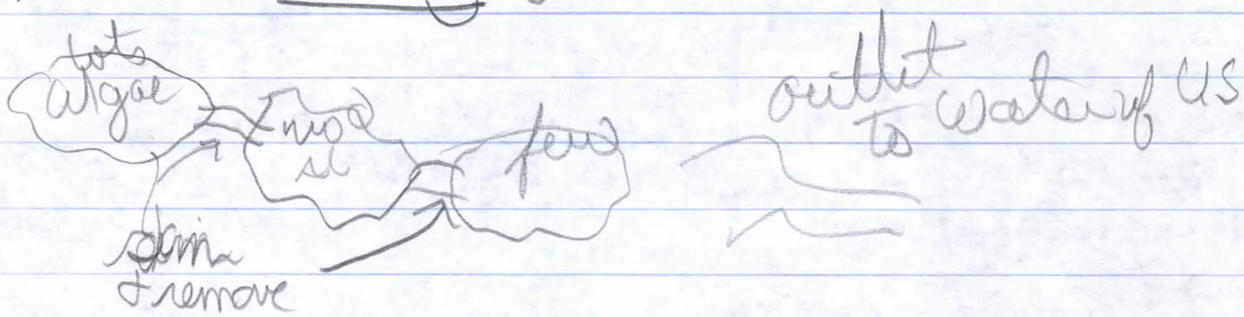
Orange Control FCD
2 Masterplan w/ Sediment Basins

~~Sandbags~~ during winter Months
foothill basins

Grass lined channels / wire + brush, drop Structures

- Channel basins:

(*) What is the role of Algal Growth in reducing Nutrient Loading?

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Groundwater Contain
Gary Guymon
Redlands

degreaser

banned since 175

→ Grund Water TCE, DECP
in wells.

clean-up by use for irrig for Citrus
atm exposure - volatile chemical
Soil wet/dry cycle 50-100' unsat zone
Biodegrade by existing soil organis
& Dispersion w/in soil particles

black?

(1)

1/28/89

Silva Culture

Richard Nichols Oregon Dept of Environ Quality

Bob Duffy Wash Dept of Ecology
State of Washington Timber Fish & Wildlife Agreement

1986 Indians, timber indust, environ & State
Timber Fish & Wildlife Agreement
Compromise not legal but is a commitment
less heavy equip wider "bare" strips along waterways

Issues:
Need continue efforts to streamline process
Refine interaction at urban/forest interface

Dean Cromwell Calif. Forest Practice Rules Assessment
Assess whole plan
100 sites
field studies last 1 yr
results not used in effercement
Pay Political - perception > fact
Burden of Proof? Who ~~Must~~ have it.

Indy Leven

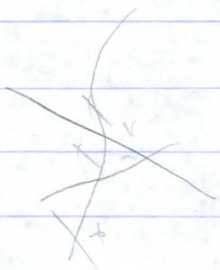
US Forest Service An Example of Successfull Nonpt Source Pollution Control through planning + program development

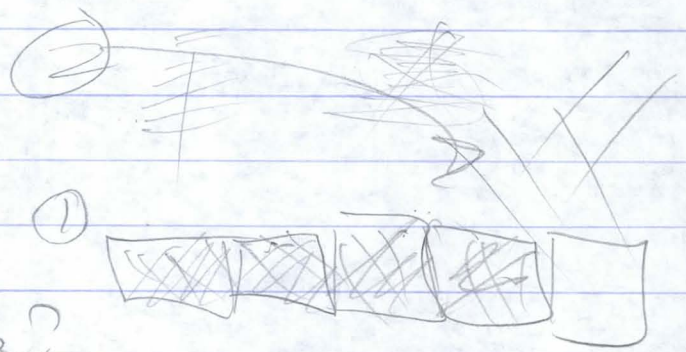
| States | Dischargers |
| --- | --- |
| Actively Solicit + encourage Part. | Become involved |
| Offer Support + technical | Develop controls |
| Encourage Formal Agreements | Become self regulating |
| Reduce Burden of NPS Reg | Voluntarily Participate |

Gilmurr

Gil Murray 208 The Endless Journey.

2500 acres or less — small operator can not afford to have their timber harvested Too expensive to met regulations.






RMZ Resource Man Zone?

Graizing impact Sargtum

Timber — short time

(3) SCS
low cost
Seed
Acid app

Polit BMP = PBMP

Mining

(3)

Jim Cooper Mercury
Nevada Carson River
1865 - 1895 Comstock Lode - powdered ore washed
→ used mercury 2 lb Hg / ton ore ~ 7,500 tons used

1983-85 Report EPA, RCRA funded study w/ State Nev.

Sediment high correlated w/ Hg concent.

Reservoir acts as sed basin & retains Hg -
but some Hg was transfered past reservoir
prior to dam construct 1915 -

Sig correlation between fish size + Hg conc.
1.00 ppm FDA action level,

— Mit
Monitor fish get a midzone feeder
w/ short life -

Alaska
Jerry Brossia Alaska Resources Extraction NPS Poll
Control Issue
(1) Class impared Mining Hg! NPS Gold
suspect God
prospect Oil

Cont of Grnd Water from underground Wastewater Disposal Systems
Upper Mohave Basin.

Septic Tank seepage pit (used 'cause caliche prevents leachbeds)

Texas
Wellhead Protection
Bead Cross

BLM NPS. Mineral Extraction