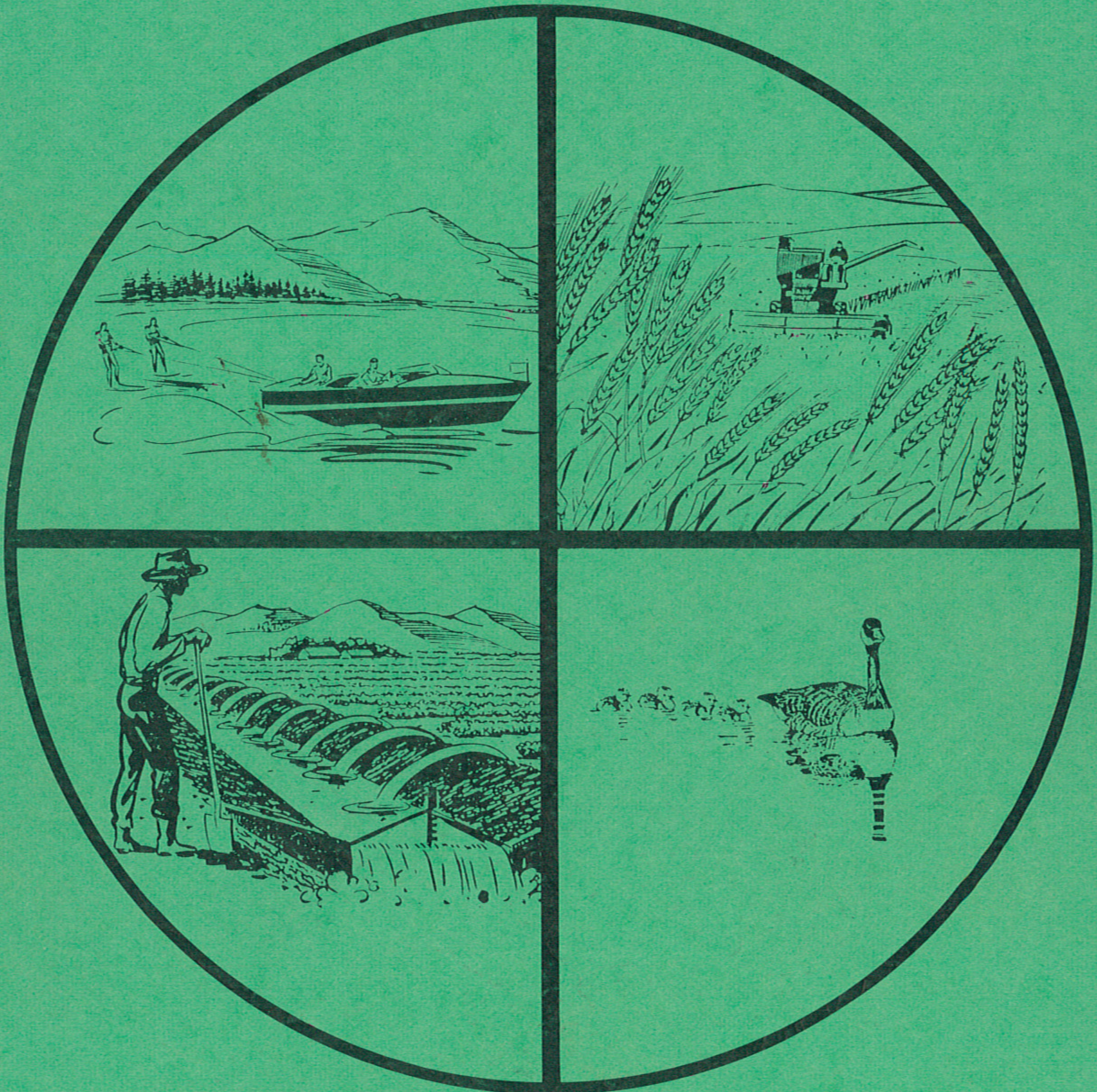
# MOSES LAKE CLEAN LAKE PROJECT
# STAGE 2 REPORT



PREPARED FOR
MOSES LAKE IRRIGATION
AND REHABILITATION DISTRICT

MARCH 1985

RICHARD C. BAIN, JR. CONSULTING ENGINEER
AND
MOSES LAKE CONSERVATION DISTRICT

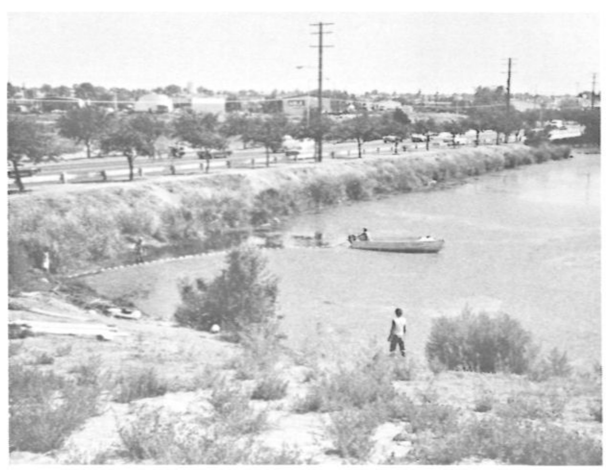
## EXECUTIVE SUMMARY

The Moses Lake Clean Lake Project was initiated in 1982 as part of an effort by a number of public and private agencies to improve Moses Lake water quality. Moses Lake has experienced extensive algae growth for over two decades, resulting in diminished recreational use of the lake. Nuisance levels of blue-green algae form unsightly floating mats in the summer recreation season. Aquatic weed growth is also a problem in some shoreline areas. Nitrogen and phosphorus are the major nutrients causing over-fertilization of Moses Lake.

The lake has been studied since the early 1960's to determine the causes of the algae blooms and to develop algae control mechanisms. Since the late 1970's, low nutrient water has been added to dilute a portion of the lake. Although this has resulted in a localized reduction of algae blooms, the dilution water is not always available. The Clean Lake Project is intended to provide for long term watershed nutrient controls to prevent further enrichment of Moses Lake.

(LEFT) Aerial View of Pelican Horn

(BELOW) Cleanup Crew Removing Algae Accumulations in Parker Horn



## STUDY AREA

Moses Lake is a large shallow lake centrally located in the State of Washington. The lake is regulated as part of the Columbia Basin Project which supplies water stored behind Grand Coulee Dam to over 500,000 acres of farmland. Moses Lake itself serves as a supply route for water passing from the East Low Canal, north of Moses Lake, south to the Potholes Reservoir, providing water to the lower part of the irrigation project. See Figure 1, location map.

Moses Lake is used extensively for recreational purposes, primarily fishing, boating and swimming. Residential and commercial development around the lake is oriented to lake views and recreational opportunities.

The total watershed for Moses Lake encompasses approximately 2,450 square miles (6,255 square kilometers). The major tributaries are Rocky Ford Creek and Crab Creek. Rocky Ford is spring fed and enters the main arm of Moses Lake from the north. Crab Creek drains over 80 percent of the watershed and flows into Parker Horn at the southeastern portion of the lake.

Much of the land in the Crab Creek watershed is devoted to agriculture. Irrigated cropping predominates in the lower watershed, while dryland wheat farming and cattle range are the major agricultural activities in the northern area. Coarse, shallow (Ephrata-Malaga) soils predominate in the southern Crab Creek watershed.

The City of Moses Lake, the major urban center in the watershed, is located on a peninsula which separates Parker and Pelican Horns. The city and surrounding urban fringe account for a population of approximately 20,000. The urban centers of Ephrata-Soap Lake (population 10,400) lie west of the watershed but contribute to the underground flow to Moses Lake. There are sewer systems in Moses Lake, Ephrata and Soap Lake, although much of the urban fringe and all of the rural population is unsewered.

## THE MOSES LAKE CLEAN LAKE PROJECT

The Moses Lake Clean Lake Project is a five year effort to restore water quality of the lake. The project is being conducted in three stages. Stage 1, completed in March of 1984 emphasized nutrient source identification through data collection and monitoring. Stage 2, completed in March of 1985, emphasized nutrient control demonstrations and analysis of the feasibility of control practices. Stage 3, to run from April of 1985 through March of 1987, will provide for the implementation of control practices which were analyzed in Stage 2.

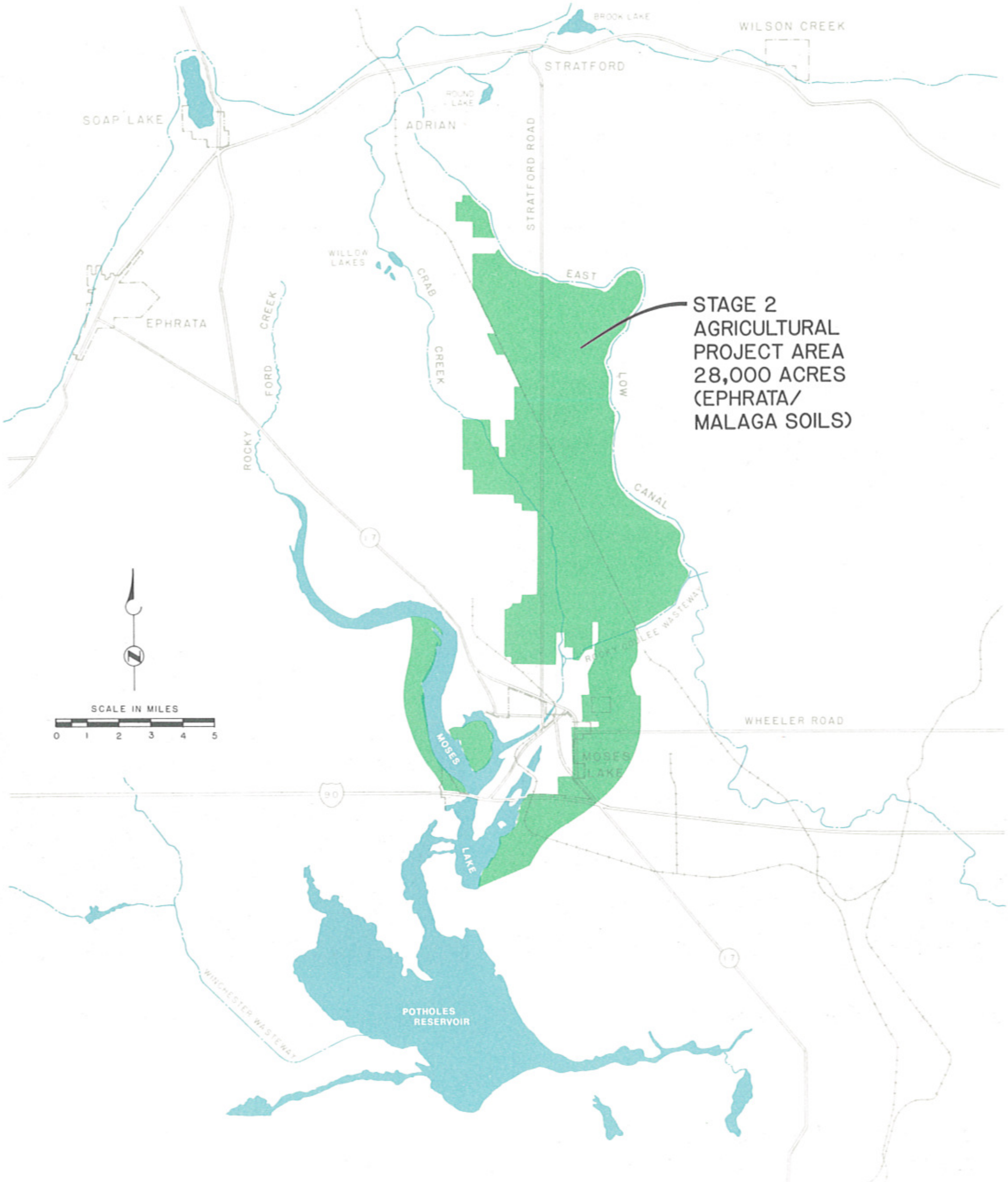
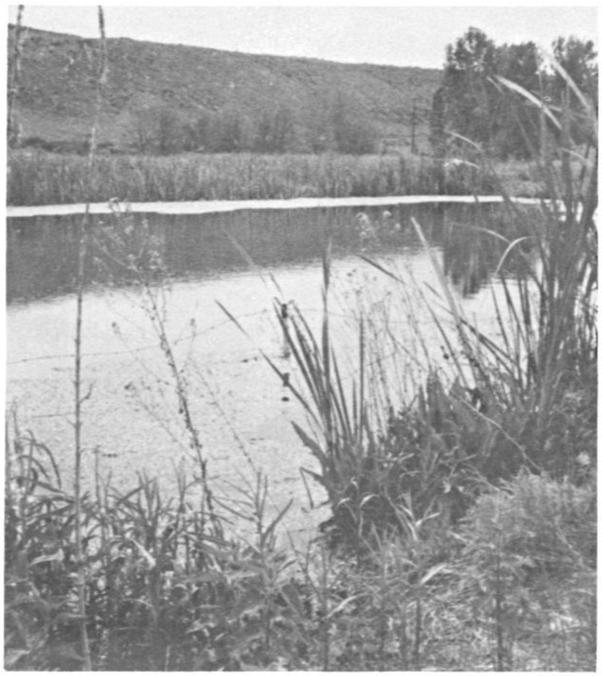



**Figure 1: Stage 2 Project Area**

The project is being funded by the Moses Lake Irrigation and Rehabilitation District, the Washington State Department of Ecology and the U.S. Environmental Protection Agency. Study participants also include the Moses Lake Conservation District, the Upper Grant Conservation District, the Grant-Adams Area Cooperative Extension, the Washington Conservation Commission, the Soil Conservation Service, and private engineering consultants. The technical staff operates from a project office in Moses Lake.

## STAGE 1 SUMMARY

Stage 1 focused on nutrient source identification. The Stage 1 effort included water quality monitoring and an inventory of existing farming practices in the watershed. Water monitoring included measurement of nitrogen and phosphorus in area streams and groundwaters and in the soil profile of irrigated farms. Data collected in the farm practice inventory included information on cropping patterns, acreage farmed, irrigation methods and fertilizer application.



Upper Rocky Ford Creek

Livestock Grazing Near Crab Creek

Data collected during Stage 1 indicated that farms in the area near Moses Lake are over-irrigating, causing deep percolation of water and nutrients (particularly soluble nitrates) in the coarse local soils. Total nitrogen losses from irrigated agriculture near Moses Lake were estimated in the range of 23.4 to 26.2 pounds per acre. Coincident with this, historical Crab Creek water quality data indicate that the highest average nitrate values occurred in years of high fertilizer use based on cropping pattern evaluations. Similarly, the lowest average nitrate concentrations coincided with the lowest fertilizer years. There are at least 28,000 acres of irrigated land in this area. Approximately 81 percent utilize sprinkler irrigation and 19 percent, furrow irrigation. Although furrow irrigation accounts for less than one-fifth of the irrigated acreage, it contributes over one-third of the nitrogen leached by deep percolation. Other sources of nutrients identified during Stage

1, include wastes from cattle operations, fish hatcheries, urban runoff, septic tanks and potential contributions from in-lake recycling of nutrients from carp and decay of aquatic plants.

Data from the off-farm monitoring program was used to develop nutrient budgets for the lake. The major sources of nitrogen included contributions from Crab Creek and groundwater. The nitrogen sources were linked to agricultural activity in the watershed between Stratford and Moses Lake. The major sources of phosphorus included Rocky Ford Creek and the City of Moses Lake sewage effluent which discharged to Pelican Horn until early 1984.

Stage 1 monitoring revealed that springs feeding Rocky Ford Creek were exceptionally high in phosphorus compared with springs monitored in Crab Creek. See Figure 2. The source of the high phosphorus load from Rocky Ford Creek was a subject for further investigation in Stage 2. The high phosphorus load was determined to be entering the groundwater basin from the Brook Lake-Adrian area along Crab Creek to the east. Impoundments such as Brook Lake trap much of the phosphorus from the Upper Crab Creek Watershed. Surface waters from this area recharge the groundwater basin tributary to Rocky Ford Creek.

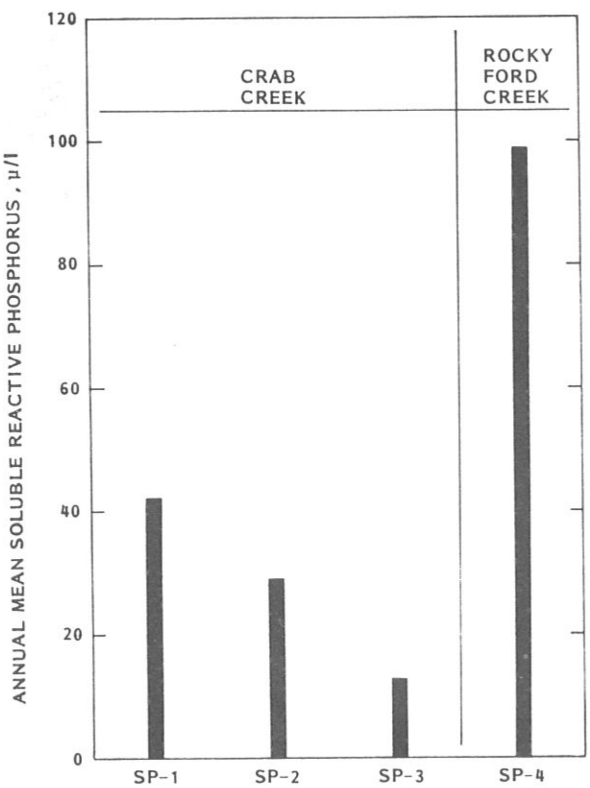
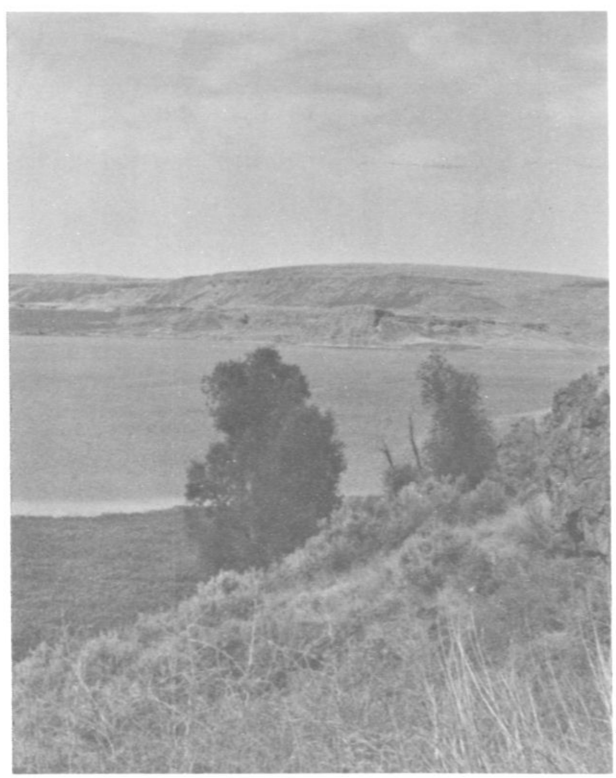



Figure 2: Phosphorus in Crab Creek and Rocky Ford Creek Springs



Brook Lake Traps Nutrients From Upper Crab Creek

## STAGE 2 SUMMARY

Stage 2 focused on the identification of nutrient controls and the evaluation of the effect of these controls on Moses Lake water quality. These included demonstration of Best Management Practices on local farms and a variety of other nutrient control approaches in the watershed and within the lake itself.

### On-Farm Nutrient Controls

Farm practices were analyzed by carrying out demonstration programs on four farms near Moses Lake during the 1984 irrigation season. The demonstration involved a combination of changes in irrigation equipment and changes in the management of irrigation water and fertilizer. Each demonstration field was monitored to determine the effect of the change in equipment or management practice on nutrient loss, irrigation water use, and crop yield. When compared to adjacent reference fields, the demonstration fields showed savings in water and nutrients as well as increased crop yields. See Figure 3.

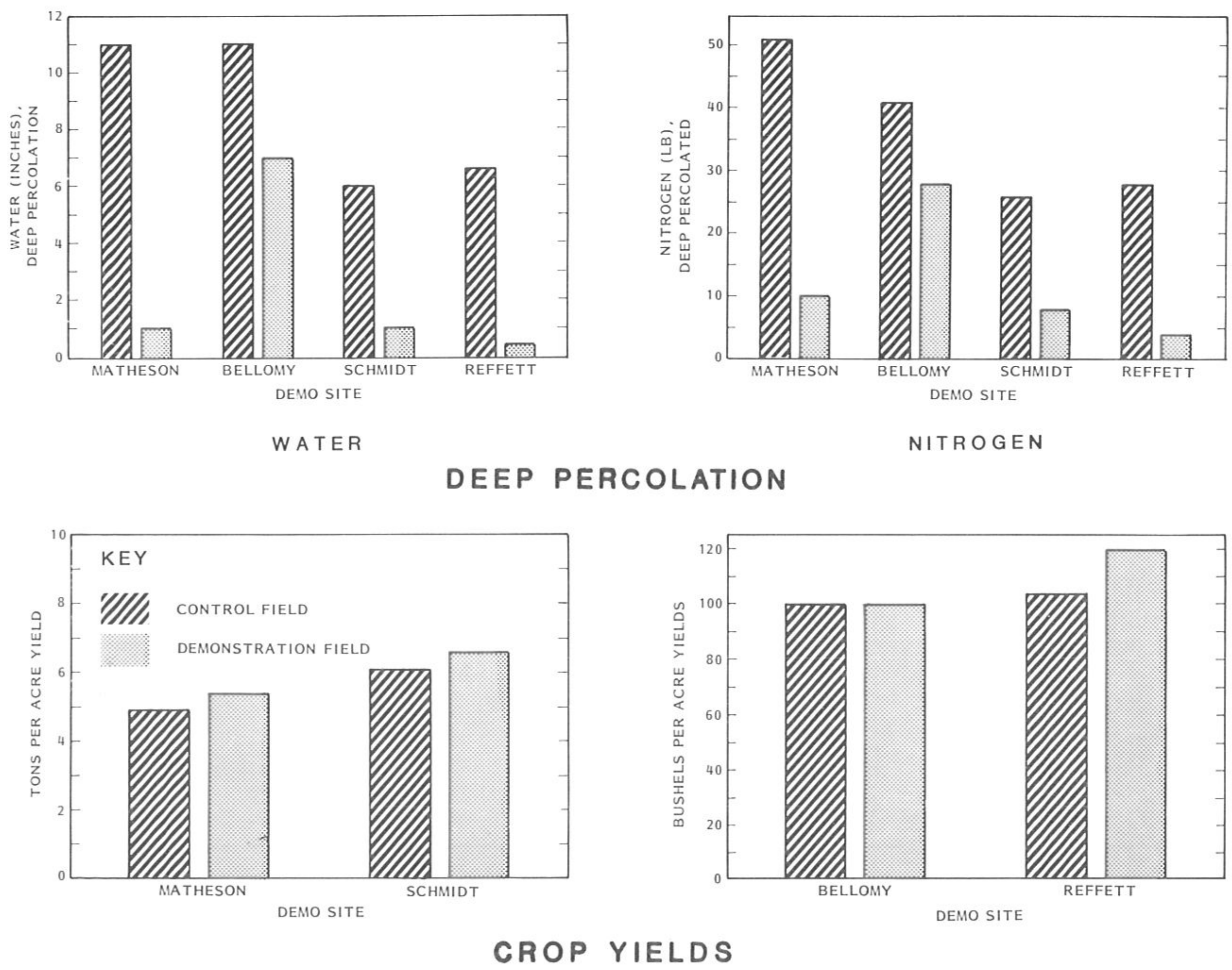
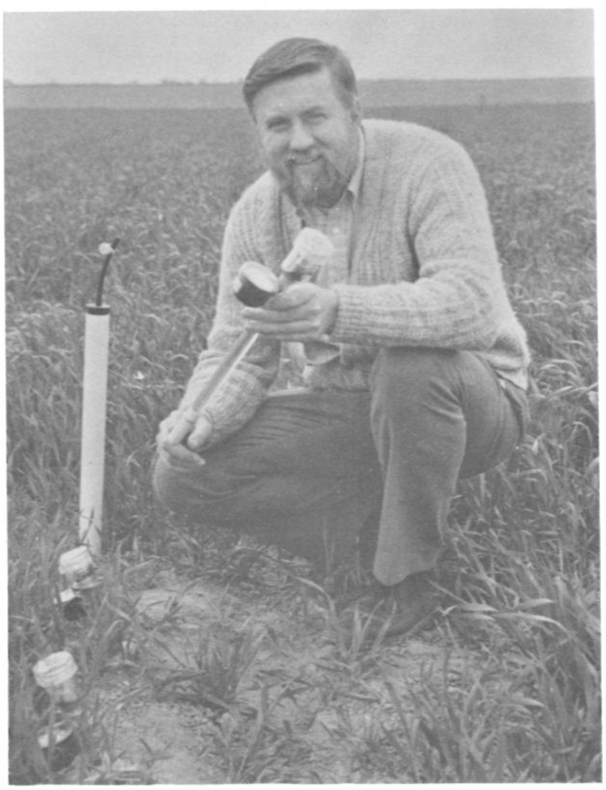



Figure 3: Farm Demonstration Results

Results from the demonstrations were then used to estimate the effect of implementing the demonstrated practices throughout the watershed. First, farmers in the 28,000 acre irrigation area near Moses Lake were asked to indicate their willingness to participate in a program implementing structural and management changes on their farms. Farmers representing 77 percent of the project area indicated they would participate. Ten model farm plans, or Water Quality Management Plans, were then developed from a representative sampling of these cooperating farms. In developing each plan, the farmer worked with the project staff in evaluating alternatives before deciding on practices which would meet his farming needs and Clean Lake Project's criteria. The farm plans described appropriate changes in equipment and management practices. Average costs of implementing these measures were developed. Nitrogen, water savings and crop yields were then estimated for three levels of participation, ranging from the full use of all practices identified in the plans (including major structural programs such as center pivot conversion) to partial use of identified practices (emphasizing primarily irrigation scheduling). The cost-effectiveness of these three levels (A, B, and C) then were analyzed, using average implementation costs which had been developed for each of the ten model farm plans. See Table 1.



Monitoring Equipment Used in 1984 Irrigation Water Management Demonstrations

An Irrigation Water Management Demonstration Project

## Table 1: Summary of Control Alternatives

| Control System | Estimated Cost ($) | Control Approach | Nutrient Load |
|---|---|---|---|
| Dilution | N/A[a] | Low nutrient release from USBR East Low Canal | No[a] |
| Irrigation Controls[b] | | Improved irrigation water and fertilizer systems and management | |
| Level A (initial)<br>Level A (projected) | 4,566,480<br>5,521,200 | Level A - Full cost share program<br>Initial 12,720 acres<br>Projected 21,560 acres | Yes |
| Level B (initial)<br>Level B (projected) | 2,814,560<br>3,479,800 | Level B - Restricted cost-share on system conversions<br>Initial 9,880 acres<br>Projected 17,640 acres | Yes |
| Level C (initial)<br>Level C (projected) | 3,859,970<br>4,634,100 | Level C - Restricted cost-share emphasizing scheduling<br>Initial 10,750 acres<br>Projected 16,900 acres | Yes |
| Alder Street Fill | 40,000 | Channel circulation improvements - Upper Parker Horn | No |
| Pelican Horn Crossings | 105,000 | Circulation improvements - Pelican Horn | No |
| Carp Control | N/A[b] | Eradication in Rocky Ford Creek | Yes[c] |
| Dredging | c | Upper Parker Horn deepening for weed control | No[d] |
| Weed Harvesting | d | Limited removal of dense weeds along shore | No[e] |
| Rocky Coulee Wasteway Pumped Irrigation Drainage | 44,400 | Diversion of nutrient-rich water to irrigation canal | Yes |
| Rocky Ford Creek Detention Pond | 74,100 | Trapping of nutrients in pond | Yes |
| Upper Crab Creek Detention Pond | 79,800 | Trapping of nutrients in large pond/marsh system | Yes |
| Lower Crab Creek Detention Pond | 29,600 | Trapping of nutrients in pond | Yes |
| Rocky Coulee Tributary Detention | 5,000 | Detention below dairy & hatchery | Yes |
| Westside Feed Lot Containment | 10,000 | Containment of animal wastes | Yes |
| Miscellaneous Livestock Controls | 30,000 | Control of cattle access to lake and tributaries | Yes |
| Septic Tank Controls | 8,650,000[f] | Connection of urban areas to sewer | Yes |

a - Dilution water is provided by the U. S. Bureau of Reclamation at no cost during years when it is feasible to use Moses Lake as a feed route to Potholes Reservoir. Nutrient concentrations in Moses Lake are lowered by dilution although nutrient loading to the lake is increased.

b - Costs shown are initial total costs including both government cost-share and farmer share based on Model Plan level participation per Table 6-4.

c - Carp would be eradicated by the Department of Game; carp disturb bottom sediments and vegetation causing resuspension and recycling of nutrients.

d - Dredging would help control weed growths primarily by reducing available light to submerged plants which grow from the lake bottom; estimated costs range from $50,000 to $850,000 depending on the extent of dredging.

e - Aquatic weed harvesting would remove some plant material from the lake; costs for two harvests per year are estimated at $22,000 annually assuming a harvester is purchased.

f - Septic tank control cost based on sewering assumptions described in Chapter 5; septic tank policy development cost is $5,000 of staff time

The most cost-effective approach was determined to be Level B Irrigation Control which was a mix of cost-share programs involving some equipment improvements and water and fertilizer management. The estimated nitrogen and irrigation water savings associated with Level B controls are shown in Table 2. These savings are estimated for the initial 9,880 acres involved and the 17,640 acres projected under full participation by cooperating farmers.

Table 2: Estimated Fertilizer and Irrigation Water Savings

| | Initial Watershed Controls | Projected Watershed Controls |
|---|---|---|
| Participating Acreage | 9,880 | 17,640 |
| Nitrogen Savings (lbs) | 208,100 | 372,200 |
| Water Savings (acre-ft.) | 5,780 | 10,319 |

## Miscellaneous Nutrient Controls

Miscellaneous nutrient controls were also evaluated, including detention ponds to trap phosphorus associated with suspended sediment from tributaries; control of runoff from livestock operations; more stringent local septic tank regulations; and projects in the lake or tributaries including dredging, weed harvesting, carp eradication and circulation improvements around existing causeways and bridges. The most cost-effective controls from this evaluation included sediment detention ponds on lower Rocky Ford Creek, lower Crab Creek, and on tributary waterways discharging to Rocky Coulee Wasteway; eradication of carp in Rocky Ford Creek; and fencing of livestock in the lower Crab Creek area. In addition, a septic tank policy is recommended for consideration by the City of Moses Lake and Grant County which would place greater restriction on septic tank designs in a defined lake sensitive zone.

## Project Related Benefits

Project-related benefits include Moses Lake water quality improvements, savings in farming costs, and increased crop yields. A mathematical model, developed specifically for Moses Lake at the University of Washington, was used for the water quality analysis. Algae content of the lake was based on simulated chlorophyll concentrations. Chlorophyll content dropped from 17 to 30 percent as a result of initial and projected nutrient controls. See Figure 4. Greater improvements were predicted when watershed nutrient controls were supplemented with dilution water releases. See Figure 5. The value of these water quality improvements was estimated to be in the $250,000 to $500,000 per year range.

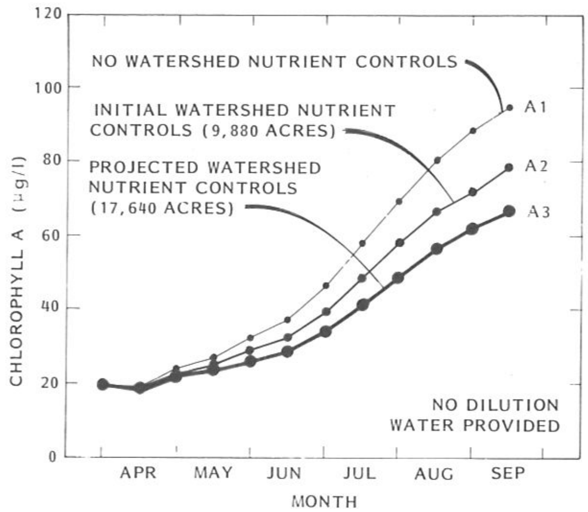



Figure 4: Predicted Chlorophyll Concentrations with Watershed Nutrient Controls

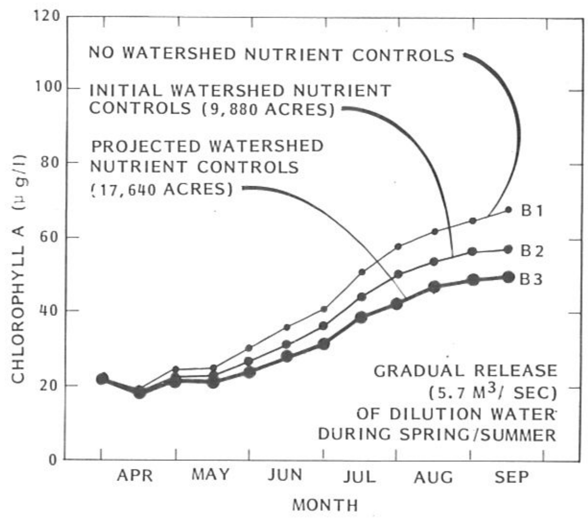



Figure 5: Predicted Chlorophyll Concentrations with Dilution Water Release and Watershed Controls

Farm-related benefits including savings in nitrogen fertilizer and irrigation water and increased crop yields are summarized in Table 3.

Table 3: Monetary Benefits of Watershed Controls to the Moses Lake Area Farms

| | ($/year) | |
|---|---|---|
| | Initial Watershed Controls | Projected Watershed Controls |
| Fertilizer | $ 52,000 | $ 93,000 |
| Irrigation | 43,200 | 77,400 |
| Crop Yield | 444,600 | 793,800 |
| Totals | $539,800 | $ 964,200 |

## STAGE 3

Stage 3 is envisioned as a multi-year program to implement cost-effective on-farm irrigation practice improvements and miscellaneous other nutrient controls which were identified in Stage 2 of the Clean Lake Project. See Figure 6. Technical assistance would be provided to participating farmers by Project staff and cost-share dollars would be reimbursed to eligible participants from the Stage 3 budget.

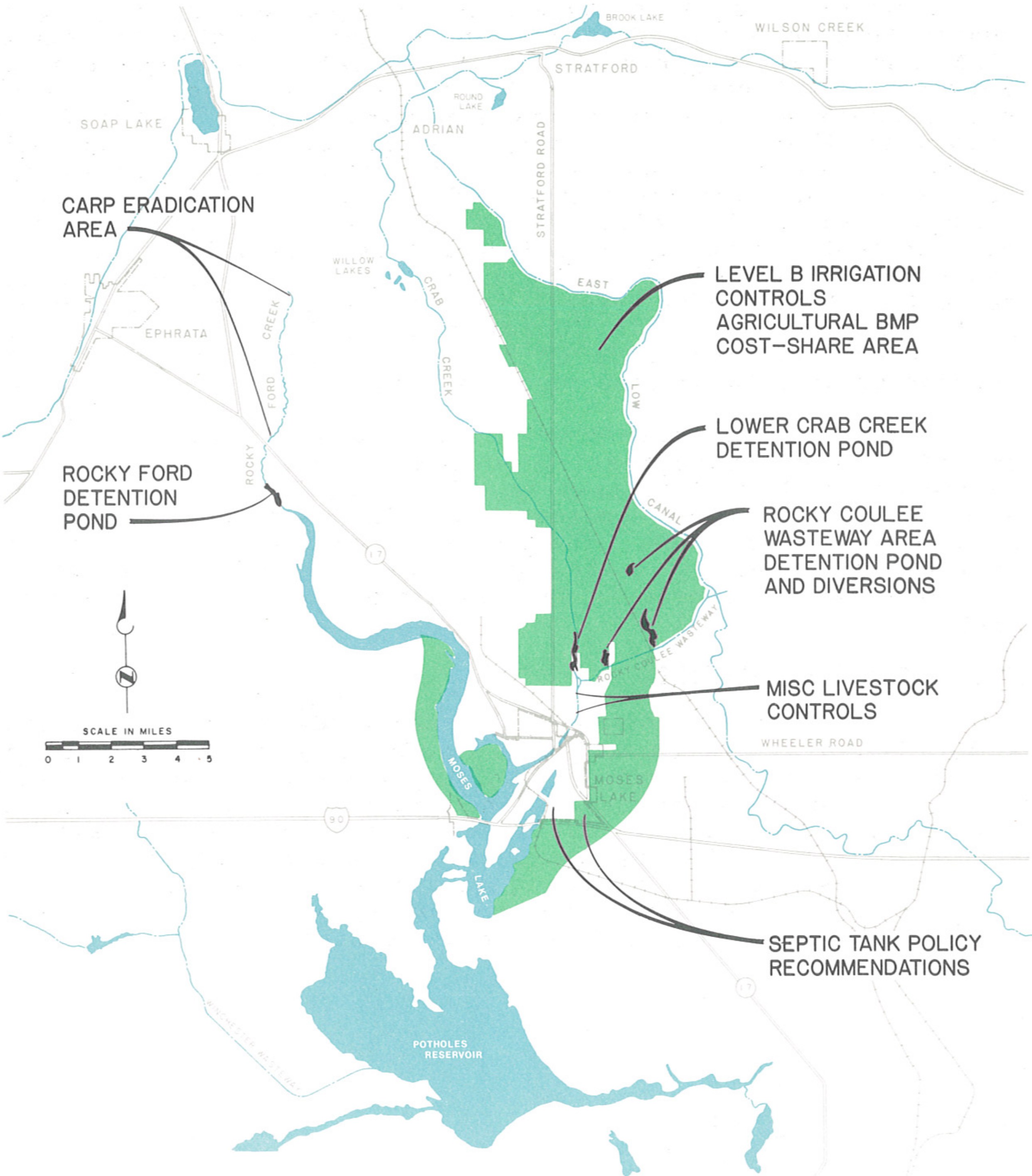



Figure 6: Recommended Stage 3 Watershed Nutrient Controls

## Cost-Share Program

A major feature of Stage 3 is a unique cost-share program funded through grants from the Environmental Protection Agency (EPA) and from the Agricultural Stabilization and Conservation Service (ASCS) cost-share budgets. Farmers who sign up to participate in the cost-share program will be rated and prioritized according to their contribution to Moses Lake nutrient loads. Funding will be provided for technical assistance and implementation of management and structural practices which will reduce the on-farm deep percolation of water and nutrient loading of groundwater from irrigation operations. Cost-share money will also be available to eligible livestock controls. Eligible structural improvements, such as irrigation system conversions from furrow practices to cablegation or sprinklers and pipeline or pumping improvements will be reimbursed at a 50 percent cost-share rate.

The use of management practices, such as installation and use of soil moisture testing equipment and soil sampling for nutrients which will be used in scheduling irrigation water and determining fertilizer applications, will be reimbursed at a 75 percent cost-share rate. The maximum cost-share available to a participating farmer is $50,000. More detailed information on the cost-sharing program is available from the Clean Lake Project staff.

## Post Project Monitoring

Post project monitoring will conclude Stage 3. Moses Lake and tributary waters will be monitored to determine the effectiveness of the project. Chlorophyll concentrations, algal type, nutrient concentrations and water transparency in Moses Lake will be evaluated. Nutrient concentrations will also be evaluated in the inflowing water from locations sampled in Stage 1. Final post-project sampling will be completed by the end of September 1987. Results of the monitoring work will be described in the project and appropriate annual reports.

Weed Harvesting Demonstration

Stage 2 Demonstrations Involved Local Farmers

# MOSES LAKE CLEAN LAKE PROJECT

## STAGE 2 REPORT

PREPARED FOR

MOSES LAKE IRRIGATION AND REHABILITATION DISTRICT

BY

RICHARD C. BAIN, JR.
CONSULTING ENGINEER

AND

GRANT COUNTY CONSERVATION DISTRICT

MARCH 1985

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# CHAPTER 1

# INTRODUCTION

Moses Lake is a large freshwater lake located near the geographic center of Washington state. The lake is shallow and over fertilized with nutrients from an extensive watershed encompassing over 1.5 million acres. The predominant land use in the watershed is agriculture including dryland wheat farming, irrigated cropland and livestock grazing. Urban areas including the City of Moses Lake have developed around much of the eastern portions of the lake which is extensively used for recreation by local residents and visitors. See Figure 1-1.

The lake is also an integral part of the U.S. Bureau of Reclamation Columbia Basin Project which supplies irrigation water to over 500,000 acres of farmland from Grand Coulee Dam on the Columbia River. Moses Lake serves as a supply route for water passing from the East Low Canal, north and east of Moses Lake, to the Potholes Reservoir, for eventual use by irrigators to the south. See Map Figure 1-2.

Moses Lake has experienced extensive blue-green algae blooms for over two decades, resulting in diminished recreational use of the lake. The lake has been studied since the early 1960's to determine the cause of the noxious blooms and to develop algae control mechanisms.[a, b, c] During the late 1970s, a restoration program involving dilution of the lake with low-nutrient Columbia River water was implemented.[d] The success of the dilution program in reducing localized algae blooms resulted in the construction of a permanent dilution facility in 1981 to further distribute dilution water within Moses Lake.

Although the dilution program was successful in reducing algal blooms, it is also desirable to reduce the nutrient load

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[a]Sylvester, R.O. and Oglesby, R.T., <u>The Moses Lake Water Environment</u>, Report by University of Washington, Dept. of Civil Engineering, 1964.

[b]Welch, E.B., et al, <u>Plankton Community and Hydraulic Characterization Preliminary to Lake Flushing</u>, Final Report University of Washington, Dept. of Civil Engineering, Oct. 1969.

[c]Welch, E.B. et al, <u>Alternatives for Eutrophication Control in Moses Lake, WA</u>, Report of Dept. of Civil Engineering for Moses Lake Irrigation and Rehabilitation District, 1973.

[d]Brown and Caldwell, Moses Lake 1977 Pilot Project, June 1978.

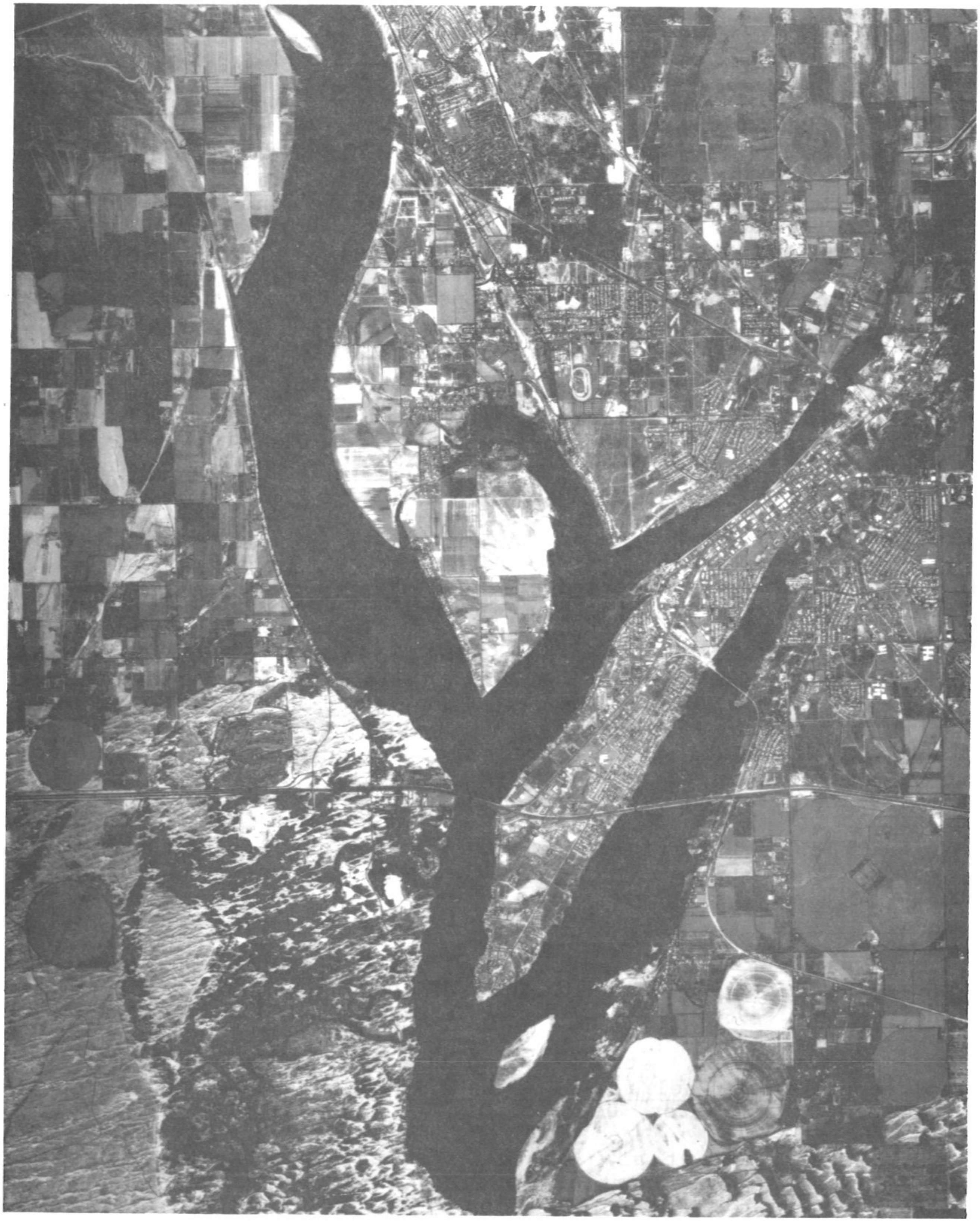

Fig. 1-1 Aerial View of Moses Lake

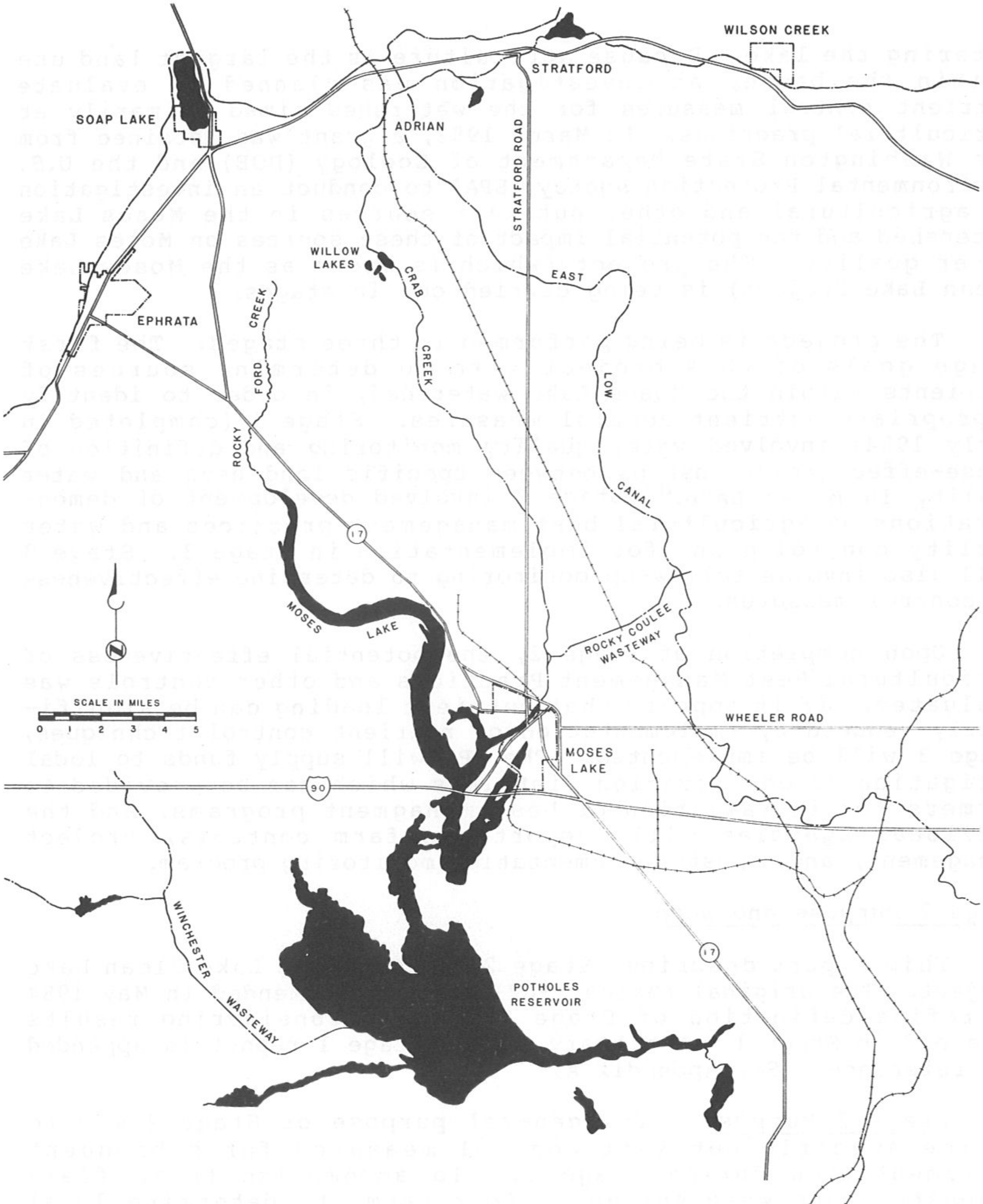


Fig. 1-2 Moses Lake and Vicinity

entering the lake. Because agriculture is the largest land use within the basin, an investigation was planned to evaluate nutrient control measures for the watershed aimed primarily at agricultural practices. In March 1982, a grant was obtained from the Washington State Department of Ecology (DOE) and the U.S. Environmental Protection Agency (EPA) to conduct an investigation of agricultural and other nutrient sources in the Moses Lake watershed and the potential impact of these sources on Moses Lake water quality. The project (which is known as the Moses Lake Clean Lake Project) is being carried out in stages.

The project is being performed in three stages: The first stage goals of this project were to determine sources of nutrients within the Moses Lake watershed, in order to identify appropriate nutrient control measures. Stage 1 (completed in early 1984) involved water quality monitoring and definition of cause-effect relationships between specific land uses and water quality in Moses Lake.[a] Stage 2 involved development of demonstrations of agricultural best management practices and water quality control plans for implementation in Stage 3. Stage 3 will also involve follow-up monitoring to determine effectiveness of control measures.

Upon completion of Stage 2, the potential effectiveness of agricultural Best Management Practices and other controls was evaluated. If it appears that nutrient loading can be significantly reduced by implementation of nutrient control techniques, Stage 3 will be implemented. The EPA will supply funds to local irrigation or conservation districts which can be provided to farmers for installation of best managment programs, and the DOE/local agencies will support non farm controls, project management, and a post-implementation monitoring program.

## Stage 2 Purpose and Scope

This report describes Stage 2 of the Moses Lake Clean Lake project. The original (March 1982) grant was amended in May 1984 to refine definition of Stage 2 efforts considering results obtained in Stage 1. A summary of the Stage 1 report is appended for reference. See Appendix A.

Stage 2 Purpose. The general purpose of Stage 2 was to define specific nutrient control measures for subsequent implementation during Stage 3. To accomplish this, field demonstrations were set up on four farms to determine local control effectiveness of several Best Management Practices designed to limit deep percolation of water and nutrients to groundwater. Additional information and controls were also

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[a]Brown and Caldwell, et al, Moses Lake Clean Lake Project Stage 1 Report, Prepared for Moses Lake Irrigation and Rehabilitation District, March 1984

developed for covering other nutrient sources identified in Stage 1, including both watershed and in-lake sources.

<u>Stage 2 Project Tasks</u>. Tasks developed for Stage 2 included work on a variety of topics as summarized below:

1. Determine the level of interest the local farmers have in participating in implementation of Best Management Practices.

2. Develop demonstration of irrigation water management systems and Best Management Practices on several local farms over one irrigation season on furrow and sprinkler irrigated fields.

3. Identify resources needed and select agency to continue management of irrigation water management systems in the project area.

4. Develop groundwater flow estimates considering groundwater levels from monitor wells to improve groundwater nutrient loading estimates. Evaluate nutrient sources in the watershed to determine possible cause of high phosphorus content in Rocky Ford Creek.

5. Evaluate septic tank leachate contributions to the lake nutrient load and communicate findings to the City of Moses Lake and Grant County.

6. Determine significance of nutrient loads, feedlots, dairies and other livestock operations and identify appropriate controls.

7. Evaluate and plan impoundments to reduce nutrient and sediment loads entering Moses Lake.

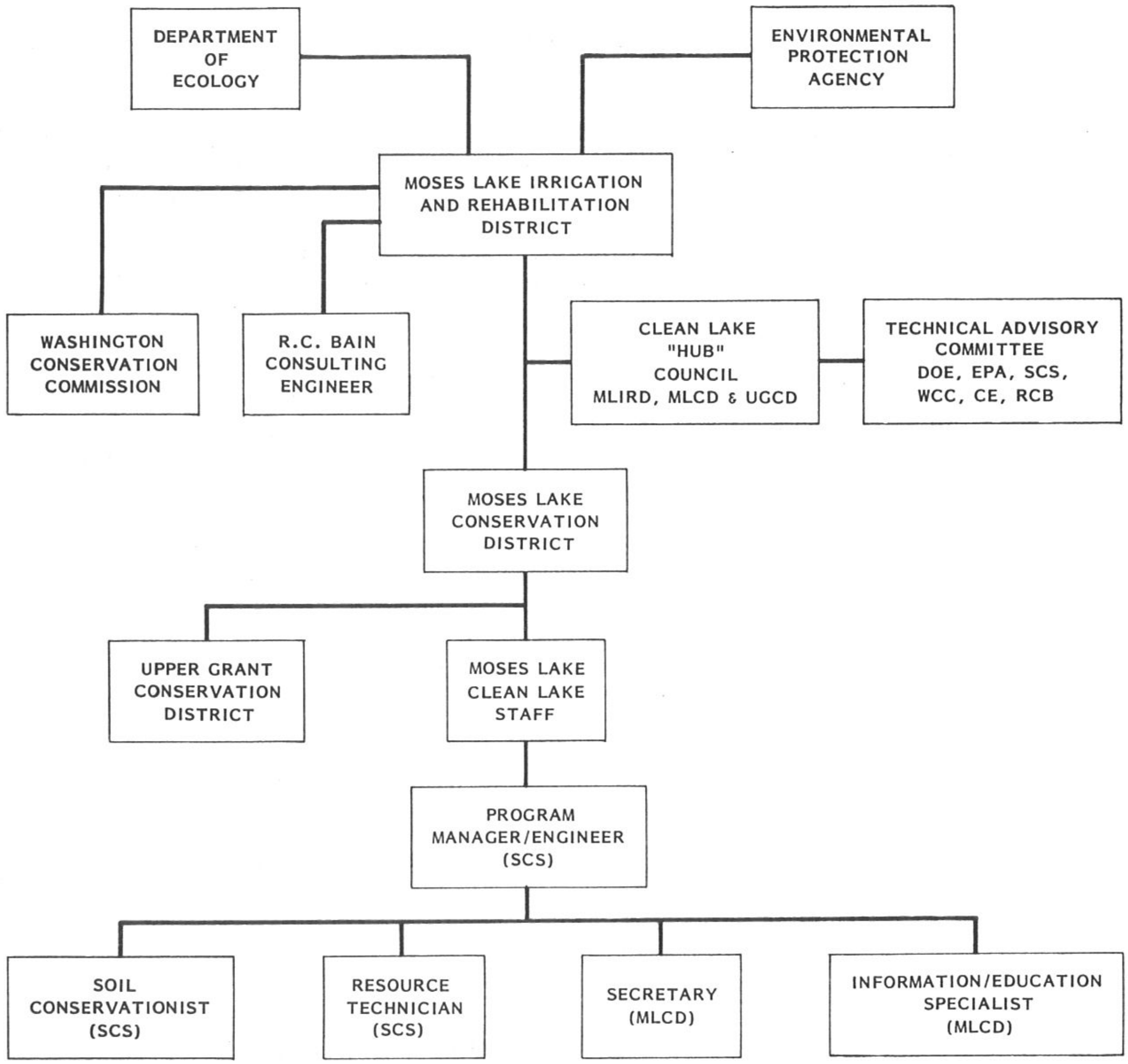
8. Evaluate in-lake controls such as dredging, carp control, and modifications to enhance water circulation in Moses Lake.

## Study Funding and Organization

The lead agency for the Moses Lake Clean Lake Project is the Moses Lake Irrigation and Rehabilitation District (MLIRD). Funding agencies include the Washington State Department of Ecology, the U.S. Environmental Protection Agency and the MLIRD.

The project was carried out by Clean Lake Project staff and consultants under subcontracts to the MLIRD. See Organization Chart Figure 1-3. The Clean Lake Project staff based in Moses Lake was staffed by employees of the Moses Lake Conservation District (MLCD) and personnel assigned to the project by the Soil Conservation Service (SCS). The MLCD operated under contract agreement with the MLIRD and subcontracted portions of the work to other agencies such as the Upper Grant Conservation District

## MOSES LAKE CLEAN LAKE PROJECT
## ORGANIZATION CHART




**LEGEND**

| | |
|---|---|
| RCB | RICHARD C. BAIN JR. (CONSULTING ENGINEER) |
| CE | GRANT/ADAMS COOPERATIVE EXTENSION SERVICE |
| DOE | DEPARTMENT OF ECOLOGY (WASHINGTON STATE) |
| EPA | ENVIRONMENTAL PROTECTION AGENCY (FEDERAL) |
| MLCD | MOSES LAKE CONSERVATION DISTRICT |
| MLIRD | MOSES LAKE IRRIGATION AND REHABILITATION DISTRICT |
| SCS | SOIL CONSERVATION SERVICE (USDA) |
| UGCD | UPPER GRANT CONSERVATION DISTRICT |
| WCC | WASHINGTON (STATE) CONSERVATION COMMISSION |

Fig. 1-3 Project Organization Chart

(UGCD) and the SCS. Other contractors with direct agreements with MLIRD included the Washington State Conservation Commission and Richard C. Bain, Jr., consulting engineer.

Agricultural demonstrations and other on-farm aspects of the project were the responsibilty of the Clean Lakes Project staff working under the direction of Leigh Nelson, project manager for this part of the work. Off-farm elements and overall responsibility for the project report were the responsibility of Richard C. Bain, Jr., consulting engineer.


Acknowledgments

This project has received financial, technical, and policy support from many agencies and individuals. Grant funds were provided to the Moses Lake Irrigation and Rehabilitation District by the Washington State Department of Ecology and the U.S. Environmental Protection Agency. Primary technical guidance has been through a Technical Advisory Committee (TAC) comprised of participant agency staff representatives. Policy guidance has been obtained through a three-member council (commonly referred to as the Hub) which included one member each from the Moses Lake Irrigation and Rehabilitation District, the Moses Lake Conservation District, and the Upper Grant County Conservation District.

Members of the TAC and the Hub are acknowledged below:

TAC Members:

Tom Newcomb/Bob Bottman, co-chairmen
Washington State Conservation Commission

Ron Pine, Washington State Department of Ecology

Elbert Moore, Martha Hoffman and Carl Nadler (retired 1984), U.S. Environmental Protection Agency

Ed Forster, Grant-Adams County Cooperative Extension Service

Shiraz Vira, Byron Fitch
Soil Conservation Service

Council Members:

DeForest (Huck) P. Fuller, Norm Estoos
Moses Lake Irrigation and Rehabilitation District

Bill Bellomy, Jr./Tom Elder
Moses Lake Conservation District

Les Rataezyk, Upper Grant County
Conservation District

Other agencies which provided reliable input to the study include the East Columbia Irrigation District (ECID), the City of Moses Lake, Grant County, the Moses Lake State Park, the Washington State Department of Game, the U.S. Bureau of Reclamation, and the National Park Service. Individuals within these agencies who were particularly helpful include Don Dunfield of the ECID, Steve Jackson of the Game Department, Rita Perstag, Public Works Director of the City of Moses Lake, and Bill Hewitt, Dan Hubbs and Francis Jensen of the U.S. Bureau of Reclamation.

The four cooperating farmers who participated in the field demonstrations deserve special recognition. These included Chris Matheson, Bob Reffett and Tracy Schmidt in the Block 40 area and Bill Bellomy, Jr. in Block 41. These demonstrations are described in Chapter 3. Assistance was received from many employees of the Soil Conservation Service offices in Moses Lake, Ephrata, Spokane and Portland. The assistance received from Tom Spofford, Irrigation Specialist, Karl Kler, agronomist, and Jay Kehne, soil scientist, in the field demonstrations was particularly helpful. Tom Ley, Irrigation Engineer with the Cooperative Extension, also provided valuable assistance in the demonstration work.

On-farm project elements were directed from the Moses Lake Soil Conservation District office by Leigh Nelson who served as Program Director for the Moses Lake Conservation District. His staff included Jerry Gilmore, soil conservationist, Bernie Kanoff, resource technician, Janine Spencer, technician, and Betty Texmo, secretary. Public information and education was coordinated by Don Beckley. Off-farm elements were carried out by Richard C. Bain, Jr., consulting engineer, in association with various University of Washington Department of Civil Engineering faculty and graduate students including Dr. Richard Horner, Dr. Eugene Welch, Sally Marquis, Jean Jacoby and Victor Okereke. Valuable assistance was provided by Upper Grant County Conservation District staff from Anita Jackson and Tony Gladue. Assistance from all these individuals is gratefully acknowledged.

The support of Clint Connelly, Huck Fuller, and Norm Estoos of the Moses Lake Irrigation and Rehabilitation District Board throughout this project is gratefully acknowledged. Without their demonstrated concern for Moses Lake, this project and the improvements that have resulted in Moses Lake would never have happened.

# CHAPTER 2

## STUDY AREA AND BACKGROUND

Moses Lake was formed years ago by drifting sand damming Crab Creek. The lake had no surface outlet until 1904 when flood waters scoured a channel and lowered the lake level by eight to ten feet. A dam constructed in 1909 failed and was not rebuilt until 1929, when the Moses Lake Irrigation District constructed an outlet works, restoring the lake to its earlier elevation of 1,046 feet. A second outflow works was constructed by the U.S. Bureau of Reclamation in 1963. Outlet structures control lake level between 1,041 and 1,048 feet. Lake level is currently maintained at about 1,046 feet through the cooperative efforts of the Irrigation District and the Bureau of Reclamation.

The lake is segmented into three major arms or horns; the main arm extends north and is fed by Rocky Ford Creek, the southern portion includes Parker and Pelican Horns which are separated by a peninsula which includes much of the commercial district of the City of Moses Lake. Parker Horn is fed by Crab Creek. A smaller embayment, called Lewis Horn, is connected with Parker Horn, see Location Map, Figure 2-1. Physical characteristics of Moses Lake and various segments of the lake are shown in Table 2-1.

Table 2-1 Physical Characteristics of Moses Lake[a]

| | | |
|---|---|---|
| Area | 6,800 acres | 2,753 hectares |
| Maximum depth | 38 feet | 11.6 meters |
| Mean depth | 18.5 feet | 5.6 meters |
| Volume | 126,000 acre-feet | $153.7 \times 10^6$ m$^3$ |
| Total length | 20.5 miles | 32.8 km |
| Parker Horn | | |
| Mean depth | 12.6 feet | 3.8 meters |
| Area | 758 acres | 307 hectares |
| Volume | 9,520 acre-feet | $11.6 \times 10^6$ m$^3$ |
| Pelican Horn | | |
| Mean depth | 15.6 feet | 4.8 meters |
| Area | 1,600 acres | 648 hectares |
| Volume | 25,000 acre-feet | $30.5 \times 10^6$ m$^3$ |

[a]Sylvester and Oglesby, 1964, based on a late water surface elevation of 1046 feet above sea level

The major urban center in the watershed is the City of Moses Lake (population 10,300). The City and surrounding urban fringe account for a population of approximately 20,000 people. The urban centers of Ephrata-Soap Lake (population 10,400) which lie outside the watershed contribute to the underground flow

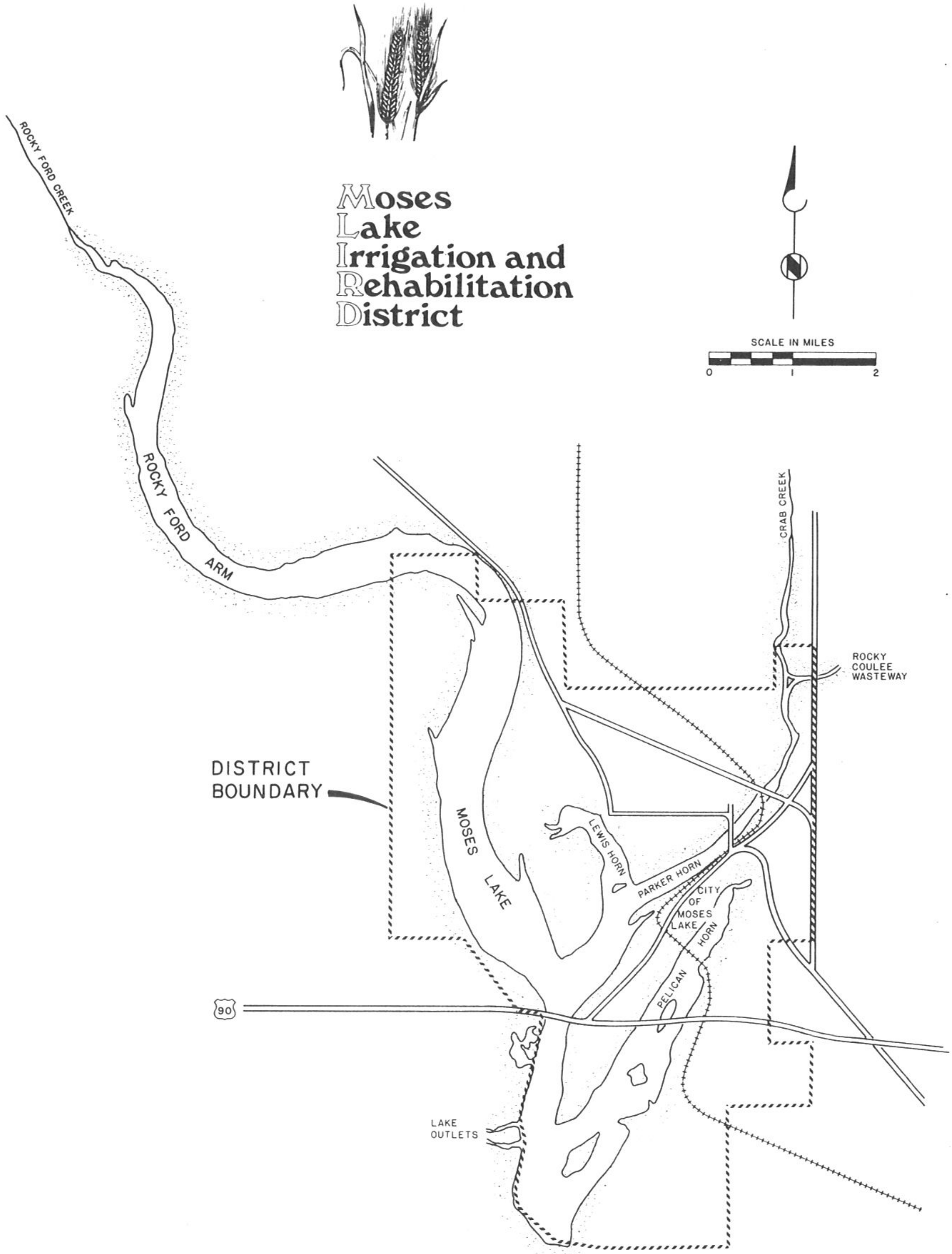



Fig. 2-1  Moses Lake

tributary to Moses Lake. Although much of the urban and all the rural population is unsewered, there are sewer systems in Moses Lake, Ephrata, and Soap Lake.

## Moses Lake Water Quality

Over production of algae is the primary water quality problem in Moses Lake. Nuisance levels of blue-green algae form unsightly floating mats in the summer recreation season. These algal scums also produce unpleasant odors and have been associated with toxicity to animals drinking at the lake shore. Aquatic weed growth is also a problem in some shoreline areas. See Chapter 5 for additional details.

Nitrogen and phosphorus are the major nutrients causing over-fertilization of Moses Lake. The principal sources of enrichment to the lake include irrigation return waters via the principal surface streams and groundwater, municipal sewage effluent and septic tank leachate, and recycling from bottom sediments through sediment-water interchange induced by wind and carp activity. Sewage effluent from the City of Moses Lake ceased to be discharged to Moses Lake during the spring of 1984.

Nitrogen is known to limit growth rate during the summer, according to studies by Dr. Eugene Welch of the University of Washington Department of Civil Engineering. However, phosphorus is also important because the principal bloom former, the blue-green algae (Aphanizomen flos-aquae) has the ability to fix nitrogen from the atmosphere. The flow-weighted average nitrate concentration flowing into the lake during spring-summer has been found to be a good predictor of summer average algae biomass. During 1980 and 1981, however, soluble phosphate concentration in lake inflow declined following the Mount St. Helen's ashfall, making phosphorus the limiting nutrient for those years. Nitrogen has since been re-established as the limiting nutrient.[a]

## General Watershed Description

The total watershed encompasses approximately 2,450 square miles (6,250 square kilometers). Crab Creek drains approximately 84 percent of the watershed. Crab Creek flows vary widely. Average flows, as reported by the U.S. Geological Survey, range between 50 and 150 cfs over the past 20 years. Higher flows occur during periods where dilution water is released into Crab Creek from the East Low Canal via Rocky Coulee Wasteway.

Crab Creek has its source near Reardan in northeastern Lincoln County and flows generally south and then west. The system drains much of Lincoln County. Entering northern Grant

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[a] Dr. Eugene Welch, University of Washington Department of Civil Engineering, personal communication.

County, Crab Creek continues to flow generally west to the vicinity of Adrian, where it turns south toward Parker Horn of Moses Lake. An additional major tributary, Wilson Creek, joins the main stem at the town of the same name.

Several impoundments downstream of Wilson Creek interrupt Crab Creek in Grant County flows, including Brook Lake, and Round Lake. See Figure 2-2. Although flow is continuous in the vicinity of Irby in Lincoln County (average 74 cfs), Round Lake normally discharges for only a few weeks during late winter runoff. Much of the Crab Creek flow is impounded within Brook Lake, although a portion of this flow is carried underground to emerge elsewhere as springs. See Chapter 4. Further south Crab Creek flows increase as it enters the irrigation area of Block 40 of the Columbia Basin Irrigation Project. Just upstream of Moses lake, Rocky Coulee Wasteway, a drainage conduit for major irrigation returns, discharges to Crab Creek.

## Climate

The Moses Lake watershed is divided into four precipitation zones: 6 to 9 inches near Moses Lake, 9 to 12 inches from Wilson Creek to Odessa, 12 to 15 inches to Harrington, and 15 to 18 inches from Davenport to Medical Lake. Approximately 60 percent of the moisture falls between November and March. Snow is the prevalent form of moisture at Davenport with an elevation of 2,370 feet. Most of the runoff and erosion occurs during winter and spring.

The average winter temperature at Moses Lake is 34 degrees F with an extreme low of -33 degrees F. The average summer temperature is 71 degrees F with an extreme high of 106 degrees F. The growing season varies from 130 to 170 days beginning in April and ending with the first fall frost, usually in September. Snowfall varies from 7 to 22 inches and occurs from November through March.

## Geology

Geology in the vicinity of Moses Lake includes two basic systems, a glacial system and a basalt system of volcanic origin. The upper glacial system consists of unconsolidated glacio-fluvial sand and gravel which forms a mantle over the underlying basalt bedrock. The glacio-fluvial deposits generally vary from about 20 to 100 feet thick. The basalts exposed in the vicinity of Rocky Ford Creek are predominantly from the Rosa member of the Wanapum Formation. This formation probably underlies most of the immediate area surrounding Moses Lake. East of the East-Low Canal, the Priest Rapids Member of the Wanapum Formation is dominant. The mantle of sand and gravel in this area is generally thinner. In most areas the Priest Rapids basalt is covered by a thin veneer of soil (0 to 6 feet thick) and weathered basalt. The Rosa member underlies the Priest Rapids member. Both the Priest Rapids and the Rosa consist of successive volcanic flows stacked on top of one another. It is the highly fractured and weathered zones which occur between the volcanic flows which, when filled with water, form the basalt aquifers. Additional details on Moses Lake area geology are provided in Chapter 4, particularly as related to groundwater flow.

Soils. The Crab Creek watershed consists mainly of two major physiographic areas, the loess mantled uplands and the channeled scablands. Loess is a wind blown deposit of silt-sized particles, generally nonstratified. The prevailing southwest winds deposited the loess from 20 inches to several hundred feet in thickness. Soil in the channeled scabland formed in sand and gravel, glacial outwash, or basalt with a thin mantle of loess. The channeled scablands formed during the Pleistocene from floods of glacial meltwaters. The meltwaters stripped the loess to bedrock and were responsible for the creation of channels, undrained basins, basalt escarpments, terraces, and terrace escarpments. Where these soils are located in the Block 40 irrigation area, they are very well drained. Coarse shallow soils which predominate in the lower Crab Creek and Rocky Ford Creek watersheds allow significant percolation. Groundwater is clearly affected by water percolating from agricultural lands; see Chapter 4.

Ephrata and Malaga soils are the two major soils in the Block 40, 401 and 41 area of the Columbia Basin Project. The irrigated area covered by these soils (28,000 acres) was selected as the primary agricultural study area for Stage 2. See Map Figure 2-2. Both of these soils formed in gravelly glacial outwash materials transported by catastrophic floods of glacial meltwater from glacial Lake Missoula 13,000 to 20,000 years ago. The surface layers of these soils later became mixed with wind-deposited, fine-grained material called loess. These are relatively young soils with low amounts of organic matter (.5 to 1 percent) and very little structure development. Clay contents range from about 5 to 10 percent. Forming in an area of low annual precipitation and high evapotranspiration has caused these soils to accumulate soluble salts or carbonates at depths of 15 to 26 inches.

These soils usually occur on terraces. In some areas, Ephrata and Malaga occur as patterned ground with Ephrata soils on mounds and Malaga soils between the mounds. The most obvious soil characteristic of both of these soils is large percentages of rock fragments. Ephrata and Malaga soil differ in their depths to extremely gravelly material.

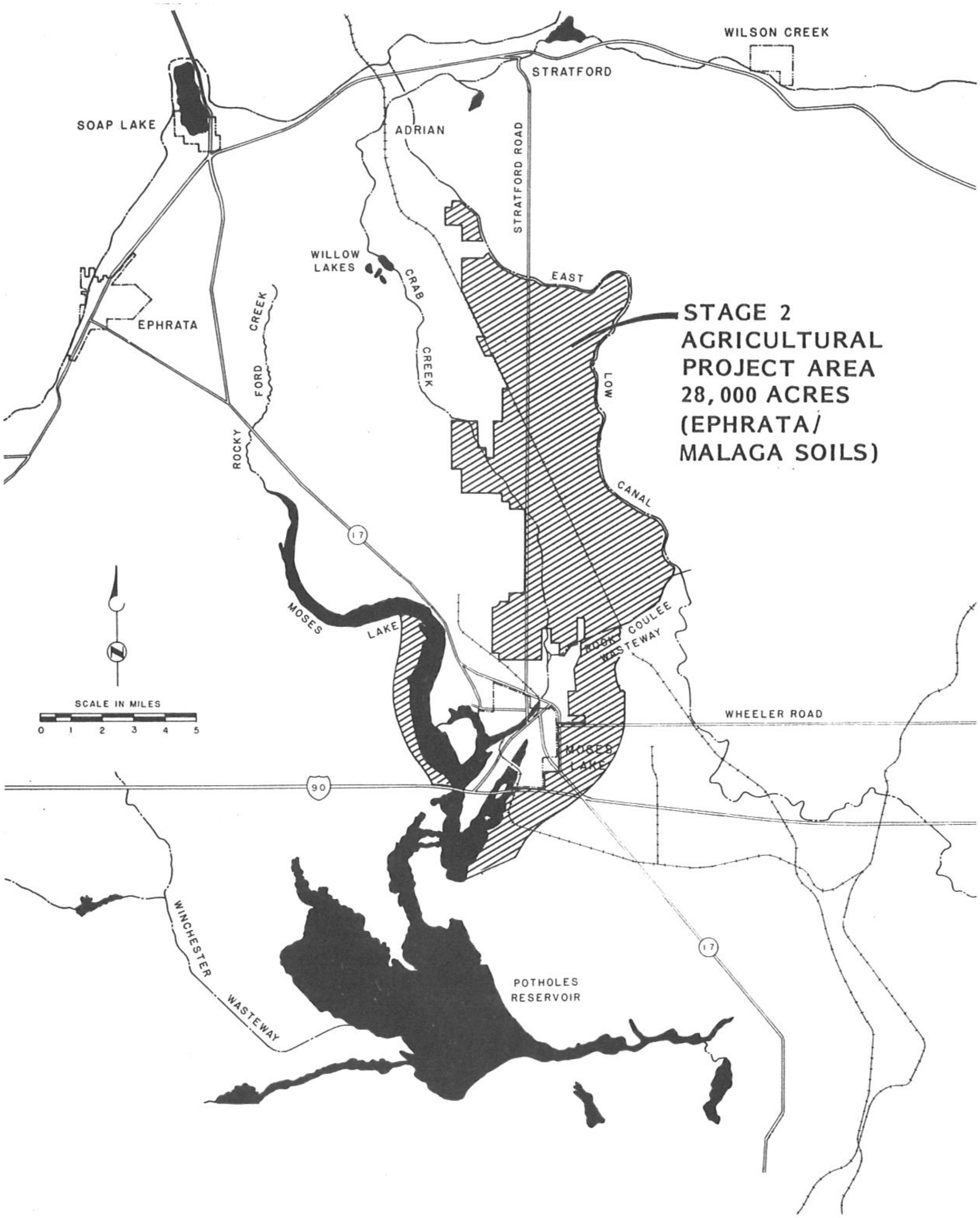



Fig. 2-2 Stage 2 Agricultural Project Area and Soils

Malaga soils range from 15 to 24 inches to extremely gravelly sand consisting of 60-85 percent rock fragments. The material above this is gravelly sandy loam or very gravelly sandy loam with 20 to 60 percent rock fragments.

Ephrata soils range from 20 to 40 inches to extremely gravelly sand consisting of 50-75 percent rock fragments. The material above this is sandy loam or gravelly sandy loam with 10 to 30 percent rock fragments. The extremely gravelly sand material in both soils having been deposited by water is tightly packed and consolidated with little void space between gravels, cobbles and sand particles. Water moves through these layers at a rapid rate, but can become temporarily "perched" above these layers due to water tension. While both of these soils are over 60 inches deep, the densely packed lower layers limit root growth. This extremely gravelly material has very little water holding capacity. As a result, most of the activities associated with plant and crop growth occur in the upper 15 to 24 inches of the Malaga soil and 20 to 40 inches of the Ephrata soil.

Water applied to these soils is either effectively used by plants in the upper layers of less rocky soil, leaves the field as runoff or evaporation, or percolates down and through the lower extremely gravelly material. Once the water has percolated below the root zone of crops, it is considered deep percolation; water which becomes deep percolation eventually enters the groundwater table and moves down gradient. See Chapter 4 for information on groundwater gradients near Moses Lake.

As these soils have a small capacity to "store" water, the amount of water leaving the profile by deep percolation or runoff is predominantly controlled by irrigation scheduling and the manner in which the water is applied. Ephrata soils with 20 to 40 inches of soil above the extremely gravelly outwash have the ability to hold more water than the Malaga soils which only have 15 to 24 inches of soil above the outwash materials.

<u>Geohydrology</u>. The geohydrology of the Moses Lake area is quite complex and the interaction between the various basalt aquifers and the glacio-fluvial aquifer is poorly understood. Recharge for both the unconsolidated glacio-fluvial aquifers and the basalt aquifers is primarily from irrigation. Groundwater discharge occurs as springs along Rocky Ford Creek and Crab Creek as well as in Moses Lake itself.

Groundwater recharge to the Rocky Ford Creek area comes from the northwest (Ephrata), the north (Soap Lake), and the northeast (Adrian). Recharge to lower Crab Creek is primarily from the east and northeast. Direct groundwater recharge to Moses Lake is from both east and west. See additional discussion in Chapter 4.

Many of area's older wells are constructed in the unconsolidated sediments. Transmissivities (T) in the glacio-fluvial aquifer range from 12,000 to 66,000 gallons per day per foot (gpd/ft). These are relatively moderate T values for unconsolidated sand and gravel aquifers. The basalt aquifers have a significantly greater range of transmissivities. The Rosa member generally exhibits T values on the order of 10,000-30,000 gpd/ft which is relatively low for basalt aquifers. The Priest Rapids member to the east typically exhibits T values in the range of 30,000 to 90,000 gpd/ft and higher. Transmissivity is primarily a reflection of the horizontal component of groundwater flow. The vertical component is harder to quantify particularly in basalt where vertical flow is via fractures and joints in the rock. However, due to head differentials, probably resulting from the heavier irrigation, downward vertical flows in the basalt east to the East Low Canal are two to three times higher than in basalts in the Ephrata and Soap Lake areas.

## Agricultural Land Use

Little agriculture occurs in the Rocky Ford Creek catchment, most of which is state game land. The only evidence of agricultural activity in this area during the project was occasional grazing by a small number of cattle.

In contrast, much of the land in the Crab Creek watershed is devoted to agriculture. There are three basic types of agriculture discussed: rangeland, irrigated cropping, and dryland agriculture. Irrigated cropping (sprinkler and furrow application) predominates in the lower watershed, while dryland wheat farming and cattle range are the major agricultural activities in northern Grant County and Lincoln County. Dry crop and rangeland contribute solids and nutrients to the system during runoff, which occurs primarily in the late winter and early spring following snowmelt.

Rangeland. Approximately 630,000 acres of the Crab Creek drainage are native and revegetated rangeland. A complex of range sites consisting of the loamy, shallow, and very shallow sites are found within the varied precipitation zones in the watershed.

Most of the rangeland is channeled scablands, and extend throughout the project in a northwest-southwest configuration. The scabland soils are shallower than the cultivated soils on adjacent uplands. In the scablands, the forage varies according to the average annual precipitation. The drier southwestern part supports a sparse natural community of wheatgrasses, primarily bluebunch wheatgrass, sandberg bluegrass, and forbs, and a few perennial shrubs, primarily big sagebrush and rabbit brush. There is a transition zone where bluebunch wheatgrass and Idaho fescue are associated with big sagebrush. Idaho fescue is on the north facing slopes and bluebunch wheatgrass on the south facing slopes. Further east, treetip sagebrush is dominant. Ponderosa Pine is on some northern slopes where the effective moisture can support it. In areas that have similar climate and topography, the kind and amount of vegetation produced on rangeland is closely related to the depth of soil.

The rangelands of the Crab Creek drainage affect runoff in several ways. Rangeland vegetation and its foliage and litter help maintain the soil's ability to absorb water. This cover prevents the sealing of the soil by the impact of the raindrops. Also, this cover forms barriers for water moving on the surface of the ground and lengthens the time of runoff which reduces the peak flow.

Irrigated Cropland. The irrigated cropland in the Crab Creek watershed includes an area of 130,520 acres. It includes 58,220 acres in Lincoln County, 72,300 acres in Grant County of which about 21,000 acres are cultivated in the Block 40, 401 and portions of Block 41 area of the Columbia Basin Irrigation Project. This irrigated area is near Moses Lake and was used as the primary study area during Stage 1. See Map Figure 2-3.

The majority of the Upper Grant and Lincoln County areas are irrigated with water obtained from deep wells that is applied with center pivots, or wheeline type sprinklers. Some water is also diverted directly from streams and applied with sprinklers. Irrigated crops are 80 percent small grains (wheat and barley) and 20 percent peas, beans, pasture, and hay. The Block 40, 401, 41 area is irrigated with water diverted from the Columbia River. This area grows numerous crops, but the major ones are alfalfa, wheat, corn, pasture, and seed. More than 80 percent of this area is irrigated with sprinklers, with the remainder irrigated by furrows. A summary of the land use and irrigation system types is provided in Chapter 3.

Dry Cropland. There are 781,408 acres of dry cropland in the Moses Lake drainage area. Most of this area is in Lincoln County. This area is mainly in small grains. Yields vary according to precipitation. The soils are generally deep silt loams with winter wheat yields averaging around 50 bushels per acre. Fertilizer application ranges from 40 to 100 pounds per acre for nitrogen and about five pounds per acre for phosphorus, depending on location and expected yields.

The number of tillage operations required for the year also increases with precipitation because of the increasing number of weeds. The crop rotations are winter wheat/summer fallow in the Upper Grant County area and winter wheat/spring grain/summer fallow in the Lincoln County portion of the watershed. Conservation practices such as terraces, strip cropping, reduced tillage, and no-tillage are being applied to the area.

Large groundwater deposits underlie both the Crab Creek and Rocky Ford Creek subwatersheds, and wells and surface springs are common. With the coarse, shallow soils predominant, especially in southern Grant County, it is reasonable to assume that groundwater is affected by water infiltrating from agricultural lands.

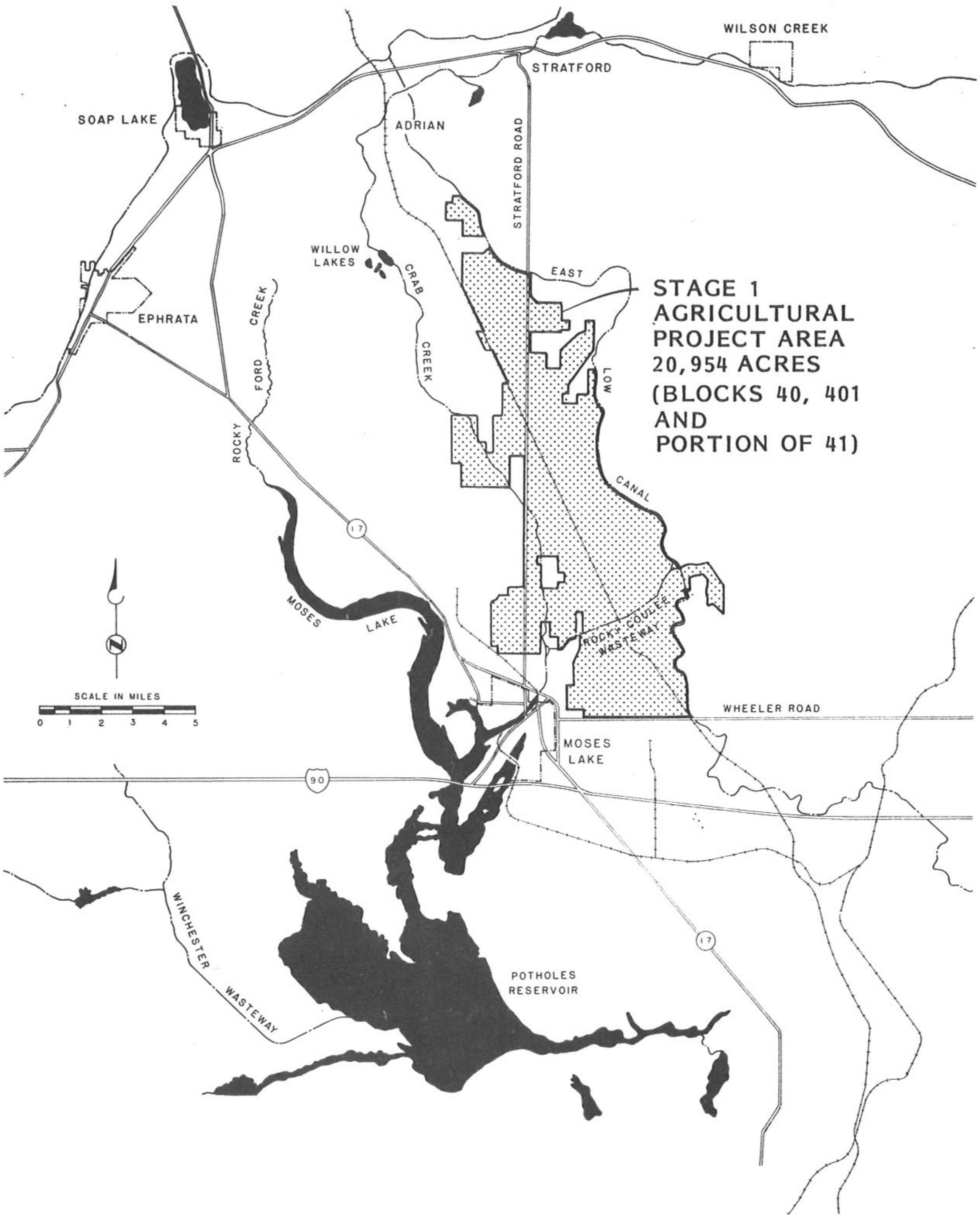



Fig. 2-3 Stage 1 Agricultural Project Area

## Monitoring Program

The project has focused on potential nutrient sources and means to control nutrient sources in the watershed. This effort included both off farm and on farm investigations. The on-farm monitoring and demonstration program was to identify the sediment and nutrient contributions from agricultural practices within the Moses Lake watershed, and test possible practices which could be used to reduce these contributions. The following potentional nutrient pathways from agricultural lands to Moses Lake were identified and investigated:

1. Runoff to surface waters transporting soluble and particulate nutrients.

2. Infiltration (leaching) of nutrients into the soil layer and subsequent percolation to subsurface waters.

3. Airborne transport of nutrient-rich soil particles, with deposition in Moses Lake or its tributaries.

During Stage 1 these pathways were investigated with the results showing that the greatest amount of nutrients came from the lower Grant area adjacent to the irrigated Blocks 40, 401, and 41. The upper portion of the Crab Creek watershed is a large acreage, but due to ponding and catchment basins above Adrian, the contribution to the total Moses Lake nutrient load was small. Some of the nutrients from this area do enter the lake via groundwater and springs feeding Rocky Ford Creek (see Chapter 4). Airborne transport of nutrients was also investigated but found to be very minor compared to the pounds of nutrient which reach Moses Lake from the other two sources.

Infiltration of nutrients from the irrigated agricultural areas adjacent to Crab Creek and Moses Lake were studied to see if water does move below the root zone of the crop and if this could be reduced. The sample locations and results of this data are shown in the Stage 1 report. Conclusions made from Stage 1 were based upon the measurement of water movement below the root zone of the crop and the measurement of flow and nutrients in the springs adjacent to Crab Creek. The amount of nitrogen which deep percolates below the root zone was estimated using the nitrogen leaching regression equation developed by Pfieffer and Whittlesey (Chapter 3) for the Columbia Basin. Using this predictive equation, an estimate was made of the amount of nitrogen which would deep percolate within the project area. Based on Stage 1 farm inventory data of water, application rates, crop use, and accepted agricultural leaching equations, 23 pounds per acre per year of nitrogen is lost to deep percolation to groundwater. This represents a total loading of 245,000 pounds per year from agricultural fertilizers from this area alone. Measured nitrogen loading in the springs covered in the year-long monitoring program accounted for 300,000 pounds. Total nitrogen losses from irrigated agriculture in the lower Crab Creek watershed are in the 500,000 to 700,000 pounds range considering rotation and all crops involved. This is further explained in the Stage 1 report.

Stage 2 concentrated on the actual measurement of nutrients which was predicted using the Stage 1 data. The area having the greatest impact on surface and groundwater nutrient loadings affecting Moses Lake was the Block 40, 401 and 41 area, where Ephrata and Malaga soils are found. There are 20,954 acres of irrigated land within these areas tributary to the lake of which 81 percent utilize sprinkler irrigation. The remaining 19 percent utilize furrow irrigation, which contributes 50 percent more nitrogen per acre to the area's groundwater due to over-irrigation. Although furrow irrigation accounts for less than one-fifth of the irrigated area, it contributes over one-fourth of the nitrogen leached via deep percolation. Additional lands irrigated in the lower watershed were also considered bringing the total acreage to 28,000. See Fig. 2-2.

It was determined if practices could be developed and installed, which would reduce on-farm deep percolation, and what level of farmer acceptance these practices would have in the area. An extensive search was made to find management and structural practices which would apply. The following is a list of items which were selected:

- Irrigation Water Management - with special emphasis on scheduling to meet plant needs.
- Irrigation System Conversions - to upgrade existing low efficiency systems to reduce over-irrigation.
- Fertilizer Management - Applying fertilizer in amounts recommended by soil tests and timed to meet crop needs.
- Animal Waste Control Facilities

Demonstrations were then planned for the 1984 irrigation season to install practices and measure their effects. A more complete description of the practices and the results tested is shown in Chapter 3, "Results of On-Farm Demonstrations."

Other nutrient controls were also evaluated. These are described in Chapter 5 and include watershed as well as in-lake controls. Watershed controls include detention ponds, livestock controls, drainage diversions and more stringent septic tank policies. In-lake controls considered include dredging, weed harvesting, carp eradication and water circulation improvements.

CHAPTER 3

# ON-FARM DEMONSTRATION RESULTS

This chapter summarizes project activities involving irrigated agriculture and covers both Stage 1 and Stage 2 results. As indicated in the previous chapter, agricultural activities are responsible for the largest proportion of nutrients entering Moses Lake. Accordingly, the study has inventoried agricultural activities and practices and measured these effects in field experiments on working farms in the vicinity of Moses Lake. The on-farm portion of the study was composed of a number of monitoring programs to measure the movement of nitrogen and phosphorus from irrigated agriculture, particularly in the coarse soils of the agricultural study area of Block 40, 401 and the northern portion of Block 41. Stage 1 inventory and monitoring results are summarized here followed by a description of Stage 2 demonstration program results carried out during the 1984 growing season.

## Stage 1 Results

Stage 1 included inventory work to determine types and trends of agricultural activities in the watershed of Moses Lake. Monitoring programs were also included which measured nitrogen and phosphorus loadings from various agricultural areas and nutrient movement through local soils during an irrigation season.

An on-farm inventory was taken to determine information such as land use, fertilizer methods and application rates, irrigation system types, and crops in the agricultural study area. Inventory of land use from 1970 to 1982 in the irrigated area, as shown in Table 3-1, indicated a change to crops which use more fertilizer, e.g., pasture to wheat. During this period, approximately 50 percent (10,000 acres) of the land area converted from furrow irrigation to sprinklers, as shown in Table 3-2.

Water Use and Losses. On-farm acreage data was then used to provide an estimate of the water use and movement in the Block 40, 401, and 41 areas. A summary of the consumptive use is shown in Table 3-3. Consumptive use is the amount of water used by the crops for the irrigation season, this is based on a 50 percent probability.

The total amount of water diverted, minus the amount used by the crops, would be the water lost. Water lost includes three components: (1) direct surface runoff, (2) deep percolation, (3) evaporation during application.

Table 3-1. Land Use--Blocks 40, 401 and Portion of 41[a]

| Year | Wheat | | Alfalfa hay | | Pasture | | Corn | | Seed[b] | | Miscellaneous[c] | | Total Acres |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent | |
| 1970 | 580 | 3 | 10,046 | 52 | 4,637 | 24 | 773 | 4 | 1,932 | 10 | 1,352 | 7 | 19,319 |
| 1971 | 771 | 4 | 10,024 | 52 | 4,434 | 23 | 1,157 | 6 | 1,928 | 10 | 964 | 5 | 19,277 |
| 1972 | 958 | 5 | 9,771 | 51 | 4,407 | 23 | 1,533 | 8 | 1,533 | 8 | 958 | 5 | 19,159 |
| 1973 | 2,351 | 12 | 9,209 | 47 | 4,506 | 23 | 1,763 | 9 | 1,176 | 6 | 588 | 3 | 19,593 |
| 1974 | 4,363 | 22 | 8,130 | 41 | 3,768 | 19 | 1,388 | 7 | 1,586 | 8 | 595 | 3 | 19,830 |
| 1975 | 4,203 | 21 | 8,607 | 43 | 3,403 | 17 | 1,201 | 6 | 1,401 | 7 | 1,201 | 6 | 20,016 |
| 1976 | 5,253 | 26 | 8,889 | 44 | 3,232 | 16 | 1,414 | 7 | 808 | 4 | 606 | 3 | 20,202 |
| 1977 | 3,056 | 15 | 10,593 | 52 | 2,852 | 14 | 1,426 | 7 | 1,019 | 5 | 1,426 | 7 | 20,371 |
| 1978 | 2,825 | 14 | 10,088 | 50 | 2,825 | 14 | 1,211 | 6 | 1,614 | 8 | 1,614 | 8 | 20,176 |
| 1979 | 5,439 | 26 | 8,368 | 40 | 3,556 | 17 | 1,255 | 6 | 1,255 | 6 | 1,046 | 5 | 20,920 |
| 1980 | 5,194 | 25 | 9,557 | 46 | 2,909 | 14 | 1,662 | 8 | 831 | 4 | 831 | 4 | 20,775 |
| 1981 | 4,278 | 21 | 9,575 | 47 | 2,241 | 11 | 1,630 | 8 | 815 | 4 | 1,834 | 9 | 20,372 |
| 1982[d] | 4,610 | 22 | 10,058 | 48 | 2,515 | 12 | 1,676 | 8 | 419 | 2 | 1,676 | 8 | 20,954 |

[a]From ARS census studies for 1970 to 1981 and Moses Lake Clean Lake farm inventory for 1982.
[b]Inclusions: alfalfa, peas, clover, corn, onion, bean, carrot, and sunflower seed crops.
[c]Inclusions: sugarbeets, potatoes, soybeans, Christmas trees, apples, oats, barley, and beans.
[d]Acreage computed from 55 percent farm inventory.

Direct surface runoff to Moses Lake or any of its tributaries involves only a small area within Block 40, 401 and 41 due to the coarse texture of the soil profile and the topography.

There are a number of springs located beteen the irrigated areas and Crab Creek. Of those sampled, it was common to see variations of 10-20 times more water two to three weeks after the beginning of the irrigation season. Most of these springs developed after the Columbia Basin Irrigation Project was built; therefore, deep percolation of excess irrigation water and canal loss is concluded to be the source of these springs.

Table 3-2. Conversion in Irrigation Systems Types, 1970 through 1982--Block 40, 401, and Portion of 41[a]

| Year | Gravity Acres | Gravity Percent | Sprinkler Acres | Sprinkler Percent | Total Acres |
|---|---|---|---|---|---|
| 1970 | 12,930 | 67 | 6,389 | 33 | 19,319 |
| 1971 | 12,354 | 64 | 6,923 | 36 | 19,277 |
| 1972 | 11,475 | 60 | 7,684 | 40 | 19,159 |
| 1973 | 11,754 | 60 | 7,839 | 40 | 19,593 |
| 1974 | 10,001 | 50 | 9,829 | 50 | 19,830 |
| 1975 | 9,007 | 45 | 11,008 | 55 | 20,016 |
| 1976 | 8,436 | 42 | 11,766 | 58 | 20,202 |
| 1977 | 6,532 | 32 | 13,839 | 68 | 20,371 |
| 1978 | 6,154 | 31 | 14,022 | 69 | 20,176 |
| 1979 | 5,839 | 28 | 15,081 | 72 | 20,920 |
| 1980 | 5,547 | 27 | 15,228 | 73 | 20,775 |
| 1981 | 4,834 | 21 | 16,012 | 79 | 20,372 |
| 1982 | 3,981 | 19 | 16,973 | 81 | 20,954 |
| Inventory | 1,876 | 19 | 7,775 | 81 | 9,651 |

[a]From Bureau of Reclamation records and Moses Lake Clean Lake farm inventory.

Table 3-3. 1982 Consumptive Use

| Crop | Acres[a] | Consumptive use,[b] inches | Volume, acre-feet |
|---|---|---|---|
| Alfalfa | 10,058 | 35.9 | 30,090 |
| Corn | 1,676 | 26.1 | 3,645 |
| Wheat | 4,610 | 23.9 | 9,181 |
| Pasture | 2,515 | 31.3 | 6,560 |
| Seed | 419 | 18.0 | 628 |
| Miscellaneous | 1,676 | 18.0 | 2,514 |
| Total | 20,954 | | 52,555 |
| Weighted Mean | | 30.1 | |

[a]Moses Lake Clean Lake Farm Inventory 1983
[b]Columbia Basin Irrigation Guide, SCS, 1973

Deep percolation in the irrigated fields was measured by using the neutron probe, which recorded the water withdrawal and movement for the major crops and types of irrigation systems. A typical example of the neutron probe data is provided in Figure 3-1, which illustrates the rapid water movement in this project area's soils.

In the example, moisture, as expressed in inches of water per foot of soil, is monitored with probes placed at intervals in the soil column ranging from 8 to 36 inches below the field surface. These data collection points occur both above and below the root limit of the crop; in this example this depth was 24 inches. Irrigation water was applied continuously over a 12-hour period and then monitored for post irrigation readings. Soil moisture readings before and immediately following irrigation are shown in the top part of the figure. The shaded area between the pre and post irrigation readings represents the net water applied. The lower portion of the figure shows soil moisture 6 hours after irrigation has ceased. Actual water measurements show losses from the upper probes (8 to 12-inch depths) where soil moisture has fallen off and soil moisture increases at the 36-inch depth. The increases at depth represent additional deep percolation which occurred over the 6-hour period after irrigation ceased. Measurements of soil moisture were continued through a 10-day period.

Neutron probe data surfaced from project area farms during Stage 1 was used to estimate deep percolation for the different types of irrigation systems for the Block 40, 401, and 41 area. Furrow irrigation percolation varied over a wide range from 0.6 to 6.9 inches depending on soil intake. The high end of the range was from the first irrigation of the season whereas 0.6 inches was typical for subsequent applications. In contrast, side roll (wheellines) deep percolated to a depth of about 0.5 inches and center pivots percolated to a depth of 0.3 inches.

The number of irrigations for the season is computed from net application amounts and the crop water requirement for the three types of irrigation systems. The total depth of water percolation for each type of system was calculated from the number of irrigations and the deep percolation/irrigation amounts. This information is summarized in Table 3-4.

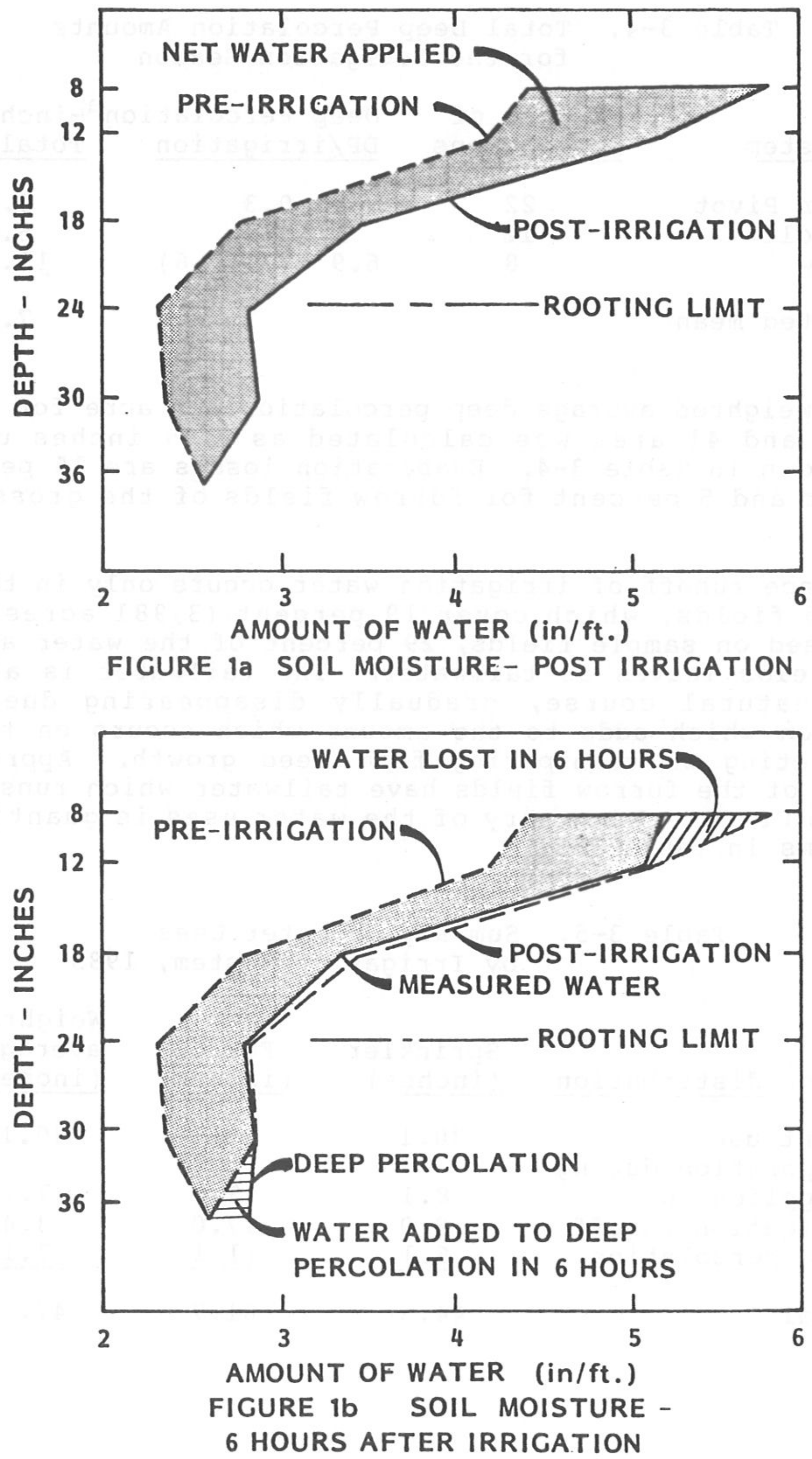



Fig. 3-1 Irrigation Water Percolation in the Soil Profile

Table 3-4. Total Deep Percolation Amounts for the Irrigation Season

| System | Number of Irrigations | Deep Percolation[a]-inches DP/irrigation | Total DP |
|---|---|---|---|
| Center Pivot | 22 | 0.3 | 6.6 |
| Sideroll | 12 | 0.5 | 6.0 |
| Furrow | 8 | 6.9 +(7)(0.6) | 11.1 |
| Weighted mean | | | 7.05 inches |

The weighted average deep percolation per acre for the Block 40, 401, and 41 area was calculated as 7.05 inches using the values shown in Table 3-4. Evaporation losses are 15 percent for sprinkler and 5 percent for furrow fields of the gross applied water.

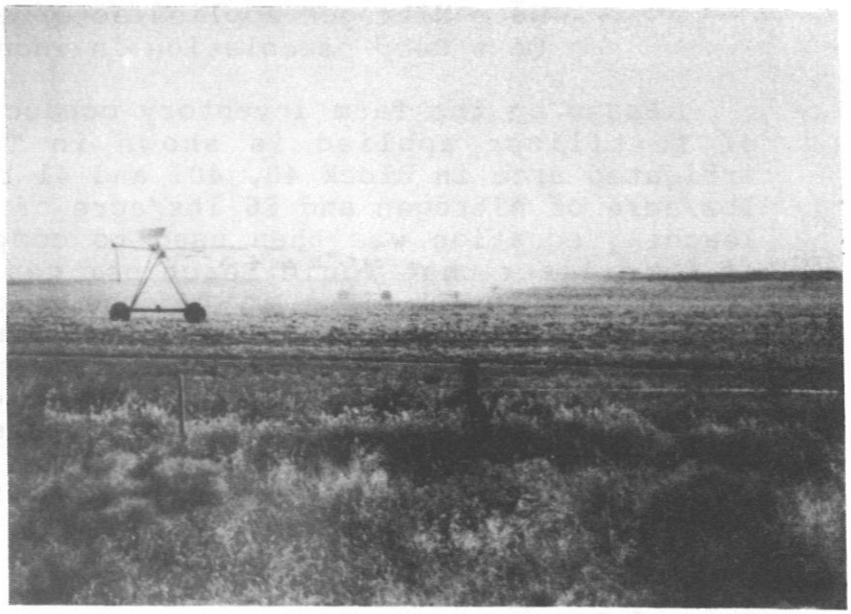
Surface runoff of irrigation water occurs only in the furrow irrigated fields, which cover 19 percent (3,981 acres) of this area. Based on sample fields, 29 percent of the water applied to furrow fields leaves as tailwater. The tailwater is allowed to run its natural course, gradually disappearing due to deep percolation which adds to the amount which occurs on the field, or evaporating or transpiring from weed growth. Approximately 800 acres of the furrow fields have tailwater which runs directly into Crab Creek. A summary of the water uses is quantified for the systems in Table 3-5.

Table 3-5. Summary of water Uses by Irrigation System, 1983

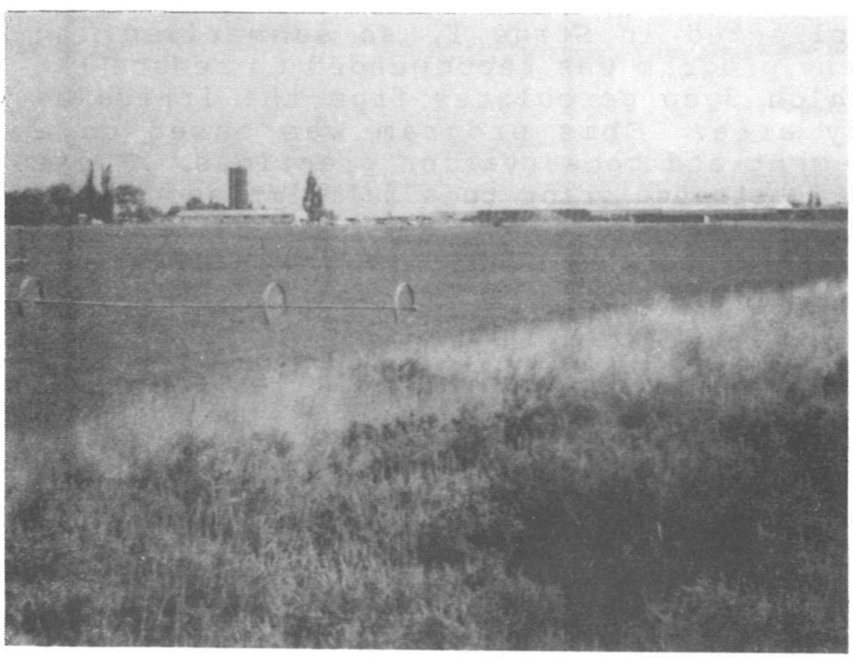
| Water distribution | Sprinkler (inches) | Furrow (inches) | Weighted average (inches) |
|---|---|---|---|
| Plant use | 30.1 | 30.1 | 30.1 |
| Evaporation during application | 8.1 | 3.5 | 7.1 |
| Irrigation runoff | 0.0 | 17.0 | 3.4 |
| Deep percolation | 6.1 | 11.1 | 7.1 |
| Total | 44.3 | 61.7 | 47.7 |

[a]Deep Percolation (DP) for this report is defined as the movement of water and nutrients below 24" which is beyond the root zone of most crops.

**RILL IRRIGATION** system.



**SPRINKLER IRRIGATION** showing center pivot circle equipment.



**VIEW OF SIDEROLL** (wheel line) irrigation system.

Table 3-5 shows that an average of 47.7 inches of water is diverted to each acre of land in the Block 40, 401, and 41 area with 30.1 inches used by the plant, 7.1 inches evaporated from the delivery system, 3.4 inches accounted for in runoff, and 7.1 inches over-applied and deep percolated to groundwater. These values are similar to those reported in U. S. Bureau of Reclamation operations reports for the project area.

Nutrient Application and Losses. During Stage 1, an estimate of the pounds of nitrogen leached was made using the amount of deep percolation, the nitrogen fertilizer loading applied on the land, and the nitrogen percolation regression equation developed by Pfieffer-Whittlesey Equation.[a] This equation is:

$$N_L = 0.029\ (Na)^{1.05}\ (Qd)^{0.7}$$

where $N_L$ = Nitrogen leached/acre/year in pounds
$Na$ = Nitrogen applied/acre/year in pounds
$Qd$ = Deep percolation in inches/acre/year

Based on the farm inventory conducted, the estimated amount of fertilizer applied is shown in Table 3-6. Overall, the irrigated area in Block 40, 401 and 41 receives an average of 161 lbs/acre of nitrogen and 66 lbs/acre of phosphorus. The nitrogen leaching equation was then used to compute the predicted amount of fertilizer that would leach per year. (See Table 3-7) Even though nearly 75 percent of the total nitrogen leached to groundwater occurs on sprinkler irrigated fields, the leaching rate of nitrogen from surface irrigated fields is 50 percent higher. The predicted nitrogen leached from Block 40, 401, and 41 areas was calculated from the measured field deep percolation. Two additional sources of deep percolation, from supply laterals and canals and from surface runoff, which deep percolates after leaving the furrow-irrigated fields, would also contribute nutrients.

## Stage 2 Demonstrations

From the data collected in Stage 1, as summarized, an agricultural management program was recommended to reduce the amount of nutrient which deep percolates from the irrigated portion of the study area. This program was based on a combination of management and conservation practices. These practices were to be demonstrated prior to a full implementation program to determine farmer participation, actual practice costs and benefit and overall water quality changes in Moses Lake.

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[a]The Pfieffer and Whittlesey equation was developed for the Columbia Basin and is described in Soil Conservation Service Economics Technical Note 1 (1978).

Table 3-6. Fertilizer Application

| Crop | Acres | Nitrogen | | Phosphorus | |
|---|---|---|---|---|---|
| | | pounds/acre | Total pounds | Pounds/acre | Total pounds |
| Wheat | 4,610 | 172 | 792,920 | 60 | 276,600 |
| Alfalfa hay | 10,058 | -- | -- | 80 | 804,640 |
| Corn | 1, 676 | 238 | 398,888 | 65 | 108,940 |
| Alfalfa seed | 419 | -- | -- | -- | -- |
| Miscellaneous | 1,676 | 80 | 134,080 | -- | -- |
| Pasture | 2,515 | 142[b] | 357,130 | 23[c] | 57,845 |
| | | Total pounds nitrogen | 1,683,018 | Total pounds phosphorus | 1,248,025 |
| | | Total acres | 10,477 | | 18,859 |
| | | Nitrogen pounds/acre average | 161 | Phosphorus pounds/acre average | 66 |

[a]From on-farm inventory data.

[b]Combination commercial and fresh manure estimates.

[c]Fresh manure estimates.

Table 3-7 Nitrogen Leached

| System | Deep percolation,[a] inches | Predicted nitrogen leached,[b] pounds/acre | Acres | Total predicted nitrogen leached, pounds |
|---|---|---|---|---|
| Sprinklers | 6.1 | 21.3 | 8,486 | 180,752 |
| Furrows | 11.1 | 32.5 | 1,991 | 64,519 |
| Total | | | 10,477 | 245,271 |
| Weighted mean | 7.1 | 23.4 | | |

[a]Deep percolation from Table 3-5.

[b]Predicted by SCS Econ. No. 1 Tech. Note.

[c]Total acerage receiving N fertilizer from Table 3-6; percent sprinkler or furrow from Stage 1 Inventory per Table 3-2.

Practices which were demonstrated or tested in Stage 2 included: Cablegation (2 fields), a Wheelline system and a Center Pivot system. Irrigation water management techniques were demonstrated in each system. Cablegation, a new practice in the area, is explained in the demonstration write-ups. Wheelline and center pivot systems involved demonstrations of improvements needed on existing systems to insure that the system is (1) applying water evenly over the entire field and (2) not applying more water than the soil can hold. Irrigation Water Management is needed to schedule irrigations so as to replace water to the soil profile when the plant has used up a specific amount.

Special equipment mentioned in the demonstration write-ups include:

Tensiometers - Ceramic tipped tube 1" in diameter and various lengths with a vacuum gauge that measures soil moisture expressed as the tension between the soil and water. This relates to the tension the plant must develop to get water. For the Ephrata and Malaga soils, 50 percent available soil moisture is approximately 45 to 50 centibars on the gauge. Gauge readings on the tensiometer for these soils should range from 5-50 centibars with 0-5 being field capacity and 50 being 50 percent of the available moisture depleted from the soil. The charts (Figures 3-1, through 3-4) showing the plots of the tensiometer readings are in centibars of the suction on the vertical scale and Julian days on the Horizontal scale. The Julian calendar starts on January 1st and goes to 365 on December 31st.

Soil Water Sampler Tube - Ceramic tipped tube, 2" diameter by five feet long, with a rubber stopper at the ground surface. These tubes were designed to place a vacuum on the tube and when water is present at the tip, the vacuum will "pull" a sample into the tube.

Neutron Probe - A device used to measure the in-place moisture content of the soil. Table 3-8 shows plots of some typical neutron probe readings.

Separate discussions of each demonstration are provided in the following sections. A summary of demonstration results follows after the individual demonstration writeups.

Chris Matheson Farm Demonstration. Chris Matheson operates a 638 acre farm in units 77, 78, 79, 80 and 84 of Block 40. Field trials had been conducted on some of Matheson's furrow fields during Stage 1. Data collected showed that there was over-irrigation which resulted in deep percolation of water.

A cablegation system was installed on a 20 acre field to measure the effectiveness of this type of system on reducing this percolation. Cablegation is an automated gated pipe system which uses a slow moving plug to allow the release of water through adjustable outlet valves. See Fig. 3-2. The system is designed to apply water at the intake rate of the soil. Additional details on cablegation are provided in Appendix B. Details of the Matheson demonstration are listed below:

| | |
|---|---|
| Field size | 20 acres |
| Soil | Malaga |
| Furrow length | 700 feet |
| Cablegation length | 1050 feet |
| Crop | Corn |
| Fertilizer | |
| Nitrogen | 250 lbs/acre |
| Phosphorus | 125 lbs/acre |

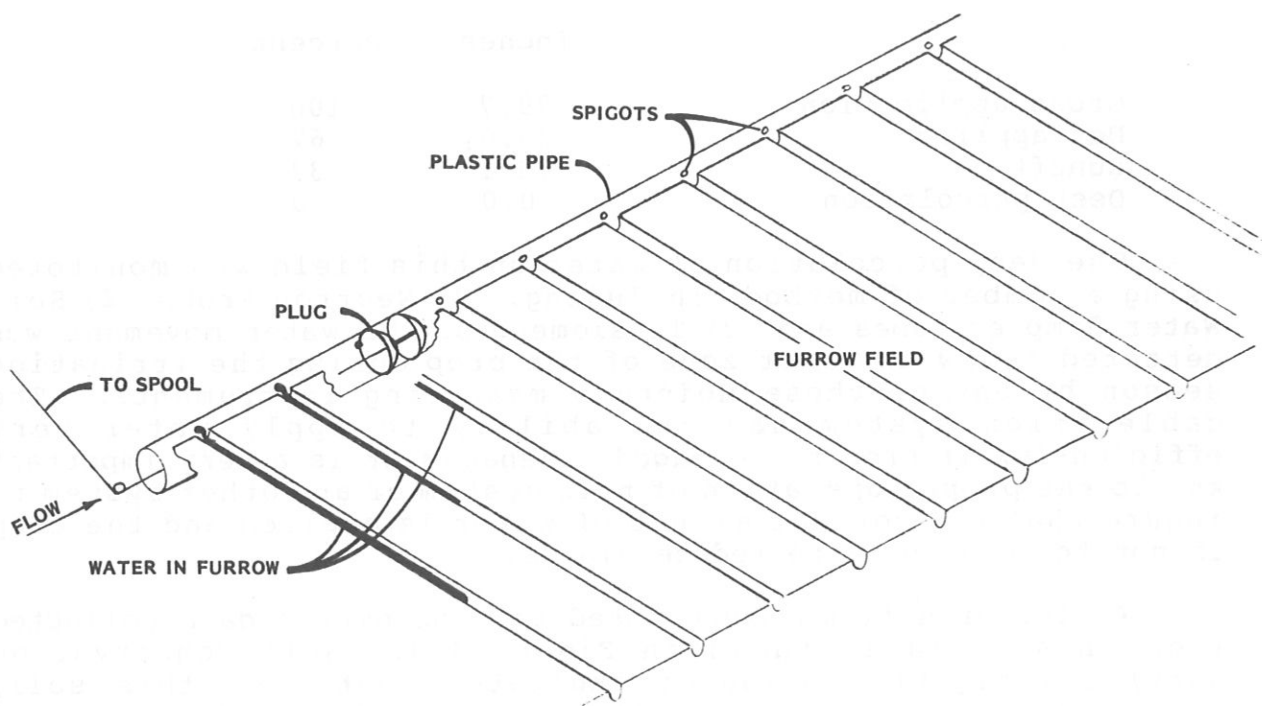



Fig. 3-2 Typical Cablegation System

Field trials were conducted on the cablegation system to determine actual runoff amounts, deep percolation, and overall efficiency. Data was also collected to measure the total water to enter and runoff this field during the irrigation season. Tensiometers were used to monitor the plant use of water and schedule irrigations.

The results from installing and managing this system for one irrigation are shown below:

| | |
|---|---|
| Irrigation set time | 9.8 hours |
| Furrow stream size | 3.9 gpm per furrow |
| Maximum runoff | 1.4 gpm per furrow |
| Gross application | 1.4 inches/acre |
| Net application | 0.9 inches/acre (available to crop) |
| Runoff | 0.5 inches/acre |
| Deep percolation | 0.0 inches/acre |

The overall application and efficiency for the season for this system is:

| | Inches | Percent |
|---|---|---|
| Gross application | 39.7 | 100 |
| Net applied | 26.6 | 67 |
| Runoff | 13.1 | 33 |
| Deep percolation | 0.0 | 0 |

The deep percolation of water on this field was monitored using a number of methods including: 1) Neutron Probe 2) Soil Water Sampler tubes and 3) Tensiometers. No water movement was detected below the root zone of the crop during the irrigation season by any of these moisture measuring instruments. The cablegation system has the ability to apply water very efficiently, if properly managed. Management is a very important key to the proper operation of this system or any other system to insure that the correct amount of water is applied and the crop is not too dry so as to reduce yields.

A plot of soil moisture based on tensiometer data collected from this field is shown in Figure 3-3. Soil Conservation Service Irrigation Guidance indicated that, for this soil, irrigation should occur when the tension between the water and soil reaches 45-50 centibars to optimize soil moisture. Irrigation should be stopped at a 5-10 centibars reading.

Figure 3-3 shows that these conditions were met through the cablegation's ability to apply light (1.0" NET) frequent (2 day) applications. By managing this system, it was possible to dramatically reduce deep percolation of water.

Field data was collected by Chris Matheson during the harvest and compared to a "control field." The control field was

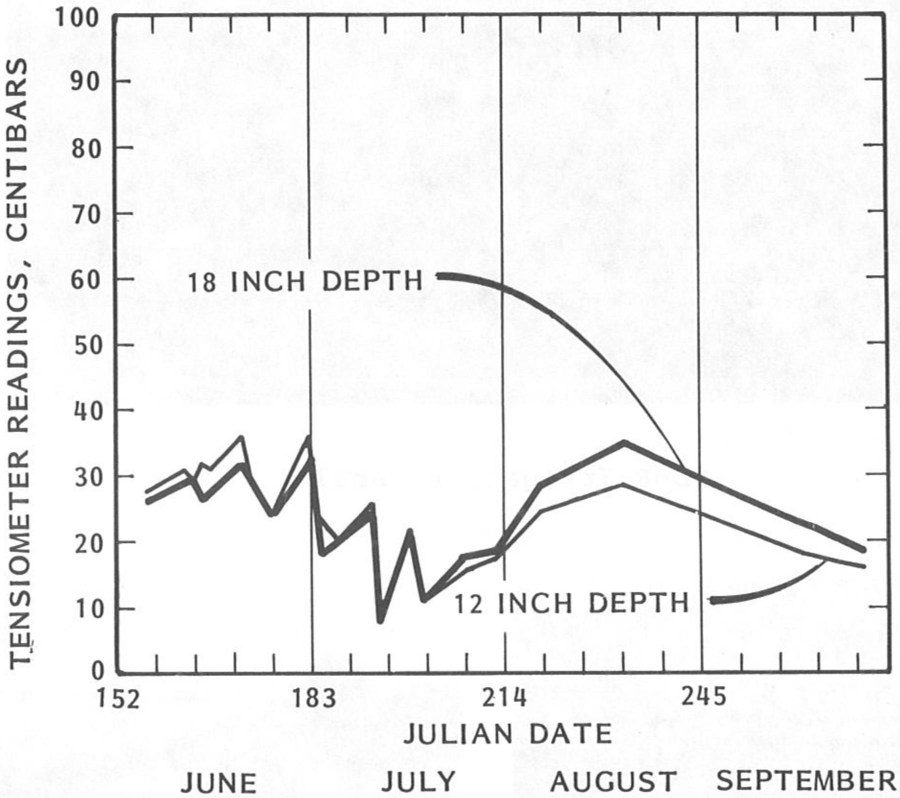
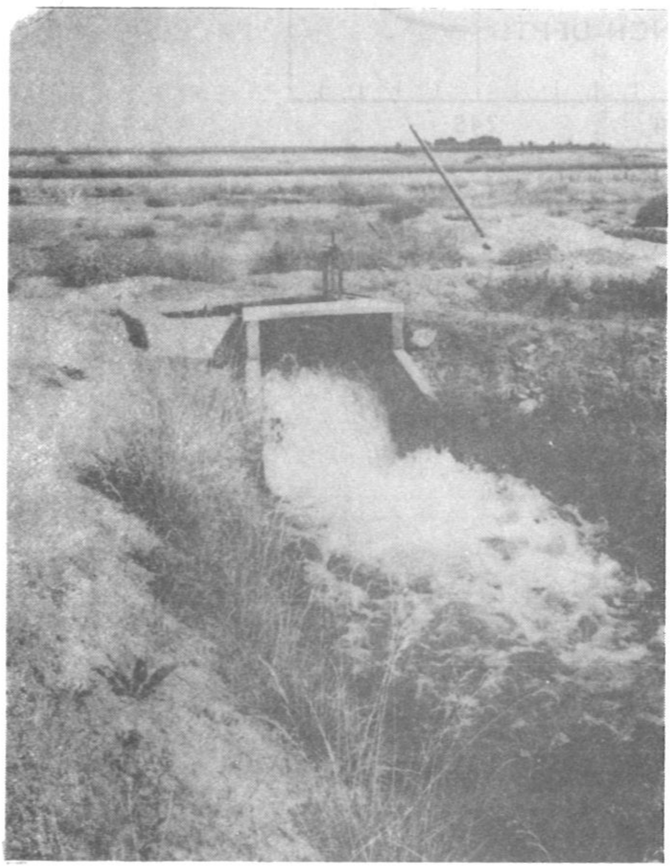



Fig. 3-3 Chris Matheson Tensiometer Readings

USBR Irrigation Canal



Drop Structure in
Irrigated Area

View of Matheson
Cablegation Controls

operated the same (fertilizer, crop tillage, etc.) as the cablegation field except that the control field was furrow irrigated using siphon tubes. The cablegation field yielded 5.4 tons of corn per acre whereas the control field yielded 4.9 tons per acre. Thus an increase of 10 percent was achieved using cablegation.

<u>Bill Bellomy, Jr., Farm Demonstration</u>. Bill Bellomy, Jr. operates an 876 acre farm in units 50, 53, 65, 66, 75, 76, 63, 229, and the northwest quarter, section 17, township 19, range 29 of Block 41. Field trials conducted on Bellomy's furrow fields have shown that the use of a cablegation system would help to reduce the deep percolation of water and nutrients. The field selected is summarized below:

| | |
|---|---|
| Field size | 22 acres |
| Soil | Ephrata |
| Furrow length | 600 feet |
| Cablegation length | 625 and 750 feet |
| Crop | Spring wheat |
| Fertilizer | |
| Nitrogen | 200 lbs/acre |
| Phosphorus | 50 lbs/acre |

The cablegation length is shown as two lengths because the inlet structure was installed at a midpoint in the line with the movable plug able to go down either side.

This system had some mechanical problems. Periodically the plug would become stuck in the pipe and once the plug became free, the system would then skip because the control cable slackened. The result was under-irrigation in sections of the field. A number of different plugs were tried before one worked, but since the gated pipe had been laid on various grades, a mechanical controller was required. The controller used also had some problems in the timing and release mechanisms. This all caused the system to be operated at efficiencies slightly better than a gated pipe system. Results from this irrigation demonstration are:

| | |
|---|---|
| Irrigation set time | 12 hours |
| Furrow stream size | 7 gpm |
| Maximum runoff | 2.1 gpm |
| Gross application | 5.4 inches |
| Net application | 2.2 inches |
| Runoff | 2.5 inches |
| Deep percolation | 0.7 inches |

The overall application and efficiency for the season for this system is:

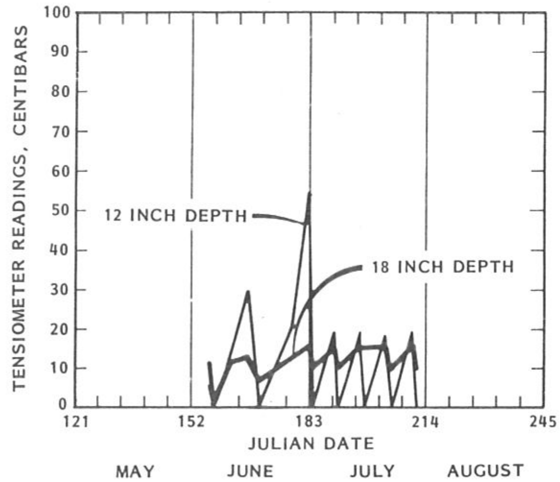



Fig. 3-4 Bill Bellomy Tensiometer Readings

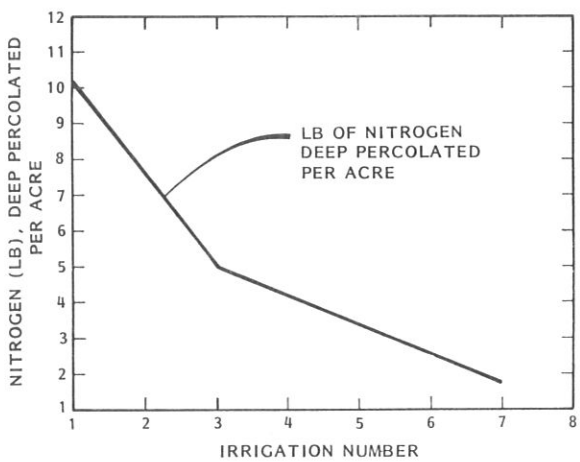



Fig. 3-5 Measured Nitrogen Which Deep Percolates Below Root Zone of Crop

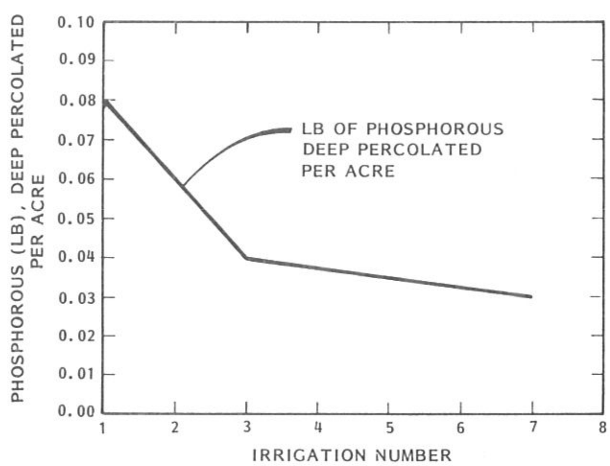



Fig. 3-6 Measured Phosphorus Which Deep Percolates Below Root Zone of Crop

| | Inches | Percent |
|---|---|---|
| Gross application | 47.6 | 100 |
| Net applied | 19.5 | 40 |
| Runoff | 21.6 | 45 |
| Deep percolation | 6.6 | 15 |

Tensiometer data collected from this field is shown in Figure 3-4. These data show excessive water was applied and was measured in deep percolation. Soil water sampler data for the demonstration and control fields are shown below.

Table 3-8. Nutrients in Deep Percolation Water[a]
Bellomy Demonstration

| Date | Nitrogen (%) | Phosphorus (mg/l) | Water (inches) | Nitrogen (lbs/acre) | Phosphorus (lbs/acre) |
|---|---|---|---|---|---|
| **Demo Field** | | | | | |
| 6-5 | 0.025 | 0.30 | 0.18 | 10.2 | 0.01 |
| 6-7 | 0.003 | 0.27 | 0.74 | 5.0 | 0.04 |
| **Control Field** | | | | | |
| 6-7 | 0.006 | 0.48 | 0.74 | 10.1 | 0.08 |
| 7-10 | 0.001 | 0.20 | 0.74 | 1.7 | 0.03 |

The same demonstration and control fields were basically irrigated the same way. By combining the data, a plot of the pounds of nitrogen and phosphorus versus irrigation provided a basis for estimating the total nutrient which would deep percolate during the season. This data is shown in Figures 3-5 and 3-6. Adding the pounds of nitrogen which deep percolate for each irrigation from Figure 3-5 the deep percolation totals are 28.4 lbs/acre for nitrogen. These results show the nitrogen leaching equation used in Stage 1 gives a very accurate estimate of pounds of nitrogen which deep percolates compared to the results from soil water sampler tubes. The plot of the phosphorus deep percolation amounts by individual irrigation (Figure 3-5) indicates only 0.33 lbs per acre moved below the root zone for the season. This indicates what has been stated by others, that phosphorus moves very slowly in the soil profile.

Crop yield measurements were not separated for the demonstration and control fields; yields were 100 bushels per acre.

---

[a]Based on soil water samplings in 1984.

Bob Reffett Farm Demonstration. Bob Reffett operates a 573 acre farm on units 203, 185, 150, 131, and the northwest and northeast quarters of township 20 north, range 28 east, on section 36 of Block 40. The center pivot on the Reffett farm for this demonstration was a 38 acre, 4 tower center pivot circle. It has an endgun which operates on about 3/4 of the circle. This system was selected due to the high level of management the Reffetts obtained during Stage 1. The field was in winter wheat for both seasons.

The principle of using an existing center pivot was to measure the effect of careful irrigation scheduling as compared with an otherwise well managed system to gain confidence in project management equipment use. Methods and a summary of the demonstration features are provided below:

| | | |
|---|---|---|
| Field size | | 38 acres |
| Pivot length | | 630 feet |
| Soil | | Ephrata and Malaga |
| Crop | | Winter wheat |
| Fertilizer (Broadcast) | 1983 Fall | 1984 Spring |
| Nitrogen | 100 lbs | 100 lbs |
| Phosphorus | 50 lbs | |
| Water applied | | 0.4 inches/day |
| Flow system | | 400 gpm |

Equipment used for data collection included a neutron probe, tensiometers, and a soil water sampler tube. Soil samples were also taken during the growing season to measure changes in nitrogen and phosphorus levels.

Total water applied for the season for this system is shown below:

| | |
|---|---|
| Gross applied | 19.3 inches |
| Crop consumptive use[a] | 16.0 inches |
| Evaporation (15% of total) | 2.9 inches |
| Deep percolation | 0.4 inches |
| Runoff | -0- |

The pivot was managed with only a small amount of measured deep percolation. A comparison of data from other center pivots is provided later in this chapter. The tensiometer readings are shown in Figure 3-7. As stated in the Matheson demonstration description, readings should be held between 5 and 50 centibars to keep deep percolation and yield losses at a minimum. This system had some mechanical breakdowns early in the season which caused the soil to dry out more than desired as shown around the 130 to 140 day readings. The remaining readings show good irrigation water management.

---

[a]Crop consumptive use is computed using the pan-evaporation data and the Blaney-Criddle Method. The amount of water applied on this field was low due to equipment breakdowns.

The soil water sampler only collected one sample on Julian day 184. Using tensiometer and neutron probe data, the amount of water which deep percolated from this irrigation would be 0.4 inches. The sample of water had the following concentrations of nitrogen and phosphorus. These concentrations have been converted to pounds per acre of nutrient leached.

Soil Water Sampler

$NO_3N$ - 28.6 ppm - 2.7 lbs/acre

p - 0.3 ppm - 0.03 lbs/acre

Total nitrogen was not measured in this sample but would be something greater than the $NO_3N$ value. Using the nitrogen leaching equation, the amount of predicted total nitrogen deep percolated would be:

$$N \text{ (deep perc)} = 0.029(200)^{1.05}(0.4)^{0.7} = 4.0 \text{ lbs/acre}$$

Although the 2.7 lbs/acre of $NO_3N$ is the actual nitrogen deep percolation as measured by the soil water sampler, the 4 lb/acre predicted by the equation is the nitrogen which would deep percolate. The $NO_3N$ is a portion of the total nitrogen and the types and forms of nitrogen will vary from field to field. This analysis shows the amount and concentrations of nutrients in the water which leaches below the root zone is reduced by using irrigation scheduling. The soil water sampler and the nitrogen leaching equation provide results which appear to be consistent.

The yield for the Reffett demonstration field was 120 bushels per acre versus 104 bushels per acre for the control field.

Tracy Schmidt Farm Demonstration. Tracy Schmidt operates a 540 acre farm on units 45, 57, 191, and 178 of Block 40. The demonstration on Tracy Schmidt's farm was to measure the effectiveness of Irrigation Water Management (IWM) on the deep percolation of water and nutrients on a wheelline sprinkler system. This system is summarized as follows:

| | |
|---|---|
| Field size | 72 Acres |
| Soil | Malaga |
| Irrigation system | Wheelline sprinkler |
| Crop | Alfalfa |
| Fertilizer | |
| Nitrogen | 0 lbs/acre |
| Phosphorus | 50 lbs/acre |
| Gross application/irrigation | 2.8 inches |
| Set time | 11 hours |
| Frequency | 7 days |

The scheduling of irrigations was done using tensiometers. The plot of tensiometers (see Figure 3-8) shows some very high peaks (50 centibars or greater) due to the time required to

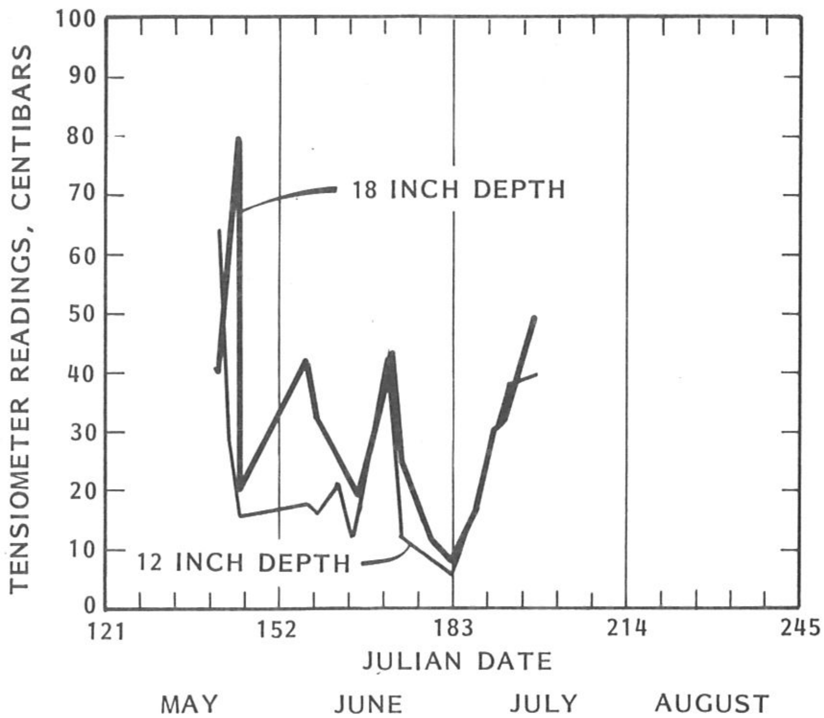



Fig. 3-7 Bob Reffett Tensiometer Readings

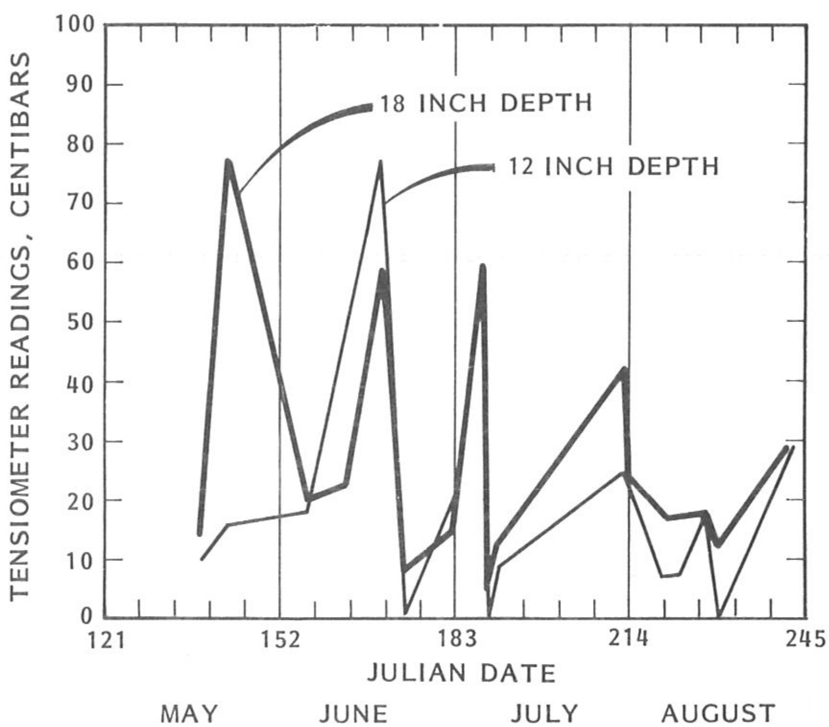



Fig. 3-8 Tracy Schmidt Tensiometer Readings

harvest the alfalfa and get the water back on the field. These dry periods cause a reduction in yield for the cuttings involved. The overall yield for the demonstration field was 6.5 tons/acre versus 6.1 tons/acre for the control field on three cuttings. If the dry periods were managed, there would be an increase in yield if water is provided in a timely manner.

The summary of water use for the Schmidt demonstration is as follows:

| | |
|---|---|
| Number of irrigations | 12 |
| Water applied/irrigation/cycle | 2.8 inches |
| Gross water applied | 33.6 inches |
| Evaporation during application | 5.0 inches (15% of gross) |
| Consumptive use by crop | 27.6 inches |
| Deep percolation | 1.0 inches |

The consumptive use is calculated from evaporation pan data and the Blaney Criddle Method[a]. Deep percolation is estimated from the plot of the tensiometer readings and neutron probe data. The soil water sampler that was installed on the control field and soil samples taken from both the demonstration and control field showed an increase in nitrogen during the irrigation season. These are summarized in Table 3-9. Phosphorus values are also shown.

Table 3-9 Comparisons of Nitrogen in Soil Profile

Soil Water Sampler

| Control Field | May 28 | July 30 | August 3 |
|---|---|---|---|
| $NO_3$-N (mg/l) | 11.3 | 15.0 | - |
| Total N (%) | .002 | - | .08 |

Soil Sampler (Relative Profile Load in ppm)

| Control Field | May 9 | July 2 |
|---|---|---|
| Nitrogen | 11 | 24 |
| Phosphorus | 19 | 15 |
| **Demo Field** | | |
| Nitrogen | 11 | 19 |
| Phosphorus | 23 | 15 |

---

[a]U.S. Department of Agriculture, Soil Conservation Service Technical Note 21, Irrigation Water Requirements, 1967.

Using the soil water sampler data with the consumptive use of the crop since the last irrigation, the amount of deep percolation of nutrients has been calculated as 26.2 lbs/acre for nitrogen and 0.008 lbs/acre for phosphorus for the season for the control field. Nitrogen loadings are of particular interest since this is on a field where no nitrogen has been applied. Since alfalfa is a legume and fixes nitrogen for plant growth, the possibility of nitrogen release from the plant during times of stress (during harvest) have been shown by others. The soil water sampler and the soil samples both confirm deep percolation of nitrogen. Soil samples on the demonstration field also show build-up of nitrogen but to a lesser extent. Modification of some alfalfa management practices with irrigation water management should be considered to reduce this leaching. For example, cutting sequences could be staged in smaller sections to enable irrigation water to be resumed more quickly.

The low loadings of phosphorus in deep percolation indicates that utilization of this nutrient was effective in the Schmidt field. The irrigation water management practices used on the demonstration field saved Tracy Schmidt two irrigations during the season compared to the control field. This amounts to 14 days worth of water, electricity and labor saved in moving wheel-lines as well as reduced wear and tear on all of the equipment. Irrigation water management also reduced the amount of deep percolation of nutrients and water. A summary comparing the demonstration with the control and Stage 1 data is included later in this chapter.

Stage 2 - Yields, Costs and Effects

The demonstrations used during Stage 2 were a combination of structural and management practices. They were used to determine the savings in nutrients which deep percolate below the root zone of the crop. Table 3-10 is a summary of the demonstrations and the control data showing the changes measured.

Impoundments Along Crab Creek Trap Nutrients

Table 3-10 Demonstration Results Summary

| DEMO TYPE | CROP | NITROGEN APPLIED (LB/ACRE) | NITROGEN DEEP PERC (LB/ACRE) | | NITROGEN DEEP PERC (% SAVINGS) | WATER DEEP PERC (INCHES) | | WATER DEEP PERC (% SAVINGS) | YIELD % CHANGE |
|---|---|---|---|---|---|---|---|---|---|
| | | | CONTROL | DEMO | | CONTROL | DEMO | | |
| MATHESON Furrow to Cablegation | CORN | 250 | 51 | 10 | 81 | 11 | 1 | 90 | +10 |
| BELLOMY Furrow to Cablegation | WHEAT | 200 | 41 | 29 | 28 | 11[a] | 7 | 37 | – [b] |
| REFFETT Pivot Management | WHEAT | 200 | 28 | 4 | 85 | 6.6[a] | 0.4 | 94 | +15 |
| SCHMIDT Wheelline Management | ALFALFA | 0 | 26 | 8 | 70 | 6.0 | 1 | 83 | + 7 |

[a] From Stage 1 Evaluation Data

[b] Crop Yield Not Differentiated

The tabulated data indicates that the use of structural and management practices does cause a significant reduction in the deep percolation of nitrogen. This is shown as a reduction of 81% and 28% for the two cablegation systems, 85% for the center pivot system and 70% for the wheelline system. There is also a savings of water which would deep percolate as shown as 90% and 37% for the two cablegation systems, 94% for the pivot, and 83% for the wheelline system. The yield changes are based on data measured by the farmers for the control and demonstration fields. Increases in yield have been noted by others when careful management practices are used. Figure 3-9 graphically compares the deep percolation of water and nitrogen and the yields from each demonstration and control field.

The costs for these four demonstration systems are shown in Table 3-11. Costs per acre, nitrogen savings, and costs per pound nitrogen saved are also developed in the table.

Table 3-11 Demonstration and Nitrogen Savings Costs

| System | Total Cost($) | Cost/Acre ($) | N Saved lbs/Acre | Cost $lbN/Acre |
|---|---|---|---|---|
| Matheson | 6,028 | 301 | 41 | 7.34 |
| Bellomy | 7,884 | 394 | 13 | 30.30 |
| Schmidt | 2,060 | 26 | 20 | 1.30 |
| Reffett | 1,220 | 32 | 24 | 1.33 |

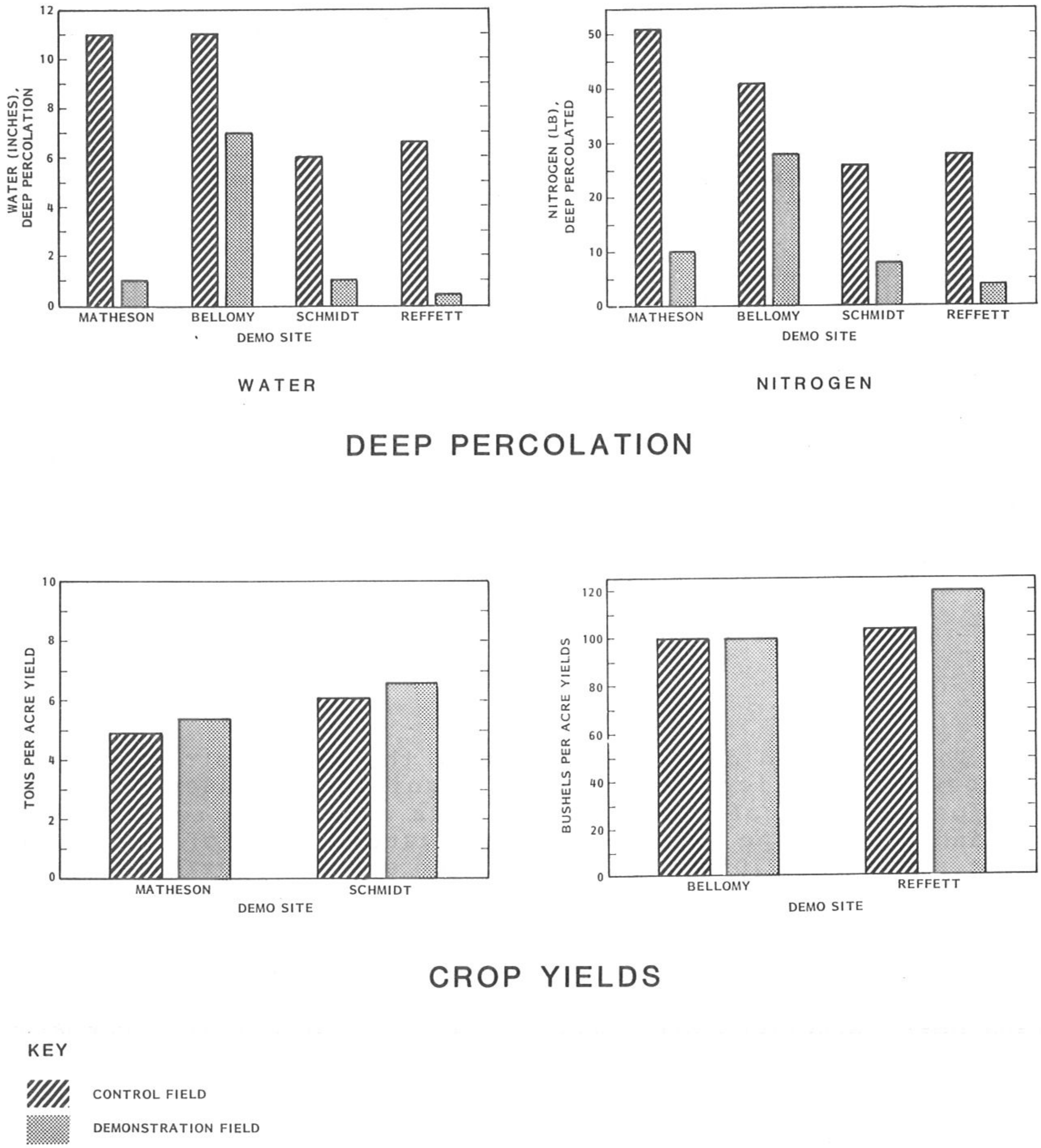



Fig. 3-9 Comparison of Demonstration Results

The cost per pound of nutrient saved from deep percolation will be used later in the report to relate on-farm practice changes to off-farm approaches to nutrient control. These costs are based on actual installation costs for the demonstrations. Not all costs need to be incurred by farmers participating in Stage 3. Cost share programs proposed for Stage 3 are described in Chapter 6.

All the demonstration data collected indicate significant savings are possible through conversion of 1) furrow to a cablegation or sprinkler system and 2) irrigation water management approaches to control the amount of water and nutrients which deep percolate. The cost of irrigation water management to the farm operator is the additional labor required for management of his system. Benefits to the farmer include increased yields, water savings and reduced wear and tear on irrigation equipment.

Data from Stage 1 and 2 can be used to determine nitrogen loadings from the 28,000 tributary area of coarse Ephrata-Malaga soils. From Stage 1 the average deep percolation measured in these soils is 7.05 inches/acre. This totals 16,450 acre feet of deep percolation over the 28,000 acres.

Nitrogen leached in deep percolation was computed from Stage 1 data as an average of 23.4 lbs/acre for fields receiving nitrogen fertilizer (see Table 3-8). Stage 2 data demonstrated that alfalfa hay fields which do not receive nitrogen fertilizer applications also experience deep percolation of nitrogen. The Tracy Schmidt alfalfa field demonstration showed a nitrogen loss of 26.2 lbs/acre based on soil water sampler data (see Table 3-8). Total nitrogen lost to deep percolation based on the Stage 1 crop pattern in the 28,000 acre project area is estimated in Table 3-12.

Table 3-12. Estimated Nitrogen Lost to Deep Percolation

| Crop | Deep Percolation Inches | Estimated Nitrogen Leached lbs/acre | Crop Area Acres[c] | Estimated Deep Percolation Acre/Feet | Estimated Total N Lost |
|---|---|---|---|---|---|
| Wheat, pasture, corn, misc. | 7.1 | 23.4 | 14,560 | 8,283 | 340,700 |
| Alfalfa hay | 6.6[a] | 26.2[b] | 13,440 | 7,700 | 352,130 |
| Totals | | | 28,000 | 15,983 | 692,830 |

[a]From Stage 1 evaluation data and demonstration results.

[b]From Stage 2 Tracy Schmidt alfalfa field demonstration data.

[c]Based on crop distributions from Stage 1 inventory.

Nutrient budgets for the lake developed in Stage 1 estimated 889,500 lbs (404,300 kg) of nitrogen contributed by groundwater and 554,400 (252,000 kg) lbs from Crab Creek flows entering Moses Lake. Revision to these budgets based on Stage 2 evaluations are discussed in Chapter 4. Based on these estimates, the total nitrogen associated with deep percolation from the 28,000 acres in the project area account for at least 50 percent of the total nitrogen associated with Crab Creek and groundwater flows. As discussed in Chapter 4, groundwater volumes reaching Moses Lake are highest in the Parker Horn/Pelican Horn vicinity down gradient from the project area. Accordingly, deep percolation of fertilizer from irrigated agriculture is the most important single contributor of nitrogen to Moses Lake. Nitrogen is the limiting nutrient to algae growth in Moses Lake and, therefore, an important element in any eutrophication control program. The effect of various nutrient controls approaches on Moses Lake water quality is discussed in Chapter 6.

Summary of Demonstration Results

Full scale demonstrations on four cooperating farms provided an opportunity for the Clean Lake Project to measure the effect of BMPs in reducing nutrient and water movement below the root zone. BMP demonstration results are summarized below:

1. Deep percolation of both water and nitrogen below the root zone was markedly reduced by the BMPs. Deep percolation of nitrogen on the two cablegation systems was reduced from 28 to 85 percent; deep percolation of nitrogen resulting from irrigation water management was reduced 85 percent on the center pivot demonstration and 70 percent on the wheelline demonstration.

2. Irrigation scheduling, by use of tensiometers and flow meters, was found to be effective and operational for the farmers involved with the demonstration fields.

3. The demonstration fields had higher yields than the control fields. It has been found that IWM generally produces higher yields due to better utilization of water and nutrients.

4. Alfalfa, which is a nitrogen-fixing crop, can release stored nitrogen during stress periods (i.e. when the hay is being cut and not irrigated). The nitrogen released is leached and deep percolated by irrigation water. The amount of nitrogen deep perked was reduced by IWM and could be reduced further by consecutively cutting 1/2 to 1/3 of the field at a time while the rest of the field continues to be irrigated, instead of ceasing irrigation on the entire field while hay is being cut.

5. The cost/lb N/acre ranged from $1.30 for IWM on the existing wheellines and the center pivot, to $7.34 for cablegation installations on Matheson's demonstration field and $30.30 on Bellomy's demonstration.

In summary, demonstration results for IWM on sprinkler systems and cablegation with IWM prove that these BMPs are viable and effective in reducing the deep percolation of water and nitrogen.

## Livestock Operations and Controls

Livestock operations in the project area were inventoried and evaluated to determine their significance to Moses Lake nutrient loadings. Six farms were covered in this inventory including one feed lot, three dairies and two non-confinement cattle feeding operations. All six were visited to observe livestock management and operating procedures. Descriptions of each operation are provided in Appendix B. Pollution controls are included with the descriptions and are further described in Chapters 5 and 6 for those farms having potential significant impact on Moses Lake nutrient loadings.

# CHAPTER 4

# GROUNDWATER FLOWS AND SOURCES

Groundwater contributions were the most significant source of nitrogen to Moses Lake according to nutrient budgets developed in Stage 1. Similarly high phosphorus contributions were found in the areas groundwaters from sampling of wells and springs. The presence of high nitrogen concentrations was not unexpected since highly soluble nitrates are often found at elevated levels in groundwaters flowing under agricultural areas. The presence of high phosphorus values in local groundwater was more surprising since phosphates are usually bound with surface soils. The very coarse Ephrata-Malaga soils appear to allow phosphorus to move more freely in local groundwaters.

The purpose of this chapter is to improve groundwater nutrient loading estimates in order to better evaluate the effect of nutrient controls in the watershed and their effect on Moses Lake water quality. Tasks involved required different approaches in evaluating nitrogen and phosphorus loads.

The nitrogen task required further evaluation of groundwater flow volumes for subsequent use in a mathematical model which computed Moses Lake water quality based on stream flow and groundwater contributions of nitrate-nitrogen. Since Stage 1 data were already available for the nitrogen concentration, the primary task was to refine groundwater flow estimates. Stage 1 flow estimates were based on water budget calculations where groundwater was computed by difference between measured and estimated lake inflows and outflows.

Phosphorus evaluations were primarily directed at sources such as the Rocky Ford Creek springs and sewage contributions from municipal and on-site waste disposal practices. Rocky Ford Creek obtains virtually all of its flow from springs which are notably high in phosphorus compared with other springs sampled in the Moses Lake watershed during Stage 1. Rocky Ford Creek at 28 percent of the lake's annual phosphorus load was the highest single source of phosphorus according to the Stage 1 nutrient budget. This proportion is now more nearly 33 percent as a result of relocation of the City of Moses Lake sewage effluent discharge from Pelican Horn to a sandy land disposal site south and east of the lake. The source of the elevated Rocky Ford Creek phosphorus values remained a question in Stage 1 and further sampling was indicated. Municipal sewage disposal practices in the Ephrata/Soap Lake area were one of the potential sources to be evaluated along with agricultural and natural sources. Septic system contributions also were singled out for more evaluation in Stage 2 because of the relatively high phosphorus content of sewage and its mobility in the coarse local soils.

## Moses Lake Area Geology

The geology and groundwaters of the Columbia Basin Project area have been described by the U.S. Geological Survey (USGS) and the State Department of Natural Resources (DNR), Division of Geology and Earth Resources. The USGS published generalized maps of basalt surface contours and groundwater gradients which are useful in evaluating groundwater movement in the vicinity of Moses Lake.[a] The State has published descriptions of the geology of Grant County and of area groundwaters.[b,c]

Two major distinct groundwater systems interact in the study area, both of which are recharged by irrigation and discharge into Rocky Ford Creek, Crab Creek and Moses Lake. The upper system consists of unconsolidated glacio-fluvial sand and gravel which forms a mantle over the underlying basalt bedrock. The glacio-fluvial deposits generally vary from about 20 to 100 feet thick. The basalts exposed in the vicinity of Rocky Ford Creek are predominantly from the Rosa member of the Wanapum Formation. This formation probably underlies most of the immediate area surrounding Moses Lake. See Figure 4-1 for map of basalt outcroppings in the vicinity of Moses Lake. East of the East-Low Canal the Priest Rapids member of the Wanapum Formation is dominant. The mantle of sand and gravel in this area is generally thinner. In most areas the Priest Rapids basalt is covered by a thin veneer of soil (0 to 6 feet thick) and weathered basalt. The Rosa member underlies the Priest Rapids member. Both the Priest Rapids and the Rosa consist of successive volcanic flows stacked on top of one another. It is the highly fractured and weathered zones which occur between the volcanic flows which, when filled with water, form the basalt aquifers.

Recharge for both the unconsolidated glacio-fluvial aquifers and the basalt aquifer is primarily from irrigation. Groundwater discharge areas are Rocky Ford Creek, Moses Lake and Crab Creek. The recharge to the Rocky Ford stream area comes from the north-

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[a]Walters, K. and Grolier, M. 1960. Geology and Ground Water Resources of the Columbia Basin Project Area, Washington. Vol. 1, Water Supply Bulletin No. 8, Prepared by the State of Washington in Cooperation with U.S. Geological Survey.

[b]Grolier, M. J. and J. W. Bingham. 1978. Geology of Parts of Grant, Adams and Franklin Counties. State of Washington, Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA.

[c]Tanaka, H. H., A. J. Hansen, Jr., and J. A. Skrivan. 1974. Digital-Model Study of Ground-Water Hydrology, Columbia Basin Irrigation Project Area, Washington, Water Supply Bull. 40. State of Washington, Department of Ecology, Olympia, WA.

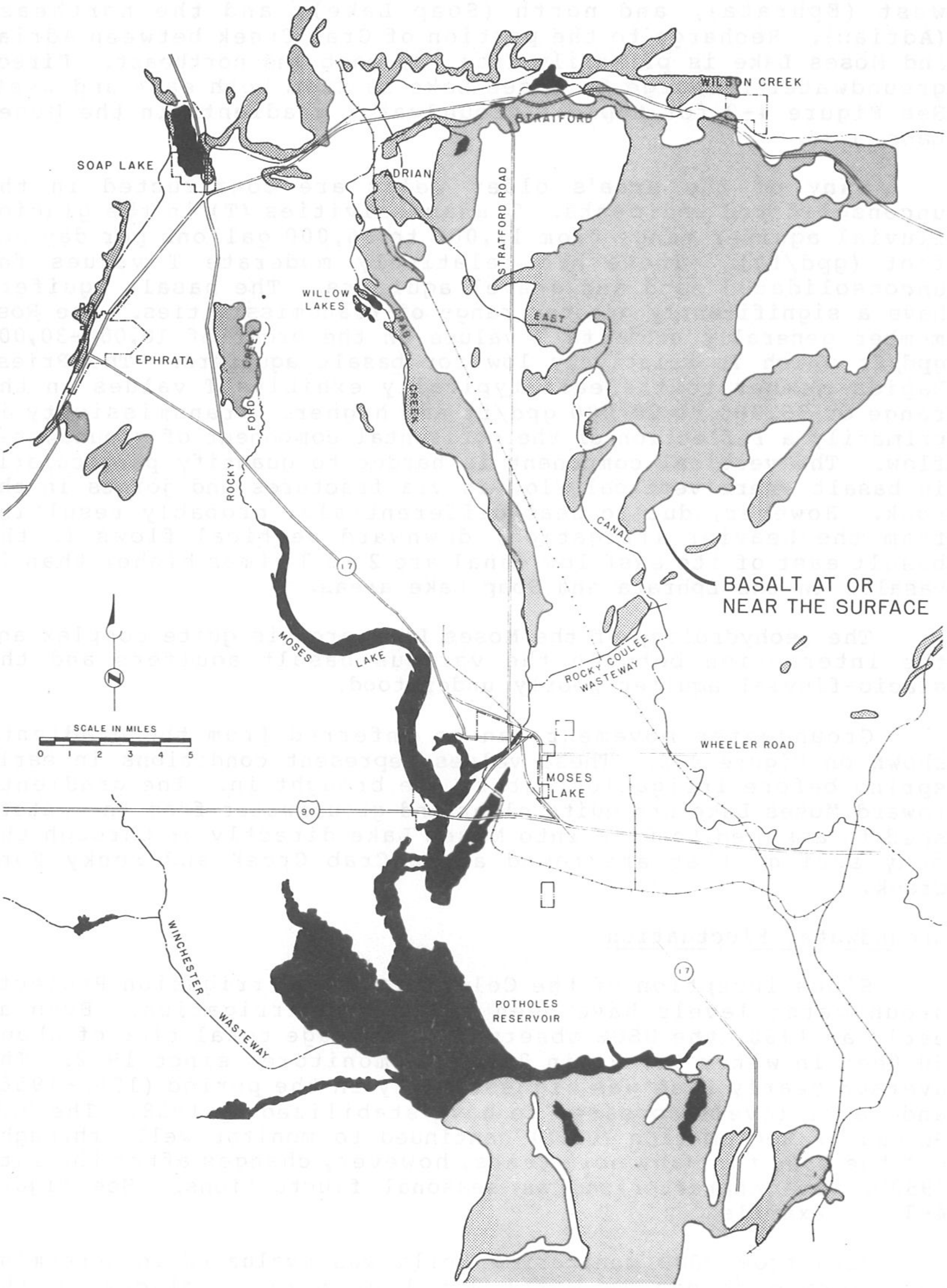



Fig. 4-1 Basalt Outcroppings Near Moses Lake

west (Ephrata), and north (Soap Lake), and the northeast (Adrian). Recharge to the portion of Crab Creek between Adrian and Moses Lake is primarily from the east and northeast. Direct groundwater recharge to Moses Lake is from both east and west. See Figure 4-2 for typical groundwater gradients in the Moses Lake area.

Many of the area's older wells are constructed in the unconsolidated sediments. Transmissivities (T) in the glacio-fluvial aquifer range from 12,000 to 66,000 gallons per day per foot (gpd/ft). These are relatively moderate T values for unconsolidated sand and gravel aquifers. The basalt aquifers have a significantly greater range of transmissivities. The Rosa member generally exhibits T values on the order of 10,000-30,000 gpd/ft which is relatively low for basalt aquifers. The Priest Rapids member to the east typically exhibits T values in the range of 30,000 to 90,000 gpd/ft and higher. Transmissivity is primarily a reflection of the horizontal component of groundwater flow. The vertical component is harder to quantify particularly in basalt where vertical flow is via fractures and joints in the rock. However, due to head differentials, probably resulting from the heavier irrigation, downward vertical flows in the basalt east of its east low canal are 2 to 3 times higher than in basalts in the Ephrata and Soap Lake areas.

The geohydrology of the Moses Lake area is quite complex and the interaction between the various basalt aquifers and the glacio-fluvial aquifer poorly understood.

Groundwater movement can be inferred from the gradients shown on Figure 4-2. These values represent conditions in early spring before irrigation waters are brought in. The gradients toward Moses Lake are quite clear and groundwater from the watershed is assumed to flow into Moses Lake directly or through the many springs that are found along Crab Creek and Rocky Ford Creek.

## Groundwater Fluctuation

Since inception of the Columbia Basin Irrigation Project, groundwater levels have been related to irrigation. Even as early as 1960, the USGS observed an average total rise of about 50 feet in water levels in 28 wells monitored since 1952. The average yearly rise was highest early in the period (1952-1956) and water levels appeared to have stabilized by 1958. The U.S. Bureau of Reclamation (USBR) continued to monitor wells throughout the area for many more years, however, changes after the late 1950's were characterized as seasonal fluctuations. See Figure 4-3 for example.

Data from USBR monitoring wells was evaluated to determine the average change in water level at various places in the watershed. Seasonal fluctuations varied from no change to 18 feet in 20 locations scattered throughout the project area. Some

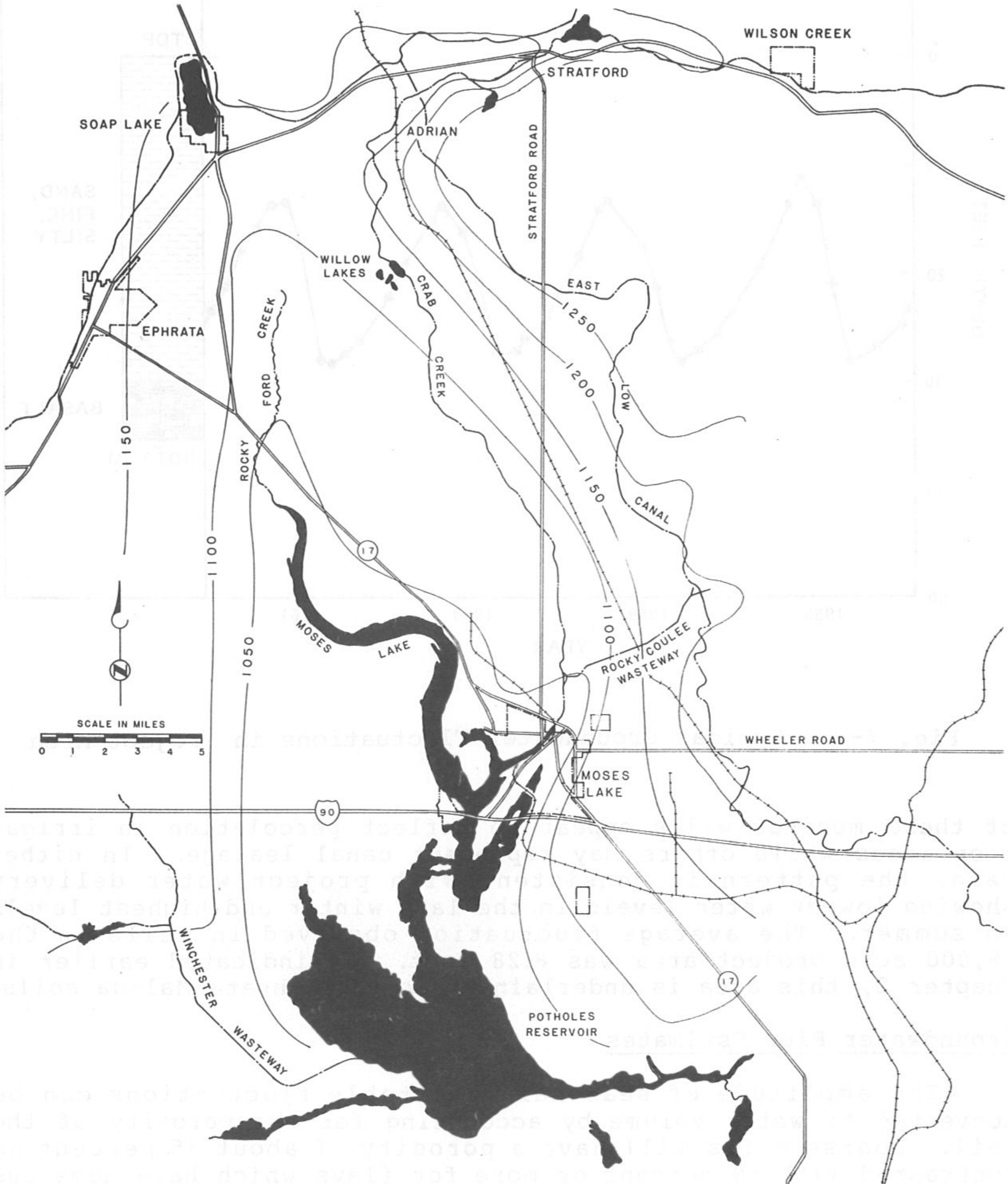



Fig. 4-2 Typical Groundwater Gradients Near Moses Lake

Ref. USBR data

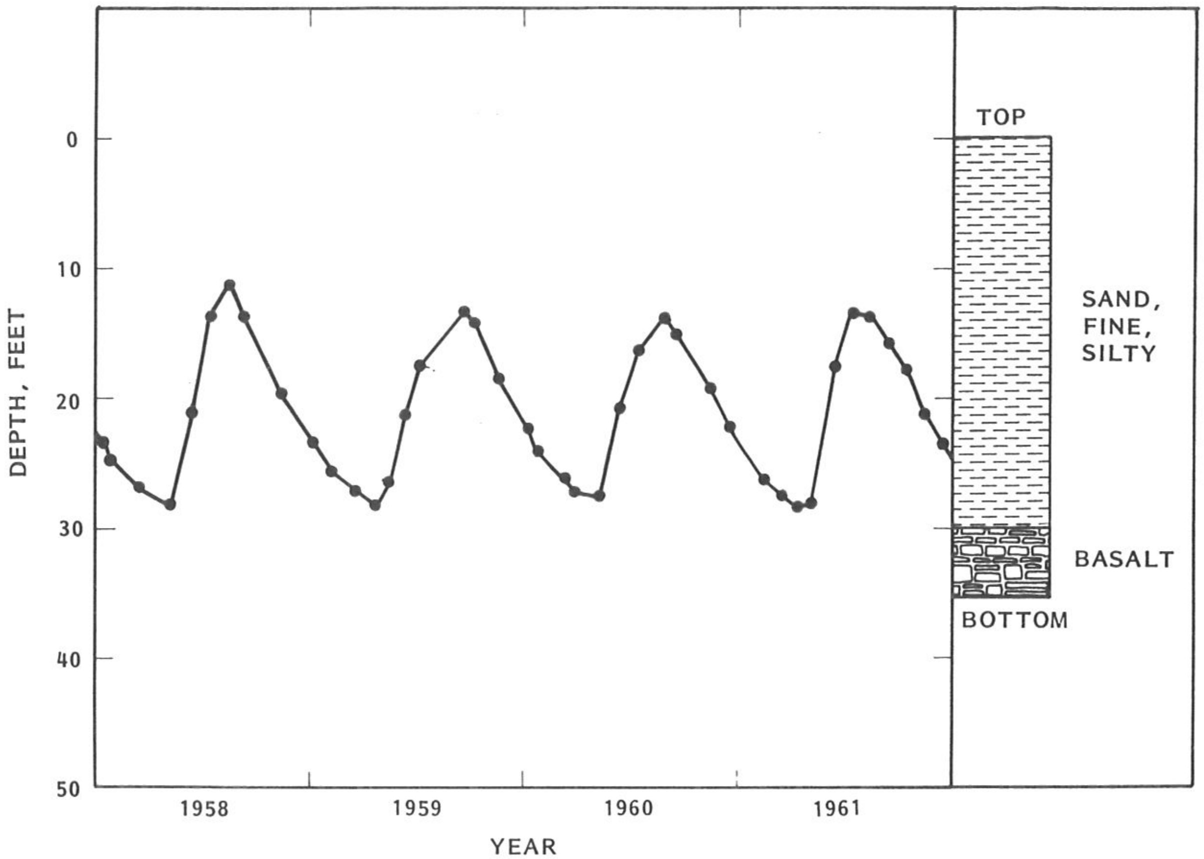



Fig. 4-3 Typical Groundwater Fluctuations in Project Area

of these monitor wells appear to reflect percolation in irrigation areas while others may represent canal leakage. In either case, the pattern is consistent with project water delivery showing lowest water levels in the late winter and highest levels in summer. The average fluctuation observed in wells in the 28,000 acre project area was 8.28 feet. As indicated earlier in Chapter 2, this area is underlain by coarse Ephrata-Malaga soils.

<u>Groundwater Flow Estimates</u>

The amplitude of seasonal watertable fluctuations can be converted to water volume by accounting for the porosity of the soil. Coarse soils will have a porosity of about 35 percent as contrasted with 50 percent or more for flays which have numerous though much smaller voids. A typical porosity of 40 percent was assumed for the Ephrata-Malaga soils for the purpose of estimating seasonal water volumes based on groundwater fluctuations. This calculation produced a total water volume of 3.31 acre feet per acre of annual groundwater fluctuation in the irrigation project area. Extending this value to the 28,000 acre irrigation area results in an estimate of 92,680 acre feet of groundwater that moves from this area each year.

An independent check on groundwater movement was conducted by using USBR project operations figures which include estimates of canal losses as reported in Monthly Water Distribution Reports. For example, using 1983 data, the East Low Canal losses totaled 0.77 acre feet per acre and lateral losses totalled 1.37 feet. During this period, 3.85 acre feet per acre was actually delivered to the farms. Using a typical figure of 25 percent loss on the farms for the delivered water, a total loss of 3.10 acre feet per acre is computed which compares favorably with the 3.31 acre feet per acre arrived at through evaluation of monitoring wells. The deep percolation and surface runoff values estimated for Block 40 area farms during Stage 1 was 10.5 inches which closely approximates the 11.5 inches estimated using 25 percent of the delivered water. Using 3.10 acre feet per acre, a total annual groundwater flow of 86,800 acre feet is estimated for the Crab Creek watershed area between Adrian and Moses Lake. Flows from the upper Crab Creek watershed appear to move into the Rocky Ford Creek area and are responsible for the major springs which emanate from this small watershed.

During Stage 1, the groundwater flow to Moses Lake was estimated considering lake operations. Inflows to the lake, such as Crab Creek and Rocky Ford Creek, were known based on surface water monitoring results. Evaporation losses were estimated from the lake surface areas. Lake outflow was known as were the surface water/volume relationships of the lake as its water surface elevation fluctuates. Sewage flows were known and urban area septic tank leachate could be estimated based on population estimates. The difference between these known or estimated inflows and outflows was assumed to be groundwater. Based on this approach, the groundwater flow estimate for Stage 1 was 68,100 acre feet using data from 1978. A similar computation for 1977 yielded 102,900 acre feet. The values calculated using monitoring wells and USBR project water loss statistics yield values in this range. The midpoint of the range of independent groundwater flow estimates is approximately 85,000 acre feet or 105 million cubic meters per year. Groundwater loading estimates used in estimating Moses Lake water quality will be based on this flow. The rate of flow for specific time periods will be based on actual groundwater level observations in wells in the lower Crab Creek area near Parker and Pelican Horn. Groundwater flow during the critical spring-summer period is assumed to be proportional to the elevation (head) above the normal operating level of Moses Lake (elevation 1,046). See Figure 4-4 for an illustration of the estimated seasonal flow pattern based on an annual groundwater flow rate of 105 million cubic meters.

Phosphorus Source Evaluation

Stage 1 nutrient budgets estimated that Rocky Ford Creek supplies 28 percent of the total phosphorus and 21 percent of the nitrate + nitrite-nitrogen annual loadings to Moses Lake. The flow of this stream is comprised largely of groundwater discharged from a series of springs at its headwaters.

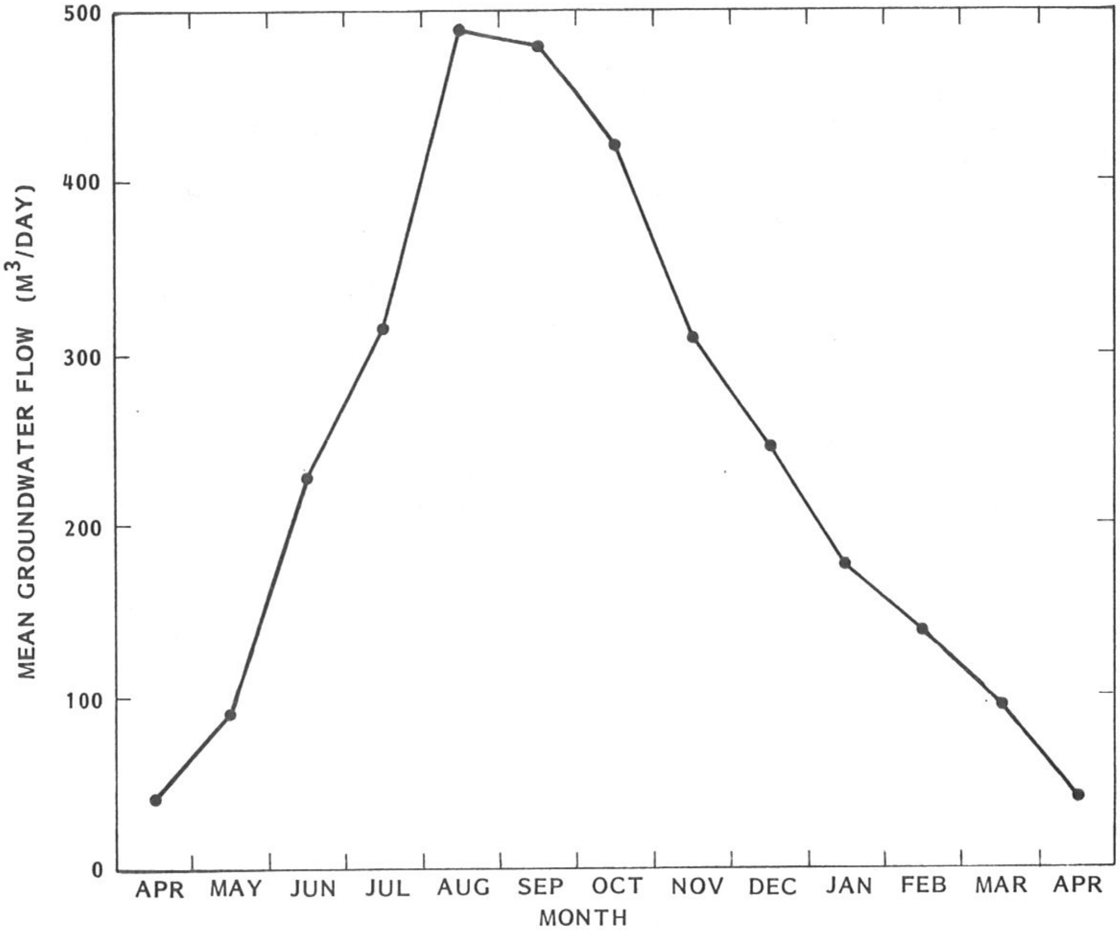
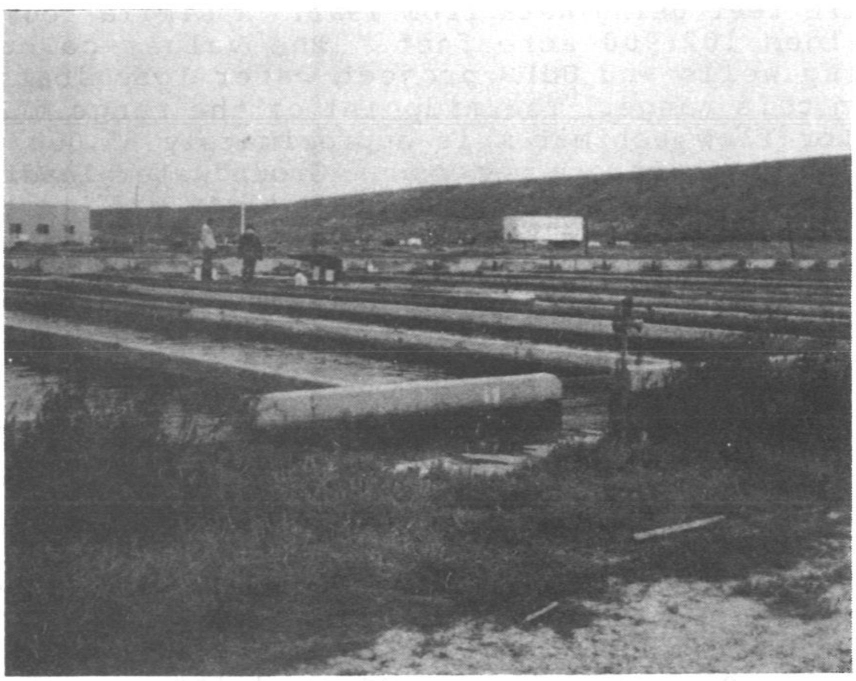



Fig. 4-4 Estimated Groundwater Flow Pattern to Moses Lake



Fish Hatchery on Rocky Ford Creek

Phosphorus concentrations are relatively high in all seasons in Rocky Ford Creek, with annual averages during the 1982-83 water year of 99 and 141 micrograms/liter for soluble reactive phosphorus and total phosphorus respectively. Groundwater is the apparent source of these nutrients; concentrations in one of the main springs averaged 99 and 120 micrograms/liter for soluble phosphorus and total phosphorus, respectively, during that water year. Nitrogen concentrations are not as elevated relative to other sources to Moses Lake but are quite stable seasonally and, with the high discharge of the stream, contribute significantly to the annual loading of this nutrient.

An investigation was undertaken to attempt to determine the ultimate source of these nutrients in the springs feeding Rocky Ford Creek. It was hypothesized that the source could lie to the west in the Ephrata area, to the north in the Soap Lake area, to the east and northeast in the Adrian area, or in all three. Agriculture, either irrigated or dryland, occurs in all three areas. Both the Ephrata and Soap Lake municipal sewage treatment plants practice land disposal of treated effluent, and Soap Lake itself has high mineral concentrations, including phosphorus that potentially could enter groundwater. Bureau of Reclamation and other personnel have reported for years that groundwater moves from Crab Creek in the Adrian area and surfaces at the Rocky Ford Creek springs. Crab Creek has several impoundments upstream of Adrian that trap nutrients entering from the Lincoln County agricultural lands as shown in Stage 1. Also, it was thought to be conceivable that natural deposits of phosphate-bearing rock may occur somewhere in these areas.

Water Quality Comparisons. To examine the hypothesized sources of nutrients, samples were taken from a number of sites, mostly wells, in all three areas and tested for phosphorus, total phosphorus and specific conductivity. Data from other sites in these areas collected during the previous project also were reexamined. Figure 4-5 shows the locations of all the sampling stations used in this investigation and the relative total phosphorus concentration found at each location. Only shallow alluvium wells were monitored since the effect of local land practices was more likely to be observable in these locations as contrasted with the deeper more complex basalt wells. These data were analyzed to attempt to determine groundwater flow patterns and the movement of nutrients to Rocky Ford Creek considering groundwater gradients described earlier. See Figure 4-2. Another part of the investigation involved surveying soils and hydrogeological information through review of reports and interviews with several persons having knowledge of these aspects of the Grant County environment.

Some of the stations shown on Figure 4-5 could be eliminated from possible involvement with the Rocky Ford Creek springs on grounds of their location or water quality characteristics. Several stations were down-gradient and thus obviously could not feed the springs. The groundwater station nearest Soap Lake had

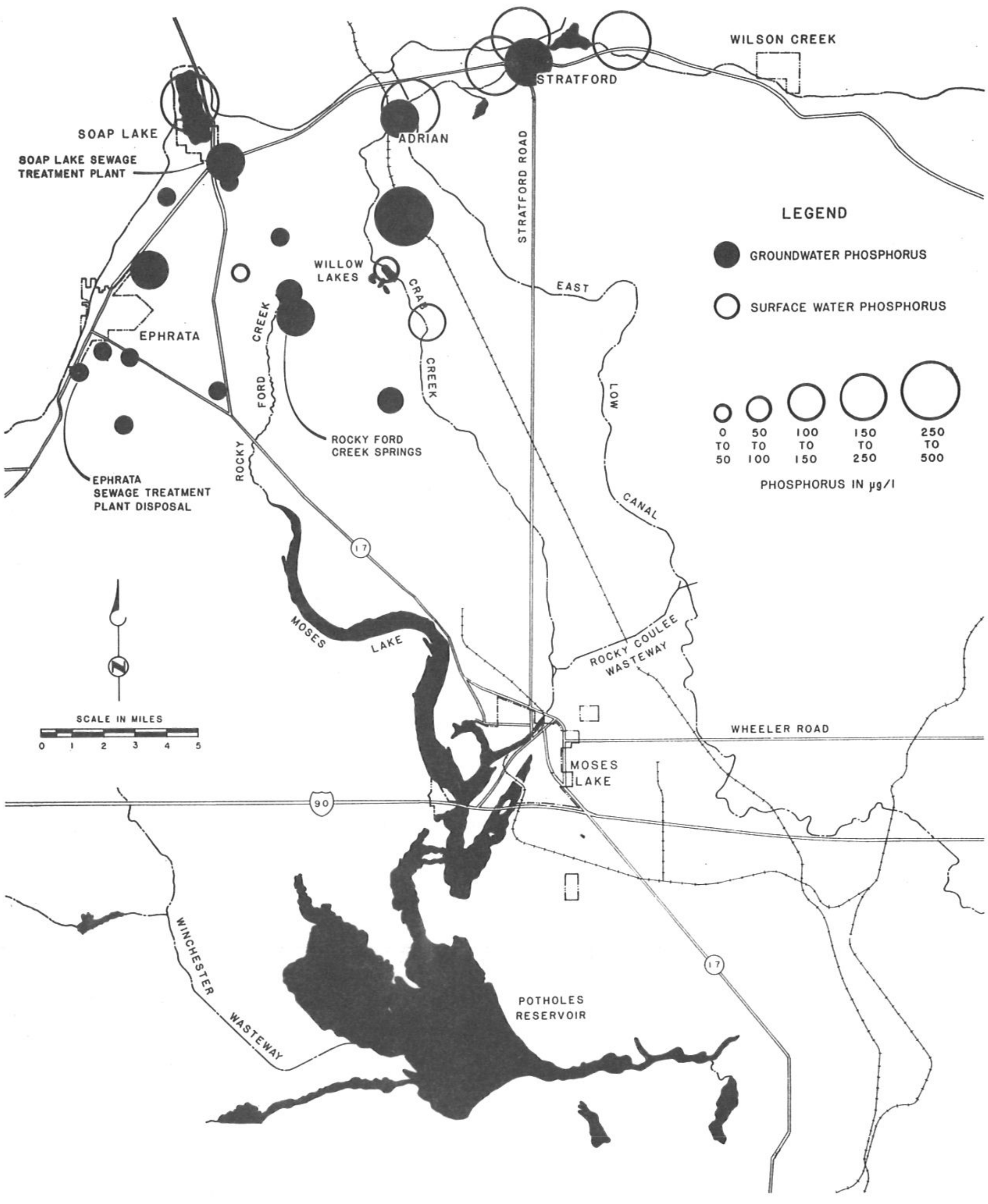



**Fig. 4-5** Relative Phosphorus Concentrations in Wells and Surface Waters in the Ephrata/Stratford Area

a substantially higher specific conductivity and must represent a different water supply. Soap Lake itself had a specific conductance of over 17,000 umho/cm whereas Rocky Ford Springs are generally below 400 umho/cm. In the Ephrata area only one station was comparable to the springs in phosphorus concentration, placing doubt on that area as source since most of the shallow wells were very low in phosphorus. The Ephrata sewage treatment plant land disposal operation was eliminated based on these observations.

Soils and Hydrogeology Review. The Grant County soils survey was consulted to determine the nature of soils near the sampling stations of greatest interest, along with some others.[a] At the Rocky Ford Creek springs themselves, the soil is stony fine sandy loam over basalt lying 12-20 inches below the surface. Soils in the vicinity of most of the stations of interest are of very coarse textures and relatively deep, often with gravel lower horizons. It is apparent that water movement would be rapid through soils of this description.

Geological maps of the area also were consulted.[b] Geology at the springs and over a wide area in every direction, except the west, is fluvial gravel, a very porous structure. Immediately to the west of the springs is a basalt formation (Rosa Member) that surfaces. It is typical that the occurance of an igneous or metamorphic formation of low porosity adjacent to unconsolidated material results in a concentration of springs such as occurs at Rocky Ford Creek. This basalt also is thought to be a barrier to groundwater penetration from the Ephrata area. Groundwater probably flows from Ephrata toward the southeast and may enter Rocky Ford Creek downstream or Moses Lake. Ephrata seems to be the least likely source of nutrients to the Rocky Ford Creek springs of the three areas considered.[c]

Extensive basalt also exists along the course of Crab Creek, mostly on the south side of the channel upstream of Adrian and on the east side after the stream changes course to the south. This basalt appears to be a barrier to groundwater transport away from Rocky Ford Creek. Therefore, any groundwater recharged from Crab Creek or the impoundments in its course likely moves through the

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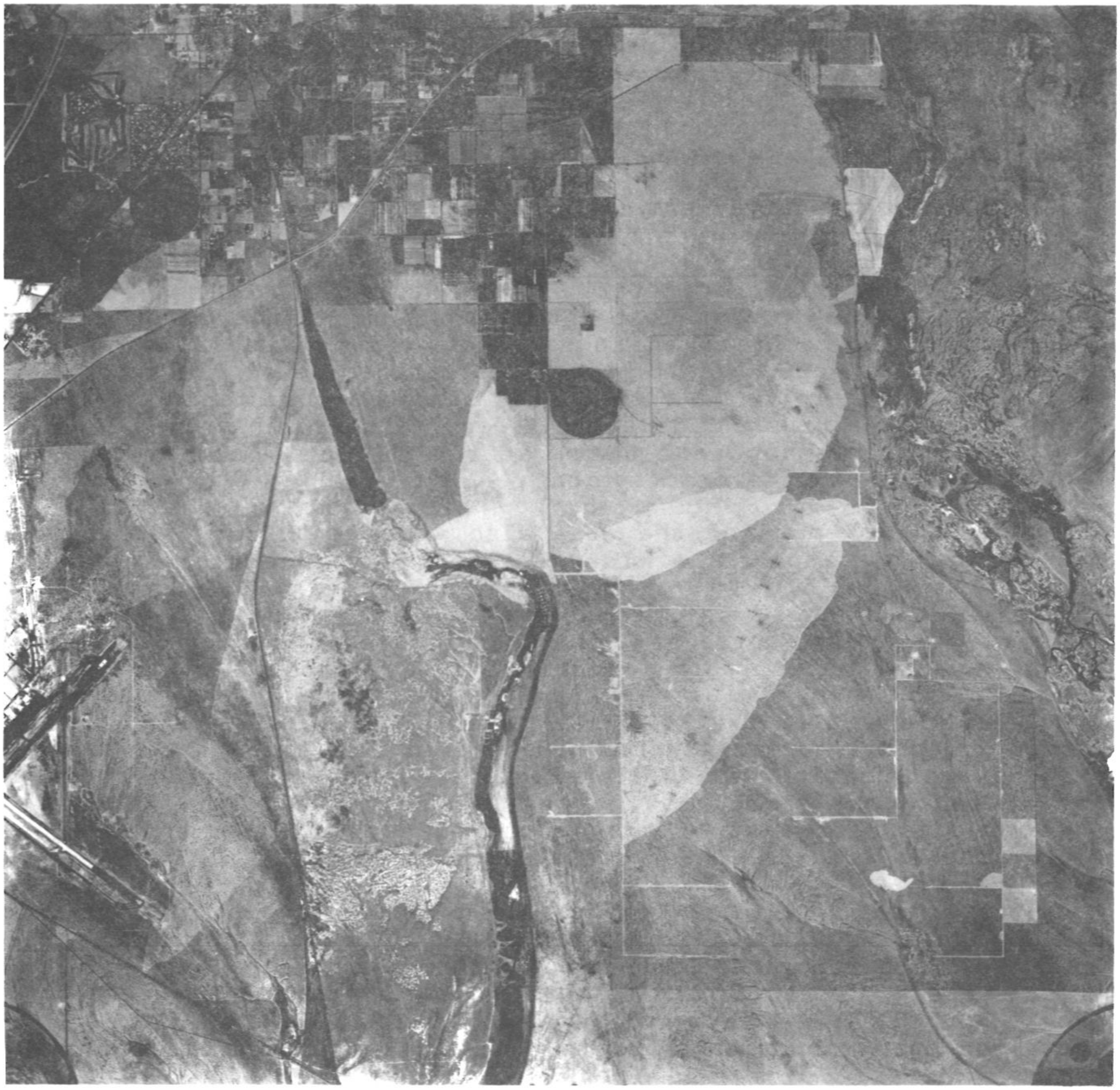
[a]U. S. Soil Conservation Service. 1978. Soil Survey of Grant County, Washington. U. S. Department of Agriculture, Washington, D. C.

[b]Grolier, M. J. and J. W. Bingham. 1971. Geologic Map and Sections of Parts of Grant, Adams and Franklin Counties, Washington, Miscellaneous Map Investigations, Map I-589. U. S. Geological Survey, Washington, D. C.

[c]Neumann, D., Bureau of Reclamation Geologist (retired), Quincy, WA, personal communication.



Aerial View of Upper Rocky Ford Creek and Portion of Soap Lake fluvial gravels to the west and southwest, toward Rocky Ford Creek.

The report literature and persons familiar with the Grant County hydrogeology were surveyed to obtain any existing information on the relationship of Crab and Rocky Ford Creeks. Mundorff et al. made the most definitive statement about that relationship, quoted below. It refers to Adrian sink, which is a glacial drainage located just west of the point where Crab Creek bends to flow south.[a]

> From Brook Lake above Stratford, through Adrian, the groundwater table is in gravel-filled channels below the surface drainage of Crab Creek, and undoubtedly Crab Creek loses much of its flow to the groundwater in this reach. In Adrian sink, extending for nearly 3 miles about midway between Adrian and Soap Lake, the normal flow and even moderately high flows of Crab Creek are completely absorbed by the gravels, and only during extreme flood conditions does any surface drainage reach Moses Lake through Crab Creek. The water which goes underground from Crab Creek below Brook Lake and in Adrian sink reappears in Rocky Ford Springs. Partial evidence for this conclusion is that a gravel-filled channel leads from Adrian sink to Rocky Ford Springs. Further evidence is the correlation of water level fluctuations in well 22/28-6R1, dug in this channel 8 miles northeast of the springs, with the discharge from the springs. A time lag of one or two months apparently represents travel time of the groundwater wave and may also represent actual travel time of the water.

Other observers also have referred to this groundwater flow pattern. Tanaka et al. in describing a model study of the groundwater hydrology, stated that Crab Creek from Adrian to Moses Lake is a constant recharge source to the upper, alluvial aquifer.[b] The Bureau of Reclamation, in the Columbia Basin Project environmental impact statement, stated that Brook Lake recharges groundwater and that the underground flow emerges at Rocky Ford Creek.[c] Grolier and Bingham stated that Crab Creek

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[a]Mundorff, M. J., D. J. Reis, and J. R. Strand. 1952. Progress Report on Ground Water in the Columbia Basin Project, Washington. U. S. Geological Survey, Washington, D. C.

[b]Tanaka, H. H., A. J. Hansen, Jr., and J. A. Skrivan. 1974. Digital-Model Study of Ground-Water Hydrology, Columbia Basin Irrigation Project Area, Washington, Water Supply Bull. 40. State of Washington, Department of Ecology, Olympia, WA.

[c]U. S. Bureau of Reclamation, 1975. Draft Environmental Impact Statement, Columbia Basin Project, Washington. U. S. Department of the Interior, Ephrata, WA.

overflows into the Adrian sink during flood stage.[a] As the data in Figure 4-5 indicate, Brook Lake, Round Lake, and a number of wells in the Adrian area could be sources of phosphorus in the concentrations measured in the springs.

The Bureau of Reclamation also discussed the involvement of the Soap Lake area in the Rocky Ford Creek hydrology. Near Soap Lake itself, groundwater moves toward the lake and is intercepted by a series of wells and pumps, known as the Soap Lake Protective Works, to protect the lake from irrigation seepage additions and maintain its highly mineralized character. However, except in the restricted Soap Lake basin itself, irrigation in Block 70 of the Columbia Basin Project is thought to contribute to the Rocky Ford Creek springs. Sampling stations near Soap Lake and Adrian lie in that portion of Block 70 that may contribute to the springs. A well near Adrian has phosphorus and specific conductance values comparable to the springs and may pinpoint a location of specific groundwater streams that emerge at the springs. It appears that agriculture outside the Rocky Ford Creek catchment could, rather directly, affect its water quality.

A search was conducted for possible natural sources of the nutrients that, apparently, reach Rocky Ford Creek through groundwater. Feldspars and apatites can contain substantial phosphorus. The geological maps showed no significant deposits of either in the area.[b] A geologist with considerable experience in the area knew of no natural structures high in phosphorus.[c] The geological maps did indicate that the fluvial gravel forming much of the geology of the area contains caliche, a crust of calcium carbonate that forms on the stony soil of arid regions and can be nitrate-bearing.

The major source of the nutrients emerging in the Rocky Ford Creek springs appears to be the impoundments that serve as nutrient sinks in the Crab Creek watershed and, ultimately, agriculture in Upper Grant County and Lincoln County. Most agricultural activity in that area involves either cattle ranging or dryland wheat cultivation, which should promote transfer of nutrients to groundwater much less effectively than irrigation.

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[a]Grolier, M. J. and J. W. Bingham. 1978. Geology of Parts of Grant, Adams and Franklin Counties. State of Washington, Department of Natural Resources, Division of Geology and Earth Resources, Olympia, WA.

[b]Grolier, M. J. and J. W. Bingham. 1971. Geologic Map and Sections of Parts of Grant, Adams and Franklin Counties, Washington, Miscellaneous Map Investigations, Map I-589. U. S. Geological Survey, Washington, D. C.

[c]Neumann, D., Bureau of Reclamation Geologist (retired), Quincy, WA, personal communication.

It has been reported, however, that terracing dryland fields encourages nutrient movement to groundwater.[a] Regardless of how important that factor is, the large movement of nutrients into Brook and Round Lakes, the trapping of these nutrients that occurs in these impoundments, and the known recharge of groundwater flowing toward Rocky Ford Creek from these impoundments is strong evidence of the association between upper Crab and Rocky Ford Creeks.[b]

A secondary source of the nutrients found in the springs is irrigated agriculture in the portion of Block 70 lying outside the Soap Lake catchment. It seems likely that this agricultural activity affects Rocky Ford Creek much as that in Block 40 influences lower Crab Creek through groundwater additions.

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[a]North Carolina Agricultural Extension Service. 1982. Best Management Practices for Agricultural Nonpoint Source Control, III. Sediment. North Carolina State University, Raleigh, NC.

[b]Horner, R. R., E. B. Welch, M. M. Wineman, M. J. Adolfson, and R. C. Bain, Jr. In press. Nutrient Transport Processes in an Agricultural Watershed. Proc. Fourth Annual Conf. North American Lake Management Society, McAfee, NJ, October, 1984.

# CHAPTER 5

# IN-LAKE AND OTHER OFF FARM CONTROLS

A variety of possible water quality control approaches were considered in addition to those involving agriculture. These include improvements to water circulation, eradication of carp, aquatic weed harvesting, dredging, detention ponds and waste diversion through wastewater transfer or more stringent septic tank design and maintenance policies. Continued reliance on dilution programs is emphasized as all of the watershed and in-lake controls are viewed as supplemental measures. Irrigated agriculture and other farm controls are described in Chapter 3. Descriptions of the non-farm measures are included in this chapter. An evaluation of the relative efforts and costs of all the improvements described for farm or off-farm controls is included in Chapter 6.

## Water Circulation

Several bridges and causeway structures cross Moses Lake and impede local water circulation. See Figure 5-1. These structures include Interstate Highway 90 (I-90) crossings of the Main Lake and Pelican Horn, two Burlington Northern Railway crossings in the extreme upper end of Parker Horn and one across Pelican Horn, a highway crossing at the mouth of Crab Creek where it enters upper Parker Horn and the Alder Street causeway and bridge which connects the downtown area of Moses Lake with the Stratford Road. Structures of particular concern to water quality are the Alder Street causeway (known locally as the Alder Street fill) and the railroad crossing on Pelican Horn. The other structures are of lesser concern due either to their location (e.g., extreme upper end of Parker Horn) or their design. The Pelican Horn Highway crossing does involve significant earth fill but has 13.5 meters of water passage compared with only 4 meters of water passage at the nearby railroad bridge. The Alder Street Causeway consists of approximately 300 meters of roadway built on earth fill extending 100-150 meters from each shore joined by a 33 meter concrete bridge structure built in the late 1950's. The Alder Street fill area, which is very visible to the public, tends to trap and accumulate wind driven algal scum and other debris, particularly in the northwestern corner. Local cleanup programs sponsored by the Clean Lakes Project were carried out to remove debris from this pocket during the summer of 1984. The feasbility of improving circulation at the Alder Street fill and the Pelican Horn crossings was considered further as part of the Clean Lake Project.

Alder Street Fill. Crab Creek flows through the shallows of upper Parker Horn and forms a deeper channel as it passes under the Alder Street bridge. Two 48 inch diameter culverts located near the northern and southern ends of the fill do not carry much of the flow since waters in these wind protected pockets is

Fig. 5-1  Moses Lake-Aerial Photograph

generally quiescent. Observations made in September 1984 showed a strong current passing under the bridge while the flow in the two culverts was actually reversed by wind effects. At that time the culverts were completely submerged. Wind fetch has frequently driven decomposing algal mats and other floatables to the area where these culverts protrude through the fill; so it is not surprising to observe wind induced flows entering Upper Parker Horn from the west at these locations.

When dilution water is available, the area around the Alder Street causway is much improved due to the suppression of bluegreen algae which ultimately form the mats and surface scums. The effectiveness of the dilution water which flows from releases to Rocky Coulee Wasteway to Crab Creek is not adversely affected by the causeway since wind induced currents assure the waters of Parker Horn are well mixed. This has been born out by observations of water quality improvements throughout Parker Horn during dilution periods. Thus changes in water circulation in the Alder Street causeway area are not necessary so long as effective dilution releases are provided.

Water quality problems are apparent during periods such as the summer of 1984 when dilution water releases were not available. Floating mats and scums will develop each summer when the lake is not diluted, and prevailing winds will cause unsightly, odoriferous mats to accumulate on the western shore of the fill. Prevention of these localized accumulations requires massive measures such as the dilution program to suppress nuisance algae growth. Changes in shoreline character or local bathimetry will not prevent these accumulations but may assist in periodic cleanups of accumulating nuisances. Minor alteration of water passage (through addition of several more culverts) through the causeway fill does not appear warranted in view of the prevailing circulation patterns around existing culverts. If the causeway were removed or substantially altered (e.g., through a pile supported roadway or a series of long span bridges) then the wind driven mats could be moved further up Parker Horn where they would be less visible to the public. Major changes to the causeway were not evaluated because of the immense cost and public inconvenience involved. Minor changes to the shoreline were considered further to allow easier cleanup and to concentrate the debris affected area to a smaller water surface area. Similarly stagnant areas on the upstream side of the causeway could be filled in to streamline the flow from Crab Creek by removing a small amount of backwater areas that tend to accumulate weeds. Small park areas could be created on these fills. See Figure 5-2.

These changes will not alter the nutrient load to Moses Lake or its general water quality. These particular projects are described here in view of public interest in reducing a localized nuisance and improving maintenance of a seasonally recurring problem during years when dilution water is unavailable.

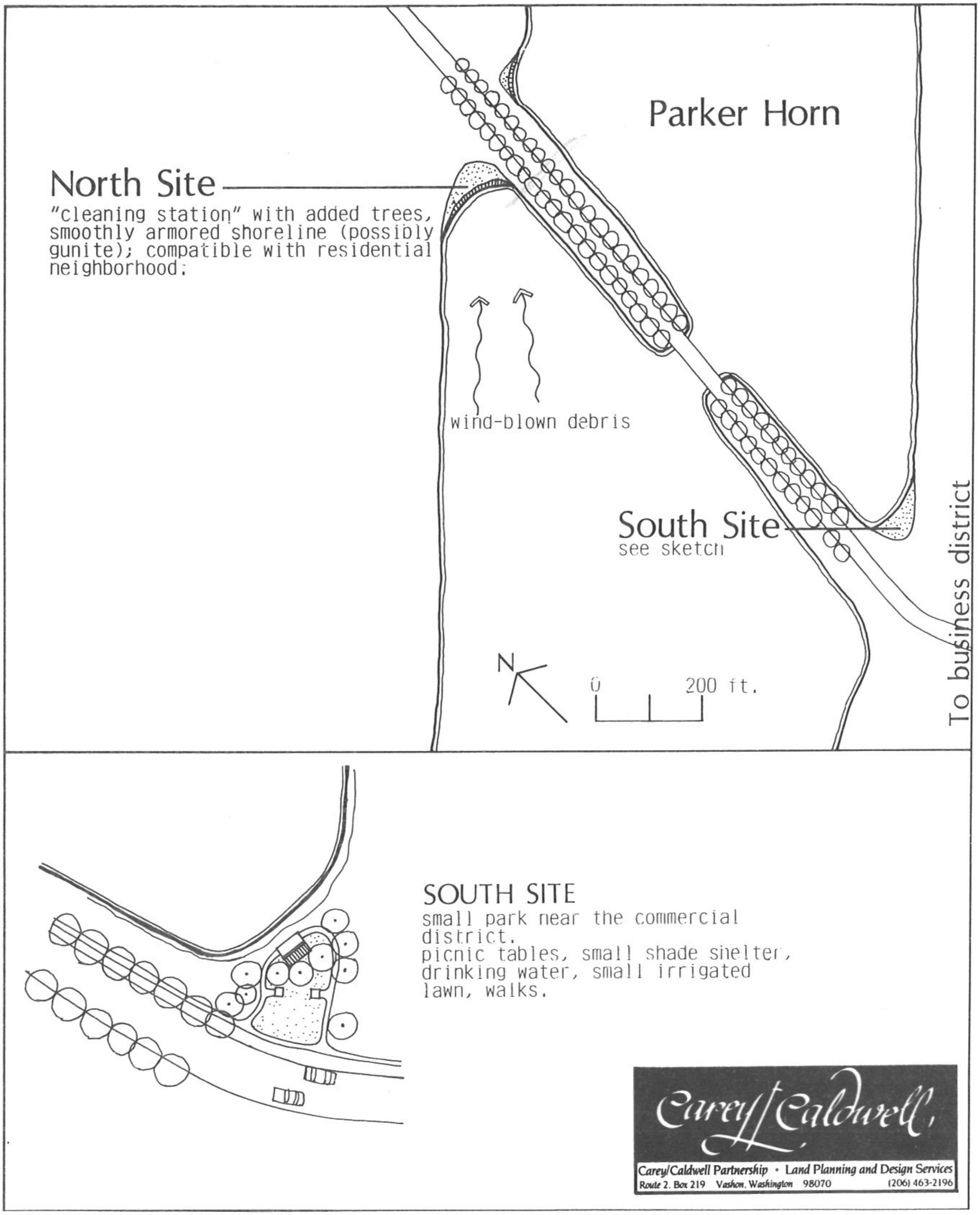


Fig. 5-2 Proposed Alder Street Fill Improvements

Costs for these improvements are minimal particularly if dredging is pursued in the upstream area. If the filling is done without a dredging project, the cost is estimated to be $40,000 based on a hauling of approximately 4,400 yards of fill material of which approximately half the material is assigned to the northwestern pocket where the greatest amount of fill and bank protection is considered appropriate.

Pelican Horn Crossings. The two Pelican Horn Crossings, like the Alder Street fill, include major earthfill causeway sections with relatively small openings for water passage. In effect the two crossings separate Pelican Horn into three sections; see Map Figure 5-3. Upper Pelican Horn, which receives pumped dilution water flow, is restricted at its southern extreme by the railway crossing causeway which has a single 4 meter opening which is further restricted by a gravel sill on its upstream side. During the periods of lake draw down this sill impounds Upper Pelican Horn. Further downstream the I-90 causeway blocks portions of Pelican Horn, particularly the east side of Marsh Island; however, there is a 13.5 meter (40 foot) opening in the deeper channel on the west side of Pelican Horn.

Studies of circulation in Pelican Horn have determined the factors affecting circulation and their influence on the dilution water release program. Results of these studies are summarized here as prologue to the evaluation of additional openings to augment water circulation between the three sections of Pelican Horn. Flushing rates and water movement were assessed during 1982 by Carlson and Welch prior, during and after dilution water releases to Parker Horn and pumped diversions to Pelican Horn.[a] Techniques used included insitu measurements of specific conductance at inflow locations and at the middle and end points of transects in each section of Pelican Horn. Large differences in concentration of dissolved solids between water from the East Low Canal and that in Moss Lake make specific conductance a useful "tracer" of dilution water in the lake. Samples were also collected from lateral transects in Upper Pelican Horn following dilution water pumping. Small drogues were also released in the dilution water discharge plume to re-evaluate circulation approximately seven weeks after pumping commenced.

Spatial variations in dilution water concentrations showed that Upper Pelican Horn behaved as a well mixed system relative to the pumped inflow. Longitudinal transects showed Upper Pelican Horn specific conductance closely resembled the values predicted by theoretical mass balance calculations. Middle and Lower Pelican Horn transects showed more dilution water than

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[a]Carlson, K. L. and Welch, E. B., Evaluation of Moses Lake Dilution: Phase II, University of Washington, Department of Civil Engineer, Water Resource Series, Tech. Report No. 80, July 1983.

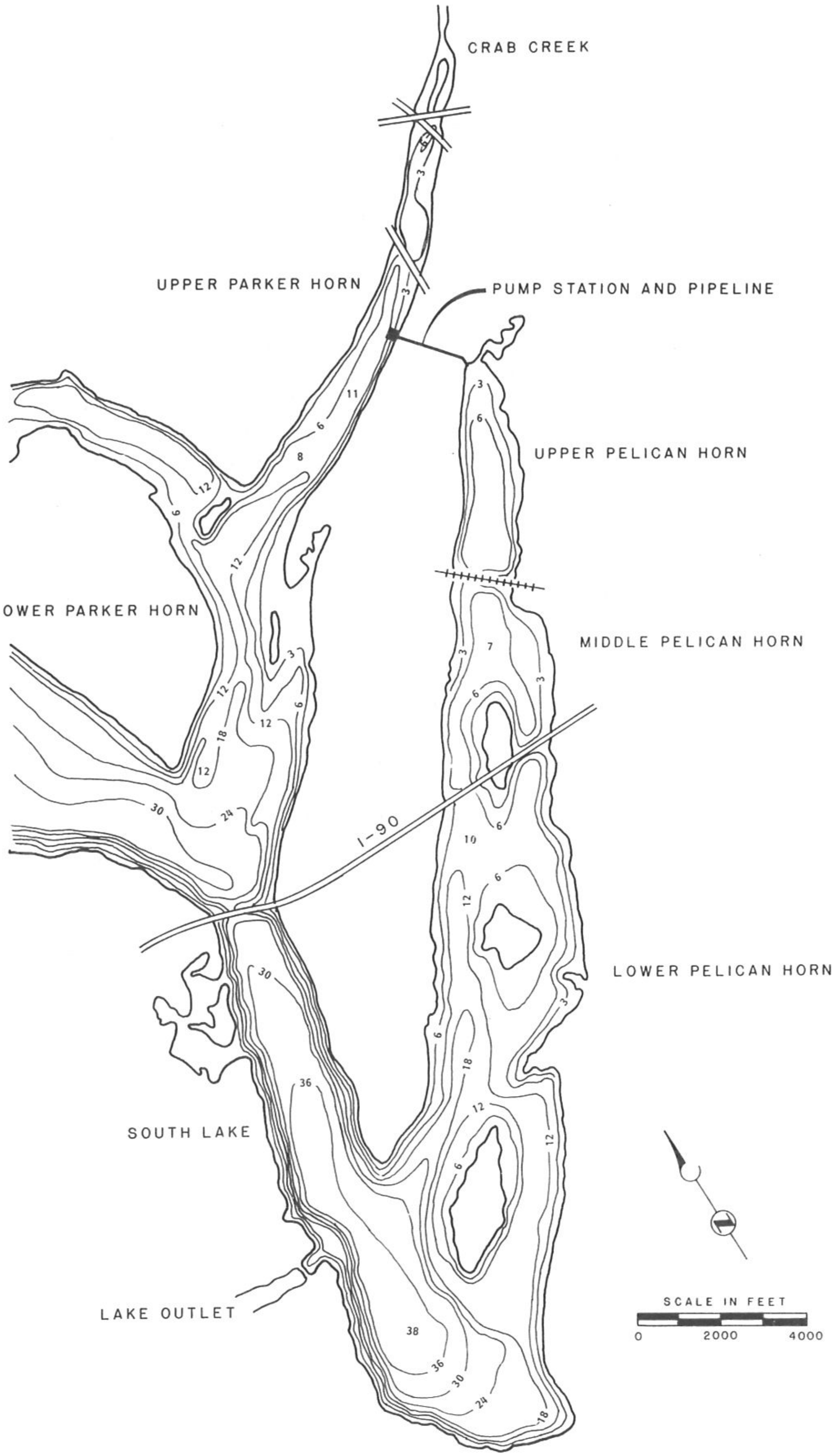


Fig. 5-3 Moses Lake Bridges and Causeways

predicted due to uplake wind-driven entrainment of diluted water reaching the southern end of Moses Lake and from the influence of the sewage treatment plant discharge to Middle Pelican Horn. Mixing within the sections of Pelican Horn appears to be good based on lateral transect measurements which showed the more isolated waters of Upper Pelican Horn were reasonably well mixed with distance from the pumped discharge outfall. Also Carlson and Welch stated that mixing effectiveness generally increased over the summer sampling as shown by a general decrease in transect variability. They attributed much of the mixing to large circulating eddies which were evident in the basin from aerial photographs and drogue studies. Strong up-arm winds, which prevail in Moses Lake during summer, are believed to be largely responsible for the mixing observed.

Thus the restrictions posed within Pelican Horn by the two crossings do not appear to significantly diminish the effectiveness of the dilution water mixing. Upper Pelican Horn clearly becomes well mixed across its full width despite introduction of the dilution water on the westen shore. Wind driven eddies within this basin account for this. The two lower basins actually become diluted at a more rapid rate than expected because wind forces dilution water in from the South Lake area as well. Thus a major effort to improve circulation in the causeway area cannot be justified on the grounds that effectiveness of dilution releases are impeded by these structures. Wind effects appear to overpower the tendency for creation of stagnant back-waters on the shallow east side of Middle Pelican Horn.

Since major circulation problems were not discovered; no major modifications to the existing causeway structures were evaluated. However, costs for transferring some water via pipes through the causeways were estimated as minor modifications to correct localized algal scum build-up or temporary stagnant conditions such as have been observed around the Alder Street fill. Costs for placing culverts under the railroad and freeway are based on use of jacking or boring techniques which would not disrupt the use of either causeway. Placement of a 36" casing under the railroad is estimated at $7000 per culvert and under the highway at $28,000 per culvert. Priority for culverts would be highest for the east side of each structure and lower for intermediate openings. Costs for a more complete culvert placement program are based on placement of three 36 inch casings in each causeway with one within 50 feet of the eastern shore of each causeway, one within 50 feet of each side of Marsh Island on the highway causeway, an two additional intermediate culverts in the railway causeway at equal distances from each existing or proposed opening. Cost for this more complete culvert placement program is estimated to be $105,000. This larger program would make the Pelican Horn crossings more nearly comparable to the Alder Street crossing in terms of the location of water passage opportunities. Such minimal water passage improvements should have been included with the original causeways construction and most likely would have if existing environmental impact procedures were in place at the time these structures were proposed. Funding of these or similar culvert improvements based on Corps of Engineer permit guidelines should be considered by the agencies responsible for the causeways.

## Carp Activity and Control

Carp (*Cyprinus carpio*), a native of Asia, was introduced to the Columbia River system in the late 19th century and are abundant in Moses Lake and its tributaries. Commercial carp fishing dates from the 1920's when Drittenbass supplied Moses Lake carp for the New York market, primarily to people of oriental and Jewish backgrounds to whom the fish has religious and cultural significance. Carp harvesting has fluctuated with market development; during the mid 1950's Collin Skane harvested Moses Lake carp for hatchery feed. During the early 1960's the Grasteits fished the lake and by 1967 Otto Cunningham was harvesting carp initially for trout and mink feed and more recently for human consumption by ethnic groups in Los Angeles. Cunningham reports past harvests exceeding 300,000 lbs. per year for trout feed markets and more recent harvests of 50,000 lbs. per year for human consumption. Harvesting is accomplished with nets.

Carp are found throughout Moses Lake in late summer but tend to congregate in the main arm during the fall. Carp are found in Rocky Ford Creek and in the lower Crab Creek system at least as far upstream as Brook Lake. Spawning occurs in shallow water (usually less than 4 feet) during spring and early summer. University of Washington researchers have noticed a high level of carp spawning activity in Pelican Horn during late June and early July. Carp become sexually mature at two or three years of age and can live 15 years or longer in natural waters. In captivity carp have lived to nearly 50 years of age. During spawning, carp tend to form groups which are active both day and night causing considerable commotion. Egg production is usually high ranging from 36,000 to over 2 million per fish, depending on the size of fish. Eggs hatch in a short time (4 days at 71 degrees F). The young move into deeper waters as they grow.

Carp consume a varied diet of zooplankton, algae, plant fragments, aquatic insects and miscellaneous organic matter. Young carp feed primarily on zooplankton whereas adult carp consume more plant material. According to Department of Game biologists, carp have effectively denuded some areas of important plant materials such as Sago pondweed, an important local food-source for waterfowl. Carp avoid swift currents and prefer quiet areas of dense vegetation. They are very tolerant of adverse conditions such as low dissolved oxygen, temperature extremes and turbidity. Because these fish feed on detritus, they disturb bottom sediments and uproot aquatic vegetation which further contributes to turbidity and recycling of nutrients. Carp activity clearly aggravates turbidity in Moses Lake, particularly in Pelican Horn, and contributes to recycling of algal nutrients from sediments.

Various University of Washington scientists have proposed research on the significance of Moses Lake carp on nutrient and sediment dynamics, and carp control programs have been suggested. Washington State Game Department biologists consider any attempt to eradicate carp from Moses Lake as infeasible, primarily because of the Lake's size and the fact that this hardy and prolific fish is abundant in many miles of tributaries. Carp are found extensively in the Crab Creek system as well as in numerous irrigation ditches. Furthermore, carp eradication was viewed as an unpopular concept because fish toxicants (e.g., rotenone) used would kill local sport fish, disrupt water supply uses, and eliminate the local commercial carp harvesting enterprise. Accordingly, a major carp elimination program was not pursued as a water quality control measure. Continued harvesting is encouraged although it is recognized that this practice cannot be expected to reduce the impact of carp significantly. Recent observations of carp catches by Cunningham indicate there may be some unexplained reduction in the average size of these fish. A smaller scale carp elimination program is included as a feature of one detention pond alternative. See discussion of the Rocky Ford Creek detention pond for additional information.

Certain types of carp have been proposed as a means to control aquatic weed growths. A distant relative of the common carp, the grass carp, has been suggested as a potential solution for controlling weed growths in lakes and ponds because of its fondness for aquatic plants. Grass carp are being studied in a five year research project sponsored by the Corps of Engineers, the Department of Ecology and the Fish and Wildlife Service to determine what aquatic plants are consumed and whether the introduction of this fish will bring environmental improvements. Stocking rates are also being evaluated to distinguish between weed control and weed elimination. Currently grass carp are banned statewide except for a few controlled experimental sites involving sterile fish.

Dredging

Prospects for dredging sections of Moses Lake were evaluated in terms of impacts on aquatic weed growth and related recreation and fishing tradeoffs. Dense aquatic weed growths, particularly curly-leaved pondweed (Potamogeton crispus) and sago pondweed (Potamogeton pectinatus) develop in the shallow waters of upper Parker and upper Pelican Horn respectively. University of Washington researchers working on the lake in 1982, a year when dilution water was available, observed these weed beds were most extensive in shallow waters, generally less than one meter depth. Light limitations are extremely important controls for submerged aquatic plants. Macrophytes may be a source of internal nutrient regeneration. Generally macrophytes derive their nutrients from rich bottom sediments; accordingly, when these plants decay, there is release of nutrients into the water column. A detailed study documenting the role of submerged weed beds in nutrient release was published by the Institute for Environmental Studies and Department of Botany, University of Wisconsin in 1979. The probability that such regeneration occurs in Moses Lake is supported by results cited in a 1983 evaluation by Carlson and Welch of the University of Washington Department of Civil Engineering.

Field Survey Results. A reconnaissance survey conducted on July 19, 1984 to assess weed growth in upper Parker Horn during a non dilution year confirmed the presence of extensive pond weeds. Earlier surveys in 1983 had encountered similar conditions. Observations in the July 1984 survey indicated the denser growths occurred in water of one meter depth or less; little or no weed growth was observed in waters of 1.5 meter depth or greater presumably due to the more turbid conditions encountered in this non dilution period. Sediment cores were taken and volcanic ash was observed beneath the upper 10 to 15 centimeters. Analyses of these cores revealed comparable nutrient values above and below the ash layer; phosphorus ranged from 0.78 mg/g P in the upper layer to 0.85 mg/g below the ash while nitrogen ranged from 0.25 mg/g N above to 0.39 mg/g below.

Additional field studies were conducted by University of Washington researchers to assess dredging feasibility. Sediment cores were collected by University personnel in upper Pelican and upper Parker Horns on November 4, 1984. Cores were collected with a three meter plastic tube by forcing it into the sediment. Collections were made from three, longitudinally distributed sites along a centerline through Pelican Horn. Because the lake was drawn down, upper Parker Horn was too shallow to launch a boat so sediment samples were collected from shore. Earlier core data were available from 1973 at sites immediately south of the Alder St. Bridge, the lower lake and middle Pelican Horn.

Wet-dry weight, phosphorus and organic matter were determined at the surface and bottom of the sediment profiles (top 5 cm and 18-43 cm, respectively). There was no significant variation with depth in any constituent. Pelican Horn sediment was low in organic content relative to Parker Horn and the lower Lake. Pelican Horn sediment phosphorus (total) was 0.85 and 0.87 mg/g, organic matter was 3.1 and 3.2 percent, and wet/dry weight ratios were 2.3 and 1.8 as averages in four core surface samples and five bottom samples, respectively. Values from Parker Horn sediment were 0.83 mg/g phosphorus, 4.5 percent organic matter and 2.6 wet/dry weight ratio. No attempt was made to represent a depth profile in upper Parker with the November collections. A 1973 core, one meter in length, collected immediately south of the Alder Street Bridge, showed that phosphorus content was rather uniform with depth with an average 1.29 with a variation of only 0.23 mg/g in 18 samples. Organic content averaged 2.7 percent with a variation of 0.9 percent. Organic content in a 1973 core from the lower lake averaged 4.4 percent. Some organic content values near Alder Street approached 4 percent.

Pelican Horn Dredging Evaluation. Sediment in upper Pelican Horn was extremely compact, relatively low in phosphorus and organic matter, and rather constant with depth, at least to 40 cm. Considering the dense blooms of algae that occur there during summer, the low level of enrichment in the sediment is surprising. The reason is apparently a well-mixed and oxygenated, shallow water body, in which decomposition is relatively complete. Although algal concentrations in the water have dropped dramatically since the transport of dilution water from Parker Horn began, the transparency has not changed; it has remained at an average of 0.4 meters. Therefore, dredging for the purpose of deepening would show no benefit because the potential for macrophyte growth (due to light availability) is not great and has not increased since dilution water pumping began. With the low and constant phosphorus and organic matter content of the sediment, no benefits from dredging could be expected in terms of decreased enrichment of the water from sediment nutrient release. There seems to be no basis that would justify a dredging project in upper Pelican Horn.

Parker Horn Dredging Evaluation. Upper Parker Horn, immediately south of the Alder Street Bridge and in the basin above the bridge, does have relatively enriched sediment. From the observed distribution of rooted plants south of the bridge, this rich sediment apparently has a beneficial effect on the growth of those plants. A survey in 1983 indicated that *Potamogeton crispus* was more abundant in soft, organically rich sediment. However, an improvement (decrease) in macrophyte abundance as a result of dredging would occur because of decreased light availability (deepening) and not because of exposure of less rich sediment for plant rooting. Phosphorus and organic matter were constant with depth south of the Alder Street Bridge up to one meter. Deepening in the area north and immediately south of the Alder Stret Bridge could have some benefit in reducing macrophyte growth because of the marked improvement in the depth of visibility since dilution began. Before dilution transparency averaged about 1.5 feet, while after dilution it has averaged about 2.8 feet.

The area north of Alder Street is about 65 acres. (Figure 5-4). Including about 10 acres south of the bridge, a total of 75 acres represents a reasonable estimate of area that could be dredged for deepening to limit the light for plant growth. From rough approximations of volume north of the bridge, a mean water depth for the area is about 2.8 feet.

Before dilution, plant problems were not severe and transparency averaged about one half the mean depth (1.5/2.8 ft.). After dilution, transparency nearly doubled. Thus, if depth were increased by a factor of two so that transparency was roughly one half the mean depth (new mean depth = 2 x 2.8 = 5.6 ft.), the removal of approximately 340,000 cubic yards would be required. Assuming use of a clamshell dredge at $2.50 per cubic


Fig. 5-4  Upper Parker Horn Bathimetry

yard, the cost for such a dredging project would be $850,000. This cost assumes soil disposal can be accomplished on adjacent land. Dredging to a lesser depth would probably not provide sufficient light limitation to produce a significant benefit through decreased plant distribution and abundance.[a]

Dredging on the scale described above is intended to substantially reduce aquatic weed growth in upper Parker Horn. This would provide benefits to some water oriented recreation activities and shoreline activities, particularly boaters. Also elimination of weed growths would improve aesthetics in upper Parker Horn, particularly in later summer. However, fishery and waterfowl interests would be compromised by removal of habitat and reduction in aquatic plant food sources. Discussions with Game Department biologists indicated there would be opposition to a major dredging project in upper Parker Horn but that a smaller project that removed less material and developed some islands with dredge spoil would be considered since benefits to wildfowl were apparent. Furthermore the overall impact on Moses Lake water quality would not be significant. Such a proposal as originally conceived would involve alteration of the channel through the western portion of upper Parker Horn so that flow from Crab Creek followed a more serpentine course. Upper Parker Horn water surface area would be reduced by 25 percent under this alternative. Cost for this alternative island oriented proposal was estimated at $650,000.

A third less costly alternative was considered that would remove approximately 20,000 cubic yards of rich sediment from the top foot primarily from shallow areas along the east side of upper Parker Horn and in the northwest corner near the Railroad bridge. This smaller scale project, which involves use of a mudcat, would cost approximately $50,000 and would presumably be of some benefit to boating but would not result in any substantial reduction in the extent or density of aquatic plant growths. Water quality benefits of the third proposal are negligible since high nutrient values are encountered below one foot depth in upper Parker Horn sediments and water depth modifications are not sufficient to significantly attenuate light reaching the bottom.

Although direct approaches to macrophyte control such as dredging or harvesting are very visible efforts that often attract public support, there are more subtle ways to deal with the problem in Moses Lake. A more cost effective approach to controlling macrophytes in upper Parker Horn, to counteract the stimulation to growth caused by increased transparency from dilution, is to regulate dilution water input in order to maximize the benefits to algae control while minimizing the

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[a] Dr. Eugene Welch, University of Washington Department of Civil Engineering, personal communication.

detriments from increased rooted macrophyte growth. That can be accomplished by distributing the dilution water more evenly over the spring-summer period. This would result in poorer transparency during April and May and better transparency during July and August. The large dilution water inputs during April-May have resulted in transparencies of 13 feet, which provides very high light availability in water two to three feet deep during the critical time of year for rooted plant growth. Further, the very high dilution water inputs are more sufficient provide adequate reduction in nutrient concentrations to achieve satisfactory algal control.

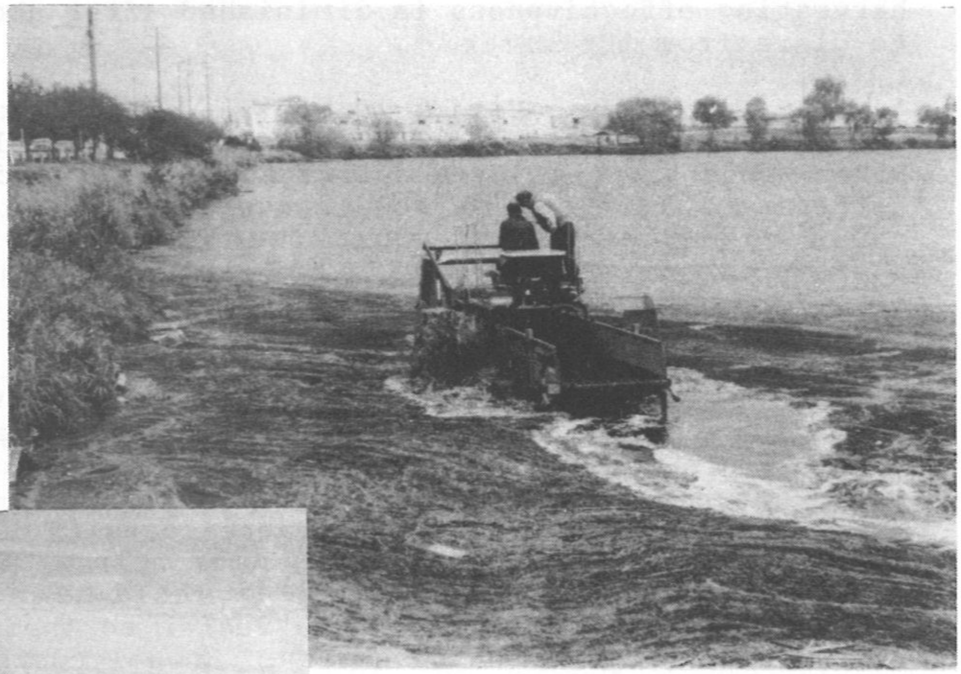
Weed Harvesting

Routine harvesting of aquatic weeds has been suggested as an approach to controlling excessive growths particularly along developed shorelines where these plants impede boat access or swimming. Over 50 percent of the 62 miles of Moses Lake shoreline is covered by emersed plants, although much of the lake surface is weed free. Exceptions include dense growths in shallow areas such as upper Parker and Pelican Horn as described earlier. Emersed aquatic weeds provide important fish and wildlife habitat and are important water fowl foods, accordingly large scale weed eradication or harvesting is not desirable from a fishery standpoint. However, localized shoreline access problems are a concern particularly in Parker Horn, since weeds foul boat propellers and impede access by boats, waterskiers and swimmers.

Generally, agencies involved with weed cutting programs in lakes (e.g., Seattle Metro) submit harvest plans for review by agencies such as the State Department of Game. An example harvest plan is included in Appendix C. Preliminary discussions with State Game Department biologists have been held to determine the extent and nature of harvesting that would be acceptable. It appears that the most likely harvest plan would involve shoreline cutting from shore outward about 20 feet in developed areas with lanes cleared to deeper water at intervals.

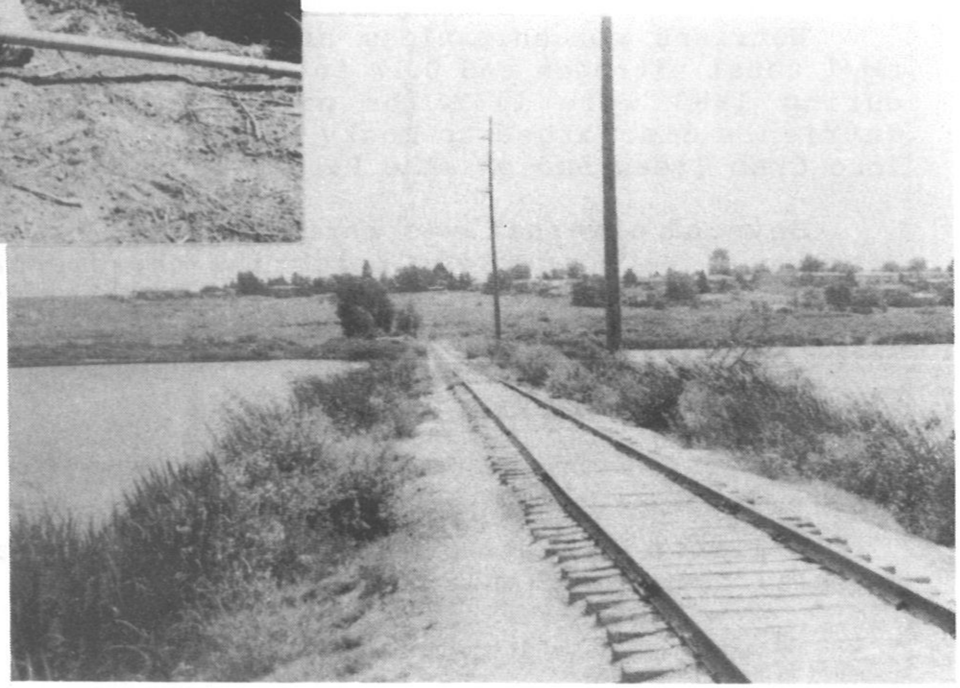
During the summer of 1984, two weed harvesters were used on Moses Lake to demonstrate equipment features and to introduce local residents to their possible regular use. One of these harvesters was loaned to the Moses Lake Irrigation and Rehabilitation District by the Municipality of Metropolitan Seattle (Metro) for a one day trial in September. This machine was a mudcat unit that cuts swaths seven feet wide to a depth of five feet. A shore conveyor is used to move harvested plants into a dump truck or directly on shore. A unit of this type would cost about $65,000 including a hauling trailer and conveyor. According to Metro staff, the machine averages two to three acres per day and is quite capable of cutting close to docks. Two operators are involved in the operation, one to drive the mudcat unit and the other to assist in launching and disposal. Ideally, the operators should rotate duties as

Weed Harvester
Demonstration
in Parker Horn



Cleanup Crew Removing Algae
Scum from Parker Horn

View of Railroad
Crossing on
Pelican Horn



harvesting effectiveness is diminished after about four hours due to glare from the water.

A second harvesting demonstration took place in early October when an equipment company brought a smaller unit to Moses Lake. This unit employed a five foot cutter and had other design differences relating to weed conveyance and storage. This unit could be purchased for approximately $40,000 with a combined shore conveyor/trailer unit. The same unit can also be provided by a harvesting contractor for approximately $100 per hour plus mobilization and operator per diem.

A small scale weed harvesting program was evaluated to determine overall costs of a direct purchase approach or contract harvesting. This analysis was based on an 80 acre harvest which would occur twice each growing season. Harvest rates of nearly 3 acres per day and annual maintenance costs ($7500) were assumed.[a] Operator rates were assumed as summer help at $6.50 per hour; it was further assumed the summer help would have other duties when not actually working with the harvester so their costs were only considered for part of the season. Annual costs of about $22,000 were estimated assuming a ten year amortization period at 12 percent interest. Contracting would cost approximately $50,000 per year assuming comparable harvest rates.

Rocky Coulee Wasteway Pumped Irrigation Drainage

The East Columbia Basin Irrigation District operates a pumping station on the south side of the Rocky Coulee Wasteway which discharges drainage from a low lying area of about 1840 acres. Irrigation records over the past five years indicate that from 300 to 400 acre feet is pumped into the wasteway during the irrigation season. Available monthly flows during peak periods are in the 1.5 - 1.7 cfs range although during some years average monthly rates do not exceed 1 cfs.

Nutrient concentrations are generally high, averaging 2.17 mg/l total nitrogen and 0.17 total phosphorus. Loadings observed during 1983 were 1462 lbs nitrogen and 117 lbs phosphorus. Nutrients discharged to Rocky Coulee Wasteway eventually flow into Crab Creek and on into Parker Horn.

Several alternatives were considered for eliminating this discharge, each involves rerouting the discharge either to an irrigation canal for reuse or to drains that avoid discharge to Moses Lake. The two most promising alternatives are described below and in Figure 5-5.

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[a]Ralph Domenoske, Municipality of Metropolitan Seattle, personal communication.

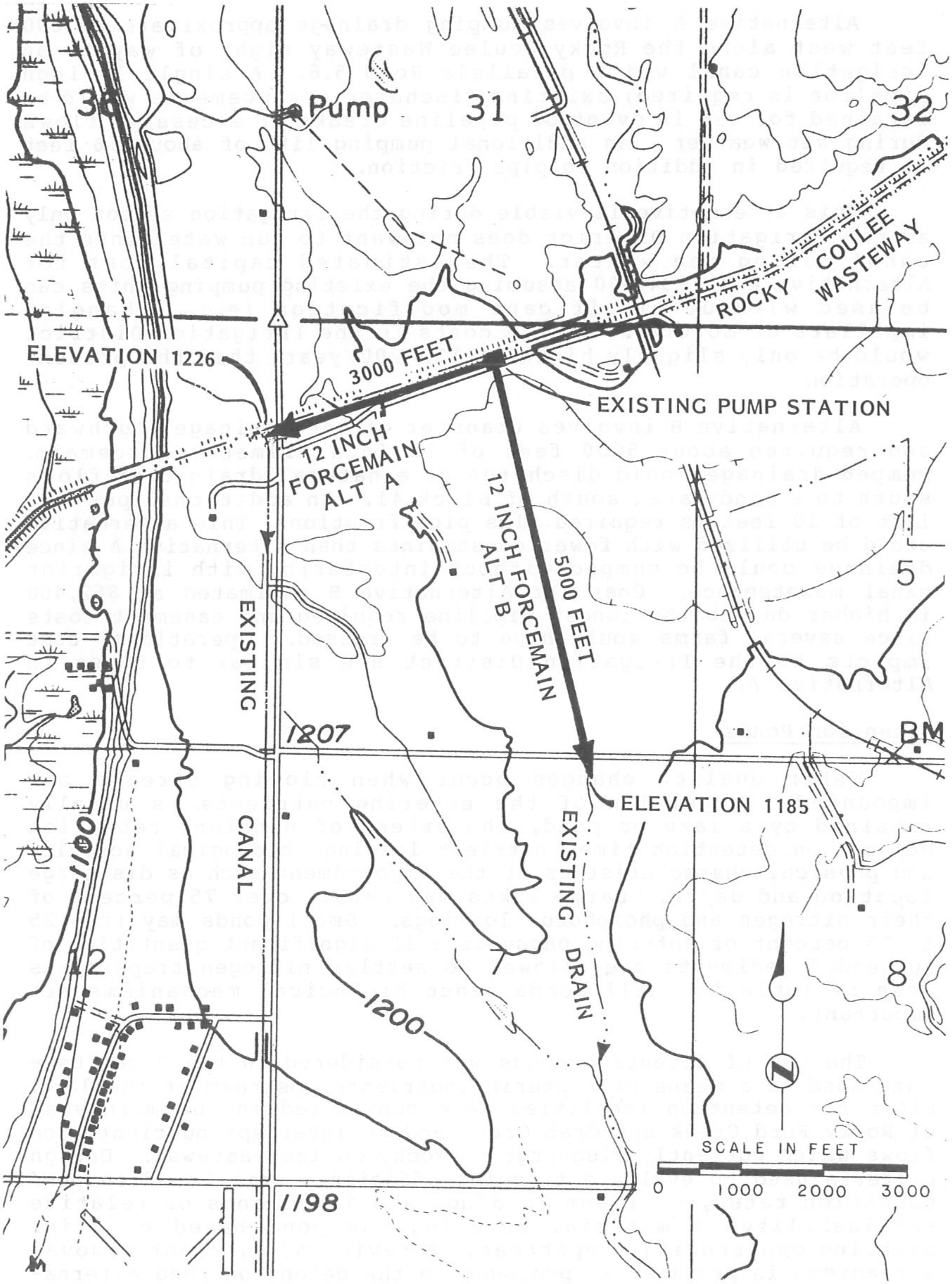


Fig. 5-5 Rocky Coulee Wasteway Drainage Diversion Alternatives

Alternative A involves pumping drainage approximately 3000 feet west along the Rocky Coulee Wasteway right of way to an irrigation canal which parallels Road 5.6. A single 12 inch pipeline is required; existing discharge arrangements would be retained for use in event of pipeline breaks or excessive flows during wet weather. An additional pumping lift of about 16 feet is required in addition to pipe friction.

This alternative is viable during the irrigation season only as the Irrigation District does not want to run water into the canal during the winter. The estimated capital cost for Alternative A is $34,400 assuming the existing pumping units can be used without significant modification (e.g., changing impellars or motors). Energy costs to the Irrigation District would be only slightly higher ($150-200/year) than the present operation.

Alternative B involves transfer of the drainage southward and requires about 5000 feet of 12 inch diameter forcemain. Pumped drainage would discharge to a natural drain that flows south to a sandy area south of Block 41. An additional pumping lift of 10 feet is required plus pipe friction. This alternative could be utilized with fewer constraints than Alternative A since drainage could be pumped without interfering with irrigation canal maintenance. Cost for Alternative B estimated at $62,400 is higher due to the longer pipeline required and easement costs since several farms would have to be crossed. Operational cost impacts to the Irrigation District are similar to those in Alternative A.

Detention Ponds

Water quality changes occur when flowing streams are impounded. A portion of the entering nutrients is usually retained by a lake or pond, the extent of nutrient retention depends on detention time, nutrient loading, biological activity and physical characteristics of the impoundment such as discharge location and depth. Large lakes may retain over 75 percent of their nitrogen and phosphorus loadings. Small ponds may trap 25 to 35 percent of entering phosphorus if significant quantities of suspended sediments are allowed to settle; nitrogen trapping is less reliable in small ponds since biological mechanisms are important.

The use of detention ponds was considered in the Moses Lake watershed as a means of capturing nutrients upstream of the lake. Sites for detention facilities were considered in the main stem of Rocky Ford Creek and Crab Creek and to intercept nutrient rich flows which currently discharge to Rocky Coulee wasteway. Design criteria used to evaluate trapping efficiency were based on pond detention rates, nutrient loadings and judgements of relative settleability of material entering the pond based on prior settling opportunities upstream. A review of nutrient removal mechanisms is provided as prologue to the detention pond alternatives themselves.

Detention Pond Nutrient Removal Mechanisms. During the time that the water resides in a pond, it is subject to physical, chemical and biological mechanisms that alter its nutrient concentrations. Physical sedimentation is the primary process through which nutrient reduction occurs. This is especially true for phosphorus. Sedimentation is driven by both chemical complexation and biological mechanisms. Nitrogen, on the other hand, is most effectively altered by biological processes such as nutrient uptake from the water by algae and some other aquatic plants. Physical sedimentation only occurs when nitrogen is bound within organic matter. Chemical mechanisms (except by biological organisms) are virtually nonexistent. The actual mechanisms are related to the natural cycles of each nutrient.

Phosphorus enters lakes through surface runoff groundwater and precipitation. Over 90 percent of the phosphorus entering with runoff in agricultural regions is bound to sediments.[a] Orthophosphorus, the only form of soluble phosphorus that is available for plant growth, is extremely reactive. It forms relative insoluble compounds with cations (Fe, Ca., etc.) that precipitate. It also absorbs to inorganic colloids and particulate compounds (clays, carbonates, etc). Its precipitation and absorption tendencies contribute to sedimentation which is the major cause of phosphorus loss from the water column. Therefore, phosphorus can be effectively reduced by sedimentary actions in holding basins.

Like phosphorus, nitrogen enters water through surface inflows, precipitation and groundwater. Bacterial fixation of atmospheric nitrogen within the lake is an additional source. Less nitrogen than phosphorus, perhaps only 50 percent in agricultural regions, is sediment bound in surface inflows.[b] Nitrate is the major form of inorganic nitrogen in water. In contrast to phosphorus, it is very soluble in water and tends to remain in the water column rather than to be associated with sedimentation. It is, therefore, less responsive than phosphorus to physical (sedimentary) processes that reduce nutrients in holding ponds.

Both phosphorus and nitrogen play important biological roles in ponds. Each is an essential nutrient to algae and nutrient content in water will, to a large extent, be a result of biological uptake and release. During the growing season, the nutrients should decline with algal growth and uptake. Nutrients

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[a]Lake, J. and J. B. Morrison, 1977. Environmental impact of land use in water-quality. Final report on the Black Creek project (Tech. report). EPA 905/9-97-007-B. 280 p.

[b]Ibid.

which would normally have existed in the outflow will instead be held within algal biomass.

Algae, like all plants, die. Although some decomposition and nutrient release does occur in the water column, most algae sink and then decompose in the sediments. Nutrient release from the sediments is affected by oxygen concentrations there. If the holding pond remains well oxygenated, phosphorus is chemically bound in the sediments. Nitrate is released but it is quickly taken up biologically (if limiting) and remains within the ponds. If the pond becomes stratified in the relatively quiet summer months and if the sediments become deoxygenated (as a result of microbiocal respiration) the situation changes. Phosphorus is released from anaerobic sediments into the lower water columns. Nitrate is converted by denitrification to N2 gas. When mixing occurs and water near the sediments is reoxygenated, some of the phosphorus is taken up biologically but most is quickly recomplexed and/or sorbed to sediments.

The role of macrophytes in the nutrient cycle is one that remains unresolved in the current literature.[a,b,c,d] An important consideration is that many types of macrophytes exist and each plays a different role in recycling. Rooted macrophytes, for example, satisfy most of their phosphorus needs by taking it up through their roots from the sediments. Some species may remove and also release small amounts directly from the water. When these rooted macrophytes die, phosphorus contained in their organic matter, much of which was originally bound within the sediments, will be released. Floating plants, on the other hand obtain their phosphorus through their foliage and only from the water column. Macrophyte-nutrient interactions are complex, and whether a pond with macrophytes would produce a net release of uptake of nutrients is species and growth-form dependent and difficult in any case to determine. On balance, because

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[a]Bole, J. B. and J. R. Allan, 1978. Uptake of phosphorus from sediment by aquatic plants _Myriophyllum spicatum_ and _Hydrilla verticillata_, _Water Research_ 12:353.

[b]Landers, D. H., 1982. Effects of naturally senescing aquatic macrophytes on nutrient chemistry and chlorophylla of surrounding waters. _Limnol Oceanog_ 27(3):428-439.

[c]Prentki, R. T., M. J. Adams, S. R. Carpenter, A. Gasith, C. S. Smith, and P. R. Weiler, 1977. The role of submersed weedbeds in internal loading and interception of allochthonous materials in Lake Wingra, Wisconsin USA. _Arch. Hydrobiol_/Suppl. 57(2):221-250.

[d]Wetzel, R. G., 1983. _Limnology_, Saunders College Publishing.

macrophytes encourage sediment trapping as water flows past, and because most plants die back and release nutrients in the late fall when most blue-green algal blooms have ended, a beneficial impact on nutrient concentration can be expected.

In summary, nitrogen and phosphorus concentrations in water should be reduced during residence in holding ponds. Because phosphorus is readily sedimented by biological, chemical and physical processes, its retention is relatively predictable. Nitrate concentrations are less predictable but should also decline in outflows as a result of biological interactions loss through sedimentation of organic matter.

Examples of Detention Pond Performance. Several examples illustrating detention pond use for phosphorus removal were found. The first involved a 3400 cubic meter sediment retention pond in an irrigated watershed in southern Idaho that was monitored for five years. Retention times averaged 2.7 hours and the pond removed 65 to 76 percent of entering sediment and 25 to 33 percent of the total phosphorus entering the pond. A 1981 paper describing this work by Brown et al is included in Appendix D for reference.[a] In a second study two sediment retention ponds in the Lake Ballinger, Washington watershed were monitored during storm and non storm periods.[b] These retention ponds removed 20 to 26 percent of their total phosphorus load.

Detention ponds are nature's way of trapping sediments and preventing downstream erosion by reducing peak runoff rates. Beaver dams provide this benefit in many areas and their construction has been encouraged in some areas of Wyoming by importing beavers and building materials to allow beavers to reclaim damaged streams.[c]

Existing ponds in the Moses Lake watershed were evaluated using monitoring results from Stage 1 and from inflow-outflow measurements during the summer of 1984. Stage 1 results had shown the effectiveness of major impoundments such as Brook Lake in holding back flow and phosphorus in the Crab Creek system. Brook Lake discharges primarily to groundwater as discussed in Chapter 4. Other impoundments in the Crab Creek area such as the Willow Lake system trap some sediment-bound phosphorus.

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[a] Brown, M. J. et al, Ponding Surface Water Drainage Water for Sediment and Phosphorus Removal, Transactions of the ASAE, 1981.

[b] Kramer, Chin and Mayo, Lake Bollinger Rehabilitation Project, Interim Monitoring Study Report, May 1981.

[c] Michelmore, Peter, The Amazing Beavers of Currant Creek, Readers Digest, April 1984.

Measurements were made below Willow Lake and in a small beaver pond at the west end of Road 10.5 to check phosphorus removal.

Little additional phosphorus removal was noted immediately downstream of Willow Lake and the water in the stream was clear. In contrast, the Beaver dam which received agricultural drainage removed 30 percent of the influent phosphorus comparable to that observed in the Idaho study and in the Lake Ballinger work. Nitrate concentrations were also reduced significantly, presumably because of biological activity in this marshy plant infested pond.

Caution must be exercised in crediting impoundments for nutrient removal since design factors strongly affect performance. For example, sediment trapping must occur before substantial phosphorus removal can be claimed. Where stream flows vary widely, negative pollutant removals may occur if hydraulic effects resuspend sediments caught previously. This should not be a problem during the summer irrigation season when stream flow is relatively predictable, but resuspension could be a factor during peak flow periods. Outlet design should assure impounded areas are not completely empty so scour effects can be minimized.

Detention Pond Efficiency. An evaluation of detention pond effectiveness in 1982 by the Environmental Protection Agency's Nationwide Urban Runoff Program established typical removal efficiencies as 65 percent for suspended solids and 25 percent for total phosphorus. These figures are generally consistent with the experience cited above. Therefore, for purposes of the Moses Lake Clean Lake project an efficiency of 25 percent phosphorus removal will be used for detention ponds with at least 4 hours retention time unless the pond is immediately downstream of another pond. In the case of ponds in series the downstream pond will be credited with 50 percent of the removal efficiency of the upstream pond (e.g., 12.5 percent). Ponds with detention times below 2 hours during the irrigation season will not be credited with any phosphorus removal. Intermediate sizes will be prorated from 12.5 percent efficiency for 2 hours retention to 25 percent for 4 hours retention based on peak irrigation season flow rates.

Minimal nitrogen removal will be credited. Where detention exceeds 4 hours, 5 percent trapping will be assumed. If 12 hours detention is provided, 10 percent trapping will be assumed. Efficiency for intermediate detention periods may be prorated. Efficiency for nitrogen trapping is independent of another pond upstream since the removal mechanisms involved are presumed to be primarily biological such as uptake by attached algae (eg. periphyton) or floating plants (eg. duckweed). Detention ponds will be designed as shallow flow through facilities with typical average water depth of less than one meter in order to encourage aquatic plant growth. Small earth dikes will be constructed with rip rap and concrete outlet spillways or pipe outlets as appropriate.

Operation and maintenance will affect pond performance. In general trapped sediments should be removed when detention is significantly reduced by accumulated sediments or debris. The ponds should be scraped out or dredged rather than sluiced since the object is to prevent sediments from reaching the lake. Periodic inspections should be performed to determine integrity of the detention structure and maintenance needs. These inspections should be performed after major runoff events. The pond systems may be operated as a marsh habitat where some sediment accumulation may be necessary to provide habitat for marsh plants.

Detention Pond Alternatives

Detention ponds considered in this study include three main stream ponds in Crab Creek and Rocky Ford Creek and several smaller ponds to intercept nutrient rich drainage that is currently entering Rocky Coulee Wasteway. These potential projects are described below:

Rocky Ford Creek Detention Pond. Lower Rocky Ford Creek was considered as a logical site for a detention pond since the creek contributes a significant phosphorus loading to Moses Lake. See discussion of this phosphorus source in Chapter 4. The earth dike forming the proposed 13 acre impoundment as shown in Figure 5-6 is located on State Game Department land at the extreme upper end of the main arm of Moses Lake. Construction would logically occur during the late fall or winter during lake draw down since the downstream toe of the dike will be below elevation of 1046. Rip rap will be required to protect the downstream portion of the dike from wind driven waves. Easements will be required since the pond would flood some upstream private properties in the riparian area. The dike would create a barrier to fish migration into Rocky Ford Creek from Moses Lake. It is assumed that the dike would be built with local soils and rip rapped with local basalt rock. An impermeable membrane would be required along the upstream face particularly if the coarse Malaga soils are used for dike construction. Use of silt loam from the stream channel should be evaluated during design as a possible cost savings feature compared to use of bentonite or other means of developing an impermeable membrane.

An alternative site on private land should be considered if favorable easement problems can be worked out. Relocation of the impoundment structure a short distance upstream would reduce the risk of erosion on the downstream toe.

Detention time of the Rocky Ford Creek detention pond is expected to exceed 5 hours for typical summer flows which averaged 64 cfs during Stage 1. Trapping efficiency is calculated to be 25 percent removal for phosphorus and 5.6 percent for nitrogen based on the design criteria established for the project.

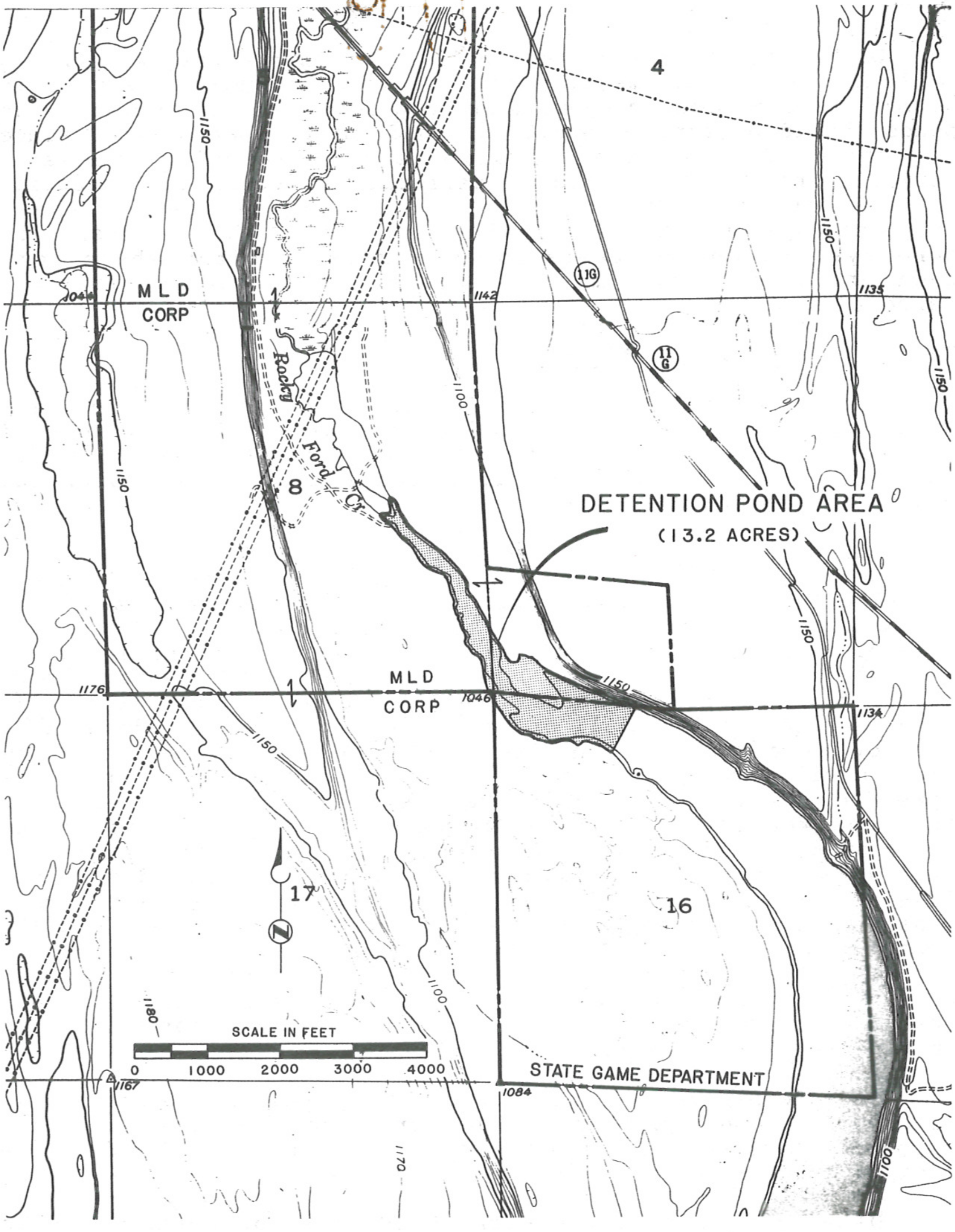


Fig. 5-6 Rocky Ford Creek Detention Pond

Although nutrient trapping is the primary benefit of this facility, a second benefit is assigned to the Rocky Ford Creek detention ponds. This second benefit is related to carp control. The dike would block migration of carp from Moses Lake into Rocky Ford. According to the Department of Game, carp currently infest the creek system to such an extent that important water fowl food, such as sago pondweed, are essentially eliminated by the disruptive feeding habits of carp. The Game Department has indicated that a carp eradication program would be feasible in the Rocky Ford Creek system if a barrier existed between the creek and Moses Lake. Accordingly, if the Rocky Ford Creek detention pond is built, the Game Department would proceed to eradicate the carp fishery assuming this could be carried out without significant environmental impact to other water uses including the Trout Lodge hatchery. If the carp eradication program is accomplished, aquatic plant growth in lower Rocky Ford Creek would be enhanced and additional nutrient trapping would be expected to occur due to stabilization of bottom sediments and biological uptake by aquatic vegetation. A 50 percent increase in trapping efficiency is assumed for the combined effects of detention and carp eradication. Costs for the Rocky Ford Creek detention pond are estimated to be $74,100. Easement costs are expected to be minimal since there are benefits to private property inherent in the project purpose.

Upper Crab Creek Detention Pond. Several sites were considered for detention ponds in upper Crab Creek, both in the main stem and in tributaries. These sites were all located on State Game Department land. There are existing detention ponds in upper Crab Creek on the creek itself and in off-channel areas. Examples include the Willow Lakes and Hidden Lake. Discussions with State Game biologists indicated the Department would probably favor enlargement of existing ponds and construction of additional ponds as water fowl enhancement features. Since existing ponds already provide adequate detention to trap some phosphorus and nitrogen, it was felt that no significant additional water quality control benefits would result from their enlargement. Construction of a new pond was considered beneficial, and an alternative was developed using State land downstream of Willow Lake. See Figure 5-7. The impoundment area is large (approximately 176 acres) and would provide considerable water fowl food and habitat in addition to nutrient control. Phosphorus removal was rated at 12.5 percent because the site is downstream from Willow Lake; nitrogen removal was rated at 10 percent based on the project criteria.

A rather long earth dike is required for this facility because of the flat terrain; local materials are coarse and subject to piping so an impermeable membrane will probably have to be developed with imported material. The spillway structure will have to be capable of passing flood flows from a large watershed area. The cost of the upper Crab Creek detention pond is estimated to be $79,800 due to these factors. No land or

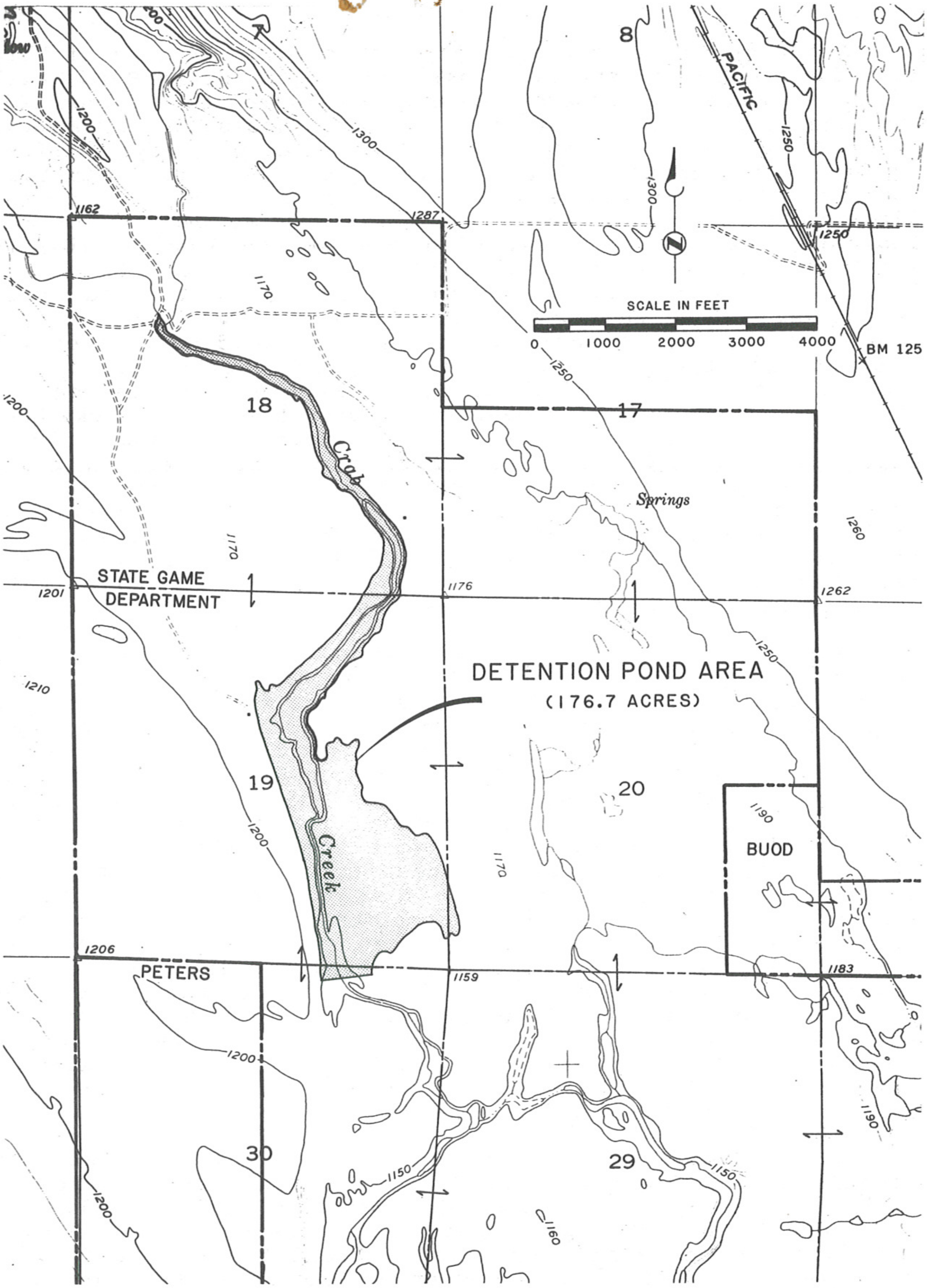


Fig. 5-7 Upper Crab Creek Detention Pond

easement costs are included since the entire project is on state land.

<u>Lower Crab Creek Detention Pond</u>. A second mainstream Crab Creek site was developed as an alternative. This site is located just upstream from the junction of Crab Creek and Rocky Coulee Wasteway. A 16 acre pond is proposed. See Figure 5-8. Crab Creek flows would pass over a submerged spillway structure. The structure is on State Game Department Land but the impounded water would encroach on riparian areas on private property upstream.

Crab Creek waters which average about 75 cfs during the spring-summer period, carry a higher nutrient loading at this downstream location compared to the upper Crab Creek site. Much of the irrigated area draining to Crab Creek occurs between these locations. No other major ponds exist immediately upstream. Estimated detention time is calculated at 5.4 hours, so the maximum phosphorus removal efficiency is assumed per the project criteria. Nitrogen removal is assumed at 6 percent.

Local soils are permeable so special measures will need to be taken to assure the dike has an impermeable zone. Also rip rap will be required to protect the structure during flood periods. The lower Crab Creek detention pond cost is estimated to cost $29,600 for construction excluding any easements which may be required.

<u>Rocky Coulee Tributary Impoundment</u>. A small (5.7 acre) impoundment is proposed on private land immediately north of the junction of a small spring fed tributary to Rocky Coulee Wasteway. Figure 5-9. This particular tributary receives some drainage from a local dairy farm and the State Game Hatchery; however, the primary sources of flow and nutrients are the springs which serve as the hatchery water supply. This impoundment would provide over 12 hours retention and thus should be very effective for both phosphorus and nitrogen control.

Costs for this facility if built at the location shown will be low because earth berms already exist on either side of a notch where the tributary flows into Rocky Coulee Wasteway. A simple barrier and rock lined overfall spillway can be constructed for an estimated cost of about $5,000. No easement or property acquisition costs are assumed because the project will benefit the dairy farmer who owns the site. An alternative site on the State Game Department land could be utilized that is upstream from the dairy.

<u>Westside Cattle Company Impoundments</u>. Three ponds are proposed to divert and contain water on the property of the Westside Cattle Company. These include a small diversion pond upstream and two detention ponds downstream of the cattle operation. See map Figure 5-10. The upstream pond would allow use of more of the drainage which otherwise flows through and becomes contaminated by the feedlot. This diversion pond would cover about 1.8 acres. Water from the diversion pond would allow more

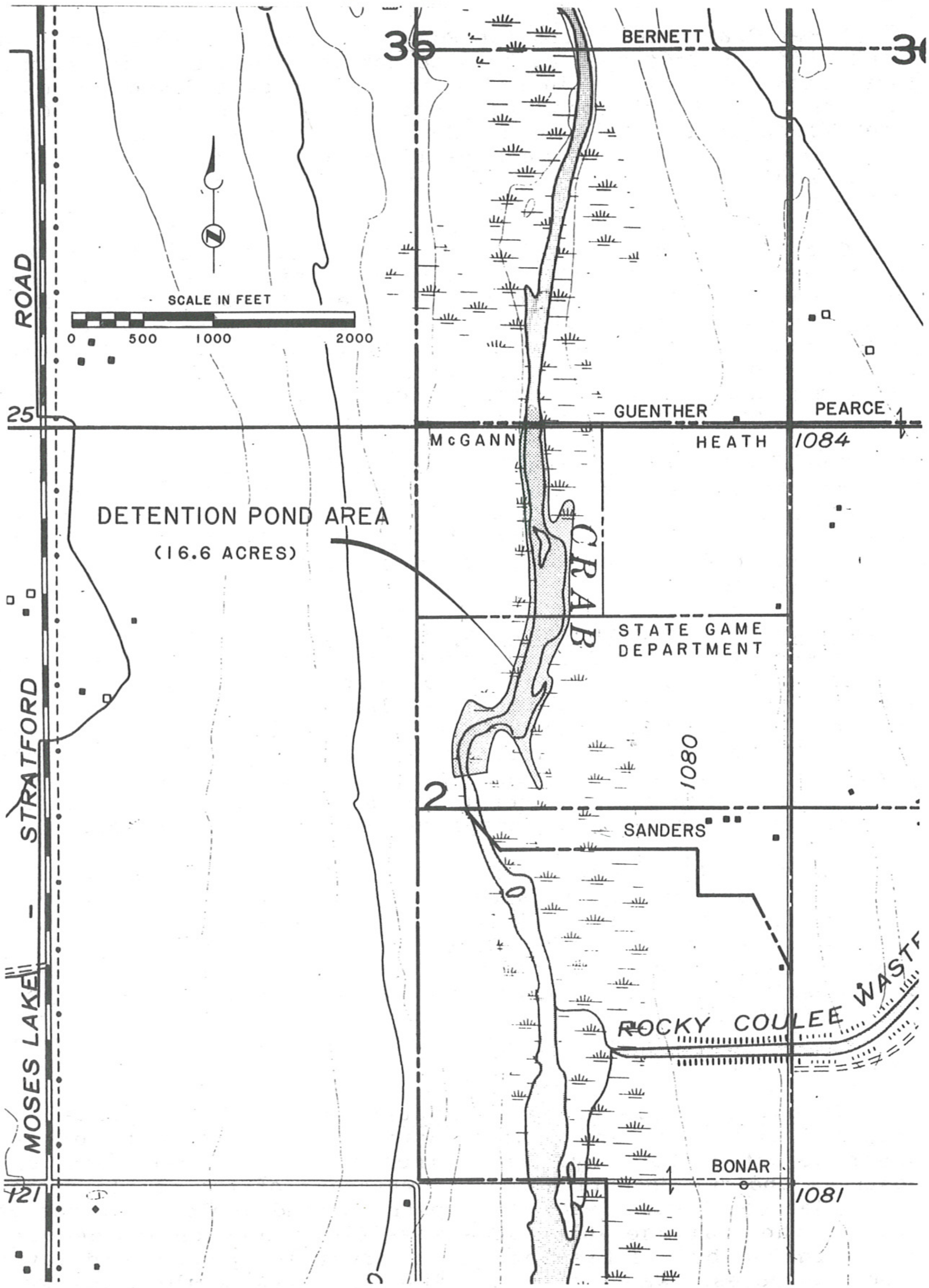


Fig. 5-8 Lower Crab Creek Detention Pond

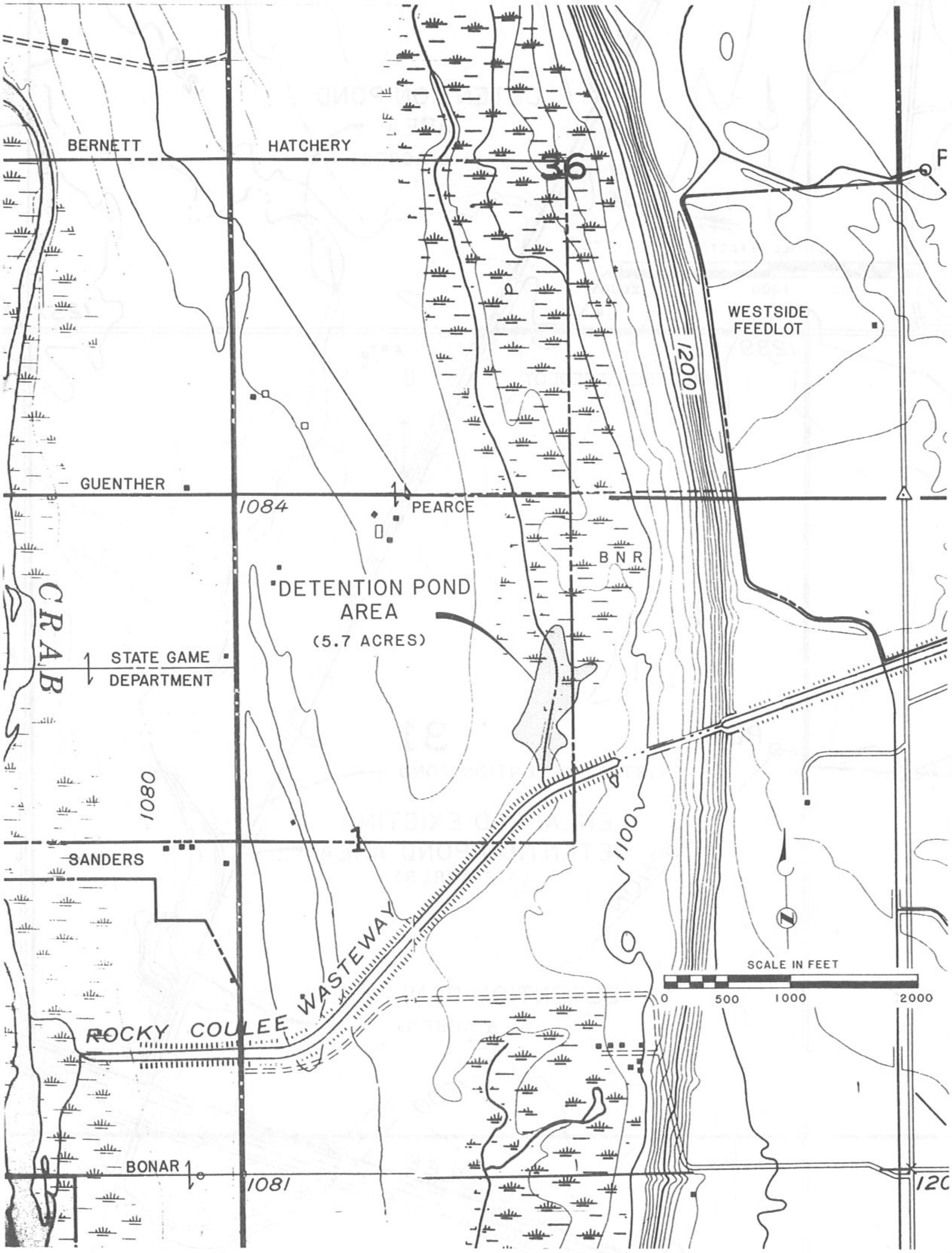


Fig. 5-9 Rocky Coulee Tributary Impoundment

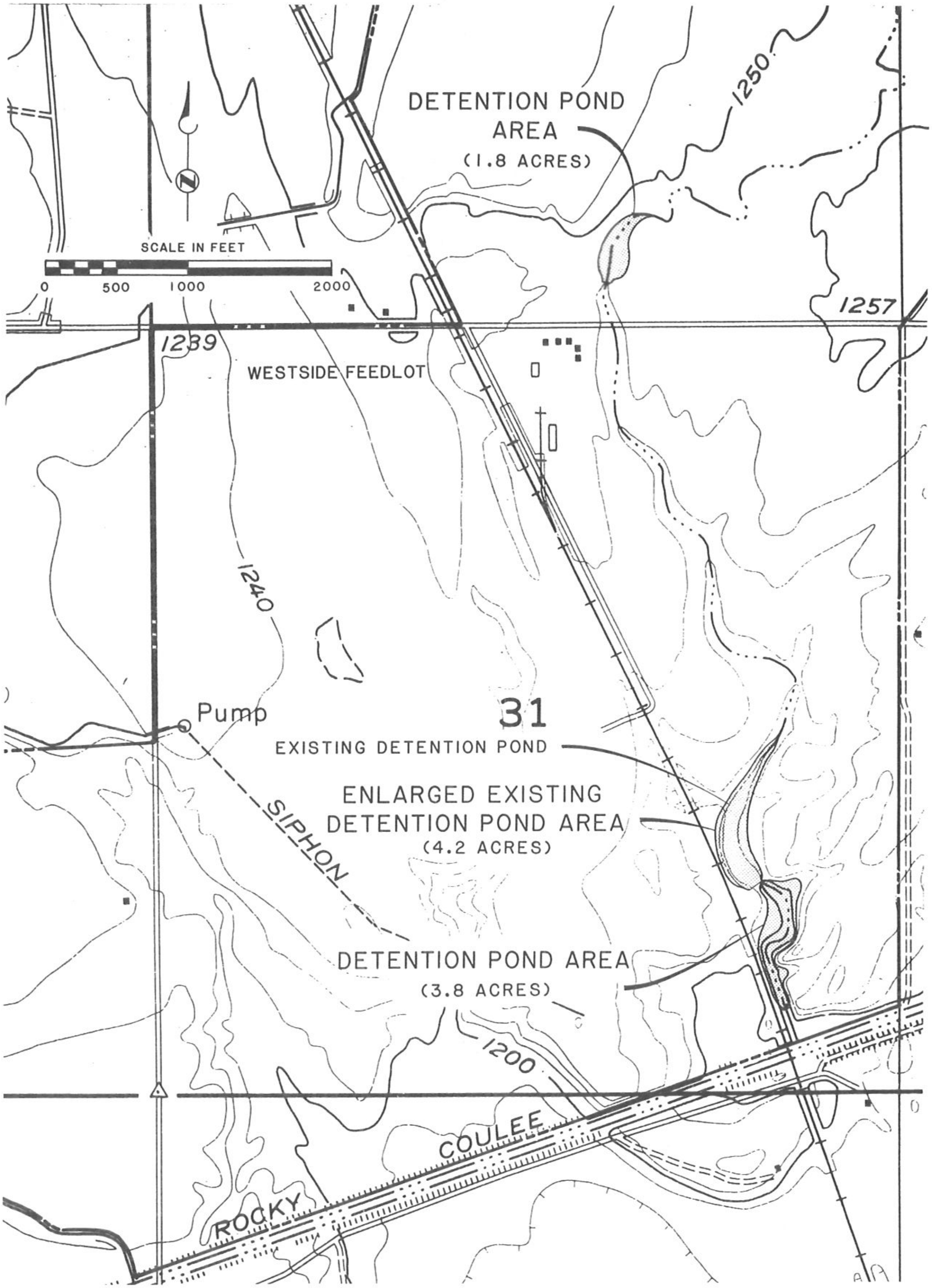


Fig. 5-10 Westside Feed Lot Controls

of the stream to be used for irrigation or stock watering. The impounded stream which is made up of irrigation return flow then passes through cattle yards and flows into an existing 2.4 acre detention pond which is badly silted up. This existing pond would be cleaned out and enlarged to about 4.2 acres to enhance trapping of nutrients and organic sediments from the feed lot. A third pond of about 3.8 acres could be constructed immediately downstream to provide additional reliability and additional storage for irrigation withdrawal. This second detention pond should accumulate less sludge, and water from it could be pumped to adjacent farmland. These three ponds provide several days' storage and should eliminate discharges to the wasteway during the irrigation season. Costs for these improvements are estimated to be approximately $10,000. No easements or land purchase is assumed since all the facilities would benefit the property owner.

Upper Rocky Coulee Detention Pond Prospects. Rocky Coulee drainage water flows for only a short duration during spring run-off; usually two weeks or less. Because of the short period of time it flows, the Rocky Coulee run-off water doesn't contribute much to the nutrient level of Moses Lake, but it does appear to contribute a high level of sediment. There are no impoundment structures along the stream so the sediment flows directly into Upper Parker Horn where much of it settles out. The sediment contributed by Rocky Coulee run-off is relatively high in relation to the amount of sediment contributed from other sources because the other sources are either ground water or water that has already been impounded.

Quantification of sediment contributions from Rocky Coulee to Moses Lake has not been determined due to the erratic flow from this basin. During January and February of 1985, 60 acre feet of run-off water from Rocky Coulee was measured by the Bureau of Reclamation, which carried sediment to Parker Horn of Moses Lake. The actual sediment loading of the 1985 Rocky Coulee run-off water is presently being quantified, and this figure will be compared to the total sediment loading from Stage 1 to determine the over-all effect of Rocky Coulee's sediment contribution to Moses Lake.

Prior to Development of the Columbia Basin Project, the Rocky Coulee drainage system was a closed basin which had no surface water flowing into Moses Lake. During the development of the irrigation project, the Rocky Coulee wasteway was built, which now allows Rocky Coulee run-off water and sediment to drain directly into Moses Lake. A detention structure could be placed in the upper part of Rocky Coulee Wasteway to control this sediment. Evaluation of this alternative can be pursued during Stage 3 after additional sediment data are available.

## Septic Tank Controls

A significant proportion of the population living in the vicinity of Moses Lake is served by septic tanks. Within the city of Moses Lake itself, approximately 1500 people are not served by the sewer system. Approximately 500 of these people are in the Lower Peninsula area where most septic systems are within 1000 feet of the lake shore. About 400 people are served by septic tanks in the Basin Homes area. See Map Figure 5-11. A larger number of septic tank systems are in the county, at least 2500 people are in densely developed areas around Moses Lake where sewers would be feasible. The total county population in the Moses Lake area is about 10,000, essentially all of whom rely on individual septic tank systems. It is recognized that some of these systems are remote from the lake and its tributaries. The Stage 1 report used a population of 4500 in determining nutrient loads to Moses Lake from septic tanks; this figure is probably conservative since it represents only 40 percent of the unsewered population in the Moses Lake area. Nutrient loads from this population would contribute 22,800 lbs. of nitrogen and 8700 lbs. of phosphorus per year if no soil retention or vegetative losses occur. Since the City of Moses Lake sewage treatment plant discharge has been diverted from the lake the potential contribution from septic tanks accounts for at least 10 percent of the total annual phosphorus load. Nitrogen loads are only one percent since agricultural contributions through deep percolation or direct runoff are by far the dominant source for this highly soluble nutrient.

The coarse soils around the lake shore allow phosphorus to move in groundwater as has been shown in sampling of wells and springs in the area as part of the Moses Lake Project and past studies by University researchers. See Chapter 4. The high permeability of the area's soils has caused the Moses Lake Project to focus considerable attention on both phosphorus and nitrogen movement in groundwater. For this same reason the local use of septic tank systems has been reviewed to determine both their possible effects and to consider alternative technologies to reduce or eliminate discharges of nutrients reaching Moses Lake from this source.

Factors Concerning On-Site Sewage Disposal. The most fundamental determinant of whether an on-site system will contribute substantially to lake nutrient loads is whether it is in proper operation. A system which has failed, if it is in a direct drainage path to a lake, can discharge large quantities of nutrients via surface runoff and interflow. A single malfunctioning system on the shore of a small Washington State lake was estimated to contribute one-quarter to one-half of the phosphorus added to the lake by all on-site disposal systems.[a, b]

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[a]Gilliam, R., U.S. Geological Survey, Reston, Virginia, personal communication.

[b]Patmont, C., Harper Owes, Inc., Seattle, WA, personal communication

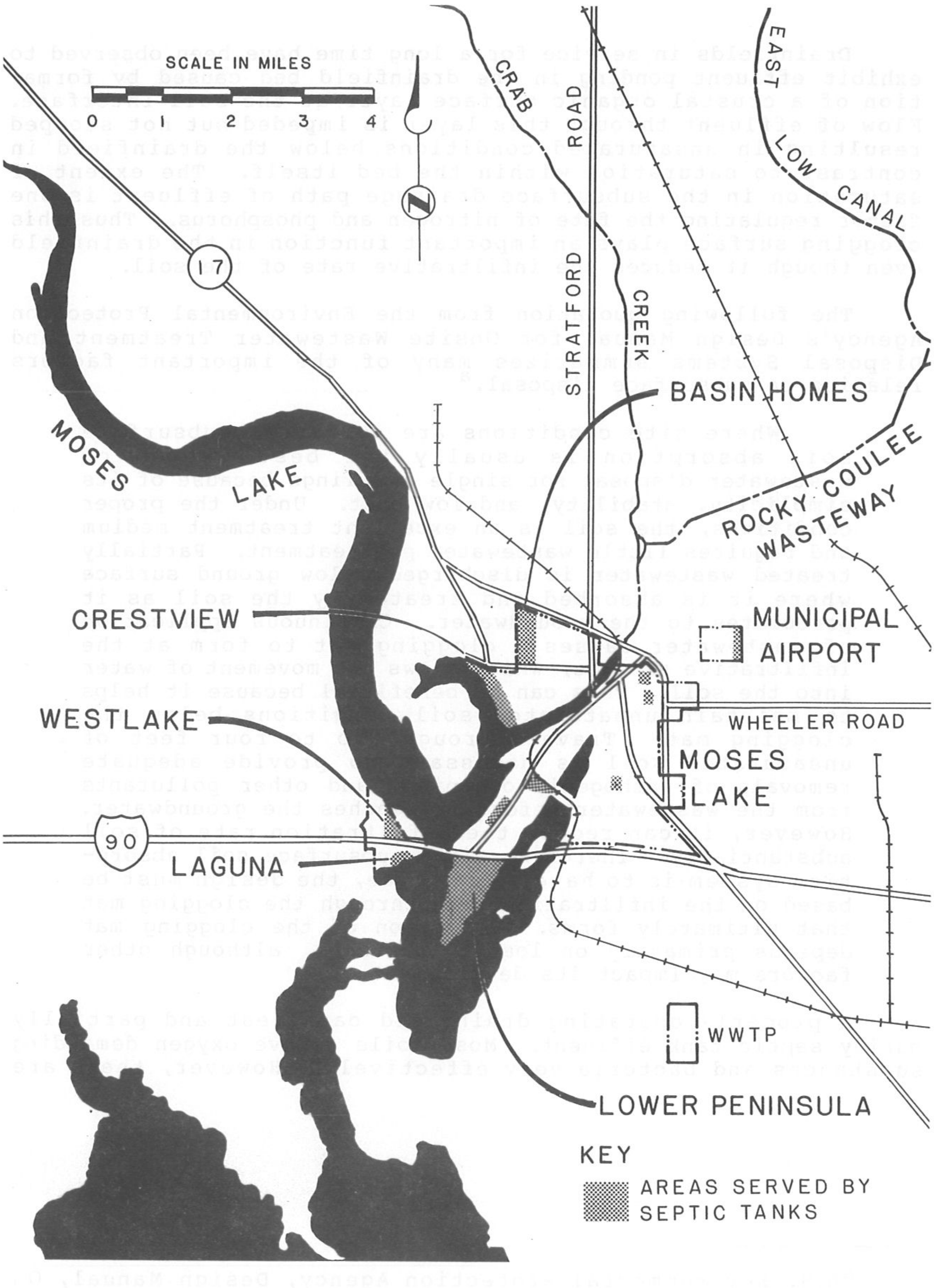


**Fig.** 5-11 Areas Served by Septic Tanks-City of Moses Lake

Drainfields in service for a long time have been observed to exhibit effluent ponding in the drainfield bed caused by formation of a crustal organic surface layer at the soil interface. Flow of effluent through this layer is impeded but not stopped resulting in unsaturated conditions below the drainfield in contrast to saturation within the bed itself. The extent of saturation in the subsurface drainage path of effluent is one factor regulating the fate of nitrogen and phosphorus. Thus this clogging surface plays an important function in the drainfield even though it reduces the infiltrative rate of the soil.

The following quotation from the Environmental Protection Agency's Design Manual for Onsite Wastewater Treatment and Disposal Systems summarizes many of the important factors relating to subsurface disposal.[a]

> Where site conditions are suitable, subsurface soil absorption is usually the best method of wastewater disposal for single dwellings because of its simplicity, stability, and low cost. Under the proper conditions, the soil is an excellent treatment medium and requires little wastewater pretreatment. Partially treated wastewater is discharged below ground surface where it is absorbed and treated by the soil as it percolates to the groundwater. Continuous application of wastewater causes a clogging mat to form at the infiltrative surface, which slows the movement of water into the soil. This can be beneficial because it helps to maintain unsaturated soil conditions below the clogging mat. Travel through two to four feet of unsaturated soil is necessary to provide adequate removals of pathogenic organisms and other pollutants from the wastewater before it reaches the groundwater. However, it can reduce the infiltration rate of soil substantially. Therefore, if a subsurface soil absorption system is to have a long life, the design must be based on the infiltration rate through the clogging mat that ultimately forms. Formation of the clogging mat depends primarily on loading patterns, although other factors may impact its development.

A properly operating drainfield can treat and partially purify septic tank effluent. Most soils remove oxygen demanding substances and bacteria very effectively. However, there are

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[a]U.S. Environmental Protection Agency, Design Manual, On Site Wastewater Treatment and Disposal System, October 1980.

definite limitations to the use of septic tank-drainfield systems. Dr. P. H. McGauhey, who directed years of research on septic tank effluent disposal summarized it best.[a] Here are his words:

> In summary it may be said that at best the septic system increases the total dissolved mineral content of local groundwaters. At worst, it may introduce bacteria, viruses, and degradable organic matter as well. From an environmental viewpoint the best is not the best of all possible alternatives in an urban situation. Rationally it would seem undesirable to concentrate 2,000 to 15,000 septic systems on the roof of a single groundwater basin or along the margin of a recreational lake. Nor is it necessary today. On the other hand, the best is certainly adequate for the isolated dwelling, where service to man far exceeds any possible environmental effect.

More specific observations on nutrient aspects of septic tank leachate disposal are offered in the following paragraphs.

Nitrogen Movement in Groundwater. The Moses Lake shoreline area is characterized by the generally excessively drained soils formed in glacial outwash. See Chapter 2. These porous soils allow migration of nutrients from septic tank systems. Both nitrogen and phosphorus are present in septic tank effluents. An understanding of their behavior in soil is important to determining their potential importance to Moses Lake water quality.

Nitrogen is present in septic tank effluents primarily in ammonium and organic forms. Typically about 80 percent of the total nitrogen is in the ammonium form, also organic nitrogen is eventually mineralized to ammonium in the drainfield soils. Ammonium, a positive ion, will sorb on soil particles in proportion to the soil's cation exchange capacity which is dependent on the proportion of negatively charged clay particles present. Coarse, sandy soils have a low exchange capacity so ammonium can move directly to groundwater. Typically, aerobic conditions exist beneath drainfield beds and ammonia is oxidized to nitrate by nitrifying bacteria. Nitrification proceeds rapidly particularly in summer. Nitrates are highly soluble and move freely to ground. Denitrification, a process which can convert nitrate to nitrogen gas, requires opposite environmental conditions to nitrification. The following excerpt from a recent review by Dr. R. Horner of the University of Washington (see Appendix E) provides valuable insight on this aspect of the nitrogen cycle:

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[a]McGauhey, P. H., Septic Tank Usage and Their Effects on the Environment, State of the Art Review, paper presented to the Rural Environment Engineering Conference, Warren, Vermont, September 1973.

Typically, unsaturated soils and aerobic conditions exist beneath drainfield beds. Walker et al measured 19.6 percent oxygen in soil pores within an effluent infiltration zone, almost as high as in the atmosphere. In this situation, nitrifying bacteria oxidize NH4-N first to NO3-N, obtaining energy for cell formation in the process. Nitrification is energetically favored and proceeds rapidly with high oxygen concentration and temperature and alkaline soil pH. Its rate is retarded with increased soil moisture tension (reduced aeration) and decreased temperature and pH. Viraraghvan and Warnock measured only 20-35 percent nitrification in winter in loam soils, compared to 80-90 percent in summer.

NO3-N is highly soluble and moves freely through the soil solution by convection, as well as by molecular and ionic diffusion due to concentration gradients. Its potential to enter groundwater is thus high, particularly in the case of porous soils draining seasonally high precipitation.

The only possible mechanism by which NO3-N can be reduced is denitrification, the conversion of NO3-N to nitrogen gas by heterotrophic, faculative bacteria operating under anaerobic conditions. Because NO3-N is a necessary reactant for this process and the aeration requirements are opposite for nitrification and denitrification, the two processes rarely occur in the same locale. In addition, denitification yields bacteria relatively little energy and is greatly retarded at pH less than 5.5 and temperature under 10 degrees C. A deficiency of carbon for the heterotrophic bacteria in sandy soils is also an impediment. For these reasons, denitrification is generally of only minor importance in some soils and practically none in others.

Considering the relative unimportance of N removal processes, such as adsorption of NH4-N and precipitation or denitrification of NO3-N, there is little to stop N transport to groundwater, especially in loose soils. Walker et al and Starr and Sawney documented N transport to groundwater without apparent loss in sandy soils. The former authors commented that the only active mechanism of lowering NO3-N concentrations in this situation is by dilution with uncontaminated groundwater. If groundwater intercepts a lake, however, the load of N it carries is available to potentially stimulate photosynthesis in the lake.

Considering the potential nitrogen transformations and generally prevailing soil moisture tensions in different textural classes, Sikora and Corey predicted the N forms likely to be present in the various soils. Nitrification is expected to be nearly complete at most times in sands, sandy loams, loamy sands and loams. Thus, N will be primarily in the NO3-N form. In silt loams and silty clay loams, a mixture of NH4-N and NO3-N is likely. In these soils, there is some possibility of NO3-N reduction through denitrification. Nitrification would be severely retarded in clay loams and clays, such that NH4-N would predominate.

In summary, most nitrogen in septic effluent rather quickly takes the ammonium form. NO3-N is subsequently formed with effective soil drainage in all but the heavier textured soils. This form is easily transported in soils and has a high potential to enter groundwater and, ultimately, surface waters. N breakthroughs to lakes as high as 50-70 percent have been reported. Using a leachate detector which measures conductivity and fluorescence, the former workers estimated a mean of 16 percent N breakthrough (in a range of 3-49 percent) around Crystal Lake, Michigan. They observed the most erupting plumes in areas of high groundwater. Whether in the NH4-N or NO3-N form, leached nitrogen is available to stimulate algal and aquatic plant growths in receiving waters.

<u>Phosphorus Movement in Groundwater</u>. Anaerobic digestion in septic tanks converts most phosphate forms to soluble ortho phosphate. Various researchers have found more than 85 percent of the total phosphorus in septic tank effluents were in this soluble form and most of the remainder is soon converted in the drainfield when effluent phosphates first contact soil sorption occurs to an extent determined by the soil's capacity. The soil's capacity to retain phosphate depends on pH and soil chemistry and texture. Adsorption capacities are low in coarse sands of low organic content and are higher in finer textured soils. Precipitation of phosphorus is also a consideration and can be predicted from soil pH relationships. The most important hydrogeological conditions influencing actual phosphorus removal are soil drainage and the position of the groundwater table relative to the drainfield. Insufficient spacing between the drainfield and the seasonal high water table would not allow opportunity for the phosphorus present in the waste and soil retention coefficients developed for various soils. However, phosphorus retention is observed for coarser soils. For example, a coarse, sandy soil may retain less than 5 percent of the phosphorus whereas a silty sand mixture may retain 60-70 percent of the phosphorus. Computations of phosphorus retention for lake shore areas using this approach are described in Dr. Horner's paper. (See Appendix) These examples considered areas extending back approximately 1000 feet from the lake shore. Dr. Horner's review states that it would be appropriate to assume all phosphorus discharged is transported to the lake in areas with steep slopes or excessively rapid drainage.

Proposed Septic Tank Policy. A policy covering individual septic tank systems was drafted as part of the Clean Lake Project to assist local agencies in minimizing nutrient migration from leach fields near the lake or its tributaries. The policy is intended to provide for more stringent measures affecting design of septic tank systems planned near the lake. The policy discourages use of septic tanks within a lake sensitive zone and urges hook-up to sewer systems where treatment and disposal measures assure nutrients are kept from entering Moses Lake. The lake sensitive zone and proposed septic system design recommendations are described below:

*Within 1000 feet of Moses Lake or its tributaries, septic tank drainfields should not be installed within 20 feet vertical distance from the water surface. Septic tank drainfields may be installed within 1000 feet of Moses Lake or its tributaries if a vertical spacing of 20 to 100 feet exists between the drainfield base and the water surface and if a fine sand filter of the depth prescribed in Table 5-1 is installed below the entire drainfield. At horizontal distances greater than 1000 feet and vertical distances greater than 100 feet from the water surface of Moses Lake or its tributaries, septic tank drainfields may be installed without these additional restrictions. For purposes of this policy, the tributaries are considered to be Crab Creek downstream of Rocky Coulee Wasteway and Rocky Ford Creek downstream of Highway 17.*

Table 5-1. Sand Filter Depths for Various Sand Particle Size Distributions and Vertical Spacings Between Drainfield Base and Water Surface

| Vertical (feet) | Spacing (feet) | Particle Size D10 | Minimum Sand Filter Depth (meters) | Minimum Sand Filter Depth (feet) |
|---|---|---|---|---|
| 20 | 20 | 0.24 | 1.3 | 4.3 |
| | | 0.30 | 1.8 | 6.0 |
| | | 0.60 | 2.8 | 9.3 |
| 35 | 40 | 0.24 | 1.0 | 3.3 |
| | | 0.30 | 1.4 | 4.7 |
| | | 0.60 | 2.2 | 7.3 |
| 50 | 60 | 0.24 | 0.8 | 2.6 |
| | | 0.30 | 1.0 | 3.4 |
| | | 0.60 | 1.6 | 5.2 |
| 75 | 80 | 0.24 | 0.44 | 1.5 |
| | | 0.30 | 0.63 | 2.1 |
| | | 0.60 | 1.0 | 3.3 |
| 90 | 100 | 0.24 | 0.16 | 0.5 |
| | | 0.30 | 0.22 | 0.7 |
| | | 0.60 | 0.35 | 1.1 |

D10 is the diameter in millimeters below which all but 10 percent of the material occurs by size.

D10 is the diameter in millimeters below which all but 10 percent of the material occurs by size.

The applicability of the policy within 1000 feet of the lake or tributary is derived from a recommendation by Dillon and Rigler (1975) that septic systems be set back that distance from the shores of lakes.[a] The policy is based on prevention of phosphorus breakthrough to groundwater adjacent to Moses Lake or one of its tributaries for the life of the septic system. System life was taken to be 25 years. Phosphorus was used in the analysis because of the greater role septic tanks play in its addition to the lake relative to nitrogen, its high tendency toward mobility in the soils of the area, and the availability of data to conduct the analysis. The time until breakthrough was estimated as follows:

Time until breakthrough = Vertical distance drainfield base to groundwater/PP

$$PP = LP/(IP)(D)(A)$$

where: PP = P penetration rate (distance/unit time)
LP = P loading rate (mass P/unit time)
IP = P immobilization capacity (mass P/mass soil)
D = soil bulk density (mas soil/unit volume)
A = drainfield area (area units)

The quantities in the second equation were selected as follows. LP was taken to be 1.8 kg/person/yr. x 4 persons/household = 7.2 kg/yr. The per capita value is at the top of the range reported in the literature, which introduces a factor conservative toward protection of the lake in the policy. IP was selected to be 10 mg P/100 g soil, at the bottom of the range reported in the literature for sand. This selection is considered to be reasonable due to the extreme coarseness of most of the soils in the area in question. A soil bulk density of 1.6 g/cu cm was used. Drainfield area was taken to be 365 sq ft, the size specified for the Bayview Heights development on Moses Lake.

Following calculation of the time until breakthrough for various vertical spacings between drainfield base and water surface, the necessary P retention coefficients (RP) for sand filters having three grades of fine sand were estimated according to:

$$RP = 1 - \text{Years until breakthrough}/25 \text{ years}$$

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[a]Dillon, P. J. and Rigler F. H. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status, Journal Fisheries Research Board of Canada, September 1975.

These values of RP were compared to the coefficients reported for 76 cm deep beds of the three grades of sand by Dillon and Rigler. It was reasoned that required sand filter depth and P retention coefficient are inversely and linearly related. On this basis the necessary sand filter depths listed in Table 5-1 were established by proportion from the needed RP and the Dillon and Rigler data. With spacing between drainfield base and water surface of at least 100 feet, the natural soils are estimated to have sufficient retention capacity to prevent breakthrough for 25 years. With spacing of less than 20 feet, no feasible fine sand filter depth will provide sufficient retention to meet the criterion. It is recognized that some depths recommended in the table may be prohibitive. Selection of the finest available grain size reduces the necessary depth.

Alternatives for On-Site Sewage Treatment and Disposal. Numerous studies of alternatives to individual septic tank systems have been completed by water pollution control agencies. Well known examples include the Wisconsin Small Scale Waste Management Project and the Oregon Evaluation of Alternatives for Onsite Sewage Treatment and Disposal and the EPA Design Manual for Onsite Systems and publications on Alternatives for Small Wastewater Treatment Systems. These studies describe newer technologies used to overcome site constraints and ways to reduce nutrient migration to groundwater. Well-known examples include mound systems which are now commonly used in many northwestern communites where poor soil permeability or high water tables prevent development and evapotransporition beds which can be used to dispose of wastewater to the atmosphere so no discharge to surface or groundwater is required. These systems are often used to service small community developments as alternatives to facilities involving more complex mechanical systems and direct discharge.

Development around the Moses Lake shoreline should be planned with sanitary sewer systems as a requirement so wastewater can be managed to minimize nutrient migration to the lake. Sewer systems serving shoreline areas could be designed so wastewater could be pumped away from the shore and treated with discharge to subsurface disposal systems such as evapotranspiration beds or for seasonal irrigation and storage of effluent as is practiced by the City of Ephrata. It is recognized that in general community sewer systems are not economical where lot sizes exceed two acres. Accordingly, some incentives should be considered that would allow cluster development or smaller lots where satisficatory community sewer and treatment/disposal alternatives are offered.

Costs for sewering the estimated 4500 people in densely populated areas of the City and County were estimated assuming 2.6 persons per household and an average cost of $5000 per house. This factor is consistent with recent estimates by the City for sewering the Basin Homes area which assumed $603,750 for hooking up about 130 homes. Using $5000 per house, a total sewering cost of $8,650,000 was estimated for 1730 homes in the City and adjacent County areas near the lake or its tributaries. Additional treatment plant costs were not included, nor was the fact that costs for sewering would become higher as sewers extended away from denser developed areas. Some areas of the City and contiguous County areas will be more feasible to sewer than others based on topography and extent of development. Hook-ups should be enforced for all where sewers are already in the streets.

Miscellaneous Livestock and Hatchery Waste Controls

An inventory of livestock and hatchery operations was conducted to determine their significance in the nutrient loadings to Moses Lake. There are six livestock operations and three fish hatcheries which were identified in the Stage 2 project study area. These facilities were evaluated considering water quality monitoring results, on-site visits, and technical literature covering these kinds of sources. Inventory results for the livestock operations are summarized in Appendix B. Several of these operations were considered candidates for nutrient source controls. Hatcheries were eliminated from further consideration because the nutrient loadings from the facilities monitored in the watershed did not show any significant contributions of nutrients. It is known that raceway cleaning operations can be a temporary source of higher loadings, but these short term loading events were not considered significant based on literature describing monitoring of these loads.[a]

Suggested livestock controls are described in Appendix B and include specific diversion and detention pond improvements for the Westside Feed lot described earlier in this chapter. Similarly, dairy waste controls for the Pearce dairy are described earlier in the discussion of a detention pond on a Rocky Coulee tributary and in Appendix B. Unconfined livestock controls are recommended for three farms on Crab Creek. These controls include fencing, access gates and alternative water supply facilities for stock watering to prevent catle from wandering in the stream and adjacent riparian area. These controls are estimated to cost $10,000 per farm. Most of the cost is in fencing which was assumed as $1.50 per foot for an installed five wire fence.

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[a]Kramer, Chin & Mayo, Inc., A Study to Determine Percentages of BOP and Suspended Solids in Fish Hatchery Effluent During Raceway Cleaning, Prepared for U. S. Army Corps of Engineers, Portland District, June 1974.

## Summary

This chapter reviews control needs and approaches for a variety of nutrient sources and other water quality factors which influence Moses Lake. These various sources and factors are listed below:

Water Circulation. Various bridges and causeways affect water quality by impeding or altering circulation and by allowing wind to concentrate floating algae mats. This is particularly important near the Alder Street Fill and in upper Pelican Horn. Possible remedies include a cleaning station near the Alder Street Fill and additions of culverts in Pelican Horn crossings. Dilution and other nutrient control programs reduce the need for such improvements by reducing the frequency and extent of floating blue green algae mats.

Carp Controls. Carp affect water quality by disturbing bottom sediments and uprooting aquatic plants. Controls are not feasible in the lake although harvesting is encouraged. Controls in Rocky Ford Creek are suggested.

Dredging. Removal of sediment accumulation in Upper Parker and Upper Pelican Horn are evaluated and found to be infeasible because of cost involved to deepen these areas sufficiently to retard weed growth.

Weed Harvesting. Aquatic weed harvesting is evaluated considering purchase or rental of a harvesting machine. The evaluation which is based on two cuttings per season over an 80 acre area showed that purchase would be the more economical approach. Weed cutting plans would need to be reviewed by regulatory agencies.

Diversion of Rocky Coulee Pumped Drainage. An existing pumped discharge of irrigation drainage from an East Columbia Irrigation District facility on Rocky Coulee Wasteway was evaluated. Diversion of the discharge to an irrigation feeder canal would reduce the nutrient loading to Moses Lake.

Detention Ponds. Several shallow detention ponds were evaluated at sites on Crab Creek, Rocky Ford Creek and Rocky Coulee Wasteway tributaries in order to trap nutrients which would otherwise enter Moses Lake. These facilities should be particularly effective in reducing phosphorus loads since phosphorus is associated with sediment particles.

Septic Tanks. Septic tank nutrient contributions are explained. Approximately 10 percent of the lake's estimated phosphorus loading comes from this source. Sewering needs and a basis for a more stringent septic tank policy are described.

Livestock and Hatchery Controls. Control needs and approaches for a major feedlot, dairies and unconfined livestock operations are summarized. Present hatchery controls appear to be adequate.

# CHAPTER 6

# EVALUATION AND PRIORITIZATION OF CONTROLS

Various water quality control approaches applicable to Moses Lake have been described in Chapters 3 and 5. These approaches range from irrigation practice changes and related water and fertilizer management to such diverse approaches as dredging, weed harvesting, detention ponds and more stringent septic tank policies. This chapter attempts to evaluate the effectiveness of these approaches in terms of nitrogen and phosphorus control costs. Priorities are established by ranking the nutrient control approaches in terms of their cost-effectiveness for achieving reductions in nitrogen and phosphorus loadings to Moses Lake. Following evaluation of the individual control approaches, alternative control strategies are described and evaluated in terms of overall cost and impact on Moses Lake water quality. A mathematical model developed especially for Moses Lake was used to assess the effect of varied nutrient inputs on algal growth in the lake with and without dilution water inputs.

Controls for agricultural nutrient inputs are emphasized since irrigated agriculture in the proximity of Moses Lake account for about 50 percent of the present nitrogen loading from the watershed. Accordingly, a series of Best Management Practices (BMP's) are proposed for consideration by local farmers in a unique federal cost-share program. The BMP's and relevant cost-share rates are summarized here. Additional details on the BMP's are provided in the Appendices. An example of a model farm plan and a cost-share handbook are also appended to this report.

## Agricultural Best Management Practices

Six BMP's are identified for agricultural application in the 28,000 acre Moses Lake project area described in this report. These practices and applicable cost-share rates for each practice element are described below:

Irrigation Water Management. This BMP is designed to improve water quality by controlling irrigation water loss so as to minimize deep percolation of nutrients. Specific approaches include renozzling and other mechanical measures to increase application efficiency of both wheelline and center pivot sprinkler systems; soil moisture monitoring, irrigation scheduling, flow metering and refurbishing of pumps. These water management approaches are assigned a 75 percent cost-share rate with the exception of pump refurbishing which is allowed a 50 percent cost-share rate.

Irrigation System Improvements. This BMP covers major irrigation equipment conversions such as furrow to cablegation or one of several sprinkler systems (e.g., wheelline or center pivot) or conversions from wheelline to center pivot. These conversions would reduce runoff and deep percolation of water and nutrients. Other structural improvements are also covered under the BMP including replacement of portable or worn mainlines at existing location, new pumps and new sprinkler systems. The maximum cost-share for irrigation system improvements is 50 percent.

Fertilizer Management. Water quality improvements are expected as a result of greater use of soil tests to determine fertilizer rates and by changes in fertilizer application practices. Increased use of "fertigation," the application of liquid fertilizer through sprinkler systems or split applications of broadcast fertilizer is eligible for a maximum cost-share rate of 75 percent. These two methods allow farmers to apply smaller amounts of fertilizer at intervals matched to crop needs. Figure 6-1 shows the impact of split fertilizer application on deep percolation of nitrogen based on the Pfeiffer-Whittlesey equation (See Chapter 3). This example shows approximately 40 percent nitrogen saved from loss to deep percolation compared to a single fertilizer application.

Animal Waste Control. Animal waste control facilities are designed to store and allow management of livestock waste. These facilities will abate pollution from existing livestock or poultry operations by controlling surface runoff to and allowing reuse of animal waste on the land. The maximum cost-share rate for animal waste control improvements is 50 percent.

Sediment and Water Control Structures. This BMP applies to specific problem areas on farms where substantial amounts of sediment or nutrients constitute a significant pollution hazard. Cost-share is authorized for detention or retention structures, channel linings, and drop structures that dispose of excess water. A maximum cost-share rate of 50 percent is allowed.

Stream Protection Systems. This BMP provides for fencing stream banks and lake shores where the bank is subject to damage by livestock. The BMP also covers installation of livestock crossings to retard pollution and costs for providing access to water for livestock. The maximum cost-share rate for these improvements is 75 percent.

## Model Farm Plans

Water quality control plans must be prepared for each participating farm before implementation can proceed under the cost-share program. Potential nutrient changes resulting from implementing a cost-share program were evaluated by developing ten model farm plans. These model plans were written after choosing a cross section of farms in the project area and from a variety of BMP's and cost-share rates described earlier. An example farm plan is included in the Appendix. A summary of all ten model farm plans is provided in Table 6-1. This table shows,

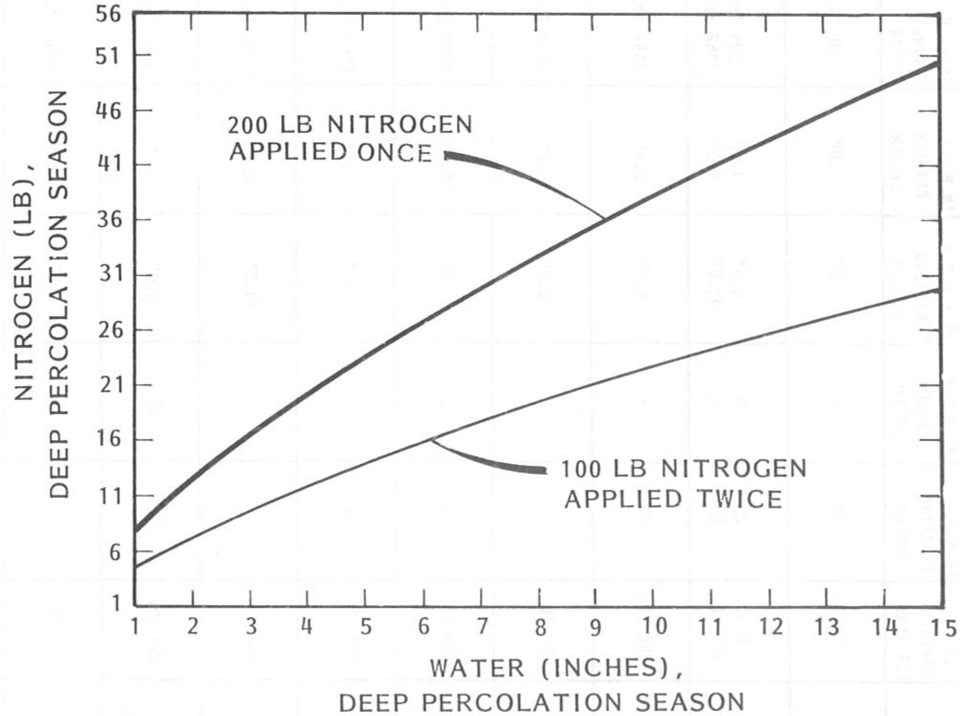



Fig. 6-1 Example of Split Fertilizer Application Effect

Clean Lake Project Staff Explaining Matheson Cablegation Demonstration

LEVEL A

# Table 6-1 Level A Irrigation Control Model Farm Plan Evaluation

| PLAN NO. | PRIORITY NO. | ACRES IRRIG. | ACRES PLANNED | COST-SHARE COST | COST-SHARE COST/A | EXISTING SYSTEM | PLANNED SYSTEM | FERT. MGMT. AFTER | LB. N APPLIED PER ACRE | LB N D.P. EXISTING SYSTEM | LB. N D.P. PLANNED SYSTEM | IN. $H_2O$ D.P. EXISTING SYSTEM | IN. $H_2O$ D.P. PLANNED SYSTEM | TOTAL N SAVINGS AFTER | COST-SHARE COST/LB. SAVED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 337 | 210 | $ 9046. | $ 43. | Wheellines | Renozzle & extra line | Fertigation | 0 lb. | 26 | 8 | 6.0" | 1.0" | 780 lb. | $ 2.39/lb. |
| 2 | 31 | 142 | 111 | $ 18968. | $ 171. | 83 A. furrow<br>28 A. wheelline | Wheelline | Broadcast Split Applic. | 0 lb.<br>111 lb. | 26<br>22 | 8<br>8 | 6.0"<br>11.0" | 1.0"<br>1.0" | 504 lb.<br>1162 lb. | $11.39/lb. |
| 3 | 34 | 160 | 139 | $ 11120. | $ 80. | Wheellines | Center pivot | Fertigation | 200 lb. | 27 | 4 | 6.0" | 0.4" | 3197 lb. | $ 6.52/lb. |
| 4 | 43 | 264 | 264 | $ 32716 | $ 124. | Wheellines | Wheellines (new mainline) | Fertigation | 180 lb. | 33 | 9 | 6.0" | 1.0" | 6336 lb. | $ 5.16/lb. |
| 5 | 31 | 80 | 50 | $ 11406 | $ 233. | Furrows | Cablegation | Broadcast Split Applic. | 126 lb. | 25 | 5 | 11.0" | 1.0" | 1000 lb. | $11.41/lb. |
| 6 | 36 | 80 | 97 | $ 28748 | $ 296. | Furrows | Center pivot | Fertigation | 153 lb. | 31 | 3 | 11.0" | 0.4" | 2761 lb. | $10.59/lb. |
| 7 | 42 | 75 | 133 | $ 15115 | $ 114. | Furrows | Center pivot | Fertigation | 200 lb. | 40 | 4 | 11.0" | 0.4" | 4788 lb. | $ 5.08/lb. |
| 8 | 37 | 20 (378 total) | 20 | $ 4165 | $ 208. | Furrows | Cablegation | Broadcast Split Applic. | 250 lb. | 51 | 10 | 11.0" | 1.0" | 820 lb. | $ 5.63/lb. |
| 9 | 32 | 213 | 120 | $ 6600 | $ 55. | Wheellines | Center Pivot | Broadcast 1x/season | 0 lb. | 26 | 4 | 6.0" | 0.4" | 2640 lb. | $ 6.85/lb. |
| 10 | 34 | 750 | 98 | $ 22876 | $ 194. | 29 A Furrow<br>69 A Wheellines | Center pivot | Fertigation<br>Fertigation | 262 lb.<br>200 lb. | 40<br>26 | 4<br>4 | 11.0"<br>6.0" | 0.4"<br>0.4" | 1044 lb.<br>1518 lb. | $ 8.93/lb. |
| | | 2121 | 1242 | $160760 | $ 129.43 | | | | | | | 7.05" | 0.7" | 29505 lb.<br>av. = 23.8#/AC | |

among other things, the acres planned for BMP improvements, type of BMP's, capital costs, pounds of nutrients saved, and the cost per pound of nitrogen saved. Average costs were determined from the ten farm plans for use in subsequent economic evaluations.

Three levels of farmer involvement were considered in the evaluation of farm plans. The levels varied with the coverage allowed by the cost-share program ranging from 77 percent participation for the full range of BMP's to 50 percent participation where wheelline to center pivot conversions are excluded. The participation figures are based on interviews with area farmers to determine how receptive the agricultural community is to a cost-share program to improve irrigation efficiency and other farm practices. The Moses Lake Clean Lakes Project staff interviewed 50 farmers who control 77 percent of the Block 40, 401 and 41 area and found they were willing to participate in the project. The model farm plans were developed using a typical cross section of ten of these farms. In each plan the farmer worked with the project staff in evaluating alternatives before deciding on practices which would meet his farming needs and Clean Lakes criteria.

A description of the three levels of involvement follow which summarize farmer participation, acreage treated, total costs, cost share levels, water saved and nutrient reduction benefits.

Level A Farm Participation. All ten model farms were involved in the level A program since this provided the maximum flexibility and cost-share incentive. The full 77 percent participation factor was applied to Level A based on the interviews described above. Model farm plan information, summarized in Table 6-1, indicated that 50 percent of the total irrigated acreage on these farms would be involved and therefore covered by cost-share programs. Costs of the cost-share items totalled $160,760 for the 1242 acres where the BMP's were planned, which averages $129.43 per acre. Applying these cost figures to the 28,000 project area, a cost of $1,646,000 was estimated as the cost share portion for Level A. The total cost for Level A programs would be $4,566,480 assuming 59 percent acreage participation on cooperating farms.

Nitrogen savings averaged 23.7 lbs per acre involved in the cost-share program for the ten farms evaluated; if extended over the project area this would produce 302,186 lbs of nitrogen saved on 12,720 acres at the 77 percent acceptance level assuming 59 percent of participating farm acreage were involved with the BMPs. This acreage assumption is based on model farm evaluations with the farmers involved. Higher acreage participation was projected after the initial years. On a cost per pound of nitrogen saved basis the Level A program is rated at $15.11 per pound. Water savings also are substantial; these are estimated at 6731 acre feet for the 12,720 acres assumed to be initially involved in Level A based on the averages for deep percolation before and after BMP implementation as shown in Table 6-1.

Level B Farm Participation. A similar analysis was performed using the model plans where the extent of cost-share programs was reduced for wheelline conversions to center pivot systems. This resulted in a drop in farmer acceptance from 77 percent to 63 percent over the project area. A slight drop (59% to 56%) in acreage involved in practice changes also occurred based on discussions with the farmers involved in the model plans. Two of the 10 model plan farms would drop out if cost-share rates for wheelline conversions were substantially reduced. The farmers indicated they had no available time for the additional movement of wheellines in order to carry out the desired irrigation water management practices for the cost-share program. Model plans for the eight remaining farms are summarized in Table 6-2. Overall the cost for Level B across the project area would be $2,814,560 and would result in 208,100 lbs of nitrogen saved for a unit cost of $13.52 per lb. Cost share is estimated as $1,140,720. The total area treated would fall to 9880 acres and total water savings from deep percolation are estimated at 5780 acre feet.

Level C Farm Participation. Level C would allow scheduling of wheelline systems without requiring additional wheellines. The benefits of this level of management are less favorable than Level A but result in less costs. The application on farm based on the model plan analysis would be 64 percent of participating farm acreage, slightly higher than on Level A, since wheelline systems generally cover a larger percent of land than center pivots for similar fields. See Summary Table 6-3 for details of Level C. The level of farmer participation is 60 percent. Total estimated costs for the project area are $3,859,970 with 206,438 lbs of nitrogen saved. Cost share levels are estimated as $1,338,950. The cost per pound nitrogen saved is $18.70. The total area treated is 10,752 acres. Water saved from deep percolation totals 5331 acre feet.

LEVEL B

# Table 6-2 Level B Irrigation Control Model Farm Plan Evaluation

| PLAN NO. | PRIORITY NO. | ACRES IRRIG. | ACRES PLANNED | COST-SHARE COST | COST-SHARE COST/A | EXISTING SYSTEM | PLANNED SYSTEM | FERT. MGMT. AFTER | LB. N APPLIED PER ACRE | LB N D.P. EXISTING SYSTEM | LB. N D.P. PLANNED SYSTEM | IN. $H_2O$ D.P. EXISTING SYSTEM | IN. $H_2O$ D.P. PLANNED SYSTEM | TOTAL N SAVINGS AFTER | COST-SHARE COST/LB. SAVED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 337 | 210 | $ 9046. | $ 43. | Wheellines | Renozzle & extra line | Fertigation | 0 lb. | 26 | 8 | 6.0" | 1.0" | 780 lb. | $ 2.39/lb. |
| 2 | 31 | 142 | 111 | $ 18968. | $ 171. | 83 A. furrow<br>28 A. wheelline | Wheelline | Broadcast<br>Split Applic. | 0 lb.<br>111 lb. | 26<br>22 | 8<br>8 | 6.0"<br>11.0" | 1.0"<br>1.0" | 504 lb.<br>1162 lb. | $11.39/lb. |
| 3 | | | | | | | | | | | | | | | |
| 4 | 43 | 264 | 264 | $ 32716 | $ 124. | Wheellines | Wheellines (new mainline) | Fertigation | 180 lb. | 33 | 9 | 6.0" | 1.0" | 6336 lb. | $ 5.16/lb. |
| 5 | 31 | 80 | 50 | $ 11406 | $ 233. | Furrows | Cablegation | Broadcast<br>Split Applic. | 126 lb. | 25 | 5 | 11.0" | 1.0" | 1000 lb. | $11.41/lb. |
| 6 | 36 | 80 | 97 | $ 28748 | $ 296. | Furrows | Center pivot | Fertigation | 153 lb. | 31 | 3 | 11.0" | 0.4" | 2761 lb. | $10.59/lb. |
| 7 | 42 | 75 | 133 | $ 15115 | $ 114. | Furrows | Center pivot | Fertigation | 200 lb. | 40 | 4 | 11.0" | 0.4" | 4788 lb. | $ 5.08/lb. |
| 8 | 37 | 20<br>(378 total) | 20 | $ 4165 | $ 208. | Furrows | Cablegation | Broadcast<br>Split Applic. | 250 lb. | 51 | 10 | 11.0" | 1.0" | 820 lb. | $ 5.63/lb. |
| 9 | | | | | | | | | | | | | | | |
| 10 | 34 | 750 | 98 | $ 22876 | $ 194. | 29 A Furrow<br>69 A Wheellines | Center pivot | Fertigation<br>Fertigation | 262 lb.<br>200 lb. | 40<br>26 | 4<br>4 | 11.0"<br>6.0" | 0.4"<br>0.4" | 1044 lb.<br>1518 lb. | $ 8.93/lb. |
| TOTALS | | 1748 | 983 | $143040 | | | | | | | | 7.82" | 0.80" | 20713 lb.<br>AV. = 21.1#/AC | |

# Table 6-3 Level C Irrigation Control Model Farm Plan Evaluation

| PLAN NO. | PRIORITY NO. | ACRES IRRIG. | ACRES PLANNED | COST-SHARE COST | COST-SHARE COST/A | EXISTING SYSTEM | PLANNED SYSTEM | FERT. MGMT. AFTER | LB. N APPLIED PER ACRE | LB N D.P. EXISTING SYSTEM | LB. N D.P. PLANNED SYSTEM | IN. $H_2O$ D.P. EXISTING SYSTEM | IN. $H_2O$ D.P. PLANNED SYSTEM | TOTAL N SAVINGS AFTER | COST-SHARE COST/LB. SAVED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 37 | 337 | 210 | $ 9046. | $ 43. | Wheellines | Renozzle & extra line | Fertigation | 0 lb. | 26 | 8 | 6.0" | 1.0" | 780 lb. | $ 2.39/lb. |
| 2 | 31 | 142 | 111 | $ 18968. | $ 171. | 83 A. furrow<br>28 A. wheelline | Wheelline | Broadcast Split Applic. | 0 lb.<br>111 lb. | 26<br>22 | 8<br>8 | 6.0"<br>11.0" | 1.0"<br>1.0" | 504 lb.<br>1162 lb. | $11.39/lb. |
| 3 | 34 | 160 | 160 | $ 14560. | $ 91. | Wheellines | Wheelline | Fertigation | 200 lb. | 27 | 12 | 6.0" | 2.0" | 2400 lb. | $ 6.06/lb. |
| 4 | 43 | 264 | 264 | $ 32716 | $ 124. | Wheellines | Wheellines (new mainline) | Fertigation | 180 lb. | 33 | 9 | 6.0" | 1.0" | 6336 lb. | $ 5.16/lb. |
| 5 | 31 | 80 | 50 | $ 11406 | $ 233. | Furrows | Cablegation | Broadcast Split Applic. | 126 lb. | 25 | 5 | 11.0" | 1.0" | 1000 lb. | $11.41/lb. |
| 6 | 36 | 80 | 97 | $ 28748 | $ 296. | Furrows | Center pivot | Fertigation | 153 lb. | 31 | 3 | 11.0" | 0.4" | 2761 lb. | $10.59/lb. |
| 7 | 42 | 75 | 133 | $ 15115 | $ 114. | Furrows | Center pivot | Fertigation | 200 lb. | 40 | 4 | 11.0" | 0.4" | 4788 lb. | $ 5.08/lb. |
| 8 | 37 | 20 (378 total) | 20 | $ 4165 | $ 208. | Furrows | Cablegation | Broadcast Split Applic. | 250 lb. | 51 | 10 | 11.0" | 1.0" | 820 lb. | $ 5.63/lb. |
| 9 | 32 | 213 | 213 | $ 11715 | $ 55. | Wheellines | Wheelline | Broadcast 1x/season | 0 lb. | 26 | 12 | 6.0" | 2.0" | 2982 lb. | $ 3.93/lb. |
| 10 | 34 | 750 | 98 | $ 22876 | $ 194. | 29 A Furrow<br>69 A Wheellines | Center pivot | Fertigation<br>Fertigation | 262 lb.<br>200 lb. | 40<br>26 | 4<br>4 | 11.0"<br>6.0" | 0.4"<br>0.4" | 1044 lb.<br>1518 lb. | $ 8.93/lb. |
| TOTAL | | 2121 | 1356 | $169315 | $12458. | 124. | | | | | | 7.05" | 1.1" | 26095 lb. | Av = 19.2 |

Summary of Irrigation Control Alternatives

Total costs, cost projected acreage treated, and water and nitrogen saved from deep percolation based on the model plans are summarized in Table 6-4. The percent of the total nitrogen lost to deep percolation (692,830 lbs.) as estimated in Chapter 3 is also shown in the table.

Table 6-4: Summary of Initial Irrigation BMPs Based on Model Plan Level Participation on Cooperating Farms

| BMP Application | Total Cost[a] ($) | Cost Share ($) | Acreage Treated[a] | Water Saved (acre-ft.) | Benefit N Saved (lbs) | % of Total N Lost[b] |
|---|---|---|---|---|---|---|
| Level A | 4,566,480 | 1,646,400 | 12,720 | 6,731 | 302,200 | 44 |
| Level B | 2,814,560 | 1,140,720 | 9,880 | 5,780 | 208,100 | 30 |
| Level C | 3,859,970 | 1,338,950 | 10,750 | 5,331 | 206,400 | 30 |

a - Based on extent of acreage participation anticipated in 28,000 acre project area per model plan evaluation

b - Percent nitrogen saved based on total of 692,830 lbs. nitrogen lost to deep percolation in the project area

A larger area would be affected as BMPs are accepted by the farming community. This increased acceptance could occur within the 28,000 project area through increased participation by the area's farmers and through increased acreage participation on the farms that have already indicated their willingness to cooperate in the program. Also, farms outside of the project area would be expected to initiate irrigation water and fertilizer management and irrigation system changes as a result of demonstrations in the project area. These include improvements on existing farms and improved practices on planned future irrigation developments in the watershed, such as the East High Area.

Although greater benefits including substantial nutrient and water saving could be forecast for a larger part of the watershed, these were not quantified because too many assumptions were involved. However, an extrapolation was done for the 28,000 acre project area based on discussion with farmers participating in the model plans. It was found that the farmers were willing to increase the acreage involved with the BMPs to full participation after experience was gained. Thus, for Level A the acreage participation could be increased from 59 percent to 100 percent for the cooperating farms. The increased acreage receiving BMPs and associated increased total costs and benefits are summarized in Table 6-5. The cost effectiveness of each irrigation control approach becomes more attractive with the projected acreage increases; for example, Level A controls are rated at $10.78 per pound of nitrogen as contrasted with $15.11 per pound under the initial program acreage. Incremental costs of extending the BMPs to the larger acreage are relatively low since the higher priority projects described in the initial BMP program involve more structural and mechanical improvements with attendant higher costs. Irrigation and fertilizer management improvements are the main BMP components associated with the added acreage described in Table 6-5.

Table 6-5: Summary of Projected Irrigation BMPs Based on Full Participation on Cooperating Farms

| BMP Application | Total Cost[a] ($) | Acreage Treated[b] | Water Saved (acre-ft.) | Benefit N Saved (lbs) | % of Total N Lost[c] |
|---|---|---|---|---|---|
| Level A | 5,521,200 | 21,560 | 11,409 | 502,170 | 72 |
| Level B | 3,479,840 | 17,640 | 10,319 | 372,200 | 53 |
| Level C | 4,634,100 | 16,800 | 8,330 | 322,060 | 46 |

a - Cost share assumed per Table 6-4 although possibilities may exist for greater cost share involvement.

b - Based on 100 percent acreage participation on farms cooperating at each level as described in text (e.g. Level A 77% cooperating in 28,000 area).

c - Percent nitrogen saved based on total of 692,830 lbs. nitrogen lost to deep percolation in the project area.

Benefits of the irrigation controls described for reducing deep percolation are significant in terms of pounds nitrogen saved. However, phosphorus reduction benefits are not claimed since demonstration project results indicated very little phosphorus migrated into deep percolation. Phosphorus control benefits from agricultural BMPs are claimed for controls affecting surface drainage, runoff from livestock operations, or livestock access to natural waters. Cost-share dollars would be matched with farmers' dollars. The percent each farmer would be spending would vary with the practices he installs.

## Evaluation of Nutrient Control Alternatives

Many water quality control approaches are described in this report. Although all are directed at improving Moses Lake water quality, not all accomplish improvement through nutrient load reduction. See Table 6-6 for a summary of the controls, their approaches and costs.

## Table 6-6: Summary of Control Alternatives

| Control System | Estimated Cost ($) | Control Approach | Nutrient Load |
|---|---|---|---|
| Dilution | N/A[a] | Low nutrient release from USBR East Low Canal | No[a] |
| Irrigation Controls[b] | | Improved irrigation water and fertilizer systems and management | |
| Level A (initial)<br>Level A (projected) | 4,566,480<br>5,521,200 | Level A - Full cost share program<br>Initial 12,720 acres<br>Projected 21,560 acres | Yes |
| Level B (initial)<br>Level B (projected) | 2,814,560<br>3,479,800 | Level B - Restricted cost-share on system conversions<br>Initial 9,880 acres<br>Projected 17,640 acres | Yes |
| Level C (initial)<br>Level C (projected) | 3,859,970<br>4,634,100 | Level C - Restricted cost-share emphasizing scheduling<br>Initial 10,750 acres<br>Projected 16,900 acres | Yes |
| Alder Street Fill | 40,000 | Channel circulation improvements - Upper Parker Horn | No |
| Pelican Horn Crossings | 105,000 | Circulation improvements - Pelican Horn | No |
| Carp Control | N/A[b] | Eradication in Rocky Ford Creek | Yes[c] |
| Dredging | c | Upper Parker Horn deepening for weed control | No[d] |
| Weed Harvesting | d | Limited removal of dense weeds along shore | No[e] |
| Rocky Coulee Wasteway Pumped Irrigation Drainage | 44,400 | Diversion of nutrient-rich water to irrigation canal | Yes |
| Rocky Ford Creek Detention Pond | 74,100 | Trapping of nutrients in pond | Yes |
| Upper Crab Creek Detention Pond | 79,800 | Trapping of nutrients in large pond/marsh system | Yes |
| Lower Crab Creek Detention Pond | 29,600 | Trapping of nutrients in pond | Yes |
| Rocky Coulee Tributary Detention | 5,000 | Detention below dairy & hatchery | Yes |
| Westside Feed Lot Containment | 10,000 | Containment of animal wastes | Yes |
| Miscellaneous Livestock Controls | 30,000 | Control of cattle access to lake and tributaries | Yes |
| Septic Tank Controls | 8,650,000[f] | Connection of urban areas to sewer | Yes |

[a] - Dilution water is provided by the U. S. Bureau of Reclamation at no cost during years when it is feasible to use Moses Lake as a feed route to Potholes Reservoir. Nutrient concentrations in Moses Lake are lowered by dilution although nutrient loading to the lake is increased.

[b] - Costs shown are initial total costs including both government cost-share and farmer share based on Model Plan level participation per Table 6-4.

[c] - Carp would be eradicated by the Department of Game; carp disturb bottom sediments and vegetation causing resuspension and recycling of nutrients.

[d] - Dredging would help control weed growths primarily by reducing available light to submerged plants which grow from the lake bottom; estimated costs range from $50,000 to $850,000 depending on the extent of dredging.

[e] - Aquatic weed harvesting would remove some plant material from the lake; costs for two harvests per year are estimated at $22,000 annually assuming a harvester is purchased.

[f] - Septic tank control cost based on sewering assumptions described in Chapter 5; septic tank policy development cost is $5,000 of staff time

Control alternatives that involve nutrient load reduction were evaluated to determine cost-effectiveness for both nitrogen and phosphorus reduction. These control alternatives are identified on Table 6-2. The controls affecting nutrient load from the watershed include all of the irrigation practice controls, diversions of irrigation drainage, livestock waste controls, detention ponds for trapping nutrients and septic tank elimination in urbanized areas near the lake or tributaries. Effects of carp eradication in Rocky Ford Creek was also included; this approach is integrated into the Rocky Ford Creek detention pond alternative. Table 6-7 summarizes the results of the cost-effectiveness evaluation.

Table 6-7: Summary of Cost-Effectiveness Evaluation of Watershed Nutrient Controls

| Control System | Total Project Cost[a] | Nutrient Reduction Nitrogen lbs. | Nutrient Reduction Phosphorus lbs. | Cost Effectiveness $/lb N | Cost Effectiveness $/lb P |
|---|---|---|---|---|---|
| Irrigation Controls | | | | | |
| Level A (initial) | 4,566,480 | 302,186 | N/A | 15.11 | N/A |
| Level A (projected) | 5,521,200 | 502,169 | | 10.78 | |
| Level B (initial) | 2,814,560 | 208,100 | N/A | 13.52 | N/A |
| Level B (projected) | 3,479,840 | 372,200 | | 9.34 | |
| Level C (initial) | 3,859,970 | 206,438 | N/A | 18.70 | N/A |
| Level C (projected) | 4,634,100 | 322,560 | | 14.56 | |
| Rocky Coulee Drainage | 44,400 | 2,094 | 167 | 21.20 | 265.87 |
| Detention Ponds | | | | | |
| Rocky Ford Creek | 74,100 | 27,738[a] | 10,807[b] | 2.67 | 6.86 |
| Upper Crab Creek | 79,800 | 676 | 73 | 118.05 | 1,093.31 |
| Lower Crab Creek | 29,600 | 6,204 | 1,825 | 4.77 | 16.22 |
| Rocky Coulee Tributary | 5,000 | 405 | 278 | 12.35 | 17.99 |
| Westside Feedlot Containment | 10,000 | 691 | 581 | 14.47 | 17.21 |
| Miscellaneous Livestock Controls | 30,000 | 6,000 | 2,000 | 5.00 | 15.00 |
| Septic Tank Controls | 8,650,000 | 22,800 | 8,700 | 379.38 | 994.25 |

a - Total Project Cost includes engineering design and construction.

b - Based on 37.5% trapping efficiency for phosphorus and 8.4 percent for nitrogen for combined effect of detention pond and carp control.

Watershed nutrient controls were ranked in terms of their effectiveness in reducing nitrogen and phosphorus loads. The five most cost-effective approaches are listed below for each of the nutrients of concern.

| Ranking | Nitrogen Control | Phosphorus Control |
|---|---|---|
| 1 | Rocky Ford Creek Detention | Rocky Ford Creek Detention |
| 2 | Miscellaneous Livestock Control | Miscellaneous Livestock Control |
| 3 | Lower Crab Creek Detention | Lower Crab Creek Detention |
| 4 | Level B Irrigation Control | Westside Feedlot Controls |
| 5 | Level A Irrigation Control | Rocky Coulee Tributary Detention |

There was a clear division among phosphorus control approaches after the first five with the unit cost per pound of phosphorus rising from $17.99 for the 5th ranked Rocky Coulee Tributary Detention Pond to over $200 per pound for the 6th ranked Rocky Coulee Pumped Irrigation Drainage alternative. Nitrogen control rankings did not reach a clear break point until the 10th ranked alternative (Upper Crab Creek Detention) passed the $100 per pound level. None of the irrigation control alternatives (Level A, B or C) were rated for phosphorus control, but would have far exceeded $100 per pound if this calculation had been performed. The 4th and 5th ranked Westside Feedlot Control and Rocky Coulee Tributary Detention each had reasonable unit cost for nitrogen control at $12.35 and $14.47 respectively.

On a watershed loading basis, the most impact is accomplished by Level B irrigation for nitrogen and by Rocky Ford Creek detention and related carp eradication for phosphorus. Septic tank controls are a close second for phosphorus, but the cost of sewering places this approach low on the ranking scale if nutrient controls alone are used for justification.

Other water quality control approaches are identified that do not reduce nutrient loading from the watershed but nevertheless impact water quality. These are discussed in some detail in Chapter 5. By far the most important of these other approaches is dilution water release from the East Low Canal and subsequent dilution release to Parker and Pelican Horn as described in Chapter 2. The other approaches (dredging, weed harvesting, alterations of causeways) are ways of abating symptoms of nuisance conditions with less emphasis on prevention. Dredging could be viewed as a prevention approach if widespread deepening is accomplished in Upper Parker Horn; however, costs are excessive ($650,000 - $850,000) and well programmed dilution releases can be used to control light penetration at much less cost.

Accordingly, the controls selected for more quantitative evaluation are the high ranked watershed controls and dilution release from the East Low Canal. See Figure 6-2. These high priority controls were evaluated using a water quality model of

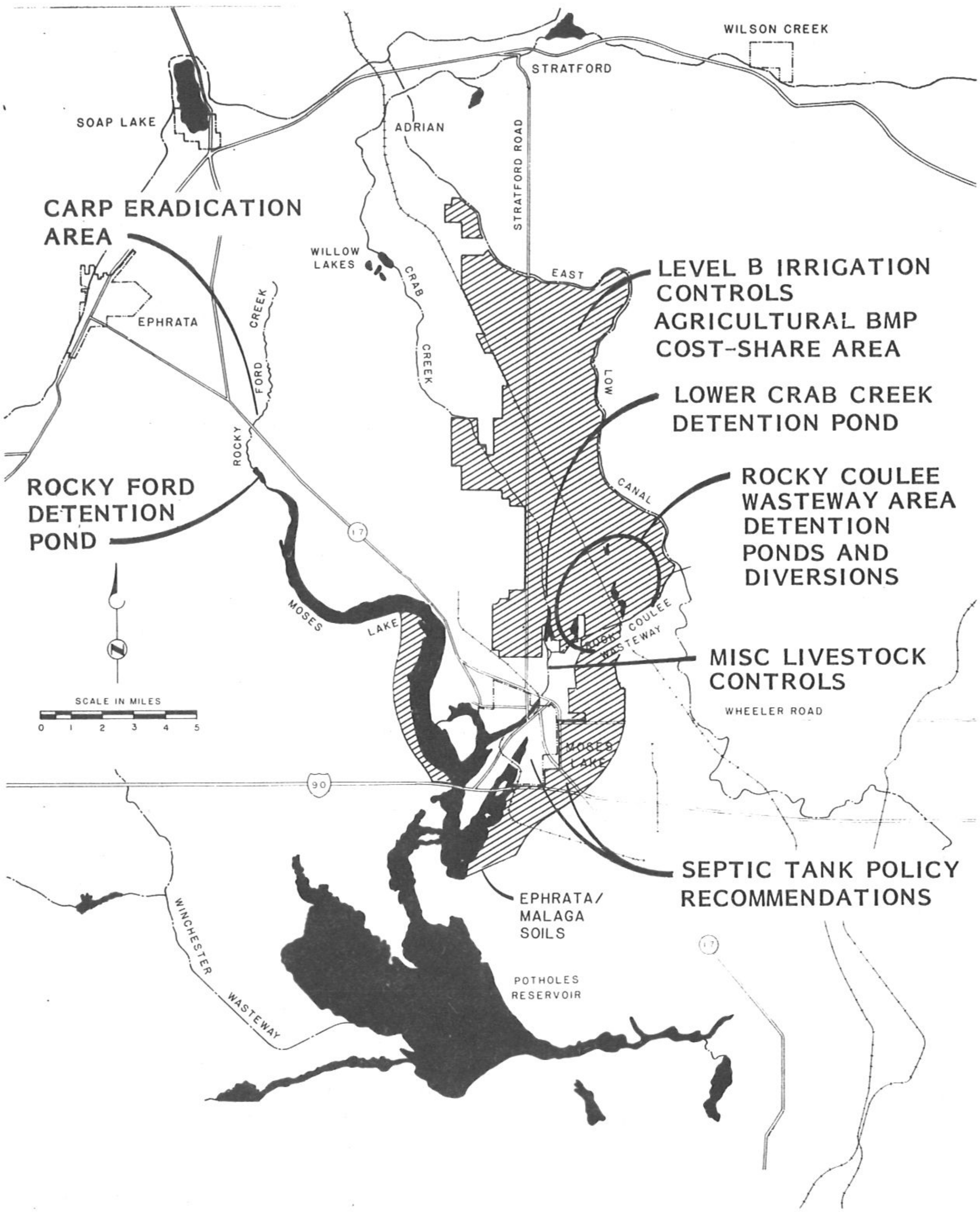



Fig. 6-2 High Priority Watershed Nutrient Controls

Moses Lake.

Moses Lake Water Quality Model

The Moses Lake water quality model considers effects of inputs from the lake's major tributaries (Rocky Ford and Crab Creek), from groundwater, and dilution water releases. Nutrient inputs (represented by the limiting nutrient nitrate-nitrogen) are translated to algal biomass (chlorophyll) in the model based on a time series allowing variation of inputs over the period April through September.

The model, known as the Moses Lake Management Model, was developed as part of a masters thesis by University of Washington graduate student Sally Marquis working under guidance of Civil Engineering Department professors Eugene Welch and Brian Mar. The model considers effects of horizontal and vertical mixing in different basins of the lake including wind effects on recycling. Predictions of algal growth (biomass and algal groups) are produced every two weeks based on relationships of algal growth rate, nitrate-nitrogen concentration and biomass as described by the Michaelis-Minton equation. See Appendix for additional descriptions of the Moses Lake Management Model.

Three scenarios were modeled to assess the effectiveness of watershed nutrient controls as related to dilution releases from the East Low Canal. These scenarios were:

1. No dilution water release with comparison of existing and modified watershed nutrient loads based on initial and projected Level B irrigation controls, the high priority detention ponds and livestock controls. No dilution water is available during some years (e.g. 1984).

2. Dilution provided as a gradual release of $5.7M^3$/sec (201 cfs) over the period April through September with and without high priority watershed controls described in Scenario 1. The gradual release scenario most closely approximates the recommended dilution release schedule based on past University of Washington research.

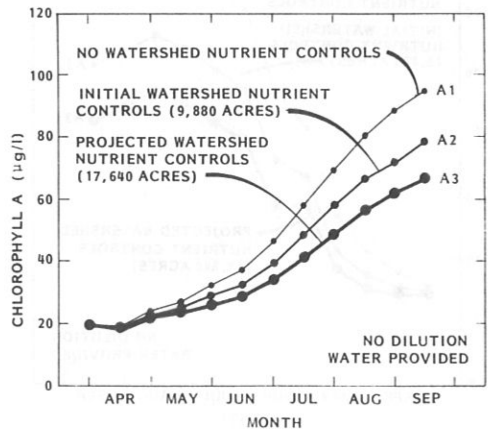
3. Dilution provided as a slug release of $30M^3$/sec (1059 cfs) during April-May with and without high priority watershed controls described in Scenario 1. The slug release scenario is similar to releases made during the recent past.

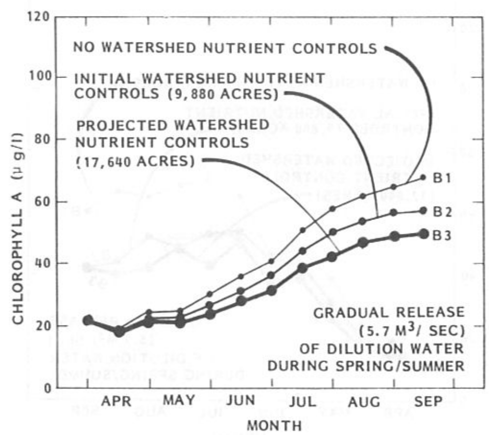
Algal concentrations were calculated for middle and lower Parker Horn at two week intervals over the period April through mid September. Rocky Ford and Crab Creek flows and concentrations were based on field measurements from Stage 1 and previous monitoring; groundwater flows were based on evaluations as described in Chapter 4. Without watershed controls, groundwater nitrate nitrogen concentrations were assumed as 3.0 mg/l based on Stage 1 monitoring results considering wells and springs in the areas sampled nearest Moses Lake. Control scenarios included a reduction of nitrogen levels in ground and surface water based on the amount of nitrogen reduction achieved. See the Appendix on model descriptions. A range of other assumptions of nutrient input from ground and surface waters were also tested to determine model sensitivity. Effects of watershed controls on nitrogen loading are based on reductions described in Table 6-7. Clearly the greatest effect of watershed control is provided by the irrigation BMP's since these have the greatest effect on nitrate levels. The scenarios and their resulting lake water quality are described below:

A. No Dilution Scenarios. Algal growth resulting from the no dilution comparisons for lower Moses Lake are shown in Figure 6-3. These are represented by three curves: A1, No Watershed Controls; A2, Initial Watershed Controls for 9,880 Acres; and A3, Projected Watershed Controls over 17,640 Acres. As shown in the Figure, summer chlorophyll values generally ranged from 60 to 100 ug/l during the summer period without watershed controls and in the 40 to 75 ug/l with these controls. The difference between no control and control increases with time and is in the 15-20 ug/l range in July for the initial level of watershed control and in the 25-30 ug/l for the higher projected control level. These mid summer values are equivalent to chlorophyll reductions of about 30 percent. By late summer the chlorophyll reductions have reached 30 ug/l. Similar trends were observed in Lower Parker Horn; see Figure 6-4.

B. Gradual Dilution Scenario. The same three levels of watershed control were run in the B series with dilution releases averaging 5.7 cubic meters per second over the evaluation period April through September. Resulting algal growth in Lower Lake with and without watershed nutrient controls are also described in Figure 6-3. Algal growth was suppressed by this dilution only scenario (B1) with concentrations in lower Parker Horn ranging from 40 to 75 ug/l by mid summer. (The mean summer value was 46 ug/l.) Comparisons of watershed controls to existing controls with dilution show about 10 to 20 ug/l difference during July. Watershed controls were approximately 20 to 30 percent lower than the no control case during mid summer. Level B3 control actually held chlorophyll below 50 ug/l through the recreation season. Model results for Lower Parker Horn are similar, see Figure 6-4.

C. Slug Dilution Scenario. Release of 30 cubic meters per second over the April-May period maintained chlorophyll below 50 ug/l through June for both the control and no watershed control cases. By July Lower Lake chlorophyll levels had reached 60 ug without watershed controls but were 10 to 20 ug/l lower with controls for reductions of 20 to 35 percent. Lower Lake chlorophylls increased to nearly 85 ug/l in September for the no control case and to 60-70 ug/l for the watershed control cases. See Figure 6-3. Parker Horn values were substantially higher by mid summer after dilution water had ceased. See Figure 6-4.



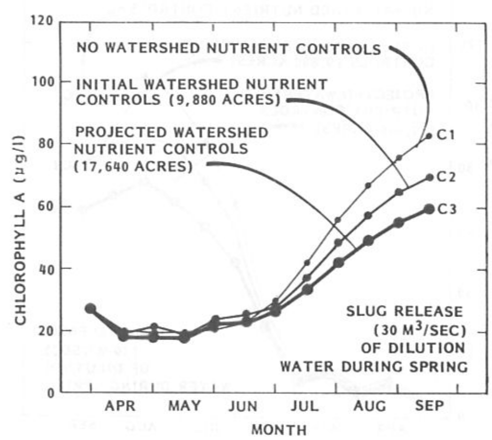




Fig. 6-3 Predicted Chlorophyll Levels - Lower Lake

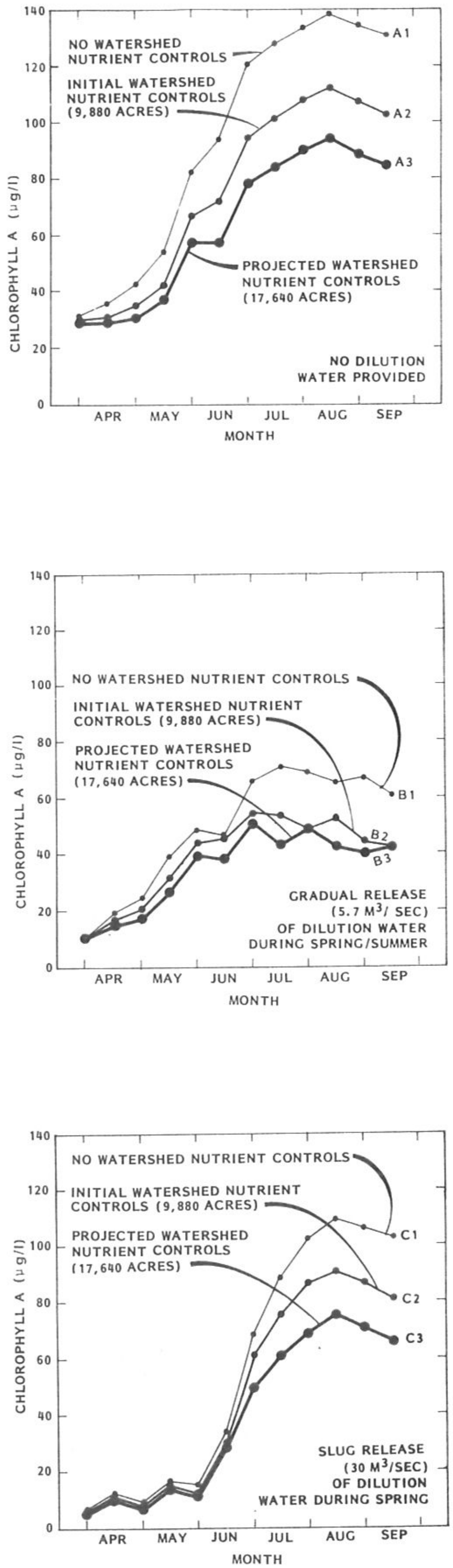



Fig. 6-4 Predicted Chlorophyll Levels - Lower Parker Horn

## Evaluation of Model Results

Model runs described in Figures 6-3 and 6-4 represent average conditions based on Rocky Ford Creek and Crab Creek nutrient concentrations and flows. Crab Creek nutrient concentrations were compared over the period 1977 through 1983, and significant fluctuations were noted. Average nitrate nitrogen values at the USGS gage site used by the University of Washington ranged from 0.53 mg/l to 1.50 mg/l for the March-September period. The average for the six years available was 0.90 mg/l $NO_3N$ which was most nearly matched by 1983. The highest average nitrogen values occurred in 1979 and 1980 which happen to coincide with years of higher fertilizer use based on cropping pattern evaluations performed by the Clean Lakes Project staff. See Figure 6-5. Similarly the lowest average nitrogen concentration coincided with the lowest fertilizer years (1977 and 1978).

Because nutrient input assumptions for Crab Creek and groundwater have a major effect on chlorophyll calculations in the model, a range of inputs was evaluated to see how the chlorophyll responses varied. These served as a sensitivity check for the model and gave further insight in interpreting results. Seven separate series of computer model runs were performed for all three dilution scenarios with varied nutrient input assumptions and watershed control effects and two different levels of initial chlorophyll in the lake.

For example, all seven series of model runs showed that slug releases of dilution water caused lower chlorophyll in the early summer than occurred in gradual release scenarios, and conversely, all runs showed lower chlorophyll occurred in late summer as a result of gradual releases. The effects of slug releases are eventually diminished by mid summer regardless of the level of nutrient assumed in Crab Creek. Similar chlorophyll patterns were observed with the watershed control scenarios. These results confirm recommendations of Dr. Eugene Welch of the University of Washington regarding the benefits of gradual release over the entire recreational season.

The watershed control scenarios were also consistent as regards the benefits of nitrogen controls in the watershed, regardless of dilution release. The magnitude of the benefit varied in terms of chlorophyll concentration reductions, but was reasonably constant when expressed as a percentage reduction. For example, for September conditions in Lower Lake the no dilution cases with high nitrogen concentrations in Crab Creek showed a 27.5 percent chlorophyll drop from watershed controls compared with a 28.7 percent drop for the gradual dilution release case. The low nitrogen comparison for Crab Creek inputs resulted in a 15.6 percent chlorophyll drop for the no dilution case versus 13.0 percent for the gradual release case. Intermediate values were found for the average Crab Creek nitrogen runs and these runs were selected for use in further evaluation of benefits to Moses Lake. As indicated earlier, this average

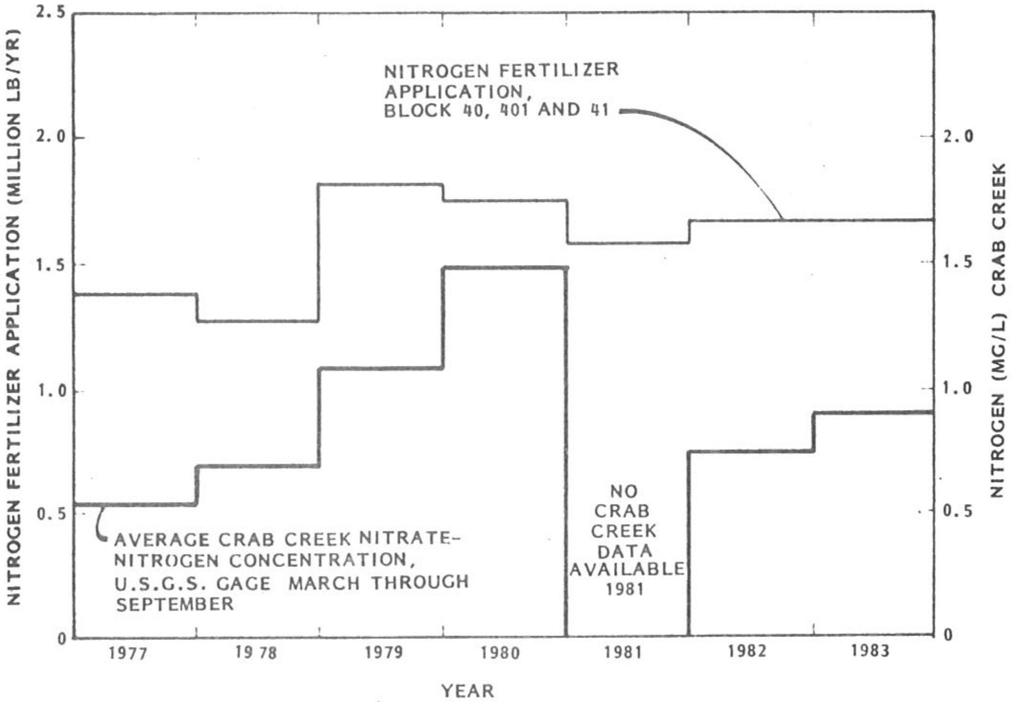



Fig. 6-5 Comparison of Fertilizer Applications and Crab Creek Nitrate Values

Agricultural Drainage Discharges into Rocky Coulee Wasteway condition also was approximated in 1983, the year the Stage 1 project monitoring took place.

Additional observations concerning the model results and Moses Lake water quality were provided by Dr. Eugene Welch of the University of Washington Department of Civil Engineering. Dr. Welch has conducted extensive research on Moses Lake over the past decade. His observations on the model results and blue green algae in the lake are summarized below.

Based on field observations, the model tends to over estimate the May to September mean and maximum chlorophyll concentrations. For example, the model predicts that the mean chlorophyll in Lower Lake would decrease from 57 to 44 ug/l with high input spring dilution, a 23% decrease. In fact, the 1977 - 1979 field results which involved large slug releases in spring show the mean decreased to 21 ug/l from the pre dilution years (1969-70) when the mean was 42 ug/l, or a 50% decrease. While the main driving force for algal production in the lake is nitrogen in the inflow, there are apparently other limitations to biomass accumulation in the lake than those considered in the model. This suggests that actual improvements from the various scenarios will probably exceed the model predictions.

Aside from the actual values predicted, the model can also be used to judge the relative merit of the scenarios. Watershed controls on nitrogen would improve the lake quality slightly more than the spring dilution scenario; 44 versus 41 ug/l for the May-September mean and 82 versus 67 ug/l for the maximum values predicted. Of course, dilution plus watershed controls would provide the greatest improvement because both decrease nitrogen in the inflow to the lake. Also, the continuous dilution scenario (B) does not appear to achieve much better improvements than spring only dilution (C) based on the summer mean, however, the maximum is considerably more reduced--82 versus 68 ug/l.

What do these values mean in terms of lake quality? The actual decrease in chlorophyll content in the lake, as a result of dilution, has doubled the average transparency during the summer. A mean chlorophyll of 20 $ug/l^{-1}$ appears to be a practical and reasonable goal for Moses Lake. In spite of the actual values predicted by the model, its prediction of the relative effect of watershed controls suggests that without dilution, watershed controls may achieve at least what dilution achieved, and with dilution the potential for improvement is even greater. In reality, watershed controls will reduce the amount of dilution water required to achieve a given level of control on cholorphyll. With watershed controls, it will be necessary to verify the model predictions by monitoring the lake and that will allow improved estimates of the appropriate dilution water inputs to achieve desired water clarity without providing excessive light stimulation to rooted macrophytes.

There are other improvements to be expected from watershed controls besides lower chlorophyll and resulting transparency improvements, for example, quality of the fishery and quality of the algae may be improved. The blooms that occur during the summer in Moses Lake are nearly 100% blue greens, primarily Aphanizomenon and to a lesser extent Microcystis. These algae form scums on the surface following several days of relatively windless days. Scums have not been as prevalent during the dilution years as during the years before dilution. Furthermore, they are usually delayed until August if dilution extends into June, whereas before they began to appear in June. The extent of the scum layer is probably a function of the algal productivity, which is in turn driven by the input of nutrients. Decreased nutrient input to eutrophic lakes that sustain large blue green blooms with the associated scums, has repeatedly led to a reduced importance of blue greens, an increased importance of diatoms and greens, and less scum problems, although the latter has not been quantified. This happened in Moses Lake; the percentage of blue greens dropped from 100 to 55 on the average during the summer even though blooms themselves still are primarily blue greens.

An explanation of the mechanism that drives blue green dominance is as follows: increased nutrients (N and P) input increases productivity, which in turn extracts $CO_2$, raising the pH and further decreasing the $CO_2$ content. That restricts photosynthesis by blue greens causing their vacuoles (unique to blue greens) to expand, allowing them to rise to the surface where $CO_2$ is more available from the atmosphere. This produces the scum formation seen during midday and late afternoon. It obviously provides blue greens with three advantages during windless (no mixing) periods; 1) greater nutrient availability, 2) resistence to sinking loss which is the fate of other algae and 3) greater light availability to themselves while shading other algae below. It is reasonable to expect that by decreasing N and/or P (depending on which is most limiting) the demands on $CO_2$ would lessen, and the advantage shift to blue greens would also lessen. Thus, while the model does not include this mechanism, one can nevertheless expect to see continued improvement in the quality of algae as the nutrient input is decreased.

Another cause for improvement which is not reflected in the model results relates to nutrient limitations. Nitrogen is currently limiting in Moses Lake because phosophorus is relatively plentiful in the inflow. If watershed controls reduce phosphorus relatively more than nitrogen, phosphorus may become limiting, and greater than expected improvements in lake quality may result.

## Summary of Water Quality Impacts

A summary of water quality impacts associated with nutrient and dilution controls is provided below. These conclusions are primarily based on model results with the understanding that these results are probably conservative since the model appears to predict higher chlorophyll values than seen in the field. A graphical summary of results from Lower Moses Lake is provided on Fig. 6-6. The text below describes observations as related to this same location in Moses Lake.

1. Without dilution water release, chlorophyll concentrations are reduced by approximately 17 percent throughout the summer recreation season (July-September) for the initial level of irrigation control in the 28,000 acre project area.

2. Without dilution water release, chlorophyll concentrations are reduced by approximately 30 percent throughout the summer recreation season for the projected level of watershed controls in the project area.

3. With gradual dilution water release (5.7 $M^3$/sec), the chlorophyll concentrations are reduced by 21 percent as an average over the summer recreation season.

4. The combination of initial watershed controls and gradual dilution flows results in a total chlorophyll reduction of 23 to 39 percent during the summer recreation season.

5. The combination of projected watershed controls and recommended dilution flows results in a total chlorophyll reduction of 33 to 47 percent.

6. Without dilution, watershed controls delay the occurrence of specific chlorophyll concentrations approximately four weeks in summer; for example, late August values with projected watershed controls are equivalent to those reached in early July without controls.

7. The combination of dilution release and watershed controls had a more dramatic effect on the lag in chlorophyll concentration and maintained average summer chlorophyll below late spring values without these controls.

8. Favorable shifts in algae population characteristics from less nuisance blue greens to more diatoms have occurred with dilution controls. Watershed controls are expected to produce this same favorable effect and reduce the level of nuisance in the lake.

Benefit Evaluation

Project related benefits include water quality improvements, savings in farming costs and increased crop yields. These benefits can be expressed in monetary terms. Water quality benefits are difficult to quantify whereas farm related benefits can be projected based on demonstration results and farmer participation levels.

Water quality benefits were estimated using two very different approaches in order to test the reasonableness of the

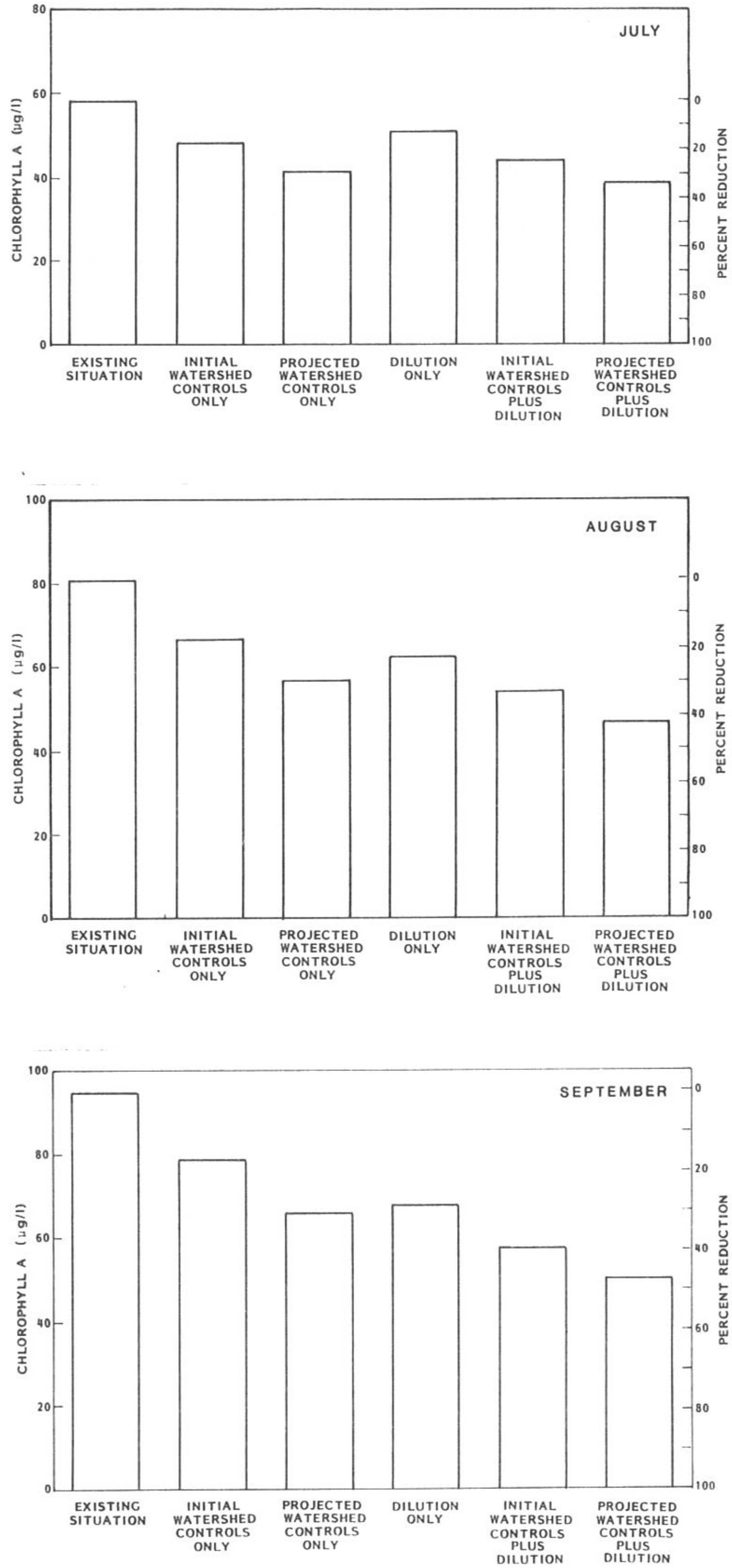



Fig. 6-6 Comparison of Watershed Nutrient Controls and Gradual Dilution Release Impacts on Water Quality in Lower Moses Lake

resulting figures. The first method involved comparison with the proven dilution technique to determine the cost of additional dilution water to achieve a projected level of chlorophyll achieved with watershed controls plus dilution. The second approach considered projected chlorophyll levels in the lake as related to recreational use and the value associated with such use.

<u>Dilution Water Equivalency Evaluation</u>. Additional model runs were performed to assess the equivalency of dilution water with watershed controls. Computer runs were made with increased dilution release rates in an attempt to match chlorophyll values achieved with watershed controls under the gradual release scenario. An example of resulting equivalent dilution rates and seasonal water volumes is summarized in Table 6-8 for a control scenario similar to that proposed for implementation.

Table 6-8: Annual Dilution Water Volume Equivalency for Initial and Projected Watershed Controls

| | Dilution Water Release Rate[a] | Dilution Water Volume April-September | |
|---|---|---|---|
| | (M /sec) | M | (acre ft) |
| Initial Watershed Control | 7.70 | 29,044,000 | 23,500 |
| Projected Watershed Control | 10.26 | 66,173,000 | 53,600 |

a - Water volumes reflect additional dilution water required to match chlorophyll levels achieved with watershed controls under the gradual dilution water release scenario (5.7 M /sec).

The volumes of dilution water have a value. There has been no charge to the Moses Lake Irrigation and Rehabilitation District for dilution water routed through Moses Lake because this water has been conveyed through the lake to feed Pot Holes Reservoir consistent with irrigation operations. Moses Lake serves as an alternate feed route for this water. However, the volume and scheduling of dilution water releases is dictated by irrigation purposes of the U.S. Bureau of Reclamation Columbia Basin Project. Water quality control is not an authorized purpose of the USBR Project; however, cooperative efforts have been made whenever compatible irrigation releases were possible. As a result, major dilution water releases (100 million $M^3$) have been provided in most years since 1977 and not in others (e.g. 1984). The actual dilution release schedule has limited most of these releases to the spring and early summer periods. At present, the U.S. Bureau of Reclamation charges $10 per acre-foot for water supplied to municipalities or industry. If municipal water cost alone was used as a measure of value to the water quality of Moses Lake, then the water equivalency for watershed controls would indicate these controls are worth from $235,000 to $536,000 per year.

Recreational Benefit Evaluation. An alternative method of assessing water quality benefits to Moses Lake was considered which is linked to water use. As water quality varies, the range of social acceptance, expressed as recreational use, is great. The reaction of the public to water quality suggests a relationship between certain physical parameters, such as temperature, clarity, color, etc., and intensity of recreational use. Many of the physical conditions affecting the average recreationist are actually created by chemical and/or biological mechanisms. The turbidity, slimes and odors produced by algal populations are but one example.

A graphical relationship was used to relate relative recreation use to the extent of enrichment in Moses Lake. This graph is based on a similar analysis used to assess benefits of dilution in Clear Lake, California, a shallow eutrophic lake with similar water quality problems. The curve shown in Figure 6-7 attempts to relate the range of water quality conditions found in lakes to public reaction to those conditions, assuming recreation alternatives exist. The relationship presented in Figure 6-7 represents the combined judgement of a number of federal water quality specialists having broad experience in eutrophic lake problems as well as the human reactions involved in recreation activities. This appraisal was originally published in a 1969 evaluation of the USBR English Ridge Project by the Federal Water Pollution Control Administration, predecessor to the US EPA.[a] Moses Lake and Clear Lake are very similar water bodies. It is included here as the best available basis upon which to estimate recreation use as affected by water quality changes anticipated in Moses Lake under alternative quality control plans.

Following the rule curve, there is virtually no impairment of water use potential for chlorophyll values below about 25 ug/l. Significant impairment for all water oriented uses was assumed when chlorophyll passed the 100 ug/l level. Intermediate levels typical of those encountered in Moses Lake can be determined from the curve. For example, the curves show from 25 to 50 percent impairment of water dependent uses at the 50 ug/l level.

Recreational Use. Annual recreational uses of Moses Lake were estimated using statistics supplied by the State Department of Game in Ephrata, the Moses Lake State Park, and the MLIRD. According to Game Department statistics, fishing uses account for 124,400 use days per year. Most of this use is related to boat

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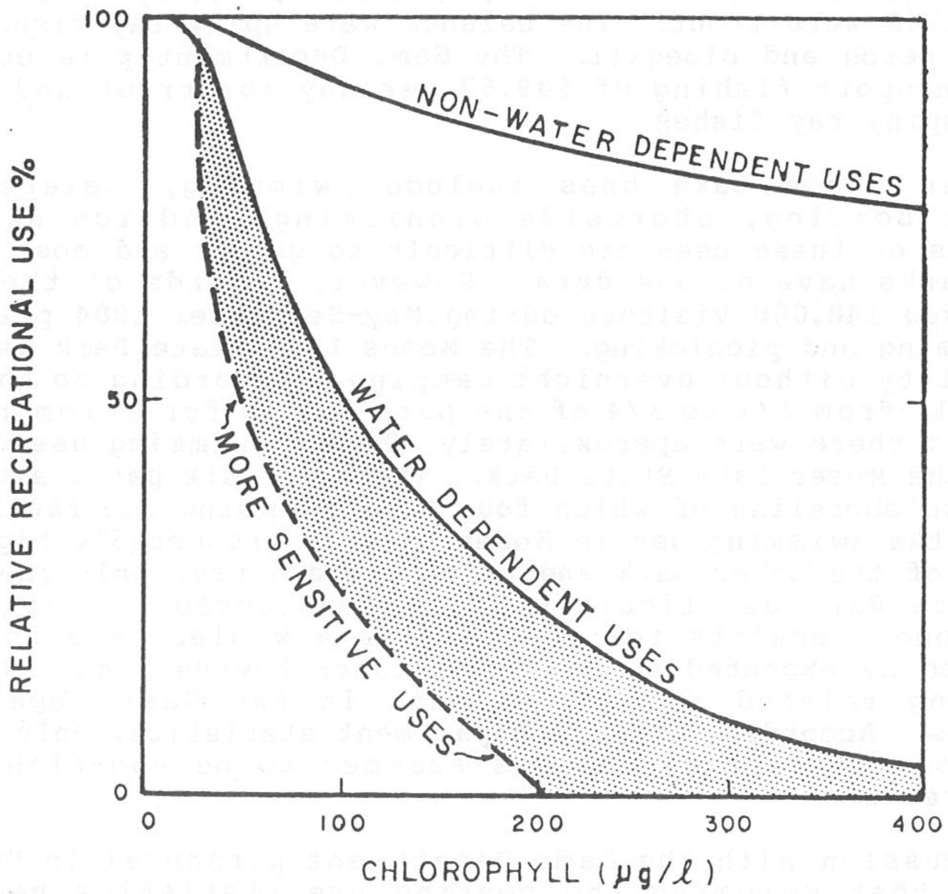
[a]Federal Water Pollution Control Administration, English Ridge Project Water Quality Control Study, Pacific Southwest Region, August 1969.




NOTE!

1) Above curves compare water dependent recreational use (swimming, water skiing etc.) and non water dependent uses (camping, sight-seeing etc.) to levels of eutrophication

Fig. 6-7 Water Quality - Recreational Use Relationship fishing. In 1983 there were 169,269 fish caught by sportsmen of which 35,766 were trout. The balance were spiny ray fishes such as bass, perch and bluegill. The Game Department puts economic values on sport fishing of $39.67 per day for trout and $24.70 for the spiny ray fishes.

Other Moses Lake uses include swimming, waterskiing, pleasure boating, shoreside picnicking, and ice skating. Statistics on these uses are difficult to gather and most of the area's parks have no use data. However, records of the State Park showed 148,000 visitors during May-September 1984 primarily for swimming and picnicking. The Moses Lake State Park is a day use facility without overnight camping. According to the park personnel, from 2/3 to 3/4 of the park use is for swimming. On this basis there were approximately 100,000 swimming use days in 1984 at the Moses Lake State Park. There are six parks along the Moses Lake shoreline of which four have swimming use facilities. Although the swimming use in Moses Lake is undoubtedly higher as a result of the other park and private beach use, only the Moses Lake State Park use figure will be considered in evaluating recreational benefits for the lake as a whole. Boating uses would also be expected to be significant; however, most boating is fishing related and is included in the Game Department statistics. According to Game Department statistics, only twelve percent of the boating use was assumed to be non-fishing or hunting related.

Discussion with the Game Department personnel in Ephrata revealed that swimming and boating use statistics had been gathered as part of a fishing and hunting survey of the lake. These statistics indicated swimming use was 6.7 percent of the total recreation use on the lake. In contrast, shore and boat fishing accounted for about 79 percent of the total. On this basis, swimming use would account for only about 10,000 visitor days or 10 percent of the State Park figures. Pleasure boating would account for about 13,000 visitor additional days. The Game Department estimates were made using aerial surveys at a time when some beaches were closed due to excessive bacterial counts.[a]

Other parks were contacted to determine if use statistics were available. The City of Moses Lake Parks and Recreation Department had no data of this kind. Airmans Beach Park on the Main Arm operated by the MLIRD had visitor statistics for 1984 based on overnight and day visitors totalling 17,400 for the May-September period. The District estimates 25 percent of these people swim at the park which would yield a total of about 4,350 swimmer use days in 1985. Swimming also occurs at Cascade Park on Lewis Horn and Montlake Park on Pelican Horn.

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[a]Steve Johnson, Washington State Department of Game, Ephrata, personal communication.

Swimming, waterskiing, and other pleasure boating were considered to be the most water quality dependent uses. Fishing, hunting and shoreside activities were not considered water quality dependent, although aesthetic conditions of the lake are certainly important in the visible areas such as the Alder Street Fill. For purposes of benefit calculations a reasonable estimate total water dependent use was felt to be in the 50,000 to 100,000 visitor days, range and a median figure of 75,000 visitor days was selected for the benefit calculation.

Recreational Values. Recreational use is difficult to value. The Tourist Bureau uses general recreation values of $35-40 per day, but these statistics are more oriented to the mode of tourist transportation than to specific recreation uses. The Interagency Committee which deals with outdoor recreation uses average figures of $15-20 per day based on typical tourist expenditures.[a] The Federal Water Resources Council has published procedures for evaluating water resource projects; their most recent report includes a point system for rating uses by category and environmental quality.[b] These values for general recreation such as swimming or boating would fall in the $3.40-3.70 per day range for Moses Lake depending on water quality conditions.

Using the water dependent use estimate, water quality impairment was computed from the rule curve based on average summer chlorophyll values for Parker Horn and Lower Lake of 100 ug/l without controls and 65 ug/l with watershed nutrient controls alone. The resulting analysis resulted in an average benefit of slightly more than $200,000 per year using the more conservative recreational values recommended in Federal Principles and Guidelines published for use in evaluating water resource projects. If IAC values are used, the benefit would exceed $1 million per year. The average of the Federal Water Resources Council guildeline and the IAC value was selected as a more reasonable figure to represent the high side of the range; this yielded a benefit of $550,000 per year. Water quality benefits estimated based on uses appear to compare well with those developed using dilution water equivalency. Accordingly, it appears reasonable to claim water quality benefits for water shed nutrient controls in the $250,000 to 500,000 per year range. The combination of dilution with watershed controls yields lower chlorophyll values and therefore enhances the benefits.

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[a]Mr. Pelton, IAC, personal communication.

[b]U.S. Water Resources Council, Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies, March 1983.

## Farm Related Benefits

Other benefits of watershed control include nitrogen fertilizer and irrigation water saved by the suggested irrigation practice changes and increased crop yields as described in Chapter 3. Fertilizer benefits were assessed using a value of 25 cents per pound for nitrogen. On this basis, the Level B irrigation controls would be worth approximately $52,000 - 93,000 per year. Savings associated with irrigation water would include the water cost as well as associated labor and other irrigation operational costs which were valued at from $5 to $10 per acre foot for a water savings depending on the irrigation water management practice used. See Appendix for additional details. Using a median value of $7.50 per acre foot of irrigation water saved, the watershed controls account for $43,200 to $77,400 per year. Increased crop yields from irrigation water and fertilizer management are generally projected to be 10 to 20 percent based on SCS experience. Yield increases will vary with crop. Demonstration results described in Chapter 3 showed typical yields in the $40-50 range. Using a figure of $45/acre for the acreages involved, the range in annual crop yield benefits are computed to be from $444,600 to $793,800. Table 6-9 summarizes these estimated farm related watershed control benefits.

Table 6-9: Monetary Benefits of Watershed Controls to the Moses Lake Area Farms

| | ($/year) | |
|---|---|---|
| | Initial Watershed Controls | Projected Watershed Controls |
| Fertilizer | $ 52,000 | $ 93,000 |
| Irrigation | 43,200 | 77,400 |
| Crop Yield | 444,600 | 793,800 |
| Totals | $ 539,800 | $ 964,200 |

## Summary of Benefit Estimates

Moses Lake water quality improvements estimated from watershed nutrient controls alone are in the $250,000 to $500,000 per year range. Higher benefits can be claimed when dilution waters are available since the combination of controls further enhances the lake's water quality. Farm related benefits are in the range of $540,000 to $960,000 per year based on savings in fertilizer and irrigation water and increased crop yields. The combination of all estimated project-related benefits is in the $750,000 to $1,500,000 per year range. The significance of the benefits to the lake and the area's farming economy was a major factor in the recommendations to implement the high priority watershed nutrient controls in Stage 3 of the Moses Lake Clean Lake Project.

# CHAPTER 7

## STAGE 3 PROGRAMS AND IMPLEMENTATION

High priority nutrient controls identified in Chapter 6 form the core of the Stage 3 Clean Lake program. These controls emphasize watershed controls affecting irrigation and livestock nutrient sources, detention ponds to trap nutrients and sediments and drainage diversions. In addition, a septic tank policy will be developed which emphasizes approaches to reduce nutrient input to the lake; this policy will be presented to the City of Moses Lake and Grant County for consideration in ordinance development.

A major element in the implementation is a cost-share program which will allow farmers in the project area to receive significant financial support for technical assistance and irrigation or livestock facilities improvements which will reduce nutrient loadings to the lake. The Stage 3 tasks and the cost-share program are described on the following pages.

### Stage 3 Tasks

A series of technical and project support tasks have been developed for the Stage 3 work plan. These technical tasks are described below:

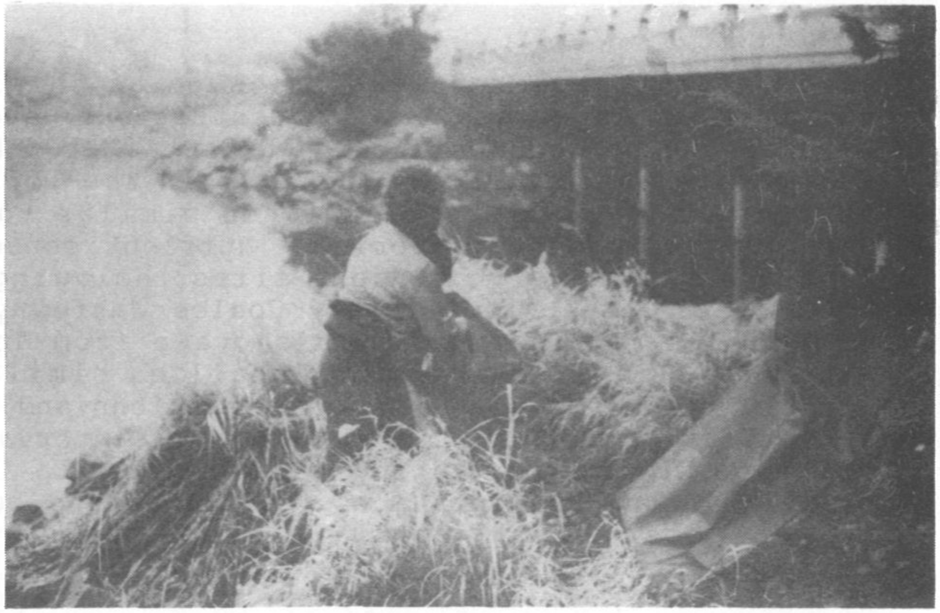
On-Farm Water Quality Management Plans. Management and structural practices on-farm were installed and monitored during Stages 1 and 2. Water nutrient savings are described in Chapter 3. The Best Management Practices (BMP's) established for the Moses Lake Clean Lake (MLCL) project area are needed to reduce the water quality problems in Moses Lake. The BMP's are: (1) Irrigation Water Management, which includes renozzling sprinklers, soil moisture monitoring, irrigation scheduling, flow meters, and refurbishing pumps to original specifications, (2) Irrigation System Improvements, i.e., equipment conversions on furrow irrigated fields to cablegation or sprinkler system, or replacement of worn-out mainlines and new pumps on sprinkler irrigated fields, (3) Fertilizer Management, such as soil tests, fertigation equipment, and split applications, (4) Animal Waste Control Facilities for storage and management of livestock wastes, (5) Sediment and Water Control Retention or Detention Structures, channel linings, and drop structures, (6) Stream Proteciton Systems for fencing stream banks and lake shores to exclude livestock, livestock crossings, and access to water. These BMP's will update or install irrigation systems as necessary and acquaint irrigators with various methods to schedule application of irrigation water and fertilizers. Water Quality Management Plans (WQMP) will be the primary tool used to implement these practices. The WQMP will be developed with the farmer and will include all the BMP's necessary to correct the water quality problems on his farm unit. The farmer will implement his WQMP over a three to five-year period under a contract with the MLIRD. Overseeing implementation of the WQMP will be accomplished by MLCD and SCS technical assistance. The farmer will receive technical assistance on the installation of these practices by the MLCL project staff as necessary. MLCL project staff will monitor these farm units throughout the irrigation season to determine the efficiency of water application and reduction of deep percolation of water and fertilizers.

Detention Pond Structures. The high priority detention ponds identified in Chapter 6 will be developed under this task. These involve weir structures on lower Rocky Ford Creek and lower Crab Creek and a small impoundment below the State Game Hatchery on a tributary to Rocky Coulee Wasteway designed to retain flows and encourage nutrient trapping. Ponds shall conform to recommended design criteria in Chapter 5 unless changes are approved by the project Technical Advisory Committee. Additional detention structures on Upper Rocky Coulee Wasteway may be authorized based on Technical Advisory Committee recommendations and Hub Council approval. Planning for possible additional detention structures will be included as part of this task.

Rocky Coulee Wasteway Drainage Diversion. An irrigation drainage diversion system will be developed to convey nutrient rich water from an existing Rocky Coulee Wasteway pumped drainage discharge to an irrigation supply canal for subsequent reuse on farms. An agreement will be developed with the East Columbia Basin Irrigation District to design, construct and operate the diversion in order to maximize nutrient reduction to Moses Lake during the irrigation season when the supply canal is in operation. Prior to design, negotiations will be carried out with the UN Bureau of Reclamation and the East Columbia Basin Irrigation District to assure the recommended diversion approach will be compatible with irrigation canal operation. If continued diversion operation cannot be reasonably assured during the spring-summer period, work on this task may be terminated.

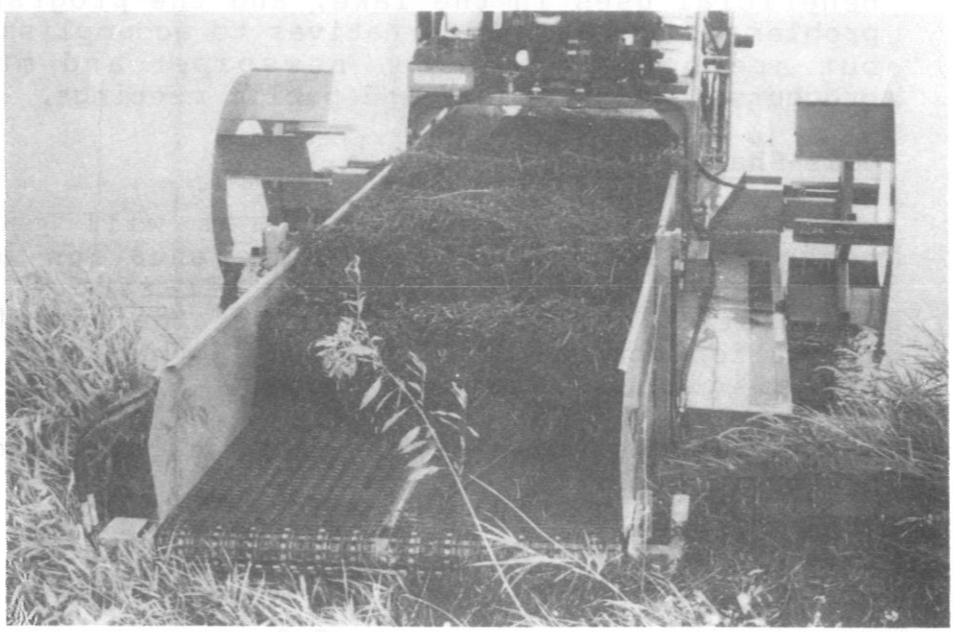
Develop On-Site Waste Disposal Policy. A policy covering wastewater disposal recommendations for on-site systems in the vicinity of Moses Lake will be developed. This policy shall identify a lake sensitive zone and describe control measures to reduce nutrient loadings to Moses Lake from developed urban areas near the lake. The policy recommendations shall be formally adopted by the Grantee and recommended to appropriate local agencies (i.e., City of Moses Lake and Grant County) for implementation. Technical rationale shall be included with the policy and the Grantee shall endeavor to achieve acceptance and implementation of the recommendations in order to accomplish reduction of nutrient loadings to Moses Lake.

Post Project Monitoring. Moses Lake and tributary waters will be monitored to determine the effectiveness of the project. Moses Lake itself shall be monitored to allow comparison with preproject conditions. Lake monitoring shall include parameters



Cleanup Efforts on Moses Lake Shoreline

Debris Disposal from Lakeshore Cleanup



Weeds Harvested from Moses Lake

used in past research studies, such as chlorophyll concentrations, algal type, nutrient concentrations, and water transparency over the period April through September. Inflowing waters to Moses Lake shall be characterized in the lower watershed using sampling and analysis techniques similar to those used in the Stage 1 preproject monitoring. Nutrient concentrations shall be determined at twelve or more sites including lower Rocky Ford, Lower Crab Creek, lower Rocky Coulee Wasteway, selected smaller tributaries, springs, and wells drawn from locations sampled in Stage 1. Sampling frequency shall be similar to Stage 1 with monthly frequency on groundwater stations and for fall and winter streamflows and approximately two week intervals on surface water stations during the spring-summer period. Final post project sampling should be initiated in October and completed by the end of September 1987. Special investigation of detention pond performance should be carried out in 1986 if ponds are operable at that time; otherwise pond nutrient trapping effectiveness should be evaluated in 1987. Selected springs, wells, and reference stream sites (i.e., Crab Creek at USGS gauge) should be monitored during 1986 to provide data continuity. Results of the post project monitoring work shall be described in the project report and appropriate annual reports.

Report Preparation and Printing. A Stage 3 final report will be prepared which includes a description of Stage 3 water quality control program and accomplishment and including a summary of irrigation and livestock controls, detention pond and waste diversion performance, septic tank policy implementation and post project monitoring. Annual reports shall be prepared covering 1985 and 1986 activities and results and a final report and summary shall be produced covering the entire project including summaries of the previous two stages.

Information/Education System. A coordinated information/education system will be implemented to inform residents of the Moses Lake area about water quality problems, the degradation of beneficial uses in the lake, and the program to correct these problems. Possible alternatives to accomplish this task include, but are not limited to, newspaper and magazine articles, brochures, slide shows, and public meetings.

Cost-Share Program

A unique cost-share program will provide funding for technical assistance and implementation of management and structural practices which will reduce the on-farm deep percolation of water and nutrient loading of groundwater from irrigation operations. Cost-share money will also be available for eligible livestock controls. Farmers who sign up to participate in the cost-share (C/S) program will be rated and prioritized as to whether they contribute significantly to Moses Lake water quality problems.

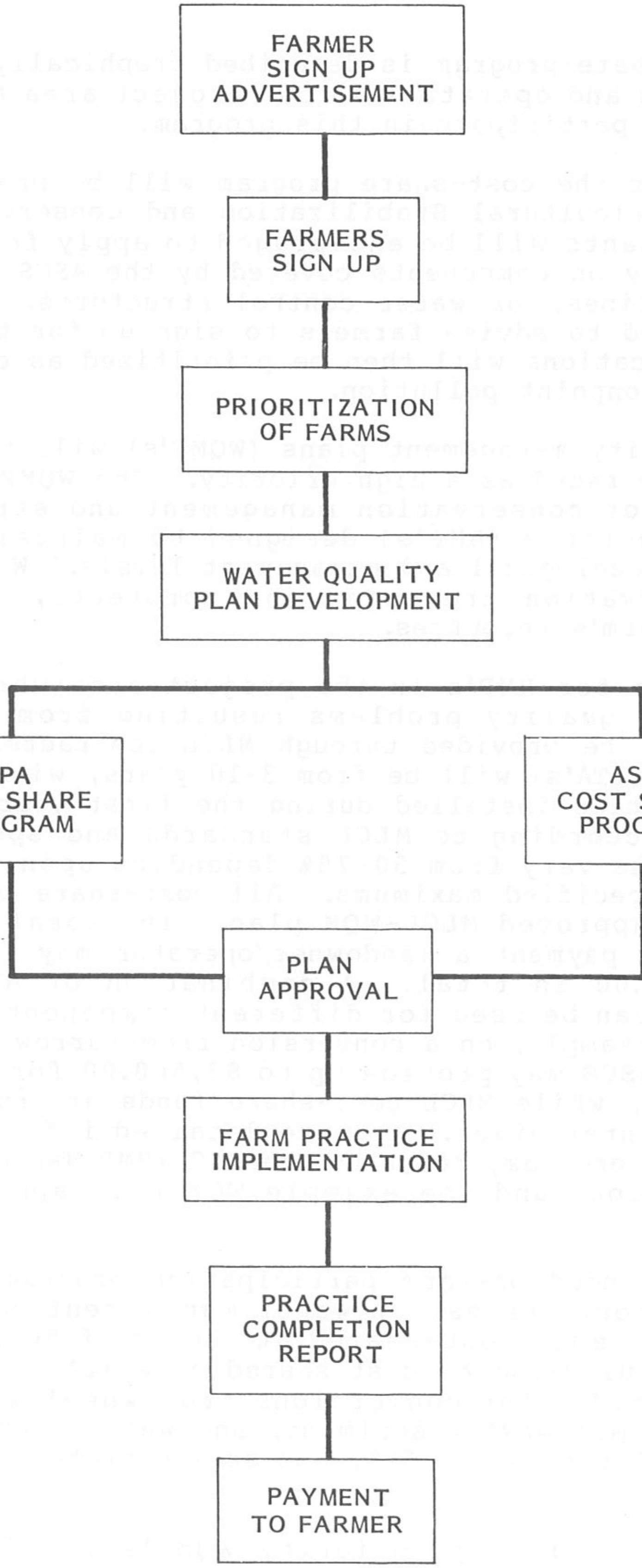



Fig. 7-1 Cost Share Program Process

The cost-share program is described graphically in Figure 7-1. Farm owners and operators in the project area (See Fig. 2-2) are eligible to participate in this program.

Funding for the cost-share program will be provided by both EPA and the Agricultural Stabilization and Conservation Service (ASCS). Applicants will be encouraged to apply for ASCS annual cost-share money on components covered by the ASCS program, such as buried mainlines, or water control structures. A newsletter will be prepared to advise farmers to sign up for the cost-share program. Applications will then be prioritized as critical areas or sources of nonpoint pollution.

Water quality management plans (WQMP's) will be written for farms which are rated as a high priority. The WQMP will include a combination of conservation management and structural Best Management Practices (BMP's) designed to maintain acceptable water quality, ecological and management levels. WQMP's may also include conservation treatment that protects, restores, or improves the farm's resources.

Cost-share for BMP's in the project area where there are critical water quality problems resulting from agricultural activities will be provided through MLCL contracts. MLCL long-term contracts (LTA's) will be from 3-10 years, with at least one cost-share practice installed during the first year. BMP's must be installed according to MLCL standards and specifications. Cost-share rates vary from 50-75% depending upon the practice, not to exceed specified maximums. All cost-share practices must be part of an approved MLCL-WQM plan. The total amount of an MLCL cost-share payment a landowner/operator may receive cannot exceed $50,000.00 in total. A combination of ASCS and MLCL Project funds can be used for different components of the same practice. For example, on a conversion from furrow irrigation to center pivot, ASCS may provide up to $3,500.00 for installation of the pipeline, while MLCL cost-share funds ar provided for the pump and the center pivot. For more detailed information on the MLCD cost-share program, refer to the MLCL/BMP Handbook, the MLCL Contract Handbook, and the example WQM plan appended to this report.

The recommended on-farm participation program involves 75% cost-share on most irrigation water management components and fertigation systems, cost-shared at a rate of 50%. Structural improvements would also be cost-shared at a rate of 50% with no cost-share provided for conversions from wheellines to center pivots. The animal waste, sediment, and water control retention and detention structures at 50%, and stream protection systems at 75% cost-share.

The critical or high priority WQMP's will be channeled through one or both funding programs. EPA cost-share will cover improvements up to a maximum of $50,000.00 per farm whereas ASCS monies will match components up to $3,500.00 providing there is no overlap in components funded. The WQMP components identified as EPA eligible cost-share items will be sent directly to the HUB Council for approval. ASCS eligible components will be evaluated through regular ASCS channels and then sent to the HUB for approval. In cases where items eligible for ASCS cost-share are not completed during the first year of the WQMP contract, a long-term agreement (LTA) must be developed to ensure money will be available.

## Project Funding and Schedule

Project funding involves several different sources. Off-farm and technical assistance aspects during Stage 3 are supported by DOE, EPA, and the MLIRD. Farm related costs are shared by local farmers, EPA, and ASCS. Project technical assistance and monitoring will be carried by SCS after Stage 3 is completed. See Fig. 7-2 for a graphical representation of agency funding and participation schedules.

Stage 3 tasks will be carried out during the period April 1985 through December 1987. A schedule for the tasks identified for Stage 3 is provided in Figure 7-3. Agency roles in the Stage 3 project are Technical Advisory Committee and HUB Council, the same as in Stage 2 as described on the organization chart provided in Chapter 1.

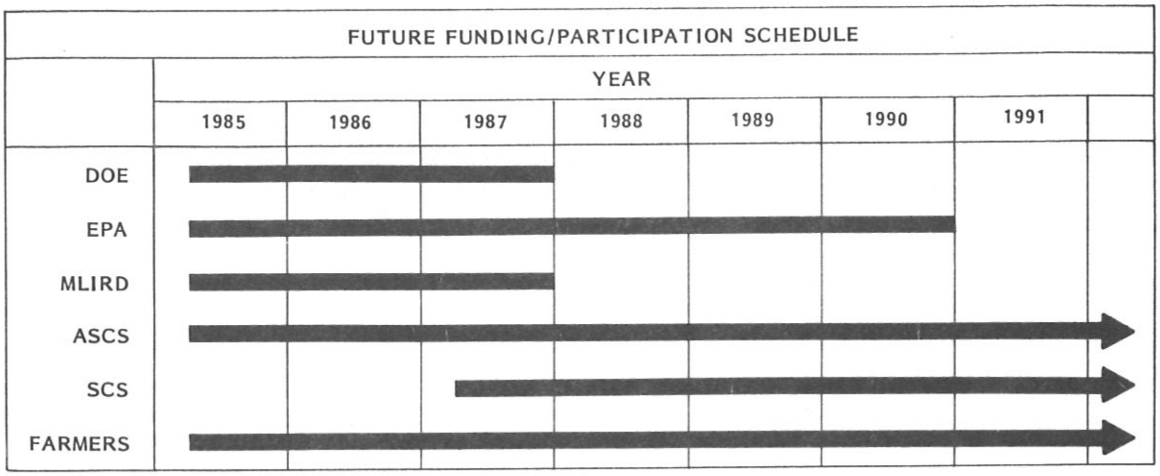



Fig. 7-2 Agency Funding and Participation Schedule

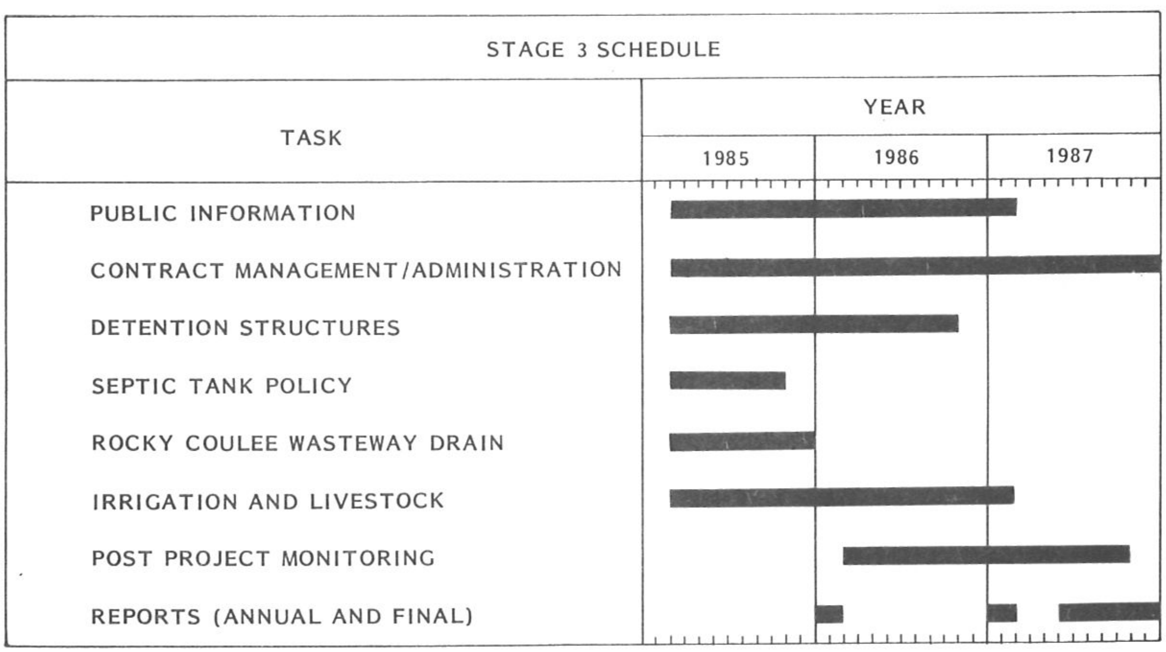



Fig. 7-3 Stage 3 Project Tasks and Schedule

# APPENDIX A

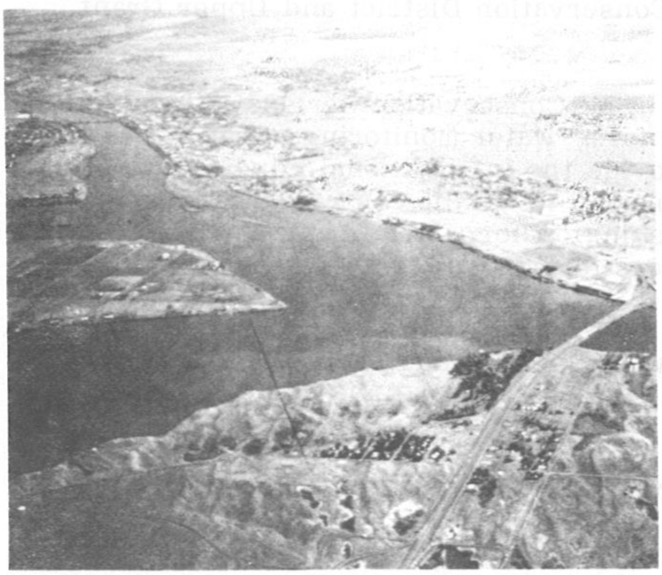
# MOSES LAKE CLEAN LAKE PROJECT STAGE 1 SUMMARY

INTRODUCTION

The Moses Lake Clean Lake Project is part of an effort by a number of private and public agencies to bring Moses Lake into compliance with Washington State water quality standards.

Moses Lake is impacted by large quantities of algae created by high levels of nutrients, mostly nitrogen and phosphorous, that enter the lake from sewage treatment effluent, agricultural runoff, and animal wastes. Swimming, fishing and boating are reduced by the undesirable algal mats that accumulate on the water surface.

Moses Lake has been studied for a number of years to determine the factors affecting water quality. Some previous studies have indicated that nutrients from agricultural lands are the cause of the poor water quality in Moses Lake. In 1982, the Moses Lake Irrigation and Rehabilitation District began pumping cleaner water from Parker Horn to Pelican Horn as a means to dilute and circulate waters in Pelican Horn.



*Aerial view of Parker Horn in upper left and Pelican Horn across upper portion of photo. Center portion of photo denotes main body of lake having algae growth.*

*Close up scene of algae mats during summer in Moses Lake.*

In July 1982, a grant agreement was signed between the Environmental Protection Agency, Washington State Department of Ecology and the Moses Lake Irrigation and Rehabilitation District to develop systems for the control, maintenance and restoration of water resources within the Moses Lake drainage basin. Also, the Moses Lake Irrigation and Rehabilitation District entered into an agreement with the Moses Lake Conservation District to identify nutrient sources and to develop potential water pollution control practices on agricultural lands in the Moses Lake watershed.

The agreement between the agencies specifies that there would be Stage I, Stage II and Stage III components to the project. Stage I would be between July 1982 and March 31, 1984 and Stage II would be between April 1, 1984 and March 31, 1985. Stage III, if implemented, would be between April 1, 1985 and March 31, 1987. A grant totaling approximately $500,000 was provided for Stage I by Environmental Protection Agency, Washington State Department of Ecology and Moses Lake Irrigation and Rehabilitation District.

During the implementation of Stage I, it was deemed appropriate to have sponsoring agencies who could represent most of the Moses Lake watershed area involved in the project. The sponsoring agencies were: Moses Lake Irrigation and Rehabilitation District, Moses Lake Conservation District and Upper Grant Conservation District.

Cooperating agreements were made with: Soil Conservation Service to provide the technical assistance and conduct "on farm" water monitoring; Grant-Adams Area Cooperative Extension to provide the informational/educational program; Washington Conservation Commission to handle contractural and administration matters; University of Washington for water sample analysis and Brown & Caldwell Consulting Engineers to provide for "off-farm" water monitoring.

This report will discuss the Moses Lake watershed, project activities, objectives, and results.

## OBJECTIVES

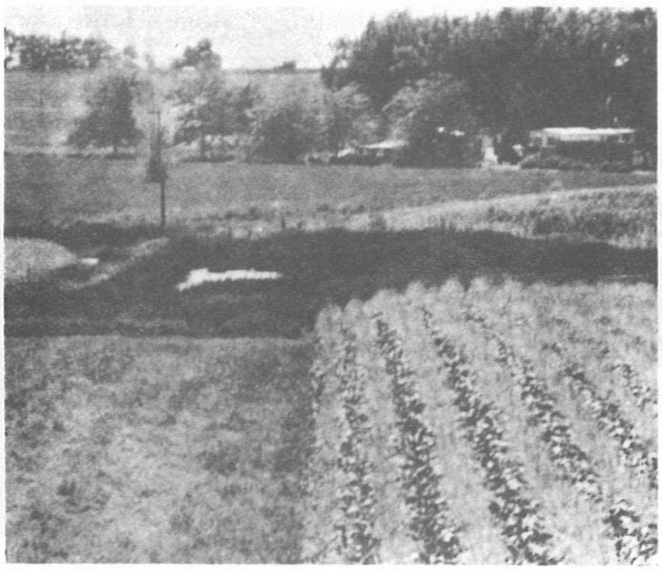
The overall objective of the Moses Lake Clean Lake Project is to bring Moses Lake into compliance with Washington State water quality standards.

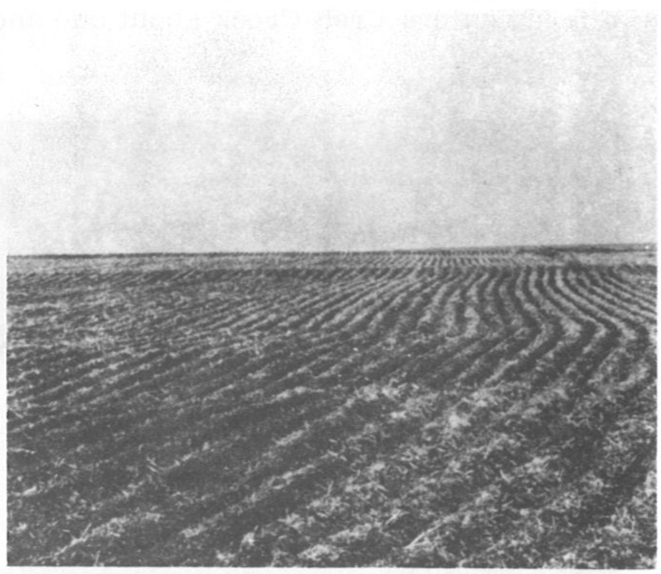
Specific objectives of the project during Stage I and Stage II are to further identify the sources of nutrients, the kinds of nutrients and the quantity of nutrients and their affect on Moses Lake; identify existing agricultural practices which may impact water reaching Moses Lake; identify potential Best Management Practices which could be implemented in Stage III and strengthen the conservation district capabilities to provide resource conservation programs needed in the area.

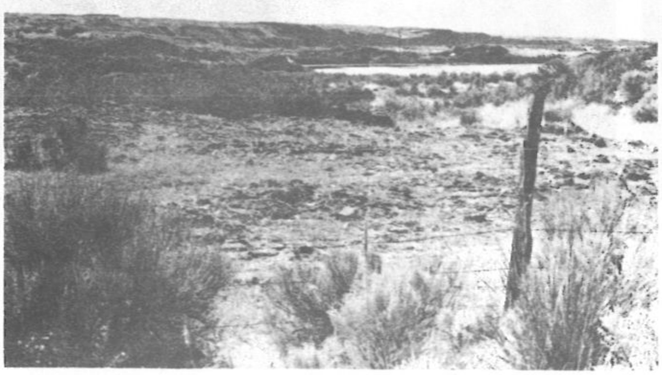
STUDY AREA

The Moses Lake watershed drains nearly two million acres of farm and rangeland in upper Grant County, a large portion of Lincoln County, and a small area of Spokane County and the northern edge of Adams County. (See map.) The area is approximately 48 percent dryland cropland, approximately 41 percent rangeland, approximately 8.5 percent irrigated cropland and approximately 2.5 percent urban.

Rainfall patterns vary from approximately seven inches near Moses Lake to 16 inches in the northeastern part of the watershed. Most of the precipitation occurs during November-March, as snow. Elevations vary from 1068 feet at Moses Lake to 2460 feet near Reardan.







*Upper Left:* *Surface irrigation near Moses Lake.*

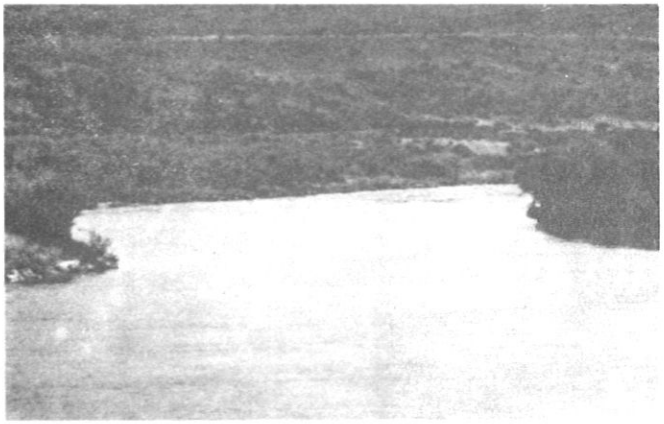
*Upper Right:* *Dryland cropland in Adams, Lincoln and Grant Counties.*

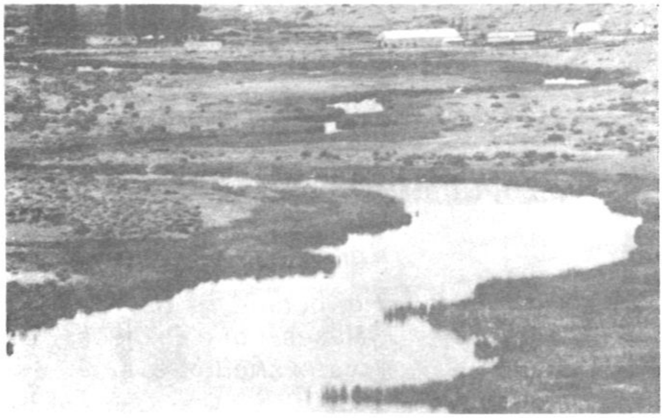
*Lower Left:* *Rangeland in the Moses Lake Project watershed.*

## WATER SOURCES

Crab Creek supplies approximately 14 percent of the water entering Moses Lake. Along its path, a number of tributaries enter Crab Creek, the largest being Wilson Creek, which drains an area in northern Grant County and northwestern Lincoln County of approximately 165,000 acres. Other creeks that contribute to Crab Creek's flow include Duck Creek, Canniwai Creek and Lake Creek. All of these creeks carry considerable water during snowmelt or a major storm event, but normally dry up in late spring or early summer. Crab Creek has continuous flow as it nears Moses Lake, with springs and irrigation return flows adding to its volume.

Rocky Coulee Wasteway is a source of clean Columbia River water from the East Low Canal to Crab Creek. This source contributes approximately 36 percent of the water entering Moses Lake. Rocky Coulee Wasteway receives several irrigation return flows and drains an area east of Moses Lake that has snowmelt runoff. It enters Crab Creek about one and one-half miles northeast of Moses Lake.





*Upper Left: Crab Creek during spring runoff near the town of Wilson Creek.*

*Upper Right: Rocky Coulee Wasteway looking west toward city of Moses Lake.*

*Lower Left: Rocky Ford Creek with fish hatchery in the background.*

*Lower Right: Wilson Creek near Almira during spring runoff.*

Rocky Ford Creek supplies approximately 21 percent of the water entering Moses Lake. It begins in a series of springs about six miles from the northern end of Moses Lake. It has a relatively even flow throughout the year, with a slight decrease in spring and winter.

Ground water is the remaining source of water to the lake and contributes approximately 26 percent to the total.

## PROJECT ACTIVITIES

### Water Monitoring

An extensive water monitoring program was conducted to document the impact of pollutants from agricultural lands on Moses Lake.

The "off-farm" portion of the water monitoring program had 275 samples taken from 25 sites. The samples were taken in the main tributaries of Moses Lake, Crab Creek and Rocky Ford Creek, springs and wells in the Moses Lake vicinity.

*Water sample being collected from Crab Creek in winter.*

*Water sample being collected from a furrow being surface irrigated.*

The "on-farm" water monitoring program involved 215 samples taken from 65 sites. The watershed was divided geographically for study purposes. In Lincoln County, 14 water monitoring sites were selected. Eight were surface sites, two were creek locations, three were well sites and one was an irrigated pasture site. A total of 35 water samples were taken for analysis. Upper Grant County had 17 monitoring sites with 38 samples taken for analysis. Six were surface runoff sites and 11 were wells. In the Moses Lake area, 30 water monitoring sites were selected with a total of 125 samples taken for analysis. The 30 monitoring locations included 12 irrigation return flows, eight springs, two overland return flows, five runoff and three domestic well sites.

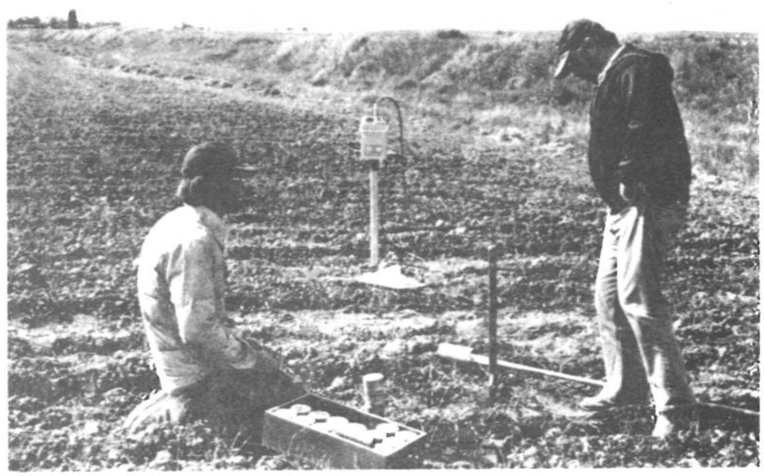
## NUTRIENT EVALUATION

Soil samples were taken to evaluate available nutrients at various depths in the soil profile. Samples were obtained from sufficient depths to determine nutrient movement as a result of irrigation. Samples were taken from an undisturbed soil site for information on naturally available nutrient levels.

## NEUTRON PROBE

Irrigation water movement in soils was monitored on ten farms in the Block 40, 401 and a portion of 41 near Moses Lake through the use of a Neutron probe. Data from the Neutron probe reading was used to determine uniformity of application, depth of penetration and irrigation efficiencies. Farms selected had different irrigation systems and cropping patterns.

Sprinkler application rates were measured using catch pans placed at 10 feet by 10 feet intervals under operating sprinklers. Pump pressure, pump size, size of the main and lateral lines, nozzle orifice size, and nozzle pressure were measured. Surface irrigated fields were evaluated using step weir and trapezoidal Parshal flume to measure the amount of water being applied. The length of row, and size of the siphon tube used were also recorded.



*Left: Neutron Probe with cable cord for measuring moisture at varying soil depths.*

*Above: Leigh Nelson and Bernie Kanoff, project personnel, taking soil samples to correlate oven dried moisture readings with neutron probe readings.*

## FARM PRACTICE INVENTORY

Farming practices were inventoried and evaluated on 50 farms in Block 40, 401 and a portion of 41. A few farms were also inventoried in upper Grant County and in Lincoln County. Questions asked included types of crops grown, acres farmed, fertilizer use, method of application, cultivation practice and tillage equipment utilized.

*Farm Practice Inventory discussion between Tracy Schmid, Block 40 farmer, and Bernie Kanoff, Project Technician. Richard Weitman, Associate Supervisor, Moses Lake Conservation District, in background.*

## INFORMATION - EDUCATION

Information and education activities were extensive during the project. Three brochures entitled "The Project", "On-Farm Water Monitoring", and "Project Summary" were written. Meetings were held for farmers throughout the watershed, for agency personnel and for the general public. Three newsletters were mailed to approximately 200 people. A narrated slide-set and a bulletin board-type display were developed and utilized at numerous meetings, conferences and at the Grant County Fair.

*Ernie Jager, Project Manager, leading discussion at one of numerous project meetings.*


*Display boards utilized for meetings, conferences and fairs.*

## RESULTS

The nutrients of greatest concern to Moses Lake are nitrogen and phosphorus. Nitrogen is currently the limiting nutrient to algae growth.

The upper Crab Creek watershed (above Adrian) makes a relatively small contribution to the total pollutants reaching Moses Lake. This may be due to several reasons: 1) Distance from Moses Lake. 2) Impoundment basins that occur along Crab Creek's path; such as Brook Lake and Round Lake trap sediment and nutrients. 3) Lack of continuous flow into the lower watershed. 4) Large areas of rangeland and dryland crops that are not heavily fertilized.

Water monitoring results from Crab Creek indicate that approximately 95 percent of the nitrate nitrogen, approximately 88 percent of the total phosphorus, and approximately 83 percent of the soluble reactive phosphorus originate downstream from Round Lake near Adrian.

Rocky Coulee Wasteway contributes approximately 88 percent of the total water flow into lower Crab Creek in the spring. This high volume reflects increased flows into Rocky Coulee Wasteway from East Low Canal releases. This East Low Canal water is relatively nutrient-free and helps dilute water in Crab Creek downstream from Rocky Coulee Wasteway.

Rocky Ford Creek is the major surface flow contributor throughout the year of soluble reactive phosphorus to Moses Lake. The source of this nutrient is not totally understood. Nitrogen levels are found to be low. However, concentrations of nutrients peak in the spring and summer indicating a possible link with irrigated agriculture.

Springs that feed into Crab Creek below Round Lake are a major contributor to the phosphorus and nitrogen levels reaching Moses Lake. The flow from these springs is responsive to the irrigation season as some spring flows increase 10-20 times. The nutrient levels also increase, reflecting the occurance of leaching on irrigated lands.

Groundwater is a major source of nitrogen during spring and summer. In addition, previous studies have documented that some groundwater enters Moses Lake through Pelican Horn. The greatest flow of groundwater occurs during fall and summer months.

Water monitoring activities have also indicated that Moses Lake has high levels of phosphorus because of Rocky Ford Creek and sewage plant effluent. Sewage effluent represents approximately 18 percent of the phosphorus loading to Moses Lake. Septic tanks around Moses Lake account for approximately 5 percent of the phosphorus load to the lake. Other nutrient sources identified were cattle operations, fish hatcheries, urban runoff, and in-lake carp and decay of aquatic plants.

Data collected from the farm practice inventory and from the ten farms monitored with the neutron probe indicate that farmers in general are over-irrigating. This over-application of irrigation water is causing deep percolation of water and nutrients to occur in Block 40, 401 and a portion of 41. There are 20,954 acres of irrigated land in this area. Approximately 81 percent utilize sprinkler irrigation and approximately 19 percent utilize furrow irrigation. Although furrow irrigation accounts for less than one-fifth of the irrigated area, it contributes over one-third of the nitrogen leached by deep percolation

# APPENDIX B

# LIVESTOCK OPERATIONS

APPENDIX B

LIVESTOCK OPERATIONS

Introduction:

Rearing and feeding of livestock has economic significance within the Moses Lake drainage basin. The purpose of this task was to locate significant animal waste sources which may reach waterways that drain into Moses Lake. Retention of these nutrient loads to the lake would result in less nutrient pollution of the lake.

The project area included six significant livestock operations including: one feed lot, three dairys and two non-confinement feeding operations. (See Map Fig. B-1) All six operations were visited to observe livestock management and operating procedures. Brief descriptions of each operation are provided on the following pages.

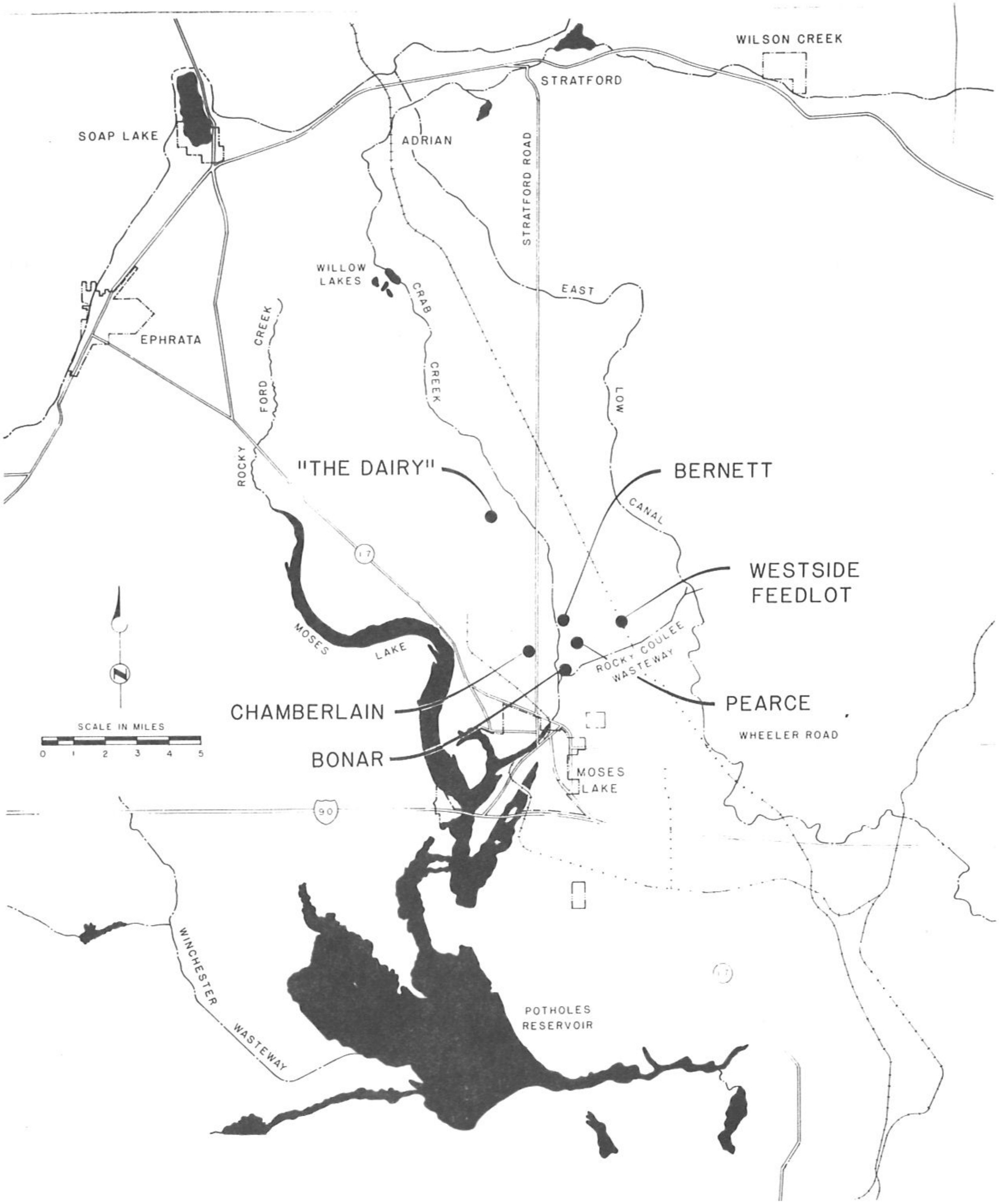



Fig. B-1 Moses Lake Area Livestock Operations

## WESTSIDE CATTLE COMPANY

The Westside Cattle Company operation is on a 1,128 acre site located on Road 7. (See Map Fig. B-1) The feed lot has an average capacity of approximately 4200 animal units. The site is underlain by porous Ephrata-Malaga soils. The feed lot portions of the operation covers approximately 2 acres and is surrounded by several hundred acres presently being used by Westside for alfalfa, corn and pasture. On the average, cattle are fattened from approximately 500 pounds to 700 pounds over a 90 day period. The cattle are then shipped off the feed lot.

The feed lot proper covers about 125 acres and has approximately 1000 feet of stream running through it; and other parts of the feed lot lie within 75 feet of this stream. The stream flows approximately nine months of each year mainly during the irrigation season. Some manure is carried from the feed lot by this waterway.

At present a 2.4 acre sedimentation pond collects some of the runoff. Overflows occur which drain directly into Rocky Coulee Wasteway. The pond is currently filled with a large amount of solids. Some storage remains of the pond are pumped to Westside land adjacent to the feed lot where two wheel lines irrigate approximately 34 acres of alfalfa. The operator estimates that he saves about $20/acre/yrs in water from this sedimentation pond source, but to date his sod test data indicates no direct savings for phosphorus or nitrogen.

While some effort has been made in the past to contain some of the nutrients from the animal discharge (e.g. the settling pond), large amounts of surface water runoff traversing the site during irrigation season have caused overflow from the sedimentation pond to run directly into Rocky Coulee Wasteway. The pond has never been cleared of sludge in the past ten years of its operation.

<u>Potential Controls</u>. An enlarged upstream pond would store and allow diversion of more of the surface water entering the property from the north. Ponded water could be used as a source for irrigating more of the upstream land owned by Westside. The portion of the stream that runs directly through the feed lot could be enclosed in a pipe thereby preventing the manure discharges entering this waterway. A bypass could be allowed when pipe capacity is exceeded in order to accomplish flood situations.

To the south the natural slope of the land away from Westside allows further sedimentation ponds to be constructed at minimal expense. It is suggested that the existing pond be cleaned out and enlarged to approximately 4.5 acres and that the sediment be cleaned out regularly and spread on adjacent crop land, with a substantial savings in fertilizer costs each year.

A second impoundment pond should be constructed below the existing pond (See attached map) to collect sediment overflow from the first pond. The existing pumping system should be maintained and expanded to irrigate more of the surrounding acreage than is being irrigated at present.

If overflows still persist, a pump system could also be installed in the second pond or additional sedimentation ponds could be added since the terrain allows for their construction. The estimated cost for the two additional pools and an extra pump is $10,000. All improvements could all be achieved within the Westside property boundaries.

These improvements would benefit Westside directly. Other potential improvements are listed below for consideration:

a. Excavate small collection canal (two feet deep) adjacent and parallel to the existing feed lot and direct its discharge via natural gradients of the land to adjacent crop lands. This canal would help intercept surface water runoff from the feed lot proper.

b. Fence off the stream downstream of feed lot proper from non-confinement grazing area. Fencing will cost approximately $1.50 per foot for a five wire cattle fence (installed price).

c. Maintain feed lot water trough regulator to prevent overflow.

d. Shape stream channel to prevent flooding of large areas.

## LELOYD PEARCE DAIRY

The Pearce Dairy on Road K is also known locally as the "Farm in a Day" since the farm buildings were originally developed in one day as a special project. The dairy farm consists of approximately 275 acres and houses 375 animal units. The milking cows are confined to a loafing barn with a concrete floor year round while in milk production. The replacement stock and some dry cows run on the pasture for part of the year.

Dung and urine intermixed with woodshavings which accumulate in the barn are scraped into a concrete holding pit daily where some evaporation takes place. This material is then transferred to a holding area where it may be stored for up to six months. The dry manure is subsequently applied to the adjacent pasture and cropland (approximately 60 acres) by spreader. This process has been carried out for 22 years with the result that no artificial fertilizer need be applied to this cropland.

A tributary to Rocky Coulee Wasteway runs along the east of the dairy (within 70 feet of the dung pit) and borders some of the pasture. The barn is surrounded by pasture and cropland. Approximately 3000 feet of pasture land borders Crab Creek. The dairy site is underlain by coarse Ephrata-Malaga soils.

While this dung pit is within 70 feet of the waterway, water testing during Stage 1 indicates that very little nutrients enter the waterway from this source. However, a silage stockpile built within 100 feet of the waterway was observed discharging some drainage into the waterway.

In summary, it appears that very little pollution of the adjacent waterway occurs from this dairy, but the close proximity to the waterway of the dung pit, silage stack, and free grazing animals increase pollution risks.

Potential Controls. Develop a small detention pond upstream from the point of discharge of the waterway into Rocky Coulee Wasteway. Preliminary estimates indicate a 5.7 acre pond could be formed for a cost of approximately $5,000. This pond would trap some of the nutrients entering from the dairy drainage cited above, but would also trap nutrients from the Columbia Basin Hatchery discharge which is fed by a nutrient rich spring.

Control drainage in the vicinity of the dung pit and silage storage area by minimizing direct discharge to the waterway. Control percolation from these areas by placing impervious materials under these nutrient rich sources and evaporate contained liquids to the maximum extent feasible.

The waterway and impoundment pond should be fenced off from the pasture land. Fencing could cost as much as $4,000. This would prevent further direct contamination of the waterway by the cows. Water troughs would have to be provided for approximately $500 cost.

Use timely manure application techniques and cultivate into the soil immediately. This appears to be an existing practice at this dairy.

Fence off Crab Creek to prevent animal access. Approximate cost would be $4,500. Electric fencing could be installed at a much reduced cost.

In summary, this dairy farmer appeared to be using good management practices. He has stated that his preference is to scrape the dung and urine mixture on a daily basis using a water flushing system. If installed, this could increase nutrient discharge to the stream adjacent to the milking barn unless the surface water runoff problem can be solved.

## MARION CHAMBERLIN DAIRY

The Chamberlin Dairy occupies 180 acres and is located about one mile west of the Pearce Dairy. This dairy has a capacity of 350 animal units. This dairy is also underlain by coarse Ephrata-Malaga soils. Dung and urine mixed with straw is graded into a concrete lined pit from which it is spread onto adjacent pasture land. Some dung and straw is left to decompose in the animal confinement area. Some drystock is kept on pasture land for six months to a year. This farm was not considered an important pollution source as it is approximately one mile away from Crab Creek with no runoff to any tributary.

## "THE DAIRY" - OWNER CASEY SHARP

This 154 acre dairy is a total confinement operation with a capacity of 340 animal units. All dung and urine is collected in a concrete pit and spread every second day on adjacent cropland. This process occurred all year. No artificial fertilizer was used on the cropland. Some rented fields bordered Crab Creek.

This farmer had approached neighbors with a view to spreading some of his manure on their fields. This property didn't appear to be a major pollution source due to distance from Crab Creek. However, the all year application of liquid manure to the pastures (including rented pasture adjacent to Crab Creek) could be considered a potential problem. This farm is also underlain by coarse soil.

In summary, this dairy farmer appeared to be using good management practices. If neighbors would allow manure application on their land, this would move the potential pollution source even further away from Crab Creek.

## BOB BURNETT - CATTLE FEEDING OPERATION

The Burnett farm is along Crab Creek near the USGS gaging station at Road 7. This farmer feeds about 200 head of cattle in a non-confinement feeding operation covering 164 acres. The cattle are allowed to wander through Crab Creek to pasture land on either bank. The feeding racks are within approximately 150 feet of the waterway. A small irrigation ditch feeds into Crab Creek on this farm. There is approximately 6000 feet of stream frontage bordering the pasture. A portion of the flatland adjacent to the creek floods during the year.

Potential Controls. Fence the river banks to prevent cattle gaining access to waterway. Cost, approximately $9,000. Provide water troughs and pump facility. Cost, approximately $1,000.

Locate fence away from creek frontage to provide for a natural filtration barrier both from the surface water runoff and the floodwaters.

Provide a limited access way across the creek with gates at both sides so cattle can be moved.

Change pasture management practices to ensure that animals have a rotational grazing program.

Relocate feeding racks further away from creekfront to prevent dung and urine buildup close to creekfront.

Reconstruct irrigation wasteway to confine and channel water directly into Crab Creek.

In summary, this property appears to have some obvious and reasonably economical remedies to potential pollution of Crab Creek.

## GUY BONNER - CATTLE FEEDING OPERATION

The Bonner farm is a non-confinement feeding operation covering approximately 100 acres at the junction of Rocky Coulee Wasteway and Crab Creek. Approximately 75 animal units graze in this area.

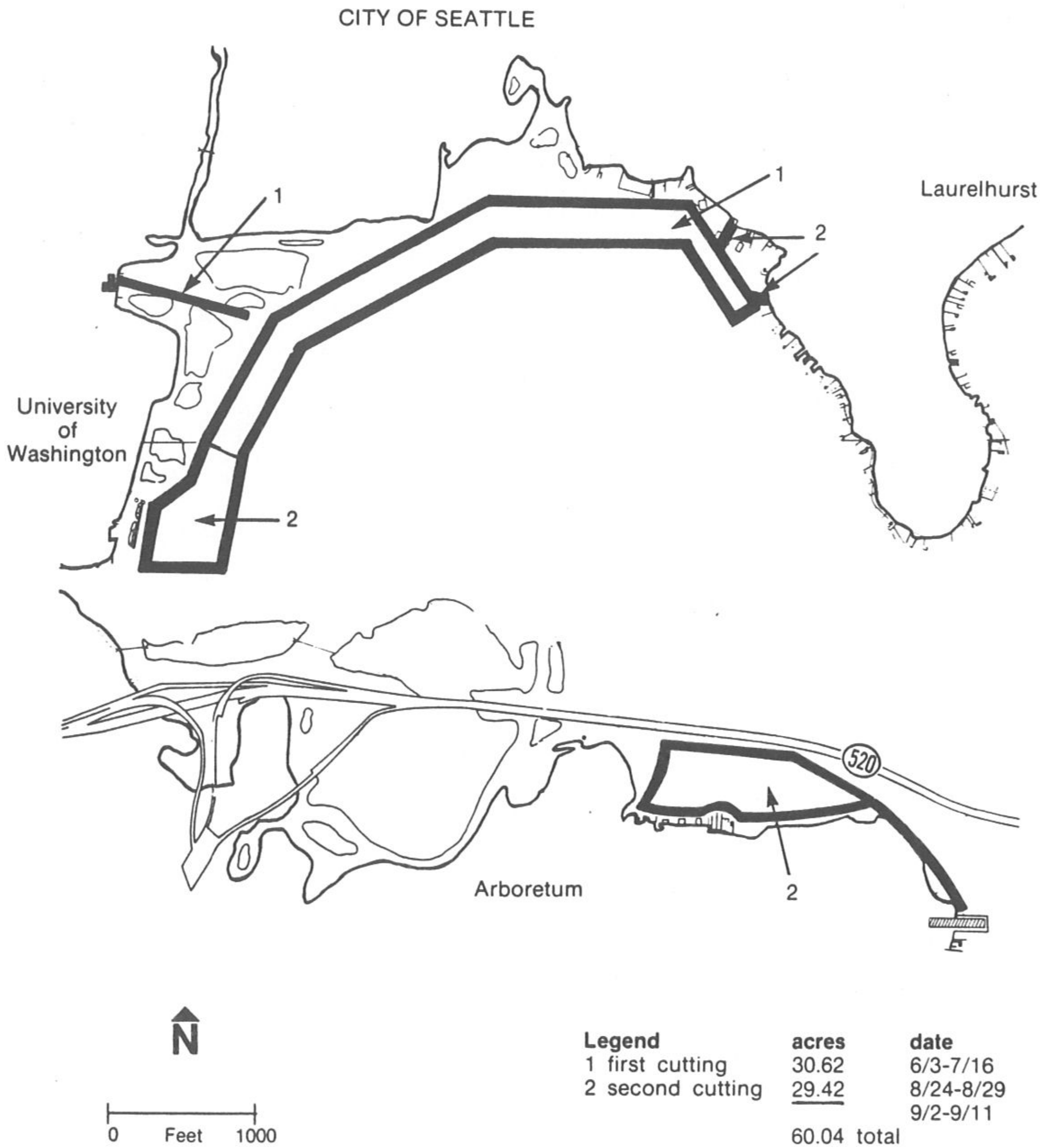
The cattle have free access to Crab Creek.

Potential controls are the same as described previously for the Burnett farm.

# APPENDIX C

# EXAMPLE AQUATIC WEED HARVEST PLAN

Union Bay




| Legend | acres | date |
|---|---|---|
| 1 first cutting | 30.62 | 6/3-7/16 |
| 2 second cutting | 29.42 | 8/24-8/29 |
| | | 9/2-9/11 |
| | 60.04 total | |

# APPENDIX D

## PONDING SURFACE DRAINAGE WATER FOR SEDIMENT AND PHOSPHORUS REMOVAL

This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 24, No. 6, pp. 1478-1481, 1981)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

# Ponding Surface Drainage Water for Sediment and Phosphorus Removal

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FELLOW
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## ABSTRACT

SEDIMENT and phosphorus (P) removal efficencies of a sediment-retention pond with a capacity of about 3400 $m^3$ receiving surface water runoff from 4050 ha of irrigated land, were measured for five years. Average daily flow through the pond, during the irrigation runoff period, was 347 L/s, with a pond retention time of 2.7 h. The pond removed 65 to 76 percent of the sediment, and 25 to 33 percent of the total P entering the pond. Sediment and phosphorus removal efficiencies depended upon the flow rate and the sediment concentration of surface return flow entering the pond. Sediment and phosphorus were most efficiently removed when the stream flow was 340 to 453 L/s and the sediment concentration was in the range of 20 to 750 mg/L. Sediment removed from the pond was used to cover protruding basalt to improve and expand a golf course.

## INTRODUCTION

Sediment, an end product of soil erosion, is the largest single pollutant of surface drainage water in southern Idaho. It hampers irrigation, pollutes rivers, and constitutes an economic loss to the farmer and the nation.

Research is needed to develop technology to reduce or eliminate sediments and adsorbed nutrients from surface irrigation return flows. Robbins and Carter (1975) reported that many small ponds have been constructed for removing sediment. Many of these ponds had no specific design, but were built to trap sediment for filling low areas, leveling land, and combining small fields into larger, more economical units. They found that 60 to 95 percent of the suspended sediments were removed from surface drainage water by these ponds.

Soil erosion not only damages the area from which the soil is eroded, but it can also damage areas where sediment is deposited. Large amounts of sediment may be carried from irrigated fields. Brown et al. (1974) reported that sediment concentrations in surface irrigation return flows ranged from 20 to 15 000 mg/L.

Carter et al. (1974) found that phosphorus (P) can be conserved by removing sediment from return flow streams. They found that the smaller particles and aggregates contained higher P concentrations than did the larger ones. The P concentrations increased as the particle or aggregate size decreased. For example, 550, 1150, and 1285 mg/L total P were attached to the sand, silt, and clay fraction, respectively, in the K-lateral drainage stream.

Under present irrigation management systems, streams and rivers are continually being loaded with sediment from irrigation drainage streams. Therefore, an efficient, economical means of controlling sediment in irrigation return flow is needed.

During irrigation, the surface runoff carries various amounts of sediment into the combination drainage and delivery system. The eroded sediment from individual fields often moves only a short distance and settles in a feed ditch or in the drainage channel as the energy to erode and the capacity to transport sediment decreases. Later, if the flow velocity increases, some of the deposited sediments are resuspended and may be transported downstream. Therefore, deposition and scouring are continual processes in the drainage system and eventually, if sediment is not removed somewhere in the system, some will reach the river.

The pond in this study was designed specifically to remove at least 50 percent of the total sediment input. Study objectives were to determine the value and effectiveness of ponding surface drainage water for controlling sediment and removing P, as well as to provide data for developing and evaluating design criteria for designing and constructing other test ponds. To achieve these objectives, data were used from one large pond constructed on a stream for which several years of streamflow and sediment data (Carter et al., 1974) had been collected.

## MATERIALS AND METHODS

The Northside Canal Company diverts water at Milner Dam on the Snake River in southern Idaho into one large North Main Canal. The water is then distributed through a series of smaller canals to irrigate about 63 350 ha (Fig. 1). Brown et al. (1974) described this study area. Irrigation water is usually diverted into the canal system beginning in April, and stopped at the end of the irrigation season, usually in October or November, depending upon the climatic conditions.

A kidney-shaped pond, 153.4-m × 18.3-m × 1.22-m deep, was constructed on the K-lateral near its confluence with the Snake River (Fig. 1) by the Northside Canal Company to conform to existing topography with

Article has been reviewed and approved for publication by the Soil and Water Division of ASAE.

Contribution from USDA-SEA-AR, in cooperation with the Water Sources Research Institute, University of Idaho, Kimberly.

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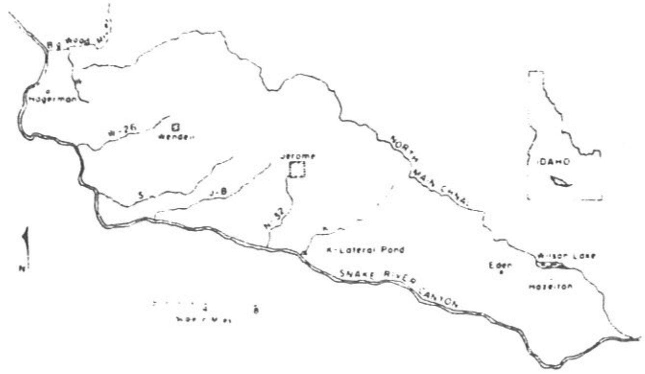

FIG. 1 The Northside irrigation tract showing the main canal, surface drains, and pond location.

minimal rock excavation. Probable removal efficiency for the pond was estimated using particle-size distributions, previously measured sediment concentrations, and an average discharge of 283 L/s. (Bondurant et al., 1975). Based on ideal settling basin assumptions of uniform inflow and outflow distribution, rectangular pond configuration and uniform horizontal velocity throughout the pond, a sediment-removal (trap) efficiency* of 54 percent was estimated. For the estimated flow and pond capacity of 3400 m³, this corresponds to an expected minimum particle-size removal of 5 μm assuming the requirements for applicability of Stokes' law were met.

Irrigation water is delivered to individual farm headgates at a constant rate of 0.87 L/s-ha continuous flow throughout the crop growing season. Water delivery may be decreased during August when water requirements for some crops decrease and when crops are nearing harvest.

Pond construction, including a 2.44 m (8.0 ft) wide suppressed weir for water measurement, was completed and studies began in 1972. The K-lateral pond was estimated to have adequate storage for two or three years' sediment with minor effects on the trap efficiency for the stream flow rates and volumes which occurred in this lateral. The pond was cleaned on alternate years, when the canal company removed sediment from the pond with a dragline in April 1973 and May 1975.

During the 5-yr study, to assure that the samples were representative of the stream and its sediment load, flow samples were collected at least weekly at a turbulent zone as the water entered the pond and at the measuring structure as it left the pond. Two samples were collected at each site. One was an unfiltered 200-mL sample, and the second was an unfiltered 10-L sample used to measure sediment concentration. Biological activity was inhibited in all samples by adding 40 mg $HgCl_2$/L. The 200-mL samples were refrigerated at 4 °C until analyzed. The total P concentration was determined in the 200-mL unfiltered sample (A.P.H.A., 1971; U.S.E.P.A., 1974; Watanabe and Olsen, 1965). Carter et al. (1974) have shown that virtually all soluble P passes directly through sediment ponds. The 10-L samples were allowed to settle for 1 week or longer in the laboratory, and then the clear, supernatant solution was siphoned off. The 1-week settling time was about three times longer than necessary, according to Stokes' law, for 1.0-μm diameter particles to settle 22 cm, the depth of the containers. The sediment remaining was suspended in a small amount of water and transferred into 600-mL beakers, dried at 105 °C, and weighed for sediment yield calculations.

*Sediment removal efficiency, expressed in percent, is the proportion of the inflowing sediment that was retained in the pond.

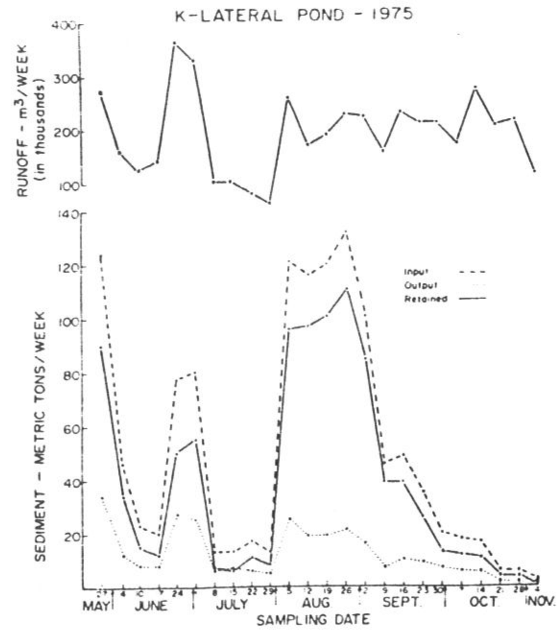


FIG. 2 Surface water runoff and sediment entering, retained, and leaving the sediment pond during the 1975 irrigation season.

The inflow sediment and the sediment retained were used to calculate the sediment removal efficiency.

## RESULTS AND DISCUSSION

Runoff volume and sediment concentration entering the K-lateral pond in 1975 (Fig. 2) is representative of the 5 yrs studied. Runoff decreased during the first 3 weeks of June and the last 3 weeks of July 1975. The low runoff rate in June was due to preplant irrigation of corn and beans, as well as irrigating small grains and alfalfa. The first irrigation of row crops yields less runoff and sediment than later irrigations. During the low runoff in July, plant water requirements were high and some crops were being cultivated. Because most of the soil being irrigated was loose and friable and runoff rates were small, sediment eroded from the fields was probably deposited in farm drainage channels before reaching the pond. This was attributed to low stream velocity in relatively flat drainage channels. Only small quantities of sediment entered the pond during these low runoff periods.

Runoff peaked the last week of June and the first week of July when alfalfa was being harvested and when most other fields had been preplant irrigated for planting corn and beans. At these times many farmers do not use their water but let it flow through the farm and into drains or lower lying laterals. Runoff peaked again during hay harvest, the first week of August, after the 4-week low runoff period in July. During these peak runoff periods, the increased water velocity carried the channel-deposited sediments into the pond.

The flow rate affected both the sediment concentration entering and leaving the pond (Fig. 3). Bondurant et al. (1975) reported that removal efficiencies were higher at higher flow rates for the same pond during the 1972-1974 irrigation seasons. This was true for the 1975 and 1976 seasons. However, frequency analysis of the daily flow

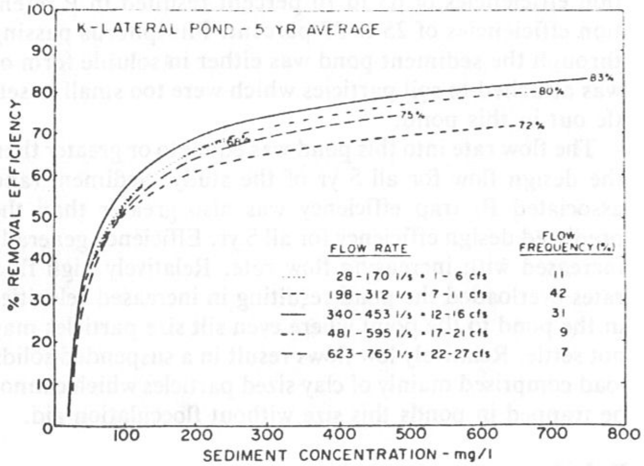


**FIG. 3 The effect of sediment concentration and flow rate on the sediment removal efficiency.**

rate and sediment concentration data entering the pond at each sampling date for the 5-yr study period indicated that this was true only for flows between 170 L/s and 453 L/s (Fig. 3). When the flow was 28 to 170 L/s, the sediment concentration entering the pond was never greater than 240 mg/L, and the peak sediment removal efficiency was 68 percent or less. At these flow rates most of the suspended sediment is smaller than 5 $\mu$m and will not settle out in this pond. The sediment removal efficiency increased to 83 percent as the flow increased from 340 to 453 L/s. However, when the flow increased to 623 to 765 L/s the sediment removal efficiency decreased to 75 percent because of the higher flow velocity. The retention time in the pond was decreased by almost 1 h at this flow rate, allowing more sediment to pass through the pond. The data showed the K-lateral pond removed sediment most efficiently when streamflow was 340 to 453 L/s and when the sediment concentration ranged from 240 mg/L up to the highest concentration measured, 750 mg/L.

The minimum and maximum retention times for the daily flows during the 5-yr study period ranged from 1.1 to 12.8 h (Table 1). The daily average retention time ranged from 2.1 to 3.4 h when the average daily flows ranged from 456 to 278 L/s, respectively. As the average retention time increased (Table 1), the sediment removal efficiency increased (Table 2) for each year studied, except 1973. The pond capacity decreased as sediment settled in the pond, decreasing the pond retention time. As sediment settled at the inlet to form a delta, the full length of the pond was no longer effective in removing sediment. Sediment was mechanically removed from the pond every other year during this study.

During 1973 (a year the pond was cleaned), the average retention time was the highest, yet the sediment removal efficiency was the lowest as compared with the other years studied. During 1973, only about one-half as much sediment entered the pond as compared with the other 4 years as shown in Table 2. Also, 37 percent of the time during 1973, the average daily flow was less than 200 L/s and sediment concentration was less than 400 mg/L. Thus, a large percentage of sediment eroded from fields could have been deposited in the K-lateral drainage channel during 1973, only to be subsequently removed mechanically, having never gotten to the pond. About 4.5 metric tons of sediment per hectare of irrigated area in the whole Northside Canal system is mechanically removed annually from laterals and drains. For the 5-yr study period, average retention time was lowest during 1976, when the flow rate exceeded 481 L/s 43 percent of the time. Also, only during 1976 was stream flow greater than 800 L/s, which occurred 8 percent of the time. As a result, a higher percentage of eroded sediment was carried through the retention pond with a resulting lower sediment removal efficiency. The annual sediment removal efficiency ranged from a low of 65 percent in 1973 to a high of 76 percent in 1975. The daily average flow rate frequently ranged from 340 to 453 L/s

TABLE 1. THE DAILY MINIMUM, MAXIMUM, AND AVERAGE WATER FLOW AND RETENTION TIME, ALONG WITH THE ANNUAL WATER FLOW THROUGH THE K-LATERAL SEDIMENT POND OVER A FIVE-YR PERIOD.

| | Water flow and retention time | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Min. flow, L/s | Ret. time, h | Max. flow, L/s | Ret. time, h | Avg. flow, L/s | Daily avg. ret. time, h | Inflow, $m^3 x 10^3$ |
| 1972 | 159 | 5.9 | 674 | 1.4 | 360 | 2.6 | 5371 |
| 1973 | 74 | 12.8 | 637 | 1.5 | 278 | 3.4 | 4205 |
| 1974 | 147 | 6.4 | 552 | 1.7 | 326 | 2.9 | 5350 |
| 1975 | 108 | 8.7 | 600 | 1.6 | 317 | 3.0 | 4606 |
| 1976 | 201 | 4.7 | 844 | 1.1 | 456 | 2.1 | 7171 |
| Avg. | 138 | 6.8 | 661 | 1.4 | 347 | 2.7 | 5340 |

TABLE 2. METRIC TONS OF SEDIMENT REMOVED ANNUALLY AND PRECENT SEDIMENT REMOVAL EFFICIENCY OF THE K-LATERAL SEDIMENT POND OVER A 5-YEAR PERIOD.

| | Total sediment | | | | |
|---|---|---|---|---|---|
| Year | Inflow | Outflow | Retained | Daily Av. | Removal efficiency, % |
| | metric tons | | | | |
| 1972 | 1245 | 401 | 844 | 4.9 | 68 |
| 1973 | 629 | 221 | 408 | 2.4 | 65 |
| 1974 | 1143 | 294 | 849 | 4.4 | 74 |
| 1975 | 1216 | 288 | 928 | 5.5 | 76 |
| 1976 | 1899 | 614 | 1285 | 7.1 | 68 |
| Avg. | 1226 | 364 | 863 | 4.9 | 70 |

TABLE 3. TOTAL P REMOVED ANNUALLY AND PERCENT REMOVAL EFFICIENCY OF THE K-LATERAL SEDIMENT POND OVER A 5-YR PERIOD.

| | Total P | | | | |
|---|---|---|---|---|---|
| Year | Inflow | Outflow kg/yr | Retained | Daily av. retained kg/day | Removal efficiency, % |
| 1972 | 1707 | 1234 | 473 | 3.5 | 28 |
| 1973 | 1375 | 1027 | 348 | 2.2 | 25 |
| 1974 | 1357 | 924 | 433 | 2.9 | 32 |
| 1975 | 1463 | 978 | 485 | 3.1 | 33 |
| 1976 | 2373 | 1726 | 647 | 3.5 | 27 |
| Avg. | 1655 | 1178 | 477 | 3.0 | 29 |

during 1975, which had the highest sediment concentration and the highest removal efficiency as compared with that for the other 4 years.

The total P removal efficiency ranged from 25 to 33 percent, with the low and high efficiency years in 1973 and 1975, respectively (Table 3). Carter et al. (1974) found that removing sediment from return flow streams also removes P because most of the P is attached to sediment. However, the P removal efficiency never equals or exceeds the sediment removal efficiencies for several reasons. First, some soluble P will always pass through the pond, even with 100 percent sediment removal. Also, when the flow rate exceeds the most efficient sediment removal value, a greater amount of small sediment particles with attached P pass through the pond. When the flow rate is lower than the most efficient sediment removal value, less sediment enters the pond and the finer clay particles with attached P still pass through the pond.

The K-lateral pond was constructed at canal company expense at our specifications on undeveloped land owned by the Jerome Country Club adjacent to a 9-hole golf course constructed on soil underlain with basalt. During this 5-yr study, sediment removed from the K-lateral pond was placed over areas of protruding basalt and grass was planted to improve the golf course. In other instances, sediment trapped in ponds has been used to fill low areas in fields and to reduce the slope on some fields, thus making them less subject to erosion.

## CONCLUSIONS

A five year study of the sediment and phosphorus trapping efficiency of a sediment pond carrying irrigation runoff water showed that P retention is directly correlated with sediment retention. Seasonal sediment retention efficiencies of 65 to 76 percent resulted in P retention efficiencies of 25 to 33 percent. Phosphorus passing through the sediment pond was either in soluble form or was attached to soil particles which were too small to settle out in this pond.

The flow rate into this pond was equal to or greater than the design flow for all 5 yr of the study. Sediment (and associated P) trap efficiency was also greater than the predicted design efficiency for all 5 yr. Efficiency generally increased with increasing flow rate. Relatively high flow rates overloaded the pond resulting in increased velocities in the pond to the point where even silt size particles may not settle. Relatively low flows result in a suspended solids load comprised mainly of clay sized particles which cannot be trapped in ponds this size without flocculation aid.

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# APPENDIX E

# LAKE NUTRIENT LOADINGS
# FROM ON-LOT WASTEWATER DISPOSAL SYSTEMS

# Literature Review: Lake Nutrient Loadings from On-Lot Wastewater Disposal Systems

by
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On-lot wastewater disposal systems at watershed residences are often suspected of contributing substantially to lake nutrient loadings. Specific documentation of their contribution is much less frequent, however. Direct measurement is hindered by soils and hydrogeological variation, even within a rather limited area, lack of technical capability, and the high cost of sinking wells. The alternative is to assess the role of on-lot systems in lake nutrient budgets by means of judgment and prediction techniques based on observations and knowledge of system operating characteristics, soils and hydrogeology, and the activities of nitrogen (N) and phosphorus (P) within these media. This review will cover relevant factors in disposal system operation and the physical, chemical and biological transformations involving nitrogen and phosphorus under various soils and hydrogeological conditions, as reported in the literature. It will then demonstrate how this knowledge can be applied to make the assessment. The review will conclude with a brief discussion of methods that have been employed to make direct measurements of the flow of disposal system effluents to lakes.

## Factors in On-Lot Disposal System Operation

The most fundamental determinant of whether an on-lot system will contribute substantially to lake nutrient loads is whether it is in proper operation. A system which has failed, if it is in a direct drainage path to a lake, can discharge large quantities of nutrients via surface runoff and interflow. A single malfunctioning system on the shore of a small Washington State lake was estimated to contribute one-quarter to one-half of the phosphorus added to the lake by all on-lot disposal systems (Gilliom, Patmont; personal communications).

Hill and Frink (1979) analyzed septic system failures and defined system half-life as the time until failure of 50 percent of the systems in a given area. In studies involving locations in three states, they documented half-lives ranging from 27 years in Connecticut to 60 years in Virginia. Categorized on a soils basis, half-lives of 23 years were observed in loose glacial till, 38 years in compact till, but as little as 3-5 years in hardpan. Gilliom (unpublished data) estimated phosphorus loadings to lowland lakes in the Puget Sound region by mass balance and compared the results to residential development patterns. The best correlation was between flooding and number of dwellings present in 1940, reinforcing the association between nutrient contribution and aged on-lot disposal systems.

Bouma et al. (1972) observed that drainfields in service for some time exhibited ponded effluent in the bed caused by a crustal organic layer at the bed-soil junction. Flow of effluent through this layer was impeded but not stopped, resulting in unsaturated conditions below the bed, in contrast to saturation within the drainfield itself. Sawhney and Starr (1977) concurred with this observation. The extent of saturation in the subsurface drainage path of effluent is one factor regulating the fate of nitrogen and phosphorus.

Nitrogen Transformations

Nitrogen is present in septic tank effluents, primarily in the ammonium-nitrogen ($NH_4^+$-N) and organic forms. $NH_4^+$-N typically represents about 80 percent of the total N (Walker et al, 1973a) and ranges in concentration from approximately 60 to 75 mg/l (Viraraghavan, 1973). Organic N is eventually mineralized to $NH_4^+$-N by saprophytic bacteria in the drainfield soils and undergoes the same transformations as the original inorganic fraction (Sikora and Corey, 1976). Walker et al. (1973a) found that organic N was sharply reduced within a distance of 15 cm below seepage beds in sands and loamy sands. During periods of soil saturation and poor aeration, mineralization may be retarded. After drying, decomposition would convert the stored organic N and produce an inorganic pulse (Starr and Sawhney, 1980). Little nitrate-nitrogen ($NO_3^-$-N) and nitrite-nitrogen ($NO_2^-$-N) are present in sewage, and essentially none forms in the anaerobic environment of the septic tank.

Ammonium in solution is rapidly sorbed by soil particles as long as sorption sites remain available (Sikora and Corey, 1976). A soil's ability to sorb $NH_4^+$-N is a function of its cation exchange capacity (CEC). CEC is in turn dependent on the proportion of negatively charged clay particles in the soil mix. Clay soils thus are high and coarse sandy soils are low in CEC. Because sorption sites are quickly consumed in any actual effluent infiltration zone, ion exchange is not normally a significant N removal process. In saturated soils, and consequent anaerobic conditions, most of the $NH_4^+$-N would move intact to groundwater.

More typically, unsaturated soils and aerobic conditions exist beneath drainfield beds. Walker et al. (1973a) measured 19.6 percent oxygen in soil pores within an effluent infiltration zone, almost as high as in the atmosphere. In this situation, nitrifying bacteria oxidize $NH_4^+$-N first to $NO_2^-$-N and then $NO_3^-$-N, obtaining energy for cell formation in the process. Nitrification is energetically favored and proceeds rapidly with high oxygen concentration and temperature and alkaline soil pH. Its rate is retarded with increased soil moisture tension (reduced aeration) and decreased temperature and pH. Viraraghavan and Warnock (1976) measured only

20-35 percent nitrification in winter in loam soils, compared to 80-90 percent in summer.

$NO_3^-$-N is highly soluble and moves freely through the soil solution by convection, as well as by molecular and ionic diffusion due to concentration gradients (Walker et al., 1973b). Its potential to enter groundwater is thus high, particularly in the case of porous soils draining seasonally high precipitation.

The only possible mechanism by which $NO_3^-$-N can be reduced is denitrification, the conversion of $NO_3^-$-N to nitrogen gas ($N_2$) by heterotrophic, facultative bacteria operating under anaerobic conditions. Because $NO_3^-$-N is a necessary reactant for this process and the aeration requirements are opposite for nitrification and denitrification, the two processes rarely occur in the same locale. In addition, denitrification yields bacteria relatively little energy and is greatly retarded at pH less than 5.5 and temperature under 10°C (Northern Virginia Planning District Commission, 1979). A deficiency of carbon for the heterotrophic bacteria in sandy soils is also an impediment (Walker _et al._, 1973). For these reasons, denitrification is generally of only minor importance in some soils and practically none in others.

Considering the relative unimportance of N removal processes, such as adsorption of $NH_4^+$-N and precipitation or denitrification of $NO_3^-$-N, there is little to stop N transport to groundwater, especially in loose soils. Walker _et al._ (1973b) and Starr and Sawhney (1980) documented N transport to groundwater without apparent loss in sandy soils. The former authors commented that the only active mechanism of lowering $NO_3^-$-N concentrations in this situation is by dilution with uncontaminated groundwater. If groundwater intercepts a lake, however, the load of N it carries is available to potentially stimulate photosynthesis in the lake.

Considering the potential nitrogen transformations and generally prevailing soil moisture tensions in different textural classes, Sikora and Corey (1976) predicted the N forms likely to be present in the various soils. Nitrification is expected to be nearly complete at most times in sands, sandy loams, loamy sands and loams. Thus, N will be primarily in the $NO_3^-$-N form. In silt loams and silty clay loams, a mixture of $NH_4^+$-N and $NO_3^-$-N is likely. In these soils, there is some possibility of $NO_3^-$-N reduction through denitrification. Nitrification would be severely retarded in clay loams and clays, such that $NH_4^+$-N would predominate.

In summary, most nitrogen in septic effluent rather quickly takes the ammonium form. $NO_3^-$-N is subsequently formed with effective soil drainage in all but the heavier textured soils. This form is easily transported in soils and has a high potential to enter groundwater and, ultimately, surface waters. N breakthroughs to lakes as high as 50-70 percent have been reported (Kerf and Skinner, 1981; Johnston _et al._, 1965). Using a leachate detector which measures conductivity and fluorescence, the former workers estimated a mean of 16 percent N breakthrough (in a range of 3-49 percent) around Crystal Lake, Michigan. They observed the most erupting plumes in areas of high groundwater. Whether in the $NH_4^+$-N or $NO_3^-$-N form, leached nitrogen is available to stimulate algal and aquatic plant growths in receiving waters.

Phosphorous Reactions

Anaerobic digestion in septic tanks converts most organic and condensed inorganic phosphate forms to soluble orthophosphate ($PO_4$-P). Magdoff et al. (1974) and Otis et al. (1975) found more than 85 percent of the total P (TP) in septic tank effluents to be $PO_4$-P. The remainder is converted to $PO_4$-P in a few hours to a few days (Hook et al., 1978). Meanwhile, other inorganic forms react with soil in a manner similar to $PO_4$-P (Block, 1970).

Various investigators have reported TP concentrations in effluents, including Viraraghavan (1973) (22-24 mg/l); Magdoff et al. (1974) (range 15.6-24.5; mean 20.6 mg/l); and Otis et al. (1975) (range 11.0-31.4; median 12 mg/l). Sawyer (1965) estimated that detergent builders comprised 50-75 percent of the total P in domestic wastewater at the time. It can be supposed that wastewater concentrations declined somewhat as smaller quantities of phosphates were incorporated in detergents, but the U.S. Environmental Protection Agency (1980) still cited a TP range of 18-29 mg/l in septic tank effluent. In light of these various pieces of evidence, a value of 20 mg/l TP appears to be a reasonable assumption for assessment purposes.

When effluent phosphates first contact soils, rapid adsorption on mineral and organic surfaces occurs, to an extent determined by the soil's adsorption capacity. That capacity is often illustrated by a Langmuir adsorption isotherm, which relates the quantity of phosphorous sorbed per unit mass of soil with the P concentration in the soil solution. Figure 1 portrays a typical isotherm shape. The quantity of P sorbed depends on exposure time; thus experiments designed to measure sorption capacity must extend over a sufficient period, for example at least 200 hours in loam soils (Sawhney, 1977).

Adsorption occurs via reactions between negatively charged PO4-P and positive iron, aluminum and calcium ions and organic surfaces carrying positive charges. Reactions with iron and aluminum predominate in acidic and neutral soils, while those with calcium are most important in calcoreous, alkaline soils. Adsorption capacities are low in coarse sands of low organic content and tend to rise in finer textured soils, as surface area per unit soil volume increases. Clay minerals also generally contain substantial iron and aluminum oxides, and adsorption increases along with their proportion. Sawhney and Hill (1975) measured P sorption increase from 9 mg/100 g of sandy loam to 29 mg/100 g in the case of fine sandy loam. Grim (1953) claimed 93-217 mg/100 g capacity for clay

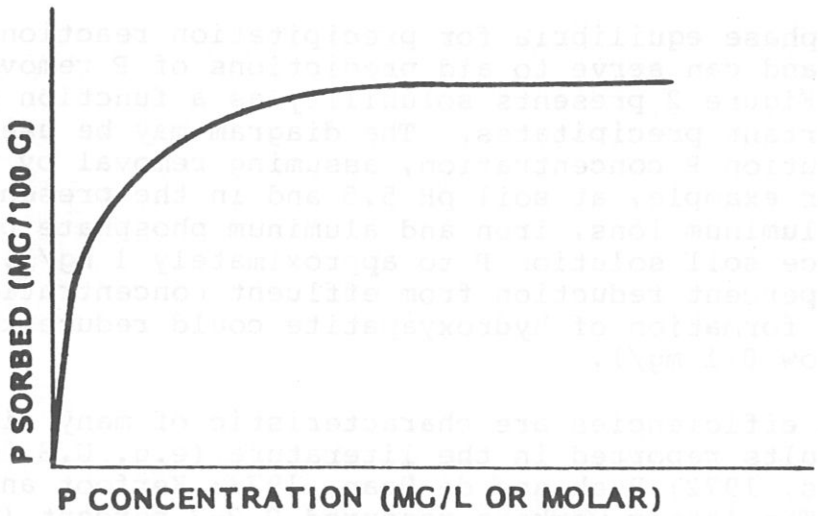


Figure 1. Typical Longmuir Adsorption Isotherm for Phosphorus

soils. The Northern Virginia Planning District Commission (1979) cited adsorption in clay loam which was predicted by Langmuir isotherms to be 25 times that in sandy soil.

Adsorption capacity depends on the specific mineralogical and textural characteristics of a soil and must be determined with experiments on the soil itself. Its measurement still does not indicate the soil's full ability to remove P. For one reason, P sorption sites can apparently be regenerated, such that considerably more sorption is possible than predicted in equilibrium laboratory experiments (Sawhney and Hill, 1975). These authors hypothesized that alternate drying and wetting brings fresh mineral surfaces in equilibrium with the soil solution.

A more important reason for the inadequacy of adsorption data to predict P removal is that phosphate precipitation reactions also readily occur after the saturation of sorption capacity. These reactions proceed at slower rates than adsorption, and thus are dependent on longer detention times. Precipitation also requires $PO_4$-P concentration in excess of 7-10 mg/l (Hook <u>et al</u>., 1978), a level almost always maintained in septic tank effluent.

Specific precipitation products depend on soil mineralogy, with calcium phosphates predominating in calcareous soils and iron and aluminum phosphates otherwise. Soils in limestone regions and clay minerals thus have relatively high capacities to both precipitate and adsorb phosphates. In calcareous soils and at high wastewater P concentrations, dicalcium phosphate ($CaHPO_4 \cdot 2H_2O$) and octocalcium phosphate ($Ca_4H[PO_4]_3 \cdot 3H_2O$), are formed initially. At the pH generally prevailing in on-lot disposal system seepage fields, a slow conversion ensues to stable hydroxyapatite, $Ca_5(PO_4)_3(OH)$.

The chemical phase equilibria for precipitation reactions are all well-defined and can serve to aid predictions of P removal by this mechanism. Figure 2 presents solubility as a function of pH for the most important precipitates. The diagram may be used to forecast soil solution P concentration, assuming removal by precipitation alone. For example, at soil pH 5.5 and in the presence of excess iron and aluminum ions, iron and aluminum phosphate precipitation would reduce soil solution P to approximately 1 mg/l, representing about 95 percent reduction from effluent concentration. In an alkaline soil, formation of hydroxyapatite could reduce the concentration below 0.1 mg/l.

These removal efficiencies are characteristic of many field investigation results reported in the literature (e.g. U.S. Army Corps of Engineers, 1972; Beek and de Haan, 1973; Kerfoot and Skinner, 1981). The latter workers measured 0.2-2 percent (mean 0.7 percent) P breakthrough at Crystal Lake, Michigan, in contrast to 3-49 percent N breakthrough. Still, the evidence for effective P removal is not unanimous; e.g. Viraroghavan and Warnock (1976) measured only 25-50 percent P reduction in several loam soils. Adsorption and precipitation depend on local hydrogeological factors and the quality of on-lot systems. Additionally, leaching of even P concentrations of the order 1 mg/l could be an important factor in the overall P loading to a small lake, an embayment, a heavily developed lake and other sensitive cases.

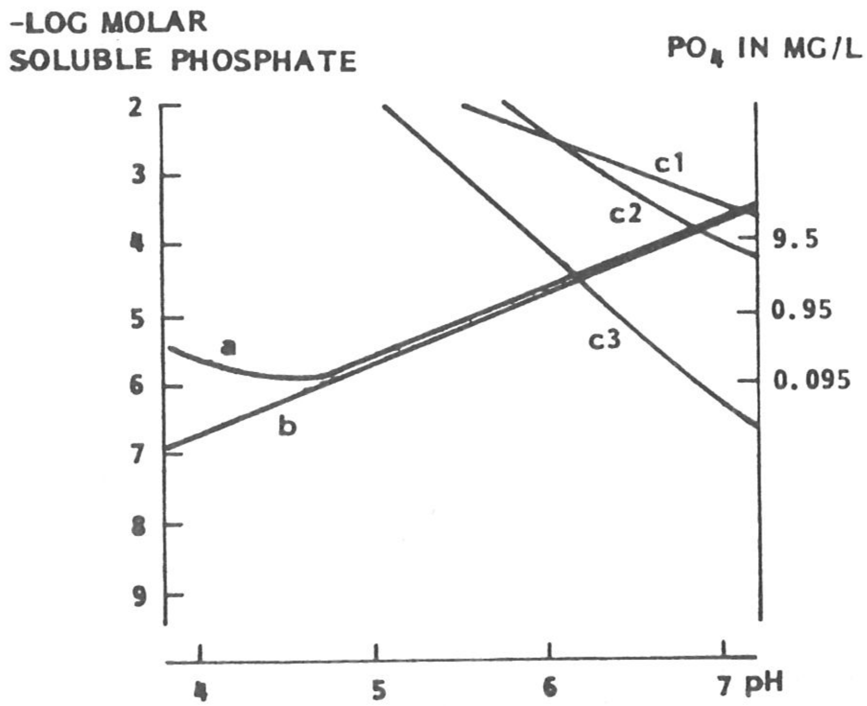


Figure 2. Total Phosphorus Solubility as a Function of pH for: (a) aluminum phosphates; (b) iron phosphates; ($c_1$) dicalcium phosphate; ($c_2$) octacalcium phosphate; ($c_3$) hydroxyafatite (Beek and de Haan, 1973)

Another way of viewing the ability of a soil to precipitate phosphorous is its capacity on a unit mass basis, as was explored for adsorption. Less evidence exists in the case of precipitation. Extractions from septic tank drainfields in sandy Wisconsin soils ranged from about 10 to 30 mg P/100 g soil, representing both adsorption and precipitation over a long period (Sikora and Corey, 1976). A column study running less than one year produced 12.1 mg/100 g capture by a sandy soil (Magdoff and Keeney, 1976). Measurements of this type would be required on specific soils in question to provide definitive evidence for assessment, and this must be interpreted in light of other local hydrogeological conditions.

The most important hydrogeological conditions influencing actual P removal are soil drainage, the position of the groundwater table relative to the drainfield, and the condition of bedrock. Insufficient spacing between the drainfield and seasonal high water table would not allow opportunity for the removal mechanisms to operate. Sawhney and Starr (1977) stated that at least 60 cm spacing is required for effective P removal.

Shallow soil overlying soluble, unconsolidated, or fractured bedrock would permit rapid passage of effluent to groundwater. Poor drainage or the presence of seasonal high groundwater or a perched water table would decrease aeration and lead to reducing conditions. Ferric iron would then be converted to the soluble ferrous form, which would convey bound phosphates along into solution.

A question which has not been adequately answered and which is crucial to phosphorous movement in soil is whether breakthrough can be expected after sufficient loading. Campbell and Racz (1975) showed that P breakthrough did occur in time beneath a feedlot. Regeneration of adsorption sites, especially where seasonal occupancy of lakeside dwellings allows soils to dry, would contribute to holding off soil saturation with P for a considerable period. Gilliom's (personal communication) evidence that on-lot disposal system P loadings to lakes are correlated with the number of old systems present may be interpreted to support breakthrough or system failures or both as possible causes of elevated loadings.

It may be possible to assess breakthrough by using adsorption and precipitation capacity and drainfield size to predict the rate of vertical P penetration. This rate could be compared with distance to mean water table to predict the occurrence of breakthrough. This subject will be explored in more detail in the following section.

Predictive Assessment of On-Lot System Nutrient Loadings

Prerequisite to assessing lake nutrient loadings from on-lot disposal systems are field observations and study of available information on pertinent watershed characteristics. Before undertaking these investigations, it must be decided what portion of the watershed will be covered. A full assessment of loadings would involve that portion entering the lake via tributaries, as well as directly along the lakeshore. If the overall objective is to establish total lake nutrient loadings, the tributary on-lot system contributions could be at least partially accounted for by measuring stream concentrations under base flow conditions and multiplying by flow to obtain loadings. That approach would omit any additions as a result of seasonal high water table involvement with upland on-lot systems, and this factor would have to be considered separately. If the overall project includes storm runoff sampling in the tributaries and if some of the sampling corresponds to seasonal high water table occurrence, then it should be possible to account for nutrient contributions by on-lot systems along tributaries under all circumstances (dry weather, seasonal high groundwater, and other wet weather conditions). The next question is the width of the band around the lake to investigate for on-lot system contributions. Definition of that band should depend on topographical, soils and hydrogeological features and should await further observations and study.

Field work should include visual observation of the affected area and interviews with those who might supplement printed information on local conditions. Tours of the area would be useful to survey development patterns and specific topographic features, to note the occurrence of surface on-lot system failures, and to discover any littoral attached algal accumulations which might indicate the presence of seeping wastewater. Kerfoot and Skinner (1981) found that the greatest densities of the nuisance filamentous green alga Cladophora were associated with the largest concentrations of erupting drainfield plumes. Personnel such as sewage enforcement officers and Soil Conservation Service employees should be interviewed to gain their knowledge of soils and hydrogeological conditions and failing systems.

The investigation should aim at collecting as much relevant printed information on the study area as possible. Useful documents would include:

- Land use and development surveys
- Demographic and resource use statistics
- Topographic maps
- Soils surveys
- Geological maps
- Percolation test reports
- Reports on the suitability of the area for such purposes as on-lot wastewater disposal and sanitary landfills

- Well logs and other groundwater surveys

- Reports on lake hydrology

Under ideal circumstnaces, the combined results of visual observations, interviews and study of printed sources would produce a rather complete description of the factors important in assessing on-lot system loadings. In reality, the description is likely to be incomplete in some degree. In that event, the assessment must either proceed with the available information, or measurements must be made which are likely to be expensive.

The total body of information available should be reviewed for the following points:

- Locations and numbers of year-round and seasonal dwellings, as well as institutions, using on-lot disposal

- Population statistics and any reported usage of water and phosphorous-based detergents

- Elevations of prominent points and slopes

- Soils textures and mineralogy

- N and P immobilization capacities

- Depths to bedrock

- Occurrence of limestone, gravel or fractured bedrock

- Depths to mean and seasonal high water table at as many points as possible

- Occurrence of perched water tables

- Occurrences of very rapid and very poor soil drainage

- Directions and rates of groundwater flow at as many points as possible

- Occurrence of such features as a clay layer which could seal the lake from groundwater

- The lake water balance to determine the importance of groundwater inflow

As a first step in applying the assembled information to the assessment, it would be useful to prepare a map depicting the important factors. Mapping should employ a shading or coloring scheme to illustrate such features as:

- Steep slopes (>15 percent)
- Soils of poor suitability for on-lot disposal
- Occurrence of limestone, gravel, or fractured bedrock overlain by shallow soils
- Areas of high groundwater and/or poor soil drainage
- Arrows indicating groundwater flow directions

Where information is sufficient, the map should show groundwater elevation contour lines to assist in the evaluation of transport toward the lake.

With all available information of the type described gathered and classified, the loading assessment can be conducted at several levels of detail, depending on the completeness of the description. When little soils and hydrogeological information exists, the assessment must depend on known development patterns and published average N and P releases. As the description improves, more discretion can be employed in applying predictive techniques. The best situation, short of direct field measurement of nutrient transport, would be when N and P immobilization capacities, drainfield characteristics, depths to groundwater, and groundwater flow characterisics are well known. Then, the time until nutrient breakthrough and the subsequent loading rates could be quite accurately estimated. These various assessment strategies will be detailed in the following paragraphs.

Dillon and Rigler (1975) presented a method for predicting the capacity of a lake for development based on it traffic status and designated levels of protection. That method includes evaluation of phosphorus loading from on-lot disposal systems. Their basic equation is:

$$L_p = S_p N_E (1-R_p) \qquad \text{(Equation 1)}$$

Where: $L_p$ = total P loading (kg/yr)
$S_p$ = P supply (kg/capita/yr), given as 0.8
$N_E$ = equivalent number capita - yr/yr in residence
$R_p$ = soil retention coefficient of total P (Table 1 lists some values; it should also be recalled that Kerfoot and Skinner, 1981, measured $\geq$98 percent retention in glacial soils)

The expression for $N_E$ encompasses both permanent and seasonal dwellings, assuming 253 capita-days/yr (0.69 capita-yr/yr) for seasonal dwellings and 4.3 persons/dwelling for permanent homes, as follows:

$$N_E = 0.69\ N_s + 4.3\ N_p \qquad \text{(Equation 2)}$$

Where: $N_s$ = number seasonal dwellings within 300 m of lake
$N_p$ = number permanent dwellings within 300 m of lake

On the basis of the previous discussion of P reactions in the soils, it can be assumed that any P that eventually enters the lake is in the soluble $PO_4$-P form.

Table 1. TP Retention Coefficients for Various Seepage Bed Soil Characteristics (after Brandes et al., 1974, as reported by Dillon and Rigler, 1975)

| Soil type | $D_{10}$ (mm)[a] | Soil depth (cm) | $R_p$ |
|---|---|---|---|
| 96 percent sand | 0.24 | 56 | 0.76 |
| 96 percent sand | 0.30 | 76 | 0.34 |
| 96 percent sand | 0.60 | 76 | 0.22 |
| 96 percent sand | 0.24 | 76 | 0.48 |
| 96 percent sand | 1.0 | 76 | 0.01 |
| 96 percent sand | 2.5 | 76 | 0.04 |
| 90 percent sand | 0.24 | 38 | 0.88 |
| 50 percent limestone, 50 percent sand | 0.24 | 38 | 0.73 |
| Silty sand | -- | 76 | 0.63 |
| 50 percent clay-silt, 50 percent sand | 0.24 | 38 | 0.74 |

[a] $D_{10}$ is the diameter below which all but 10 percent of the material occurs by size.

Improved estimates would result when information availability would permit adaptation of the model to local circumstances. It should first be considered whether the analysis can be partitioned into separate determinations for different soils and hydrogeological characteristics around the lake. If so, organization of the analysis would be guided by the preliminary findings and mapping of relevant features. Subareas might be defined on the basis of:

- Areas with more or less than 15 percent slopes.
- Soil types.
- Areas with more or less than 60 cm spacing to groundwater (or otherwise classified on the basis of relative drainage rates).
- Areas with more or less than 60 cm spacing to bedrock (with indication of the condition of bedrock).

- Areas contributing and not contributing groundwater to the lake.

It would be appropriate to assume that all P produced is transported to the lake ($R_p = 0$) in areas with excessively steep slopes, insufficient spacing to groundwater or poor-quality bedrock or excessively poor or rapid drainage. Areas in which groundwater flow is away from the lake should be considered non-contributors of phosphorus.

Other modifications to the model can be made when the condition of on-lot systems is known. Surface failures in the direct drainage to the lake should be assumed to contribute all of the P produced to the lake ($R_p = 0$). When the ages of the systems are known, a rough estimate of the number of disfunctional systems could be made on the basis of the half-life data presented previously. Table 2 presents an interpretation of that data, assuming a linear failure rate within each half-life interval. Thus, linear interpolation is possible to estimate the percentage of failures after a given number of years.

Table 2. Estimated Time until Certain Percentages of On-Lot System Failures have Occurred for Three Soils (after Hill and Frink, 1979)

| | Years to failure | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cumulative percent failure: | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| Soil | | | | | | | | | |
| Loose glacial till | 4.6 | 9.2 | 14 | 18 | 23 | 32 | 41 | 54 | 78 |
| Compact glacial till | 7.6 | 15 | 23 | 30 | 38 | 53 | 68 | 90 | 160 |
| Hardpan | 0.8 | 1.6 | 2.4 | 3.2 | 4 | 5.6 | 7.2 | 9.5 | 17 |

The model might also be revised by modifying the constants in equations (1) and (2) when local evidence warrants. There is disagreement in the literature concerning the 0.8 kg/capita/yr TP supply cited by Dillon and Rigler (1975j, although Otis <u>et al</u>. (1975) measured the same quantity in field measurements. Other estimates have fallen in the range 0.5 (cited by Sawhney and Hill, 1975) to 3 kg/capita/yr (cited by Sikora and Corey, 1976). Two recent reports have placed the figure in the range 1.1-1.8 kg/capita/yr (Sedlak, 1980; U.S. Environmental Protection Agency, 1980). It is likely that the quantity depends on lifestyle (e.g. diet, use of dishwasher detergents), and therefore affluence, and that a value in the range 0.8-1.8 kg/capita/yr can be selected by judgment.

An expression in the form of equation (1) can also be used to predict N loading with the substitution of appropriate supply ($S_N$) and retention ($R_N$) values. Estimates of per capita annual N supply range from 2.2 - 8.2 kg/capita/yr (U.S. Environmental Protection Agency, 1980; Walker et al., 1973b). Use of the average effluent N concentrations cited previously and domestic water usage of 50-75 gal/capita/day (Metcalf and Eddy, 1972) yields $S_N$ of about 5-6 kg/capita/yr.

As with phosphorus, $R_N$ should be taken as zero when surface failures are known or suspected and where excessively steep slopes, involvement with groundwater, poor-quality bedrock under thin soils, and very poor or very rapid drainage occur. No N contribution should be assumed where groundwater flow is away from the lake. In other situations, there is little solid information on which to base judgements on N retention. In relatively coarse soils (sand, loamy sand, sandy loam, loam), the evidence is strong that most N reaches groundwater as $NO_3$-N ($R_N$ = 0-0.5). In silt loam and silty clay loam, there could be some denitrification of $NO_3$-N, with $NH_4$-N and remaining $NO_3$-N transported to groundwater ($R_N$ = 0.2-0.8). In clay loam and clay, there is some adsorption of $NH_4$-N but much would reach groundwater untransformed ($R_N$ = 0.1-0.5). The retentions cited are little more than guesses, guided somewhat by the 3-49 (mean 16) percent N penetration measured by Kerfoot and Skinner (1981) for glacial soils.

Another possible means of predicting nutrient loadings from on-lot disposal systems is to estimate the period until breakthrough would be expected on the basis of N and P immobilization capacity exhibited by the soils. Sikora and Corey (1976) presented a procedure and some immobilization data to estimate P breakthrough in this way. As pointed out, few N immobillzation mechanisms exist, and similar data have not been reported for that nutrient. Thus, N loadings at present must be forecast according to the procedure outlined above. The procedure for P follows:

1. Select a value of minimum drainfield area requirement (A). Current requirements of the Pennsylvania Department of Environmental Resources (1974) are:

| Percolation rate (min/in) | Absorption area required (sq ft/bedroom): Septic tank | Aerobic tank |
|---|---|---|
| 0-5 | Sand filter trench or aerobic tank required | 120 |
| 6-15 | 175 | 120 |
| 16-30 | 250 | 170 |
| 31-45 | 300 | 200 |
| 46-60 | 330 | 220 |
| 60-90 | 425 | 425 |
| >90 | Unsuitable | Unsuitable |

2. Select a value of per capita annual P supply ($S_p$) from the information given previously (range 0.8 - 1.8 kg/capita/yr) and multiply by population in each section of the watershed to be analyzed (based on soils) to obtain P loading ($L_p$).

3. Determine a value of P immobilization capacity representing sorption and precipitation ($I_p$) for each soil. In the absence of information published for the specific soil, $I_p$ must be determined by long-term measurements or selected from general published data. Values of 10-30 mg P/100g soil (Sikors and Corey, 1976) have been published for sand and 93-217 mg P/100g soil (Grim, 1953) for clay. It is presumed that loams and silts fall between these extremes.

4. Determine soil bulk densities (D). Typical values are (U.S. Department of Agriculture, 1969):

| Soil | D (g/cu cm) |
|---|---|
| Sand | 1.6 |
| Loamy sand | 1.7-2.0 |
| Sandy loam | 1.8-2.2 |
| Loam | 1.6-2.1 |
| Silty clay loam | 1.5 |

5. Calculate P penetration rate ($P_p$, cm/yr) for each section:

$$P_p = \frac{L_p \times 10^2}{I_p \, DA} \qquad \text{(Equation 3)}$$

6. Determine depth to mean water table for each section and divide by $P_p$ to estimate the number of years until breakthrough.

7. Consider slopes, seasonal high water table positions, drainage, bedrock and groundwater flows to estimate the chances for P transport to the lake prior to theoretical breakthrough, as described previously.

8. For sections where it appears that a long period will pass before breakthrough, assign a zero P loading until breakthrough ($R_p$ = 1 in equation 1) and a maximum value $R_p$ = 0) after breakthrough.

Direct Measurement of On-Lot Disposal System Effluents

The following methods are available to directly measure characteristics of groundwater beneath drainfields or entering lakes:

1. Well monitoring: Wells should be sunk to the top of the aquifer for this purpose. Its major disadvantage is the high cost of obtaining full coverage of all soils and hydrogeological conditions in a sizable watershed.
2. Deducing on-lot system loadings from stream baseflow measurements: Nutrient concentrations and baseflow rates are measured in streams in the lake watershed and multiplied to estimate loadings. These loadings are divided by the number of on-lot systems which might be leaching to the stream. The unit loadings thus derived are employed to estimate annual mass loadings from lakefront homes in areas similar to the stream catchments where the unit loadings were derived.

3. Dye tests: A biodegradable and easily detected dye such as sodium Fluorescein is flushed into a selected number of on-lot systems in order to identify erupting plumes. The disadvantages are that many applications are often necessary to obtain breakthrough and the behavior of the dye does not simulate that of the nutrients. It may be preferable to find likely locations of erupting plumes by observing concentrations of attached filamentous algae.

4. Use of the septic leachate detector: This device was invented by K-V Associates, Inc., Falmouth, Mass. (Kerfott and Brainard, 1978). It monitors conductivity and fluorescence, resulting from organics derived from detergents and biodegradation, on the theory that a stable ratio exists between these quantities in septic tank effluent. The detector scans the shoreline to identify erupting plumes. Once the plume is located, the device can sample it for nutrient analysis. In conjunction with readings from a groundwater flow meter, this measurement allows direct computation of nutrient loadings. The detector and flow meter are expensive to buy and operate and have not been widely enough used to prove their reliability under all circumstances.

5. Aerial infrared photography: The U.S. Environmental Protection Agency's Enviropod camera can be used to locate failing on-lot systems. The technique is very expensive, however, and is of limited usefulness in wooded areas.

Techniques also exist to directly measure the nutrient immobilization capacities of soils. Working in the field, soils can be excavated from leachate fields and analyzed for N and P mass per unit soil mass. The results of similar measurements on nearby soils unaffected by leachate would then be subtracted to arrive at the nutrient quantity immobilized. In the laboratory, soil columns can be constructed and dosed with simulated wastewater of known flow rate and N and P concentrations. Use of these quantities and measurements of effluent concentrations and soil volume and bulk density would permit estimation of immobilization. Such experiments must be run over long periods, of the order 200 hours, to determine adsorption capacity and until equilibrium is established to represent adsorption plus precipitation. Previous reported experiments of this type have extended close to a year.

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# APPENDIX F

# BEST MANAGEMENT PRACTICES AND GUIDELINES

# MLCD PRACTICE GUIDELINES

1. GENERAL:

All MLCL/BMPs recommended by Moses Lake Conservation District (MLCD) project Plan of Work must be approved by the MLCL Project Council (HUB) before they are authorized for cost-sharing. Increases in MLCL/BMPs C/S levels must be approved by (HUB).

2. MLCL/BMP NUMBERING SYSTEMS:

The list of Moses Lake Clean Lake Best Management Practices (MLCL/BMPs) included in the system was recommended as MLCL/BMPs from Stages One and Two of the MLCL project. The practices have been summarized, a title provided and a MLCL/BMP number assigned. The MLCL/BMPs are broken into a brief discription of the practice and its intended purpose, where the practice applies,and the practices that must be included.

A complete set of all standards and specifications for all MLCL/BMPs approved for use in the project is to be filed in the MLCL Field Office.

3. MLCL/BMP DEVELOPMENT:

MLCD shall develop MLCL/BMPs that are needed to solve water quality problems in the selected project area. MLCL/BMPs that are developed and meet the purposes shown in the MLCL list are to be titled and numbered accordingly. Other MLCL/BMPs developed by MLCD shall show "MLCL/BMP" with appropriate number and title. Each practice shall be developed and submitted to the HUB Council according to the practice format shown in paragraph 4 of this exhibit.

4. LIST OF MLCL/BMPs AND FORMAT FOR MLCL/BMPs RECOMMENDED:

A. Purpose: Each practice will show a brief descriptive statement of what or how the improvement of water quality will be achieved.

B. Applicability: State where the installation or establishment of the MLCL/BMP would be applicable for the improvement of water quality.

C. Policies: Provide the policy to be followed in carrying out the MLCL/BMP. This shall include, but is not limited to:

1. Items for which cost-sharing is authorized.

2. Items for which cost-sharing is not authorized.

3. Considerations that should be given to wildlife, pesticides, etc.

4. Other authorities or restrictions that may apply to the MLCL/BMPs.

5. Lifespan. Each MLCL/BMP shall have a specified lifespan recommended by the MLCD and shall be based on the following restrictions:

a. All MLCL/BMPs are to be carried out as specified in the WQM contract. MLCL/BMPs may not be destroyed during the minimum lifespan unless approved by MLCD.

b. The minimum lifespan for MLCL/BMPs shall be 5 years or as shown in this exhibit. A shorter lifespan that is requested and justified may only be approved by the HUB Council.

c. Lifespans of 5 years or more, but less than shown in this exhibit, must be approved by the HUB Council.

d. Lifespans may be longer periods than shown in this exhibit.

D. Specifications.

1. Show the angency responsible for providing technical assistance for the MLCL/BMPs.

2. A complete set of all standards and specifications for all MLCL/BMPs approved for use in the project is to be filed in the MLCL Field Office.

E. Technical Responsibility.

1. Show the agency designated approval authority for the practice.

F. Maximum Federal C/S.

1. Show the C/S level, or rate recommended, or both for each cost-sharable item.

2. The C/S level shall not exceed levels outlined in the MLCL Project C/S Program Handbook.

I. IMPROVING AN IRRIGATION WATER MANAGEMENT SYSTEM. (MLCL/BMP-1)

A. The Purpose of this practice is to improve water quality by effectively managing irrigation water to minimize loss of plant nutrients and to control undesirable water loss.

B. Apply this practice on farmland where excessive application of irrigation water contributes significantly to the water qualtiy problems as determined by the priority rating system.

C. Policies for this practice are as follows:

1. Cost-share is authorized for the following measures only if included in a Plan or portion of a Plan approved by the MLCL Project Staff for Irrigation Water Management.

   a. Renozzling or other mechanical measures required on side-roll or center pivots to increase the application efficiency of the system.

   b. Tensiometers or other approved instruments used to monitor soil moisture.

   c. Cost of rebuilding a pump to system specifications.

   d. Irrigation scheduling.

   e. Flow Meters or similiar devices needed to monitor water delivered to or running from a field.

2. Cost-sharing is not authorized for:

   a. Any items not listed in the Water Management Plan.

   b. Gypsum blocks.

3. Cost-share is eligible only for 3 consecutive years per type of irrigation system per farm for irrigation scheduling.

4. An Irrigation Water Management Plan must be developed and followed. The Plan must be approved by the MLCL Staff.

5. The Plan shall be maintained for a minimum of 10 years following the calendar year of installation.

6. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

7. Equipment cost-share will be repaid if IWM is not done.

(Continued on page 4)

D. Specifications.

Will be in accordance with MLCL Standards and Specifications.

E. Technical Responsibility.

Is assigned to the MLCL Project Staff.

f. Maximum Cost-shares.

1. 75% of the actual cost of tensiometers, nozzles, sprinkler heads, flowmeters, and other mechanical devices needed as identified in the Irrigation Water Management Plan.

2. 50% of the actual cost of rebuilding a pump.

3. Irrigation scheduling paid at the following rates:

   a. Furrow Irrigation-- $7.50/ acre

   b. Sideroll Irrigation-- $5.62/ acre

   c. Center Pivot Irrigation-- $3.75/ acre

II. IMPROVING AN IRRIGATION SYSTEM. (MLCL/BMP-2)

A. The purpose of this practice is to improve water quality on farmland that is currently under irrigation, for which an adequate supply of suitable water is available, and on which irrigation will be continued.

B. Apply this practice on farmland which significantly contributes to the water quality problems as determined by the priority rating system.

C. Policies for this practice are as follows:

1. Cost-sharing is authorized for the following system design only if included in a plan or a portion of a plan approved by MLCL Project Staff for reorganizing an irrigation system. All systems must be permanently installed. A Water Management Plan will be included in the reorganization of the system and must be followed. Irrigation Water Management is reimbursable under MLCL/BMP-1.

   a. Conversion of an existing lined or unlined head ditch system to cablegation.

   b. Conversion from furrow irrigation to a sprinkler system.

   c. Conversion from sideroll/handline irrigation to a center pivot.

   d. Additional siderolls needed to apply irrigation water at the proper frequencies.

   e. Cost of center pivot and installation.

   f. Replacing a mainline or portable mainline at the same location.

2. Cost-sharing is not authorized for the following:

   a. Removal of concreted lined ditches. Ditches less than ten years old and installed with ASCS cost-share monies require written approval by ASCS/COC before removal.

   b. Reorganizing a system, if the primary purpose is to bring additional land under irrigation.

   c. Portable pipe, cleaning a ditch, or installations primarily for the farm operator's convenience.

   d. Restoring a system which has deteriorated due to lack of maintenance during periods of non-use.

   e. Land under irrigation for practice eligibility purposes must have been irrigated 4 of the last 5 years.

   f. Cost of bringing power to the pump.

(Continued on page 6)

3. The system must be maintained for a minimum of 10 years following the calendar year of installation.

4. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

D. Specifications.

Will be in accordance with applicable MLCL technical standards and specifications.

E. Technical Responsibility.

Is assigned to the MLCL Project staff. Practice must be performed according to an approved design. The Water Management Plan is also required.

F. Maximum Cost-shares.

1. Cost of materials and installation which are necessary for the proper functioning of the project as follows:

   a. 50% of the actual cost of pumps and appurtences needed for installation of new systems.

   b. Cost of PVC pipeline--50% of the actual cost, not to exceed the maximums listed below.

| HIGH PRESSURE PVC | | LOW PRESSURE PVC |
|---|---|---|
| 4" | $1.20/ft. | $ .70/ft. |
| 5" | $1.45/ft. | $ .88/ft. |
| 6" | $1.74/ft. | $1.05/ft. |
| 8" | $2.50/ft. | $1.40/ft. |
| 10" | $3.39/ft. | $1.75/ft. |
| 12" | $4.61/ft. | $2.10/ft. |

   c. 50% of the actual cost of siderolls.

   d. 50% of the actual cost of center pivots when converting from furrow irrigation. HUB committee has ultimate approval authority.

   e. 30% of the actual cost of center pivots when converting from sideroll irrigation. HUB committee has ultimate approval authority.

   f. 50% of the actual cost not to exceed the maximum of $1,000 for wildlife watering facilities.

## III. FERTILIZER MANAGAGEMENT. (MLCL/BMP-3)

A. The Purpose of this practice is to improve water quality through needed changes in the fertilizer rate, time, or method of application to achieve the desired degree of control of nutrient movement in critical areas contributing to water pollution.

B. Apply this practice on farmland which significantly contributes to the water quality problems, as determined by the priority rating system.

C. Policies for this practice are as follows:

1. Cost-share is authorized for the following:

   a. Soil tests for nitrogen and phosphorous content in the soil.

   b. Equipment needed to implement a Fertigation System.

   c. Split application.

   d. Permanently installed systems.

2. Cost-share is not authorized for the following:

   a. Fertilizer.

   b. Systems installed primarily for the operator's convenience.

   c. Restoring a system which has deteriorated due to lack of maintenance during periods of non use.

3. If you are eligible for this practice, it may be cost-shared on only if this practice is part of an approved Water Quality Management Plan.

4. This practice must be maintained for 10 years.

5. Cost-share is only eligible for 3 consecutive years per type of irrigation system.

6. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

D. Specifications.

Will be in accordance with applicable MLCL Standards and Specifications.

E. Technical Responsibility.

Is assigned to MLCL Project Staff.

F. Maximum Cost-shares.

1. 75% of the actual cost of soil tests.
2. A flat rate of $5.00 per acre per year for split application of nitrogen.
3. 75% of the actual cost of fertigation equipment.

IV. ANIMAL WASTE CONTROL FACILITIES. (MLCL/BMP-4)

A. The purpose of this practice is to reduce the existing pollution of water by animal wastes.

B. Apply this practice to areas on farmland where animal wastes from the farm constitute a pollution hazard.

C. Policies for this practice are as follows:

1. This practice is designed to provide facilities for the storage and handling of livestock and poultry waste and the control of surface run-off water to permit the recycling of animal waste onto the land in a way that will abate pollution which would otherwise result from existing livestock or poultry operations.

2. Waste Management Plan is required in the WQM Plan.

3. Cost-sharing is limited to solving the pollution problems where the livestock or poultry operation is part of a total farming operation.

4. Cost-sharing is authorized for the following:

a. Only for animal waste storage facilities such as: aerobic or anerobic lagoons, liquid manure tanks, holding ponds, collection basins, settling basins, and similar measures needed as part of a system on the farm to manage animal wastes.

b. For: (1) Permanently installed equipment needed as an integral part of the system. (2) Vegetative cover (including mulching needed to protect the facility). (3) Leveling and filling to permit the installation of an effective system.

c. Only if the storage and diversion facilities will contribute significantly to maintaining or improving the water quality.

5. Cost-sharing is not authorized for the following:

a. For measures primarily for the prevention or abatement of air pollution, unless the measures also have water conserving benefits.

b. For: (1) Portable pumps. (2) Portable pumping equipment or other pumping equipment. (3) Building or modifications of buildings. (4) Spreading animal wastes on the land with mechanical spreading equipment.

c. For the portion of the cost of animal waste structures installed under or attached to buildings that serve as part of the building or its foundation.

(Continued on page 9)

d. For animal waste facilities that do not meet local or State regulations.

e. For installation primarily for the operator's convenience.

f. For new or substantially enlarged livestock operations or for relocation of livestock operations, including buildings on the same farm or ranch.

6. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

7. The practice shall be maintained for a minimum of 10 years following the calendar year of installation.

D. Specifications.

The practice shall be performed in accordance with a plan prepared by SCS in consultation, as necessary, with other interested agencies prior to development of the particular project.

E. Technical Responsibility.

Is assigned to the MLCL Staff.

F. Maximum Cost-Shares.

1. 50% of the actual cost of excavation, not to exceed .86¢ per cubic yard.

2. 50% of the actual cost of concrete, including reinforced steel, rock or masonry, including cost of installation, not to exceed an amount determined by the HUB Council.

3. 50% of the actual cost of other necessary appurtenances for proper operation of the permanent structure, including the cost of installation, not to exceed an amount determined by the HUB Council.

4. COST STATEMENTS ARE REQUIRED.

5. Cost-share is limited to least cost alternative which meets the project objective.

V. SEDIMENT RETENTION, EROSION OR WATER CONTROL STRUCTURES. (MLCL/BMP-5)

A. The purpose of this practice is to reduce erosion and the pollution of water from agricultural non-point sources.

B. Apply this practice to specific problem areas on farms where run-off of substantial amounts of sediment or nutrients constitute a significant pollution hazard.

C. Policies for this practice are as follows:

1. Cost-sharing is authorized for the following:

   a. For sediment detention or retention structures, such as erosion control dams (excluding water storage type dams), desilting reservoirs, sediment basins, debris basins, or similar structures.

   b. For channel linings, chutes, drop spillways, and pipe drops that dispose of excess water.

   c. For fencing a vegetative cover and for leveling and filling to permit the installation of the structure.

   d. For installing sediment retention structures on public roadsides only where such structures are essential to solve a farm-based pollution or conservation problem.

   e. Only if the measures will contribute significantly to maintaining or improving water quality.

2. Cost-sharing is not authorized for irrigation structures which are part of a distribution system for irrigation water.

3. Consideration must be given to the needs of fish and wildlife when establishing the protective measures.

4. The structure shall be maintained for a minimum of 10 years following the calendar year of installation.

5. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

D. Specifications.

Specifications will be established in accordance with MLCL Project standards and sepcifications. Where required permits will be obtained by applicant before practice begins.

(Continued on page 11)

E. Technical Responsibility.

Technical responsibility is assigned to the MLCL Project Staff.

F. Maximum Cost-shares.

1. 50% of the actual cost of excavation, not to exceed .86¢ per cubic yard.

2. 50% of the actual cost of pipe installed, not to exceed an amount determined by the HUB Council.

3. 50% of the actual cost of necessary appurtenances including drop spillways, channel linings, chutes, pipe drops and channels, not to exceed an amount determined by the HUB Council.

G. COST DATA IS REQUIRED FOR EARTHMOVING, PIPE, AND APPURTENANCES.

## VI. STREAM PROTECTION SYSTEMS. (MLCL/BMP-6)

A. The purpose of this practice is to improve water quality by protecting streams from pollution from sediment or nutrients.

B. Apply this practice to specific problem areas on small streams or lakes located on or adjacent to farmland where the bank is subject to damage from livestock or where sediment or runoff containing nutrients constitute a significant pollution hazard.

C. Policies for this practice are as follows:

1. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

2. Cost-sharing is authorized for the following:

   a. For permanent fencing to protect banks from damage by domestic livestock.

   b. For planting trees, shrubs, and/or perennial grass cover as filter strips or buffer zones along banks.

   c. To provide access to water for livestock.

   d. To install livestock crossings that will retard sedimentation and pollution.

   e. Revegetation and/or shaping of banks to reduce sedimentation and pollution by stream erosion.

   f. Revegetate areas no longer irrigated due to system conversion under MLCL/BMP-2.

3. Fish, wildlife, and environmental consideration must be given when designing this practice.

4. The practice shall be maintained for a minimum of 10 years following the calendar year of installation.

5. Cost-sharing is not authorized for cover which includes only legumes.

6. An Operation and Management (O&M) Plan is required for all applications of this practice. The O&M Plan must cover and be followed for the lifespan of this practice.

D. Specifications shall be established in accordance with MLCL standards and specifications. Where required, permits must be obtained by the applicant before the practice may begin.

(Continued on page 13)

E. Technical responsibility is assigned to the MLCL Project Staff.

F. Maximum Cost-shares.

1. 75% of actual cost of excavation, not to exceed .86¢ per cubic yard.

2. 75% of actual cost of vegetation needed for bank stabilization.

3. 75% of actual cost of fencing and other material needed to protect banks from livestock damage.

## REMINDER SHEET

1. These practices may be cost-shared only if part of an approved Clean Lakes Water Quality Management Plan. (WQMP)
2. Application must be made at the Clean Lake Project Office in Moses Lake in person or in writing.
3. Making application is not a guarantee that you will receive cost-share monies.
4. Cost-share money is not obligated to you until your Water Quality Management Plan is approved by the HUB Council. Any work done prior to approval may be at your expense.
5. If your Water Quality Management Plan is not approved by the HUB Council, you may appeal the decision within 30 days of the date you are notified of the decision.
6. Billing statements with invoices must be sent to the Moses Lake Clean Lakes Field Office as soon as your practice is completed in order to facilitate payment.

# APPENDIX G

# MODEL FARM PLAN

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-CPA-11
3-81

# PLAN/SCHEDULE OF OPERATIONS



OMB–Form Approval No. 0578-0013

| NAME | COUNTY | STATE | CONTRACT OR AGREEMENT NUMBER | TOTAL ACRES |
|---|---|---|---|---|
| EDDIE L. ELWARD | GRANT | WASHINGTON | | 49 |

| ITEM NO. | FIELD | PLANNED TREATMENT (RECORD OF DECISIONS) | ESTIMATED AMOUNT (UNITS) | * AVERAGE COST $ | * COST-SHARE RATE % | TIME SCHEDULE AND ESTIMATED COST SHARE BY YEAR (FOR NONCOST-SHARE ITEMS SHOW UNITS) 19 85 | 19 86 | 19 87 | 19 88 | 19 89 | REFERENCE NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | MLCL/BMP - 2<br>Inlet structure with trash kicker | 1 ea. | 1500 | 50 | $ 750 | | | | | |
| 2 | 1 | MLCL/BMP - 2<br>Flow meter | 1 ea. | 685 | 50 | $ 343 | | | | | |
| 3 | 1 | MLCL/BMP - 2<br>Pipeline | 300 ft. | 4.20 | 50 | $ 630 | | | | | |
| | | Underground low pressure pipeline (Job Sheet #1) | | | | | | | | | |
| 4 | 2 | MLCL/BMP - 2<br>Cablegation - control box | 1 ea. | 2000 | 50 | $ 1000 | | | | | |
| 5 | 2 | MLCL/BMP - 2<br>Cablegation - gated pipe | 1500 ft. | 3.20 | 50 | $ 1725 | | | | | |
| 6 | 2 | Gated pipe | 700 ft. | N/C | | 700 | | | | | |
| 7 | 2 | MLCL/BMP - 2<br>Pipeline | 850 ft. | 3.50 | 50 | $ 1488 | | | | | |
| | | Underground low pressure pipeline (Job Sheet #1) | | | | | | | | | |
| 8 | 3 | MLCL/BMP - 2<br>Cablegation - control box | 1 ea. | 2000 | 50 | $ 1000 | | | | | |
| 9 | 3 | MLCL/BMP - 2<br>Cablegation - gated pipe | 1300 ft. | 2.30 | 50 | $ 1495 | | | | | |
| 10 | 6 | Gated pipe | 500 ft. | N/C | | 500 | | | | | |
| 11 | 6,4 | MLCL/BMP - 2<br>Pipeline | 800 ft. | 2.80 | 50 | $ 1120 | | | | | |
| | | Underground low pressure pipeline (Job Sheet #1) | | | | | | | | | |
| 12 | 4 | MLCL/BMP - 2<br>Cablegation - control box | 1 ea. | 2000 | 50 | $ 1000 | | | | | |

* FOR NONCOST-SHARE ITEMS SHOW N/C

NOTE

This information is used in both the development and implementation of a Conservation, Reclamation or Water Quality plan as the basis for technical assistance and/or cost sharing. The authorities for such work are: 16 USC 590a-f (Soil Conservation); 16 USC 1301-1311 (Water Bank); 16 USC 590p(b) (Great Plains); 30 USC 1236 et seq (Rural Abandoned Mines); 33 USC 1288 et seq (Rural Clean Water). Furnishing information is voluntary and will be confidential; however, it is necessary in order to receive assistance.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-CPA-11
3 - 81

# PLAN/SCHEDULE OF OPERATIONS



OMB-Form Approval No. 0578-0013

| NAME | COUNTY | STATE | CONTRACT OR AGREEMENT NUMBER | TOTAL ACRES |
|---|---|---|---|---|
| EDDIE L. ELWARD | GRANT | WASHINGTON | | 49 |

| ITEM NO. | FIELD | PLANNED TREATMENT (RECORD OF DECISIONS) | ESTIMATED AMOUNT (UNITS) | * AVERAGE COST $ | * COST-SHARE RATE % | TIME SCHEDULE AND ESTIMATED COST SHARE BY YEAR (FOR NONCOST-SHARE ITEMS SHOW UNITS) 19 85 | 19 86 | 19 87 | 19 88 | 19 89 | REFERENCE NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 4 | MLCL/BMP - 2<br>Cablegation - gated pipe | 750 ft. | 1.80 | 50 | $ 675 | | | | | |
| 14 | 4 | Gated pipe | 350 ft. | N/C | | 350 | | | | | |
| 15 | 2,3,4 | MLCL/BMP - 1<br>Irrigation Water Management | 49 A | 7.50 | 75 | | $ 276 | $ 276 | $ 276 | | |
| | | Irrigation water will be managed and controlled to avoid deep | 49 A | N/C | | | 49 | 49 | 49 | 49 | |
| | | oercolation and the leaching of plant nutrients. Irrigation | | | | | | | | | |
| | | water will also be applied of meet the needs of the crops. | | | | | | | | | |
| | | (Job Sheet #2) | | | | | | | | | |
| 16 | 2,3,4 | MLCL/BMP - 3<br>Fertilizer Management | 3 smpl. | 10 | 75 | | $ 23 | $ 23 | | | |
| | | Fertilizer will be done in accordance with recommendations obtained from | 49 A | N/C | | | 49 | 49 | 49 | 49 | |
| | | an actual soil test. | | | | | | | | | |
| 17 | 2,3,4 | Conservation Cropping System | 49 A | N/C | | | 49 | 49 | 49 | 49 | |
| | | A rotation of five (5) years alfalfa hay and two (2) years small grain | | | | | | | | | |
| | | (wheat and grain corn) will be incorporated. | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

* FOR NONCOST-SHARE ITEMS SHOW N/C

NOTE → This information is used in both the development and implementation of a Conservation, Reclamation or Water Quality plan as the basis for technical assistance and/or cost sharing. The authorities for such work are: 16 USC 590a-f (Soil Conservation); 16 USC 1301-1311 (Water Bank); 16 USC 590p(b) (Great Plains); 30 USC 1236 et seq (Rural Abandoned Mines); 33 USC 1288 et seq (Rural Clean Water). Furnishing information is voluntary and will be confidential; however, it is necessary in order to receive assistance.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-CPA-11
3-81

# PLAN/SCHEDULE OF OPERATIONS

Sheet 3 of 3

OMB-Form Approval No. 0578-0013

| NAME | COUNTY | STATE | CONTRACT OR AGREEMENT NUMBER | TOTAL ACRES |
|---|---|---|---|---|
| EDDIE L. ELWARD | GRANT | WASHINGTON | | 49 |

| ITEM NO. | FIELD | PLANNED TREATMENT (RECORD OF DECISIONS) | ESTIMATED AMOUNT (UNITS) | * AVERAGE COST $ | * COST-SHARE RATE % | TIME SCHEDULE AND ESTIMATED COST SHARE BY YEAR (FOR NONCOST-SHARE ITEMS SHOW UNITS) | | | | | REFERENCE NO. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 19 85 | 19 86 | 19 87 | 19 88 | 19 89 | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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| | | | | | | | | | | | |
| | | TOTAL ESTIMATED COST-SHARE | | | | $11406 | $ 299 | $ 299 | $ 276 | | $12280 |
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* FOR NONCOST-SHARE ITEMS SHOW N/C

NOTE

This information is used in both the development and implementation of a Conservation, Reclamation or Water Quality plan as the basis for technical assistance and/or cost sharing. The authorities for such work are: 16 USC 590a-f (Soil Conservation); 16 USC 1301-1311 (Water Bank); 16 USC 590p(b) (Great Plains); 30 USC 1236 et seq (Rural Abandoned Mines); 33 USC 1288 et seq (Rural Clean Water). Furnishing information is voluntary and will be confidential; however, it is necessary in order to receive assistance.

Form SCS-CPA-11, plan/schedule of operation, is used to list the best management practices (BMP's) that are planned to be implemented. These BMP's will be practices which will solve the water quality problems. The participant is agreeing to implement these BMP's.

The BMP's are items in the plan/schedule of operation which are listed in a sequential order. Each line item will have a title, the quantity, cost of quantity, cost-share rate, and the amount of cost-share money the participant will receive for each BMP in any given year.

The plan/schedule of operation is correlated with the conservation plan map. The conservation plan map would show location of home, fields, acres in each field, and the BMP's. Each BMP will have an item number (I-1) by it to be identified on the plan/schedule of operation sheet. Some items will be unnumbered (UN) which are practices that are recommended by the MLCLP staff but failure to carry out these items does not constitute noncompliance with the plan/schedule of operation.

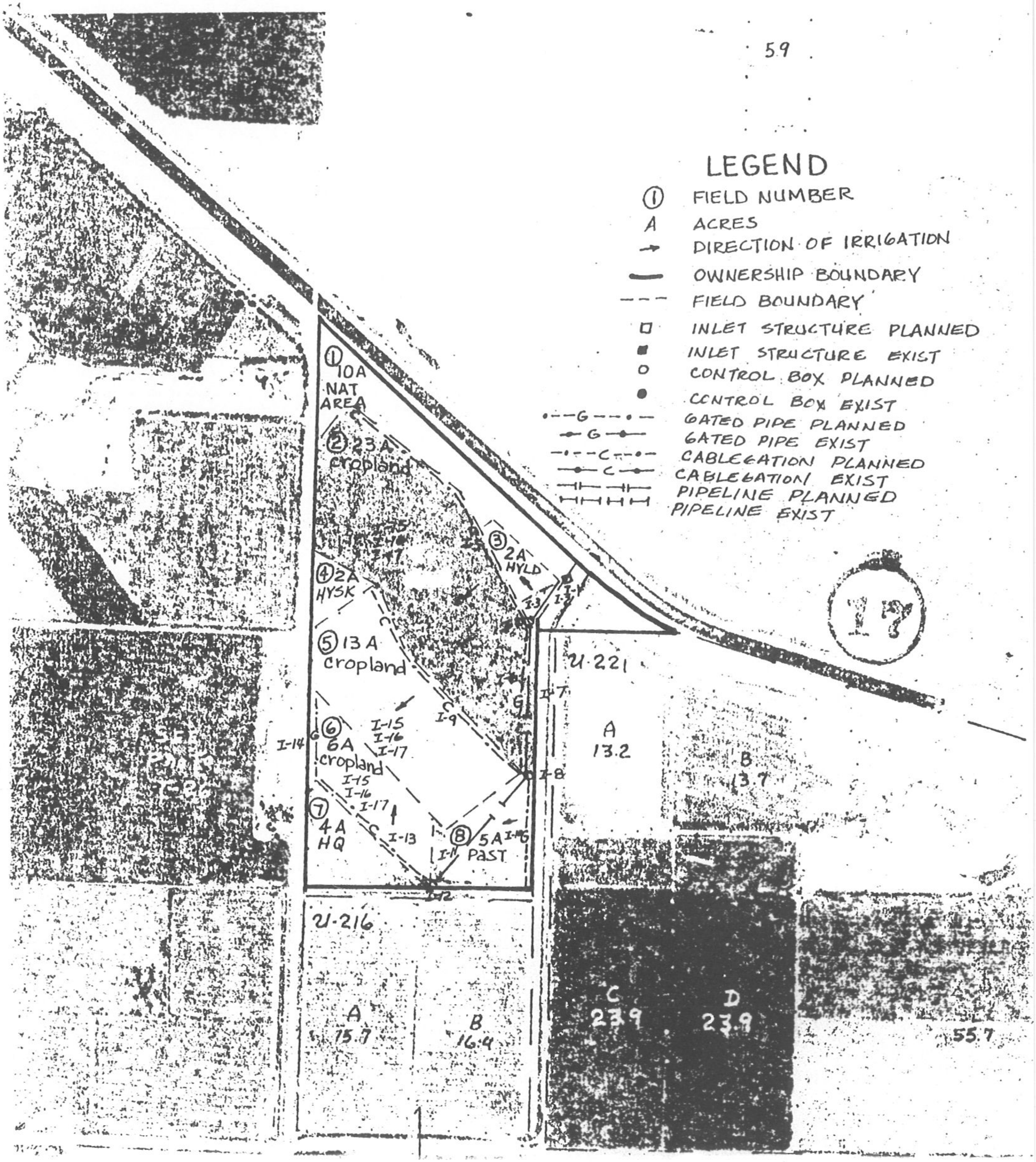
SCS-CONS-14
**CONSERVATION PLAN MAP**

OUR SOIL ★ OUR STRENGTH

*pared by* UNITED STATES DEPARTMENT of . .ICULTURE ★ SOIL CONSERVATION SERVICE
cooperating with
MOSES LAKE
S. C. DISTRICT

OWNER
OPERATOR SAME
GRANT, WASHINGTON
COUNTY STATE

BLK 40
FARM NO. 222 B DATE 11-1-84
SCALE 1" = 660' ACRES
APPROXIMATE
PHOTO NO.



# APPENDIX H

# MOSES LAKE CLEAN LAKE PROJECT
# COST-SHARING PROGRAM

## MOSES LAKE COST SHARING PROGRAM FOR AGRICULTURAL WATER QUALITY

I. General Provisions

1. The objectives of the Moses Lake Clean Lake (MLCL) Agricultural Water Quality Management (WQM) Program are to:

   A. Achieve improved water quality in watersheds contributing to Moses Lake with specific emphasis on Blocks 40, 41, and 401. This will be achieved considering the need for adequate supplies of food, fiber, and a quality environment.

   B. Assist agricultural landowners and operators:

      (1) Reduce agricultural nonpoint source water pollutants.

      (2) Improve water quality in runoff from Blocks 40, 41 and 401 to meet water quality goals established for Moses Lake.

   C. Develop and apply programs, policies, and procedures for controlling agricultural nonpoint source pollution to Moses Lake that will be integrated into local agency programs and continued after completion of the cost-share program.

2. Program Description

The MLCL Agricultural WQM program will provide financial and technical assistance to private landowners and operators. It must control agricultural lands designated as critical areas or sources of non point pollution in the approved project area.

A. Cost-share assistance will be provided through MLCL contracts to install Moses Lake Clean Lake/Best Management Practices (MLCL/BMPs) in the project area where there are critical water quality problems resulting from agricultural activities.

B. To be cost-share eligible, a farm water quality management plan must reflect the water quality priority concerns developed through the WQM planning process identified in Stage 2 of the MLCL project.

C. MLCL contract periods will be three to ten years. Each approved contract must have a minimum of one cost-share practice installed during the first year of the contract.

D. Participation in the MLCL Agricultural WQM Program is voluntary.

3. Program Administration

The Moses Lake Irrigation and Rehabilitation District (MLIRD) will be responsible for funding administration and disbursement. The Moses Lake Conservation District (MLCD) will administer the On-Farm MLCL Agricultural WQM Program. The MLCD will obtain technical and administrative assistance from federal, state, and local governmental agencies or private entities subject to the approval of the funding agencies i.e., EPA and DOE. Consultation and coordination will also be done with the Agricultural Stabilization and Conservation Service (ASCS) County Committee to avoid conflicts and duplications of agricultural conservation programs in the project area.

A. MLIRD will:

(1) Review and approve each farm WQM plan that is grant eligible for cost share.

(2) Approve cost-share payment to eligible landowners and operators after farm WQM plans are constructed and certified complete by the MLCD Board of Supervisors.

(3) Coordinate with DOE and other appropriate agencies and individuals in designing, implementing, and evaluating a water quality monitoring program to measure the effectiveness of applied BMPs in reducing water quality impact agents.

B. MLCD will:

(1) Provide overall management and administration of the Agricultural WQM Program. Review and certify each farm water quality management plan that is grant eligible for cost-share.

(2) Maintain an overall financial management and tracking system for the cost-share program and provide quarterly and annual financial reports to MLIRD for their reporting to EPA and DOE.

(3) Coordinate overall public involvement and awareness for the Moses Lake Clean Lake Program.

(4) Receive applications from the landowners and operators for participation in the MLCL program.

(5) Provide or obtain technical assistance for the development of site-specific farm WQM plans based on the priority of potential water quality problems with cost and nutrient benefits from the plans included.

(6) Be responsible for the accounting and documentation on goods and services used to construct and implement the WQM plans of each individual landowner and/or operator. The MLCL Program Manager will review this documentation and certify work completed. Cost data will be used to monitor and adjust the average costs.

C. Moses Lake Clean Lake Technical Advisory Committee (TAC) will:

(1) Continue to provide all functions as written in the "Technical Advisory Committee Constitution and By-Laws".

(2) In consultation with the MLCL Program Manager, shall monitor and adjust average cost-share rates as needed for each approved MLCL/BMP.

(3) Make recommendations to "Hub" on approval or actions on farm WQM plans which require specific technical review to assist in resolving conflicts.

D. Moses Lake Clean Lake Council ("Hub") will:

(1) Continue to provide all functions as written in the "Moses Lake Clean Lake Project Council Constitution and By-Laws".

(2) Be the reviewing field entity of the water quality management plans as submitted by the MLCL Project Manager on each individual landowner's submitted plan.

4. Program Overview by Grant Agencies

EPA will:

A. Participate on the MLCL Technical Advisory Committee (TAC) as an ex-officio member.

B. Receive and review quarterly progress reports on the Agricultural WQM program from the MLIRD. The report format and schedule will be developed by EPA in consultation with MLIRD, MLCD, and the Washington State Department of Ecology (DOE).

C. Conduct on-site quarterly progress reviews of all phases of the program and provide appropriate recommendations to MLIRD.

D. Provide grant funds through Section 314 of the Clean Water Act to provide financial assistance for implementing the Agricultural WQM program.

DOE will:

A. Participate on the MLCL Technical Advisory Committee (TAC) as a voting member.

B. Receive and review quarterly progress reports on the Agricultural WQM program from MLIRD.

C. Participate with EPA in conducting on-site quarterly progress reviews for all phases of the program and provide appropriate recommendations to EPA.

D. Coordinate the monitoring and evaluation of the water quality effectiveness of the project in improving the water quality of Moses Lake and tributaries.

E. Coordinate the MLCL Agricultural WQM Program with other ongoing water quality programs in the project area.

II. Program Operations

1. Plan of Work

The MLCL Plan of Work will be developed by MLIRD in consultation with MLCD for the project period (approximately three years). It will be updated annually. It must identify the specific goals, objectives, and strategy for their accomplishment. The current Stage 2 planning will provide the basic information for preparing the Plan of Work.

The Plan of Work must include:

A. How nutrient reduction goals and objectives will be met.

B. Specific tasks, schedules, or time frames for accomplishments, including the number of site-specific plans to be developed and implemented.

C. A summary of the planning process for developing site-specific farm WQM plans.

D. A summary of roles and responsibilities for agencies and groups involved in performing work plan tasks, including any appropriate sub-agreements or contracts.

E. A process for determining planning and cost-sharing priorities (Exhibit 1) for the development of site-specific farm WQM plans and MLCL cost-share contracts.

F. A Water Quality Monitoring Plan to assess program effectiveness

G. Budget including sources of funding.

2. Cost-Share (C/S) Policy

A. Limitations

(1) Unless approved by EPA, the federal C/S for each BMP shall not exceed 75 percent of actual cost, but in no case shall it exceed any specified maximums.

(2) The combined C/S by federal government, state government, or subdivision of state, and others, shall not exceed 100 percent of the cost of carrying out the WQM plan.

B. Cost Development

(1) The compiled actual cost must be certified by the MLCD before disbursement to the farmer.

(2) Actual cost data from the MLCL Project incurred from each completed Long Term Agreement (LTA) shall be used in updating average cost. Cost shall be updated annually and reviewed by TAC.

C. The total amount of MLCL agricultural cost-share payment that a landowner/operator may receive shall not exceed $50,000. on one or more farms in the project area. The payment limitation is not restricted to any fiscal year.

3. BMP Eligibility

A. Only BMPs applied to lands significantly contributing to the water quality problems are eligible for financial and technical assistance.

(1) Only BMPs included in the approved Work Plan are eligible for inclusion in the participant's contract.

(2) All agreed to BMPs must be applied even when there is not cost-share assistance provided in the contract for those specific BMPs.

B. Site specific BMPs needed to treat critical areas or sources of pollutants shall be identified in the participant's water quality plan.

C. BMPs must be installed according to NLCL standards and specifications.

EXHIBIT 1

Priority for Site-Specific Technical Assistance, Planning, and Implementation.

A. Confined Animal Feeding Operation (CAFO) will be given first priority. A CAFO is defined as a concentrated, confined animal or poultry growing operation for meat, milk, or egg production, or stabling in pens or houses wherein the animals or poultry are fed at the place of confinement and crop or forage growth or production is not sustained in the area of confinement.

B. Priorities for all other problem sites will be determined by rating each farm application according to the following criteria. These criteria are developed as a guide: Intermediate values may be used where appropriate.

A Conservation Treatment Unit (CTU) is defined as a field or group of fields or other units of land with similar soil and water conservation problems requiring similar combinations of landuse and conservation treatments.

(1) Ephrata or Malaga complex soil:

| | |
|---|---|
| 100% of Conservation Treatment Unit | 10 |
| 50% of Conservation Treatment Unit | 5 |
| 10% of Conservation Treatment Unit | 1 |

(2) Surface Runoff to a watercourse which supplies a tributary of Moses Lake.

| | |
|---|---|
| a) Surface runoff to a tributary of Moses Lake | 5 |
| b) No direct surface runoff reaches Moses Lake | 0 |

(3) Type of system existing on Conservation Treatment Unit

| | |
|---|---|
| a) Furrow | 5 |
| b) Wheelline | 3 |
| c) Center Pivot | 1 |

(4) Land area of sign up in Conservation Treatment Unit

(1 pt/20 acres, round to the nearest ½ pt.)

| | |
|---|---|
| a) 200 acres | 10 |
| b) 100 acres | 5 |
| c) 20 acres | 1 |

(5) Fertilizer Practices and Amount Deep Percolated

The amounts of fertilizer deep percolated depend upon when applied, how, and amounts applied.

The points given will be computed using the Pfeiffer-Whittlesey equation for the types of practices and systems. (Use ½ point for each pound leached.)

(6) Pasture

| | |
|---|---|
| a) yes | 5 |
| b) no | 0 |

# APPENDIX I

# MOSES LAKE CLEAN LAKE PROJECT
# CONTRACTING HANDBOOK

# MOSES LAKE CLEAN LAKES CONTRACTING HANDBOOK

## §404.00 GENERAL:

(a) This document has been developed using the Part 404--Land Treatment--Long Term Contracting of the SCS General Manual. Other additions have been added for further clarification when more specific data was required for the Moses Lake Clean Lake (MLCL) Project.

The form numbers shown are SCS numbers to use as a reference. These numbers may be used, but are not restricted to these forms, until a better format is developed which is specific for use on this Project.

(b) The Moses Lake Conservation District (MLCD) will provide available technical assistance when requested for developing plans and installing scheduled conservation practices. Participants are to be encouraged to use assistance available from other Federal and State agencies and private sources. All cost-shared practices are installed using a long-term contract.(LTC)

(c) The LTC will spell out the participant responsibilities, Conservation District responsibilities, and the consequences of violating the contract. A LTC is in force for a minimum of 3 to a maximum of 10 years and requires the participant to carry out the work with his or her own resources or contract for the work. The contract period is to be the length of time necessary for the participant to carry out the plan plus 2 years to ensure adequate establishment of the practices. The basis for the LTC is the plan/schedule of operations developed with the participant. The Conservation District will designate the Contracting Officer (CO).

(d) Cost-share payments are made to participants upon the completion of installation of practices or components of practices. Participants may use any annual Federal cost-sharing program in carrying out their plans unless restricted by other program policies.

## §404.01 METHODS OF CONTRACTING:

(a) LTC between MLCD and participant.

(1) Cost-sharing arrangements for installation of conservation treatment will be made through long-term contracts with participants on the land they own or control. Cost-sharing is to be based on eligible conservation treatment in an approved Water Quality Plan (WQP). The Water Quality Plan will be used as a basis for developing the long-term contract to solve identified problems. O&M requirements are included in the long-term contract and are the responsibility of the participant. (See Section 404.27)

(2) Cost-share payments are to be made by MLCD after an eligible unit of the conservation practice has been completed and certified. Payment shall be based on the cost-share prescribed by MLCD. Participants must file an application for payment.

§404.02 DEFINITIONS:

(a) Applicant. A land user who has declared in writing the intention of participating in a long-term contract.

(b) Average Costs. The calculated cost, determined by averaging recent actual costs and current cost estimates, considered necessary for a participant to carry out a conservation practice or a designated component of a conservation practice. Actual cost includes labor, supplies, and other direct costs required for physical installation of a practice.

(c) Case file. A document folder maintained in the MLCD Project Office for each recipient of MLCL technical assistance. It may contain information regarding inventory, evaluation, decision making, and implementation.

(d) Compensatory treatment. The installation of one conseravation practice to replace a paractice destroyed, or removed, or existing.

(e) Component. See identifiable unit.

(f) Conservation District. A subdivision of a State or territory organized pursuant to the State Soil Conservation District Law, as amended. In some states these are called Soil Conservation Districts, Soil and Water Conservation Districts, Resource Conservation Districts, or Natural Resource Districts. Conservation Districts are locally created and operated. They are controlled by an elected and/or appointed governing body, generally made up of resident land users. In most states, Conservation Districts are under the general supervision of a State Soil Conservation Commission, Committee, Board, or Agency. Functions, operations, purposes, and powers of Conservation Districts vary widely from state to state.

(g) Conservation practice. A measure commonly used to meet a specific need in planning and carrying out soil and water conservation programs for which standards and specifications have been developed. (It may be all or part of a resource management system.)

(h) Contracting officer (CO). The Conservation District employee authorized to sign long-term contracts.

(i) Cooperator. An individual, group of people, or representative of a unit of government who has entered into an understanding, working arrangement, or cooperative agreement with a Conservation District (or Association of Conservation Districts) to work together in planning and carrying out soil and water resources use, development, and conservation on a specific land area.

(j) Cost. The amount actually paid or engaged to be paid by the participant for equipment use, materials, and services for carrying out an identifiable unit, or if the participant uses own resources in carrying out an identifiable unit, the constructed value of own labor, equipment use and materials.

(k) Cost-share payments. Payments made to or on behalf of participant at established rates as specified in contracts for carrying out a conservation practice or an identifiable unit of such practices according to the contract.

(l) Cost-share rate. The percentage of the cost paid by the Federal Government for completing the installation of a practice.

(m) Flat rate. A fixed amount of cost-share paid for carrying out certain conservation practices on a per-unit basis.

(n) Project Manager. An employee designated to be responsible for the day-to-day administration of a project agreement for MLCL functions relating to long-term contracts between the conservation district and the participant.

(o) Identifiable unit. All of an eligible conservation practice, or a part thereof, that when carried out can be clearly identified as a segment in the sequence of carrying out the conservation practice. (Also referred to as a component.)

(p) Joint agreements. (Also called pooling agreements.) Two or more participants who are cooperating to carry out conservation practices that can best be accomplished by combining resources.

(q) Land unit. Part or all of an operating unit.

(r) Land user. Any eligible land user, producer, operator, lessor, occupier, group, nonpublic legal entity, or other who individually, collectively, or by other arrangement has conservation planning and implementation responsibility for the land involved.

(s) Long-term contract. (Called long-term agreement by ASCS.) A binding agreement between the conservation district and the participant that includes the conservation or other plan and provides for cost-sharing of the conservation treatment.

(t) Operating unit. A parcel or parcels of land whether contiguous or noncontiguous, constituting a single management unit for agricultural purposes. (An operating unit shall be designated as located in the county in which the principal dwelling is situated, or if there is no dwelling thereon, it shall be regarded to be in the County in which the major portion of the land is located. Questionable cases will be decided by the HUB Council.)

(u) Participant. Any land user who is a party to an executed long-term contract.

(v) Plan of operations. A written plan of farming or ranching operations designed to solve identified problems. It schedules the participant's decisions concerning land use, management systems, and cost-shared and noncost-shared practices to be installed on all land in the unit to protect, develop, and use the soil, water, and related resources. (Also referred to as a Conservation Plan of Operations or Plan/Schedule of Operations.)

(w) Program plan. A broad plan of action developed to achieve specific goals of the MLCL Program.

(x) Project Agreement. A written agreement between SCS and the Conservation District establishing detailed working arrangements for the installation of conservation treatment.

(y) Required conservation treatment. The combination of conservation practices that, when installed, will provide the treatment required to solve the identified problems to the degree needed to meet identified program objectives. This treatment may or may not be cost-shared.

(z) Resource management system. A combination of conservation treatment and management identified by the primary use of land or water that, if installed, will protect, at a minimum, the resource base by meeting tolerable soil losses and maintaining acceptable water quality and ecological and management levels for the selected resource use. Resource management systems may include conservation treatment that protects, restores, or improves the resource base.

## SUBPART B--APPLICATION FOR ASSISTANCE

### §404.10 GENERAL:

(a) Applications to participate in long-term contracting under this cost-share program are to be taken to the Moses Lake Conservation District, 316 A. South Chestnut Street, Moses Lake, WA 98837. The application will be reviewed by the Project Manager (PM) and the MLCD representative and given a priority.

(b) Applications will be serviced on a priority basis and the availability of appropriated program funds and installation requirements, as specified in the program plan.

### §404.11 ELIGIBILITY.

(a) Eligible land user. Any person or entity that has control of an eligible land unit in a designated area and meets the requirements of 404.11 (c) is eligible for participation if they submit an acceptable plan of operations. It is the applicant's responsibility to furnish acceptable evidence of control of the land unit for the period required to carry out the plan of operations.

(1) SCS employees. It has been determined administratively that SCS and Conservation Districts may enter into long-term contracts with full-time employees of SCS. Employees may not service their own contracts. Each SCS employee entering into a long-term contract with a Conservation District must have one complete contract document (including all modifications and payment forms) on file in the Fincancial Management Division, Compliance and Audit Branch for Management Oversight.

(2) Conservation District employees. The same requirements [(§404.11(a)1)] which apply to SCS employees apply to Conservation District employees.

(3) Members of Congress. Land users who are Members of Congress are eligible for participation only in the Great Plains Conservation Program (GPCP), August 1937. A copy of each GPCP Contract, modification, and payment application from a Member of Congress is to be sent to the Financial Management Division, Complicance and Audit Branch for Filing and Management Oversight.

(b) Eligible land.

(1) In designated counties or areas. Long-term contracting is applicable to---

(i) Privately owned land, and

(ii) Nonfederally owned public land under private control for the contract period and included in the participant's operating unit.

(iii) Federally owned land when the applicability thereto is for installation of conservation treatment that directly and primarily conserve or benefit nearby or adjoining privately owned land of persons who maintain and use the federal land udner agreement with the department or agency having jurisdiction over the land.

(c) Other eligibility requirements.

(1) Land must have been irrigated for the past 4 out of 5 years.

(2) Land must have Ephrata and/or Malaga soils and lie within the shaded area on the MLCL Project Map to meet Project boundaries and standards.

§404.12 SUBMITTING APPLICATIONS.

(a) The application should be submitted to the Moses Lake Conservation District Office. It is to be signed and dated by the applicant.

§404.13 PROCESSING APPLICATIONS.

(a) General. On receipt of an application for program assistance, the Project Manager (PM) and a representative of the Conservation District are to check the application for completeness. If any information is missing or items in the application need further clarification, the application is to be returned to the applicant with instructions for completing any missing or incomplete items.

(b) Applications meeting eligibility and priority criteria are to be separated into two categories.

(1) If submitted by the previous participant or a new land user on a land unit consisting primarily of land which has been under a long-term contract within the last 10 years (120 months), they are to be considered for a second contract (§404.54).

(2) If submitted by the previous participant or a new land user on a land unit consisting primarily of land which has not been under a long-term contract within the last ten years (120 months), they are to be considered for initial contracts.

(3) If submitted by the previous participant or a new land user on land unit consisting of land which was under a long-term contract within the last 10 years (120 months) plus a substantial acreage never under a long-term contract, they are to be considered for initial contracts.

(c) Record of applications.

The office that develops long-term contracts will maintain a record of each application submitted. This may be done using form SCS-LTP-3 or other approved form.

(d) Priority of technical assistance.

(1) Priority rating system. The Moses Lake Conservation District shall develop a system for determining the priority in which technical assistance is to be given to eligible applicants for developing plans of operations and contracts. The system shall be so devised to give highest priority to applicants with the most severe problems as defined in the planned objectives, program objectives, or other guidelines.

(2) Rating applications. The Project Manager, in consultation with the Conservation District, shall rate each eligible application received according to the Clean Lakes priority criteria and record the assigned priority designation on the application.

(3) Servicing applications. After priorities are assigned, the Project Manager determines the order in which applications are serviced. Applications of the highest priority group normally shall be serviced first to ensure that limited cost-share funds and technical assistance are directed to the most serious problems. Some of the factors to be considered in setting the order in which applications are to be serviced within a priority group are--

(i) The urgency of work to be accomplished in relation to the Conservation District Long Range Program and Annual Plan of Work.

(ii) The interest of the applicant and his readiness, willingness, and ability to move ahead with a sound conservation program.

(iii) Chronological order of applications received and

(iv) The seasonal nature of the conservation work to be accomplished.

(e) Review of unserviced applications.

(1) Unserviced applications shall be reviewed annually with the applicants to determine current status. Those which cannot be developed into contracts in the foreseeable future for reasons other than shortage of cost-share funds or technical services (farm sold, applicant deceased, etc.) shall be cancelled.

(2) Changes in priority classification and proposed cancellations shall be reviewed by the Project Manager with the Conservation District. The date of review, findings, and actions may be recorded on the application and on Form S C S -LTP-3. Applicants will be advised in writing of the cancellation and that new applications may be filed if their circumstances change.

## SUBPART C--PLAN/SCHEDULE OF OPERATIONS

§404.20 General.

(a) The basis for a long-term contract (LTC) is an approved Water Quality Plan/Schedule of Operations developed by the applicant with assistance from SCS and the Conservation District. The plan/schedule of operations for LTC's is to include the portion of the land controlled by the applicant and requiring treatment as specified in the program plan. The plan/schedule of operations for LTCs is to include all required conservation treatment before it(the LTC) can be accepted and approved. A plan/schedule of operations may be on less than the entire farm, but must cover the entire problem area.

(b) Principles of conservation planning are outlined in the National Conservation Planning Manual and are to be used in preparing the plan/schedule of operations.

§404.21 Preparation of plan/schedule of operations.

(a) A Conservation Plan/schedule of Operations (CPO) is to be keyed to a map and prepared on Forms SCS-CPA-11 or 11A. (See exhibit §404.84 for instructions on how to complete these forms.)

(b) The key to successful implementation of a conservation plan is a schedule of operations that outlines a logical sequence of work to be accomplished within a reasonable time. All required treatment should be scheduled two years before the expiration of the contract. Some primary considerations in setting the time schedule are the seasonal nature of practices, the interrelation of practices, the availability of contractors and materials, the participant's financial situation, and the need for and availability of technical services. Management practices should be scheduled to support needed vegetative and structural practices and permit the participant to comply with the time schedule.

§404.22 Applicable conservation treatment.

(a) The conservation treatment included in the plan/schedule of operations should be compatible with the planned resource management systems.

(b) Any practice listed in the National Handbook of Conservation Practices that has a set of approved standards and specifications in the local SCS field office TECHNICAL GUIDE and meets program criteria may be considered.

(c) Treatment must be planned and applied in accordance with the approved practice specifications on file in the SCS TECHNICAL GUIDE or meet special design standards and specifications approved by the HUB Council.

§404.23 Conservation treatment already on land.

(a) Compatible conservation practices or components thereof established before entering into a contract are to be used to the extent practical in combination with planned conservation treatment. Maintenance of the existing practices necessary to meet the objectives of the program are to be included as part of the LTC. A contract does not relieve participants of their obligations with respect to maintaining practices previously installed with assistance from SCS or any other agency.

(b) If the destruction of an existing practice is planned, the participant must furnish evidence that all obligations with regard to cost-shared practices to be destroyed have been met and a record of the evidence must be included in all copies of the contract.

§404.24 Conservation District review.

(a) Contracts must be reviewed by the HUB Council prior to making significant changes in plans resulting from addition or deletion of land by contract modification. District concurrence of the plan is to be indicated on the last page of the plan/schedule of operations.

(b) If the HUB Council chooses to review the plan and does not concur, the Project Manager is to advise the TAC Committee. If the TAC committee is unable to resolve the problem with the parties concerned, the matter is to be referred to the Moses Lake Conservation District and the Moses Lake Irrigation District for a final decision.

§404.25 Approval by HUB Council.

(a) The plan/schedule of operations and contract modifications are to be approved by the Project Manager. This includes approval of plans developed by other agencies. The Project Manager's signature constitutes certification that the scheduled contract items provide for safe and practical land use of all land under contract and the required conservation treatment to achieve planned program objectives.

§404.26 Conservation assistance notes.

Conservation Assistance Notes are kept in the field office contract file. Form SCS-CPA-6 and 6a may be used for the purpose. Notes should be concise factual statements that document information relating to significant activities and situations such as--

(a) Planning and application materials delivered, such as participant's copy of contract, job sheets, and engineering data;

(b) Potential noncompliance with contract provisions and actions taken;

(c) Scheduling arrangements and--

(d) Visits and agreements reached with the participant,that are not documented in other parts of the contract, should be noted since they may be useful in future followup.

§404.27 Operation and maintenance.

(a) The key to proper functioning of all conservation treatment is the continued maintenance after installation. Maintenance requirements vary with the conservation treatment applied. The need for proper maintenance must be conveyed to the participant.

(b) The Best Management Practices (BMPs) must be maintained for approval lifespan, even if land ownership is transferred. Not maintaining installed BMPs during this time constitutes a contract violation.

(c) The LTC, when approved by the landowner and HUB Council, becomes a part of the deed. Transfer of land ownership requires transfer of contract to the new owner or the contract will be in violation.

§404.28 Violations in projects and long-term contracts.

(a) Contract violation procedures require the Project Manager to investigate possible O&M and other contract violations prior to discussions and determinations by the HUB Council.

(b) The HUB Council shall immediately investigate alleged violations of any O& M agreements or the O&M requirements of long-term contracts. If the HUB council determines that a violation has occurred that may prevent the conservation practice or project work from functioning as intended, that would create a health or safety hazard, or that would prevent the accrual of intended benefits, the sponsor/land user will be notified in writing of:

(1) The nature of the violation.

(2) Specific actions the sponsor/land user must take to correct the deficiency.

(3) A reasonable time frame for the sponsor/land user to start and complete corrective actions.

(4) Actions that will be taken if violation is not corrected within the time frame established, and--

(5) The sponsor's/land user's right to appeal to the HUB if they do not agree that a violation has occurred, that the specified corrective action is not appropriate, or that the time frame for taking the corrective action is not reasonable and proper. The decision of the HUB Council may be appealed to the TAC Committee, and if the matter still can't be resolved, it will then be referred to the Moses Lake Conservation District. After the MLCD decision, a final appeal may then be made to the Moses Lake Irrigation District; their decision will be the final decision, and the matter can not be appealed again as no further administrative appeal is authorized.

(c) If the sponsor/land user fails to carry out the terms and conditions of the O&M agreement or long-term contract and fails or refuses to take corrective action deemed necessary by the HUB, the Moses Lake Conservation District will take any or all of the following actions:

(1) Withhold further assistance:

(2) Require the sponsor/land user to reimburse the government for MLCL financial assistance provided for the practices which were not operated and maintained as provided in the O&M agreement or long-term contract and appropriate portions of the financial assistance for other practices that will be adversely affected by the resulting malfunction or failure and/or:

(3) Pursue other action authorized by law:

(d) If the Moses Lake Conservation District becomes aware of an emergency situation which could result in the loss of life if not immediately addressed, the MLCD will simultaneously notify authorities having proper jurisdiction and the sponsor/land user without going through the steps listed in (a) and (b) above.

## SUBPART D--COST SHARING

### §404.30 Methods of Cost-sharing.

Cost-sharing with participants may be based on (a) average cost, (b) actual cost not to exceed the average cost, (c) actual cost not to exceed a specified maximum cost, or (d) flat rate cost.

(a) Average cost (AC).

Average cost is used if adequate cost data is available. Average costs are to be developed for each practice or component of a practice identified in the plan as eligible for financial assistance. Average costs are to apply to a County, watershed, or other defined geographical area within a State and are to be approved by the Project Manager. Cost lists are to be uniform among programs in a County.

(b) Actual cost not to exceed average cost (AA).

The actual cost not to exceed average cost method is to be used if:

(1) The participant can buy materials and services in quantity at discount prices below the average costs allowed for average size jobs. This applies particularly to unusually large jobs subject to competitive bids, such as those frequently scheduled under joint agreements.

(2) It is likely that the cost of materials and services will go down sufficiently to result in windfall payment to the participant, or:

(3) Used materials are installed as allowed in §404.58

(c) Actual cost not to exceed a specified maximum cost (AM).

(1) The actual cost not to exceed a specified maximum method is to be used if--

(i) There are insufficient data or it is not feasible to determine reliable average costs for a practice or components:

(ii) It is not practical or feasible to determine average cost for a practice because of difficulty in measuring quantities, or:

(iii) It is determiend that a definite limit is to be imposed on a particular practice.

(2) All practices and identifiable units that are cost-shared according to specified maximum cost must be supported by documentation of how the costs were determined.

(d) Flat rate (FR).

The flat rate method is to be used to encourage the adoption of new conservation practices where it is difficult to establish the actual cost. Flat rates usually are on a per-unit basis.

§404.31 Cost lists.

(a) Actual cost data are to be collected on a representative number of jobs on all applicable measures and practices in each County, watershed, or other defined area. In determining average costs, information from suppliers, Agricultural Stabilization and Conservation Service (ASCS), Extension Service (ES) and other sources may be considered in addition to data collected from participants. Cost data are to be recorded and summarized on Forms SCS-CPA-154 and SCS-CPA-155 or similar forms. Average cost lists are to be prepared, reviewed, and updated at least annually to determine if changes are required. Changes in average costs can be made at any time if supported by justification and approved by the Moses Lake Conservation District; however, changes generally should not be made unless actual costs have increased or decreased by 10 percent or more.

(b) Average costs developed by the Project Manager are to be reviewed and concurred with by TAC, HUB, the MLCD, or appropriate agencies.

§404.32 Establishing Cost-share rates.

(a) Where the flat rate method is desired, the appropriate charge, based on either equipment rental rates or custom ownership rates in the area, should be used to determine the flat rate to be allowed.

§404.33 Use of other funds.

The participant's share of the cost of installing practices may come from any source other than Federal funds without a reduction in funding. If other Federal funds are used, the Clean Lakes share will be reduced by the amount of the other Federal funding.

## SUBPART E--CONTRACTING

### §404.40 GENERAL.

(a) The Conservation District will designate a Contracting Officer to work with the Project Manager assigned by the Moses Lake Clean Lake Project. The Contracting Officer (CO) will assure that the LTCs are being carried out in accordance with the MLCL procedures.

(b) The contract is to be based on the participants plan/schedule of operations regardless of who develops the contract. The Project Manager is to assemble the contract and forward it to the Contracting Officer for review, fund certification, and signing.

§404.41 (Save this section.)

### §404.42 Joint Agreements.

(a) A participant may enter an agreement jointly with other participants. Joint participation is permitted when it will result in better land use and treatment than individual participation.

(b) Whenever participants enter agreements jointly with other participants, the arrangement is to be documented. The agreement is to describe and show on a map or sketch the location of the practice or practices to be installed, specify the benefits each participant is to receive and the distribution of the cost-sharing payments, and define the maintenance responsibilities of each participant.

(c) Separate contracts are to be signed with each participant. The joint practice or practices may be included in the contract that includes the land on which the major portion of the practice or practices is to be installed. In these cases, the other contracts are to be cross referenced to the contract containing the practice or practices and each is to include the portion of the cost sharing applicable to the joint practice.

(d) A copy of the joint agreement is to be included in each contract.

§404.43 Control of land unit.

(a) A contract may be entered into with a participant who has control of a landunit for the contract period. Control means possession of the land by ownership or written lease. The HUB Council may waive this requirement in unique cases where a written lease is not customarily used. If control of the land unit is questioned, a participant will be required to furnish evidence of control satisfactory to the HUB. All participants, or person(s) designated by power of attorney, who control or share control of the land unit must sign the contract. The status of each participant, such as owner, co-owner, tenant, partner, or operator, is to be shown.

(b) The participant is responsible for obtaining the necessary permits to perform the planned work and furnishing necessary landrights and water rights. The MLCL Project may provide technical assistance to the participant in accordance with policy. When working with the Conservation District, the participant must certify that adequate land and water rights have been obtained. The Project Manager is to receive a copy of the certification; the PM is responsible to file this copy of certification in the participant's plan.

§404.44 Contract components.

The contract is to include the following documents:

(a) The long-term contract.

(b) Special provisions and supplements, if needed.

(c) Plan/Schedule of Operations, Forms SCS-CPA-11 or 11A.

(d) Plan map.

(e) Soil map, legend, and interpretations, if needed.

(f) Explanation of violations and procedures to be followed.

§404.45 Special contract provisions and supplements.

(a) Special provisions that provide for additional terms and conditions are to be made part of the contract under certain conditions and for specific purposes provided they are not contrary to established policies. Additional terms and conditions are to be prepared on a separate sheet under the heading "Special Contract Provisions" and must be referenced in Part II of the contract form and attached to the contract.

(b) The payments and time schedule clauses,included as a special provision, are to be included in all applicable contracts. The time schedule clause reduces the number of modifications required to reschedule measures or practices. Items to which this clause will apply must be carefully selected. The expected items are to be listed by number.

(d) If two or more participants sign a contract, it may be supplemented to provide for making cost-share payments to one participant or to permit one participant to sign applications for cost-share payments.

(e) The contract form may also be supplemented to authorize a designated individual to sign contract modifications or certain types of modifications. The person authorized need not be signatory to the contract.

§404.46 Contract period and limitations.

(a) A contract is to be for a period that is needed to install and ensure establishment of all measures and practices in the plan. The contract period may not be less than 3 years (36 months) nor more than 10 years (120 months). The contract begins on the date the contract is signed by the HUB Council. No cost-share payments will be made for contract items where the work was started before that date. Work on the installation of cost-shared practices must begin within one year (12 months) of the signing of the contract. No cost-share payments may be made for new work added by a contract modification until after the date the HUB signs the modification indicating funds are available.[404.50(c)(2)]

A contract is to extend for at least 2 years (24 months) after the initial application of the last required conservation treatment to ensure adequate establishment of the treatment. This means that all required treatment must be scheduled and installation completed no later than the 8th year of a 10-year contract. The 2-year period may be reduced for unusual circumstances with approval of the HUB Council.

(b) No more than $50,000.00 of cost-share Moses Lake Clean Lake funds may be paid to any one individual family, corporation, or combination of these, where the party has a mutual interest in the land.

§404.47 Responsibilities.

(a) Participant will--

(1) Carry out land use changes and conservation treatment according to the plan/schedule of operations, which is made a part of the contract, and in accordance with sepcifications in the SCS field office TECHNICAL GUIDE or MLCL approved special design.

(2) Submit to the Moses Lake Conservation District an application for payment, and itemized statements of cost of materials and copies of contractor's invoices whenever practices are cost-shared on an actual cost basis.

(3) Permit free access to SCS and Conservation District representatives to provide technical assistance and inspect the work at any reasonable time during the life of the installed practice.

(4) Forfeit all rights to further payments under the contract and refund to the ML Conservation District all payments received upon termination of the contract.

(5) Upon transfer of his or her right and interest in the land unit during the contract period, forfeit all rights to further payments under this contract, and--

(6) Refund all payments made under the contract if the transferee will not assume the obligations of the contract, and--

(7) Maintain the conservation treatment installed on the land unit as provided in the plan/schedule of operations.

(b) Conservation District will--

(1) Establish the cost-shared percentage.

(2) Provide authorized technical assistance, including but not limited to--

(i) Obtaining basic information.

(ii) Preparation of drawings, designs, and specifications.

(iii) Peformance of layout.

(iv) Inspection during installation,and

(v) Certification on completion of installation, and

(3) Make payment to the participant covering the share of the cost when--

(i) The technical adequacy and amount of work installed is checked and certified by MLCL Project, and

(ii) The participant has furnished required certifications and itemized statements of cost of materials and copies of contractor's invoices when practices are cost-shared on a actual cost basis.

§404.48 <u>Numbering and Distribution of Contracts.</u>

(a) Numbering.

(b) Distribution.

Contracts are to be distributed as follows:

(1) Original--

(A) The Moses Lake Clean Lakes Project Office.

(2) First copy to the participant who will conduct contract business.

(3) Other copies go to:

(A) The Moses Lake Conservation District.

(B) Other participants signatory to the contract.

§404.49 Assembling of Contracts.

Long-term contracts may be assembled in six (6) part folders. A suggested folder arrangement is as follows:

(a) First cover.

(1) Contract (SCS-LTP-2), Attachment A--Violations, and contract related forms, i.e., special provisions, supplements, equal opportunity (AD-369), noncompliance (SCS-CPA-153), violation (SCS-CPA-151), transfer (SCS-CPA-152), termination, etc.

(2) Program application form.

(b) Second cover:

(1) Status Review, SCS-CPA-13.

(2) Conservation Assistance Notes, SCS-CPA-6 (Field Office copy only).

(3) Location map.

(c) Third cover:

(1) Plan map and legend.

(2) Soil map and legend.

(d) Fourth cover:

(1) Revision or modification of Conservation Plan of Operation (latest action on top), SCS-CPA-12.

(2) Conservation Plan of Operation, SCS-CPA-11 or 11A or approved computer-generated CPO.

(e) Fifth cover:

(1) Job sheets (referenced from CPO).

(2) Worksheets (referenced from CPO).

(f) Sixth cover:

(1) Application for Payment-SCS-FNM-141.

(2) Joint Agreement (if any).

(3) Check-out notes and other support data. Reference to location of these data if they are not filed here.

(4) General correspondence (in date order).

(g) Soil Conservation District Agreement sheets will not be filed in the contract folder.

## SUBPART F--CONTRACT ADMINISTRATION

### §404.50 Modifications.

(a) General.

(1) To modify a participant contract, use Form SCS-CPA-12, Revision of Schedule of Operation or Modification of Contract.

(2) The basis for modifying the contract must be stated clearly on the modification or on an attachment to the modification.

(3) A modification is not necessary because of the substitution of mixtures, changes or elimination of component parts of a practice, increase in average cost or a change in the amount of a practice, provided the cost-share rate is the same, the substitution or change does not significantly increase or decrease the cost-share payment, and it is in accordance with the SCS TECHNICAL GUIDE or MOSES LAKE CONSERVATION DISTRICT HANDBOOK. One noncost-share practice may be substituted for another as long as the substituted practice meets the objective of the plan and is in accordance with the SCS TECHNICAL GUIDE.

(4) The HUB is to supplement this part to specify what is considered significant.

(i) If the average cost in effect at the time of starting the installation of a practice is less than the cost specified in the contract, cost-share payment is made at the lower cost and no contract modification is required.

(ii) Any change of a contract item that is not considered significant and, therefore, is not covered by a modification, must be explained on the Application for Payment Form.

(b) Actions requiring modifications.

(1) Adding Land. Both the participant and the CO must agree to adding land that is not currently under an existing contract. Enough time must remain under a contract to meet the 2-year requirement [§404.45(a)] to establish needed land treatment on any land to be added. If the land being added is already under contract, see §404.55 for the procedure.

(2) Deleting Land. See §404.55 for procedure.

(3) Changing contract period. For contracts exceeding three years, the contract period may be reduced with the approval of the CO if it is mutually beneficial. The contract period may not be reduced to satisfy or avoid contract violation problems or avoid the two year requirement [§404.45 (c)]. It cannot be used to reduce the contract to fewer than 3 years.

(4) Adding contract items. All new contract items,that are to be installed as part of the contract, are to be added to the LTC before performance on the new item is started. This includes adding an item to provide for the reapplication of a practice or identifiable unit.

(5) Deleting contract items. A contract is to include all conservation treatment agreed to by the participant that will accomplish the program objectives. A participant is expected to carry out all scheduled practices. There must be valid reasons not adverse to the Conservation District's interest and conservation objectives for deleting any contract item. Each modification must include sound justification for the deletion. For items to be carried out under other Federal programs or without cost-sharing, only the cost-share information is to be deleted and the items are to be shown in the plan as noncost shared (N/C).

(6) Changing time schedule. Although many uncontrollable factors influence a participant's ability to carry out conservation treatment as scheduled in the plan, progress should be monitored sufficiently to reduce the need for modifying contracts to avoid noncompliance with the time schedule.

(7) Changing specifications or materials. Modifications to authorize changes in specifications or materials may be made if the changes meet SCS and MLCL Project requirements.

(8) Significant changes in average specified maximum costs.

(i) Modifications for increasing or decreasing average or specified maximum costs are required when the change in the cost-share obligation is significant [§404.50 (a)(3)]or failure to modify the contract would result in extensive loss to the participant.

(ii) Modifications that increase average costs and make no other change need only the signature of the Project Manager.

(iii) Modifications that increase or decrease average or specified maximum costs are to be limited to works that are scheduled or planned for installation in the current year. The contract cannot be modified to increase average costs for a practice or conservation treatment after a participant has started work on the respective practice.

(9) Significant changes in the amount of a practice. Modifications to change the amount of a practice are required if the increase or decrease in amount is known before actual installation and will result in a significant increase or decrease in the cost-share obligation.

(10) Permitting participants to destroy or break up a practice.

A modification is required to permit a participant to destroy or break up any practice established under the contract or any existing practice for which maintenance is specified in the contract. It is the participant's responsibility to obtain approval from the agency concerned to destroy or break up a practice that was cost-shared under any other conservation program if the practice has not fulfilled its life span or maintenance requirements.

(i) The Project Manager must establish clearly defined needs before approving the destruction. It must be considered essential to the most practical operation of the land unit.

(ii) The destruction of the practice must be followed with needed compensatory treatment to adequately protect the area and to preserve the effectiveness of other practices already installed on the land unit.

(iii) All MLCL cost-share payments made for the practice destroyed or brokenup are to be deducted from the cost-share payment due for the replacement practice. Additional eligible costs that result from carrying out a replacement practice may be authorized for cost-sharing. If compensatory treatment consists of noncost-shared practices, all cost-share payments made for the destroyed practice are to be refunded by the participant. The refund may be deducted from future cost-share payments due the participant.

(iv) Failure to replace the practice destroyed with needed compensatory treatment constitutes violation of the contract, and all cost-share payments made for the destroyed practice are to be refunded by the participant.(§404.75)

(11) Adding special provisions. Special provisions, terms, and conditions may be added to a contract by modification.

(12) Changing method of cost-sharing. Contracts may be modified to change the method of cost-sharing at any time before the date a practice is started.

(c) Procedures.

(1) Indicate modifications to the contract by recording the number of the modification in the reference column of Form SCS-CPA-11, 11A, on the line of the contract item that is modified. To determine the status of contract items, all modifications and the CPO must be checked.

(2) The effective date of a contract modification is the date it is signed by the HUB. In approving modifications, the Project Manager is to initial all modifications to show approval before transmitting to the HUB for signing. No cost-share payments may be made for new work included by a modification if the application work is started before the modification is signed by the HUB indicating that funds are available; however, if circumstances will not permit delay in obtaining the signature of the HUB, the HUB Chairman may give approval by telephone and document the file to support the action.

(3) Funds scheduled for cost-sharing any practice may be deleted from a plan and contract by modification if a participant elects to carry out the practice under another cost-sharing program, or at his or her own expense before installation is started. If any part of a practice is begun before modification of a contract, all of that practice must be carried out under that cost-sharing program.

(4) The consecutive numbering of contract items is to be continued for new items added by modifications and is to be maintained for the life of the contract. The originally assigned item number is to be used for any item that is modified.

§404.51 Contract status review.

(a) Active contracts are to be reviewed annually, on the land and with participants if possible, to assess current conditions and progress in carrying out the plan/schedule of operations. Final review of a contract is to be made with the participant at least 90 days before the contract expires.

(b) Even though the acreage under contract must be visited one or more times during a year, the annual review should be the occasion for careful evaluation of the participant's needs and problems and the status of the contract and operations. Following are some areas to be checked and finding recorded on SCS-CPA-13, Status Review. (See next page.)

(1) Maintenance of practices previously applied.

(2) Application of practices scheduled in the current year.

(3) Need for changes in time schedule or practices.

(4) Adequacy of applied conservation practices in relation to erosion control achieved.

(5) Determination of whether land under contract is still under the participant's control.

(6) Items needing attention next year.

(c) The Project Manager must sign the report. Any MLCL staff member or other designated person who makes a review should sign immediately above the space for the PM's signature. If the review is made with the participant, he or she should sign or initial the report to indicate concurrence. The original report is to be sent to the Moses Lake Clean Lake Project Office, and copies furnished to all other holders of the contract.

§404.52 Spot checks of performance.

Performance of conservation treatment installed under contracts is to be checked as stipulated in the SCS GENERAL MANUAL under Section 450, part 407, and in accordance with State policy.

§404.53 Reapplication of conservation treatment.

(a) Contracts may be modified to cost-share reapplication of practices that initially failed to achieve desired results or deteriorated, provided that:(1) Reapplication is required to solve the identified problem to the degree needed to meet program objectives, (2) The specifications for the practices were met in the original application, and (3) Failure or deterioration of a practice because of circumstances within the control of the participant constitutes a violation of the terms and conditions of the contract.

(b) Reapplication of practices will not be scheduled until the original application has failed or deteriorated. Reapplication of cost-shared practices may be approved after the 8th year of a 10 year contract, if needed. It may not be carried out after the contract is completed.

(c) The cost-share rate for the reapplication is to be the same rate established in the original contract. Contract items included on modifications for reapplying practices are to be numbered the same as the original contract item, suffixed with the letters "RA".

(d) Reapplication payments may be for only the dollar amount difference remaining between the amount expended on the original contract and the program limitation (§404.64). Where reapplication costs would require exceeding the program financial limitation, a new limitation may be approved by the HUB Council.

§404.54 Second Contracts.

(a) Subsequent contracts entered into with the same or new land user on the same land unit or an operating unit made up primarily of land under previous long-term contracts are considered to be second contracts.

(b) Second contracts may be developed for only the dollar amount difference remaining between the amount expended on the original contract and the program limitation (§404.54 (d)(1)] and reconstruction would require exceeding the program financial limitation, a new limitation may be approved by the Moses Lake Conservation District.

(c) Second contracts may not be entered for the purpose of circumventing financial or contractural limitations--for example: to permit beginning or completing practices,planned but not completed under the initial contract,primarily for purposes such as converting grassland enterprises to cash grain; developing new or redesigning irrigation systems; or converting conventional terraces that meet the conservation needs to parallel--or to replace treatment, established or maintained under the previous contract, which has been destroyed.

(d) Second contracts may be entered into for the following purposes:

(1) Practice failure. To repair or reconstruct practices, cost-shared under previous contract, that failed or deteriorated for reasons beyond the control of the participant.

(2) Initial contract terminated. With new participants only, to apply needed conservation practices on land units under previous contracts terminated for cause or by mutual consent before the planned measures were applied.

(3) New land units. To make land use adjustments and apply needed conservation practices on new land units created through subdivision of a larger unit or through combination of smaller units under a previous contract. Examples: conversion of cropland to grass, water development, fences and related measures.

(4) Advanced technology. For conservation, development, and use of soil and water resources not considered feasible under the initial contract. Examples are installation of artesian or deep wells, pipeline water distribution systems, or additional fences and water facilities needed to establish specialized grazing systems.

§404.55 Transfer of Land.

(a) Land will be considered "transferred" if the participant loses control of the acreage for any reason. The term "transferor" means the participant who loses control, and the term "transferee" means the person who acquires control of the land. Table(§404.1)provides guidance for determining the new financial and contract period limitations for the transferred contract.

(b) If all or part of a land unit under contract is transferred, the contract terminates with respect to the transferred acreage; however, the transferee may assume the obligations of the contract with respect to the transferred acreage. The procedure for transferring the rights and obligations under a contract is dictated generally by the extent of the acreage transferred and how the land unit will be operated after the transfer. If the transferee will not assume the obligations of the contract (noncompliance) with respect to the transferred acreage, the transferor is subject to forfeiture and refunds of payments received on the transferred acreage. (§404.75).

(c) If all of a land unit under contract is transferred and is to be operated as a separate unit, a Transfer Agreement, For SCS-CPA-152, is to be executed. (§404.93) The transferee, by signing the transfer agreement, assumes all of the rights and obligations of the contract. The contract period of the original contract applies. The description of the acreage transferred and all practices to be carried out by the transferee are to be listed on the transfer agreement. The transferee is to be furnished a complete copy of the contract, including all modifications. The original copy of the executed transfer agreement is to be filed with the original copy of the contract. Copies,manually signed by both parties and the Contracting Officer,are to be furnished to the transferee and transferor. Conformed copies are to be furnished to all others having copies of the contract.

(d) If all of the land unit under contract is transferred and is combined with another land unit under contract, transfer the obligations of the contract by modification of the contract, Form SCS-CPA-12. Prepare a contract modification to delete all remaining items from the transferor's contract. Modify the transferee's contract to add the acreage transferred and the practices remaining to be installed. The modification is also to list all of the practices carried out on the transferor's land unit and provide that these practices be maintained by the transferee. Do not show cost-sharing information for practices already installed. They are to be designated N/C(not cost-shared) in the new contract. The contract period of the transferee's contract is not changed even though the dates on the two contracts may be different.

(e) If only part of a land unit under a contract is transferred and not made part of another land unit under contract, prepare a new contract. Include all practices to be carried out on the transferred land and all practices installed on the transferred land that are to be maintained by the transferee. Do not show cost-sharing information for practices already installed. They are to be designated N/C in the contract with the transferee. The new contract is to be for a period required to establish the scheduled practices; however, the period is to be not less than 3 years (36 months) nor more than 10 years (120 months). The transferred acreage and all applicable practices are to be modified out of the transferor's contract. This is to be done after the new contract is signed by the transferee.

(f) If only part of a land unit under a contract is transferred and made part of another land unit under contract, transfer the acreage and obligations of the contract by modification. Two modifications are required, one to transfer the acreage and obligations from the transferor's contract, and one to transfer the acreage and obligations into the transferee's contract. The modification to transfer the acreage and the obligations out of the transferor's contract must not be approved by the HUB before approving the modification transferring the acreage and obligations into the transferee's contract.

(g) If all of the land unit under contract is transferred and is combined with another unit not under contract but the transferee has requested a contract, prepare a new contract. Include all practices to be carried out on the transferred land unit and all practices installed on the transferred land unit that are to be maintained by the transferee in the new contract. Do not show cost-sharing information or practices already installed. They are to be designated N/C in the new contract with the transferee. The transferred acreage and all practices are to be modified out of the transferor's contract. This is to be done after the new contract is signed by the transferee.

SEE SUMMARY OF LAND TRANSFERS GRAPH NEXT PAGE:

TABLE 404.1 SUMMARY OF LAND TRANSFERS

| | FINANCIAL LIMITATION | TIME LIMITATION |
|---|---|---|
| 1. All acreage transferred and operated as a separate unit. | No change | No change |
| 2. All acreage transferred and combined with another unit under contract. | Cost-share payments made on transferred acreage before transfer not considered. Cost-share payments made to transferee on the transferred acreage applies to limitation in existing contract. 1/ | Transferee's original contract limitation controls. 1/ |
| 3. Part of the acreage transferred but will not be combined with another unit under contract, new contract signed. | -Difference between cost-share paid to transferor and original contract. 2/<br>-New contract limitations apply. 3/ | A new contract limitation applies. |
| 4. Part of the acreage transferred and combined with another unit under contract. | Cost-share payments made to transferor before transfer not considered. However, cost-share payments made to transferee for work performed on the transferred acreage applies to limitation in transferee's original contract. 1/ | Transferee's original contract limitation controls. |
| 5. All acreage transferred (combined with another unit not currently under contract but transferee desires a contract. | New contract limitations apply. | A new contract limitation applies. |

1/ If limitation will not permit transferee to carry out all planned work on transferred acreage and existing contract, HUB will determine the limitation.

2/ Applicable if no significant new acreage added by transferee.

3/ Applicable if significant acreage added by transferee not previously under contract.

§404.56 Expiration and Termination of Contracts.

(a) Contracts expire at 12 p.m. (midnight) on the expiration date. All items in a contract must be reviewed onsite at least 90 days before the expiration date. This review should be made with the participant. The findings must be recorded on Form SCS-CPA-13, Status Review. Notice of contract expiration is not required; however, the HUB may recognize successful completion with a personal letter to the participant.

(b) Failure to satisfactorily complete all contract items before the contract expires constitutes violation of the contract, and the participant may be subject to refund the total cost-share payments made under the contract (§404.75). If it is determined by the HUB that failure to complete the contract was caused by circumstances beyond the control of the participant, refund or adjustment of cost-share payments is not required.

(c) A contract will be terminated if the installation of cost-shared practices is not started within one year (12 months) of the signing of the contract.

(d) If all or a part of a land unit is transferred by sale or otherwise, the contract terminates with respect to the acreage of land transferred. Land will be considered "transferred" if the participant loses control for any reason. All cost-share payments for practices and components carried out on the transferred land must be refunded if the transferee does not assume the responsibility for the contract. (§404.75)

(e) Contracts are terminated with forfeiture or refund as agreed to or as imposed as a result of violation of the contract (§404.61 and §404.75).

(f) Contracts may be terminated by mustual consent for any mutually acceptable reason if the participant agrees to refund all of the cost-share payments made under the contract (§404.75).

(g) Land lost or transferred from a land unit because of encroachment for such public purposes as highway development, military installation, or municipal expansion will require a refund or an adjustment of all cost-share payments made for practices and components carried out on that land (§404.75). If the remaining land unit after encroachment is not a feasible or practical operation, the HUB may authorize termination of the contract by mutual consent without refund of cost-share payments made on the remaining land.

(h) A contract may be terminated because of death of the participant or because it is determined that a participant is under such physical or mental disability that it would not be reasonably possible to carry out the terms and conditions of the contract and that to require compliance would cause undue hardship. Termination of this nature may be made without recovery of cost-shares with approval of the HUB Council and the Moses Lake Conservation District.

(i) The HUB is to issue a notice of contract termination to the participant in all cases, except for expiration. There are no printed forms for notice of termination. Termination notices,issued as a result of transfers and by mutual consent, should follow the format and content illustrated in the exhibits. The particpant's signature is required if termination is by mutual consent. Termination notices issued as a result of violations are to be in the form of a letter to the participant. The letter is to state the nature of the violation, that the contract is terminated, the amount of refund and interest due, and how repayments are to be made. (§404.75).

## §404.57 Nondiscrimination and equal employment requirements.

(a) The Equal Opportunity clause and Nonsegregated Facilities provisions applicable to federally-assisted construction contracts include construction work carried out through long-term contracts. They apply if--

(1) A participant enters into any single contractual arrangement with a contractor and the estimated cost exceeds $10,000.00 or--

(2) A participant performs the construction work and employs personnel for the specific purpose of assisting in performing the work, and the estimated cost exceeds $10,000.00 for work to be carried out during a 12 month period.

(b) The following clauses are to be included as special provisions in contracts for which the estimated cost exceeds $10,000.00:---

(1) The participant agrees to include in any single contractual arrangement estimated to exceed $10,000.00-the Equal Opportunity clause and Nonsegregated Facilities-provisions applicable to federally-assisted construction contracts.

(2) The participant agrees to comply with Executive Order 11246 and the Nonsegregated Facilities provisions with regard to employment of people specifically to assist the participant in construction work estimated to exceed $10,000.00 to be installed in any 12-month period.

(3) The participant agrees to actively assist the Conservation District in obtaining from the contractor full compliance with the Equal Opportunity clause and the Nonsegregated Facilities provisions in any contractual arrangement entered into be the participant. The CO is to furnish the participant all forms, posters, and instructions for compliance with Executive Order 11246 and the Nonsegregated Facilities provisions.

(c) Form AD-369, Equal Opportunity, Form SCS-ADS-818, Certification of Nonsegregated Facilities, and Form SCS-ADS-819, Notice to Prospective Federally Assisted Construction Contractors, are to be furnished to participants for inclusion in any contractural arrangement exceeding $10,000.00. Form SCS-ADS-818 is to be signed by the contractor and copies are to be furnished to the SCS State Office.

## § 404.58 Materials Required.

(a) New materials are to be used in all work installed unless the contract specifically provides for the use of used materials.

(b) Used materials may be authorized if the criteria set forth in the National Engineering Manual, Part 543, are met. The determination that used materials meet SCS requirements rests with the individual having job approval authority.

(c) Cost-sharing for used materials is permitted only if they are purchased by a participant for a specified practice. Cost-sharing is not allowed for used materials that the participant has on hand. Used materials are to be cost-shared on the basis of actual cost, not to exceed the average cost of new materials.

## SUBPART G--VIOLATIONS

### §404.60 Causes.

(a) Noncompliance.

(1) Failure to comply with all terms and conditions of the contract is considered to be noncompliance. This includes, but is not limited to, failure to carry out the LTC as scheduled, failure to begin within a 12-month period, failure to meet specifications for establishing practices, failure to satisfactorily complete all contract items, or failure or deterioration of a practice because of circumstance within the control of the participant.

(2) A participant who fails to carry out a practice as scheduled in the LTC will not be considered in violation if the practice is promptly rescheduled by modification. Modifications to reschedule cost-share practices should not be approved after the eighth year of a contract, because the 2-year establishment requirement could not be met.

(b) Practice destruction. Destruction of a practice established under the terms of the contract without approval of the CO or failure to apply compensatory treatment for a destroyed practice.

(c) False application for payment. Filing a false application for cost-share payment.

### §404.61 Determination of Violations.

(a) Moses Lake Conservation District participant contracts.

(1) The Project Manager is to furnish the HUB Council any information obtained that indicates a violation may have occurred. The HUB is required to ascertain if a violation has occurred and, if so, determine if a forfeiture, refund, payment adjustment, or termination is warranted. (§404.75)

(2) Following the investigation, the HUB is to make a written report to the Moses Lake Conservation District. The report is to include information received by the HUB and findings of fact and determination. If no violation has occurred, or if a violation has occurred, but no forfeiture, refund, payment adjustment, or termination is required, no further action is necessary. A copy of the report of the HUB, approved by the Moses Lake Conservation District, will be provided to all holders of copies of the contract.

(3) If a violation is apparent and forfeiture, refund, payment adjustment, or termination is required, the HUB, in consultation with the Conservation District, is to try to obtain an agreement. The agreement is to be on Form SCS-CPA-153, Agreement Covering Noncompliance.

(4) If no agreement is reached, a notice of violation is to be issued on Form SCS-CPA-151, Notice of Agreement or Contract Violation. This notice is to be forwarded to the participant by certified mail--return receipt requested. After a Notice of Agreement or Contract Violation has been issued, follow the procedure outlined in §404.62 and §404.75.

§404.62 Violation Procedures.

(a) Scope. This section prescribes the regulations dealing with contract violations. No cost-share payment shall be made pending the decision on whether a contact has been violated.

(b) Determination by Project Manager. Upon notification that a contract may have been violated, the Project Manager is to:

(1) Determine, with the approval of the HUB Council, that a violation did not occur or that the violation was of such a nature that no penalty of forfeiture, refund, payment adjustment, or termination is necessary. No notice is issued to the participant, and no further action is to be taken or:--

(2) Determine, with the approval of the HUB Council, that a violation did occur, but the participant agrees in writing to accept the penalty. If the participant agrees in writing to accept the penalty of forfeiture, refund, payment adjustment, or termination, no further action is necessary.

(c) Notice of possible violations.

(1) When the HUB Council is notified that a contract violation may have occurred that may warrant a penalty or forfeiture, refund payment adjustment or termination, the HUB is to notify, in writing, each participant who signed the contract of the alleged violation. This notice may be personally delivered or sent by certified or registered mail. A participant is considered to have received the notice at the time of personal receipt acknowledged in writing, at the time of the delivery of a certified or registered letter, or at the time of the return of a certified or registered letter when delivery was refused.

(2) The notice setting forth the nature of the alleged violation is to give the participant an opportunity to appear before a hearing officer. The participant's request for a hearing is to be submitted in writing and must be received in the Conservation District office within 30 days after receipt of the notice. The participant is to be notified in writing by the hearing officer of the time, date, place for the hearing. Participants have no right to a hearing if they do not file a written request, or if they or their representative do not appear at the appointed time, unless the hearing officer permits an appearance at another specified time. A request for a hearing filed by a participant is considered to be a request by all participants who signed the contract. The request also supercedes any further bills for collection and interest charges if the violation involves refunds.

(d) Hearing Officer.

(1) The Hearing Officer,appointed by the Conservation District,should be someone other than the Project Manager. If a violation involves considerable money or possible termination of a contract, it would be advisable to confer with the Conservation District's attorney.

(e) Hearing.

The Hearing Officer is to limit the hearing to relevant facts and evidence, and is not to be bound by the strict rules of evidence as required in courts of law. Witnesses may be sworn in at the discretion of the Hearing Officer.

(1) Participants or their representatives are to be given full opportunity to present oral or documentary evidence about the alleged violation. Likewise, the Conservation District may submit statements and evidence. Individuals not otherwise represented at the hearing may be permitted, at the discretion of the Hearing Officer, to give information or evidence. The hearing officer, at his discretion, may permit witnesses to be cross-examined.

(2) The Hearing Officer is to make a record of the hearing so that the testimony can be summarized. A summary of the testimony is to be made. A transcript of the hearing is to be made, if requested, by either the Conservation District, or participant at least 10 days before the hearing. If a transcript is requested by the participant, the participant may be assessed the cost of a copy of the transcript.

(3) The Hearing Officer is to close the hearing after a reasonable time if the participant or the participant's representative is not present at the scheduled time. The Hearing Officer may accept information and evidence submitted by others present for the hearing.

(4) The Hearing Officer is to furnish the Conservation District with a written report setting forth the findings, conclusions, and recommendations. The report is to include a summary of testimony or transcript of the hearing and any other information that would aid the Moses Lake Conservation District in reaching a decision.

(f) Decision.

(1) The Conservation District is to make a decision, after considering the Hearing Officer's report, recommendation to the Conservation District, and any other information available. The decision is to state whether the violation is of such a nature as to warrant termination of the contract, or if the contract is not to be terminated, the amount of the forfeiture, refund, or payment adjustment. The Conservation District may authorize or require the reopening of any hearing before a Hearing Officer for any reason at any time before the decision is rendered.

(2) If the decision provides for termination of the contract, it is to state that the contract is terminated, that all rights to further cost-share payments under the contract are forfeited, and that cost-share payments received under the contract are to be refunded. The decision is to state the amount of refund, interest charges, and method of payment. The decision also reinstates required bills for collection and interest charges where refunds are due. (§404.75)

(g) Appeal to the Moses Lake Conservation District.

Any participant adversely affected by a determination of the Conservation District shall have the right of appeal. A participant who wishes to appeal must file with the Moses Lake CD. This appeal and any briefs or statements must be received within 30 days after the participant has received notice of the determination of the Moses Lake CD. Where refund amounts are due, the appeal supercedes bills for collection and interest. The Conservation District may file a brief or statement in the office of the Moses Lake Irrigation District within 15 days after the participant's brief or statement is received there. The appeal shall be limited to the records and the issues made before the Conservation District which will be submitted to the Moses Lake Irrigation and Rehabilitation District (MLIRD) for their decision from which there shall be no further appeal. The decision will be based upon the record before them and the issues presented by the appeal and the participant shall be notified in writing. A final decision reinstates bills for collection and interest charges where refunds are due.

## SUBPART H--COST-SHARE PAYMENTS

### §404.70 Application for payment.

(a) Participants are to apply to the Moses Lake Conservation District for cost-share payments on Form A 19-1, State of Washington Invoice Voucher, upon completion of the installation of any cost-shared practice or practice component listed in the plan/schedule of operations. The Project Manager may help participants prepare their applications. Applications for payments due are to be filed by September 30 of the year following the calendar year in which the practices or components were completed. Those made after this date require approval of the HUB Council.

(b) The participant is to be advised that acceptable itemized receipts, invoices, or cost statements must support application for payments if cost-sharing is based on actual costs.

(c) To receive reimbursement from the Moses Lake Irrigation District for work installed under Conservation District-Participant Contracts, the Conservation District is to submit Form A19-1 and include copies of original acceptable receipts, billings, or statements of costs if cost-sharing is on an actual cost basis. (Form A19-1, State of Washington Invoice Voucher).

(d) Payments by the Moses Lake Irrigation District will be made only to the participant(s). No direct payments will be made to contractors or vendors.

### §404.71 Payments not authorized.

Cost-share payments may not be authorized under the following conditions:

(a) For unapplied materials or for services that partially complete a component of a practice.

(b) For a practice or component that depends on the performance of another practice that failed to meet specifications and for which cost-share payment was denied. The participant must be informed by an explanation on Form SCS-CPA-153, Agreement covering Noncompliance with Provisions of Contract.

(c) For any work performed by a participant before the date the contract or modificaiton adding new work is signed by the HUB Council.

(d) For use of used materials except as authorized in §404.58.

(e) For any application that would result in duplicate payment.

(f) If cost-share payment will result in total payments exceeding the program limitation.

§404.72 Payment to a designated participant.

A contract may be supplemented to provide for making cost-share payments to one participant when two or more sign the contract, The following clause is to be added as a supplement to the contract in order to make payments to only one participant.

> It is further agreed that ____________________ is the participant who will carry out all conservation treatment for which cost-share payments will be made. Therefore, all payments shall be made to ______________________________. Application for Payment shall be signed only by ____________________________________.

§404.73 Signing of Applications for Payment by designated participant.

A contract may be supplemented to provide for signing the Application for Payment by one participant when two or more participants sign the contract. Cost-share payments under a contract so supplemented are to be drawn in the names of all participants who signed the contract. The following clause must be added as a supplement to the contract to authorize signature by only one participant.

> Application for Payment will be signed only by
>
> ____________________________________________.

§ 404.74 Filing of false payment applications.

Applications for cost-share payments for practices or components not carried out or that do not meet required specifications constitute false applications. Participants filing false or fraudulent applications are subject to a fine of not more than $10,000.00 or imprisonment of not more than 5 years or both.

# APPENDIX J

# ASCS COST-SHARE PROCEDURES

# INTRODUCTION

The Moses Lake Clean Lakes Project study has been in progress for the past two years.

Several factors contributing to the water quality problems in Moses Lake have been determined. One factor is the level of nitrogen and phosphorus from agricultural cropland that is leaching into the lake.

The Agricultural Stabilization and Conservation Service has provided cost-share funds to solve conservation problems for over 40 years under the Agricultural Conservation Program (ACP).

For the first time in Grant County, the County Committee has requested and received special project funding under ACP which will be targeted solely to improve the water quality of Moses Lake by making conservation improvements in the Ephrata Malaga soil areas identified by the maps on the following pages.

If you own or operate commercially producing agricultural land within the special project boundaries, you could qualify for up to $3500 in cost-share assistance to perform some of the practices offered in the handbook. The cost-share is based on 75% of the total cost of performing a project.

Most of the practices are identical to those offered in the regular ACP handbook, EXCEPT for the Irrigation Water Conservation Practice where several regular ACP restrictions have been eliminated. In the special project area only, pipeline replacements, converting from portable to underground lines, installing mainline to corners of circles, and converting from one type of sprinkler system to another will qualify for cost-sharing along with other types of irrigation system improvements.

A two week sign-up is scheduled from March 11th through the 22nd for projects to be performed this spring. A sign-up will be held later for fall practices. You must visit the ASCS Office to make application.

If you have any questions concerning eligibility, contact the ASCS County office in Ephrata at 754-2051 or the Moses Lake SCS Office at 765-3261.

Sincerely,

John Gauntt, Chairman
Melvin Schwab, Vice-Chairman
Richard Heathman, Regular Member

By: [signature]
Ben J. Davis
County Executive Director

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## SOLUTIONS TO WATER QUALITY PROBLEMS

SL1 PERMANENT VEGETATIVE COVER ESTABLISHMENT

A The purpose of this practice is to protect the soil and reduce water, air, or land pollution from agricultural or silvicultural nonpoint sources.

B Apply this practice to establish permanent vegetative cover on farmland or ranchland that is subject to wind or water erosion, and on which the use is to be changed from small grains or cultivated crops to permanent vegetative cover.

C Policies for this practice are as follows:

1 Cost-sharing is authorized for seed, seedbed preparation and seeding. The requirments for eligible seeds (mixtures) must be substantiated as needed by an official of the Soil Conservation Service and the recommended seeding plan designed by SCS must be followed.

2 Cost-sharing is not authorized for:

a Land eroding at "T" value or less, if the practice is installed to control erosion. It is not necessary to use soil loss rates to determine eligibility if the practice is being installed primarily to improve water quality.

b Clearing of rocks or other obstructions from the area to be seeded.

c Fencing.

d Vegetative cover which included only legumes.

e Establishing vegetative cover on SCS Class I and II lands. (Exception: Class IIE land is authorized for cost-sharing.)

3. The acreage seeded must be protected from grazing by domestic livestock until the stand is well established.

4. The vegetative cover must be maintained without additional cost-sharing for a minimum lifespan of 5 years after the calendar year in which the cover was established. Cost-shares must be refunded if the farmer destroys the cover during its lifespan.

5. Give consideration to the needs of wildlife when making determinations about seed varieties and other practice specifications.

6. Cost-sharing shall be limited to the minimum seed(s) needed to establish adequate cover to control erosion.

7. Harvesting a cash nurse crop from this seeding will disqualify this practice for payment.

D. Specifications

Establish in accordance with SCS Technical Standards and Specifications.

E. Technical Responsibility

Assigned to SCS.

F. Maximum Federal Cost-Sharing seedbed preparation, seed and seeding of grass or grass and legume mixture alone or with a nurse crop that will not be grazed or clipped for hay $21.18 per acre.

SL5 DIVERSIONS

A The purpose of this practice is to conserve water, control erosion, and reduce pollution of land, water or air from agricultural nonpoint sources.

B Apply this practice to farmland subject to erosion from excess surface or subsurface water runoff where the problem can be corrected by diversion facilities.

C Policies for this practice are as follows:

1 Cost-sharing is authorized for:

a Diversions, ditches, or dikes.

b Installation of structures such as pipe, chutes, underground outlets, or other outlets, if needed, for proper functioning of a ditch or dike, for more even flow, or to protect outlets from erosion.

c Necessary leveling and filling to permit installation of an effective system.

2 Cost-sharing is not authorized for ditches or dikes designed to impound water for later use, or that will be a part of a regular irrigation system.

3 A protective outlet or waterway that is installed solely as an outlet for a diversion system and serves no other conservation purpose can be cost-shared as a component of this practice. A protective outlet or waterway that, by itself, solves a conservation problem, but also serves as an outlet for a diversion system, can be cost-shared under practice WP1 or WP3.

4 The system shall be maintained for a minimum of 10 years following the calendar year of installation.

D Specifications Establish in accordance with SCS Technical Standards and Specifications.

E Technical Responsibility is assigned to SCS.

F Maximum Federal Cost-Sharing

1. 75% of the actual cost of constructing terraces less than $2\frac{1}{2}$ feet in height with standard bottom not to exceed .60¢ per linear foot.

2. 75% of the actual cost of excavation not to exceed .86¢ per cubic yard.

3. 75% of the actural cost of pipe installed not to exceed an amount determined by the COC.

4. 75% of the actual cost of constructing protective outlets not to exceed an amount determined by the COC.

COST DATA REQUIRED

WC 4 IRRIGATION WATER CONSERVATION

A The purpose of this practice is to conserve irrigation water, improve water quality, control erosion, and reduce the pollution of water or land from agricultural nonpoint sources.

B Apply this practice to organizing systems on land currently under irrigation for which an adequate supply of suitable water is available, on which irrigation will be continued, and on which a significant soil or water conservation problem exists.

C Policies for this practice are as follows:

1 Cost-sharing is authorized only for the following measures if included in a plan or a portion of a plan approved by SCS for reorganizing an irrigation system (where water management is included as a part of the reorganization plan the applicant is to be encouraged to follow it).

a Tailwater recovery systems, or desilting ponds, or other installations for the conservation of soil or water where needed as an integral part of the irrigation system being reorganized.

b Permanently installed systems.

c Lining irrigation ditches.

d Installing or replacing underground mainlines.

2 Cost-sharing is not authorized for:

a Reorganizing a system if the primary purpose is to bring additional land under irrigation.

b Portable pipe, cleaning a ditch, or installations primarily for the farm operator's convenience.

c Installations to convert an existing sprinkler or overhead system to a gravity system.

d Restoring a system which has deteriorated due to lack of maintenance during periods of non-use.

3 Consideration must be given to the needs of wildlife, preserving or enhancing the appearance of the area, and potential pollution hazards, when reorganizing the system.

4 The land under irrigation for practice eligibility purposes must have been irrigated 4 of the last 5 years.

5 The system must be maintained for a minimum of 10 years following the calendar year of installation.

D Specifications. Establish in accordance with applicable SCS technical standards and specifications.

E Technical Responsibility is assigned to SCS. Practice must be performed according to plan approved by the technician. (A Water Management Plan is also recommended).

F Maximum Federal Cost-Sharing.

1 Cost of materials and installation which is necessary for the proper functioning of the project as follows:

a High Pressure pipelines (Steel or PVC)

| Size | Cost-Share Per Foot |
|---|---|
| 4" | $1.80 |
| 5" | 2.18 |
| 6" | 2.60 |
| 8" | 3.76 |
| 10" | 5.12 |
| 12" | 6.89 |

.57¢ per diameter inch per linear foot for all pipe larger than 12".

.45¢ per diameter inch per linear foot for eligible pipe installed less than 4".

b .23¢ per diameter inch per linear foot of low pressure plastic or concrete pipe installed.

c $3.32 per linear foot of concrete lined ditch installed.

d Cablegation pipelines.
.30¢ per diameter inch per linear foot of cablegation pipeline installed.

e Spigoted Pipelines.
.27¢ per diameter inch per linear foot of spigoted pipelines installed.

f 75% of the actual cost of excavation for desilting ponds not to exceed .86¢ per cubic yard.

g 75% of the actual cost of installing inlet or outlet structures for concrete ditches or pipelines not to exceed an amount determined by the COC.

COST DATA REQUIRED FOR EXCAVATION & APPURTENANCES.

WP1 SEDIMENT RETENTION, EROSION OR WATER CONTROL STRUCTURES

A The purpose of this practice is to reduce erosion and the pollution of land or water from agricultural or silvicultural nonpoint sources.

B Apply this practice to specific problem areas on farms where run-off of substantial amounts of sediment or runoff containing pesticides or fertilizers constitute a significant pollution hazard.

C Policies for this practice are as follows:

1 Cost-sharing is authorized:

a For sediment detention or retention structures, such as erosion control dams (excluding water storage type dams), desilting reservoirs, sediment basins, debris basins, or similar structures.

b For channel linings, chutes, drop spillways, and pipe drops that dispose of excess water.

c For fencing a vegetative cover and for leveling and filling to permit the installation of the structure.

d For installing sediment retention structures on public roadsides only where such structures are essential to solve a farm-based pollution or conservation problem.

e Only if the measures will contribute significantly to maintaining or improving soil or water quality.

2 Cost-sharing is not authorized for irrigation structures which are part of a distribution system for irrigation water.

3 Consideration must be given to the needs of fish and wildlife when establishing the protective measures.

4 The structure shall be manintained for a minimum of 10 years following the calendar year of installation.

D Specifications County practice shall provide for any requirements upon which cost-sharing is conditioned. Technical specifications may be incorporated by reference.

E Technical Responsiblility is assigned to SCS.

F **Maximum Cost-Shares**

1 75% of the actual cost of excavation not to exceed .86¢ per cubic yard.

2 75% of the actual cost of pipe installed not to exceed an amount determined by the COC.

3 75% of the actual cost of necessary appurtenances including drop spillways, channels linings, chutes, pipe drops and channels not to exceed an amount determined by the COC.

COST DATA REQUIRED FOR EARTHMOVING, PIPE, AND APPURTENANCES.

WP3 SOD WATERWAYS

A The purpose of this practice is to reduce existing erosion and water or land pollution from agricultural nonpoint sources.

B Apply this practice to farmland needing permanent sod waterways to convey excess surface runoff water in a manner that will reduce erosion.

C Policies for this practice are as follows:

1 Cost-sharing is authorized for site preparation, grading, shaping, filling, and establishing permanent vegetative cover. Also cost-sharing is authorized for subsurface drains that are necessary for proper functioning of the waterway.

2 The cover may consist of sod-forming grasses, legumes, mixtures of grasses and legumes, or other types of vegetative cover that will provide the needed protection from erosion.

3 Close-sown small grains, annuals, or mulching may be used for temporary protection if eligible permanent vegetative cover established by seeding or natural revegetation is established later.

4 The practice shall be maintained for a minimum of 10 years following the calendar year of installation.

D Specifications Construct in accordance with a guide prepared by SCS.

E Technical Responsibility is assigned to SCS for need and practicability, site selection, other preliminary work and layout.

F Maximum Federal Cost-Sharing

1 75% of the actual cost of excavation not to exceed .86¢ per cubic yard.

2 75% of the actual cost of pipe installed not to exceed an amount determined by the COC.

3 Seed, seedbed preparation, and seeding $25.20 per acre.

COST DATA REQUIRED FOR PIPE AND EXCAVATION

## WP4 ANIMAL WASTE CONTROL FACILITIES

A The purpose of this practice is to reduce the existing water, land, or air pollution by animal wastes.

B Apply this practice to areas on farmland where animal wastes from the farm constitute a significant pollution hazard.

C Policies for this practice are as follows:

1 This practice is designed to provide facilities for storing and handling livestock and poultry waste and controlling surface run-off water to permit the recycling of animal waste onto the land in a way that will abate pollution which would otherwise result from existing livestock or poultry operations.

2 Cost-sharing is limited to solving the pollution problems where the livestock or poultry operation is part of a total farming operation.

3 Cost-sharing is authorized:

a Only for animal waste storage facilities, such as aerobic or anerobic lagoons, liquid manure tanks, holding ponds, collection basins, settling basins, and similar facilities as well as diversions, channels, waterway outlet structures, piping, land shaping, and similar measures, needed as part of a system on the farm to manage animal wastes.

b For: (1) Permanently installed equipment needed as an integral part of the system. (2) Vegetative cover (including mulching needed to protect the facility). (3) Leveling and filling to permit installing an effective system.

c Only if the storage and diversion facilities will contribute significantly to maintaining or improving the soil or water quality.

4 Cost-sharing is not authorized:

a For measures primarily for the preventing of air pollution unless the measures also have soil and water conserving benefits.

b For: (1) Portable pumps and agitators. (2) Pumping equipment or other portable equipment. (3) Building or modifications of buildings. (4) Spreading animal wastes on the land, including systems using irrigation pipelines.

c For the portion of the cost of animal waste structures installed under or attached to buildings that serve as part of the building or its foundation.

d For animal waste facilities that do not meet local or State regulations.

e For installation primarily for the operator's convenience.

f For new or substantially enlarged livestock operations or for relocation of livestock operations, including buildings on the same farm or ranch.

5 The practice shall be maintained for a minimum of 10 years following the calendar year of installation.

D Specifications.

1 The practice shall be performed in accordance with a plan prepared by SCS in consultation, as necessary, with other interested agencies prior to development of the particular project.

E Technical Responsibility is assigned to SCS.

F Maximum Federal Cost-Sharing.

1 75% of the actual cost of excavation not to exceed .86¢ per cubic yard.

2 75% of the actual cost of concrete, including reinforced steel, rock or masonry, including cost of installation not to exceed an amount determined by the COC.

3 75% of the actual cost of other necessary appurtenances for proper operation of the permanent structure, including the cost of installation, not to exceed an amount determined by the COC.

COST STATEMENTS REQUIRED

# APPENDIX K

# PARTICIPATION FORM

| MOSES LAKE CONSERVATION DISTRICT<br>CLEAN LAKES WATER PROJECT<br>Request for CLWP Contract | Farm Unit - Block<br><br>Total Acres in Unit<br><br>Request Number |
|---|---|
| Farm #    NAME & ADDRESS    YEAR | Priority No. established jointly with CD |

I have an existing CLWP Contract (check one)    Yes    No

I hereby request a CLWP Contract on the farm identified above. I understand all Best Management Practices (BMP's) under such contract must be consistent with a Water Quality Plan approved by the Moses Lake Conservation District. I intend to perform an eligible BMP within one year of the date the contract is approved by the Hub Council.

| Signature of Applicant | Date | Name(s) of other persons who will participate if contract requested is approved. |
|---|---|---|
| Signature of Applicant | Date | |

| Field No. | Brief Description of Water Quality Problem(s) to be Solved | Planned Practices | Nutrient Savings |
|---|---|---|---|
| | | | |

CERTIFICATION OF SOIL CONSERVATION SERVICE ( SCS)

I certify that the BMP's listed on the attached Water Quality Plan are approved for the Project area. The Conservation District and applicant(s) have agreed to the proposed sequence in which the BMP's are to be performed. At least one eligible BMP is scheduled to be installed within one year. If funds are not available, this request is cancelled on April 30, 1985.

| Signature of SCS Representative | Title | Date |
|---|---|---|
| | | |

# APPENDIX L

# PUBLIC INFORMATION SUMMARY

Information/Education

The Stage 2 Information/Education portion of the Moses Lake Clean Lake Project has been an aggressive "activist" effort areawide to accomplish two goals. The first was to disseminate, through all possible media methods, a message of enlightening awareness and individual responsibility for water quality in the body of water called Moses Lake. The second goal was to gather information feedback from all sources to provide Moses Lake Clean Lake management and staff with local response to their proposed courses of action.

These courses of action have caused a positive reaction from the community and for the Moses Lake Clean Lake management and staff as the information and education communications flowed back and forth.

This overall approach of aggressive and assertive action has been and continues to be in variance to the usual planned, programmed, and perhaps more subdued approach to the Information/Education portion of a water quality project. That is not to say that the general plan has not been outlined, defined, and followed, but the ability to act and interact to media and exposure opportunity, sometimes spontaneously, has created good results. Being able to motivate a community collectively and yet individually and not be presented as "canned" information is and sometimes must be accomplished when the recipients are ready to "receive" in spite of the "planned" approach.

Finally the direct approach of doing "things" as the need arises, and doing them on a judgmental basis has, in the long run, given the Information/Education section more time out in the community disseminating information and, thereby, causing positive interaction to and with the Moses Lake Clean Lake Project.

A synopsis of the activities and "happenings" of the Information/Education section of the Moses Lake Clean Lake Project are as follows:

Staffing - One person was assigned to the Information/Education function. This person was hired as of June 3, 1984 and was assigned to the Moses Lake Clean Lake Project office and placed under the direct supervision of the Moses Lake Clean Lake Project Manager. This was done as a positive step on the Moses Lake Conservation District's part to bring more direct involvement of this position as it evolved from Stage 1 and Stage 2. In other words, as the project moved from the infancy of Stage 1 to the Stage 2 phase, the excellent initiating efforts of Cooperative Extension Service were transferred to a direct "on-site" person to carry on and this has worked well.

While the Information/Education staff level is at one person, an excellent teamwork attitude caused an involvement of the complete Moses Lake Clean Lake staff on nearly every happening throughout the year.

Promotional -

Billboard Advertising - One unit on a city throughfare near the lakeshore. The theme was basically "Clean Water Starts at Home".

Sign on office building for office identification - Unit was designed and purchased.

Hats - 250 hats with logo for distribution to farmer participants, staff, contributing officials, and general supporters of the Clean Lake Project.

Bumper Stickers - 1500 which were distributed to stores, service stations etc. These units were also placed on garbage receptacles at all parks, shopping centers, schools, churches, etc.

Radio Spots - The two main local radio stations were used both on a "purchased" advertising as well as public service spot basis. A general campaign of "Hey you with a Beautiful Body" was created and used to draw attention to the "beautiful body" of water called Moses Lake. It was designed and worked to cause every**body** to realize water quality was everybody's responsibility. Christmas greeting ads and special events such as the lakeshore cleanup day were also used in the radio ad program.

Business cards - Business cards were prepared for all staff members to "professionalize" the business calls made to farmers and businesses in daily operations.

Newspaper Advertising - "Spot" ads were developed with the local newspaper that were designed to keep the public aware on a daily basis on a full year schedule of the Moses Lake Clean Lake Project.

Photography and Video Camera Recordings - Over one hundred slides of appropriate scenes and happenings were taken to capture the essence of the Moses Lake Clean Lake Project for future use by staff in public presentations. Video recordings were made of the weed harvester demonstration and the lakeshore cleanup day for public viewing in the future.

Weed Harvester Demonstrations - In August and September of 1984, two aquatic weed harvesters were demonstrated to the leadership of the Moses Lake Irrigation & Rehabilitation District as well as other persons in leadership positions within the community. These demonstrations were provided though a coordinated effort by the Information/Education section to show the elected Moses Lake Irrigation & Rehabilitation District commissioners and their constituents how such equipment might be used to remove the unsightly biomass islands of weeds and algae waste from the Parker Horn area and other sites on the lake where the problem occurs.

News Media, Press Releases, and Stories - Approximately twelve to fifteen press releases and feature stories were effected to the media thus providing news articles, many of which were front page articles on the Moses Lake Clean Lake Project. There was also a feature article in the statewide "Washington Farmer/ Stockman" and the national trade publication "Irrigation Age". Several examples are attached.

Dues and Subscriptions - Certain trade association publications were subscribed to in order to gather information on other water quality projects.

Newsletters and Brochures - In this category, only one information letter was sent to the nearly 300 landowners in the project as an informational item during the Stage 2 phase. More are anticipated as the project enters Stage 3.

Fair Booth - An informational booth was developed and staffed during the Grant County Fair, August 19th through August 24th. During this time, nearly 85,000 people were given information and exposure to the Moses Lake Clean Lake Project via photos, cablegation demonstrations, pamphlets, brochures, and sign-up interest sheets.

Lakeshore Cleanup Day - On November 26, 1984, the Moses Lake Clean Lake Information/Education section, along with help from the complete Moses Lake Clean Lake staff, administered the first known lakeshore cleanup day in the history of the city and, indeed, the lake itself. Approximately 200 people with litter bags in hand were assigned sections of the lake in teams of four to eight people. Four hours later nearly 25 tons of trash and residue were removed from the lakeshore and placed in receptacles and taken to the county landfill. Immediately following the cleanup, a chili feed was provided to the volunteers compliments of various merchants and service organizations.

# Plans completed for lakeshore cleanup

The only real concern now of organizers of next Friday's lakeshore cleanup effort in Moses Lake is: How many people are going to show up?

If the turnout is less than 100 people, only the worst areas in the city limits will be picked up. But if more volunteers arrive, some vacant lots bordering areas near the lake will be cleaned up too.

"We won't turn anyone away from participation, since there is trash galore through the city boundaries," said Don Beckley of the Moses Lake Clean Lake Project.

Everyone who shows up at the Moses Lake Conservation District office behind city hall Friday morning will be signed in, given a litter bag and assigned an area to work in.

"The more people we have show up, the quicker we'll get it done and the better our lake and city will look," Beckley said.

Nov. 24 has been designated Moses Lake Lakeshore Cleanup Day by the Moses Lake Irrigation and Rehabilitation District. Clean Lake Project staff is organizing the effort.

## Special cleanup day slated here next Friday

Registration will begin at 8 a.m. After a cold day of difficult work, volunteers will be treated to chili and hot drinks at the park behind city hall.

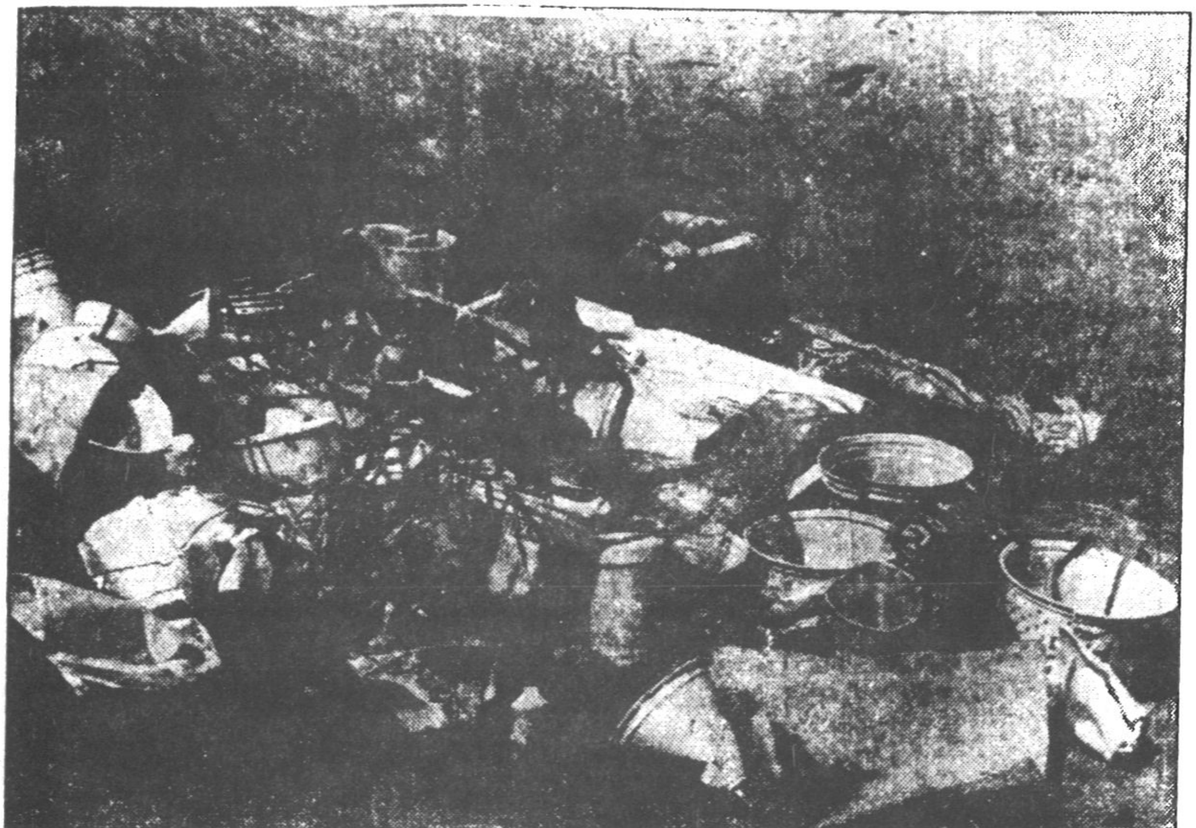
The cleanup project needs people who'll volunteer the use of and operate small boats to pick up and shuttle garbage to designated spots along the lake. Pickup and truck owners are needed to carry trash.

The job promises to be muddy, cold and demanding. Workers on the lakefront are advised to wear waders or rubber boots and warm clothing.

Organizers ask that smaller children not be included in the work parties due to the hazardous conditions that may be associated with the cleanup.

At a recent organization meeting, local Boy Scouts offered their help. Others offering to help clean up the lake or help serve chili after the work include the local Rotary Club, Lions Club, Sunrise Kiwanis, Telephone Pioneers, senior citizens, Moses Lake LDS, ham radio operators, Moses Lake Yacht Club, Safeway milk plant employees, Carnation Co. employees, Soroptimists and Sandy Sams RV Club.

If the weather is bad, a decision may be made the morning of the cleanup to postpone the effort. Anyone having questions or wanting to let officials know they intend to be there Friday morning should call the Moses Lake Conservation District office at 765-3261.



## 15 minutes work

This pile of plastic debris was collected along the Moses Lake shoreline in 15 minutes. Volunteers are needed next Friday for a lakeshore cleanup effort to rid at least some of the city's shoreline of the unsightly garbage.

—Judie Neilson photo

# APPENDIX M

# MOSES LAKE MANAGEMENT MODEL

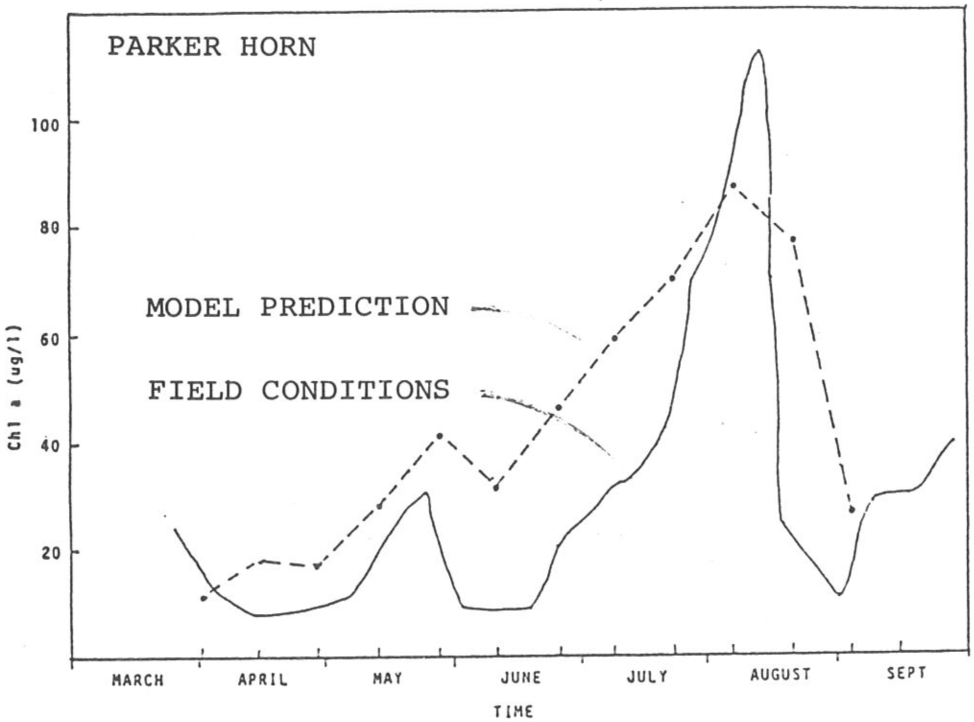
# A wind-phytoplankton model for the water quality management of Moses Lake

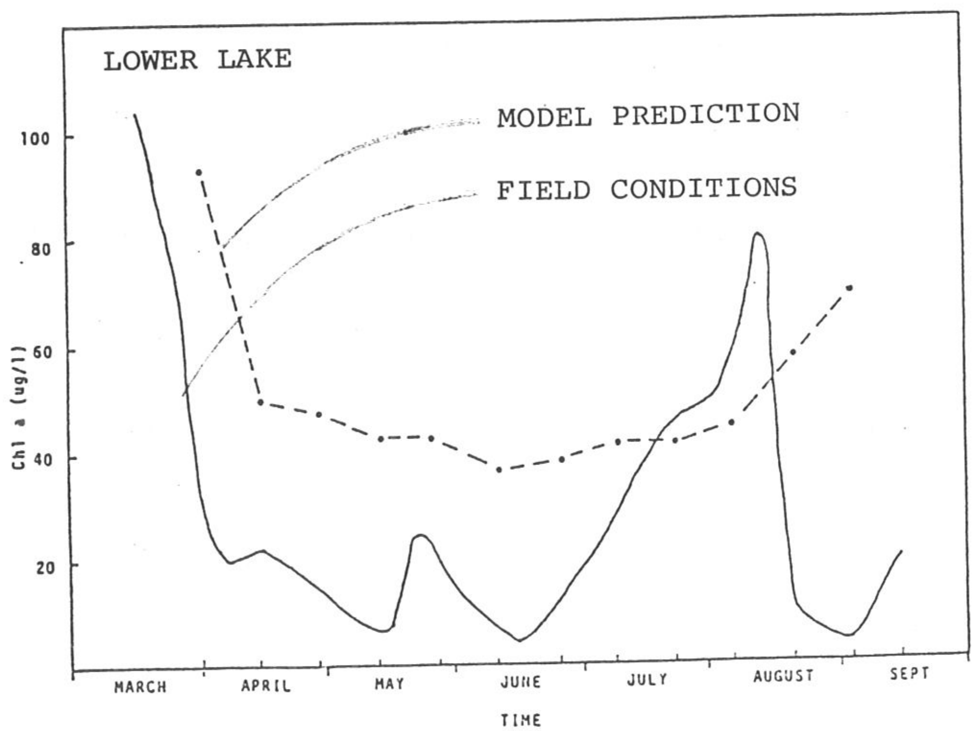
S.L. Marquis, B.W. Mar and E.B. Welch
Department of Civil Engineering
University of Washington
Seattle, Washington 98195

Models of wind-induced vertical mixing and nitrogen-limited phytoplankton growth were constructed to produce data used to create a management model for Moses Lake, a hyper-eutrophic lake located in eastern Washington. This approach preserved the simplicity and flexibility of the management model without sacrificing advantages offered by complex models.

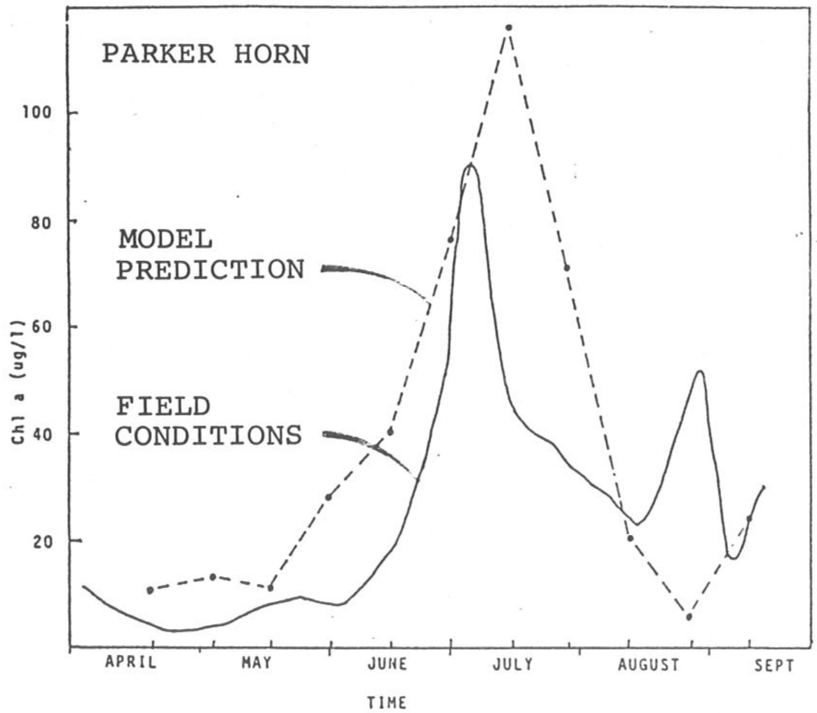
The management model predicts total chlorophyll a over two week time periods for each sub-basin of Moses Lake, excluding Pelican Horn. It was calibrated and verified with limitations (figures 1 and 2). While the model predicts the timing of blooms and the pattern of algal concentration fluctuations well, it tends to exaggerate total biomass. The decay of blooms is not modeled.

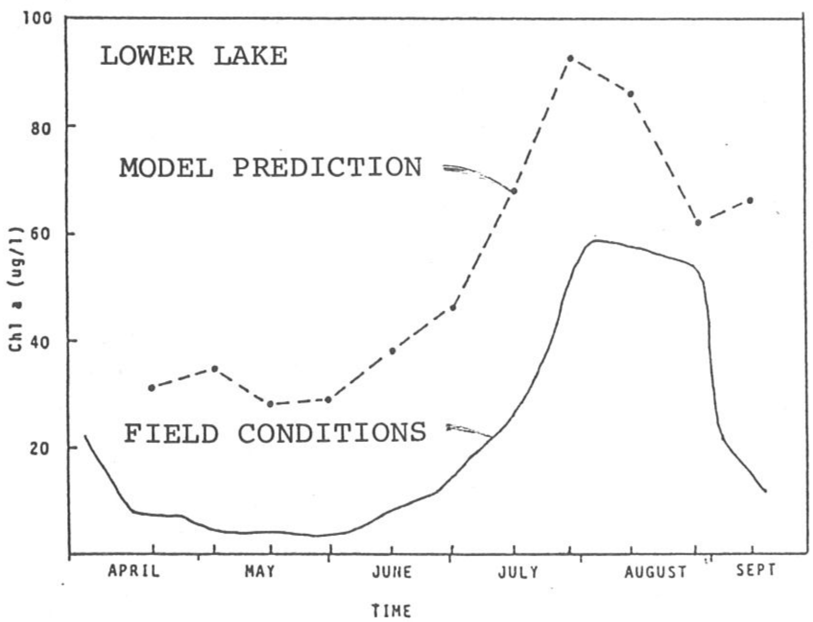
The model was utilized to evaluate scenerios of dilution water inputs and best management practices strategies. For the Moses Lake watershed, a constant dilution water addition of 5.7 m3/sec produced significantly greater chlorophyll a reductions when compared against no dilution or 30 m3/sec springtime dilution scenerios. Reductions in chlorophyll a were demonstrated with decreased nutrient loading into the lake (i.e., controlled fertilizer additions to irrigated land).




Model Calibration for 1977 Conditions




Model Calibration for 1979 Conditions

# APPENDIX N

## CABLEGATION INFORMATION

WASH FARMER - STOCKMAN
10/4/84

# Cablegation May Help Clean Up Moses Lake

**By Mike Wohld**

"CABLEGATION" may help clean up Moses Lake.

Cablegation, the innovative automatic gravity irrigation concept developed a few years ago by USDA agricultural researchers at the Snake River Conservation and Research Center at Kimberly ID, is among tools and systems for improving irrigation which are being tried in Blocks 40, 401 and part of 41 in the Columbia Basin Project. Overirrigation on farms in these blocks apparently is flushing plant nutrients into Crab Creek. This creek, which drains parts of watersheds extending as far north as Davenport and east as far as Medical Lake, is one source of nitrogen and phosphorus which feed the large quantities of algae in Moses Lake.

Irrigated farms are only one among many sources of the pollution of Moses Lake, a report of March, 1984 on the Moses Lake Clean Lake Project indicates. Among other sources are septic tanks around Moses Lake, cattle operations, fish hatcheries, urban runoff and unknown sources of phosphorus in Rocky Ford Creek, the same report indicates. Sewage effluent was identified as a source, but apparently this has been cleaned up.

One aspect of the Moses Lake Clean Water Project is to encourage irrigation practices which will reduce whatever contribution irrigated farming is making to the mess in Moses Lake. Federal-state cost-sharing on appropriate practices is included. In the case of the two cablegation demonstrations, 100% cost-sharing has been provided through the Moses Lake Clean Water Project. "The overall project [Moses Lake Clean Water Project] is a joint effort of the Moses Lake Conservation District, the Moses Lake Irrigation and Rehabilitation District, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency," according to a press release from the Project.

"Cablegation is one possible tool to reduce the amount of water being flushed out through fields and runoff, or percolated down through soil into groundwater," said Don Beckley, information and education technician for the Moses Lake Clean Lake Project. He emphasized that farms are but one source of the nutrient loads in Moses Lake and said final cleanup of the lake is a long-term project which is going to have to involve "everyone."

Apparently, the complete picture on sources is still being developed.

Cablegation, if it proves out, probably will only play a minor role in the Moses Lake cleanup, since furrow irrigation is done on a small percentage of the area believed to be one of the major contributors of N and P to Moses Lake. The report notes in part that "overapplication of irrigation water is causing deep percolation of water and nutrients to occur in Block 40, 401 and a portion of 41. There are 20,954 acres of irrigated land in this area. Approximately 81% utilize sprinkler irrigation and approximately 19% utilize furrow irrigation. Although furrow irrigation accounts for less than one-fifth of the irrigated area, it contributes over one-third of the nitrogen leached by deep percolation."

Cablegation reportedly results in less runoff than most surface irrigation systems and for this reason it is being tried out on two cooperating farms in Block 40 to see how it works and how it might be improved, Beckley said. The cooperating farms are the Matheson and Bellomy family farms northeast of Moses Lake. The Mathesons are irrigating an 18-acre corn field with the cablegation system. They farm about 650 acres, all but about 90 of which have been furrow (rill) irrigated. They grow alfalfa seed, alfalfa hay, wheat and corn, and feed out some cattle.

"We are irrigating this field with less water and the irrigation is more uniform," said Larry Matheson. And it has required less labor than when irrigating with siphon tubes, he said.

"There were a few bugs at first, but it seems to be working pretty well now," he added.

"We are also looking for water and fertilizer savings, but we won't know until the crop is done," said Chris Matheson. He and his wife, Nell, have been farming here since about 1954.

The Bellomys irrigated about 28 acres of wheat with a cablegation system this year. They farm about 670 acres and, with the exception of about 160 acres of sprinkler irrigation, it has been rill irrigated. "I think it will work real good when we get all the kinks worked out," Bellomy said.

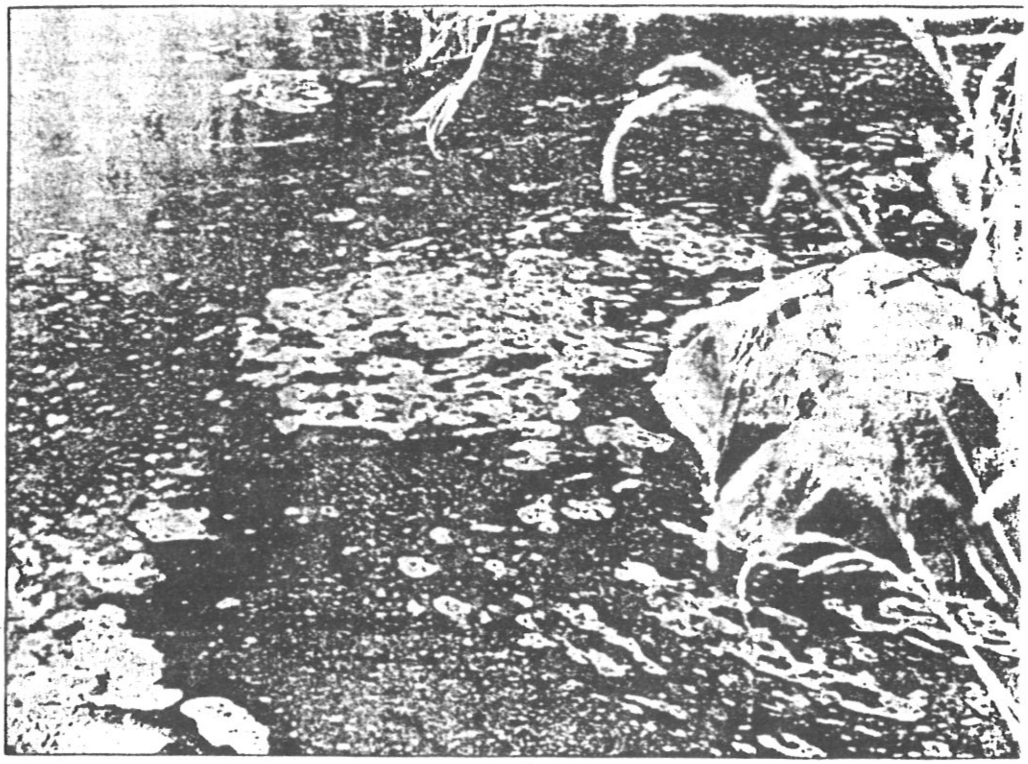
Larry Matheson.

Bill Bellomy

Winner of Sigma Delta Chi general excellence award

CBH COLUMBIA BASIN DAILY HERALD

43rd Year—No. 36 Moses Lake, Washington, Wednesday, September 19, 1984 Price 25c



## Algae growth

Patterns of floating algae give the appearance of a swampy marsh to many sections of Moses Lake, including this Cascade Valley shoreline. Clean Lake Project officials are paying closer attention to septic tank drainfield· the Moses Lake area as a possible source nutrients that encourage algae growth.
—Herald ph

# *Septic tank systems scrutinized*

By KRISTINE ROSEMARY
Herald Staff Writer
*Part of a series on Moses Lake*

Efforts to bring Washington's second largest natural lake into compliance with state water quality standards may mean closer scrutiny of septic tank drainfield systems near Moses Lake.

Regional and local conservation agencies, joining forces in a $2.5 million Clean Lake Project, have been fighting the problem of massive algae growth in sections of the 20-mile long, shallow lake.

The algae proliferates when nutrients — chiefly nitrogen and phosphorus — seep into lake water from farm irrigation runoff, the Rocky Ford and Crab Creek watershed systems north of the lake, and from storm and septic tank drainfields.

The nutrients filter into surface aquifers and thousands of underground springs feeding the lake over more than 2,000 square miles, making the task of pinpointing a pollution source difficult at best. An intensive water testing program for the Clean Lake Project is under way, but probably will not be completed before the end of the year.

Although environmental officials guess that about 5 percent of the nutrients entering the lake are coming from septic tank drainfields, no one is yet certain which specific areas contribute the greatest share of the problem, said Richard Bain, a Seattle consulting engineer performing the water monitoring studies.

Properly operating individual septic tank systems, however, don't pollute lake water or pose any danger to public health.

This week, Grant County Health District officials started a new septic system approval program to be operated under the direct supervision of a certified health officer and regulated by a registered sanitarian.

County environmental health director Dave Hickok said the sanitarian will inspect sites of proposed septic systems, take soil tests and make recommendations on building properly functioning systems. Final inspection procedures also will be more detailed than in the past, Hickok added.

"We get between 2·0 and 300 permit applications in the county annually," Hickok said, "with more going in all the time."

About 20,000 people live in the greater Moses Lake area, with an estimated 5,000 septic systems in operation outside the city limits. Clean Lake officials speculate that some systems could have a detrimental influence on lake water quality.

"To prove or disprove that would be a monumental task," Hickok added.

Inside the city limits, as many as 1,500 people use septic tank systems. City planning officials say none of them drain directly into the lake. "That wouldn't be allowed," said city planner Larry Angell. As new developments increase, the city's unwritten policy is to encour hookups to the city's sewer treatment plant, planners said. Still, city ficials are reviewing their procedures on how to evaluate and con new septic systems in cooperation with the county's environmer health officers, said Rita Perstac, director of municipal services.

In addition, Clean Lake Project agencies have worked with farm north of Moses Lake, gaining their cooperation to refine irrigat methods to cut back on farm field runoff, acknowledged as the ma source of nutrients to the lake. Elbert Moore, an Environmental Prot tion Agency water quality expert in Seattle, said that septic tanks "c be a problem in some instances, but in relative magnitude they are not much of a problem" as agricultural runoff.

Still, "septic tanks need to be monitored better, with a curr program set up to deal with any problems," said Moore, who wo closely with officials from the Moses Lake Conservation District, Moses Lake Irrigation and Rehabilitation District, and other regi agencies involved in Clean Lake project work.

He praised work done by Moses Lake IRD commissioners to turn o $1 million in EPA grant money to the city of Moses Lake for work o new sewage treatment plant. "That shows an unusual level cooperation," he said.

The plant provides for treated effluent drainage onto sand dun ending discharges into the lake and eliminating about one-fifth of total nutrient contribution to summer algae blooms.

On the lake, unchecked algae blooms can produce toxic conditi harmful to other aquatic life. Bacteria consuming the dead plants winter tend to proliferate, and the decaying process robs the water dissolved oxygen.

Freshwater biologists doing research work on Moses Lake, one of most exhaustively studied lakes in the Pacific Northwest, have warr against allowing an overload of nutrients to flow into lake waters. La have a distinct life span, and as a lake ages, sediments fill the botto making it shallower, nutrients flow in, and the water warms a evaporates. Adding uncontrolled quantities of man-made nutrients c accelerate the process, causing the lake to age more rapidly.

"You and I — people — we all caused this pollution," said Clint Conne ly, chairman of the Moses Lake Irrigation and Rehabilitation Distri "We all have to take responsibility for cleaning up the lake."

Connelly, acknowledged as one of the prime movers in clean lake forts over the past 10 years, added that progress in cleanup is steady b slow.

"In the 1950s, few people considered fishing in this lake or cared build their homes anywhere near it," he said. In some areas, "the alg. looked like thick pea soup. But it's getting better — we're mak progress."

# CUTTING OUTLET CONTROL COSTS

A simple low-cost method of controlling gravity irrigation — called cablegation — has been put into operation in several states in the US. Doral Kemper, supervisory soil scientist, and TJ Trout, agricultural engineer, both with the US Department of Agriculture's Snake River Conservation Center in Idaho, describe the technique.

Automated irrigation application systems can save labour, improve water control and application precision, and apply water on schedules governed solely by crop needs.

However, although centre-pivot sprinkler systems have proven these values of automation, high initial costs and rising energy costs are keeping them out of the economic reach of most farmers.

Most fully automated application systems use sophisticated valves and electronic controllers to switch water from one branch of a system to another. These have been widely used in pressurised systems (sprinkler and drip), where pipe sizes and valves can be justified.

The use of automatically controlled valves has not been widely accepted in surface (gravity) irrigation because of factors such as the high cost of large valves, occasional failures of electronic controllers and a general need for separate pipes to perform the conveyance and distribution functions.

The technique known as cablegation uses a single, simple, low-cost controller, a single pipe for conveyance and distribution, and no valves. The only moving parts are a plug attached by a cable through the pipeline to a slowly rotating reel (see diagram).

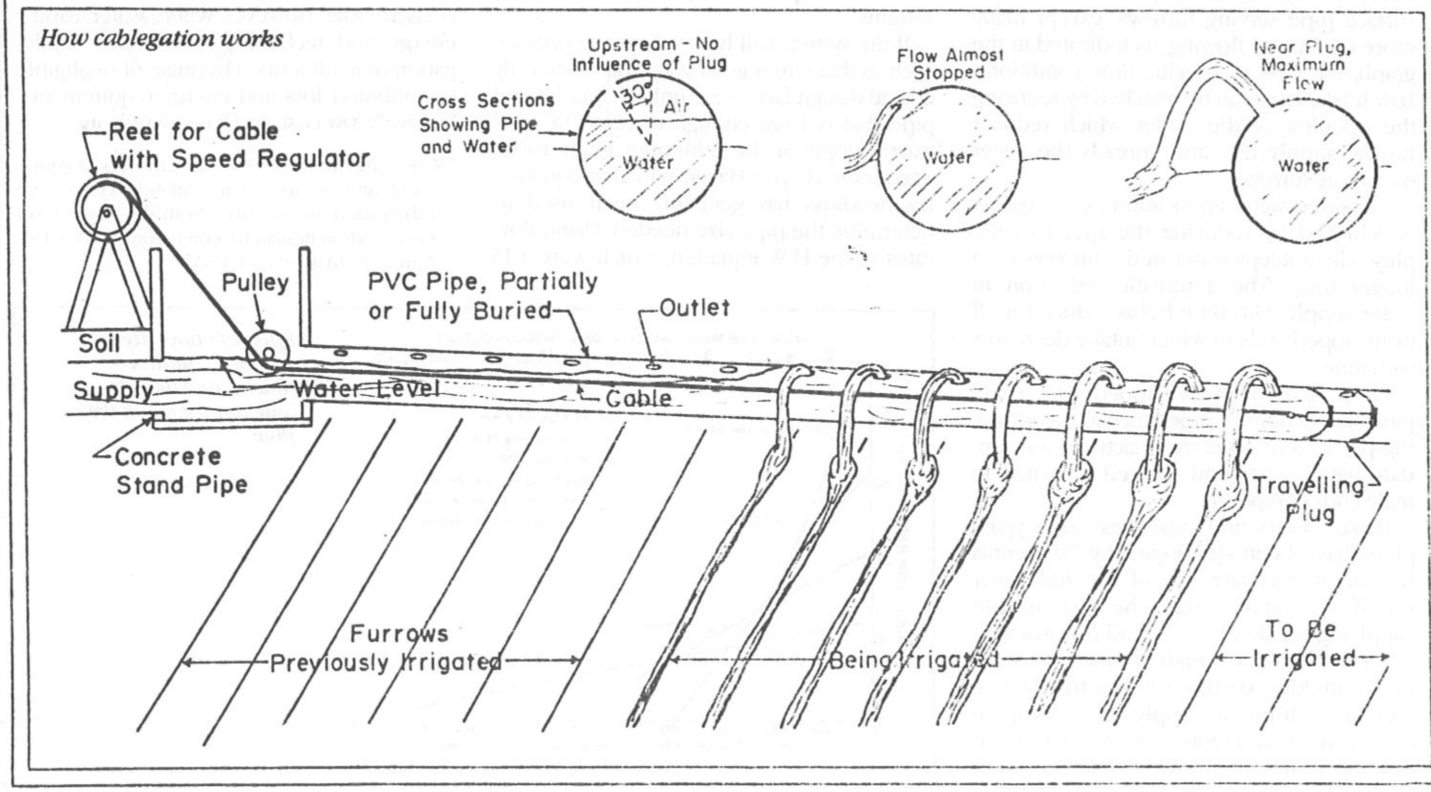
Outlets are positioned near the top side of the pipe and the pipe size is chosen so that, at the available grade, the level of free-flowing water will remain below the outlets. The plug in the pipe stops the forward motion of the water. This causes water to back up and forces it through outlets to supply furrows or bordered strips (see diagram) immediately upstream from the plug.

The number of outlets flowing depends on the pipeline size and grade, supply rate, and outlet size. Time for which water is supplied to a furrow depends on the number of outlets emitting water and how fast the plug moves down the pipe. Water pressure pushes the plug down stream and its rate of travel is governed at speeds in the range of 2-10m/hour by the angular velocity of the reel.

Several sources of energy have been used to control angular velocity of the reel including DC and AC electricity and water power, via paddle wheels. Electronic controllers, which can be set at precisely the desired and can be programmed to change speeds are being produced by a new company.*

Polyvinyl chloride (PVC) pipe is commonly used for cablegation pipelines, although aluminium pipe can also be used. The pipe can be buried with risers to the surface or laid on the surface. The outlets must be on grade to ensure uniform water distribution.

Standard surveying techniques, laser-controlled trenching, and hydraulic levelling



have been used to attain the precise grade needed for installation of cablegation pipelines when the outlets are attached directly to the pipe. When risers are used from the pipe to the outlets, the grade on the pipe is not critical, but the outlets must be precisely on grade.

Outlets have varied from holes out in the pipe to adjustable valves. Adjustable outlets give the system more flexibility to meet changing soil infiltration rates.

Plugs are made of two flexible gaskets attached to two ends of a core. Flexible plastic bowls, wastebaskets, buckets, and heavy rubber sheet have been used for gaskets. Flexible gaskets will slide past obstructions in pipes such as the intruding portions of gates manufactured for standard gated pipe and inward tapered or rolled male ends of pipe.

Cablegation systems have been built for water supply rates of one to 100 l/s using pipes of 100-300mm in diameter. Field sizes have ranged from 1.5 to 30ha; pipeline slopes from 0.0015 to 0.025. Forces on the cable have measured from 2kg for a 100mm diameter pipeline on the surface to near 100kg for a 310mm diameter pipeline buried about 1.1m deep with risers bringing water to the surface.

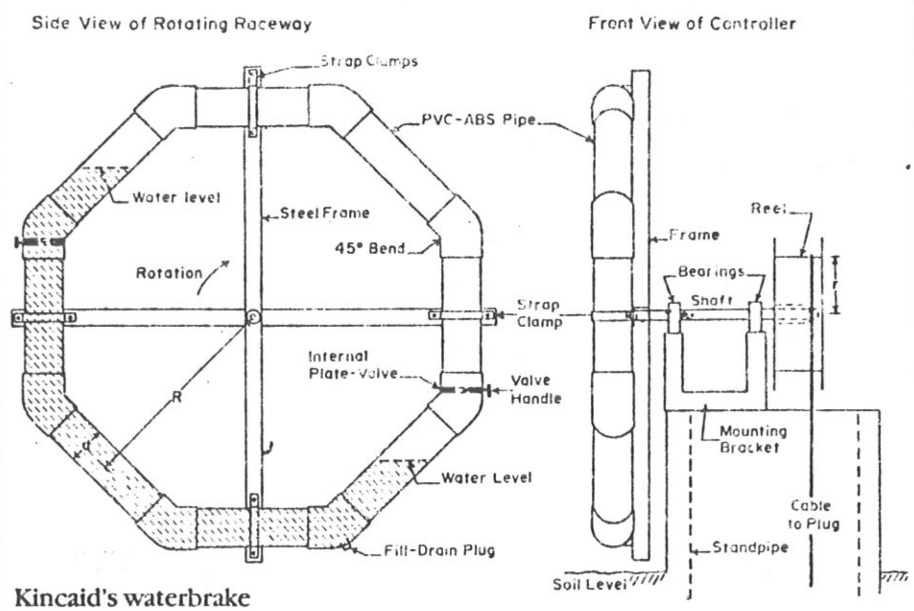
If the operator of a system supplying water to bordered strips desires all the water to flow to one strip at a time, the outlet (and riser) must be large. Reducing the outlet size decreases flow rate in the outlet next to the plug, increases the hydraulic head in the pipe and causes water to come out of one or more upstream outlets.

Reducing outlet size has the same general effect on smaller closely spaced outlets from surface pipe serving furrows, except many more outlets are flowing, as indicated in the graph, for a set of specific flow conditions. Low intake rates can be matched by reducing the opening of the outlet which reduces furrow supply rate and spreads the water over more furrows.

Increased water application per irrigation is achieved by reducing the speed of the plug which keeps water in the furrows for a longer time. The automatic reduction in water supply with time helps reduce runoff from sloped soils in which intake decreases with time.

Plugs have been developed which will pass obstructions in pipes such as the intruding portions of gates manufactured for standard gated pipes and tapered or rolled in male ends of pipe.

Bypass weirs and pipelines and bypass plugs have been developed by Dr Dennis Kincaid to facilitate use of the full water supply, starting the plug at the inlet end and supplying top and bottom end furrows with water for the same length of time as furrows in the middle reaches. Outlets to facilitate accurate setting of supply rate, dissipate excess energy and reduce erosion have been developed and are available from commercial sources*. Some of these outlets operate on a siphon principle and cut off the water supply to furrows when it decreases below a rate specified by the operator.




## Kincaid's waterbrake

**One of the simplest and most popular controllers is the "waterbrake" designed by Dr Dennis Kincaid. Elements of the waterbrake are shown above. The plug, being pushed with a relatively constant force by the water, pulls on the cable, tending to turn the reel. As the reel rotates, it turns the raceway, which is about half full of water. Plates blocking the raceway then push against the water until the unbalanced weight of the water in the raceway causes sufficient torque to balance the torque caused by the pull on the cable. Adjustable openings in the plates allow water to flow through the plates at slow controlled rates and thereby govern the rates at which the reel rotates and the plug moves.**

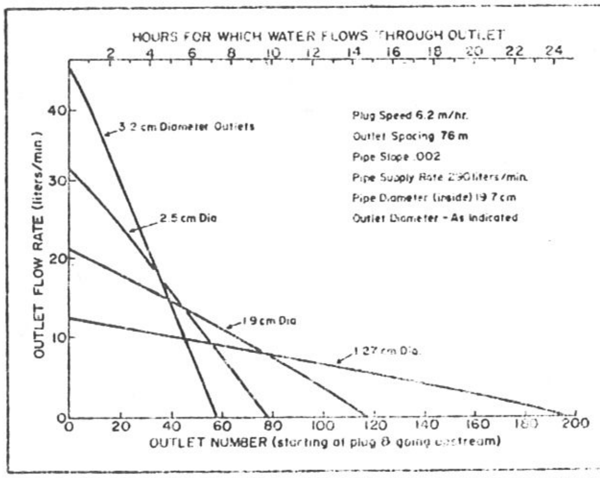
A computer model has been developed and verified to make these calculations. Dimensionless graphical plots of the computer solution are available to enable those without computers to design cablegation systems.

If the system will have adjustable orifices, such as those in regular gated pipe, the only critical design factors are uniform grades and pipe that is large enough to carry the total water supply at the minimum grade to be encountered. The Hazen-Williams equation for headloss has generally been used to determine the pipe size needed. Using flow rates in the H-W equation, which were 1.15 times the anticipated maximum flow rate, has given pipe sizes which kept the free flow water levels below the outlets.

Cablegation type systems, first conceived in 1980, are now in operation in a wide range of situations in seven of the western United States.

Cablegation systems have not been field tested in developing countries where labour costs are low. However, where water, capital energy and technology are scarce, cablegation may fill a need because of negligible transmission loss and energy requirements, relatively low cost, and basic simplicity.

*Names and addresses of manufacturers of equipment and additional information concerning cablegation are available from the Snake River Conservation Research Center, Route 1, Box 186 Kimberly, Idaho 83341, USA.

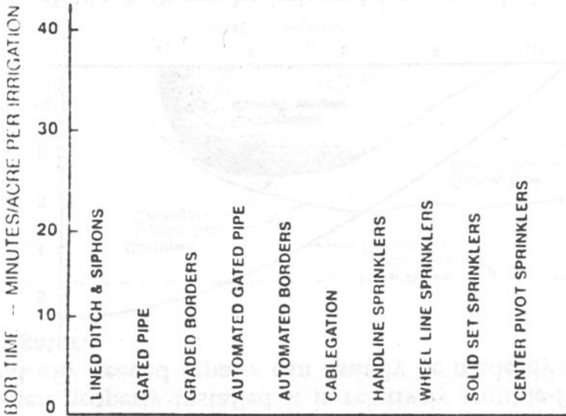



*Effect of outlet size on number of outlets flowing and the rate and time for which they flow*

Are you surface irrigating and looking for ways to reduce labor and runoff?

If you've answered "yes," you might consider a system called "Cablegation" which is an automatic gravity irrigation concept developed and tested at the U.S.D.A. Snake River Conservation & Research Center in Kimberly, Idaho. This unique system requires less labor and results in less runoff than most surface irrigation systems. A cablegation system bonus is that it uses very little energy to operate.

Anyone whose field and soil conditions are suited for surface irrigation and who is looking for a less labor intensive irrigation system. The chart below illustrates approximate labor involved with various irrigation systems.



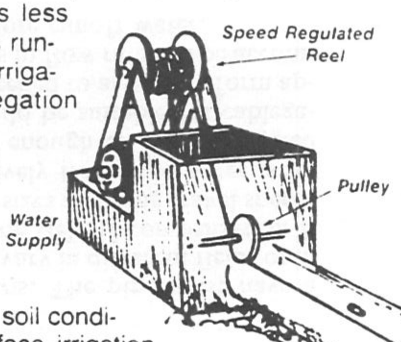
APPROXIMATE LABOR REQUIREMENTS FOR IRRIGATION SYSTEMS

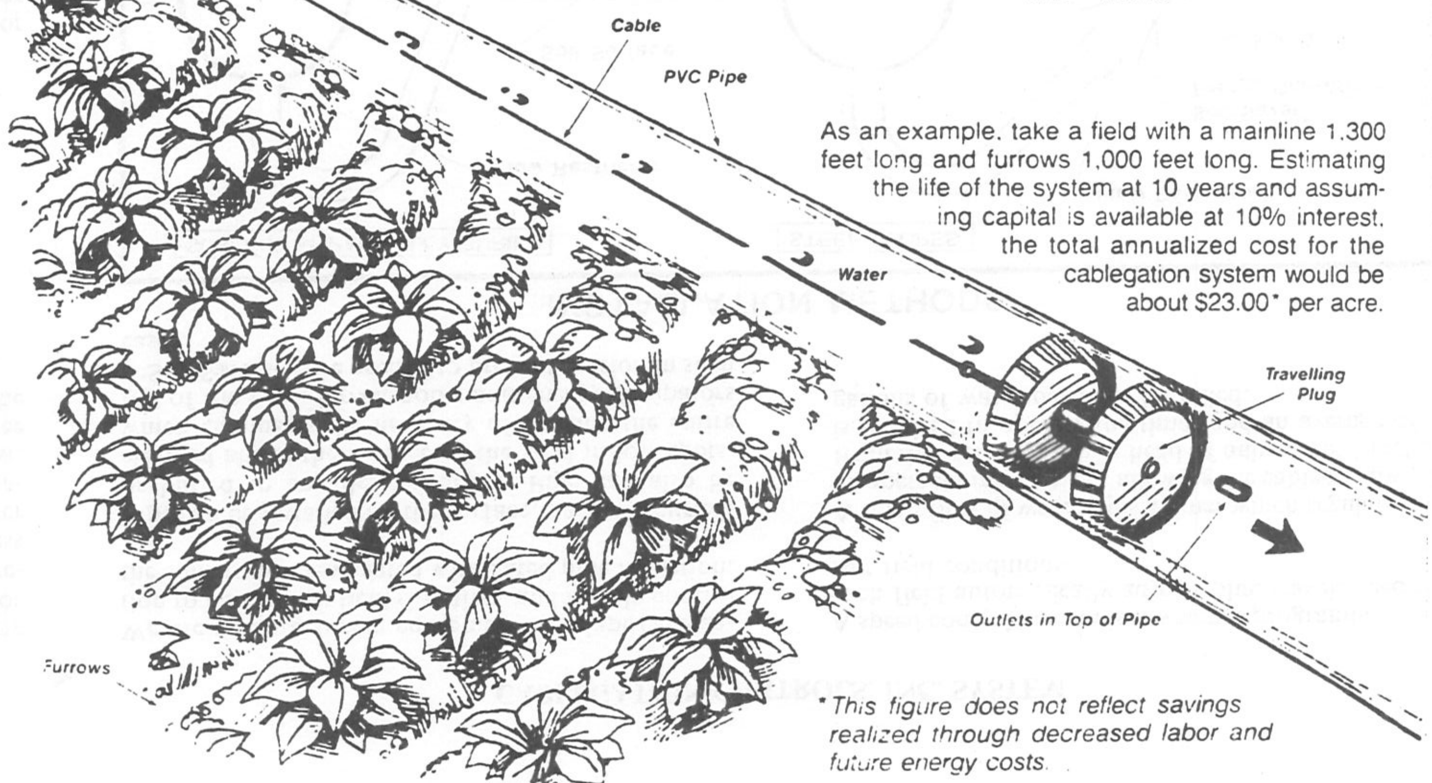
As with other gated pipe systems, the cablegation system uses a single PVC pipe as both the supply and distribution line. Installation of the mainline pipe to assure proper slope is critical.

Holes in the pipe are positioned 30° from vertical toward furrows to be served, then a movable plug is inserted in the pipe. The rate at which the plug in the pipe moves downstream is controlled by a cable attached to a reel which turns at a rate governed by a small battery-powered DC electric motor and a gear reduction assembly.

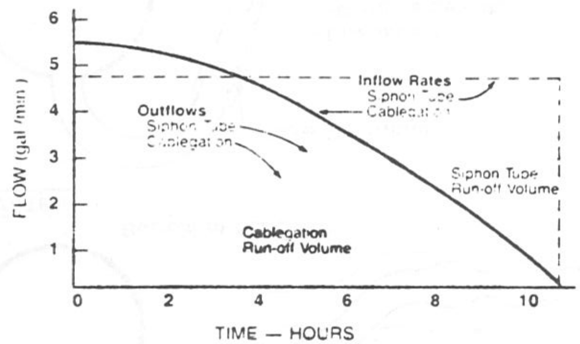
As water comes down through the pipe, it backs up behind the plug, fills a section of the pipe and flows out of the holes. As the plug moves from the upper to lower end of the pipe, water fills the furrows in steady succession.

Ideally when surface irrigating, the initial supply of water to each furrow should force the water quickly to the end of the row. The amount of water should then be reduced to avoid excessive runoff. With the cablegation system this process is accomplished automatically. Maximum flow rate for any given hole occurs immediately after the plug has passed. The flow rate then tapers to zero as the plug continues down the pipe. To vary flow rates, the hole sizes can be changed by inserting round plastic gates commercially available for a few cents each.






Because of the variability of furrow intake rates, a uniform supply of water to all furrows results in some run-off from furrows with low intake. The volume of run-off for cablegation systems is less than for most other surface irrigation systems. (See chart below) More efficient water application also reduces soil erosion and siltation. Cablegation can be readily adapted to your soil intake rate by simply varying the plug speed.

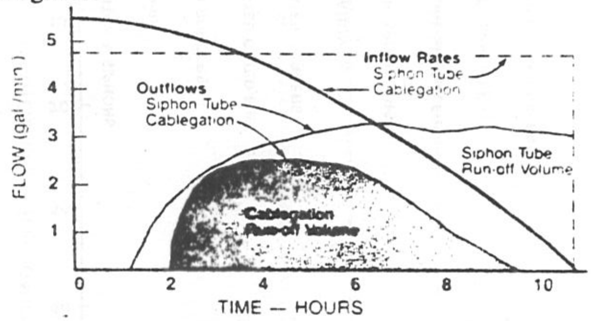



As an example, take a field with a mainline 1,300 feet long and furrows 1,000 feet long. Estimating the life of the system at 10 years and assuming capital is available at 10% interest, the total annualized cost for the cablegation system would be about $23.00* per acre.

*This figure does not reflect savings realized through decreased labor and future energy costs.

## CABLEGATION — KEY TO LOW COST IRRIGATION

Cablegation is the key to lower irrigation costs. Very little external energy is required for operation. Labor cost can be reduced as much as 75 percent. Water requirements are reduced about one third due to less runoff. Equipment and installation costs are lower than any other type of automated system. Cablegation is simple and has very low maintenance cost. When properly installed it is relatively trouble-free and any needed repairs can usually be made by the irrigator.




Any field which can be irrigated from gated pipe or by open ditch can be irrigated with cablegation. For more efficient operation the furrows should be at least 400 feet long and the field should have at least five times as many runs as can be irrigated in one "set".

There are some limitations. The pipe must have a constant slope. Slope can vary in different fields or in different parts of the same field if compensation is made by changing orifice sizes and plug travel speed. A constant flow of relatively trash free water is required. Any water clean enough to not plug gated pipe or siphon tubes should be suitable for cablegation. A uniform flow is needed to assure uniform application. Small variations in flow rate can be accommodated at the cost of more runoff water.

Cablegation can be used if the slope on the pipe is at least 2 ft/1000 ft (0.2% slope). Maximum slope is dependent on pipe size, rate of flow, and pressure capacity of plug, cable and controller, Slopes of 30 ft/1000 ft can be handled. Erosion can be a problem if the field has more than 0.5% slope.

## CABLEGATION CONTROLS, INC. SYSTEM

We are manufacturing equipment to adapt cablegation to almost any field situation, and to help control the soil erosion associated with gated pipe irrigation.

Pipe can be installed on the surface, partially buried, or buried to any desired depth. Pipe can also be elevated above the surface of the field in low spots, which eliminates the necessity of leveling the entire top of the field. Downspouts and energy dissipators ("Soil Savers") are needed to prevent erosion in such cases.

A speed control mechanism which is programmed for each field automatically adjusts plug travel speed to suit field conditions.

A small flow of water runs a timer which regulates an escapement mechanism, allowing the cable to unwind from the reel. A pressure head of only about 6 inches is required to operate the timer and an average of 5 gallons of water per hour is spilled.

## INSTALLATION METHODS