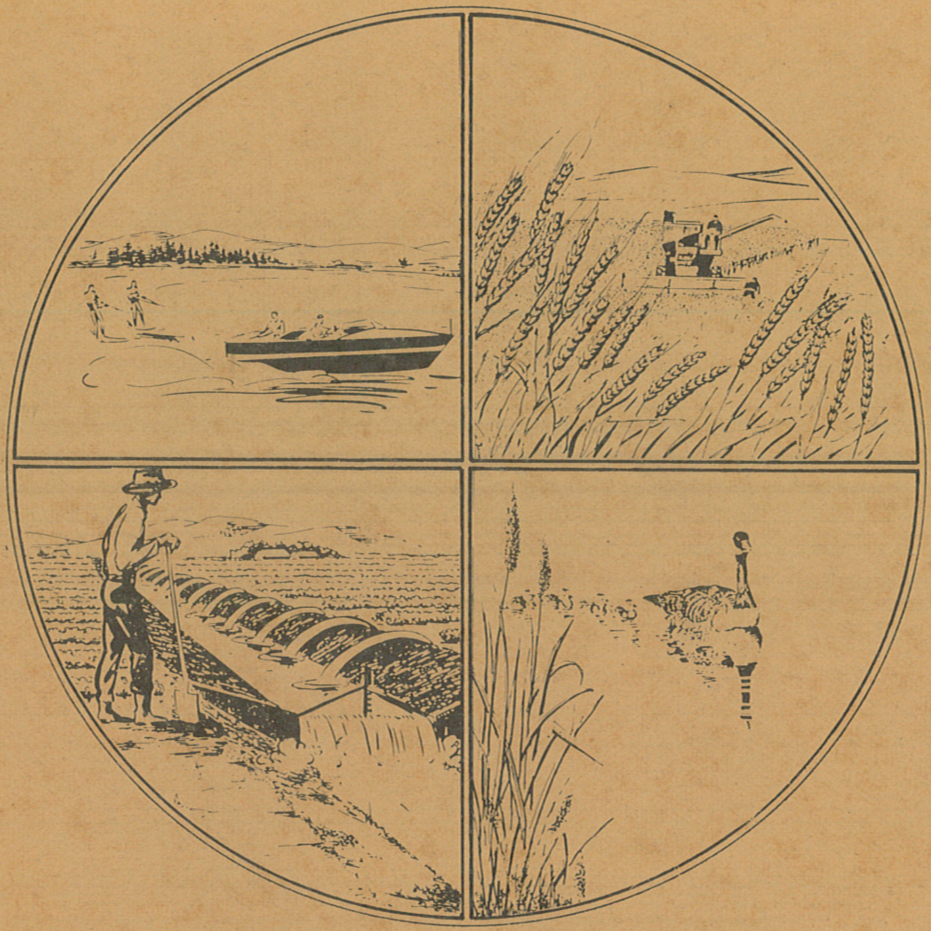
MOSES LAKE CLEAN LAKE PROJECT

FINAL STAGE 3 REPORT



PREPARED FOR

MOSES LAKE IRRIGATION
AND REHABILITATION DISTRICT

WITH GRANT FUNDING ASSISTANCE FROM

WASHINGTON STATE DEPARTMENT OF ECOLOGY

U.S. ENVIRONMENTAL PROTECTION AGENCY

MAY 1987

PREPARED BY

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

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CHAPTER 1

INTRODUCTION

The Moses Lake Clean Lake Project represents a five year effort designed to identify and control non point pollution sources affecting Moses Lake water quality. The lake is shallow and over-fertilized with nutrients from an extensive watershed encompassing over 1.5 million acres and from urban development around the lake. See watershed Map Figure 1-1. 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 and southern portions of the lake.

Moses Lake is a large freshwater lake located near the geographic center of Washington state. The lake is highly prized for water-oriented recreation, particularly fishing, boating, swimming and water fowl hunting. 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 Project Area 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. During the late 1970's, a restoration program involving dilution of the lake with low-nutrient Columbia River water was implemented. 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 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) was carried out in stages.

The project was 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)

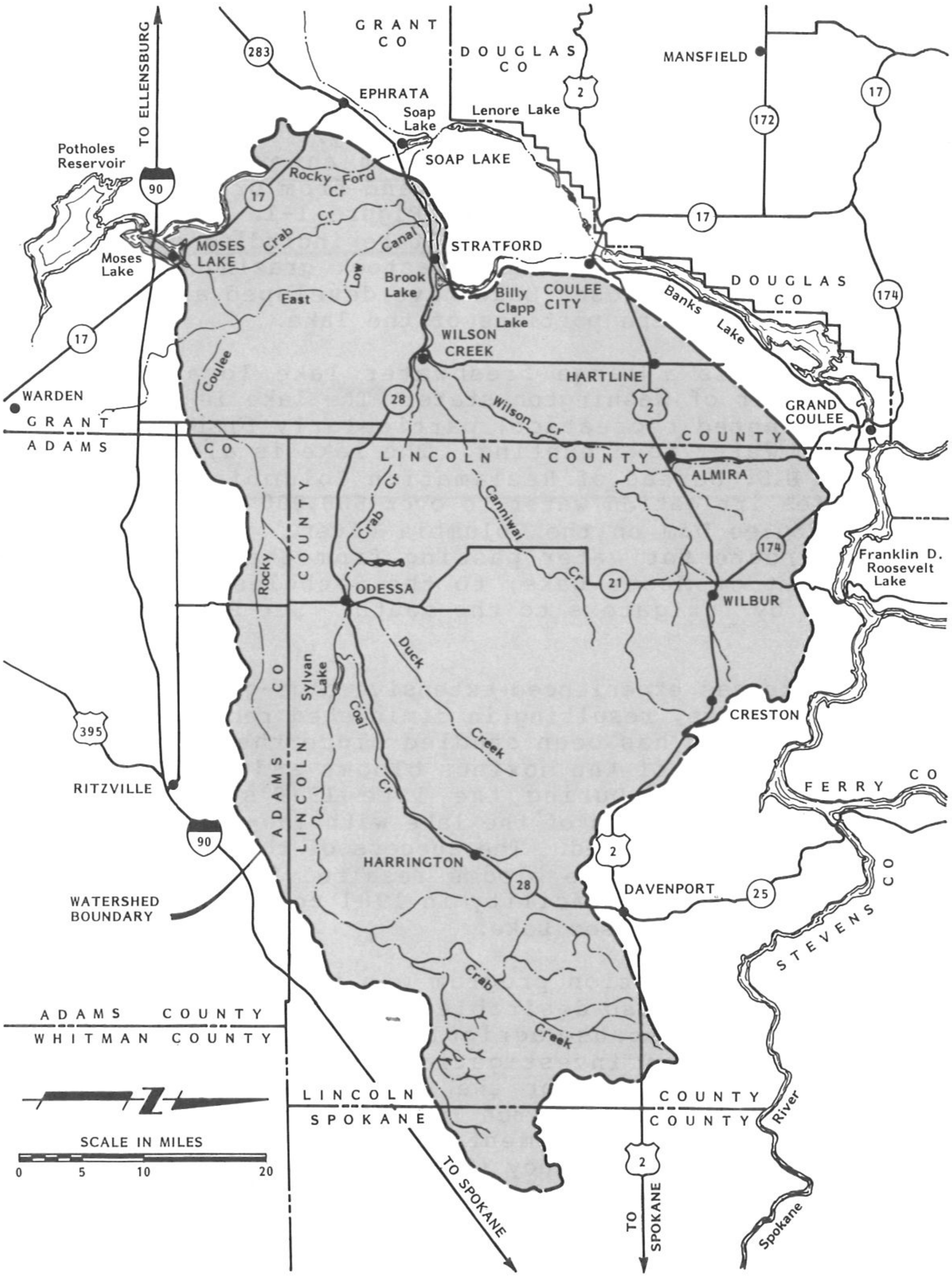

Figure 1-1 Moses Lake Watershed Map

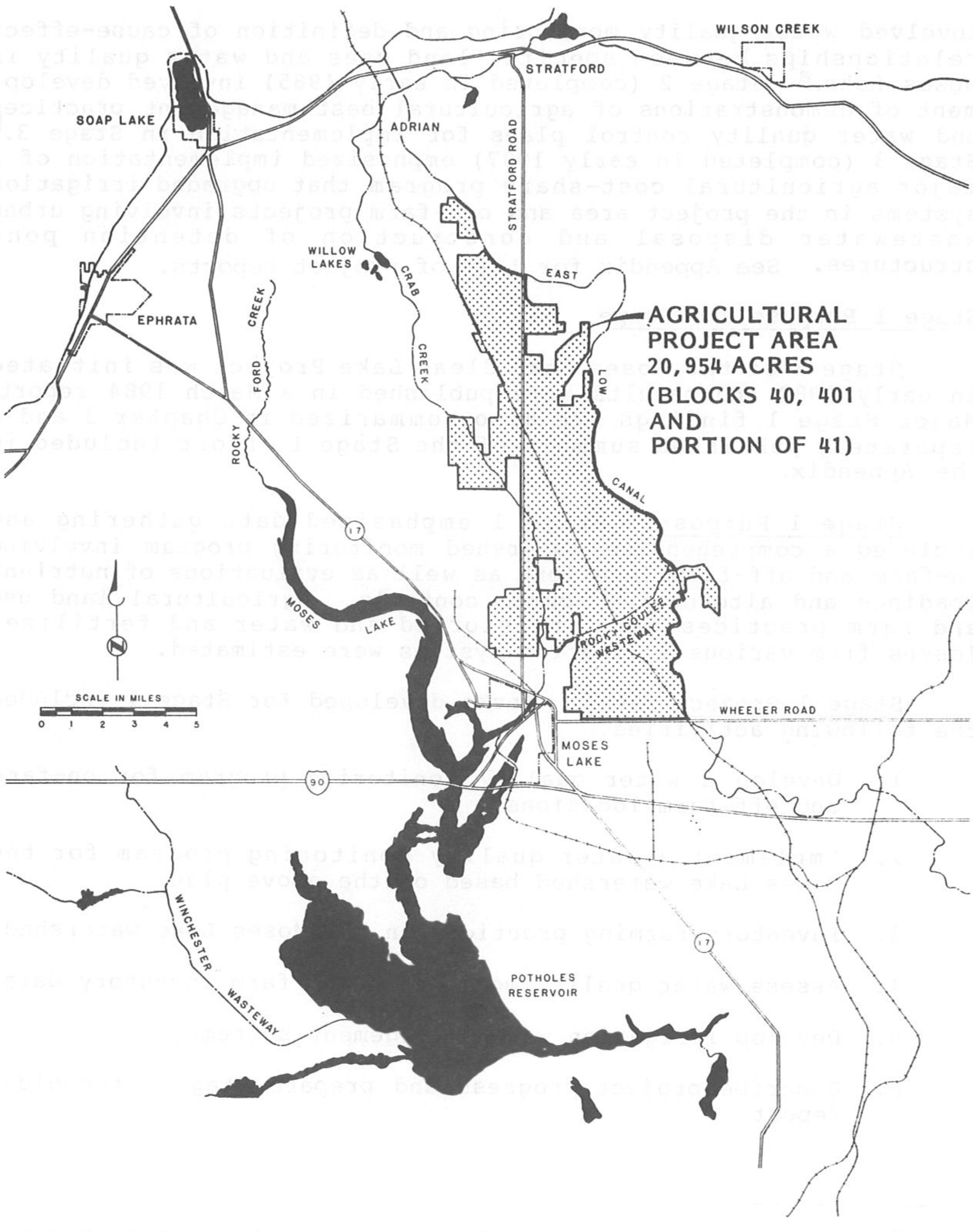

Figure 1-2 Moses Lake Clean Lake Project Area

involved water quality monitoring and definition of cause-effect relationships between specific land uses and water quality in Moses Lake.[a] Stage 2 (completed in early 1985) involved development of demonstrations of agricultural best management practices and water quality control plans for implementation in Stage 3.[b] Stage 3 (completed in early 1987) emphasized implementation of a major agricultural cost-share program that upgraded irrigation systems in the project area and off-farm projects involving urban wastewater disposal and construction of detention pond structures. See Appendix for list of project reports.

Stage 1 Purpose and Scope

Stage 1 of the Moses Lake Clean Lake Project was initiated in early 1982 and results were published in a March 1984 report. Major Stage 1 findings are also summarized in Chapter 3 and a separately published summary of the Stage 1 effort included in the Appendix.

Stage 1 Purpose. Stage 1 emphasized data gathering and included a comprehensive watershed monitoring program involving on-farm and off-farm locations as well as evaluations of nutrient loadings and alternative source controls. Agricultural land use and farm practices were inventoried and water and fertilizer losses from various irrigation systems were estimated.

Stage 1 Project Tasks. Tasks developed for Stage 1 included the following activities.

1. Develop a water quality monitoring program for on-farm and off-farm locations.
2. Implement a water quality monitoring program for the Moses Lake watershed based on the above plan.
3. Inventory farming practices in the Moses Lake watershed.
4. Assess water quality monitoring and farm inventory data.
5. Develop irrigation water management systems.
6. Describe project progress and prepare Stage 1 technical report.

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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.

[b]Richard C. Bain, Jr. and Moses Lake Conservation District, Moses Lake Clean Lake Project Stage 2 Report, prepared for Moses Lake Irrigation and Rehabilitaiton District, March 1985.

7. Develop and carry out public information and education program.

Stage 2 Purpose and Scope

This report includes a summary of Stage 2 of the Moses Lake Clean Lake project. A separate Stage 2 report was published in March 1985 and the summary from that report is included in the Appendix.

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

Stage 2 Project Tasks. 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.

Stage 3 Purpose and Scope

Stage 3 was primarily an implementation phase. This report describes activities during Stage 3 and also summarizes the previous stages. A separate executive summary is bound in this report and is also available as a separately bound pamphlet which describes highlights from the entire project.

Stage 3 Purpose. As indicated above, Stage 3 emphasized implementation steps. The primary implementation measures include and agricultural best management practices cost-share program an construction of detention pond structures. Other Stage 3 activities included a review of urban wastewater disposal water quality monitoring and irrigation water management recommendations.

Stage 3 Project Tasks. Tasks carried out during Stage 3 included the following:

1. Develop water quality management plans with best management practices for farms in the project area based on farmer sign-ups and priority ratings based on nutrient savings.

2. Institute and manage a cost-share program for irrigation system and other farm improvements using water quality management plans.

3. Identify irrigation water management agency and approach for subsequent follow-through by farmer participants in the cost-share program.

4. Develop an urban wastewater disposal policy covering percolation disposal of wastewater in the Moses Lake area.

5. Design and construct a carp barrier/detention pond structure on lower Rocky Ford Creek to reduce nutrient loadings to Moses Lake.

6. Monitor groundwater and surface waters in the project area to supplement data gathered in Stage 1 and to begin post project monitoring phase.

7. Provide public information/education.

8. Prepare technical reports describing Stage 3 activities.

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 (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 joint responsibility of the Clean Lake Project staff with Don Beckley, project manager, and his staff handling accounting, secretarial, and information/education portions, and SCS staff under subcontract handling the technical planning and compliance portions 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.

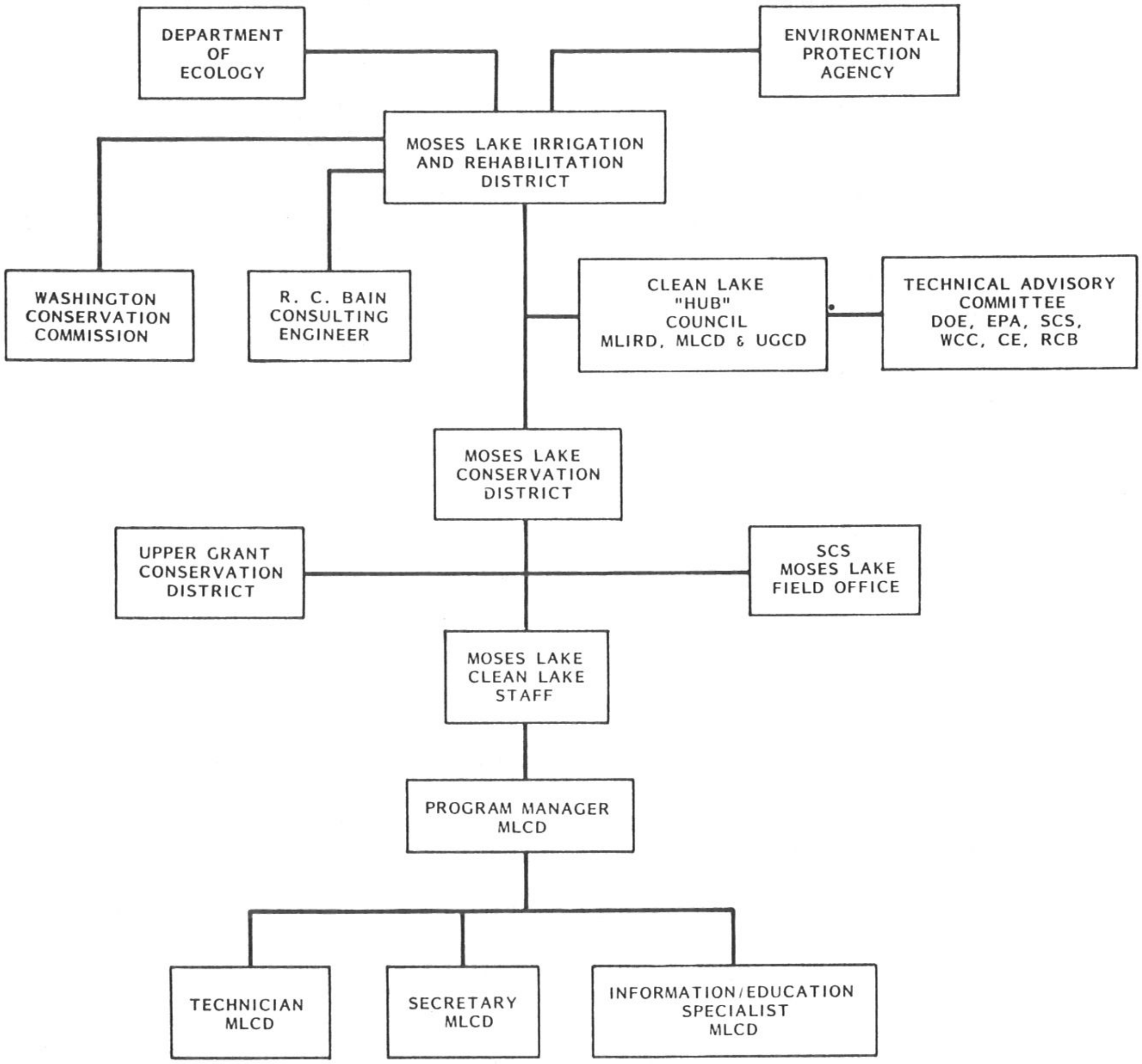
Members of the TAC and the Hub are acknowledged below:

TAC Members:

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

Charles Carelli/Ron Pine, Washington State Department of Ecology

Elbert Moore, Sally Marquis, Martha Hoffman and Carl



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

Figure 1-3 Project Organization Chart - Stage 3

Nadler (retired 1984), U.S. Environmental Protection Agency

Ed Forster, Grant-Adams County Cooperative Extension Service (Stage 1 and Stage 2 only)

Shiraz Vira, Byron Fitch
Soil Conservation Service

Council Members:

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

Dan Roseburg/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 Basin Irrigation District (ECBID), 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 Dick Erickson of the ECBID, Steve Jackson and Ray Duff of the Game Department, Rita Perstag, Public Works Director of the City of Moses Lake, Jerry Campbell of the Grant County Health District, Billy Sumral of Grant County Planning, and Bill Hewitt, Dan Hubbs and Francis Jensen of the U.S. Bureau of Reclamation.

Project technical work during Stage 1 was managed under two separate contracts; on-farm activities were managed by Ernie Jaeger, a Soil Conservation Service employee, as project manager by agreement with MLCD and as per SCS subcontract. Off-farm activities were managed by Richard C. Bain, Jr. of Brown and Caldwell, who also prepared the Stage 1 report. Stage 1 information/education programs conducted by Glen Blackburn under the supervision of Ed Forster of the Cooperative Extension Service. During Stage 2, Leigh Nelson, Soil Conservation Service Engineer, managed the on-farm activities under a contract with the Moses Lake Conservation District. Off-farm activities during Stage 2 were managed by Richard Bain who was retained directly for this work. Mr. Bain also wrote the project reports.

The four cooperating farmers who participated in the field demonstrations during Stage 2 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.

During Stage 3, on-farm program elements were accomplished through Moses Lake Conservation District with technical service provided through subcontract to Soil Conservation Service. Don Beckly as project manager for MLCD on-farm program managed the MLCD employees working on the project, Roseann Palmer vouchering technician, and Tom Elder, field technician for billings. Technical services through SCS were under the direction of Byron Fitch, SCS District Conservationist. The staff from the SCS Moses Lake field office operating on the Moses Lake Clean Lake project included Jerry Gilmore, soil conservationist, Bernie Kanoff, resource technician, Janine Spencer, technician, and Leigh Nelson, agricultural engineer. Public information and education during both Stage 2 and Stage 3 was coordinated by Don Beckley.

The Agricultural Stabilization and Conservation Service provided special cost-share assistance to the project which supplemented the EPA grant. The cooperation of Ben Davis, Grant County Executive Director, and Avis Heilman of his staff are gratefully acknowledged.

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 Tony Gladue. Local field survey and design work for the Rocky Ford Creek detention pond structure and access road were provided by Boundary Engineers under the supervision of Ron Baker, principal, and Tina Rogers, project manager. Special thanks is extended to Ron Swanson of Harry Davidson, Inc. who was very helpful in obtaining the Rocky Ford Creek project easements, Jo Bryan Dano and the Dano law firm for legal assistance, and to David and Regan Bonato for their help in financial and grant administration matters. Special assistance on septic tank policy development and related groundwater investigation was provided by David Hitchcock. Laboratory support was provided by Laucks Laboratories for water quality testing and by Northern Testing for soil related tests.

Special thanks goes to Charles Carelli and Ron Pine of the DOE, to Elbert Moore and Sally Marquis of the EPA and to Tom Newcomb and Bob Bottman of the Conservation Commission for their sustained support through the years. And last, but by no means least, 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. Special acknowledgements are also extended to the Conservation Districts involved; recognition of the long hours of volunteer time by the MLCD commissioners is appreciated.

CHAPTER 2

PROJECT AREA CHARACTERISTICS

The Moses Lake Clean Lake Project began with an evaluation of the entire watershed during Stage 1 and focused on the urban and irrigated cropland area near Moses Lake itself in subsequent stages. Maps showing the larger drainage area and Stage 2 and 3 project areas are provided in Chapter 1.

The urbanized area covered by this study includes approximately 185 square miles of urban and rural land around Moses Lake. See map, Figure 2-1. This area includes the City of Moses Lake as well as several densely populated areas around the city that are within the unincorporated area of Grant County. The outer portions of the study area shown on Figure 2-1 are essentially rural in character. The dominant feature in this area is Moses Lake itself.

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 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 1-1. 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 later 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. 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.

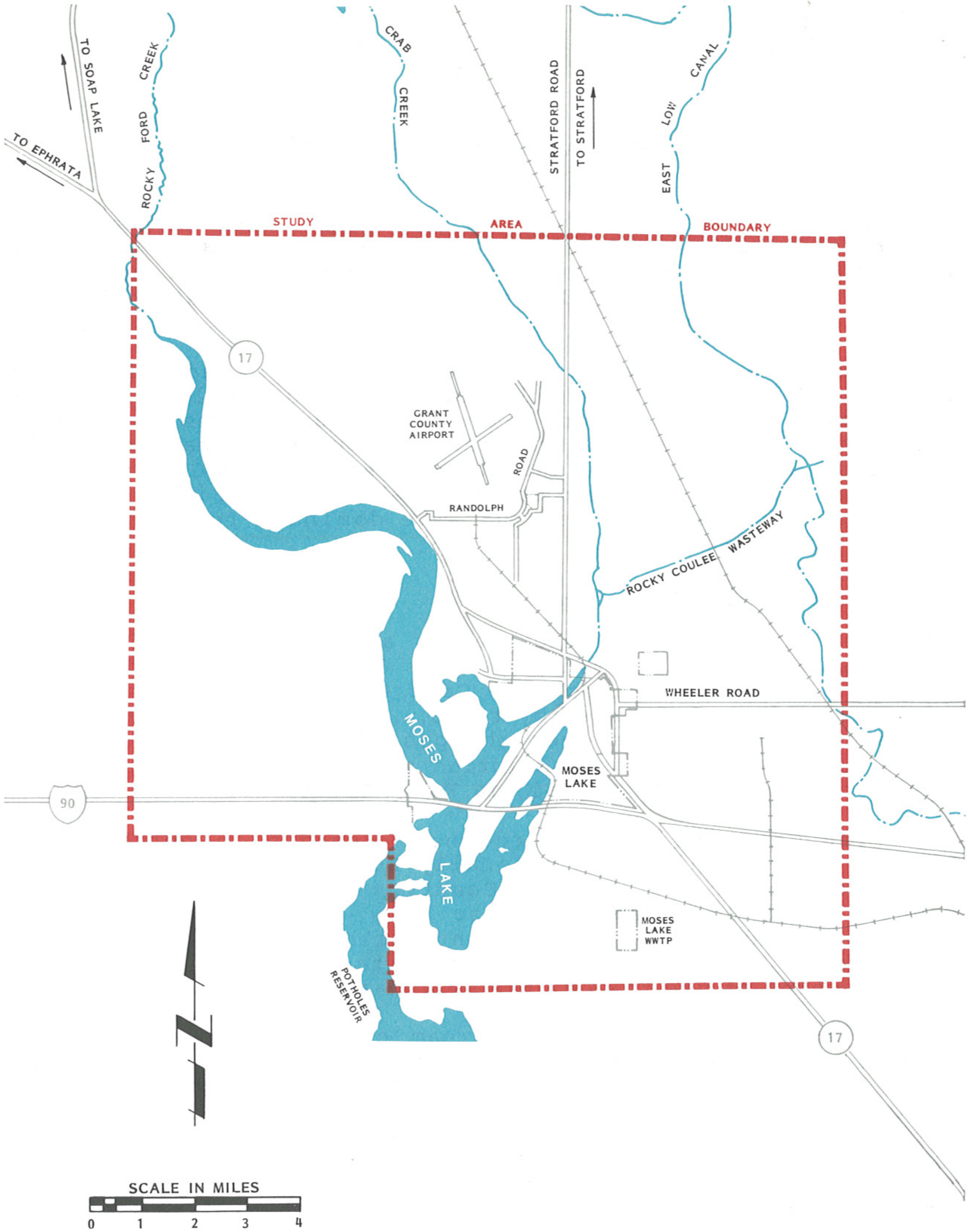


Figure 2-1: Moses Lake Project Area
Urban Wastewater Study

Moses Lake History and Characteristics

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 aerial photograph, Figure 2-2. 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	153.7×10^6 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	11.6×10^6 m^3
Pelican Horn		
Mean depth	15.6 feet	4.8 meters
Area	1,600 acres	648 hectares
Volume	25,000 acre-feet	30.5×10^6 m^3

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

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 6 for additional details.

Figure 2-2 Aerial View of Moses Lake

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 included by wind and carp activity. Sewage effluent from the City of Moses Lake was discharged directly to Pelican Horn for many years. Following construction of a new treatment facility south and east of the City, the lake discharge was terminated in the spring of 1984. The City's new treatment plant discharges to land in the sand dunes area which is down gradient from Moses Lake.

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 prinicipal 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]

Climate

The entire Moses Lake watershed (2,450 square miles) is divided into four precipitation zones, of which the area nearest Moses Lake is the driest. Only 6 to 9 inches of precipitation fall near Moses Lake in contrast to 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.

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

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 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.

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.

Ephrata and Malaga soils are the two major soils in the Moses Lake area. 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.

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 perlocates 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.

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.

Moses Lake Area Groundwater

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]

Recharge for both the unconsolidated 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 northwest (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.

Typical ground water gradients in the Moses Lake area are shown in Figure 2-3. These gradients are based on data from the U.S. Geological Survey as provided to the U.S. Bureau of Reclamation.

Directions of groundwater movement can be inferred from the gradients shown on Figure 2-3. These values present 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.

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 2-4 for example.

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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

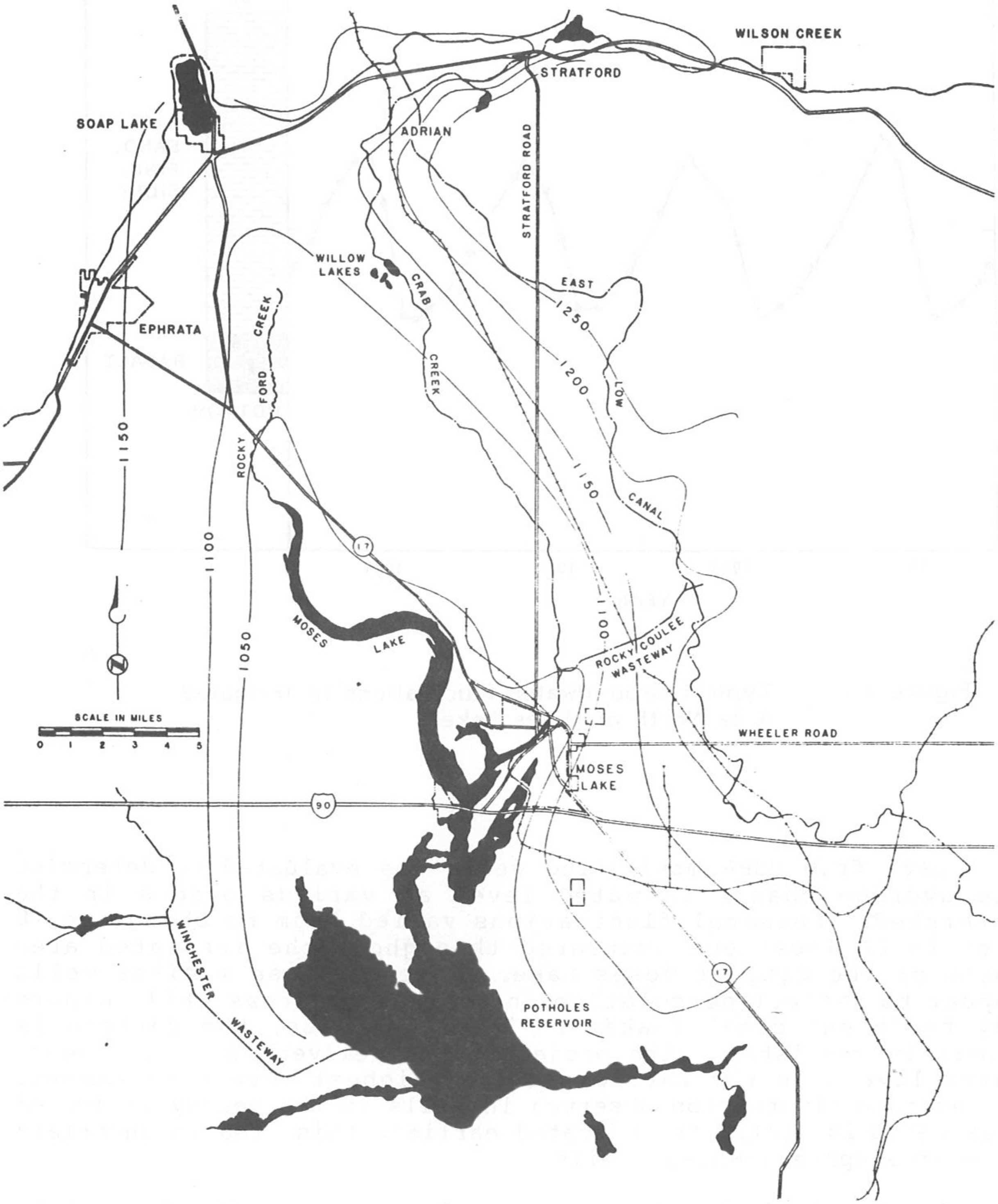

Figure 2-3 Typical Groundwater Gradients Near Moses Lake

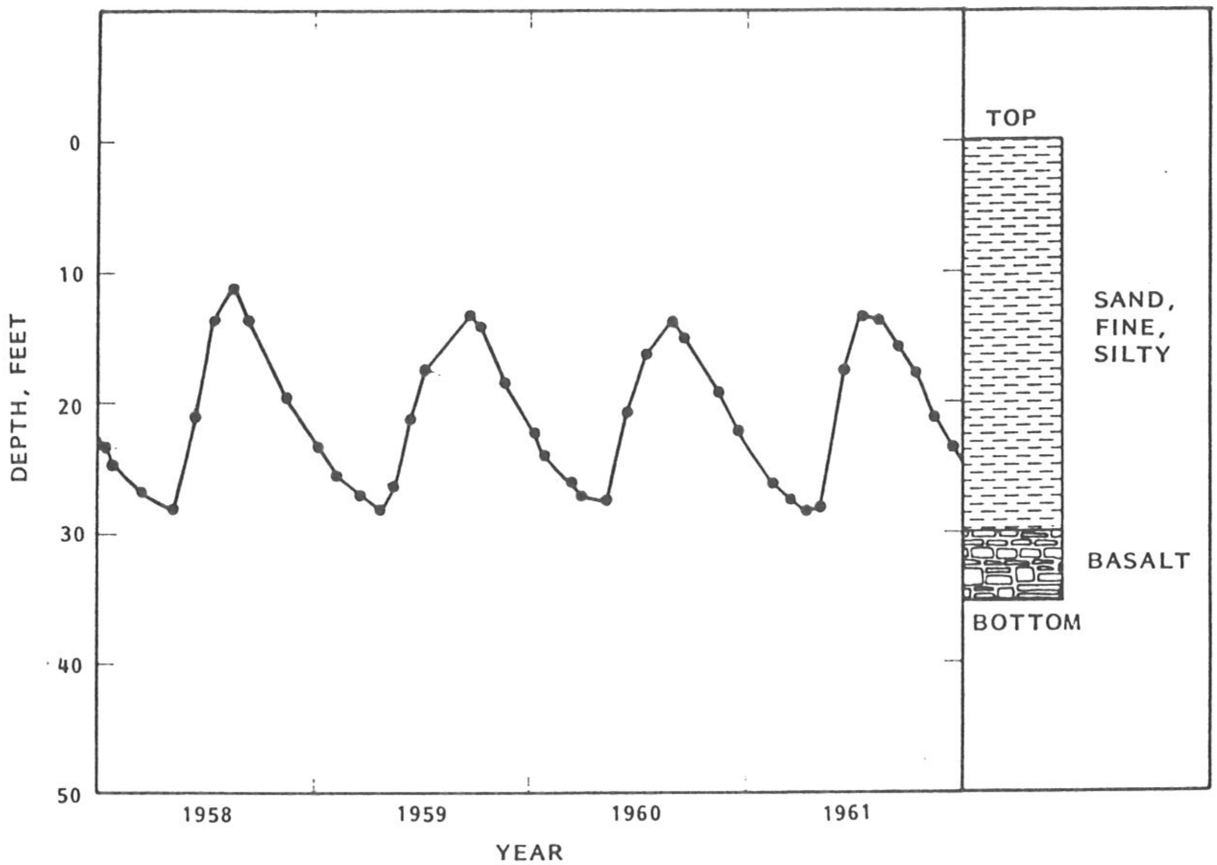

Figure 2-4: Typical Groundwater Fluctuations in Irrigated Area North of Moses Lake

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 irrigated area north of the City of Moses Lake. Some of these monitor wells appear to reflect percolation in irrigation areas while others may represent canal leakage. In either case, the pattern is generally 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 nearby irrigated area was 8.28 feet. As indicated earlier, this area is underlain by coarse Ephrata-Malaga soils.

Localized fluctuations in groundwaters near the Moses Lake shoreline are also evident as a result of seasonal drawdown of Moses Lake. This practice, which typically occurs from November through March each year, is to allow local residents to repair shoreside structures such as bulkheads and docks.

Environmental Constraints

Wastewater disposal through septic tank drainfield or other percolation methods is constrained by environmental factors such as topography, proximity to surface water and groundwater and soil characteristics. Regulations dealing with wastewater practices usually recognize such constraints by requiring disposal fields to be set back from steep banks and water sources, some prescribed distance above groundwater, and to be in soils having at least moderate permeability. See Chapter 5 for discussion of local on-site sewage disposal regulations. As discussed in Chapter 5, wastewater disposal regulations affecting septic tank systems are particularly oriented to protection of the public health and, therfore, are directed to prevention of the spread of disease from bacteria, viruses and parasites that are present in sewage. Accordingly, emphasis is placed on keeping wastewater from surfacing or contaminating local water supply wells.

In contrast, very few local ordinances deal directly with ways to minimize nutrient enrichment of local groundwaters. It is well recognized that nutrient levels in sewage are high and that even treated sewage effluent often causes eutrophication of lakes. Many communities have eliminated direct discharges of sewage effluent to their lakes to improve water quality. Lake Washington in Seattle is a classic example of water quality improvement attributed to diversion of sewage effluent discharges. The City of Moses Lake has recently diverted its treatment plant discharge from Pelican Horn. Since direct discharge is unacceptable, the use of septic tank leach field systems and wastewater percolation methods is relatively common around lakes. However, while these practices may meet public health guidelines, they do not eliminate the nutrient enrichment problem. In the Moses Lake environment the pracice of wastewater disposal by effluent percolation does very little to lessen the nutrient load on Moses Lake because of the coarse nature of the local soils.

Environmental constraints maps were developed which display various physical factors of concern relative to wastewater disposal by percolation. These maps for Moses Lake area are provided on Figures 2-5 and 2-6. Figure 2-5 illustrates topographic slope constraints, surface waters and areas subject to high groundwater either seasonally or year round. Figure 2-6 illustrates soils constraints relative to septic tank leachate disposal. Areas shown as having severe limitations on the soil map include tight soils (with low permeability) and coarse soils (with excessive permeability) based on information published by the Soil Conservation Service.[1] Excessive permeability is a particular concern in the Ephrata-Malaga soils found in the Moses Lake area because of the mobility of nitrogen and phosphorus through these granular soils. These constraints maps may be

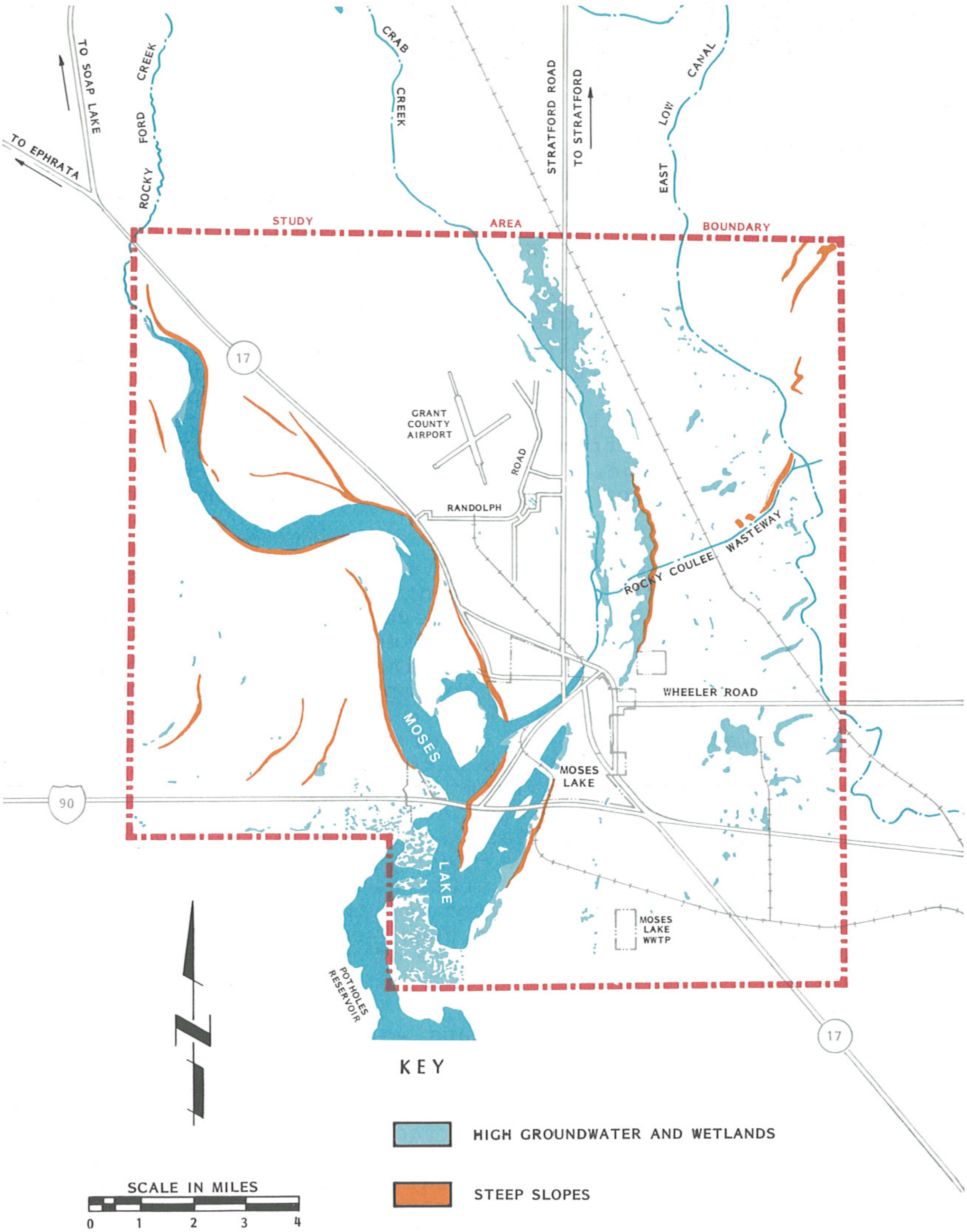

Figure 2-5: Wetlands, Steep Slopes and Areas with High Groundwater

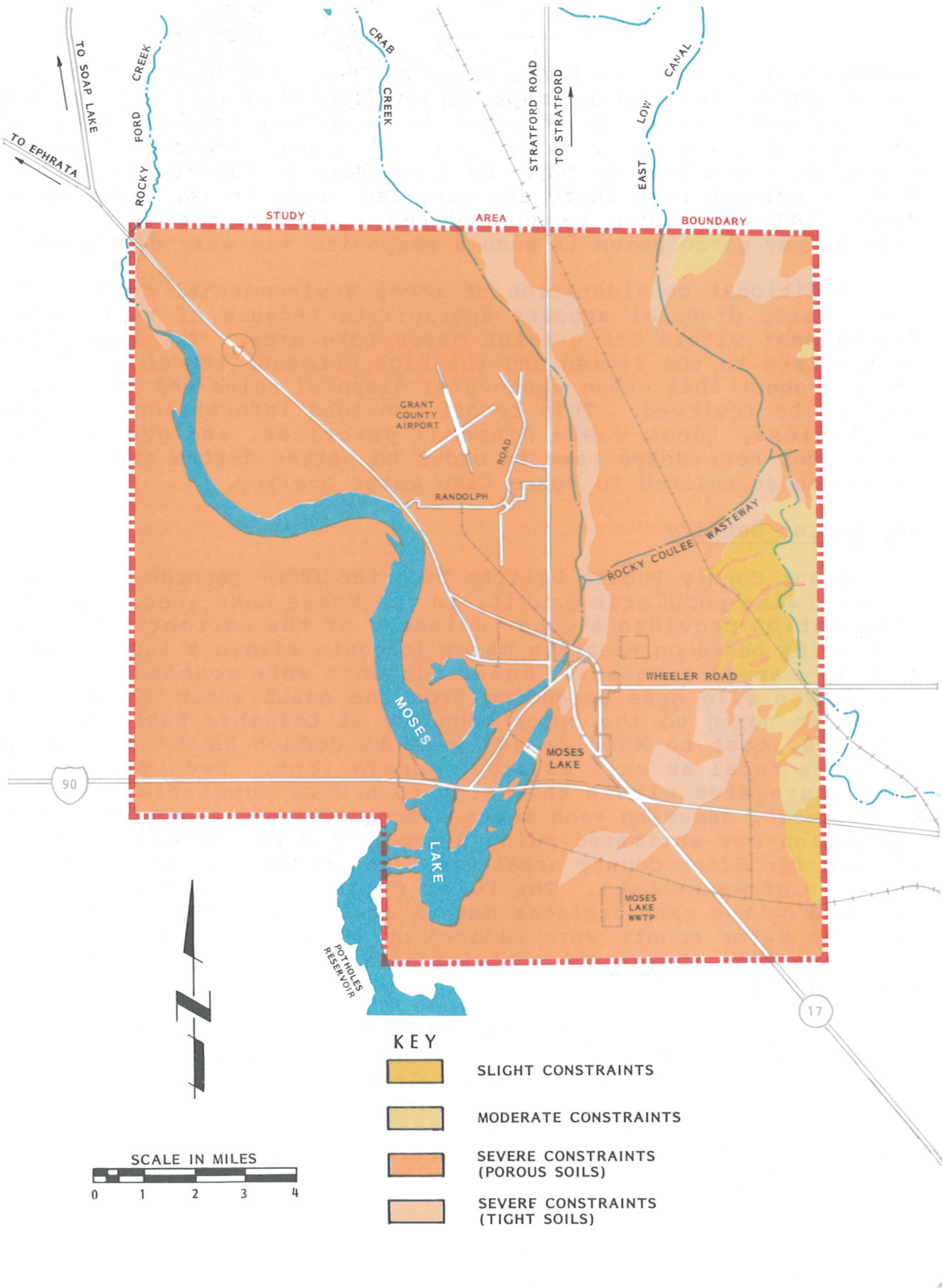

Figure 2-6: Soils Constraints Relative to Wastewater Disposal

combined using the overlay approaches described by Ian McHarg.[2] For example, transparent maps depicting varied constraints such as topographic slope, groundwater depth and excessively tight and excessively porous soil can be placed one upon another to create a composite constraints map. By inspection of Figures 2-5 and 2-6 it is evident that there are very few areas in the vicinity of Moses Lake that can be considered suitable for wastewater disposal by percolation if such a composite map were developed.

Additional consideration of local environmental constraints for on-site disposal appears appropriate because of rapid urban development within the greater Moses Lake area. The importance of the lake to the region and the high permeability of the local soils suggest that urban wastewater disposal rules and facilities need to be reviewed. This report provided information on urban populations, local waste disposal practices, and groundwater conditions near Moses Lake in order to better define the present situation as related to Moses Lake water quality.

Population Density

Grant County Public Utility District (PUD) records were used to determine populatin density in the Moses Lake area. The PUD information provided a good indicator of the current number of households based on electric meter accounts within a large number of well-mapped subareas. Meter accounts were counted within a 250 square mile area extending from the north shore of Potholes Reservoir north to the upper boundary of Columbia Basin Project Block 40, east to Wheeler and west to Dodson Road. This area includes rural as well as urban populations. Twenty subareas were aggregated within this area to assess population density within each, assuming each meter was equivalent to one household. Population was estimated using a population per household of 3.2 persons for Grant County areas and 2.68 persons per household for the City of Moses Lake. The lower figure used for the city was selected so the many business meters would not bias the estimate. Electric meter counts were reduced by 10 percent to account for meters serving commercial activities, irrigation pumps and other non residential uses.

Nearly 27,000 people (26,764) currently live in the 250 square mile area based on the estimates developed from the PUD meter billing data. This is equivalent to an overall density of 107 people per square mile. Approximately 95 percent of these residents live within the 185 square mile study area shown in Figure 2-7. Within the twenty subareas the density ranged from less than 10 people per square mile near Dodson Road to more than

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[1] U. S. Department of Agriculture, Soil Conservation Service, Soil Survey, of Grant County, Washington, issued January 1984.

[2] McHarg, Ian L., Design With Nature, Doubleday/Natural History Press, 1971

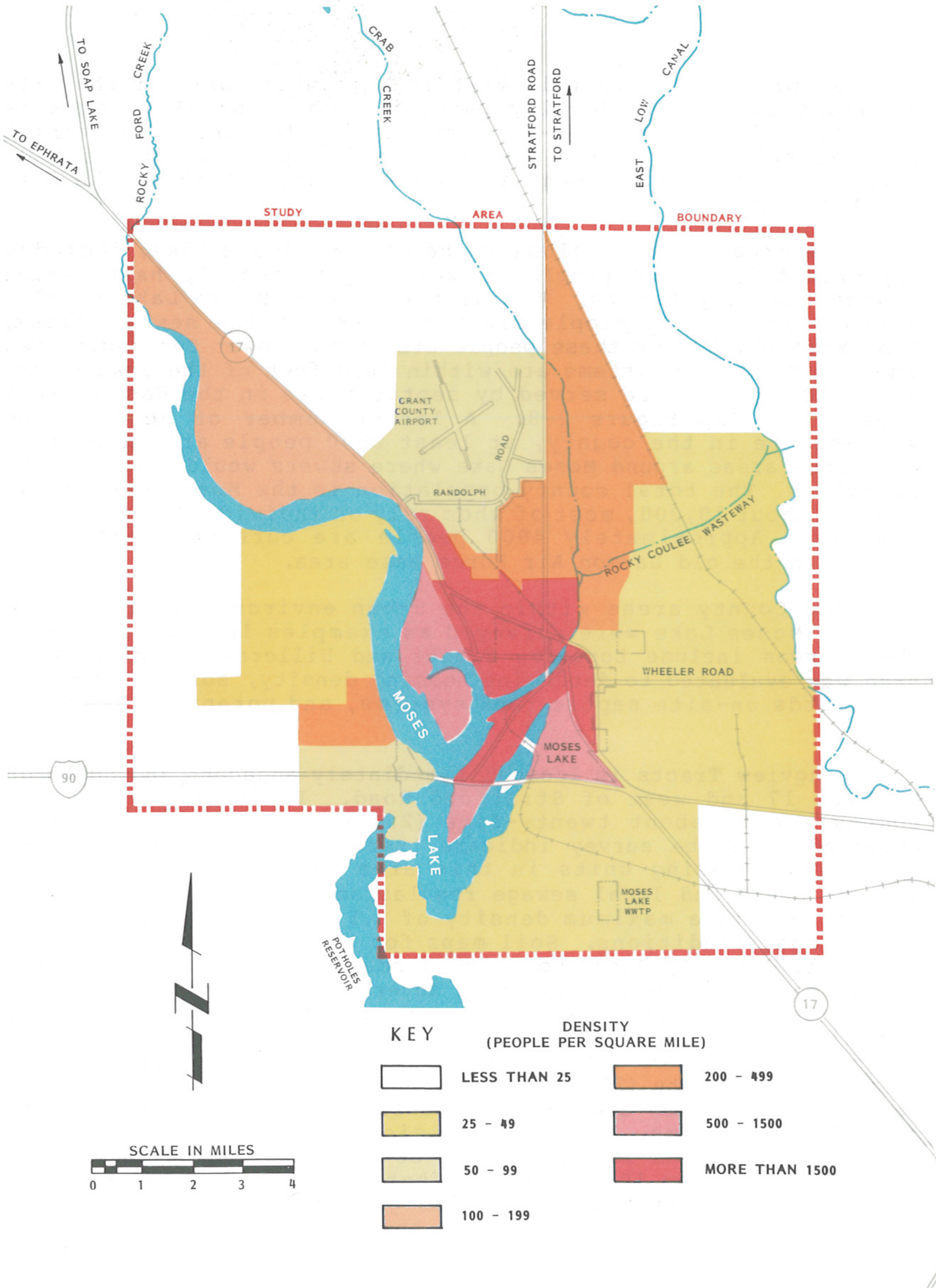


Figure 2-7: Population Density

2500 people per square mile within the central part of the City of Moses Lake. The density pattern within the study area is illustrated in Figure 2-7. Population density also varies considerably within the subareas and there are pockets of extremely dense development in unsewered areas both in the City and the County.

The urban area, including the City of Moses Lake, includes approximately 20,000 people of which approximately half reside inside the city limits. 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 2-8. 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 appear to be feasible. The total county population in the Moses Lake urban area is about 10,000, most of whom rely on individual septic tank systems. Approximately 4000 people are currently served by sewers in the old Larson Air Force Base area.

Two County areas within the urban environment around the city of Moses Lake were surveyed as examples in November 1985. These areas include Longview Tracts and Hillcrest Tracts. Each area was evaluated to determine housing density, soil suitability as regards on-site septic tank systems, and potential sewering needs.

Longview Tracts is located immediately adjacent and north of Highway 17 and west of Stratford Road. It is located in the county and is about twenty-five (25) acres in size. Results obtained from the survey indicate there are one-hundred-eighty-nine (189) housing units in this area or 7.5 homes per acre. Present state and local sewage regulations allow septic tanks to be utilized to a maximum density of 3.5 housing units per acre under ideal conditions. Soil maps for this area identify soils as Malaga Gravelly Sandy Loam and a small percentage of Ephrata-Malaga complex. These soils have severe limitations for treating septic tank effluents as they are excessively permeable and do not filter or treat effluents properly. According to Soil Conservation Service information, permeability of these soils is greater than twenty (20) inches per hour and may be classified as Class I soils which are not acceptable for standard septic tank/drainfield systems. This subdivision is over forty (40) years old and some of the lots have four or more housing units. Many lots are less than 10,000 square feet in area. Several systems in this plat consist of fifty (50) gallon barrels and seepage pits. Gutted washing machines are known to be used also. Based on density alone, this development should be considered as a prime candidate for sewers.

Hillcrest Tracts is an over 40 year old plat located north and immediately adjacent to the Grant County Fairgrounds on Airway Drive. The tract extends east to the Basin Homes area

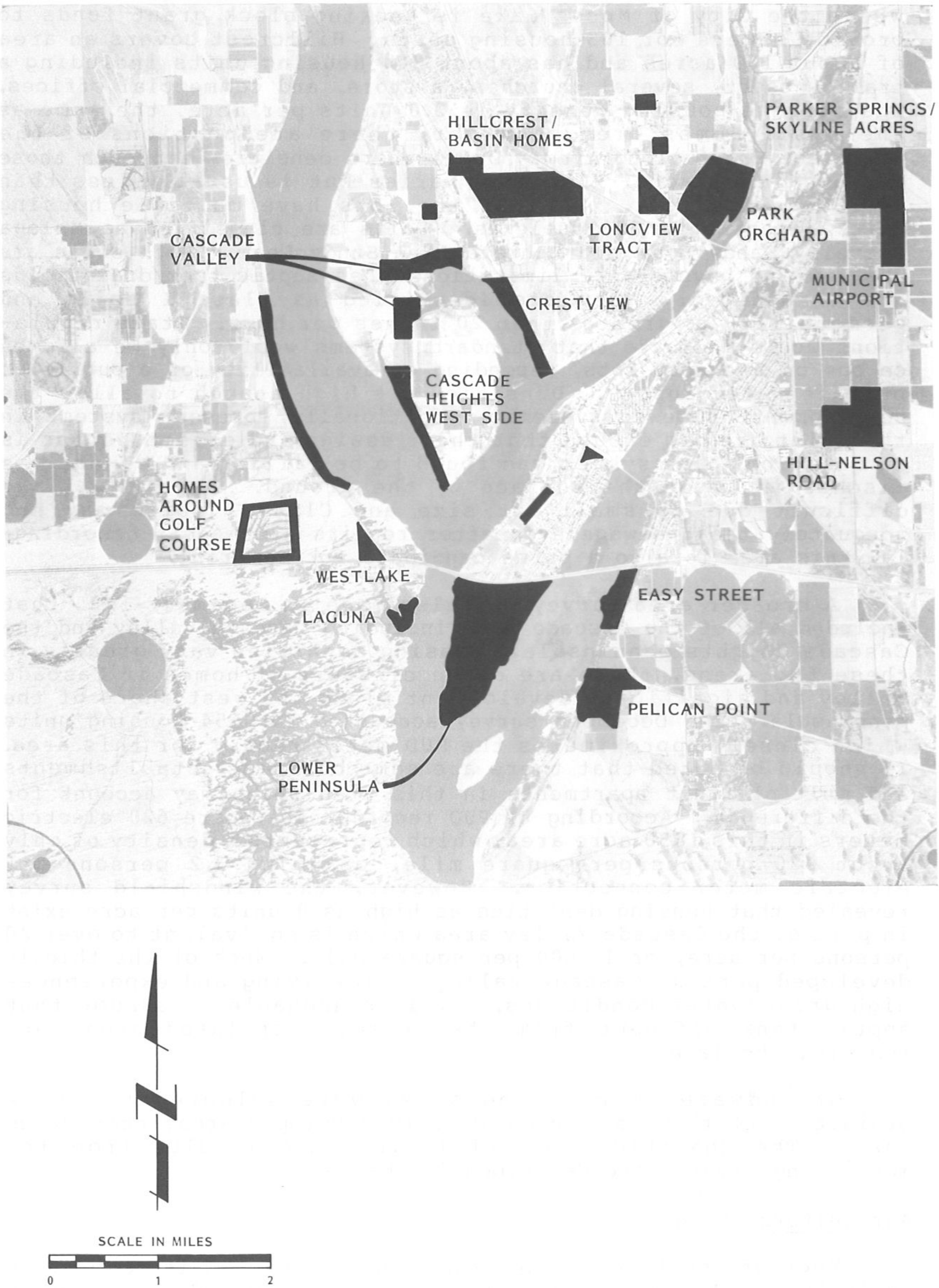


Figure 2-8 Densely Developed Areas Served by Septic Tanks in the Moses Lake Area

where the City of Moses Lake is seeking block grant funds to provide sewers for 103 housing units. Hillcrest covers an area of about 160 acres and has about 324 housing units including a trailer court, several churches, a store, and commercial offices. The average housing density is 2.0 units per acre, the same as the Basin Homes area, however, there are portions of the Hillcrest Tract along Airway Drive where densities approach those in Longview Tracts. Lot size varies but is usually less than 12,500 square feet. Some of the lots have multiple housing units, apartments and duplexes. Soils are classified as Malaga Gravelly Sandy Loam and Ephrata Fine Sandy Loam. Both soils are shallow and have severe limitations when septic tank/drainfields are considered. They are identified as Class I soils and permeability is greater than 20 inches per hour. State regulations would indicate that standard systems would only be allowed on one or two acre lots, depending on availability of a public or private water supply. Densities are high enough to allow the development of sewer systems. Additionally, present systems in this plat are old enough that their design and effectiveness is in question. One system was found to be failing and sewage was discharging upon the surface of the ground. Repair will be difficult due to small lot size and Class I soils may not adequately treat sewage even after repairs are made. Accordingly, this area is also a prime candidate for sewering.

A broader area survey was also made in December 1985 that included all of the Cascade area including Cascade Valley and the Cascade Heights penninsula. Housing densities vary greatly in these two areas, there are dense clusters of homes in Cascade Valley and significant development along the west shore of the penninsula. The December survey accounted for 554 housing units which closely approximates the PUD meter record for this area. It should be noted that there are some business establishments and multiple unit apartments in this area which may account for the difference. According to PUD records, there are 620 electric meters in this 1850 acre area, which represents a density of only about 680 persons per square mile, assuming 3.2 persons per electric meter connection. However, the windshield survey revealed that housing densities as high as 8 units per acre exist in part of the Cascade Valley area which is equivalent to over 20 persons per acre, or 12,800 per square mile. Much of the thickly developed part of Cascade Valley is low lying and experiences high groundwater conditions. It is reasonable to assume that septic tank effluent from the densely populated areas are reaching the lake.

Groundwater monitoring sites were selected to allow evaluation of these and other densely developed areas near Moses Lake. The specific monitoring sites and results from the monitoring program are described in Chapter 5.

Agricultural Land Use

Much of the land in the Crab Creek watershed is devoted to agriculture. There are three basic types of agriculture: 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 later winter and early spring following snowmelt.

In contrast, 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 time period was occasional grazing by a small number of cattle near the Highway 17 crossing. This grazing had ceased by 1985.

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, threetip 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 2-9.

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. This was verified in subsequent project evaluations in 1984.

CHAPTER 3

FARM INVENTORY AND ON-FARM DEMONSTRATIONS

On-farm project activities during Stage 1 and Stage 2 of the Moses Lake Clean Lake Project emphasized definition of agricultural contributions of nutrients to Moses Lake as well as demonstration of control techniques. As indicated in Chapter 2, the most significant contribution of nitrogen was associated with irrigated agriculture. 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		Sprinkler		Total Acres
	Acres	Percent	Acres	Percent	
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.

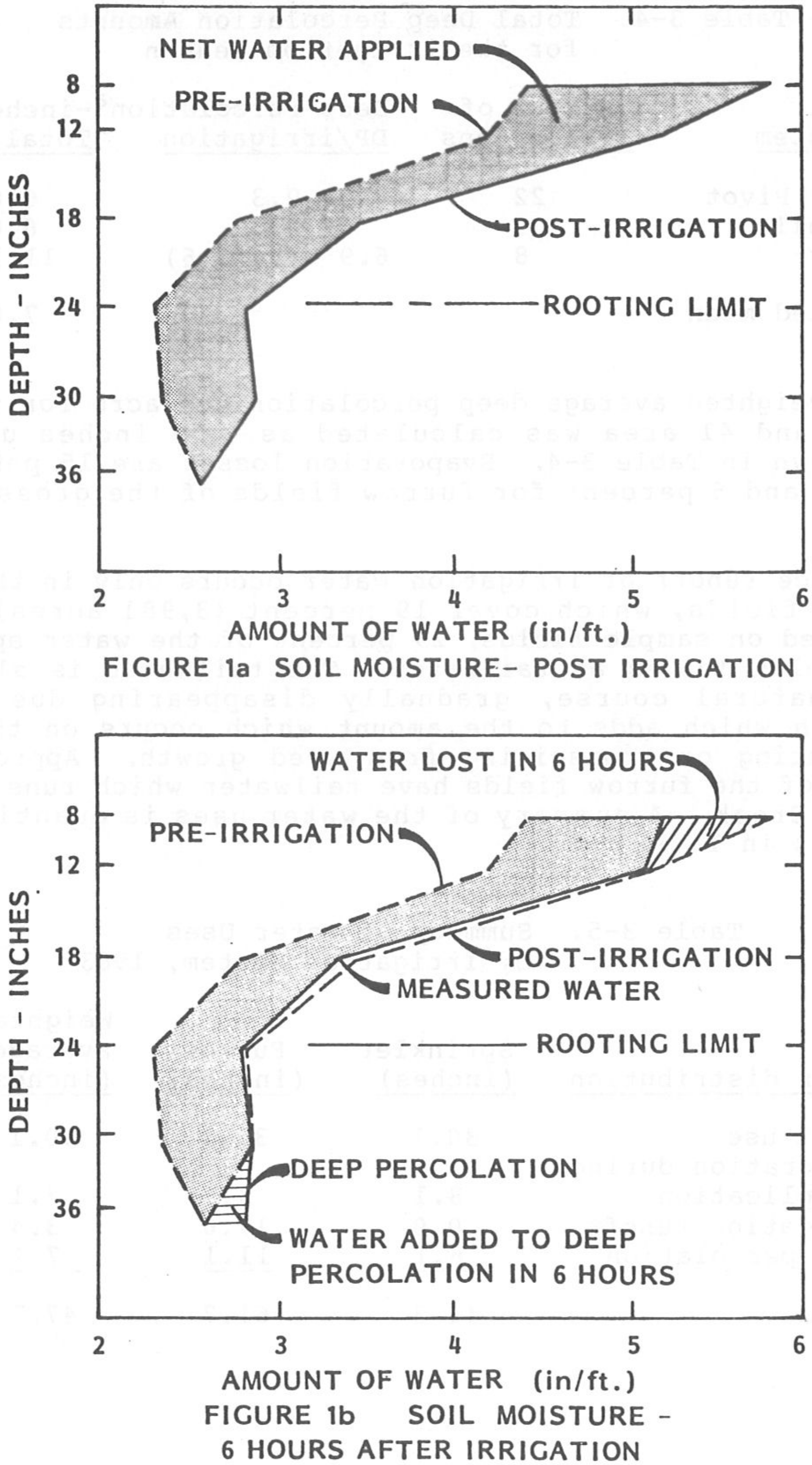


Fig. 3-1 Irrigation Water Percolation in the Soil Profile

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.

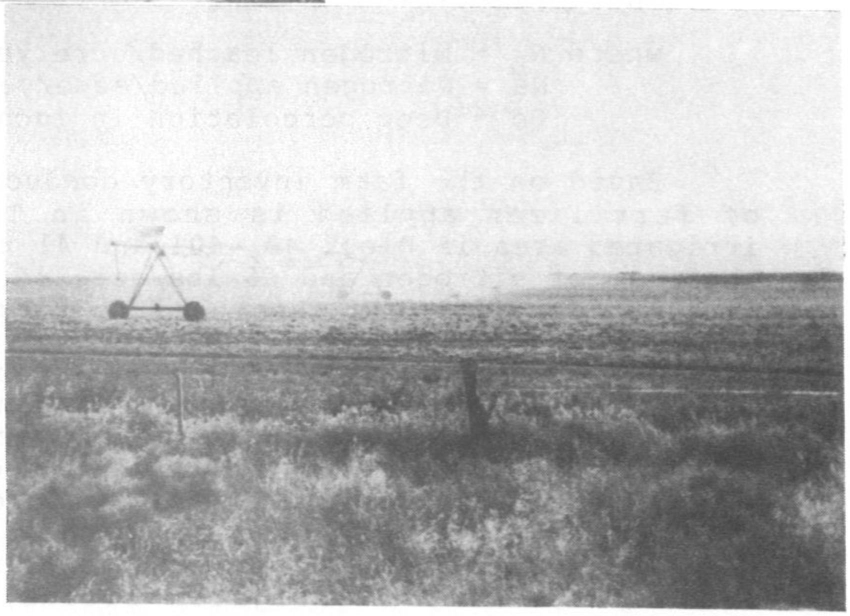
Table 3-5. Summary of water Uses by Irrigation System, 1983

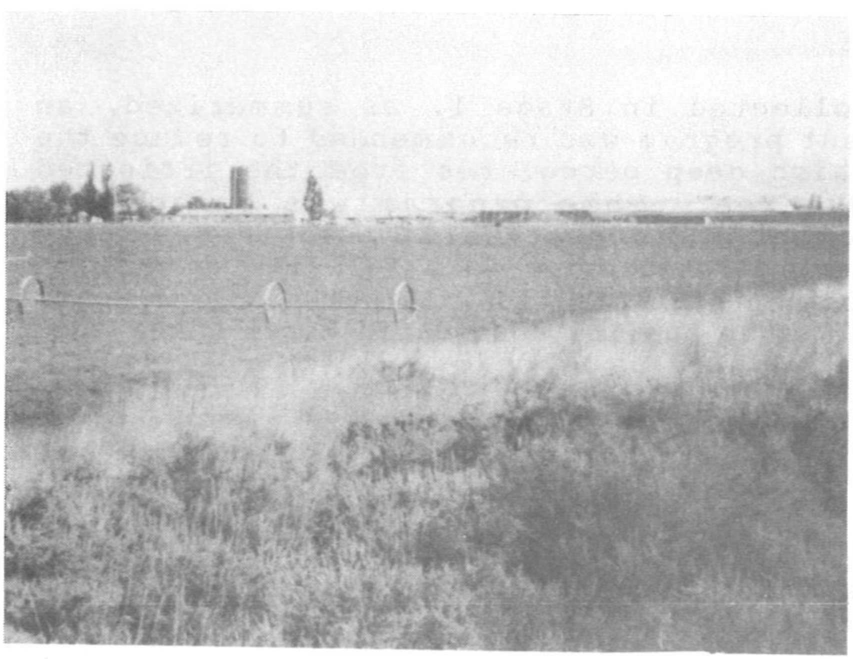
Water distribution	Sprinkler (inches)	Furrow (inches)	Weighted average (inches)
Plant use	30.1	30.1	30.1
Evaporation during application	8.1	3.5	7.1
Irrigation runoff	0.0	17.0	3.4
Deep percolation	6.1	11.1	7.1
Total	44.3	61.7	47.7

[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 pounds/acre	Nitrogen Total pounds	Phosphorus Pounds/acre	Phosphorus 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 3-8) 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

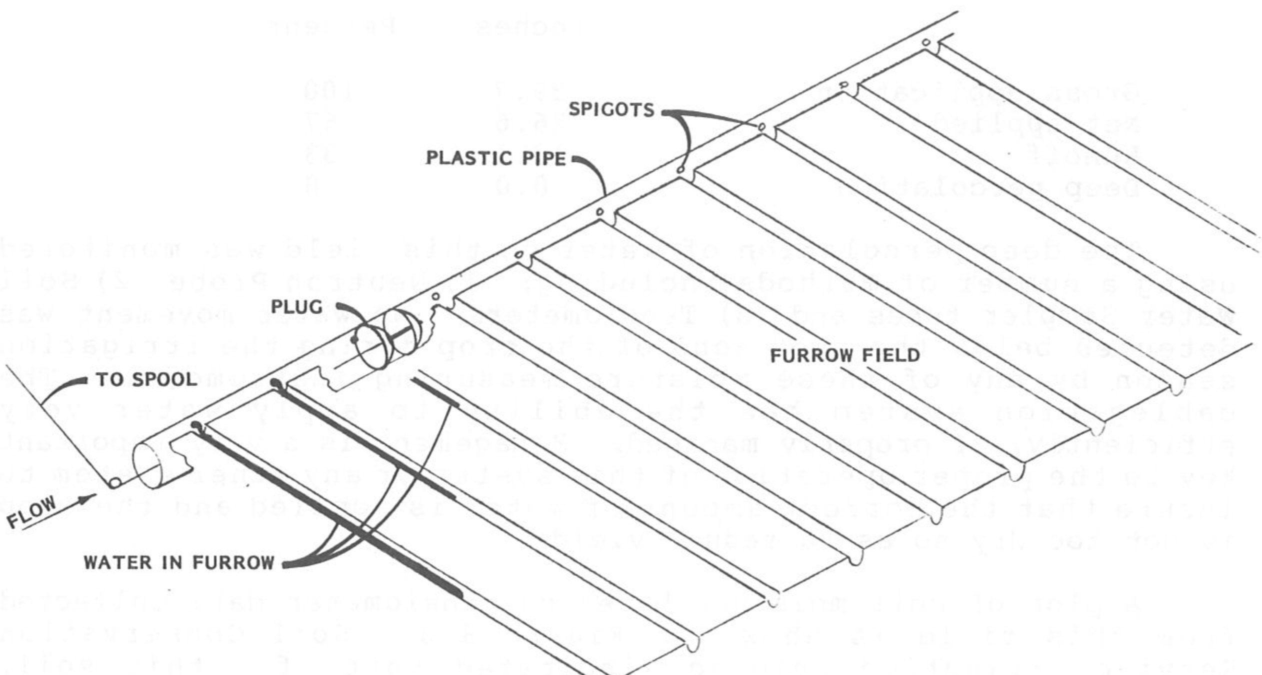


Fig. 3-2 Typical Cablegation System

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

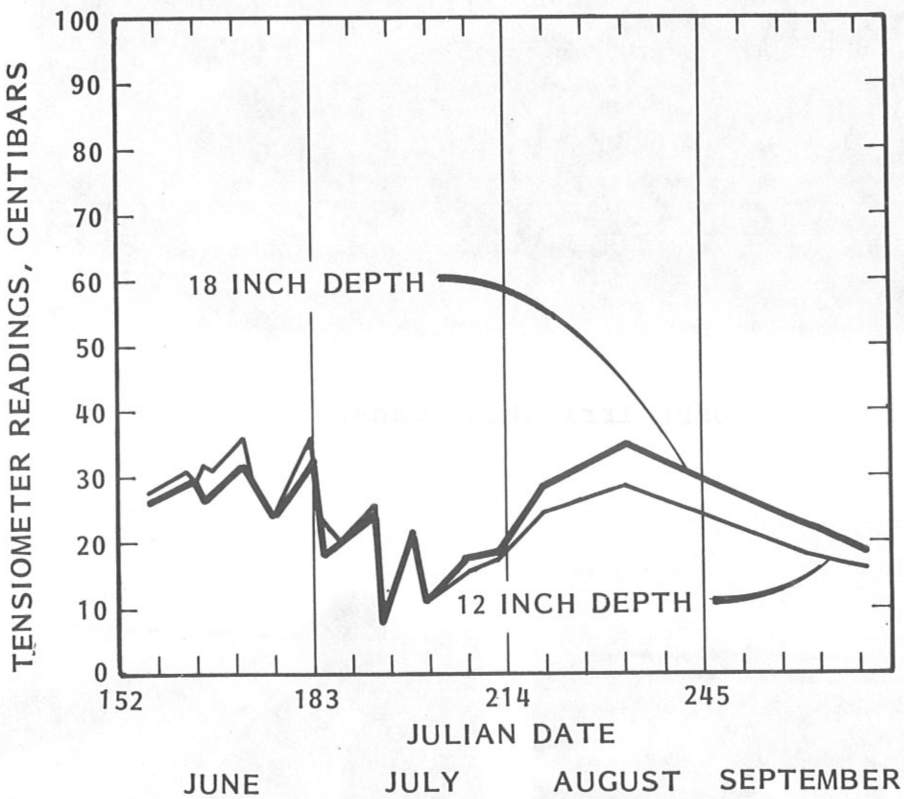
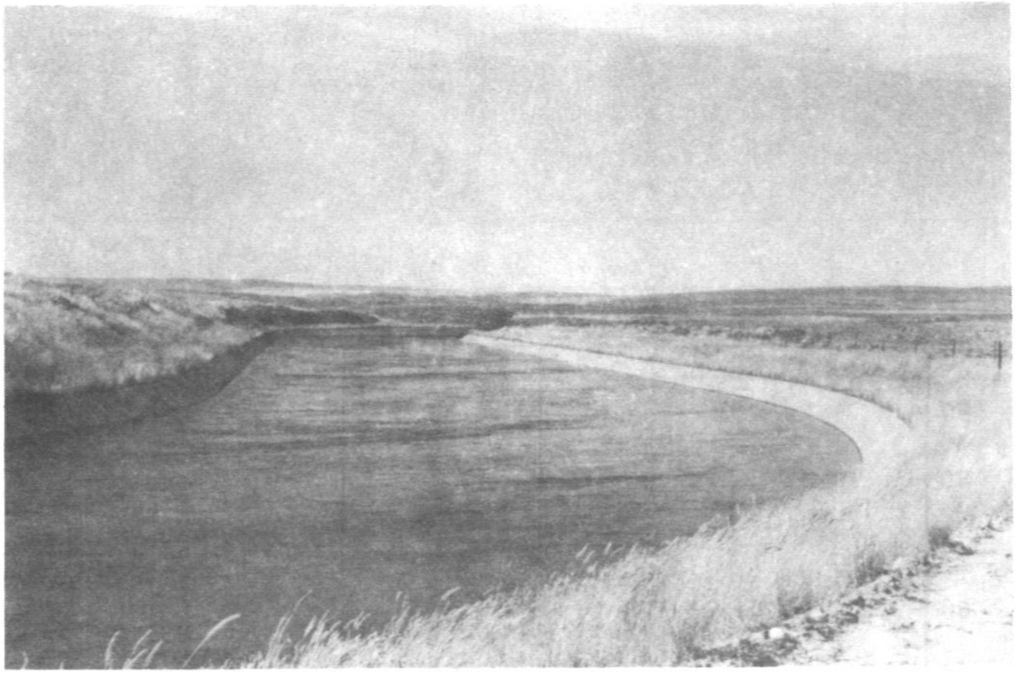


Fig. 3-3 Chris Matheson Tensiometer Readings



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.

Bill Bellomy, Jr., Farm Demonstration. 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:

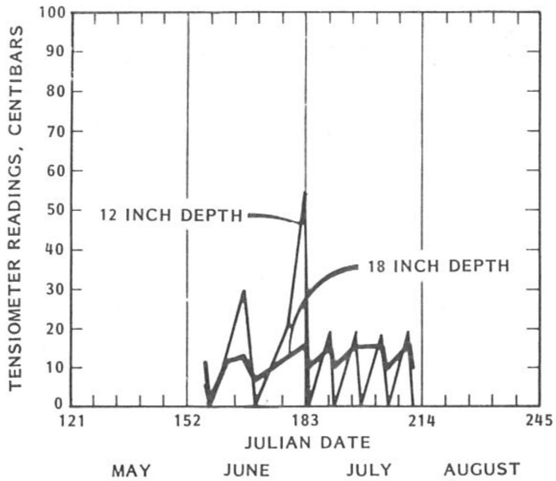


Fig. 3-4 Bill Bellomy Tensiometer Readings

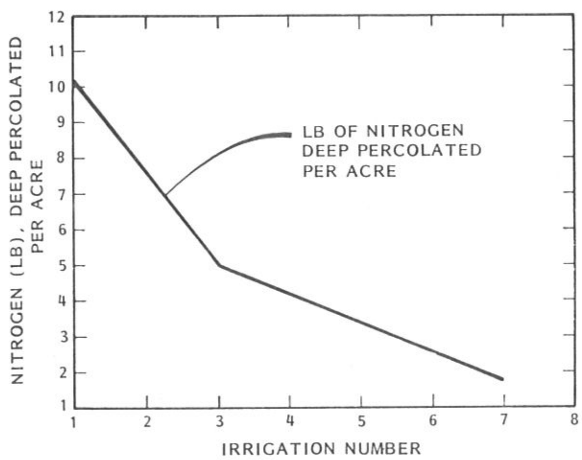


Fig. 3-5 Measured Nitrogen Which Deep Percolates Below Root Zone of Crop

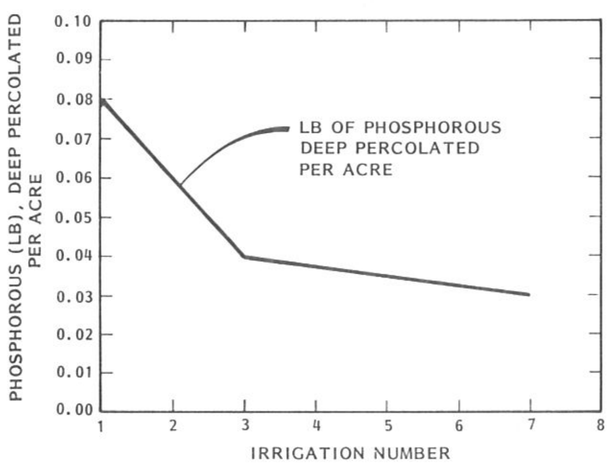


Fig. 3-6 Measured Phosphorus Which Deep Percolates Below Root Zone of Crop

	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.

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[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.

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[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.

<u>Tracy Schmidt Farm Demonstration</u>. 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

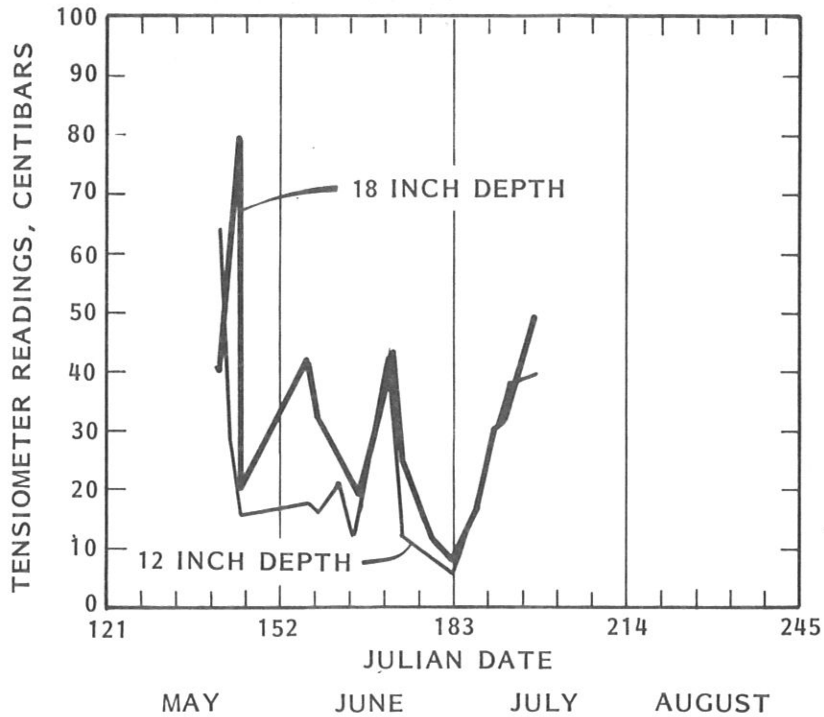

Fig. 3-7 Bob Reffett Tensiometer Readings

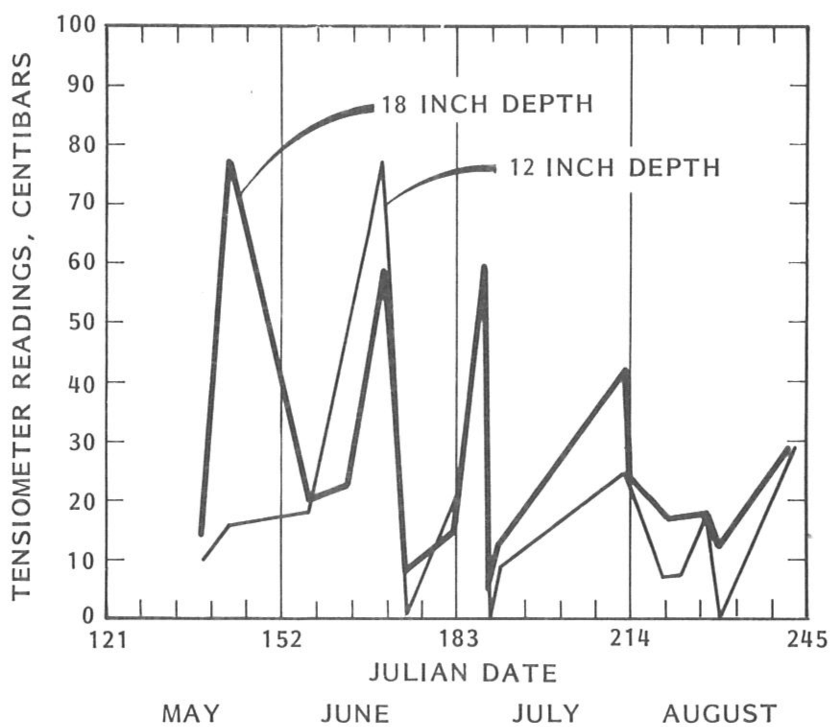

Fig. 3-8 Tracy Schmidt Tensiometer Readings

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 8
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

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[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

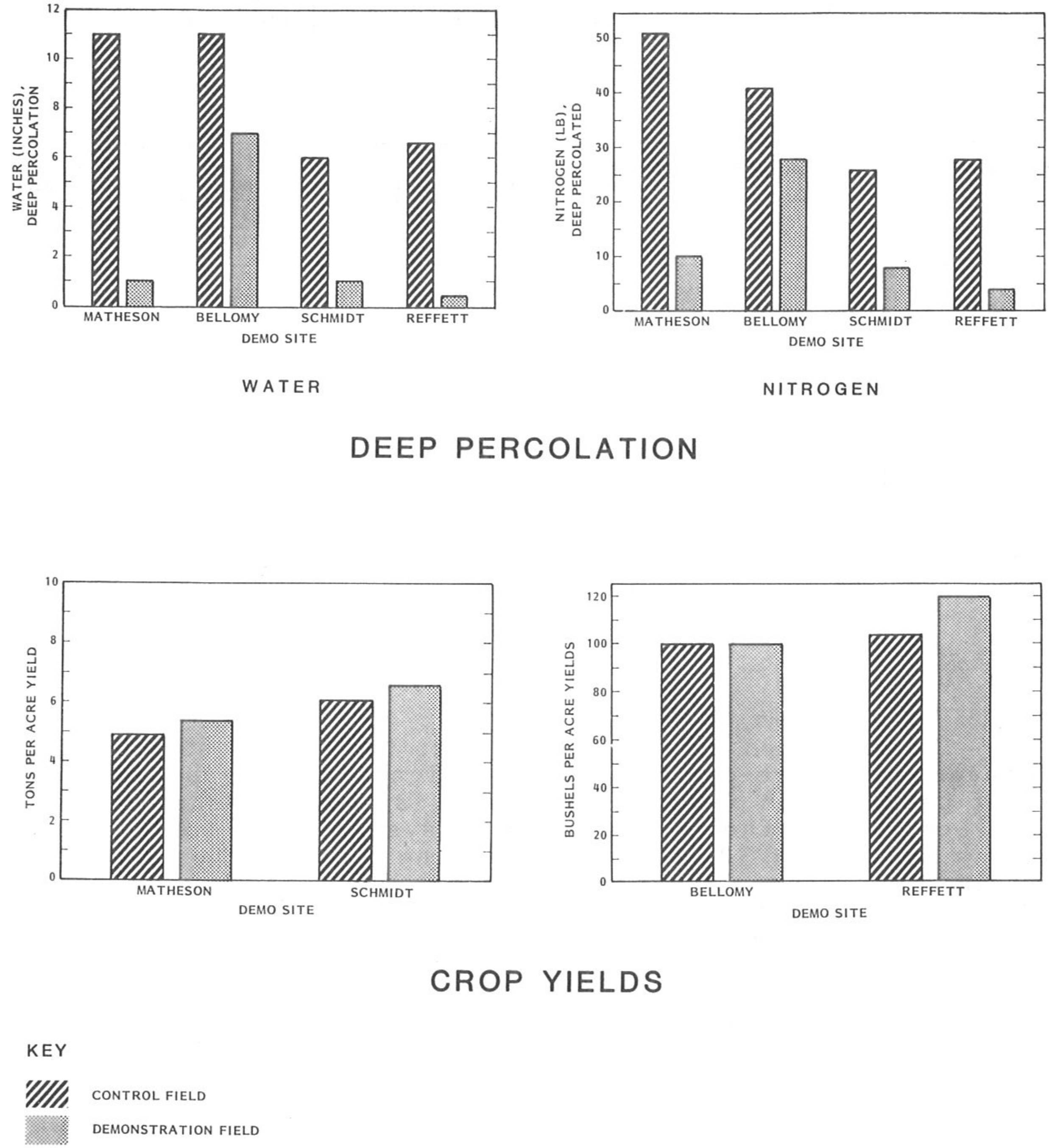


Fig. 3-9 Comparison of Demonstration Results

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 4.

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 7. 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 7.

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

STAGE 3 ON-FARM ACTIVITIES

Stage 3 of the Moses Lake Clean Lake Project included a major multi-year cost-share program which implemented cost-effective on-farm irrigation practice improvements. Project activities included technical assistance to farmers as well as management of a cost-share program which funded a portion of eligible costs for irrigation equipment and irrigation and fertilizer management practices.

During Stage 2 the control of nutrients from agricultural sources was emphasized based on the finding that irrigated agriculture accounted for about 50 percent of the nitrogen loading to Moses Lake. Accordingly, various Agricultural Best Management Practices (BMP's) were proposed for consideration by local farmers in a unique cost-share program. The BMP's were described in a cost-share handbook which is 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 4-1 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.

Development of the Stage 3 Irrigation Control Program

Alternative levels of irrigation control activities were evaluated in Stage 2 to determine the feasibility of Stage 3 operations prior to implementation of the cost-share program. This evaluation was carried out by evaluating potential nutrient changes resulting from implementation of ten model farm plans. These model plans were prepared by SCS technicians who worked with ten farmers representing differing irrigation control needs. BMP's appropriate to each farm were identified and cost share rates were determined. An example of one of the model farm plans is included in the Appendix. A summary of the ten model farm plans is provided in Table 4-1. This table shows, 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.

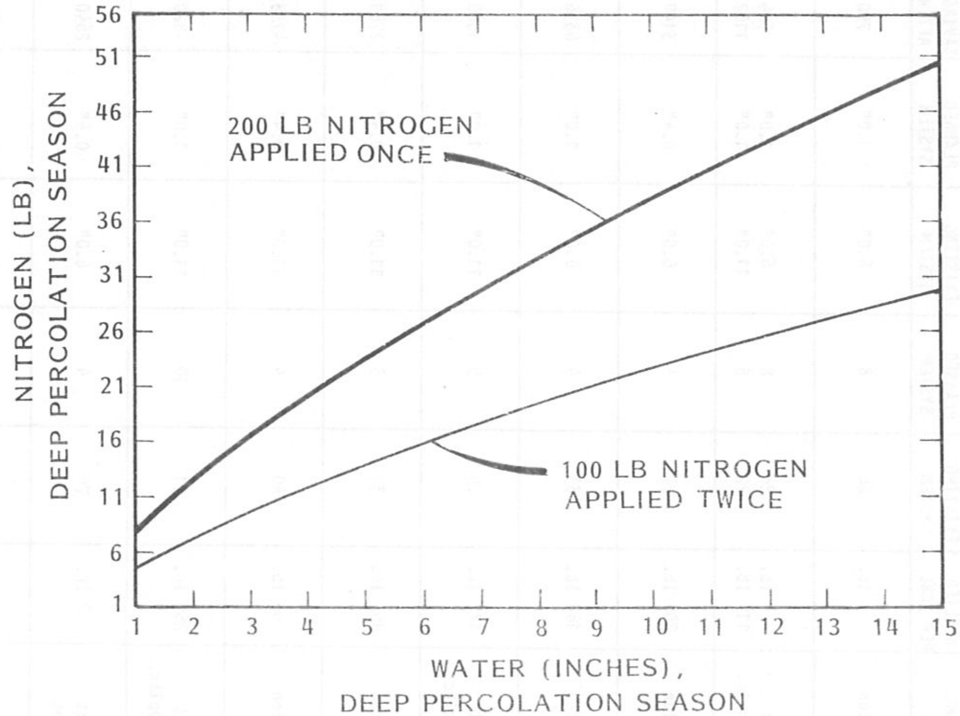


Fig. 4-1 Example of Split Fertilizer Application Effect

Clean Lake Project Staff Explaining Matheson Cablegation Demonstration

LEVEL A

Table 4-1 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 28 A. wheelline	Wheelline	Broadcast Split Applic.	0 lb. 111 lb.	26 22	8 8	6.0" 11.0"	1.0" 1.0"	504 lb. 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 69 A Wheellines	Center pivot	Fertigation Fertigation	262 lb. 200 lb.	40 26	4 4	11.0" 6.0"	0.4" 0.4"	1044 lb. 1518 lb.	$ 8.93/lb.
		2121	1242	$160760	$ 129.43							7.05"	0.7"	29505 lb. av. = 23.8#/AC	

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. This evaluation is drawn from the Stage 2 report.

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 4-1, 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 4-1.

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 4-2. 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 4-3 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.

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 4-4. 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 4-4: 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

LEVEL B

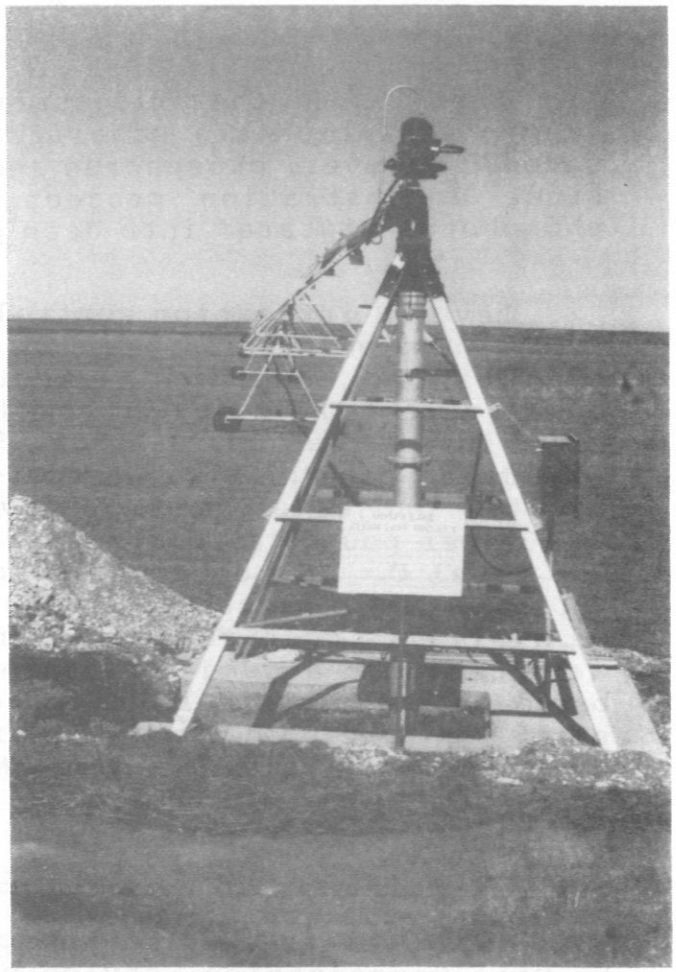
Table 4-2 Level B Irrigation Control Model Farm Plan Evaluation

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 28 A. wheelline	Wheelline	Broadcast Split Applic.	0 lb. 111 lb.	26 22	8 8	6.0" 11.0"	1.0" 1.0"	504 lb. 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 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															
10	34	750	98	$ 22876	$ 194.	29 A Furrow 69 A Wheellines	Center pivot	Fertigation Fertigation	262 lb. 200 lb.	40 26	4 4	11.0" 6.0"	0.4" 0.4"	1044 lb. 1518 lb.	$ 8.93/lb.
TOTALS		1748	983	$143040								7.82"	0.80"	20713 lb. AV. = 21.1#/AC	

Table 4-3 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 28 A. wheelline	Wheelline	Broadcast Split Applic.	0 lb. 111 lb.	26 22	8 8	6.0" 11.0"	1.0" 1.0"	504 lb. 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 69 A Wheellines	Center pivot	Fertigation Fertigation	262 lb. 200 lb.	40 26	4 4	11.0" 6.0"	0.4" 0.4"	1044 lb. 1518 lb.	$ 8.93/lb.
TOTAL		2121	1356	$169315	$12458.	1244						7.05"	1.1"	26095 lb.	Av = 19.2

Center Pivot Irrigation System Sponsored by the Project



Cablegation Irrigation System Sponsored by the Project

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.

Level B irrigation controls were selected as the basis for Stage 3 implementation based on favorable ratio between costs and benefits (e.g., nitrogen control). At the initial control level (9,880 acres) the cost per pound of nitrogen saved was $13.52 for Level B, whereas Level A cost $15.11 per pound and Level C cost $18.70 per pound. Similar cost-benefit relationships were found for the projected control level with Level B the least cost ($9.34 per pound) as compared with $10.78 for Level A and $14.56 for Level C. The control approach identified with Level B was subsequently implemented in the Stage 3 program up to the limit of available cost-share dollars. Stage 3 irrigation controls were centered around the cost-share program which in turn was based on the technical assistance provided by Clean Lake Project staff who developed the water quality management plans for participating farms using specific BMP's appropriate to the individual farm.

On-Farm Technical Assistance Activities

Technical assistance was provided to participating farmers by Soil Conservation Service personnel working with the Moses Lake Conservation District. The primary technical assistance role of the SCS were to develop Water Quality Management Plans for each farm participant and to inspect construction and certify that installations met present standards. Participants were identified through a sign-up and prioritization process described elsewhere in this chapter.

Water Quality Management Plans were drawn up based on contract requests signed by applicant farmers. These requests acknowledge that the applicant understands that all Best Management Practices (BMP's) identified in a particular plan are to be binding on the applicant.

SCS personnel prepared these plans after discussions with each farmer and on-site evaluations of his practices, soils and farm conditions. A plan and schedule of operations was drawn up consistent with a site specific Water Quality Management Plan (WQMP). These documents were incorporated in individual files which also include specification sheets, soil data, and information on cost-share activities such as payment requests. A Model WQMP and Schedule of Operations is shown in the Appendix for reference. Typical of all such plans, both structural and management elements are included, each coded to a particular BMP consistent with the Clean Lake Project Contracting Handbook (also appended).

A larger area would be affected as BMPs are accepted by the farming community. This increased acceptance could occur within the 28,000 acre 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 4-5. 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 4-5.

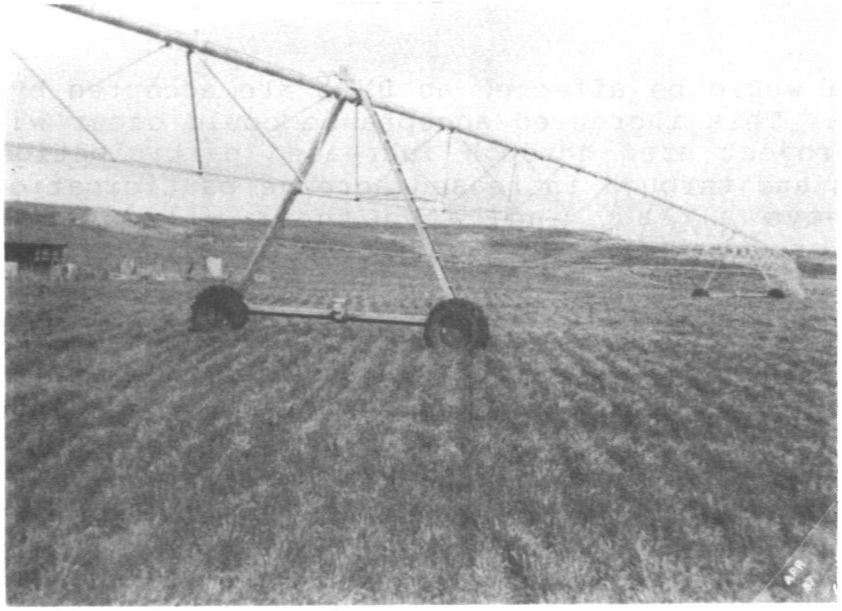
Table 4-5: Summary of Projected Irrigation BMPs Based on Full Participation on Cooperating Farms

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.



Center Pivot Sprinklers are used extensively in the Project Area

Physical or structural improvements described in a WQMP range from inlet structures and screens to irrigation piping such as a main line for a center pivot to entire center pivot sprinkler systems or gated pipe and control plugs for cablegation. Specification sheets were furnished with each WQMP which provide details on construction materials and installation.

Management aspects of the plans include irrigation water and fertilizer management, instructions of which are described further in detailed specification sheets which include instructions on tensiometer use and interpretation and soil sampling for fertilizer amendment recommendations. Examples of these management specifications are provided in the appendix.

On-Farm Cost-Share Program

A unique cost-share program was provided during Stage 3 to project area farmers with funding through grants from the Environmental Protection Agency (EPA) and from the Agricultural Stabilization and Conservation Service (ASCS) cost-share budgets. Farmers who wished to participate in the cost-share program were rated and prioritized according to their contribution to Moses Lake nutrient loads. Funding was provided for technical assistance and implementation of management and structural practices which reduce the on-farm deep percolation of water and nutrient loading to groundwater from irrigation operations. Eligible structural improvements, such as irrigation system conversions from furrow (rill irrigation) practices to cablegation or sprinklers, and pipeline or pumping improvements are reimbursed at a 30 to 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, is reimbursed at a 75 percent cost-share rate. The maximum cost-share available to a participating farmer from the EPA grant program is $50,000.

Farmers wishing to participate in the cost-share program were first asked to sign up during the spring of 1985; a second sign-up was held in the fall, and yet a third sign-up occurred in the spring of 1986. The normal sequence of events following sign-up is itemized below:

1. Sign-up held and priority determined

2. SCS contacts farmers who sign up

3. SCS/farmers develop WQMP

4. WQMP's are presented before the HUB Council

5. Farmer receives acceptance letter from project manager within 30 days (if approved by HUB)

6. Contract with MLIRD is signed following legal review provided farmer has his secured financing

7. System engineering designs approved by SCS

8. Construction begins

9. SCS inspects construction

10. SCS certifies completed project meets applicable standards and specifications

11. Project manager initiates application for payment

12. Project manager checks invoices submitted by farmer

13. Project manager sends application for payment to MLIRD

14. MLIRD issues check to farmer

15. SCS begins the work-up on irrigation and fertilizer management to maximize benefits to lake water quality

The status of the on-farm cost share program is summarized in Table 4-6. As of March 31, 1987, 104 participants had signed up. All participants were rated according to their nutrient savings and prioritized as high, medium or low. Ninety of the 104 have completed plans which have been approved by HUB representing 14,955 acres for an estimated annual nitrogen savings of 343,696 pounds. As of March 31, 1987, HUB had committed $1,081,963 of the $1,098,129 EPA funds available in 36 separate on-farm cost-share contracts. Total expenditures on these 36 projects totaled $1,939,575 as of March 15, 1987, including the grant payments and the farmers' share. These contracts represent 5,346 acres and a total of 122,223 pounds of nitrogen saved annually. Before contracts were signed, each farmer had to show satisfactory financial arrangements for his portion of the cost. A total of 18 farmers cancelled from the program because of financing and farm economy concerns.

Table 4-6 Summary of On-Farm Activities[a]

	Number	Acreage	Nitrogen Saving (lbs)
Farmer Sign-ups	104		
WQMPs Prepared	90	14,955	343,696
WQMPs Contracted	36	5,346	122,223

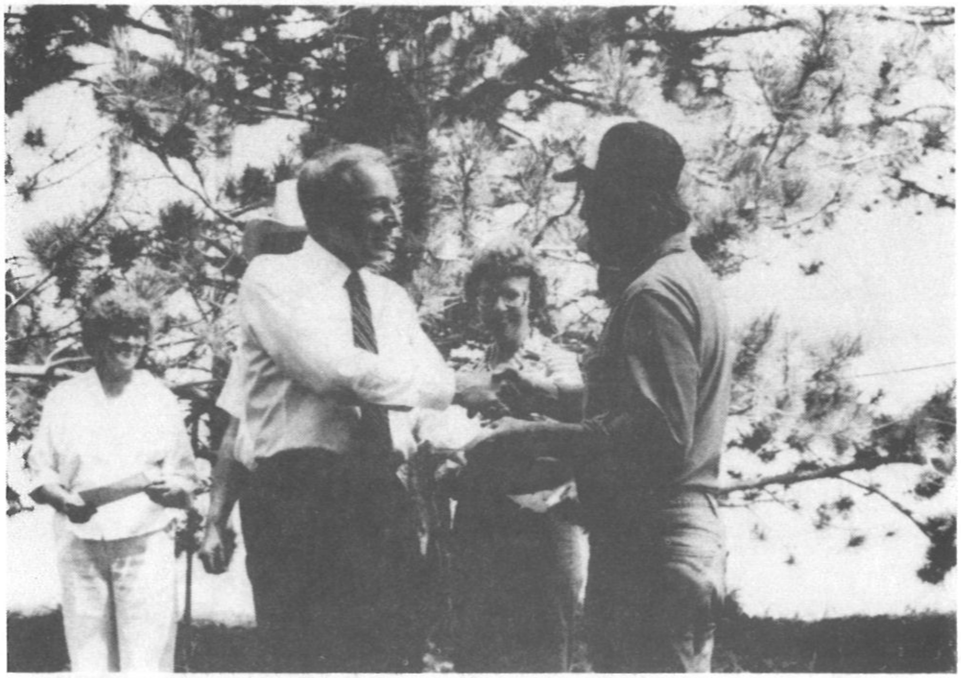
[a] As of February 5, 1987

In addition, ASCS support has been received by farms in the project area for improvements such as mainlines for conversions from rill to sprinkler irrigation. The maximum amount of cost-share money available to an individual farm under the ASCS program is $3,500. Approximately $108,200 was paid out to cooperators under the ASCS part of the program.

Figure 4-2 shows the location and area occupied by farm units under long-term contracts. The acreage involved represents nearly 20% of the 28,000 acre irrigated area near Moses Lake.

System changes accomplished by the Stage 3 program are illustrated in Figure 4-3. This figure shows 51 systems including 32 center pivots, 18 wheel lines and one cablegation system, all constructed or improved as part of the Stage 3 cost-share program. These systems account for conversion of 2,417 acres of rill irrigated ground to more efficient systems and upgrading and conversion of 2,928 acres of sprinkler irrigated ground.

The actual 5,346 acres involved in the Stage 3 cost-share program was less than the 9,880 projected for Level B controls in part because individual farm improvements proved more costly and partly because total cost-share dollars available from EPA were less than originally projected. Nevertheless, the projected nutrient savings to be achieved accounts for nearly 50 percent of the initial Level B projection. The nutrient savings must be achieved through careful fertilizer and irrigation water management as demonstrated during Stage 2. A fertilizer and irrigation water management program scheduled for implementation over a three year period is described in a later chapter. This management program is required on all farms receiving cost-share money under the Stage 3 project. Projected benefits of the nutrient savings are discussed in Chapter 7.



Farmer Receiving Cost-Share Check
from Congressman Sid Morrison

Project Signs Were Posted in the Community

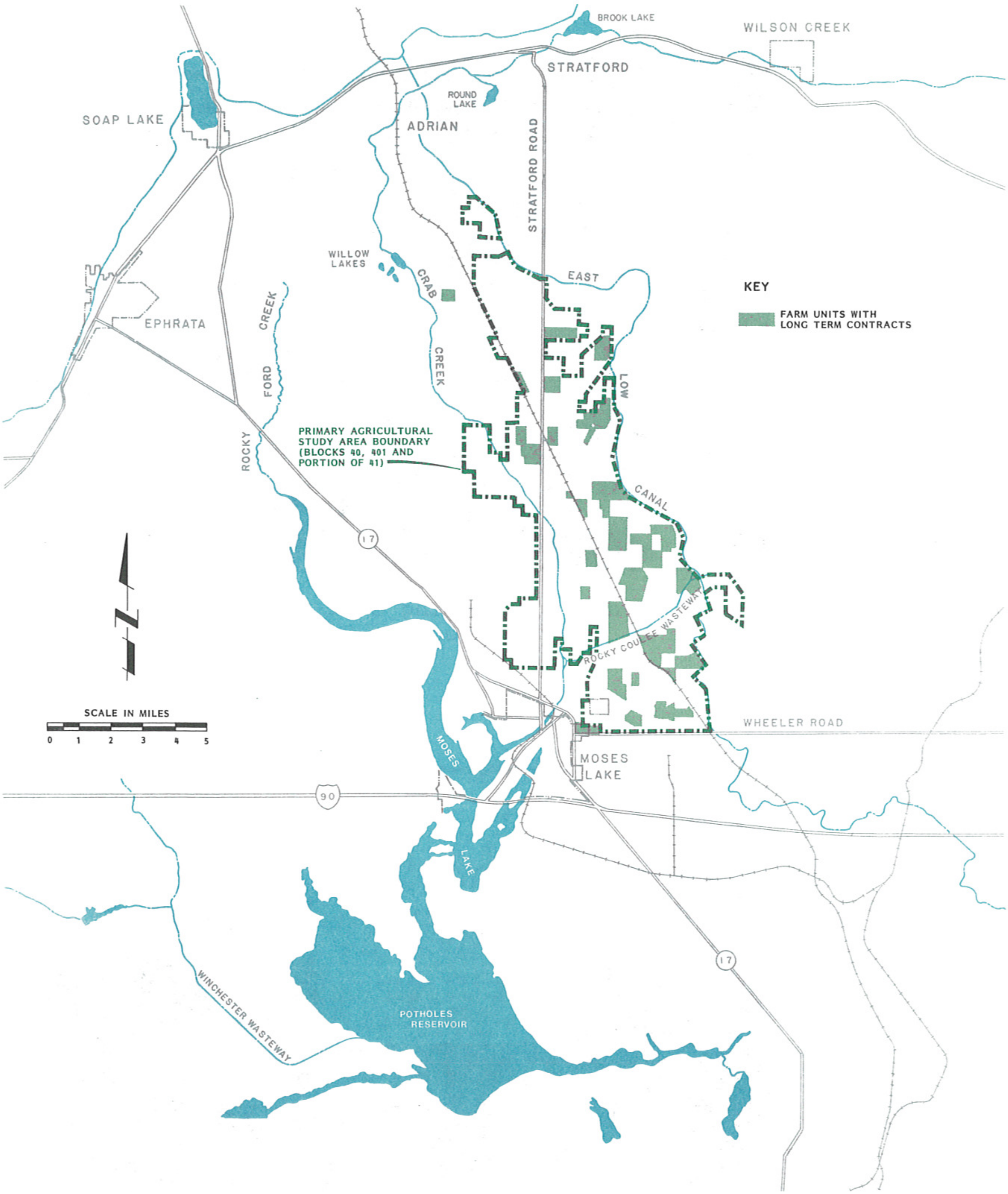


Figure 4-2 Farms Participating in Stage 3 Cost Share Program

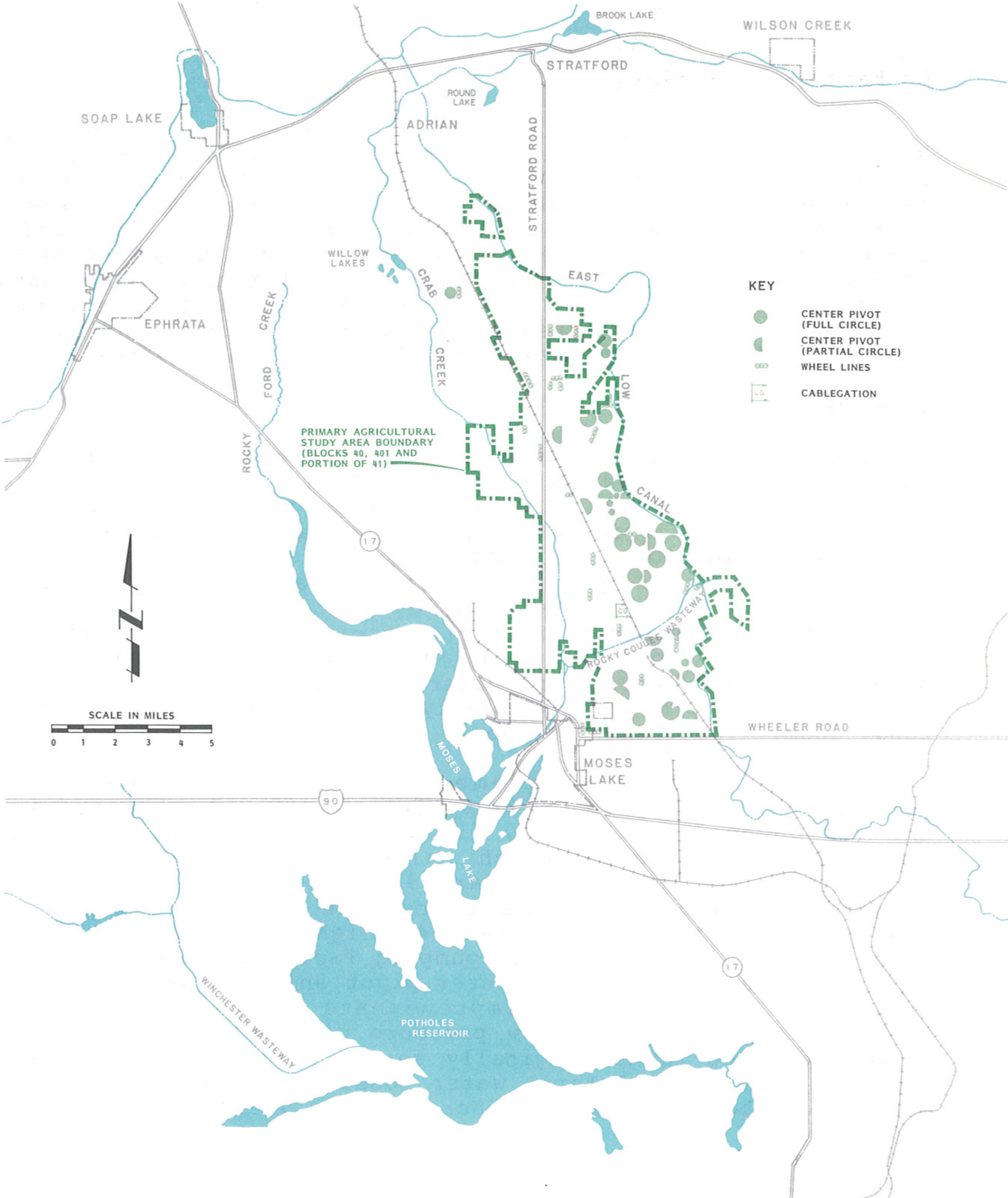


Figure 4-3 Irrigation System Improvements Accomplished by Stage 3 Cost Share Program

On-Farm Case Studies

Six of the 36 farms involved in the cost-share program are described in more detail in this report. These six were selected as representative case studies to illustrate the kinds of changes the Stage 3 program caused on individual farms. These examples cover the various kinds of irrigation systems involved in conversions from one system to another in the program as well as some of the complexities encountered in implementing such changes on an individual farm. Five of the six are full-time farming operations involving acreage of 100 acres or more and one is a smaller part-time farm involving only 16 irrigated acres.

Demar Duvall Farm

The Demar Duvall Farm is located on Road 9 NE and occupies farm units 93 and 94 within Block 40 of the Columbia Basin Project. In past years this farm produced hay from approximately 160 acres of rill irrigated ground. The water was delivered from a surface irrigation supply ditch which bisected the farm. This supply ditch was fed by an East Columbia Basin Irrigation Lateral to the west. Approximately 10,000 feet of older farm ditches conveyed water to ten or more rill irrigated fields as shown in the left hand portion of Figure 4-4. These ditches had deteriorated and were losing water from excessive seepage. Soils on this farm are Ephrata gravelly sandy loam and Malaga cobbly sandy loam. Topography is level.

A water quality management plan was developed by SCS personnel for this farm in the spring of 1985 and was approved by the HUB Council on June 17, 1985. The plan identified a new water delivery system which called for elimination of the existing supply lateral and farm ditches and substitution of a sprinkler irrigation system to replace the rill system. See right hand portion of Figure 4-4 which illustrates the farm improvements. New piping and pumping facilities are included to supply both a new 141 acre center pivot and a 17 acre wheel line irrigation system. These improvements were eligible for EPA cost- share monies. The new pressure pipe delivery system also serves adjacent farms originally served by the surface lateral. The plan eliminates lateral water losses, reduces the amount of water and labor required and increased hay yields are projected.

Irrigation water and fertilizer management improvements were also incorporated in the plan. Cost share monies are identified for this farm through 1989. This particular farm operated with the new sprinkler irrigation system in place during 1986 and the farmer testified in a December 1986 public meeting that he saved an estimated $10,000 in fertilizer cost for the 1986 season based on soil test information, and saved significantly on his water bill as he irrigated less often and for shorter duration, and saved $3,500 on excess water costs alone. Nutrient savings projected by the project are more modest and approximately 4,000 pounds of nitrogen saving was forecast by SCS which represents a

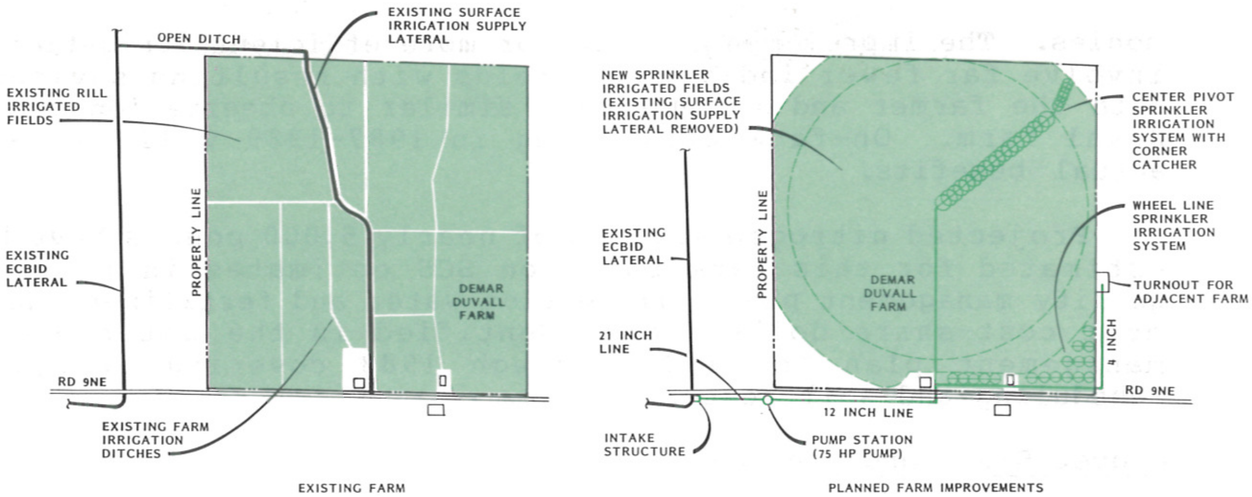


Figure 4-4 Demar Duvall Farm - Before and After

monetary savings of about $1,000. The farmer may have saved more because of over-fertilization in past years. Future savings would be expected to be closer to the SCS estimate.

Chris Matheson Farm

The Chris Matheson Farm is located on farm units 77 through 85 within Block 40 of the Columbia Basin Project. This farm was also a demonstration participant in Stage 2. The Matheson farm produced wheat, corn, hay and pasture in previous years. Soils on this farm are of the Ephrata and Malaga series.

The Water Quality Management plan for the Matheson Farm was first approved in December 1985. The structural aspects of the Stage 3 cost-share program for the Matheson farm involved conversions of approximately 214 acres of rill irrigated ground to a 261 acre center pivot sprinkler irrigation operation involving four center pivots on farm units 79 and 80. Approximately 21 acres were also placed in upland wildlife habitat as part of the Stage 3 program. This aspect of the project is being coordinated with the Game Department with the hope that increased habitat improvement can result.

Physical improvments include approximatly 4,281 feet of underground high pressure mainline which received ASCS special water quality funds and a control station, four center pivots, a fertigation system, and flow meters which received EPA cost-share monies. The improvements allow for more efficient irrigation and involve far fewer individual fields with resulting savings to both the farmer and in nutrients similar to observations on the Duval farm. On-farm monitoring in 1987-1989 will establish actual benefits.

Projected nitrogen savings of nearly 5,000 pounds have been estimated for this farm based on SCS estimates in the water quality management plan. Irrigation water and fertilizer management cost-share dollars are identified in the water quality management plan for 1986 through 1988 covering irrigation scheduling and soil tests.

Grover Black and Sons Farm

Grover Black and Sons farm occupies farm units 23, 24, 34 and 35 within Block 41 of the Columbia Basin Project. The area of this farm is approximately 268 acres, of which 233 acres were rill irrigated prior to Stage 3. Crops grown on this farm include wheat, corn and pasture. Soils are within the Ephrata-Malaga series.

The water quality management plan for the Grover Black farm was approved in May 1985. Stage 3 cost-share monies from EPA and ASCS were used to provide assistance to the Black family for conversion of the rill irrigated ground to new sprinkler irrigation systems.

The physical improvements included two center pivot installations including one full circle and one partial circle covering 194 acres total as well as 30 acres of wheel line. See Figure 4-5. Benefits to the farmer will be evaluated in 1987-89 as a result of system operations with irrigation water and fertilizer management programs which are specified for this farm.

John Dills Farm

The John Dills farm occupies 163 acres on farm units 16, 22 and 23 within Block 41 of the Columbia Basin Project.

The farm includes cropland, hay land, and pasture. Approximately half of the 127 acres actually farmed was rill irrigated and the balance was on wheel line sprinklers. Mr. Dill grows small grain crops, primarily barley. Soils include Royal loamy sand and Outlook fine sandy loam.

The water quality management plan which was approved in January 1986 called for a small (28 acre) center pivot to upgrade a portion of the rill ground, retention of 62 acres of wheel line sprinklers, and retention of some rill irrigated cropland and pasture. The southeastern part of the farm is not cropped and will provide upland wildlife habitat. This plan was approved in early 1986. Structural improvements built in 1986 included a new intake structure, a sprinkler mainline and control station and a center pivot system, all under the EPA cost-share program.

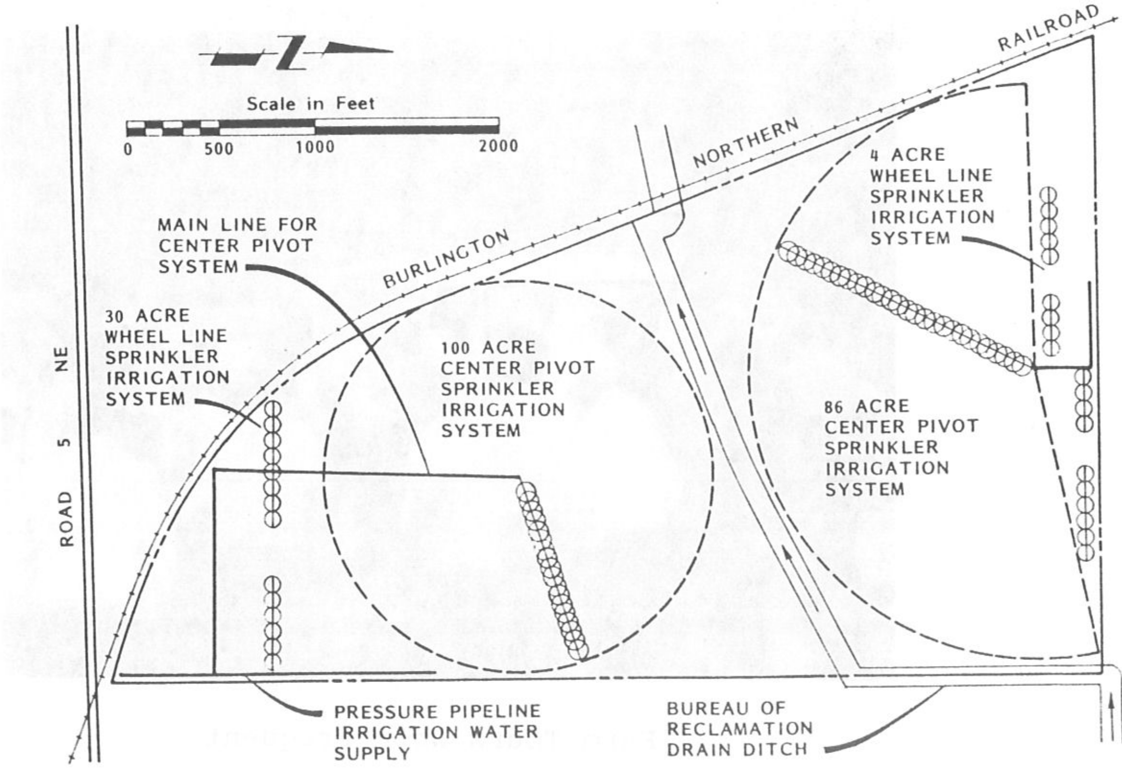


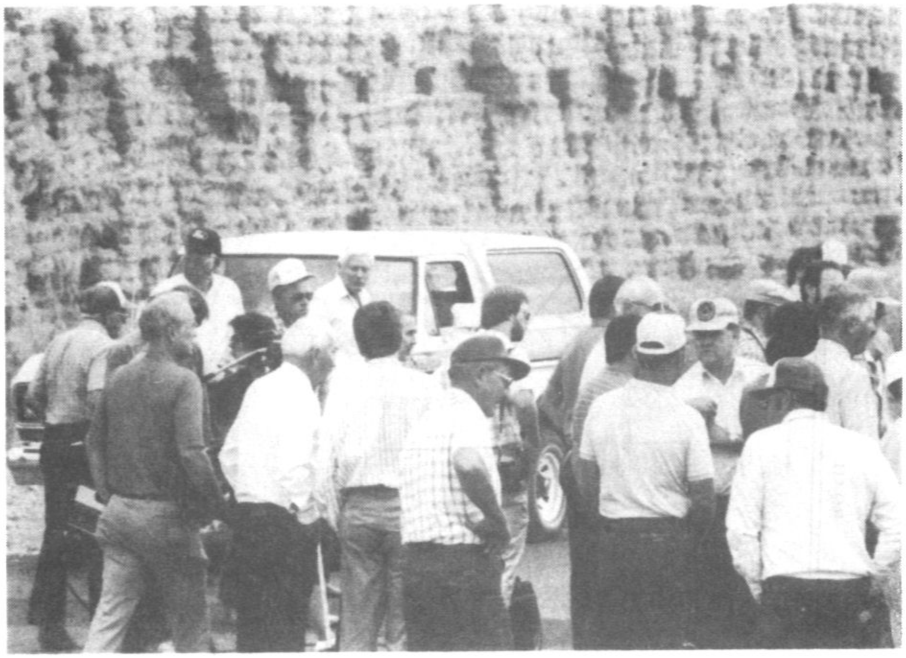
Figure 4-5 Grover Black and Sons Farm Improvements

Irrigation and fertilizer management cost-share items were also included with cost-share eligibility for 1987 through 1989. Nitrogen savings of 2,300 pounds are estimated for this farm project.

Richard and Trudy Watson Farm

The Watson farm, which is operated by Ron Hansen, covers approximately 164 acres within farm units 148 and 149 of Block 40. The farm includes 105 acres of rill irrigated ground and 59 acres irrigated by wheel lines. This farm is underlain by Ephrata Malaga soils. Corn has been the primary crop in recent years.

The water quality management plan for this farm was approved in August 1985. In accordance with the plan, the rill irrigated portion of the farm was converted from conventional rill irrigation to cablegation serving the same acreage and represents one of the largest cablegation systems ever built. Separate cablegation systems were constructed on each of the two farm units including an inlet structure with control box and plug, a flow meter, and gated pipe. See the appendix of this report for a description of the cablegation method. The water quality management plan describing these improvements estimates 4,305 pounds of nitrogen savings per year associated with effective operation of this irrigation system. All structural components



Farm Tours Were Frequent

Tour of Cablegation System

are eligible under the EPA cost-share program; irrigation water management activities are eligible for cost share for 1986 through 1988 for the 105 acre cablegation system and for 50 acres of hayland irrigated by wheel lines.

Tom Martinez Farm

The Tom Martinez farm is a small holding of 25 acres located within farm unit 212 in Block 40. A wheel line system is in place which irrigates 16 acres. Crops grown on this farm include alfalfa and wheat. There are approximately 7 acres in pasture. Soils are Malaga cobbly sandy loam.

A water quality management plan was approved in July 1986 for this farm which provides minimal structural improvements (improved inlet structure with screen and flow meter). However with these few improvements to facilitate water measurement, irrigation water management can be implemented. Accordingly this farm is brought into the best management practices aspect of the program at low cost and can serve as an example for other small holdings. Cost-share dollars are being made available to Mr. Martinez for soil moisture devices, irrigation scheduling and fertilizer tests and split fertilizer applications in the same way the program is being carried out on the large farms. The Martinez farm represents the smallest cost-share total of the 36 cost-share participants, but is particularly efficient in terms of the cost of nitrogen savings. An estimated 336 pounds of nitrogen wil be saved annually from this farm at a cost of less than $5 per pound of nitrogen saved.

Evaluation of Irrigation System Improvements

Irrigation system improvements accomplished by the Moses Lake Clean Lake Project fall into two categories. The first is the structural change that occurred as a result of the Stage 3 cost-share program, such as the irrigation system modifications and conversions described in the previous examples. These structural improvements occurred on all 36 participant farms and accounted for over 85 percent of the cost-share funds disbursed during Stage 3. See Appendix for Summary of Water Quality Management Plans and Expenditures. The second irrigation system improvement category is irrigation water management (IWM); this important cost-share component will be emphasized in the 1987 through 1989 period. See Chapter 8 for more details on the IWM phase.

The effectiveness of the structural improvements is closely linked to the IWM program. The structural changes provide the appropriate plumbing; the actual results follow from careful management of the individual irrigation systems. Performance monitoring is needed to document the actual results. Both lake and watershed monitoring programs are needed to provide data on water quality changes over the coming years. These monitoring programs are discussed further in Chapter 8.

More dollars were spent on center pivot systems than any other system type. Although center pivots are expensive, they were found to conserve more nitrogen than any other system. Labor-saving features of center pivots as compared with wheelline systems also were a factor in their selection. One large cablegation system was installed to upgrade a rill irrigated field with a more manageable irrigation system.

Priority systems were developed and used for rating the potential for nitrogen savings relative to cost of each project. Ratings for all 104 farms from the sign-ups are provided with the water quality management plan summary in the Appendix. Most of the highly rated farms from the first two sign-ups in 1985 who could arrange their part of the financing became cost-share participants. Other farms with lower ratings were accepted in the cost-share program based on their ability to proceed.

CHAPTER 5

URBAN WASTEWATER DISPOSAL

Urban wastewater disposal from septic tank systems and from the Larson Wastewater treatment plant is evaluated in this chapter in terms of impacts on Moses Lake water quality. The evaluation considered local soils and groundwater conditions as well as wastewater disposal practices as related to nutrient enrichment of Moses Lake or its tributary waters. Some new water quality data was gathered in 1985 and 1986 for this evaluation.

The evaluation serves to better define the water quality problems associated with present waste disposal in the urban area as related to Moses Lake itself and local groundwaters. Although potential remedies are discussed, this evaluation is not a facility plan or a comprehensive wastewater management plan.[1] The focus is on problem definition and it is intended to stimulate additional efforts by appropriate wastewater management agencies. Support for this effort and follow-up actions has been received from numerous sources within the community including a professionally conducted opinion poll and letters and resolutions of support from numerous community agencies and groups.

Nitrogen and phosphorus concentrations were obtained from groundwaters and specific waste sources in the urbanized Moses Lake area. this information was gathered and evaluated in order to determine if local on-site sewage disposal practices were affecting the nutrient content of groundwaters that flow into Moses Lake.

Samples from the Larson Sewage Treatment Plant operated by the City of Moses Lake were also analyzed to determine influent and effluent nutrient content as well as other chemical constituents that might be important in considering this effluent for crop irrigation. Data from previous water quality investigations were also evaluated to characterize a nutrient content of Columbia Basin Project agricultural wasteway drainage as well as groundwater in the rural areas of Block 40 and 41 upstream from Moses Lake. Much of the earlier data came from a year long water quality monitoring program conducted in 1984 during Stage 1 of the Moses Lake Clean Lake Project.

Groundwater Monitoring

A special monitoring effort was carried out in order to determine if urban area groundwaters were being affected by local wastewater disposal practices such as percolation of septic tank

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1) Guidance from the DOE in the form of a December 17, 1985 letter concerning the scope of this report is appended to this report for reference.

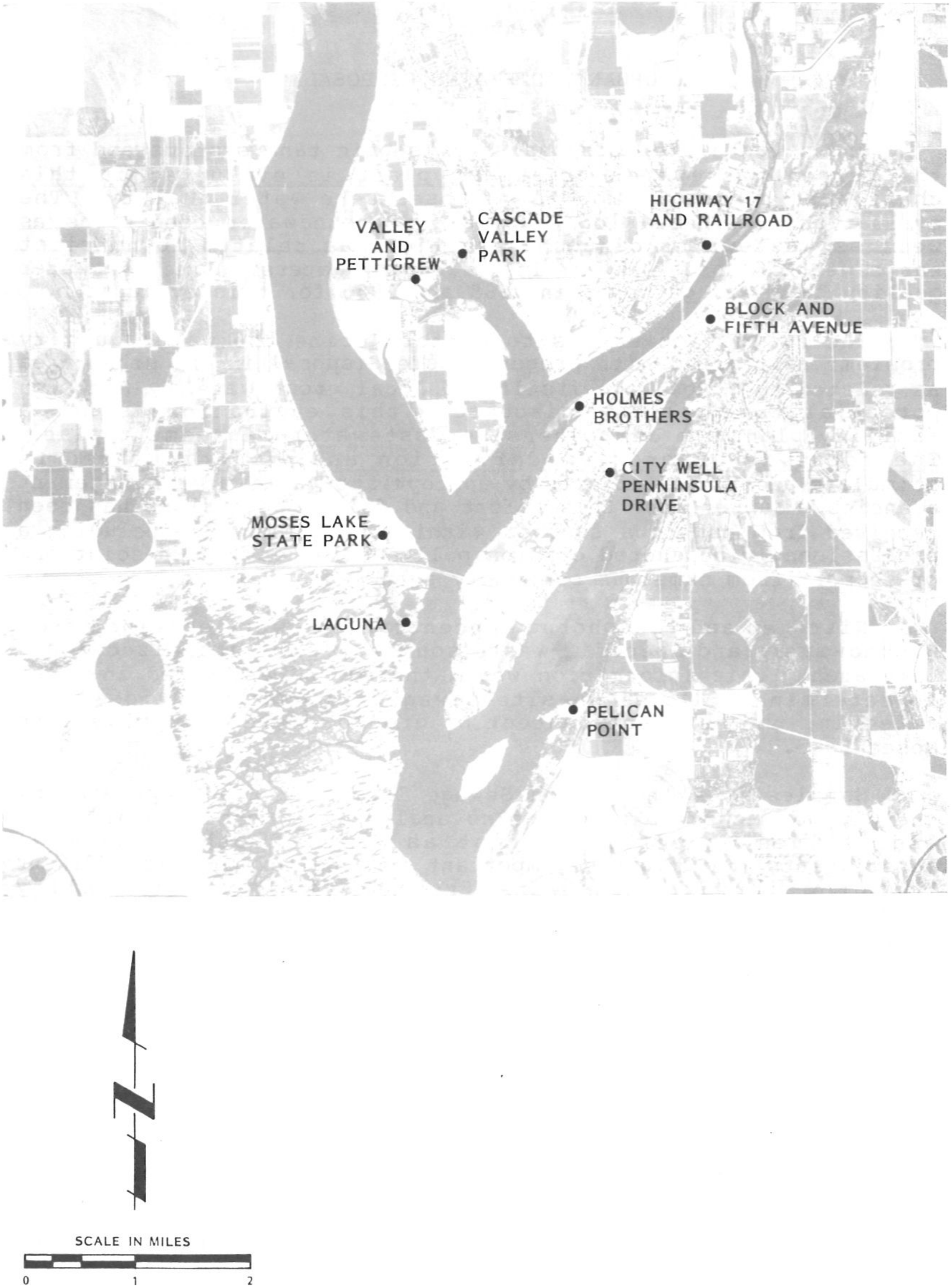

Figure 5-1 Groundwater Monitoring Wells

effluent. Monitoring was conducted in late 1985 and early 1986 by sampling special monitoring wells and various seeps and springs observed in the Moses Lake shoreline area during the period of lake drawdown. Several rural area wells were also sampled to compare results with previous (1984) monitoring programs and for analytical quality control purposes. Laboratory analyses were performed by Laucks Laboratories, a Seattle analytical testing laboratory in business since 1908.

Water quality parameters checked most frequently in the monitoring program included total phosphorus, nitrate-nitrogen, and Methylene Blue Active Substances (MBAS), a test which picks up substances found in laundry detergents. Some of the shoreside seep samples were also analyzed for ammonia-nitrogen. Larson Sewage Treatment Plant influent and effluent samples were also analyzed as part of the monitoring effort. The treatment plant effluent was of particular interest from a nutrient standpoint because this wastewater is discharged to percolation ponds in an area of coarse soils. The Larson sewage influent and effluent also provide perspective on the chemical characteristics of local sewage.

<u>Monitoring Wells</u>. Groundwater monitoring wells were established by the Clean Lake Project in the Moses Lake urban area. These wells were developed in an effort to establish a direct relationship between increased amounts of nutrients in groundwater and high density usage of on-site sewage disposal systems. Ten monitor wells were drilled; however, one was dry and was abandoned. The nine wells actually sampled are shown on Figure 5-1.

Well locations were selected based on the assumption that a nutrient-rich effluent from on-site systems which reached the unconfined groundwater would flow down gradient toward the lake. Accordingly, most well sites were located between the lake shore and heavily populated areas which utilized on-site sewage disposal. See Table 5-1. In one instance a well was located in an area of known high groundwater.

Joy Drilling Company of Moses Lake was employed to drill the test wells. Prior to drilling, property owners were contacted and permission was obtained to develop the test wells. The wells will remain in place indefinitely. A small rotary drilling rig was utilized to drill small diameter test wells approximately 5 to 10 feet below static groundwater level to anticipate lake draw down in winter. The wells were drilled from October 2 through October 16, 1985.

Well screens were obtained by drilling holes in PVC pipe installed in the wells below water level in gravel strata. Where sandy soils were encountered, the well casing itself was slit. The space between the well casing and the bore hole was not sealed. Wells were capped with PVC caps approximately six inches

Table 5-1 Moses Lake Urban Area Monitoring Wells Characteristics and Location Criteria

	Monitoring Well	Depth (ft.)	Dominant Material	Site Selection
1.	Valley and Pettigrew	8	Gravel	Down gradient from older housing development
2.	Cascade Valley Park	14	Sand	Below fairgrounds and Crestview/Hillcrest housing areas
3.	Highway 17 & Railroad	9	Boulders	Below Longview Tracts and commercial complex
4.	Block and Fifth Ave.	10	Clay & Rock	High groundwater area
5.	Holmes Bros.	10	Boulders	Down gradient from major commercial area
6.	Lower Penninsula (School Property)	54[a]	Clay, Sand & Rock	Near unsewered residential area
7.	Pelican Point	11	Sand & Cobbles	Below observed seepage from hillside near subdivision
8.	Laguna	15	Sand	Within Laguna Subdivision
9.	Moses Lake State Park	15	Sand	Near State Park sewage lagoon and subdivision
10.	Penninsula & Pheasant (city well site)	52	Clay, Sand & Rock	Near unsewered industrial area

[a] Dry hole, monitoring well abandoned

underground and buried to prevent tampering or vandalism. Well heads are located by distances and direction from permanent reference points. Each well head is surrounded by four metal locator pins each 2 feet from the head at 0°, 90°, 180°, and 270° from magnetic north.

Groundwater Sampling Program. The first series of water samples were taken on October 15, 1985. One well was not completed, and subsequently, not sampled. Samples were obtained by uncovering the well head and removing the well cap. A sample collection device was lowered into the well and water was collected. The device was rinsed twice prior to obtaining a sample. The static water level was measured with a well probe. Total depth was measured with the water sampling collection device. After sampling, the wells were recapped and recovered. On January 22 and 23, 1986, a second set of samples was obtained for analysis; on April 16, 1986 a third set of samples was obtained. The collection routine was the same as described above.

Table 5-2 Static Water Levels in Urban Area Monitoring Wells

MONITORING WELL NUMBER	LOCATION	STATIC WATER DEPTH[a] (INCHES) 10/15/85	1/22/86	4/15/86	DIFFERENCE (INCHES) Fall Drop	Spring Rise
1	Valley & Pettigrew	40	71	45	-31	+26
2	Cascade Valley Park	99	126	107	-27	+19
3	Highway 17 & RR	40	87	62	--	+25
4	Block & Fifth	5	5	9	0	+ 4
5	Holmes Bros.	79	106	79	-27	+27
6	Lower Penninsula	Dry	Dry	--	N/A	N/A
7	Pelican Point	67	72	78	- 5	+ 6
8	Laguna	64	92	65	-28	+27
9	Moses Lake State Park	68	60	15	+ 8	+45
10	Penninsula & Pheasant	N/A	123	104	N/A	+19

[a] Static water level in inches as measured from the top of the well casing.

Moses Lake Water Surface Elevation	Differences
October 15, 1986 = 1046.76 feet	Fall Drop = 2.46 feet (approx. 30 inches)
January 22, 1986 = 1044.30 feet	
April 15, 1986 = 1046.56 feet	Spring Rise = 2.26 feet (approx. 27 inches)

Table 5-2 shows depth to groundwater in the test wells as measured in October, January and April. Static water levels in the lake were markedly different in these two periods as Moses Lake is lowered approximately 3 feet to accommodate 1985 winter maintenance of docks and other waterfront structures. Between October and January 1986, water levels dropped approximately the same amount as the lake level was lowered in four of the wells. The Block and Fifth remained the same, which was expected, as this is an area with very high groundwater associated with springs and seepage in the nearby industrial area. The raising of the lake level in early spring showed a similar response in half of the monitoring wells.

The Pelican Point well level dropped very little which can be explained partially by the fact spring and underground water flow through the area year around as noted by hillside seeps. At the Moses Lake State Park site, the static water level increased slightly which may be due to water recharge from rain and runoff during wet months. The U. S. Bureau of Reclamation has established that groundwater in the general area fluctuates with the Potholes Reservoir. However, where monitoring wells are close to the lake, it is assumed groundwater is flowing down gradient or toward the lake. This was substantiated during the winter freeze when groundwater could be observed trickling from lakeshores into the lake.

Groundwater Sampling Results. Results from the monitor well water sampling reveal increased levels of phosphorus many times greater than background levels from wells and springs in rural areas of the Crab Creek or Rocky Ford Creek drainages. These results are illustrated graphically in Figure 5-2 which compares some of the urban area wells with groundwater quality in the rural area. Phosphorus content of sewage effluent from the Larson Treatment Plant is also illustrated in Figure 5-2 for reference.

As shown in previous reports published as part of the Moses Lake Clean Lake Project, Rocky Ford Creek springs carry relatively high phosphorus concentrations compared with Crab Creek area wells.[a,b] During a year-long monitoring program in 1984, the springs which feed Rocky Ford Creek averaged 0.1 mg/l soluble phosphorus and frequently reached 0.15 to 0.20 mg/l as total phosphorus, whereas Crab Creek area wells and springs were more frequently around 0.05 mg/l as soluble phosphorus and were generally below 0.10 mg/l as total phosphorus. Similar values

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(a Moses Lake Clean Lake Project, Stage 1 Report, Brown and Caldwell with Dr. R. Horner of the University of Washington Department of Civil Engineering, March 1984.

(b Moses Lake Clean Lake Project, Stage 2 Report, Richard C. Bain, Jr. with Moses Lake Conservation District, March 1985.

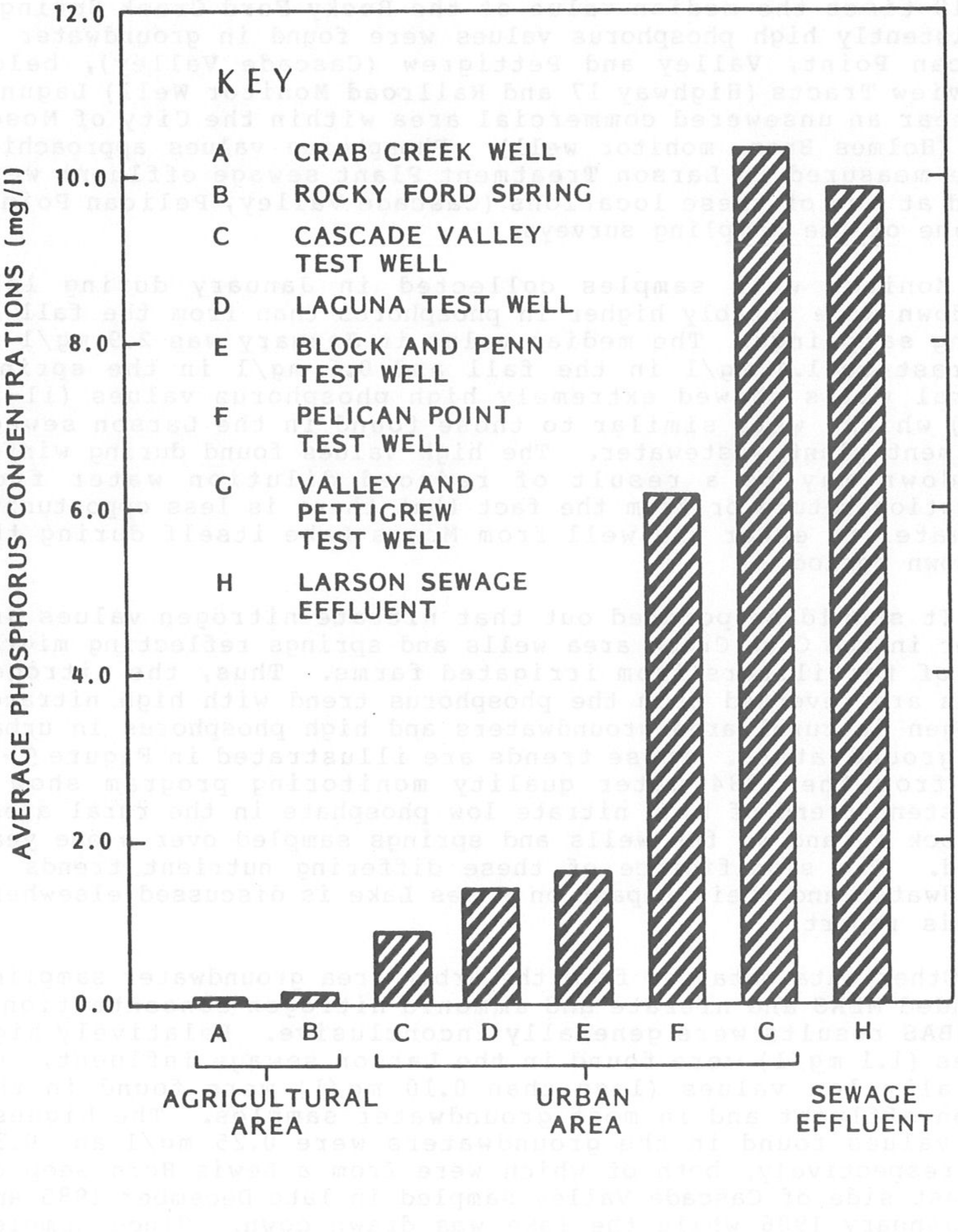

Figure 5-2: Phosphorus Content of Selected Urban Area Wells Compared with Rural Groundwater and Sewage

were recorded for other rural wells in the Moses Lake area during the 1985 sampling program. In contrast, the monitoring wells in the urban area ranged from 10 to 100 times the total phosphorus content found in the rural area wells and springs. The median phosphorus value in the urban area wells was 1.50 mg/l which is approximately 20 times the median values found in Crab Creek area and 10 times the median value of the Rocky Ford Creek Springs. Consistently high phosphorus values were found in groundwater at Pelican Point, Valley and Pettigrew (Cascade Valley), below Longview Tracts (Highway 17 and Railroad Monitor Well) Laguna, and near an unsewered commercial area within the City of Moses Lake (Holmes Bros. monitor well). Phosphorus values approaching those measured in Larson Treatment Plant sewage effluent were found at two of these locations (Cascade Valley, Pelican Point) in some of the sampling surveys.

Monitor well samples collected in January during lake drawdown were notably higher in phosphorus than from the fall or spring samplings. The median value in January was 2.9 mg/l in contrast to 1.4 mg/l in the fall and 0.6 mg/l in the spring. Several wells showed extremely high phosphorus values (11-17 mg/l) which were similar to those found in the Larson sewage treatment plant wastewater. The high values found during winter drawdown may be a result of reduced dilution water from irrigation return or from the fact that there is less opportunity for water to enter the well from Moses Lake itself during the drawdown period.

It should be pointed out that nitrate nitrogen values are higher in the Crab Creek area wells and springs reflecting migration of fertilizers from irrigated farms. Thus, the nitrogen trends are reversed from the phosphorus trend with high nitrate-nitrogen in rural area groundwaters and high phosphorus in urban area groundwaters. These trends are illustrated in Figure 5-3. Data from the 1984 water quality monitoring program show a consistent trend of high nitrate low phosphate in the rural areas of Block 40 and 41 for wells and springs sampled over a one year period. The significance of these differing nutrient trends in groundwater and their impact on Moses Lake is discussed elsewhere in this report.

Other data obtained from the urban area groundwater sampling included MBAS and nitrate and ammonia nitrogen concentrations. The MBAS results were generally inconclusive. Relatively high values (1.1 mg/l) were found in the Larson sewage influent, but generally low values (less than 0.10 mg/l) were found in the Larson effluent and in most groundwater samples. The highest MBAS values found in the groundwaters were 0.25 mg/l and 0.30 mg/l respectively, both of which were from a Lewis Horn seep on the east side of Cascade Valley sampled in late December 1985 and late January 1986 while the lake was drawn down. Since samples from this location were consistently high, a local detergent source is probable. Other MBAS samples were generally less than 0.10 mg/l and no conclusions should be drawn from these due to the insensitivity of this test at such low concentrations.

Nitrogen concentrations were measured primarily as a check on previous (1984) work and to compare rural area wells' nutrient patterns with those in the urban area. Examples of the rural and urban patterns are illustrated in Figure 5-3 for several representative sampling locations. As shown in the Figure and indicated above, the rural area groundwaters generally have elevated nitrates and low phosphates, whereas the urban area wells show a reverse pattern. The rural area wells checked included shallow domestic wells in Mae Valley, Cascade Valley and lower Crab Creek, and all showed the relatively high nitrate, low phosphate pattern observed in previous studies. This also served to corroborate the laboratory work since similar patterns and concentrations were found by the testing laboratory (Laucks) and by the 1984 monitoring survey conducted and analyzed by the University of Washington.

Ammonia nitrogen was not analyzed as frequently as nitrate, but was checked occasionally at selected wells and seeps. Ammonia levels in area groundwater were low (less than 0.1 mg/l) as compared with the more stable and soluble nitrate form.

Nutrients in Moses Lake Area Wastewaters

Nitrogen and phosphorus, the primary nutrients of concern to Moses Lake water quality are found in wastewaters discharged from both urban and rural sources. The primary urban sources of concern in the Moses Lake area include sewage treatment plant effluent and percolating leachate from septic tank systems. As discussed in Chapter 2, the Moses Lake urban area includes approximately 20,000 people, of which about 12,000 are housed in areas that are connected to municipal sewers. The balance are on septic tank systems, including approximately 1500 people within the city of Moses Lake itself. The City of Moses Lake treatment plant serves most of the city's residents; the city treatment plant discharges to a sand dune area south and east of Moses Lake. However, approximately 4,000 of the sewered population are county residents whose homes are connected to the Larson Treatment Plant which discharges its effluent to groundwater via percolation beds. Thus, over half of the urban population contributes wastewater effluent to groundwaters which eventually flow to Moses Lake. Nutrient movement in the area's groundwaters is well-documented. As in other areas, the soluble nitrates move freely with underground flows. However, phosphates which are usually retained on finer soil particles also move through the coarse Ephrata Malaga soils.

The human body excretes about one pound of phosphorus per year. The use of phosphate detergents and other domestic phosphates increases the per capita contribution to about 3-3½ pounds per year of phosphorus. Phosphorus is relatively abundant in sewage. Effluent from the Larson Treatment Plant contained an average of 8.9 mg/l total phosphorus based on samples taken in

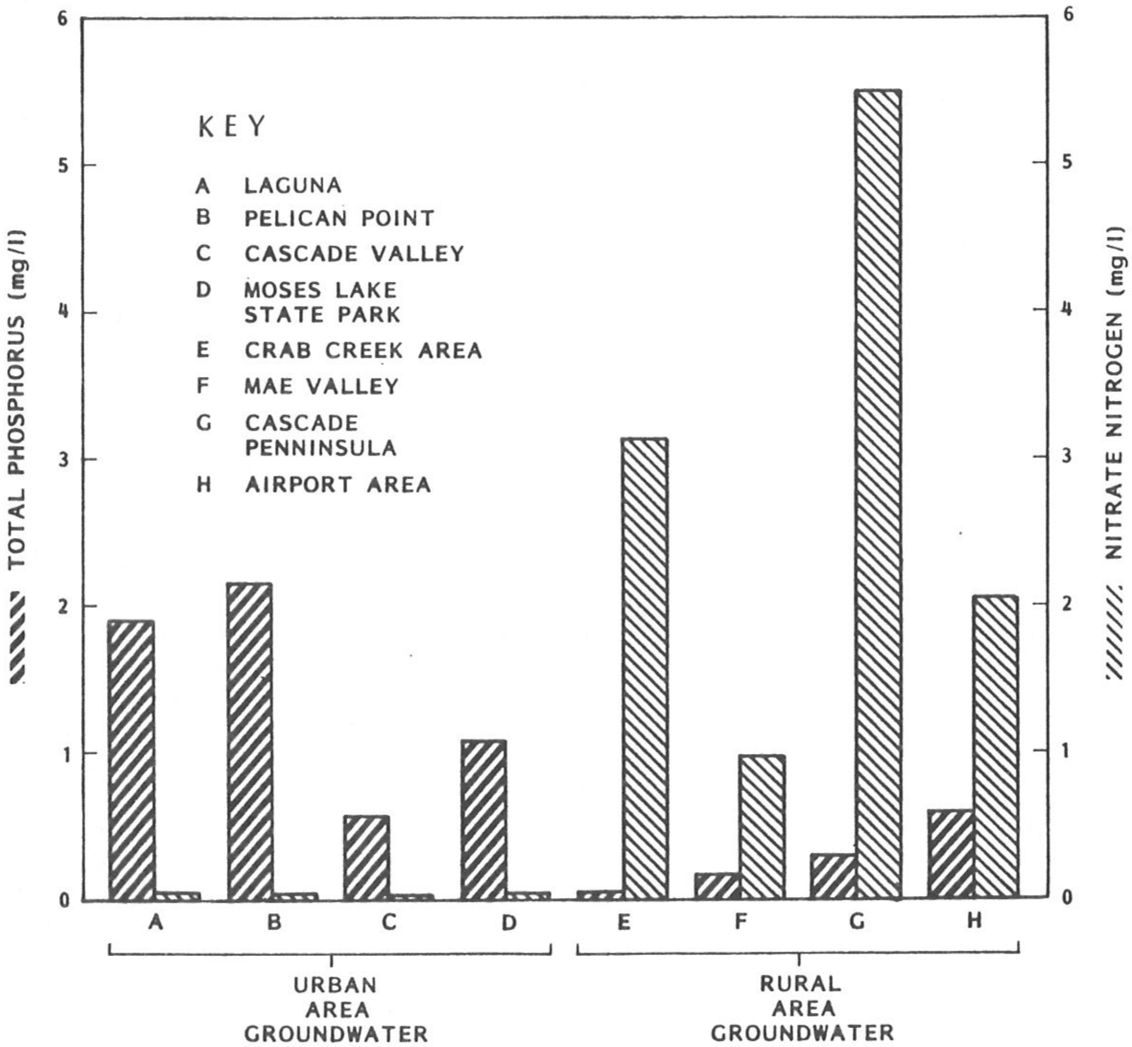

Figure 5-3: Comparison of Urban and Rural Area Groundwater Nutrient Patterns, October 1985

October and December 1985. Influent phosphorus was higher (16 mg/l); however, some phosphorus is utilized by microorganisms, including algae, in the treatment plant's aerated ponds and is settled out as a sludge in the settling ponds prior to discharge. Total nitrogen levels in the Larson effluent as measured in December were approximately 42 mg/l for a N:P ratio of approximately 5:1; however, nitrate values are barely detectable.

In contrast, although wastewaters from irrigated agriculture have lower nutrient concentrations, they contain relatively more nitrogen than phosphorus. Wasteways sampled in the Moses Lake area contain nitrate concentations that are frequently 15 to 40 times higher than their total phosphate phosphorus value. For example, Rocky Coulee Wasteway nitrate nitrogen was typically about 3 mg/l during January-February 1984 when no canal water was discharged into this drain. Total phosphate phosphorus ranged from 0.10 to 0.23 mg/l during this same period for an N:P ratio of 13 to 30. Samples from Winchester Wasteway taken in March 1986 contained 0.11 total phosphate phosphorus and 3.5 mg/l nitrate nitrogen for a N:P ratio of 32. Thus the ratio of nitrogen to phosphorus may be useful as a way to differentiate sources affecting local groundwater quality.

Dominant nitrogen forms vary between sewage sources and agricultural drainage. Nitrogen in sewage is predominantly in the organic or ammonia form unless the wastewater has undergone extensive nitrification. Even though the Larson Treatment Plant employs large aerated ponds to oxidize the influent wastewater, the nitrate content of the percolated effluent is barely detectable.

In contrast, nitrogen found in percolating water under irrigated agricultural lands contains high quantities of nitrates and surface drains characteristically have significant concentrations of nitrates. Thus, wells in rural areas near irrigated uplands would be expected to have significant concentrations of nitrates, whereas groundwaters near septic tank discharges may not always yield nitrogen in the nitrate form unless nitrification is occurring in the soil. Nitrification does occur in the aerated zones of soils near the ground surface; however, most septic tank discharges are in trenches two to three feet deep, and the water containing the unoxidized nitrogen is already devoid of oxygen (septic) which inhibits bacterial forms necessary to convert ammonia to nitrite and then to nitrate. Where unsaturated soils and aerobic conditions exist below septic tank drainfields, there is opportunity for nitrification to occur; however, its rate is retarded in soils with increased moisture (reduced aeration) and under decreased temperature and pH. Thus, nitrogen is more likely to be highly mobile as soluble nitrate under a well-drained agricultural area than below a septic system leach field.

Phosphorus applied to soils within the root zone of crops is more likely to be utilized by the crops or sorbed to the finer soil particles which are found in the surface layer. Thus, phosphorus is a more likely pollutant from a Moses Lake area septic tank system, because sub-soils are very coarse and have little or no ability to sorb phosphorus. High concentrations of total phosphate found in the urban area monitoring wells demonstrate this point. These considerations explain the different nutrient patterns for rural and urban areas shown in Figure 5-3.

On-Site Wastewater Disposal Problems

Problems associated with on-site wastewater in the urban area around Moses Lake encompass a variety of factors. Water quality issues are of paramount concern; however, solutions to the water quality related problems bring on a host of other issues which must be resolved before increased water quality protection can be assured. First and foremost there must be a consensus on the existence of water quality problems. Otherwise, consideration of solutions only leads to greater debate since such solutions are often costly. This report documents the problem, and should be the basis for building a consensus.

Water quality related problems and related concerns associated with potential solutions are listed below for consideration. Additional comment on potential solutions is also provided in this chapter to stimulate discussion among implementing agencies and others concerned with the Moses Lake area. The following list begins with water quality problem statements and continues with issues associated with regulations, financing and institutional roles.

1. Groundwater Quality. Elevated phosphorus values in shallow groundwaters around Moses Lake are indicative of sewage contamination from nearby septic tank areas.

2. Moses Lake Water Quality. Groundwater is an important nutrient source contributing to the over-fertilization of Moses Lake. Local monitoring wells with high phosphorus concentrations are hydrostatically connected to Moses Lake.

3. Environmental Constraints. Local soils and groundwater levels in many areas near Moses Lake are unsuitable for septic tank systems either because subsoils are too coarse or seasonal groundwaters are too high, or both.

4. Population Density. Certain unsewered areas of Grant County around Moses Lake exceed housing densities allowed by Washington State laws for on-site sewage disposal systems even for most optimum soils. There are several densely populated areas within the City of Moses Lake which are served by on-site systems where sewers are not currently available.

5. Local Ordinances. Ordinances covering on-site sewage disposal in Grant County are designed to protect public health

and are not oriented to nutrient control. City of Moses Lake ordinances have been recently strengthened to enforce hookup where sewers are available.

6. Sewerage Operations. Grant County does not currently operate sewerage facilities; those areas of Grant County near Moses Lake which have sewers are served by special arrangement with the City of Moses Lake. This includes the Larson treatment plant which discharges effluent to groundwater. See later section of this chapter for further evaluation of the Larson situation.

7. Comprehensive Wastewater Planning. Although a general county comprehensive plan exists, no detailed evaluation of wastewater management needs for the greater Moses Lake area has been conducted since 1970. Considerable population growth has occurred in the past 15 years, especially in unincorporated areas near the City of Moses Lake.

8. Financial Issues. Opportunities for federal funding support are diminishing; however, recent state legislation may offer incentives for accelerating local sewerage planning and construction projects. Local sewerage needs should be identified and prioritized to enhance local opportunities for state grants.

9. Political Consensus. Although local agencies and organizations have actively supported water quality control activities and most encourage development of a comprehensive wastewater management plan, there is still some debate over the need, scope and organizational aspects for such an endeavor.

10. Development Confusion. Urbanization of Moses Lake continues. Developments in unincorporated areas are experiencing typical urban problems. Increasing protests affecting real estate plat approvals and proposal changes in rules for on-site sewage disposal are causing confusion and resentment among affected developers, homeowners and public agencies.

Problems identified in the foregoing list cover a wide variety of topics ranging from technical and scientific findings concerning water quality and environmental constraints to local planning and ordinance requirements to broader economic and social questions. The technical issues of water quality, soil and groundwater constraints and existing demographic patterns of population density are described in Chapter 2. Problems associated with on-site sewage regulations and comprehensive planning needs as well as some of the broader issues of public financing are described in this chapter.

On-Site Sewage Disposal Regulations. The State of Washington Department of Social and Health Services (DSHS) has adopted rules and regulations for on-site sewage disposal systems. These rules were established as minimum requirements for the State. Local agencies may adopt more stringent rules. Grant County, through the Health District, has adopted conforming requirements by referencing the published State Rules and Regulations for On-Site Sewage Disposal System.

The State regulation includes two methods to determine minimum gross land area (e.g., lot size) requirement for each single family housing unit. Method 1 provides for specific lot sizes depending on soil type and whether water supply is public or private. Where individual water supplies (e.g., domestic wells) are involved, the minimum lot ranges from one to two acres with the lower size lots allowed on more optimum soils (medium or fine sand, sandy loam or loam). In the case of public water systems, lot sizes may be as low as 12,500 square feet (3.5 units per acre) if medium sand is available for leach field disposal on site. Where soils are coarse (coarse sand or coarser) lot sizes should be no smaller than one acre, even with a public water supply. Moses Lake area soils are coarse and subsoils are often gravel. See Chapter 2. Method 2 allows for site specific evaluations of soils, drainage, topography, groundwater, land use and other factors in a report which is then reviewed by local health authorities. Although method 2 contains reference to a minimum gross land area of 3.5 units per acre, there are allowances for reduced areas below the one acre requirement for the coarse (Class 1) soils. Alternative systems with equivalent treatment to mounds or sand filters are described; however, the State recognizes guidelines for these systems are not published. Accordingly, the gross land area per residence is still limited to no less than one-half acre (e.g., 2.0 units per acre). As pointed out in Chapter 2, there are developed subdivisions on septic tank systems in the Moses Lake area which far exceed this density.

The Grant County Commissioners have recognized more stringent regulations are necessary and have provided recent guidance to encourage for improved on-site systems as well as for future sewering of developments. The Commissioner established the following policy on April 28, 1986:

> "Where there is development along shorelines of the County's lakes and streams, septic tank drainfields shall be located near roads so that the future incorporation of a sewer system is feasible."
>
> "Pressurized septic tank systems will be required, based on the Grant County Health District evaluation of the system related to the water surface level."

The State regulations also deal with connections to public sewer systems. The minimum state standard states that connections of existing dwellings with failing on-site sewage systems shall be made to a public sewer system where there are adequate public sewers within 200 feet of the dwelling unless the health officer approves a replacement on-site sewage system. Until recently, a City of Moses Lake ordinance allowed property owners to continue using on-site systems even though the sewer was within 150 feet. In addition, the City has taken other steps to tighten up sewage disposal requirements affecting both existing buildings and new construction.

Groundwater Monitoring Well in Cascade Valley (Valley and Pettigrew)

Densely developed area on septic tank systems north of City of Moses Lake

Mobile home park connected to Larson Sewer System

In October 1985 the city amended Section 13.04.150 of its ordinance which stated:

> "The owner of all houses, buildings, or properties used for human occupancy, employment, recreation or other purpose, situated within the city and abutting on any street, alley, or right-of-way in which there is now located or may in the future be located a public sanitary or combined sewer of the city, is required at his expense to install suitable toilet facilities therein and to connect such facilities directly with the property public sewer in accordance with the provisions of this chapter, within 90 days after date of official notice to do so; provided, that the public sewer is within 150 feet of the property line."

This section which has been in existence from at least 1978 has never been enforced. This policy has allowed property owners to continue to utilize on-site sewage systems even though the sewer is within the 150 foot distance. In some instances the sewer abuts the property line. The lower Peninsula area of the city is an example of this; sewers were extended to serve this area several years ago, however, it is estimated only 10 - 15% of the dwellings are actually hooked up to the city system.

The city's amendment (Ordinance 1187) replacing the foregoing language read:

> <u>Installation and Connection to toilet facilities with Sewer</u>: The owner of all houses, buildings, or properties used for human occupancy, employment, recreation, or other purpose, situated within the city and abutting on any street or alley in which there is constructed and now located or within 200 feet of any street or alley in which there is constructed and now located a public sanitary or combined sewer of the city, is required at his expense to install suitable toilet facilities therein and to connect such facilities directly with the public sewer in accordance with the provisions of this chapter and as permitted by RCW 35.24.240 (a) as now in effect or herein after amended, within six months after the date of official notice to do so.

This section was changed because the Revised Code of Washington, quoted above, states; "the city shall have the power to compel all property owners within 200 feet of sewers to connect to such sewer." Thus, the city has now amended this portion of the city code to be in compliance with the more stringent state code.

There is a concern of how to implement this requirement. There are a number of low income persons who state they cannot afford to comply. The city is in the process of developing a plan to deal with this. The city may need to assess expenses of such a project against the property in the form of a lien and acquire working capital to make such a connection when property owners will not voluntarily comply. The city council is expected to discuss this issue in the near future.

In October 1985, the Moses Lake City Council also amended the Moses Lake Municipal Code to regulate new construction. Prior to this action the city code stated:

> "private sewer systems, septic tanks, and on-site sewage disposal systems may be allowed with the approval of the city for the use of buildings to be constructed or subdivisions located more than 300 feet from a public sewer."

The city council revised this section to read:

> "Private Systems: Private sewer systems, septic tanks and on-site sewage disposal systems are prohibited."

In actuality, this change prohibits any new plats, or new buildings to be developed or constructed within the City of Moses Lake without being connected to the city sewer system. Such a requirement will most certainly facilitate the development of sewer extensions into the developing areas of the city which are presently utilizing on-site sewage disposal systems.

Larson Treatment Plant Effluent Disposal

The City of Moses Lake operates the Larson Sewage Treatment Plant which serves an unincorporated area north of the city which once housed personnel when the Larson Air Force Base was active. The Larson service area currently includes all of the original Base housing, the Port of Moses Lake (Grant County Airport), Big Bend Community College as well as additional housing areas and mobile home parks which have been connected to this system. Approximately 4,000 people are currently served by this facility.

The Larson Treatment Plant was constructed in 1973, replacing older facilities built for the Air Base. The Larson Plant provides secondary treatment which oxidizes the wastewater and provides effective solids removal. Influent wastewater is communuted and discharged to two aerated lagoons which are followed by two sedimentation basins. A large (50 hp) blower agitates the wastewater in the aerated ponds to provide oxygen for the treatment process. Standby blower capacity is available if required. The plant is designed for 0.6 million gallons per day (mgd). Wastewater is retained in the treatment basins for approximately 17 days at design flow. Present wastewater flows are approximately 330,000 gallons per day and yielding over 30 days detention. Prolonged detention reduces coliform bacterial densities. Coliform bacteria are an indication of contamination from humans and other warm blooded animals. The open ponds and long detention also accommodate growth of green algae.

Effluent is finally discharged to one of three leaching ponds which allow the wastewater to percolate into the underlying soils. The treatment ponds themselves are lined with 20 mil PVC so all wastewater receives secondary treatment and prolonged detention prior to disposal by percolation.

Soils in the vicinty of the Larson Treatment Plant are Malaga stony sandy loam and Malaga cobbly sandy loam. Both are very deep soils formed in glacial outwash on terraces. Permeability is very rapid through the soil substratum. Risk of contamination of groundwater from seepage from septic tank absorption fields is considered high according to the Soil Conservation Service Soil Survey of Grant County.

Larson Treatment Plant Effluent Quality. Secondary treatment is the method commonly employed to remove pollutants from municipal sewage which would otherwise pollute surface waters. The pollutants addressed by secondary treatment processes include suspended solids, biochemical oxygen demand (BOD) and bacterial contaminants (as measured by total or fecal coliform bacteria). The EPA definition of secondary treatment refers to these pollutants and calls for at least 85 percent removal of suspended solids and BOD. Disinfection for bacterial contaminant removal is usually accomplished by disinfection or by long term retention in ponds.

Groundwaters are less susceptible to pollution from particulate contaminants (e.g., suspended solids) or BOD since soils filter out solids and there is usually little or no oxygen in groundwater. However soluble pollutants are of concern. One of the most common pollutants affecting groundwater quality is nitrate, a soluble form of nitrogen. Nitrates are generally not present in high concentrations in municipal sewage, however, as wastewater oxidizes, the nitrogen bound in organic or ammonia forms convert to nitrate. This may occur in a treatment plant if prolonged oxidization occurs or in receiving waters or in aerobic layers of soil. The Larson plant discharge contains substantial organic nitrogen because of algae growth in the treatment ponds.

Phosphorus is abundant in municipal sewage as discussed in previous chapters. Although phosphorus usually has an affinity for soil and does not migrate in groundwater, the coarse soils of the Moses Lake area do not bind phosphorus very well. As a consequence, phosphorus is found in local groundwaters as discussed earlier.

Both nitrogen and phosphorus are nutrients of concern in the Moses Lake area as these fertilizing elements contribute to the entrophication of Moses Lake. Groundwaters entering Moses Lake are an important source of both of these nutrients. Groundwater gradients as determined by the U.S. Geological Survey show that local groundwater movement is toward Moses Lake. Thus, effluent from the Larson Treatment Plant is a potential contributor of nutrients to the lake since the wastewater effluent is percolated into coarse local soils.

Samples of Larson Treatment Plant effluent were obtained in October and December 1985 to determine nutrient content as well as other effluent characteristics. The nitrogen content of the effluent was 42 mg/l and the phosphorus content averaged 8.9 mg/l for the two dates sampled. Virtually all of the nitrogen was in the ammonia or organic form. Other wastewater characteristics measured included MBAS (Metylene Blue Active Substances), boron, selenium and specific conductance.

MBAS, a measure of detergents, was measured in both influent and effluent to determine levels in sewage for the purpose of comparison with septic tank monitoring results discussed in Chapter 3. The influent wastewater contained 1.1 mg/l whereas the effluent was much lower (0.02-0.08 mg/l). The treatment plant clearly is effective in breaking down the detergent substances although detergent-like foam is still present at points of turbulence following the sedimentation ponds.

Boron, selenium and electrical conductivity values were obtained for subsequent use if effluent were to be used for irrigation on agricultural crops. Boron was measured at 0.46 mg/l. Boron should not exceed 0.75 mg/l for long term use on sensitive citrus crops and is tolerated on most crops at levels as high as 2.0 mg/l, on neutral or alkaline soils. Selenium was not detectable (less than 0.005 mg/l). Electrical conductivity was 720 micromhos (25°C) which is equivalent to a total dissolved solids value of approximately 500 mg/l. Detrimental effects are not usually associated with use of waters containing this level of dissolved solids for irrigation, even for sensitive crops.

<u>Potential Larson Treatment Effluent Impacts</u>. Effluent from the Larson Treatment Plant represents a potential nutrient loading to Moses Lake of approximately 10,000 pounds of phosphorus per year. This loading is derived from several different calculations and is based on the assumption that phosphorus discharged to the percolation basin will reach underlying groundwaters and eventually reach Moses Lake. As discussed earlier, the coarse glacial outwash soils underlying the percolation area are very porous and there is little or no permanent phosphorus retention expected on these coarse soils.

The annual loading can be computed using the average effluent discharge rate (a typical value of 0.33 mgd was used). Actual wastewater flow values ranged from 0.280 to 0.366 mgd in 1984. Using 8.9 mg/l total phosphorus, the loading based on effluent characteristics is 8940 pounds. A per capita estimate was used to check the reasonableness of the loading figure using a figure of 3.5 pounds of phosphorus per year as typical of contributions in wastewater including detergent use.[a]

Assuming 4,000 people on the Larson system, an annual loading figure of 14,000 pounds is computed for the influent wastewater. Since a portion of this load would be removed by the plant as sludge, the loading estimate based on effluent flow and quality appears reasonable. Based on the coarse nature of the soils, no retention of phosphorus is assumed; however, this worst case assumption could be evaluated by the city.

Total phosphorus loadings to Moses Lake were estimated to be 102,894 pounds based on monitoring work carried out in 1982-83. This figure includes 17,556 pounds which were attributed to the City of Moses Lake sewage treatment plant discharge into Pelican Horn which has since been eliminated. The adjusted annual estimate for total phosphorus loading to the lake would be approximately 85,000; however, the actual loading is probably somewhat higher due to population growth and earlier over-optimistic assumptions regarding phosphorus retention on soils. Thus an annual value of about 90,000 pounds appears reasonable. On this basis the Larson Treatment Plant discharge is contributing 10 percent of the annual phosphorus load to the lake, assuming little or no phosphorus retention on coarse soils and lakeward groundwater movement as discussed above.

Larson Sewage Treatment Plant Alternatives

Four fundamentally different scenarios have been identified for the Larson Treatment plant. Three of these address the groundwater nutrient issue described earlier. The fourth is a no-action alternative. The fundamental scenarios are listed below.

Scenario A - Seasonal Effluent Irrigation. Effluent disposal to land using crop irrigation techniques on nearby land with reliance on percolation beds in non irrigation season.

Scenario B - Wastewater Diversion to Main City Plant. Treated effluent or raw sewage could be diverted to the city treatment plant for disposal in the sand dunes area south and east of Moses Lake.

Scenario C - Nutrient Removal with Effluent Percolation or Reuse. Effluent from the Larson plant could receive further treatment to remove nitrogen and phosphorus with discharge to the existing percolation beds or use for industrial use such as cooling water.

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[a] Water Quality Criteria for Water, U.S. Environmental Protection Agency, July 1976.

Scenario D - Percolation of Secondary Effluent. (No Action) Continuation of the present practice of secondary treated effluent disposal to groundwater remains an option at this time.

Each of the three action-oriented scenarios can involve many alternative configurations. Scenario A (Seasonal Effluent Irrigation) could be oriented to irrigation on city-owned land, Port of Moses Lake land or on a neighboring farm. Scenario B (Wastewater Diversion to City Main Plant), may take any one of several forms ranging from effluent transfer via force main to the sand dunes to various gravity sewer alignments to convey raw sewage to the new city treatment plant. Scenario C (Nutrient Removal) may involve any of several processes for reducing the nitrogen and phosphorus content of the effluent. Separate discussions are offered for each of these scenarios which identify alternative facility arrangements for subsequent evaluation. A preliminary evaluation is offered which provides a basis for narrowing the field of potentially feasible alternatives. Ultimately the choice remains with the City of Moses Lake and appropriate regulatory agencies.

Seasonal Effluent Irrigation. Seasonal effluent irrigation was considered as a possibility on municipal land near the Larson plant on nearby farm land and as a water source for Big Bend College, which needs water for irrigating lawns and athletic fields as well as for a community gardens concept demonstration being considered by the college. The Port and the Grant County Housing Authority also have need for water. Use of wastewater effluent for uses having potential for direct human contact were not pursued since these clearly have more liability risk than other available choices. If such solutions are to be evaluated further, the sewage disinfections accomplished at the Larson plant will need to be carefully evaluated and public health agencies will need to be involved.

Two alternatives have been developed under the effluent irrigation scenario. See Figure 5-4. These differ only in the location of irrigation equipment as shown in Figure 5-4. Storage, miscellaneous piping and pumping facilities are provided on city-owned land for either alternative. The two alternatives are described below:

Alternative A-1 Effluent Irrigation on Public Land
Treated effluent is pumped from a holding pond on city land to property owned or controlled by the Port of Moses Lake north and east of the Larson plant, using a solid set irrigation system on pasture land.

Alternative A-2 Effluent Irrigation on Private Land
Treated effluent is pumped from a holding pond on City land to an adjacent farm wherin effluent is mixed with US Bureau of Reclamation Columbia Basin Project water and applied to alfalfa through a sprinkler system.

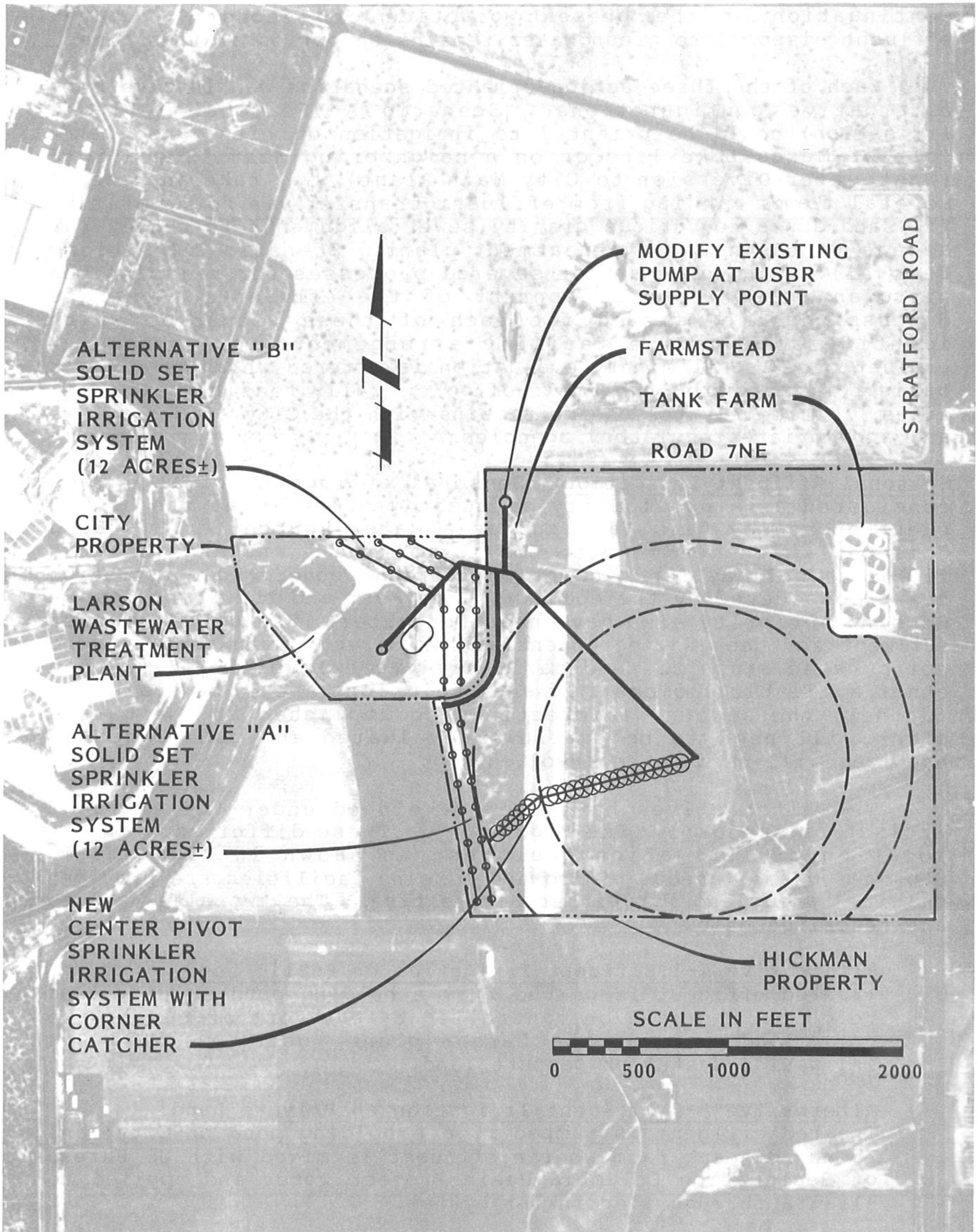


Figure 5-4 Seasonal Effluent Irrigation Alternative, Larson Wastewater Treatment Plant

The solid set system envisioned in Alternative A-1 was taken through preliminary design for cost estimating purposes. Approximately 2400 feet of 4 inch (125 psi) irrigation supply pipe and two sizes of solid set piping (2 inch and 3 inch diameter) involving a total of 6500 feet were required along with 224 risers with sprinklers. This system was estimated to cost approximately $22,000 for the irrigation supply piping and solid set sprinkler system. Estimated storage costs for this system were $30,000 for earth work and a 30 mil PVC liner for a pond on city property.

Alternative A-2 involving an adjacent farm has been considered in more detail. Discussions were held with the farmer, Tom Hickman, and layout details such as valving pressure guages and piping arrangements were worked out for the effluent tie in to the irrigation supply. The design envisioned irrigation on 102 acres of alfalfa with the Larson effluent allowing the farmer to use less Columbia Basin Project water. Storage (3 days minimum) was necessary to even out flow to the farm and to allow the farmer to pump a constant flow of about 200 gpm to a center pivot sprinkler system. Estimated costs for the irrigation system improvements including pumping, pipelines, valving and related pressure controls were approximately $9,000. As with Alternative A-1, storage pond with liner located on city property was estimated at approximately $30,000. This brought the total for Alternative A-2 to $39,000.

Alternative A-2 was the least cost alternative; however, liability concerns arising from potential implications of crop contamination by use of sewage effluent on the alfalfa crop were raised. Since neither of the seasonal effluent irrigation alternatives provide for year-round nutrient control, this approach is discouraged in favor of more permanent year-round solutions.

Wastewater Diversion to Main City Plant. Removal of the Larson wastewater could be accomplished by transferring the sewage to the main treatment plant which serves the City of Moses Lake. This would involve hooking the Larson sewer system to the city system and making appropriate piping and pumping station improvements to accommodate the Larson flows. There is adequate capacity at the new city plant to accommodate the Larson flows.

Details of pipeline routes and various sewerage system corrections necessary to remove any bottlenecks along the route to the city plant are best left to the City of Moses Lake. The route could go past Valley Vista Shopping Center as there appears to be sufficient capacity in a 12 inch diameter pipeline on Central Drive. Another pumping station and crossing under Parker Horn is also being discussed. Plans for sewering Basin Homes could also be tied into a Larson sewage transfer system. The Larson plant could be used as an equalization basin which might permit use of existing city sewers for a longer period of time. No costs were developed for the Larson sewage transfer alternative; as this is clearly best accomplished by the City of Moses Lake itself and is outside the scope of the Clean Lake Project. Specific guidance from the DOE has stipulated that the Clean Lake Project not carry out sewerage facility planning work. See Appendix for December 17, 1985 letter on this subject.

Nutrient Removal with Effluent Percolation or Reuse. The nutrient removal scenario is conceptually valid but is extremely expensive. Nitrogen and phosphorus removal from municipal wastewater is possible, but the technology, operating costs including chemical costs, and degree of operator sophistication remove this as a feasible alternative. Wastewater reuse involving nutrient removal for such uses as cooling water are practiced in water short areas. The Moses Lake area has ample supplies of low cost clean water available for industrial growth.

The Future of the Larson Treatment Plant

The City of Moses Lake is working with the Department of Ecology to develop a waste discharge permit for the Larson plant. According to the City, groundwater monitoring wells will be a requirement for that permit. More exact information on groundwater impacts from the Larson plant discharge will be available after the City's waste discharge monitoring program is implemented. At that time, technical questions concerning the extent of phosphorus retention on the coarse soils underlying the leaching ponds can be resolved. The City could also consider conducting experiments to evaluate phosphorus retention on representative soils by passing effluent through a column to assess phosphorus retention experimentally. Future decisions concerning Larson plant effluent disposal practices should be made with specific knowledge of the nutrient impact of these practices on the quality of groundwaters entering Moses Lake.

Alternatives to present practices at the Larson Treatment Plant are costly. Effluent diversion to the City's main plant would be the most effective solution but may not be financially feasible at this time. A clearer perspective on the Larson plant impact is necessary. The City's planned groundwater monitoring program should provide that perspective.

CHAPTER 6

MISCELLANEOUS OFF FARM CONTROLS

Other in-lake and watershed water quality control approaches were considered in addition to those involving agriculture and urban wastewaters. These include improvements to water circulation, dilution water releases, eradication of carp, aquatic weed harvesting, dredging and construction of detention ponds to trap nutrients. Continued reliance on existing dilution programs is emphasized since all of these watershed and in-lake controls are viewed as supplemental measures. Irrigated agriculture and other farm controls are described in Chapter 4 and urban wastewater control alternatives are described in Chapter 5. An evaluation of the relative benefits and costs of all the improvements described for farm or off-farm controls is included in Chapter 7.

Water Circulation Improvements

Several bridges and causeway structures cross Moses Lake and impede local water circulation. See Figure 6-1. 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. The causeway structure of greatest concern to water quality is the Alder Street causeway (known locally as the Alder Street fill). This causeway provides one of the primary views of the lake within the city limits. The other structures are of lesser concern due either to their location (e.g., extreme upper end of Parker Horn) or their design. The feasibility of improving circulation at the Alder Street fill was considered further as part of the Clean Lake Project.

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 Lake Project were carried out to remove debris from this pocket during the summer of 1984.

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

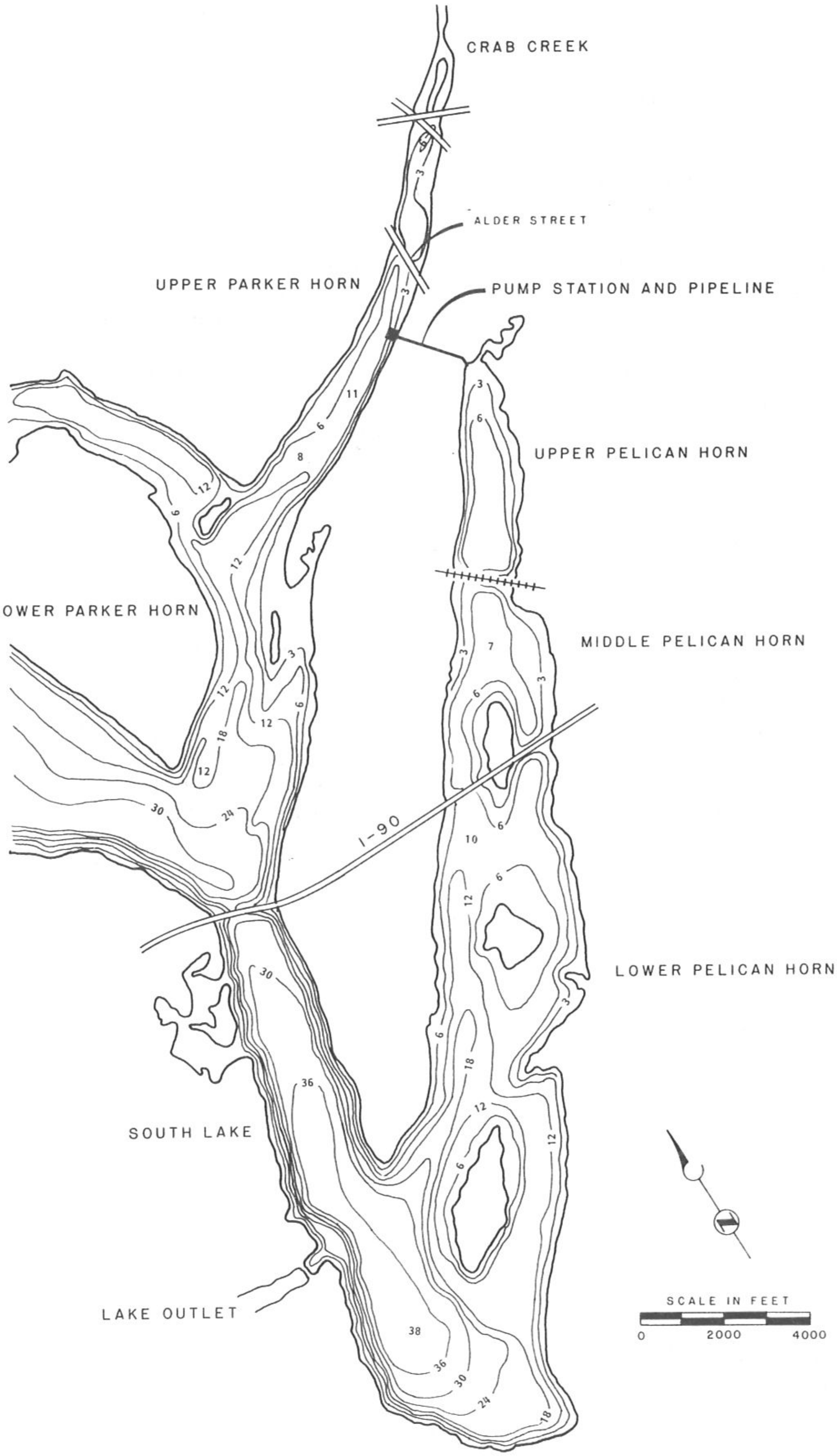


Fig. 6-1 Moses Lake Bridges and Causeways

waters in these wind-protected pockets are 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 causeway 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 was also evaluated to determine if improvement could be made to 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. However, minor changes to the shoreline were made 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 were improved by changing the culvert intakes.

A concrete bulkhead was constructed around the northwestern edge of the Alder Street fill. This structure extends along approximately 150 feet of shoreline from an existing 48 inch culvert outlet north and west to an existing bulkhead on private property. See Figure 6-2 for details on this project. The clean face of the bulkhead accommodates removal of wind swept algal

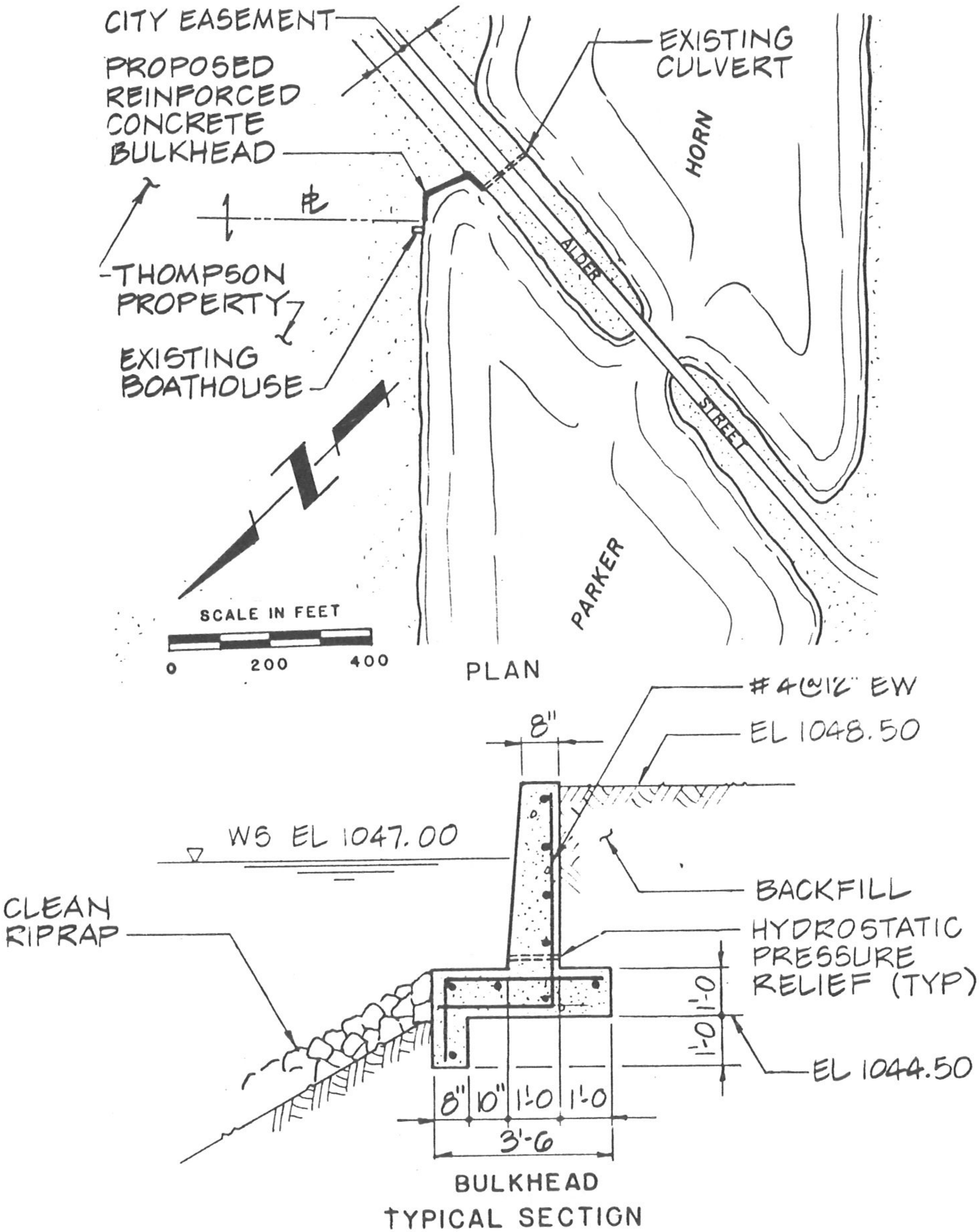


Figure 6-2 Alder Street Bulkhead Improvements

scums and other debris that accumulate in this pocket. Cost for the bulkhead design and construction totaled $24,000; all of these costs were paid for directly by the Moses Lake Irrigation and Rehabilitation District (MLIRD) as this work was not considered part of the Clean Lake Project grant.

Circulation was improved on the upstream end of the 48 inch culverts through addition of an extension to the outlet which catches the eddy current that prevails in this area. This improves local water movement and should also help circulation on the bulkhead side of the fill. Cost for the outlet extension was a nominal $400 which was paid for directly by the MLIRD.

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.

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.

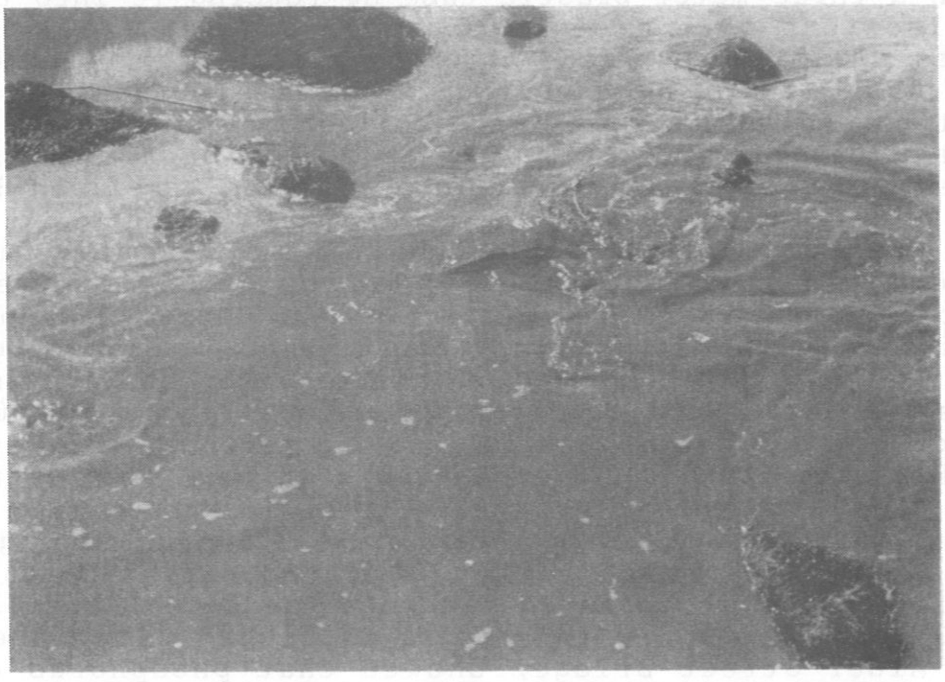
Carp consume a varied diet of zooplankton, algae, plant fragments, aquatic insects and miscellaneous organic matter. Young carp feed primarily on zooplankton, whereas adult carp consumer more plant material. According to Department of Game biologists, carp have effectively denuded some areas of important plant materials such as Sago pondweed, an important local food source for waterfowl. 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. Carp have effectively denuded the lower Rocky Ford Creek area which once supported more extensive riparian and in-stream vegetation valuable to bird life.

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 itself 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 Rocky Ford Creek and numerous irrigation ditches. Furthermore, carp eradication within the lake 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.

<u>Dredging</u>

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 (<u>Potamogeton crispus</u>) and sago pondweed (<u>Potamogeton pectinatus</u>) 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,

Rocky Ford Creek Carp Barrier



Migrant Carp Congregating Below Spillway 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 6-3). 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. 6-3 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 than sufficient to provide adequate reduction in nutrient concentrations to achieve satisfactory algal control.

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 1,840 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.

Several alternatives were considered during Stage 2 for eliminating this discharge; each involved rerouting the discharge either to an irrigation canal for reuse or to drains that avoid discharge to Moses Lake. These approaches were rejected as too costly. It was found that on-farm improvements in this drainage would reduce the volume through improved irrigation systems and irrigation water management. A total of three farms, representing over 20 percent of the irrigated acres in the drainage served by this pumping station, were included in the cost-share program.

Detention Ponds

Construction of detention ponds was included in the Stage 3 program 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 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 detention pond nutrient removal mechanisms was provided in the Stage 2 report including examples of detention pond performance. Based on the literature and local monitoring results in the Moses Lake watershed, detention pond nutrient removal efficiency was estimated. 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. Therefore, for purposes of the Moses Lake Clean Lake project, an efficiency of 25 percent phosphorus removal was used for detention ponds with at least 4 hours retention time.

Minimal nitrogen removal will be credited. Where the 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 considered independent of sedimentation rates since the removal mechanisms involved are presumed to be primarily biological such as uptake by attached algae (e.g., periphyton) or floating plants (e.g., duckweed). Detention ponds will be designed as shallow flow through facilities with typical average water depth of less than five feet in order to encourage aquatic plant growth. 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 reachng 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. Further instructions on operation and maintenance are provided in the Appendix.

Detention ponds constructed during Stage 3 include one main stream pond on lower Rocky Ford Creek and a small pond to intercept nutrient rich drainage that is currently entering Rocky Coulee Wasteway from a cattle feed lot. These 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. The proposed impoundment structure is shown in Figure 6-4. This project is located on private land near the upper end of the main arm of Moses Lake. Construction began early in 1987 and is projected to be complete in June 1987. Easements were obtained from the Moses Lake Development Corporation for the structure and pond area. Road access easements were also obtained from the MLDC and other private property owners.

The structure creates a barrier to fish migration into Rocky Ford Creek from Moses Lake. The dike is being built with local soils and rip rapped with local basalt rock. The dike extends approximately 700 feet across the valley floor. The dike structure includes an embankment zone of compacted local soil, a concrete spillway section with removable stop logs, and a fuse plug zone on the west side which is designed to wash out in the event of a catastrophic flood. Rip rap placement is specified at the spillway abutments and below the spillway apron and at the eastern edge of the fuse plug section. A core trench filled with

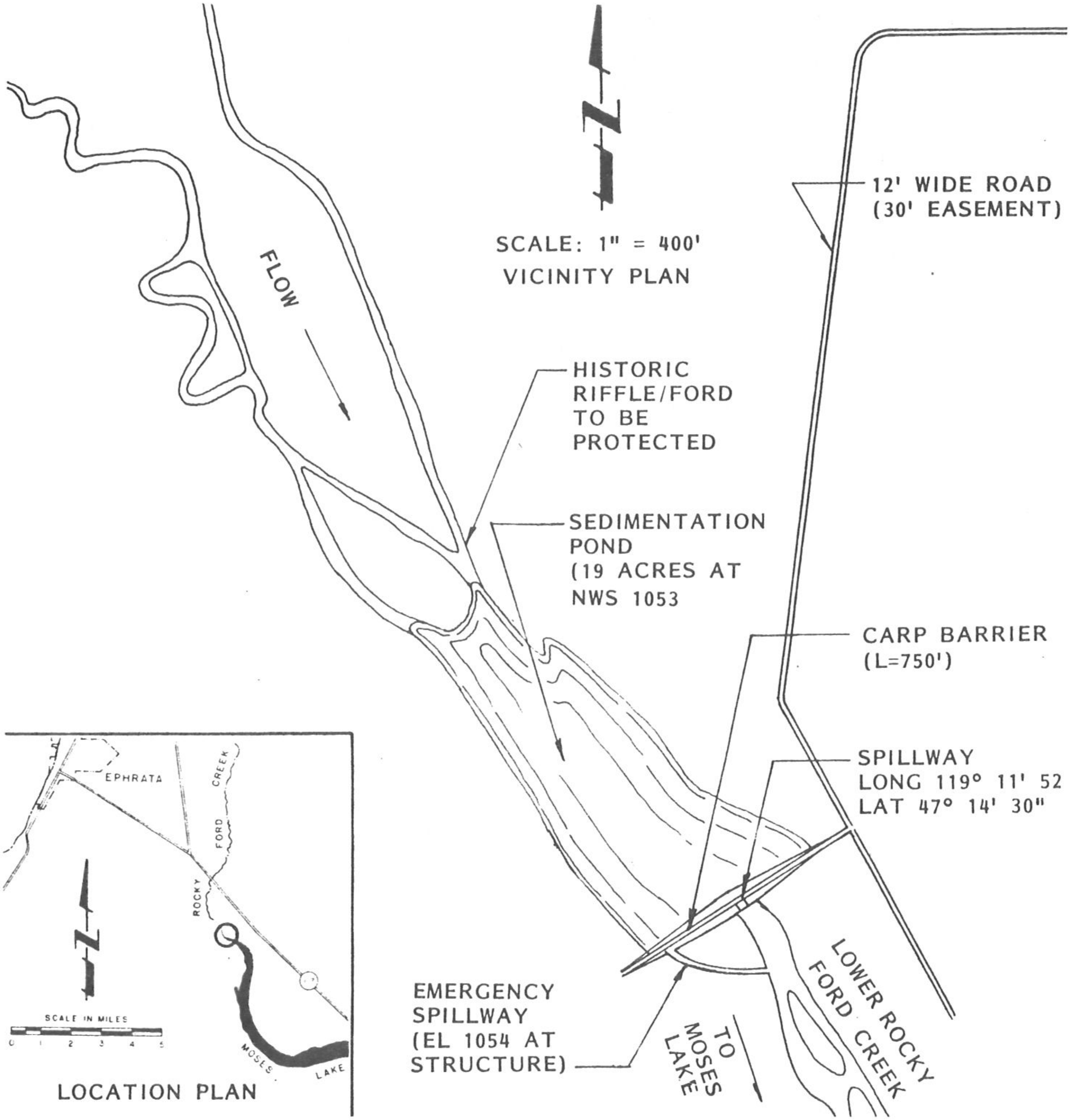


Fig. 6-4 Rocky Ford Creek Detention Pond Plan

fine sand was specified in portions of the dike area based on results of a geotechnical investigation involving Department of Ecology Dam Safety staff. The fuse plug zone was also incorporated in the design at the request of the Department of Ecology because of the difficulty in forecasting extreme flood events from snow melt events or intense localized thunderstorms.

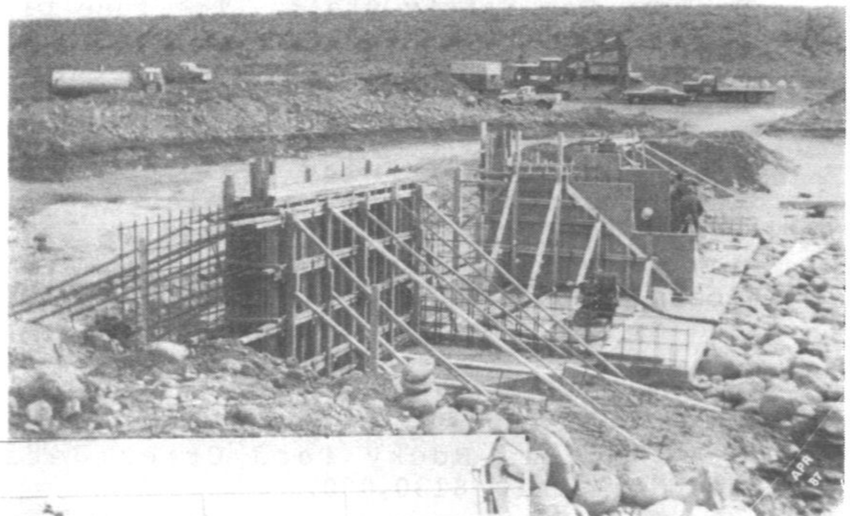
The access road was constructed by North Central Construction and was completed March 1987. This road and associated gate and culverts cost approximately $30,000. The impoundment structure contractor is Marchand Construction of Moses Lake who bid approximately $99,000 for this work. The dam and spillway were completed in late April and the reservoir was filled on April 29. In May, large numbers of adult carp were attempting to swim upstream, but were unable to stay on the spillway apron due to turbulent currents. The total construction cost of the Rocky Ford Creek detention pond project was approximately $130,000.

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.

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 agreed to carry out a carp eradication program in the Rocky Ford Creek system after the barrier is complete. This program is expected to be carried out in 1988. The Game Department is making arrangements to Rotenone the creek after protective measures are made to protect the Trout Lodge hatchery. After the carp eradication program is accomplished, aquatic plant growth in lower Rocky Ford Creek should 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.

The Rocky Ford carp barrier and detention pond is located in the southeastern quadrant of Section 8, Township 20 North, Range 27 East. Most of this section and Section 15 to the north are owned by the Moses Lake Development Corporation. This land was part of a large sheep and cattle ranch in the late 19th and during most of this century. During the 19th century, it was owned by Lord Blythe, an English cattleman, and after about 1915, it belonged to the Drumheller family. Rocky Ford Creek runs through these two sections and forms a broad valley between two ridges which rise to a plateau approximately 100 feet above the

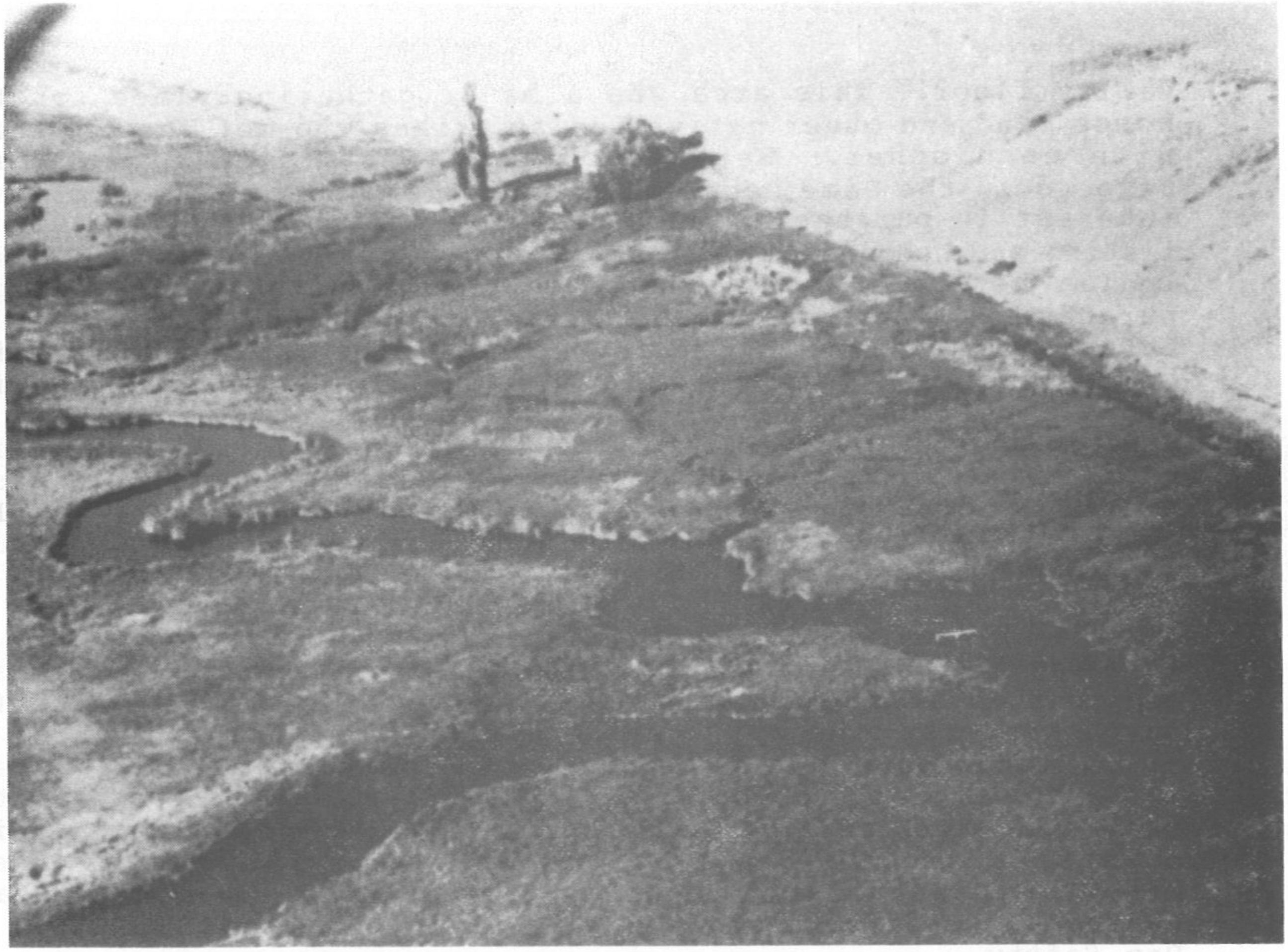
Forming Spillway
Walls



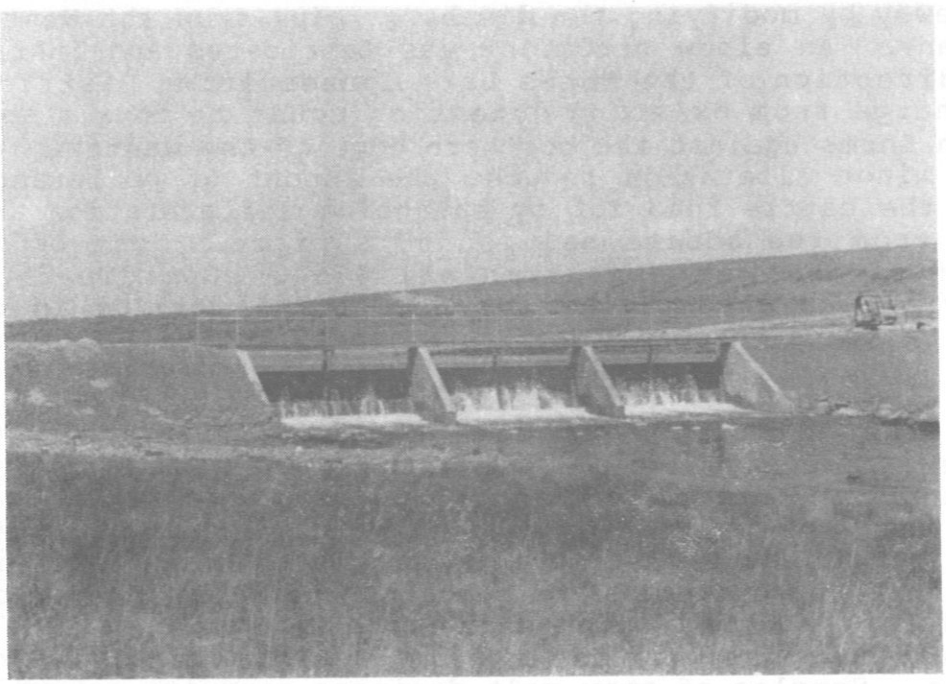
Spillway Showing
Stoplogs and
Catwalk

Clearing
Diversion
Channel

Rocky Ford Creek Detention Pond Construction



Aerial View of Rocky Ford Creek



View of Completed Detention Structure

valley floor. This area was a major gathering place for the Moses Band and other native Indian tribes who met here to trade with each other. Because of the area's significance and resources, the Game Department and other groups have expressed interest in purchasing much of the area. Those interested in fishing and hunting as well as those interested in historical and Indian heritage aspects have gathered together to work up a purchase plan so the area can be protected under public trust. Purchase negotiations are in progess for a phased acquisition with the property in Section 8 around the detention pond having highest priority. Second priority for purchase is for land in Section 15 near highway 17, and third priority is for lands lying between these two proposed purchases along the Rocky Ford Creek riparian corridor. The total purchase is expected to involve approximately 800 acres south of State Highway 17 and may include some acreage north of the highway as well. See Figure 6-5.

The 50-foot wide spillway and downstream concrete apron are designed in accordance with Game Department recommendations for carp barriers. The spillway itself has removable stop logs to allow pond draw-down for maintenance purposes. The concrete apron has a gentle slope of six inches over its 15-foot length, below the apron is a concrete cutoff wall with rip rap extending down as a transition stream to the natural stream channel. Structural details as well as geotechnical conditions and hydrology used for design were reviewed by the DOE Division of Dam Safety.

Rocky Coulee Wasteway Discharge Impoundment. A small impoundment was created on the north side of the Rocky Coulee Wasteway by modifying the discharge pipe from the Westside Cattle Company. An elbow structure was fabricated and installed under the direction of the Moses Lake Conservation District to allow discharge from existing detention ponds to form a shallow pond which forms against the northern edge of the wasteway embankment. This minor alteration reduces the amount of pollutant discharge from the cattle feed lot by enhancing sedimentation and evaporation from the additional ponded surface. Cost of this minor modification was approximately $650. Coordination of this activity was accomplished by MLCD staff working in cooperation with agencies responsible for the Rocky Coulee Wasteway.

Other impoundments were considered in the Rocky Coulee Wasteway drainage including a large pond at the upper end of the wasteway and a small detention pond on a tributary which flows from the Game Department Hatchery and past a local dairy before entering the wasteway. The upper wasteway pond project was not pursued because there were concerns that temporary flooding on a local farm at the head of the wasteway would spread weed seeds and add unwanted pesticides from upstream areas on the farmers' fields. Samples of snow melt drainage carrying extensive amounts

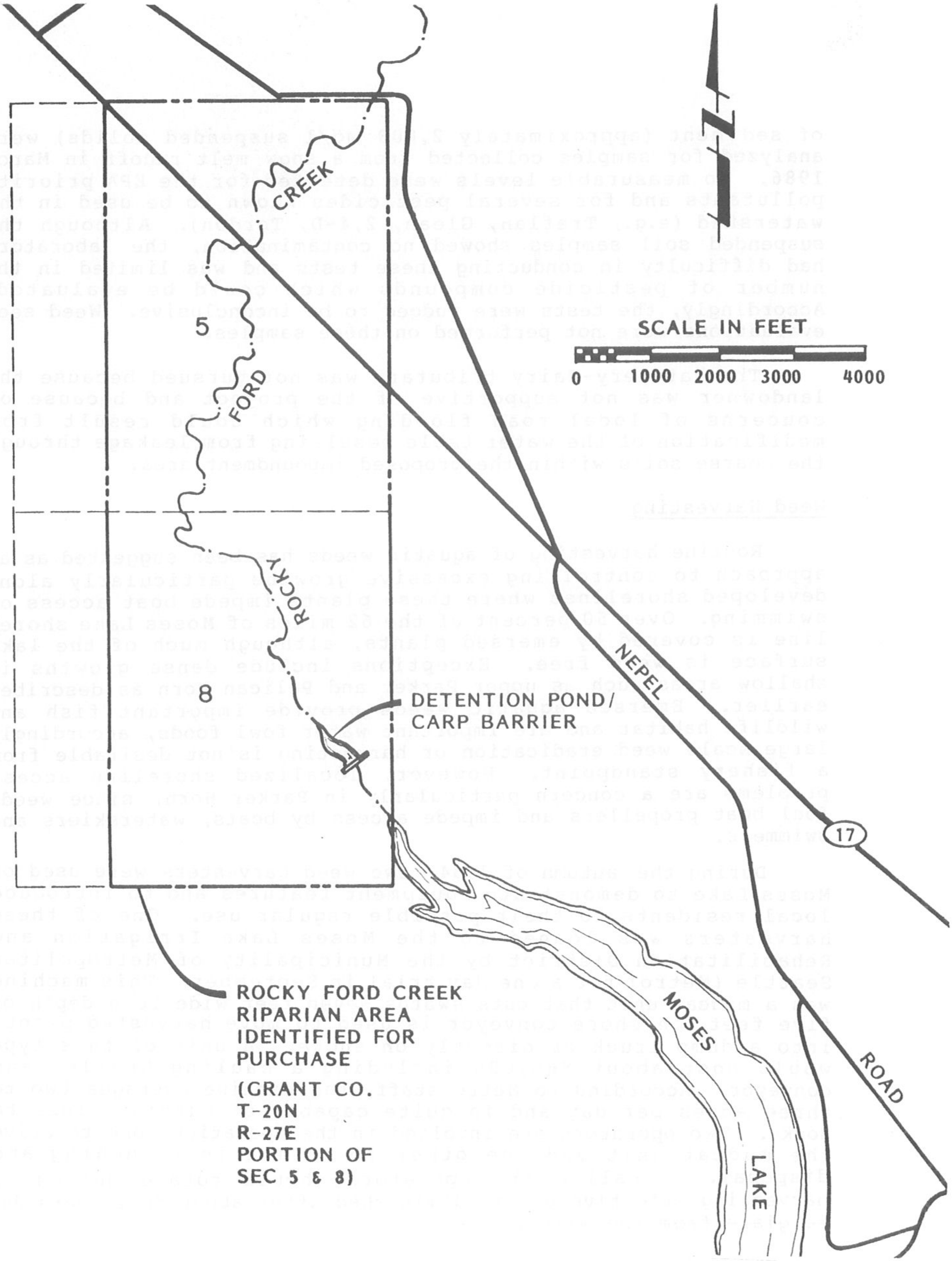


Figure 6-5 Proposed Land Aquisition Along Rocky Ford Creek Riparian Corridor

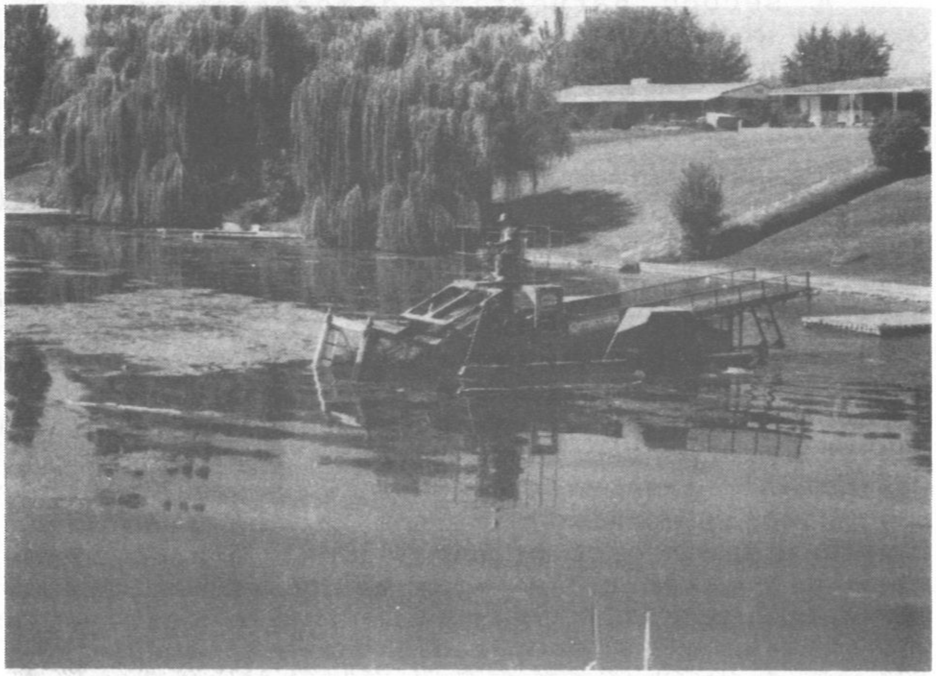
of sediment (approximately 2,000 mg/l suspended solids) were analyzed for samples collected from a snow melt runoff in March 1986. No measurable levels were detected for the EPA priority pollutants and for several pesticides known to be used in the watershed (e.g., Treflan, Glean, 2,4-D, Tordon). Although the suspended soil samples showed no contamination, the laboratory had difficulty in conducting these tests and was limited in the number of pesticide compounds which could be evaluated. Accordingly, the tests were judged to be inconclusive. Weed seed evaluations were not performed on these samples.

The hatchery-dairy tributary was not pursued because the landowner was not supportive of the project and because of concerns of local road flooding which could result from modification of the water table resulting from leakage through the coarse soils within the proposed impoundment area.

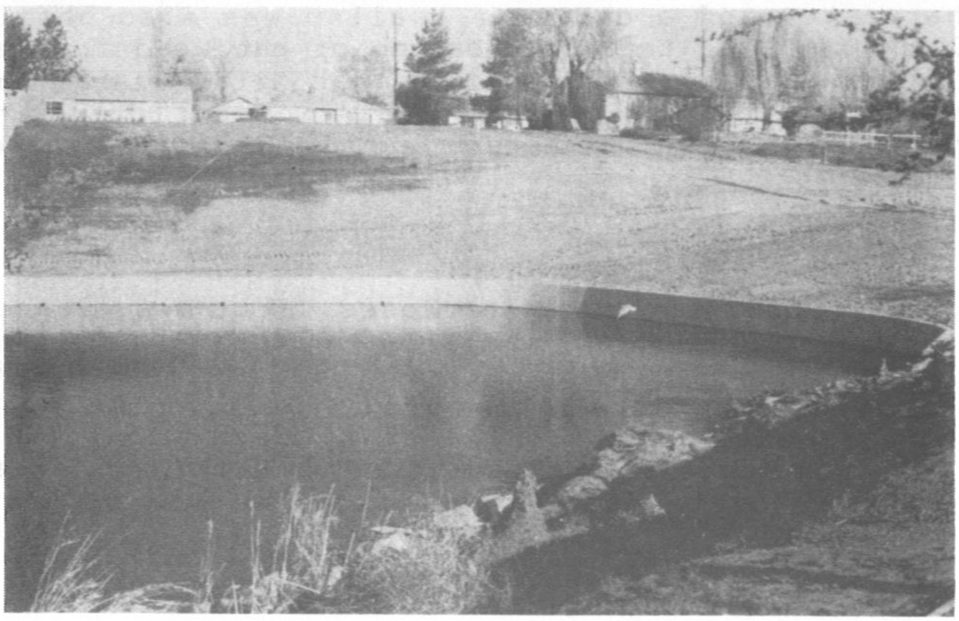
Weed Harvesting

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.

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



Aquatic Weed Harvester in Use



View of New Bulkhead Near Alder Street Fill

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.

During 1985, the MLIRD was able to secure one of the Metro harvesters on a lease basis. Aquatic weed harvesting was carried out during the 1985 season following discussions with the Department of Game on cutting depths and locations. The lease arrangement was continued during 1986 and Metro's second harvester and a conveyor trailer was also obtained under the lease to facilitate off-loading of cut weed fragments. In early 1987 the District was advised that Metro wished to surplus these machines, and as of March 1987 the District was negotiating to purchase the two harvesters and the conveyor trailer.

Lakeshore Clean-up

Shoreline areas of Moses Lake were cleaned up as a direct result of project public involvement activities. Community groups and individuals were assigned reaches of shoreline for litter and debris removal, filling several dumpsters on designated Lakeshore Clean-up days sponsored by the project during Stage 2 and Stage 3. Don Beckley initiated and managed these local clean-up efforts and was instrumental in their success.

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

Trash Removed from Lake Shore

Volunteers Disposing of Lakeshore Debris

Dilution Water Releases

Moses Lake has benefited from a unique dilution water release program over the past ten years. The program has been carried out as a cooperative effort between the U.S. Bureau of Reclamation and the MLIRD. High quality (low nutrient) water originally from the Columbia River system is released from the East Low Canal through Rocky Coulee Wasteway into Parker Horn. This water ultimately serves as feedwater to fill Potholes Reservoir to supply irrigation users in the southern portion of the Columbia Basin Project. Since Moses Lake spills into Potholes Reservoir, the lake can be used as a feed route which, in turn, benefits lake quality. Moses Lake had received feed water releases as early as 1966, however, major spring and summer releases through Rocky Coulee Wasteway were not common until after 1976. In the ten years prior to 1976, releases occurred only during four years (1966-19,000 acre-feet, 1967-120,700 acre-feet, 1972-61,520 acre-feet and 1973-130,762 acre-feet). After 1976 releases occurred every year except during 1984.

1977 Dilution Demonstration. A dilution demonstration project was conducted in the spring and summer of 1977 using Parker Horn as the major test area. Arrangements for delivery of dilution water were made with the U.S. Bureau of Reclamation Columbia Basin Project Office in Ephrata. Ultimately some 150,000 acre-feet were released with about 105,000 acre-feet from March 18 through May 9, approximately 10,000 acre-feet from May 24 through June 7, and a third release of 35,000 acre-feet from August 13 through September 12. Dilution water was provided from the East Low Canal via the Rocky Coulee Wasteway which flows into Crab Creek 1-1/2 miles upstream of Parker Horn.[a]

The demonstration project focused on water quality measurements before, during, and after each canal release period to provide data which could be compared with conditions when no dilution release occurred as measured by the University of Washington in 1969. In addition, the project enabled comparisons to be made for the differing conditions which were created during 1977 at various locations within Moses Lake and in downstream areas, particularly Potholes Reservoir. Past concern over aquatic growths in the Potholes area and in downstream irrigation canals urged caution with respect to potential water quality changes which could result from a Moses Lake "dilution" project and thereby affect downstream irrigation operations.

The 1977 sampling program for the Moses Lake demonstration project included a total of 17 stations, 8 in Moses Lake itself, 2 in Potholes Reservoir, and the remaining 7 in adjacent streams and wasteways. Sampling was conducted weekly or biweekly depending upon station during the March-through-September sampling period. In addition to measurement of standard water quality parameters, samples were analyzed for nutrients and

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(a Details on the 1977 dilution pilot project are contained in a June 1978 report by Brown and Caldwell.

planktonic algae concentrations.

Water quality goals were established. A phosphorus goal was established at 50 ug/l based on earlier work by Welch, a level believed necessary to control algal growth below 20 ug/l chlorophyll. Similarly, a water clarity goal was established which is in part dependent on algal growth levels (i.e., chlorophyll) as well as on the nature of the growths (e.g., diatoms vs. floating blue-green algae forms). The transparency goal, 4 feet, as measured by Secchi disc, is also tied to swimming safety; the transparency and chlorophyll goals are also a gross measure of aesthetic conditions in the lake.

Generally stated, the overall effect of the three additions of dilution water was to reduce total phosphorus, total nitrogen, and chlorophyll a levels and to increase water clarity (as measured by Secchi disc) in the lake. Improvement in Parker Horn itself was more marked than in other locations as replacement with dilution water is greater in Parker Horn. However, the effects of dilution extended much further than Parker Horn. Significant improvements in water quality were observed well into the lower lake and lower Pelican Horn, into the main lake, and even into Lewis Horn.

Changes that occurred due to the 1977 dilution program were related to the differing nutrient characteristics of upper Crab Creek and the Columbia River. Total phosphorus concentrations, as observed over the 1977 sampling program for each of these sources, are displayed in Table 6-1. Similar drops in nitrogen concentrations were observed.

Table 6-1. Comparison of Selected Water Quality Parameters[a]

Parameter	Goal	Parker Horn (Station 7)		Lower lake (Station 9)	
		1969	1977	1969	1977
Total phosphorus (μg/l)	50	135	78	135	91
Chlorophyll a (μg/l)	20	73	29	44	24
Transparency (Secchi disc, ft)	4.0	2.0	3.9	3.3	6.2

[a]Average values for stations indicated.

Chlorophyll concentrations responded to dilutions more dramatically than the nutrients. Comparisons of stations in

Parker Horn illustrate changes observed; by mid August, two months after dilution water had ceased, regrowth had occurred and nuisance conditions were prevalent.

Phytoplankton were identified and counted. Shifts in major population groups occurred throughout the period. From March through May diatoms were generally dominant coupled with a fair representation of greens; by June blue-greens had achieved dominance; and by August, when the nuisance chlorophyll concentrations had developed, the blue-greens peaked with 98 percent of the count observed on August 10. This large, blue-green algal biomass which existed at the beginning of the third and last dilution period was dominated by the genus Aphanizomenon. The decrease in chlorophyll following dilution was paralleled by a decrease in blue-green algae. The rapid decrease in blue-greens was accompanied by an increase in clean-water associated diatoms and green algae.

Secchi disc readings for Moses Lake in the Parker Horn-lower lake area clearly varied in response to changing water mixtures during and following the dilution experiments. Figure 6-6 compares 1969-70 Secchi disc values with those observed during 1977 for middle Parker Horn. The data comparisons also reveal a more turbid condition existed in 1969 than in 1977. Major improvements in Secchi disc readings were observed with widespread achievement of the 4.0-foot transparency goal, often to the point that readings were double those in the baseline year (1969). Explanations of transparency responses were linked with chlorophyll and algal concentration measurements.

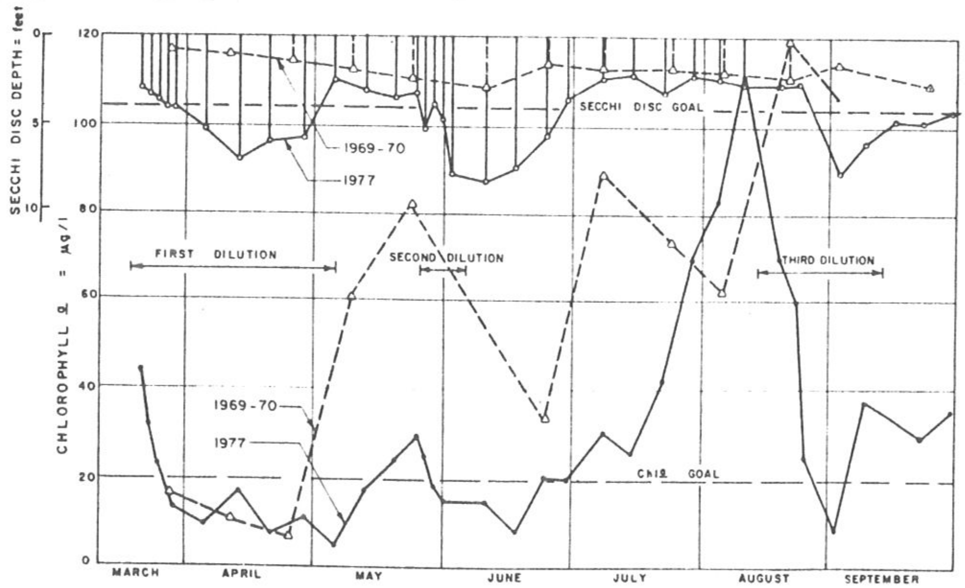


Figure 6-6. Middle Parker Horn Transparency and Chlorophyll a Changes during 1977

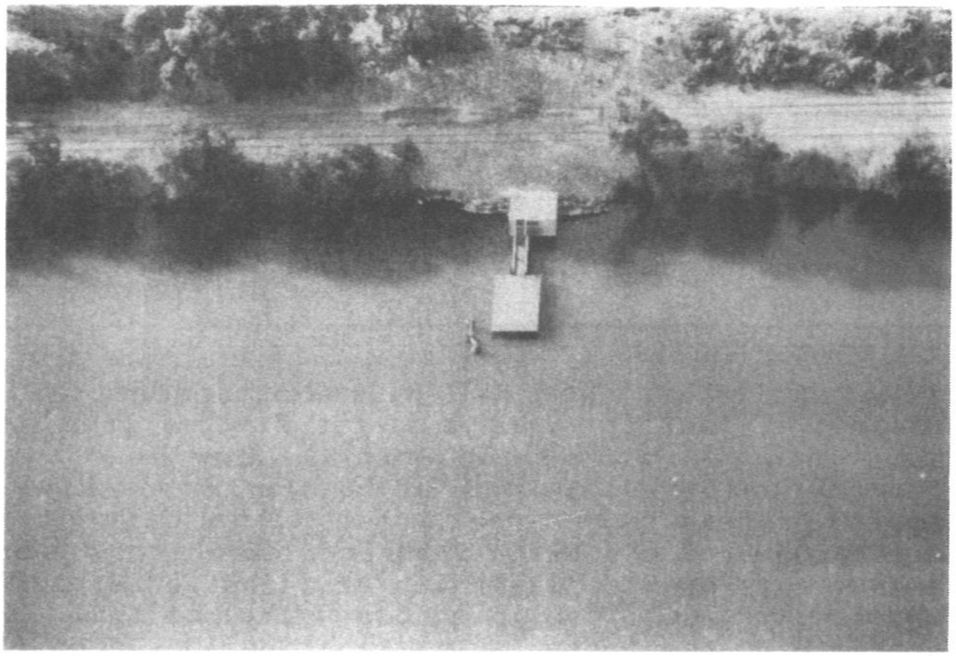
Dilution effects progress as inflow water moves throughout the lake. Lake water is first displaced from Parker Horn, followed by displacement from the Rocky Ford Arm and the Lower Lake almost simultaneously. Once dilution water input ceases, undiluted high nutrient inflow water rapidly replaces diluted lake water. The shorter the period of dilution input, the faster high nutrient water returns. Increased algal biomass rapidly follows the return of high-nutrient water.

Parker Horn Pump Station Construction

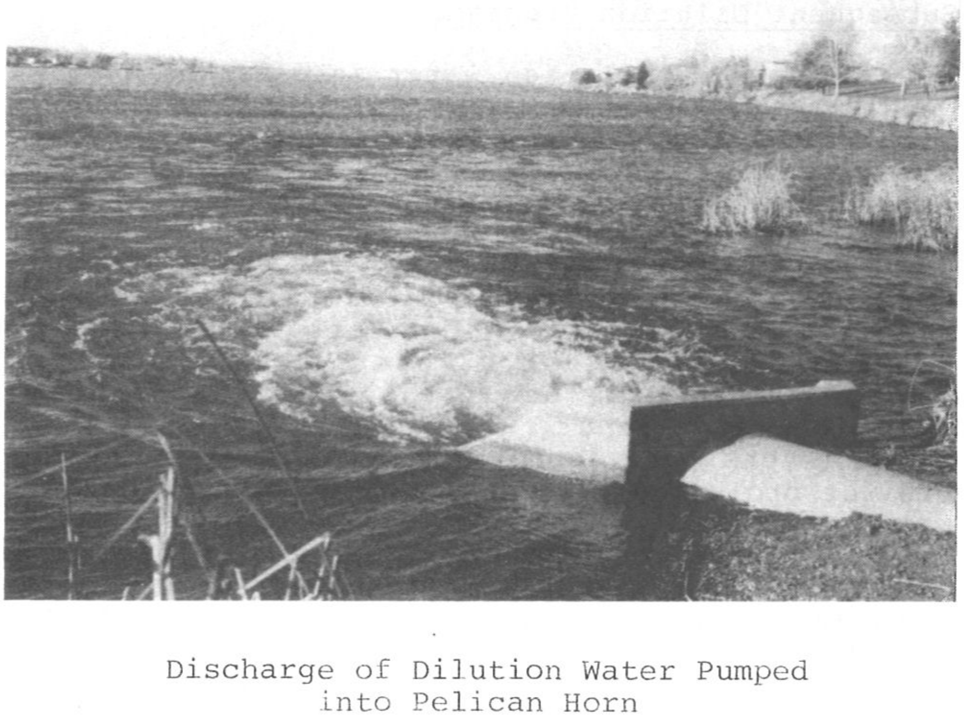
Results of the 1977 dilution demonstrations stimulated funding of facilities to transfer diluted lake water from Parker Horn into nearby Pelican Horn. A low head pumping plant was designed with a capacity of 50 cfs to transfer dilution water approximately 2,800 feet across the City of Moses Lake for discharge at a shoreline park located at the upper end of Pelican Horn. This project was built at a cost of approximately $875,000 and put in operation during the summer of 1982. Grant funds were provided to the Moses Lake Irrigation and Rehabilitation District by the Department of Ecology and the Environmental Protection Agency. An additional dilution project was also evaluated for the main arm of the lake via Rocky Ford Creek; however, this project was not feasible. Grant funds originally dedicated for this project have since been used to assist in removing the City of Moses Lake's sewage effluent from Pelican Horn and to fund evaluations of nutrient control approaches in the watershed as described in this report.

Subsequent Dilution Programs

Release of dilution water into Parker Horn from the East Low Canal via Rocky Coulee Wasteway and Crab Creek has continued to occur over most of the past ten years. See Table 6-2. Total amounts of water during spring and summer generally reached or exceeded 100 million cubic meters (81,000 acre-feet). Major exceptions were in 1984 when no release water was available and during 1980-81, after the Mount St. Helen's ashfall. Approximately four inches (10 cm) of ash fell on the Moses Lake area and transport of that material into Crab Creek by wind and erosion was extensive. However, only one year (1985) had a consistent release occur through the end of August. Average dilution water input rates ranged from 350 to 700 cfs (10 to 20 cubic meters per second) although at times releases reached 1200 cfs for prolonged periods. Significant releases (up to 1200 cfs) were being made in the spring of 1987 and the USBR expected to release water at least until the end of May. The pumping plant on the shore of Parker Horn transferred water from Parker Horn to Pelican Horn beginning in April 1982 and from April to early July in 1983. Undiluted water was pumped during August and September of both years and during 1984 when dilution water was unavailable. The pump station has been used each spring and



Aerial View of Parker Horn Pumping Station



Discharge of Dilution Water Pumped
into Pelican Horn

summer with dilution water available since 1985. The pump discharge rate was constant at about 50 cfs. Typically, water is transferred from Parker Horn to Pelican Horn throughout the spring-summer period. Pumping usually starts in April after dilution water has improved Parker Horn quality in the vicinity of the pump intake structure.

Table 6-2

Moses Lake Dilution Water Releases
(1976 - 1986)

Year	Dilution Release (acre-feet)	Comments
1976	64,070	
1977	150,630	Demonstration Project
1978	81,840	
1979	214,540	
1980	19,540	Mt. St. Helens Ash Fall
1981	56,050	
1982	144,180	Parker Horn Pump Station built
1983	73,250	
1984	0	Cool weather
1985	154,350	Weed harvesters in use
1986	106,230	Weed harvesters in use
	1,064,680	Total Volume Release
	96,789	Average Annual Release

Although the pattern of dilution water input has been inconsistent over the past ten years, the levels to which average algal biomass has been reduced and transparency increased (compared to predilution years) have remained rather similar. Exceptions were the considerably lower transparency and biomas during the ashfall of 1980 and excessive algal growths during 1984 when no dilution water was released. Otherwise, chlorophyll a has averaged 60 percent lower and Secchi transparency was nearly doubled over the period of dilution, compared to non dilution years. In spite of the impressive improvements in quality, intense algal blooms still occur during late summer following cessation of dilution input.

Dilution programs in Moses Lake have been extremely successful, particularly for the Parker Horn portion of the lake; however, dilution water is not always available, particularly during the late summer. The Bureau of Reclamation has been very cooperative in allowing the release water to be routed through Moses Lake. The East Columbia Irrigation District and the South Irrigation District which receives the water from Potholes

Reservoir have also been very cooperative with the Moses Lake Irrigation and Rehabilitation District in this effort. Nevertheless, the availability of dilution water in the future remains a question, especially as the Columbia Basin Irrigation Project proceeds to ultimate development. For example, when the East High area does develop, the availability of dilution water is likely to be substantially reduced while the quantity of return flow is likely to increase. Conservation measures affecting irrigation and fertilizer practices will be needed to counteract the otherwise inevitable increase in nutrient loading to Moses Lake. The best management practices demonstrated in the Clean Lakes Project and described in this Stage 3 report are important mitigating measures. The irrigation and fertilizer management programs described in Chapter 8 are a key element of this mitigation.

CHAPTER 7

PROJECT PERFORMANCE AND MONITORING RESULTS

The impact of Clean Lake Project watershed nutrient control activities on Moses Lake water quality is the ultimate measure of project performance. Several ways of assessing this impact have been incorporated into the project. Some of these involve direct monitoring while others are largely predictive. Some of these impacts go beyond water quality and include monetary benefits to recreation as well as benefits to farmers. Monetary benefits to farmers are measurable in terms of fertilizer and water savings and crop yield increases. This chapter describes these performance measurements and predictions and summarizes water quality monitoring results to date.

Nutrient Load Reductions

Nutrient loads to Moses Lake will be affected by changes in fertilizer and irrigation water management and by nutrient trapping behind the Rocky Ford Creek detention pond structure. These reductions are described in Chapters 4 and 6. Further reductions are also possible as urban wastewater disposal practices are eventually modified as suggested in Chapter 5. These potential nutrient load reductions are listed below:

Table 7-1

Potential Nutrient Loading Reductions

	Nutrient Reduction (lbs/yr) Nitrogen	Phosphorus
Installed Agricultural BMP's (5,346 acres)	122,223	-
Projected Agricultural BMP's (17,640 acres)[a]	372,200	-
Rocky Ford Creek Detention/Carp Control[b]	27,700	10,800
Urban Wastewater Disposal Improvements[c]	45,000	18,000

[a]Projected control level assumes voluntary improvements made through Stage 2 assessment of farmer cooperation.

[b]Based on 37.5% trapping efficiency for phosphorus and 8.4% for nitrogen for combined effect of detention pond and carp control using Stage 1 nutrient loadings.

[c]Based on hook-up of septic tanks for 4,000 people in Moses Lake area plus transfer of the Larsen Treatment Plant effluent.

Moses Lake Water Quality Predictions

Estimates of the impact of nutrient load reductions on Moses Lake water quality were made using a mathematical model developed specifically for Moses Lake. 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 concepts used are applicable in other lakes. For latest details on the model, contact Dr. Eugene Welch of the University of Washington Department of Civil Engineering.

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.

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 of flows and sources and groundwater fluctuations. 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.

Data from USBR monitoring wells was evaluated to determine the average change in water level at various places in the watershed. See Chapter 2 for example of monitor well fluctuations.

The amplitude of seasonal water table 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 clays 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 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 was 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 7-1 for an illustration of the estimated seasonal flow pattern based on an annual groundwater flow rate of 105 million cubic meters.

Control scenarios included a reduction of nitrogen levels in ground and surface water based on the amount of nitrogen reduction achieved. 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 7-1. 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 7-2. 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 gnerally 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 cholorphyll reductions have reached 30 ug/l. Similar trends were observed in Lower Parker Horn; see Figure 7-3.

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 7-2. 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 7-3.

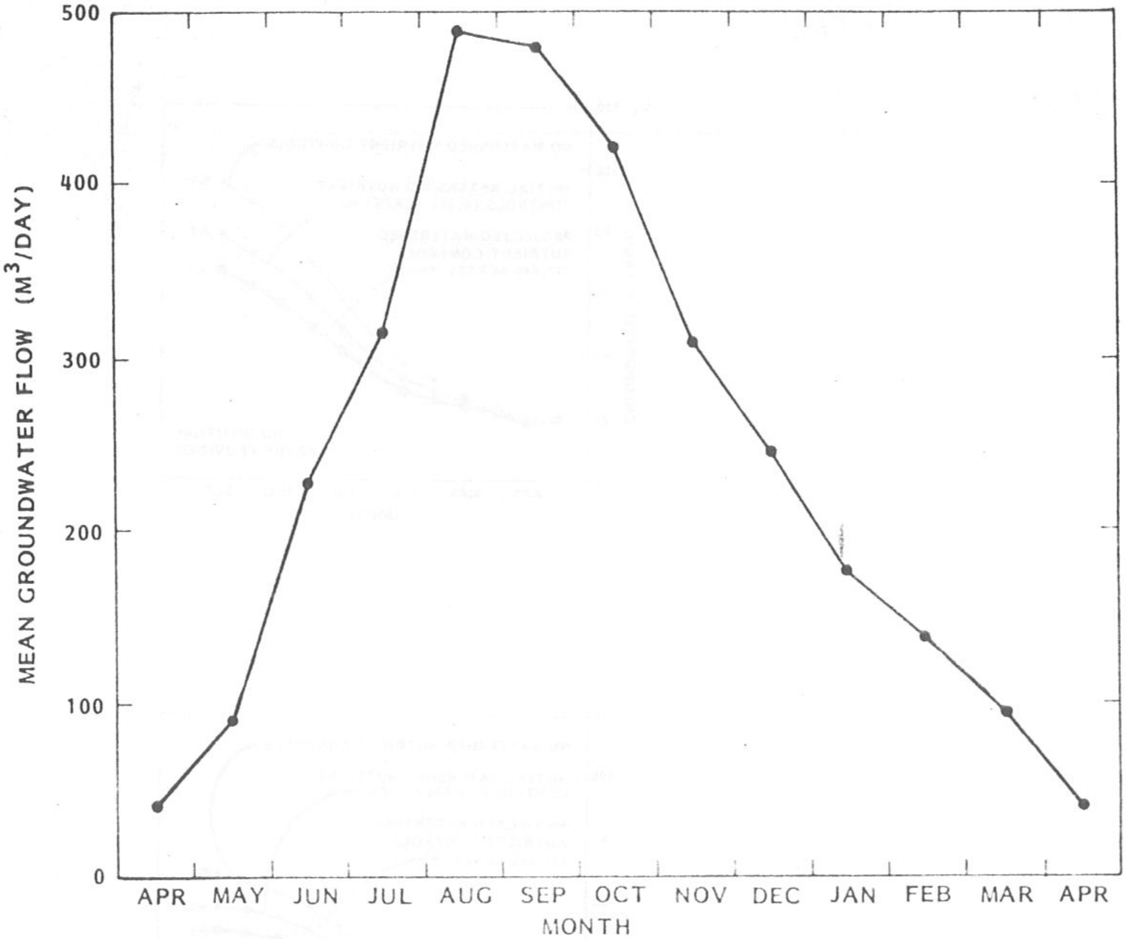
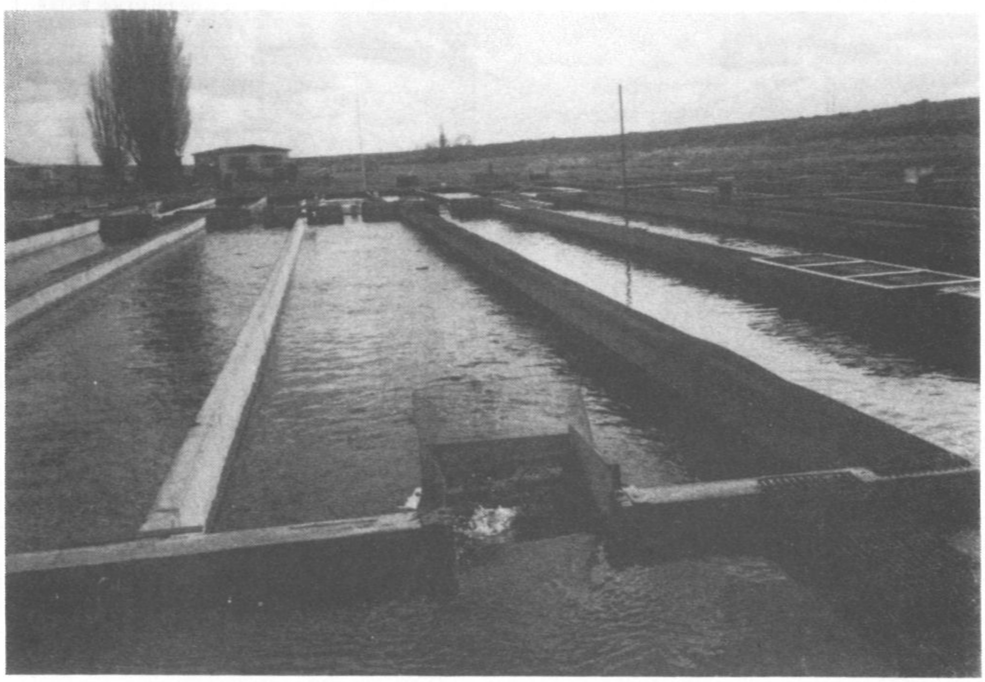


Fig. 7-1 Estimated Groundwater Flow Pattern to Moses Lake



Fish Hatchery on Rocky Ford Creek

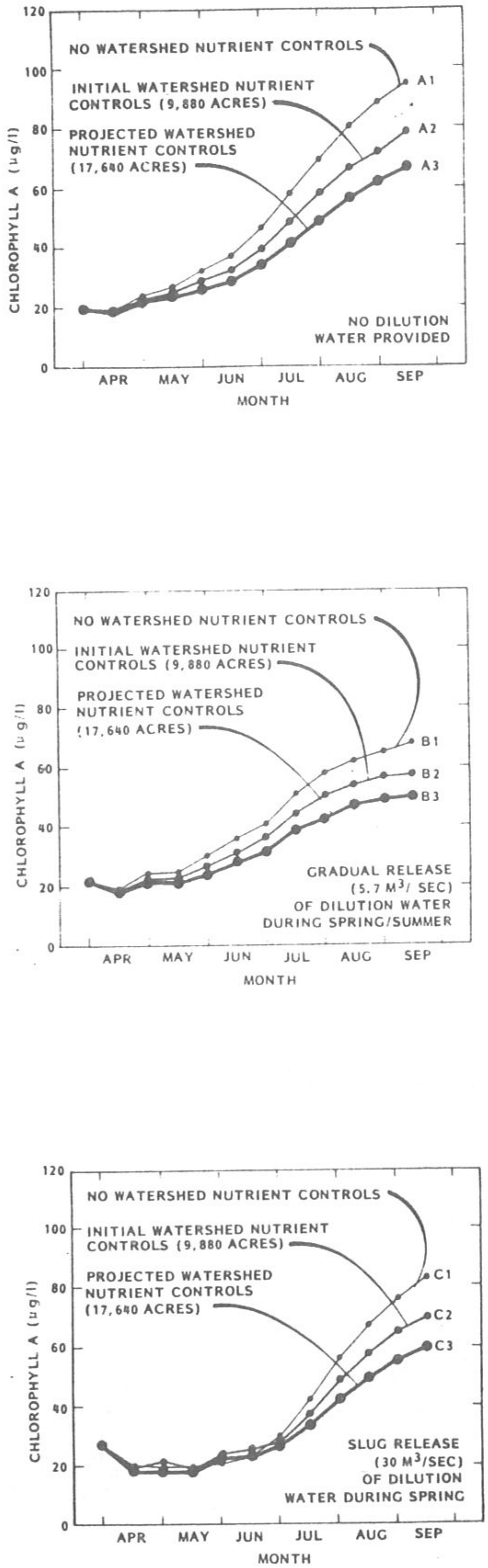


Fig. 7-2 Predicted Chlorophyll Levels - Lower Lake

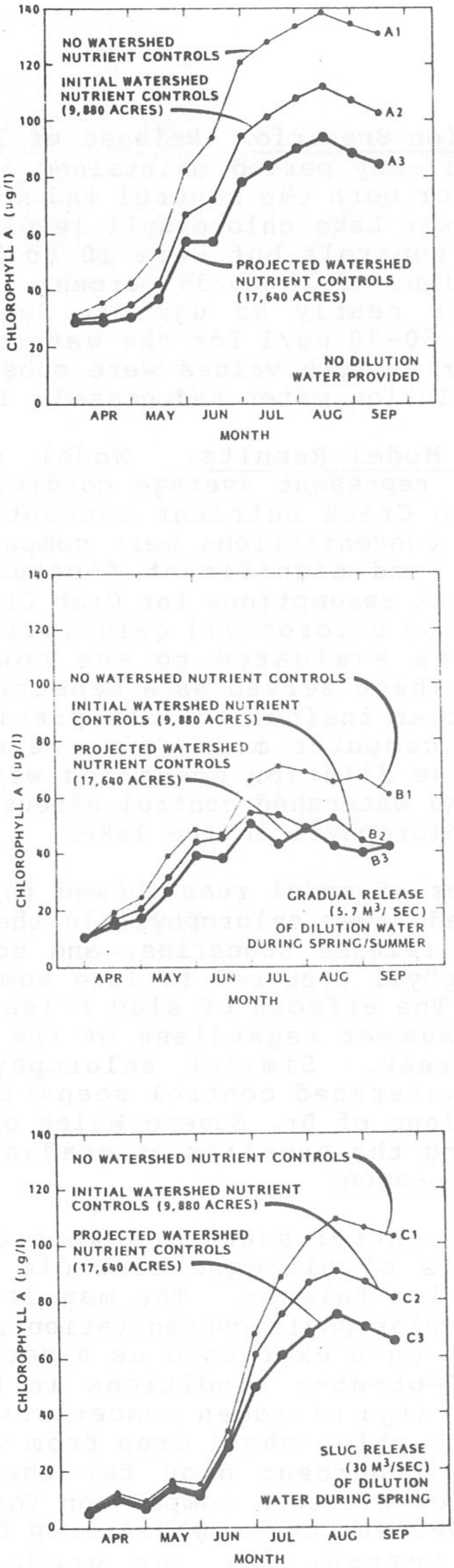


Fig. 7-3 Predicted Chlorophyll Levels - Lower Parker Horn

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 7-2. Parker Horn values were substantially higher by mid summer after dilution water had ceased. See Figure 7-3.

Evaluation of Model Results. Model runs described in Figures 7-2 and 7-3 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. 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 during Stage 2 for all three dilution scenarios with varied nutrient input assumptions and watershed control effects and two different levels of initial chlorophyll in the lake.

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.

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 chlorphyll 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 phosphorus 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

Benefit Evaluation

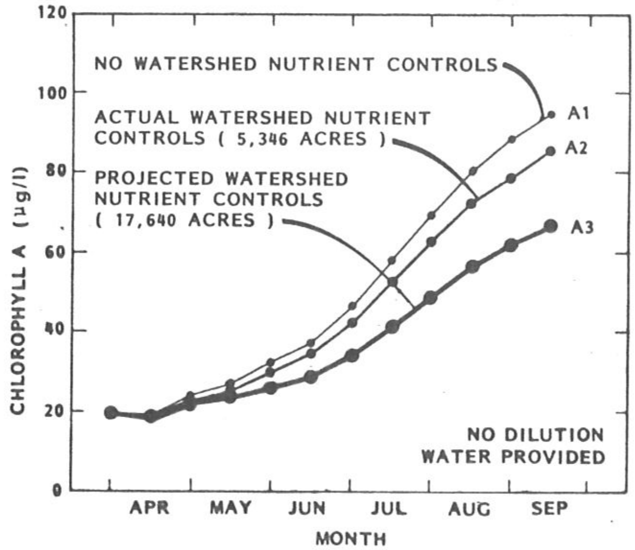
Actual on-farm improvements resulted in a lesser nitrogen reduction than was initially projected for Level B controls. As discussed in Chapter 4, the actual acreage affected by on-farm improvements was 5,346 as compared with the 9,880 acres projected for initial Level B controls under Stage 3. Nutrient reductions were actually rated at 122,223 lbs. of nitrogen or nearly 60% of the 208,100 lb. Level B initial benefit. Accordingly, estimates of Moses Lake water quality improvement were adjusted downward to reflect a lower annual total nutrient reduction. Adjusted values were based on interpolations between calculated values from the previous model runs. These revisions are illustrated in Figure 7-4.

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 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 during Stage 2 with increased dilution release rates in an attempt to match chlorophyll values achieved with watershed controls under the gradual release scenario. These release rates were also adjusted based on actual nutrient reductions achieved in Stage 3. This resulted in a dilution water equivalency estimate of 14,100 acre feet for the actual Stage 3 controls and 53,600 acre feet for the projected watershed control level.

These 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 $140,000 to



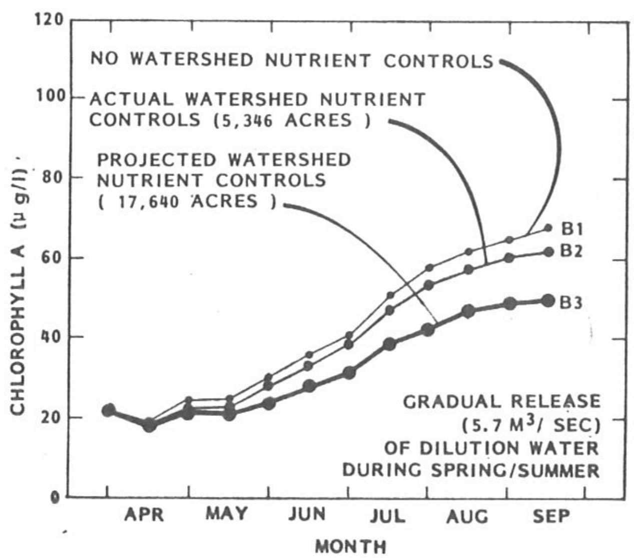


Fig. 7-4 Predicted Chlorophyll Level Based on Stage 3 Results - Lower Parker Horn

$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 biolgical 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 7-5 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 7-5 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 U.S. 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.

Moses Lake water related uses are described in the Stage 2 report. 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

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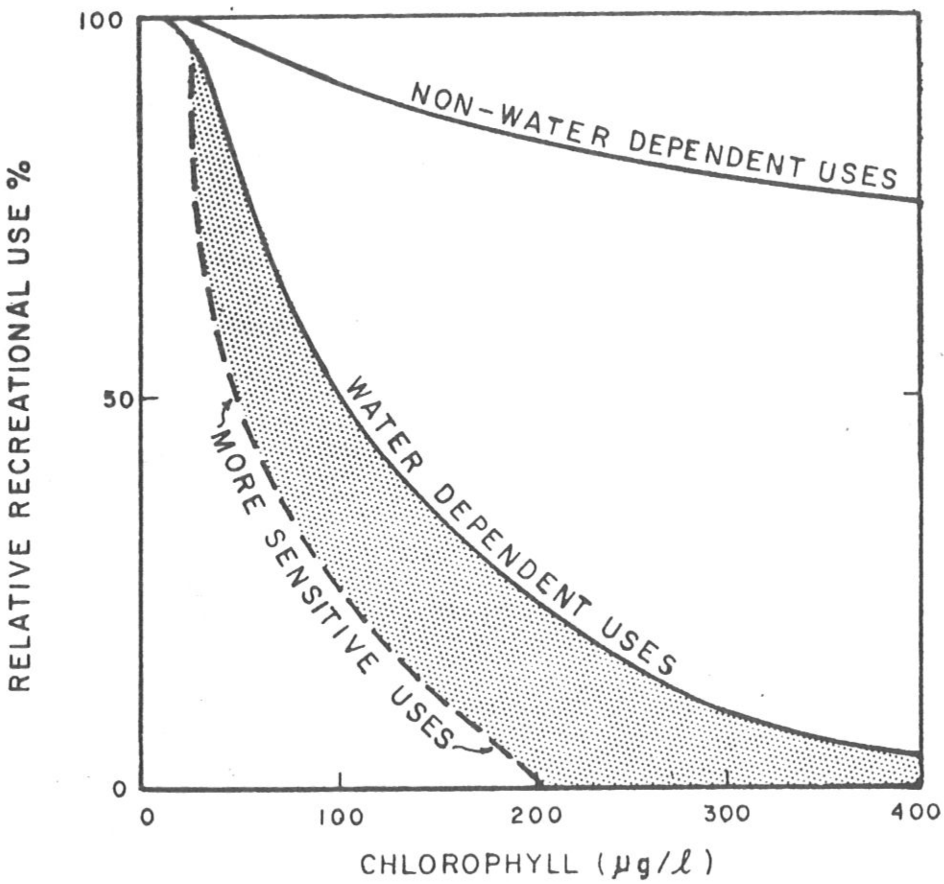
[a]Federal Water Pollution Control Administration, English Ridge Project Water Quality Control Study, Pacific Southwest Region, August 1969.



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

Figure 7-5 Water Quality - Recreational Use Relationship 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 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 cholorphyll 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 guideline 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 for projected watershed controls. Accordingly, it appears reasonable to claim water quality benefits for watershed nutrient controls in the $150,000 to $500,000 per year range. The combination of dilution with watershed controls yields lower cholorphyll values and therefore enhances the benefits.

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,

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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.

the irrigation controls would be worth approximately $31,000 - 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 $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 $266,700 to $793,800. Table 7-2 summarizes these estimated farm-related watershed control benefits.

Table 7-2: Monetary Benefits of Watershed Controls to the Moses Lake Area Farms

	($/year) Actual Watershed Controls	Projected Watershed Controls
Fertilizer	$ 31,000	$ 93,000
Irrigation	25,900	77,400
Crop Yield	266,700	793,800
Totals	$ 323,600	$ 964,200

<u>Summary of Benefit Estimates</u>. Moses Lake water quality improvements estimated from watershed nutrient controls alone are in the $150,000 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 $323,600 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 $500,000 to $1,500,000 per year range. Thus, benefits accrue to both agriculture and to water quality control since the nutrients and water saved benefit both. The farmer realizes an added benefit of higher crop yields by maintaining fertility in the root zone rather than leaching soluble nitrates deeper into the soil through over-irrigation. These findings also contribute to the science of water quality control and will be stressed in public information and education activities during the post project irrigation water management phase.

Moses Lake Water Quality Monitoring

A report describing Moses Lake water quality was issued by the University of Washington Department of Civil Engineering in June 1986 as an interim report convering results of in-lake monitoring from 1983 through 1985.[a] This report provides three years of monitoring data and evaluates the lake's response to dilution water releases and division of the City of Moses Lake sewage effluent discharge from Pelican Horn. Dilution water releases occurred in 1983 and 1985; no release water was provided in 1984, however, the city sewage effluent discharge was diverted from the lake in April of that year.

Monitoring Approach

The lake was sampled approximately twice each month from March through September. Major inputs to the lake were sampled on a year-round basis including Crab Creek and Rocky Ford Creek and a spring on Pelican Horn. Lake samples included transects using a boat mounted sampling tube which was operated when the boat was travelling at a constant velocity. Vertical profile samples were also obtained within the transects as discrete samples or composites. A total of 14 sampling locations were included, of which 8 were within the lake itself and 6 were input sources.

Analyses included pH, temperature, dissolved oxygen, phytoplankton cell volume, chlorophyll a, nitrogen, phosphorus, specific conductance and transparency. Special investigations were carried out to determine variability in nutrient and chlorophyll concentrations. These allowed the researchers to compute sampling errors and generally confirmed the value of the transect sampling procedures.

The report also describes a computerized management model of Moses Lake which was used in evaluating effects of dilution releases and alterations to the lake's nutrient load. This model is described in detail in a Master of Science thesis completed at the University of Washington in May 1985.[b] This model is the same one used in predicting water quality for Moses Lake as described earlier in this chapter. The model calculates up lake-down lake mixing, vertical mixing (including both solar energy

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[a] Welch, E.B., et al. Management of Moses Lake Quality, Department of Civil Engineering, University of Washington, prepared for the Moses Lake Irrigation and Rehabilitation District and Washington State Department of Ecology, June 1986.

[b] Marquis, Sally L. A Wind-Phytoplankton Model for the Water Quality Management of Moses Lake, thesis in partial fulfillment of Master of Science, University of Washington, May 1985.

and wind) and growth of two groups of algae (blue greens and diatoms). Nitrate-nitrogen was assumed to be the growth-limiting factor. Net algal growth was also computed considering sinking of diatoms from the water column, zooplankton grazing and death.

Dilution flows into Parker Horn and records of pumping Parker Horn water across into Pelican Horn were reviewed, and records of earlier predilution work in 1969-70 were subsequently compared. The period 1977-1983 was analyzed as a group since dilution water was provided and the city sewage effluent was being discharged to the lake. 1984, a year of no dilution release and the first year of sewage effluent diversion, was considered separately. 1985, the first year which experienced major dilution flows after the effluent was diverted, was also tabulated separately.

In-Lake Monitoring Results

In-lake water quality comparisons for the various years or groups of years were made using total phosphorus, chlorophyll a and transparency as measured by Secchi disc. Improvements in total phosphorus in the lower Parker Horn (Station 7) and Main Lake transects (Station 9) were noted from 1969-70 to 1977-83 when phosphorus concentrations dropped by 50 percent. This improvement was even greater for chlorophyll a (62 percent decrease) and for transparency (83 percent increase). Diversion of sewage effluent showed a reduction of total phosphorus of 60 percent in Pelican Horn in 1984 as compared with 1977-83. By 1985 the total phosphorus content had dropped by 90 percent as compared with 1969-70 (83 percent as compared with 1977-83). Chlorophyll decreased proportionately by over 50 percent since the 1977-1983 period. Transparency improved substantially in Parker Horn, but did not change as much in Pelian Horn due to its shallowness and the presence of large numbers of carp that disturb the organic sediments. An example of the water tansparency improvement in the Parker Horn area is provided in Figure 7-6 .

Algae composition changed as a result of sewage diversion. Green algae concentrations decreased after diversion and were dominant through most of the summer except for bloom periods when blue greens dominated. A massive bloom of blue greens occurred in September 1984. Thus, although a reduction in biomass occurred following effluent diversion, there was a shift to the blue green forms. Results in 1985 (a dilution year) were disappointing as a massive blue green algae bloom occurred in late August and September.

In Lake Monitoring Conclusions

1. Water quality in most of Moses Lake has improved by at least 50%, in terms of algae (chlorophyll) and nutrients (total phosphorus), and by nearly 100% in terms of water transparency, since dilution of the lake began in 1977.

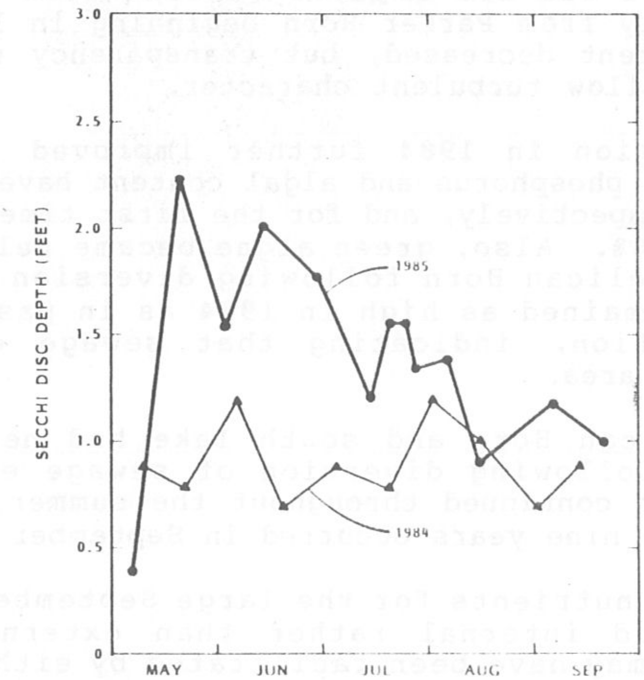
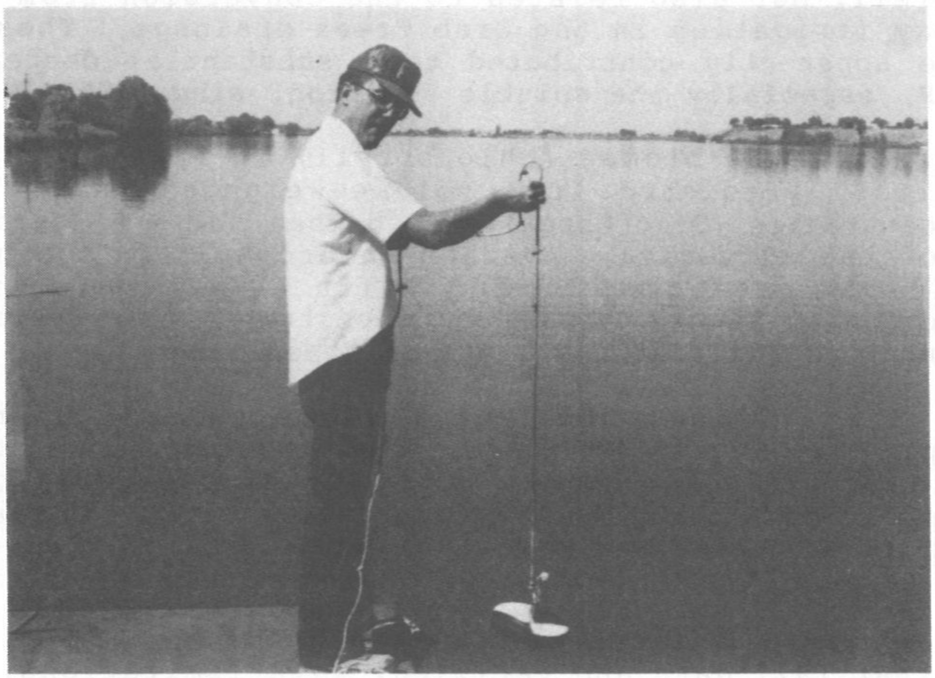


Figure 7-6 Water Transparency as Measured by a Secchi Disk



A Secchi Disk is a Plate-like Target that is Lowered Into the Water to Measure Water Clarity

2. Dilution water did not improve Pelican Horn until it was pumped directly from Parker Horn beginning in 1982, when TP and algae content decreased, but transparency remained poor due to its shallow turbulent character.

3. Sewage diversion in 1984 further improved Pelican Horn quality; total phosphorus and algal content have decreased by 84 and 60%, respectively, and for the first time transparency improved by 50%. Also, green algae became relatively less abundant in Pelican Horn following diversion. Quality at south lake remained as high in 1984 as in past years even without dilution, indicating that sewage effluent had affected that area.

4. Although Pelican Horn and south lake had nearly reached equilibrium following diversion of sewage effluent, and dilution water continued throughout the summer, the largest algal bloom in nine years occurred in September 1985.

5. The source of nutrients for the large September 1985 bloom was considered internal rather than external, and the availability may have been facilitated by either increased wind mixing or buoyant algae. Extensive harvesting of macrophytes in upper Parker Horn for the first time in 1985 (late August through September) was probably not a significant source of nutrients for the bloom.

6. There has been a trend from nitrogen (N) to phosphorus (P) limitation in the lake, largely since the Mount St. Helens ashfall, but also related to the conversion from flood to spray irrigation in the Crab Creek drainage. Those events have apparently contributed to a substantial decrease (75%) in P, especially the soluble fraction, since 1969-1970.

7. Average algal biomas (chlorophyll) in Parker Horn can be reliably predicted from volume-weighted inflow nitrate concentration (Crab Creek) except when the N/P ratio is high (4 of the 11 years). Average chlorophyll in south lake is reliably predicted by the Smith (1982) equation, as a function of TP and TN, which demonstrates the interaction of N and P as limiting nutrients in Moses Lake.

8. The large *Daphnia pulicaria* continued to dominate the zooplankton during 1983-1985. That species, and others, were more abundant in Pelican Horn than elsewhere in the lake, possibly due to the more appropriate size of food particles. *Daphnia* abundance was lowest in Parker Horn in 1985, possibly due to continuous dilution water input.

9. The dynamic Moses Lake management model was calibrated against 1977 data and verified, with limitations, against 1978 and 1979 data. Patterns of biomass change are represented reasonably well, but results generally overestimate biomass.

Watershed Monitoring Results

Water quality measurements were made in the Moses Lake watershed during two periods. The first monitoring period occurred during Stage 1 and included the 1983 water year (October 1982 through September 1983). This Stage 1 monitoring program was a watershed wide survey effort. The second monitoring, which occurred in 1986-1987, was focused on the lower watershed and provided supplemental baseline data for selected stations from the earlier watershed survey. The second monitoring effort was primarily related to irrigation operations and was not conducted on a water year basis.

1982-1983 Monitoring. The Stage 1 monitoring program involved over 80 stations scattered throughout the 2,450 square mile watershed. A total of 25 stations were monitored on a regular basis in what was termed the off-farm monitoring program. The remainder were part of a broad survey effort that was more specifically oriented to impacts of farming practices. Approximately half of the stations were on-farm locations where agricultural runoff or return flows were suspected. These were checked on a periodic basis during the irrigation season following storms. There were nine off-farm stream stations monitored on a regular basis throughout the water year. Groundwaters were evaluated at 26 wells and 12 spring locations. Nine of the wells and four springs were monitored on a regular basis as part of the off-farm program, the remainder were designated on-farm stations and checked on a less regular basis.

Off-farm stations locations are provided on Figure 7-7 and are described further in terms of location, frequency and flow measurement methods in Table 7-3. On-farm monitoring locations are identified in Figure 7-8. Nutrients (nitrogen and phosphorus) were emphasized throughout the monitoring work although suspended solids and specific conductance values were also gathered at many locations. A full discussion of methods and results is provided in the Stage 1 report and data summaries are tabulated in a separately bound appendix. Major findings are summarized in this report.

The data gathered in Stage 1 was helpful in defining the overall nutrient loading to Moses Lake and in identifying the portions of the watershed which most influenced these loadings. The data also provided a background record to be referenced in future years after Stage 3 and other watershed nutrient controls are fully operational. In addition, the data gathering effort was helpful in answering questions which arose in specific parts of the watershed, particularly as related to origins of flow to certain springs. Stream flow and water quality data gathered in Crab Creek and in Rocky Coulee Wasteway also characterized the dilution water input during the spring and summer of 1983. As indicated in Table 6-2, the dilution release that year was 73,250 acre feet. Figure 7-9 shows flow patterns in Rocky Coulee Wasteway as measured upstream and downstream of the East Low Canal.

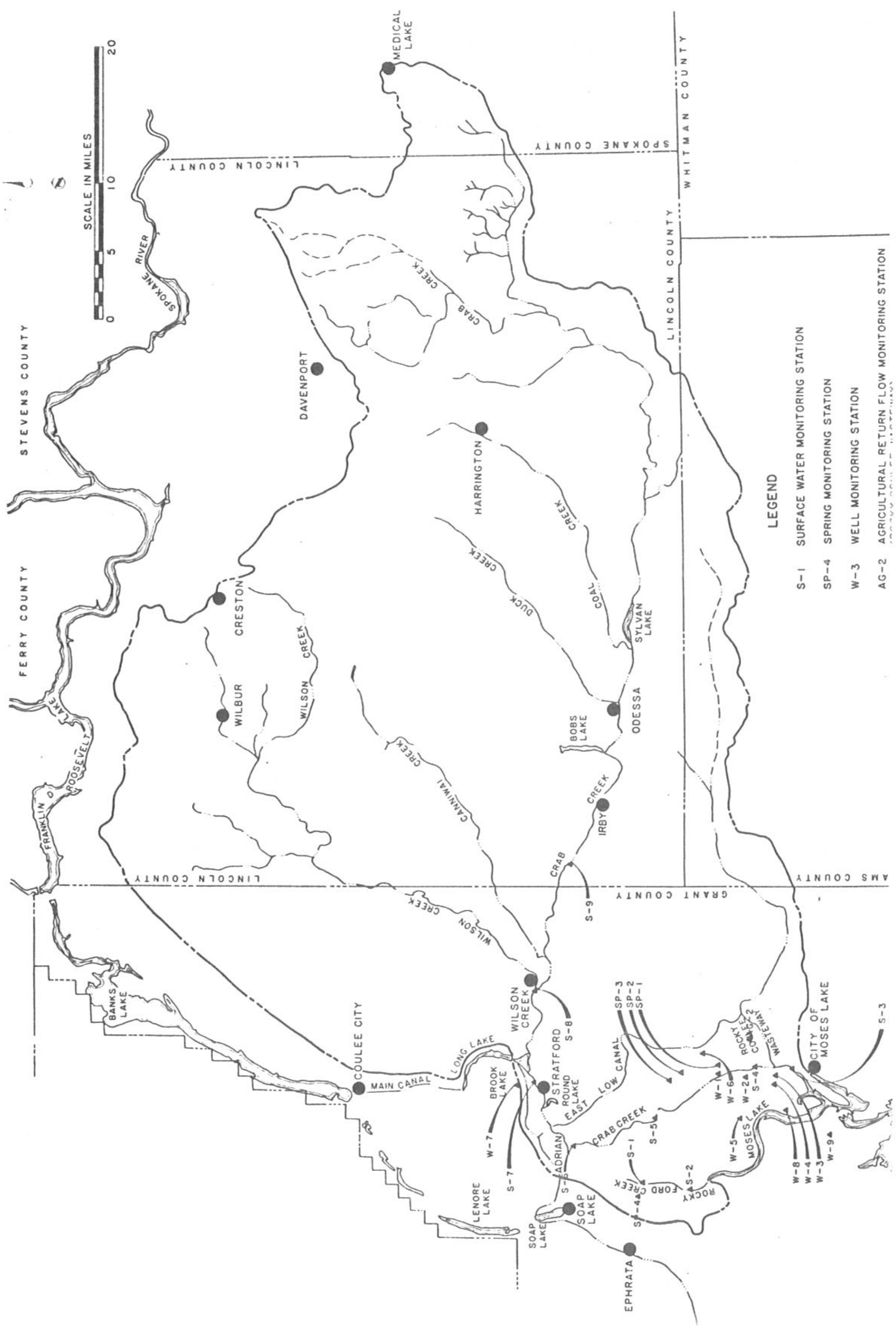


Figure 7-7 Off-Farm Monitoring Stations

Table 7-3 Off-Farm Program Sampling Stations

Station number	Location	Sampling frequency	Flow measurement
S-1	Rocky Ford Creek, downstream from hatchery	Biweekly 2/15 - 8/31 Monthly 9/1 - 2/14	Based on readings at S-1
S-2	Rocky Ford Creek at Rt. 17 (existing site)	Same as S-1	Current meter and staff gage
S-3	Mouth of Crab Creek (existing site)	Same as S-1	Current meter and staff gage
S-4	Crab Creek, upstream from wasteway (existing site)	Same as S-1	USGS gage
S-5	Crab Creek, midway between Stratford and Moses Lake	Same as S-1	Current meter
S-6	Crab Creek south of Adrian	Minimum 3 runoff events and routine during period of flow	Flow-weighted based on USGS gage at Irby; current meter on routine occasions
S-7	Crab Creek at Stratford	Same as S-6	Same as S-6
S-8	Crab Creek at confluence with Wilson Creek	Same as S-6	Same as S-6
S-9	Crab Creek at Irby	Same as S-6	USGS gage
AG-1	Mouth of Rocky Coulee Wasteway (existing site)	Biweekly 5/1 - 9/30 Monthly 10/1 - 4/30	Current meter and staff gage
AG-2	Tributary of Rocky Coulee Wasteway, upstream from railroad tracks	Same as AG-1	Current meter
SP-1	Spring at Game Dept. hatchery	Bimonthly	Game Dept. records
SP-2	Craig Springs	Bimonthly	Current meter
SP-3	Magpie Spring	Bimonthly	Timed level rise behind dam
SP-4	Spring at Rocky Ford Creek hatchery	Bimonthly	Current meter
W-1	Game Dept. hatchery well	Bimonthly	None
W-2	Grant County PUD well	Bimonthly	None
W-3	Parker well	Bimonthly	None
W-4	Simpson well	Bimonthly	None
W-5	City of Moses Lake	Bimonthly	None
W-6	Post well	Bimonthly	None
W-7	DeMille well (Stratford)	Bimonthly	None
W-8	Essex/Ayers well	Bimonthly	None
W-9	Hansen well	Bimonthly	None
Sed-1	Sediments at mouth of Crab Creek	Quarterly	None

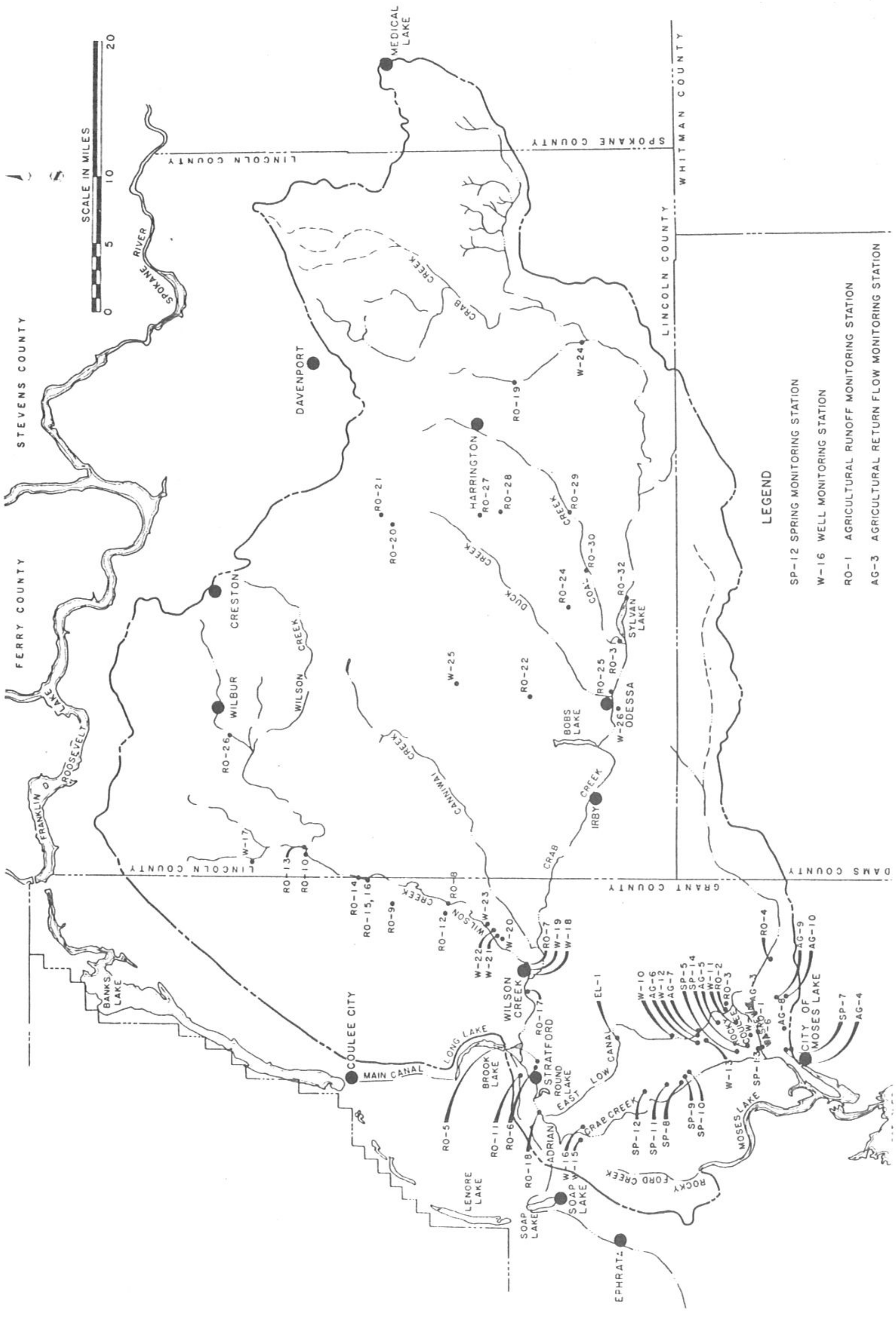


Figure 7-8 On-Farm Monitoring Stations

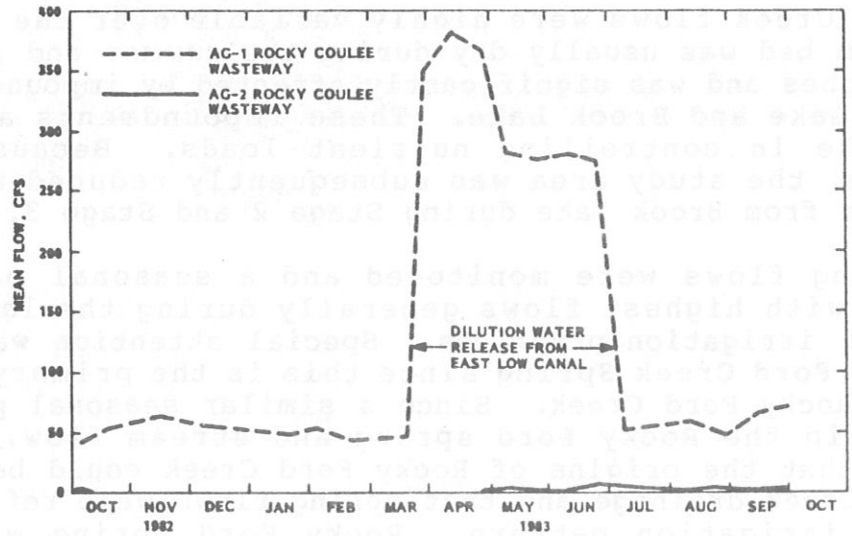


Figure 7-9 Measured Flow, Rocky Coulee Wasteway

Crab Creek Downstream of Rocky Coulee Wasteway

Crab Creek flows were highly variable over the watershed. The stream bed was usually dry during the summer and fall in the upper reaches and was significantly affected by impoundments such as Round Lake and Brook Lake. These impoundments also have a major role in controlling nutrient loads. Because of this influence, the study area was subsequently reduced to the area downstream from Brook Lake during Stage 2 and Stage 3.

Spring flows were monitored and a seasonal pattern was apparent with highest flows generally during the late summer, reflecting irrigation practices. Special attention was given to the Rocky Ford Creek Spring since this is the primary source of water in Rocky Ford Creek. Since a similar seasonal pattern was observed in the Rocky Ford spring and stream flow, it became apparent that the origins of Rocky Ford Creek could be traced to the Crab Creek drainage and that spring flows were reflecting the seasonal irrigation pattern. Rocky Ford Spring was notably higher in phosphorus than springs in the lower portions of Crab Creek. Subsequent evaluations of water quality in wells near the Rocky Ford springs were conducted during Stage 2; these results gave further evidence that the source waters came from the east and north. This finding was consistent with findings of the U.S. Bureau of Reclamation and observations of various geologists. See Stage 2 report for a more complete discussion of the origins of Rocky Ford Spring flows.

Crab Creek flows, influenced by surface runoff, dominated winter loading to Moses Lake. As precipitation decreased in the spring and irrigation began, the source of loading shifted to groundwater. Both pathways are being affected by agriculture: surface-applied fertilizer washes off the land surface during rainfall events in the winter, and nutrients not utilized by plants percolate downward to reach underlying aquifers.

In general, runoff samples had a very high percentage of total nitrogen loading compared to nitrate loading (the dissolved portion). The relationship between soluble and total phosphorus is much the same: in runoff, most of the phosphorus load in contributed by total phosphorus as opposed to soluble phosphorus. Wells and springs, on the other hand, contributed a much larger portion of the soluble constituents, with nitrate and soluble phosphorus constituting most of the load. This leads to the conclusion that runoff loading is largely particulate-lade pollutants, while percolation of soluble nitrogen and phosphorus is the major component of groundwater loading.

Surface water impoundments along the Crab Creek watershed prevented most of the surface water-transported nutrients generated in the upper watershed from reaching Moses Lake. This is illustrated on Figure 7-10. Therefore, the area of primary concern to prevent short-term nutrient enrichment in Moses Lake is the lower portion of the watershed, particularly the irrigated area of Block 40, 41 and 401.

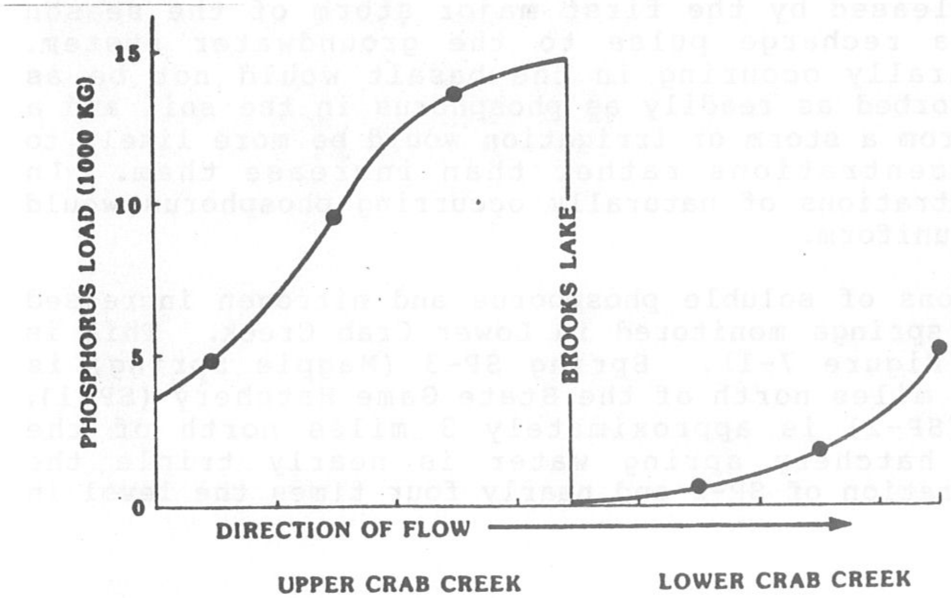


Figure 7-10. Phosphorus Loadings in Crab Creek

Conductivities for the area's groundwater are generally in excess of 300 micro MHOs which reflects a concentration of total dissolved solids. Conductivities of 300 to 500 micro MHOs are not unusual for discharging groundwaters. The long transit time and contact with subsurface materials results in high conductivities as compared with conductivities in the range of 100 to 150 micro MHOs for Columbia River water in the East Low canal. Three stations exceeded conductivities of 800 micro MHOs, indicating a high possibility of surface water contamination of the well or spring. In the case of wells, this is quite typical of unsealed or improperly sealed wells.

The phosphate concentrations in groundwater are not unusually high, ranging from about 20 to 250 ug/l. Although levels of this magnitude could normally be attributed to naturally occurring phosphorus, the concentration distribution, reaction to recharge effects and variability would indicate that the phosphorus present in the groundwater can probably be attributed to land use activities. Rocky Ford Spring had a consistently higher phosphorus concentration than the Crab Creek springs. See Figure 7-11.

In virtually all of the sampling stations evaluated, the soluble reactive phosphorus (SRP) or orthophosphate component was usually 50 to 100 percent of the total phosphorus which is much higher than the 10 to 30 percent distribution normally found in groundwaters. The highest concentrations of phosphorus tend to occur during the first storm period of the year. This is the first flush phenomena characteristic of phosphorus. Apparently, phosphorus builds up in the soil or rocks due to adsorption or partial adsorption. The phosphorus (or most of it) is then dissolved or released by the first major storm of the season which creates a recharge pulse to the groundwater system. Phosphorus naturally occuring in the basalt would not be as likely to be adsorbed as readily as phosphorus in the soil and a recharge pulse from a storm or irrigation would be more likely to dilute the concentrations rather than increase them. In addition, concentrations of naturally occurring phosphorus would tend to be more uniform.

Concentrations of soluble phosphorus and nitrogen increased downgradient in springs monitored in Lower Crab Creek. This is illustrated on Figure 7-11. Spring SP-3 (Magpie Spring) is approximately 4 miles north of the State Game Hatchery (SP-1). Craig Springs (SP-2) is approximately 3 miles north of the hatchery. The hatchery spring water is nearly triple the nutrient concentration of SP-2 and nearly four times the level in SP-3.

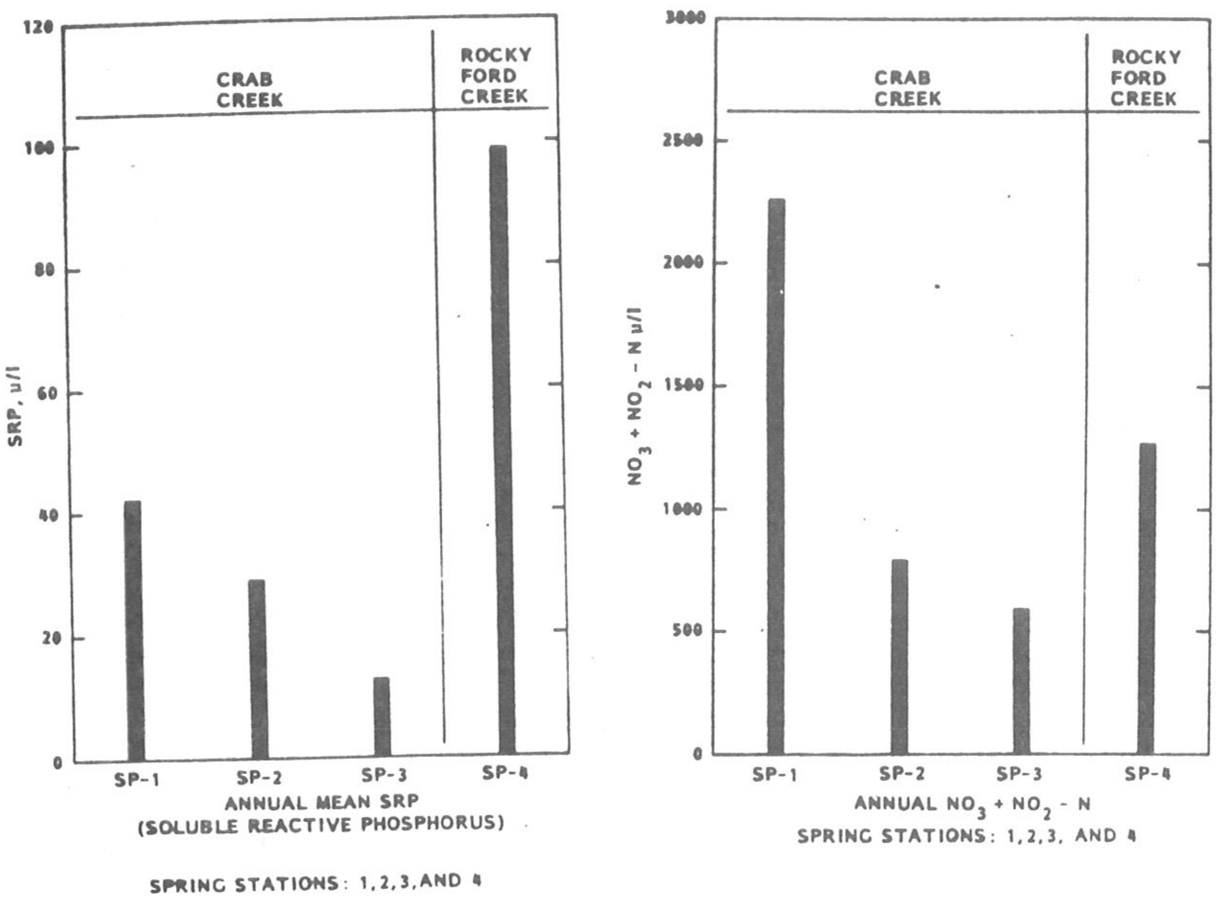


Figure 7-11. Soluble Nutrient Concentrations in Off-Farm Springs

Nitrate concentrations in the groundwaer usually ranged from 1,000 to 3,000 ug/l. However, recharge pulses due to storms and irrigation were also evident where concentrations increased to more than 7 mg/l with the highest being 51 mg/l. These higher concentrations indicate a high potential for surface water contamination of the wells and springs. Most of the wells east of Moses Lake in the vicinity of Crab Creek exhibited a wide range in nitrate fluctuations. Two to four mg/l fluctuations are not unusual. Rocky Ford Creek, on the other hand, exhibited a fluctuation range of less than 1.5 mg/l.

Clearly irrigation practices affect the groundwater quality. The data indicates some surface water contamination of wells is probable. Most of the wells in the vicinity of Crab Creek or heavily irrigated areas increase their nitrate concentrations in response to both stormwater and irrigation recharge pulses.

1986-87 Watershed Monitoring. A total of 15 stations were sampled in the watershed from March 1986 to March 1987. These monitoring locations included six surface water stations, four springs and five wells. See Map Figure 7-12 for locations. All but one of these stations (Rocky Ford Creek damsite) were also occupied during the 1982-1983 Stage 1 off-farm monitoring program. Data are provided in a separately bound appendix. Results are summarized here and compared with the Stage 1 data.

Recorded flows in Crab Creek were lower in 1986-87, which significantly affected nutrient loadings. Total phosphorus and nitrate nitrogen concentrations were generally lower in 1986-87 also. The overall overage concentration of total phosphorus in Rocky Ford Creek (Station S-2) was 0.166 mg/l in Stage 3 (1986-87) compared with 0.196 mg/l in Stage 1 (1982-83); Rocky Ford Creek nitrate nitrogen was 1.34 mg/l in Stage 3 and 1.64 mg/l in Stage 1. Crab Creek measurements at the USGS gaging station showed total phosphorus of 0.08 mg/l in Stage 3 compared with 0.07 mg/l in Stage 1 while average nitrate dropped slightly (0.93 mg/l in Stage 1 and 0.88 mg/l in Stage 3 sampling). Rocky Coulee Wasteway exhibited reduced nitrogen and phosphorus concentrations in Stage 3 samples.

Nutrient concentrations in three of the four springs sampled were consistent with the stream results. The Rocky Ford Creek spring at the headwaters of the creek showed a drop in total phosphorus from 0.12 mg/l to 0.08 mg/l between the Stage 1 and Stage 3 sampling. Nitrate was essentially unchanged. Notably higher phosphorus values within the creek itself were presumably due to the stream bottom disturbance effects of carp and other waterbed activities. Nitrate did not increase significantly downstream as compared with the spring values. Crab Creek springs at the Game Hatchery (SP-1) and at Reffett Springs (SP-2) showed only very slight reductions in phosphorus (about 5%) and were comparable for nitrate between Stage 1 and Stage 3 although SP-2 nitrates were about 10% higher during Stage 3. The values reported for Magpie springs were very different and there is a

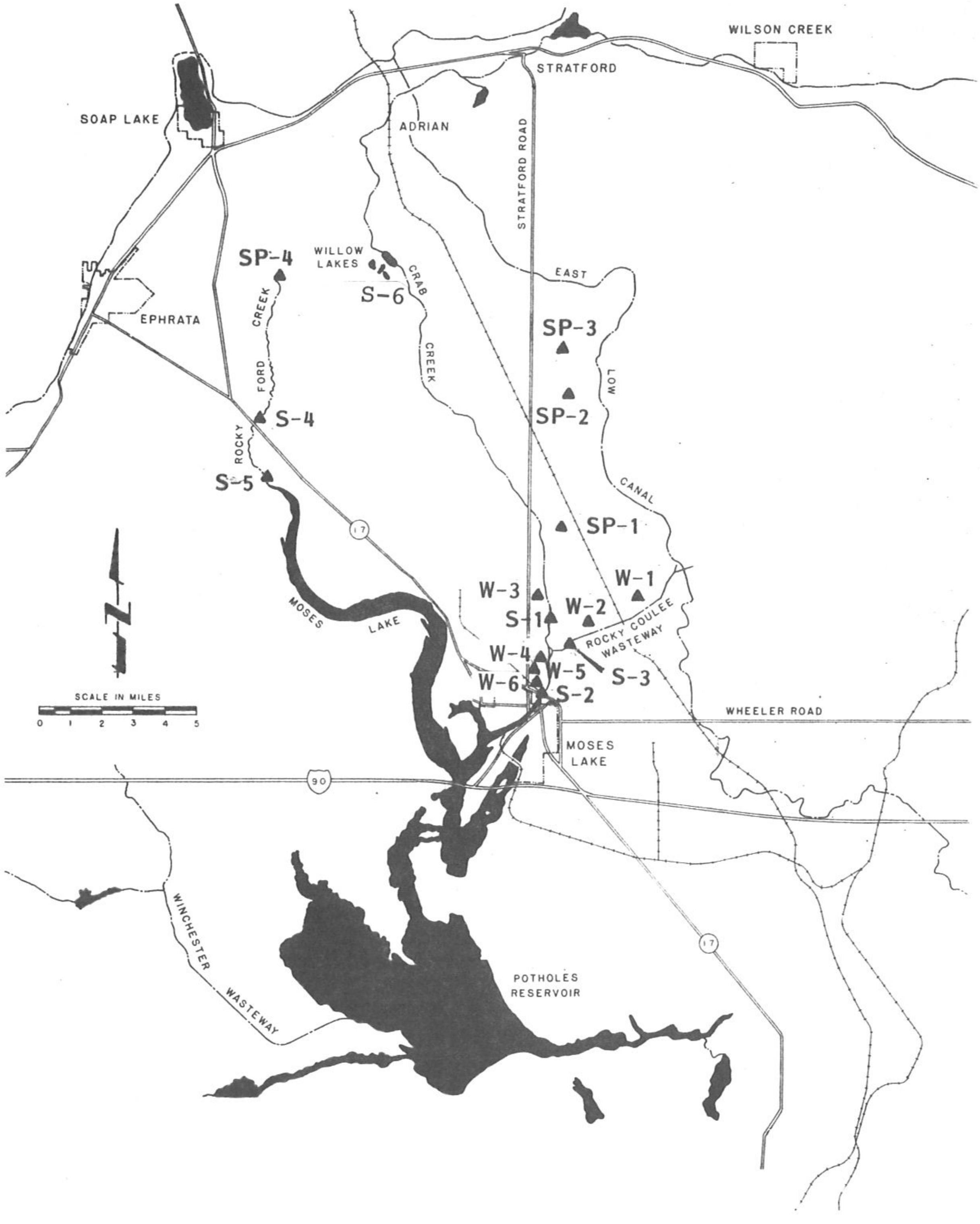


Fig. 7-12 Moses Lake Watershed Monitoring Stations

question whether the sampling location was the same between Stage 1 and Stage 3. Significantly higher Stage 3 nutrient values (more than double) and earlier confusion on the Stage 1 spring location suggest the wrong spring may have been sampled.

Wells sampled showed generally lower nutrients for those sampled on the west side of Crab Creek. For example, the Grant County Public Utility District well (W-2) averaged 0.05 mg/l total phosphorus in Stage 3 sampling compared with 0.07 mg/l during Stage 1 and averaged 1.92 mg/l nitrate nitrogen in Stage 3 compared with 2.35 mg/l in Stage 1. In contrast, on the east side of Crab Creek, the Dean Black well averaged 3.08 mg/l in Stage 1. Phosphorus values for the Black well were only very slightly higher in Stage 3. The other east side well (Burman) showed slightly (10%) higher total phosphorus in Stage 3 but had generally lower nitrate values.

The Stage 3 watershed monitoring provides additional background data for subsequent comparisons after future watershed nutrient controls are accomplished. Irrigation water and fertilizer management programs scheduled for 1987 through 1989 are expected to cause reductions in nutrient losses from participating farms. Monitoring of selected watershed stations in 1988 and 1989 is being recommended in Chapter 8 in order to provide data on potentially affected ground and surface waters in the vicinity of Moses Lake.

CHAPTER 8

RECOMMENDED FUTURE ACTIVITIES

This report describes the activities covered under the three stage Clean Lakes Project including the dilution project activities that preceded it. The capital improvements aspect of the EPA on-farm cost-share program has been completed and, as a direct result, improved irrigation systems are in place on 36 farms. However, the operational phase is just beginning and each farmer has a contractual obligation to carry out irrigation and fertilizer management. EPA cost-share money has been obligated to fund eligible portions of these on-farm management programs for a three-year period. Technical support will be needed over this three-year period to establish appropriate irrigation and fertilizer management practices. This effort will require additional funding to be successful.

Another future activity includes annual in-lake monitoring studies which have been funded by a DOE grant to the MLIRD which is in effect through 1989. These yearly studies include evaluations of Moses Lake water quality which will be conducted by Dr. Eugene Welch of the University of Washington, Department of Civil Engineering.

A third activity which has been scheduled for the post project period is watershed monitoring. The objective of this monitoring effort is to determine if water quality changes have occurred in the groundwaters and surface waters entering Moses Lake and to determine if changes can be attributed to the Clean Lake Project.

More detailed descriptions of these three planned post project activities are provided in this chapter. All three activities are recommended, however, at this time only the in-lake monitoring effort has full funding support. The irrigation water management tasks may receive limited funding in 1987 from unexpended Stage 3 DOE grant funds; however, there is uncertainty over the amount of residual funding available. No post-project monitoring funds have been identified, although grant funding possibilities exist for this activity as well as for irrigation water management purposes.

Irrigation Water Management Tasks

At the close of Stage 2 the on-farm technical assistance and monitoring work was expected to be carried out by the SCS as a part of that agency's mandate. This role was considered logical at that time; however, agency budget constraints and commitments associated with the 1985 Farm Bill have forced a re-evaluation of post project implementation. At the close of Stage 2 selection of an irrigation water management agency had not been completed and this important topic eventually became one of the more intensely considered elements of Stage 3. The importance of the post project management phase became all the more evident as the Stage 3 cost-share contracts were formalized and implemented.

The Moses Lake Clean Lake Project has provided federal cost share monies to 36 farms in the Block 40 and 41 area of the USBR Columbia Basin Project. Approximately $1.1 million in federal cost share has come from Environmental Protection Agency (EPA) funds through the Region X office in Seattle. Over $100,000 in additional cost-share money has been provided through the ASCS field office in Ephrata. Most of the cost share money was used to convert or upgrade existing irrigation installations to modern sprinkler systems. Participating farmers received 30 to 75 percent of the necessary funding from the EPA cost share program up to a maximum of $50,000 for an individual farm. ASCS contributions were limited to $3,500 per farm per year.

Farmers receiving EPA cost share monies signed contracts which require participation in a 5-year program involving improved irrigation water and fertilizer management as well as upkeep and use of the installed systems. The following work scope outlines the tasks involved during this management phase.

Task 1 Irrigation System Operation Verification

Each of the participating farms has signed an agreement with the Moses Lake Irrigation and Rehabilitation District which obligates the contracting farmer to maintain and operate irrigation system improvements funded under the cost share program. This task involves periodic inspections to verify the cost share equipment is on the farm and being maintained and used for its intended purpose. Each of the 36 farms which participated in the Stage 3 cost share program will be checked each year and an annual verification certificate will be prepared and placed in the appropriate farm file maintained by MLIRD.

Task Outputs:

- Verification folder (farm file) for each participating farm by October 31, 1987

- Annual certifications of operation for each farm by October 31 of each year (1987, 1988, 1989)

Task 2 Soil Testing and Fertilizer Application Verification

Most farms involved in the cost share program have a budgeted amount of money set aside for purposes of soil testing and fertilizer management. Split fertilizer applications are one of the cost-share items which have been identified and an annual allowance is established in each water quality management plan at $5 per acre which can be reimbursed after verification. Inspections will be necessary and farm records will be reviewed to determine that acceptable soil testing procedures (based on Extension Service Soil Testing Certifications) and acreage and fertilizer timing eligibilities are verified and considered appropriate to the soil and crop involved. Inspectors' findings will be noted on the annual verification certificate in the MLIRD files.

Task Outputs:

- Annual records of fertilizer application for each farm by October 31 of each year

- Soil test results for each farm

- Annual inspection report on split fertilizer application in farm file by October 31 of each year

Task 3 Irrigation System Performance Testing

All irrigation systems will be field checked to determine if water is being applied uniformly. Container grid tests will be performed on systems to determine the uniformity of irrigation water application. The extent of grid testing will be dependent on field evaluations. Judgement of the farmer and personnel involved in water management will be relied on in determining whether to perform such tests. Field conditions including wind will be monitored and field results will be evaluated in a manner acceptable to SCS standards when such tests are performed. In some cases, such tests may be limited to corners or end gun areas which have proven to be more susceptible to variations in irrigation water distributions. Use of infra red photographs may be used to supplement field testing or as a diagnostic tool in evaluating uniformity or adequacy of irrigation water applications.

Task Outputs:

- Irrigation system test needs noted in farm file (annual entry during season)

- Test results and follow-up report for each system tested

- Infrared photos in farm file with notes on their interpretation

Task 4 Irrigation Scheduling Evaluation

Participating farmers will install tensiometers in their fields at depths of 12 and 18 inches. Tensiometers are a cost share item in this management phase of the project and EPA budget is set aside for this item for each farm. Farmers have been required to use soil moisture results from the tensiometers as part of their irrigation scheduling decision process. Project personnel will assist the farmer in the use and maintenance of the tensiometers and will be available for consultation in the irrigation scheduling process. The farmers are required to maintain Irrigation Water Management hand books (furnished by the project) which include data on tensiometers, irrigation system operation timing and fertigation. Using this data, an analysis will be performed by the project staff to determine water application, evaporation and crop uptake rates and this information will be provided to the farmer to assist him in making proper water management decisions. At the end of each irrigation season, a water use summary will be prepared which will be cross-checked with East Columbia Basin Irrigation District water delivery records and with USBR stream flow check station records as applicable.

Task Outputs:

- Tensiometer installation report in farm file by October 31, 1987

- Farm consultation visit log in farm file with notes on conversations

- Copy of IWM Handbook for each year in farm file

- Copy of each irrigation water analysis provided to farmer

- Water use and yields summary by December 31 for each year

- Irrigation District/USBR records check re water use by December 31 of each year

Task 5 Verification Records and Reporting

Each farm operation will be evaluated as described in Tasks 1 through 4 and an annual summary prepared on the irrigation water management program and its results. Crop yield and comparisons of past fertilizer and water use patterns and other pertinent information will also be gathered to help determine the extent of cost savings as well as farmer acceptance in the program. Projections of the effect of these farm practice changes will be made to estimate their impact on Moses Lake nutrient loadings and water quality. These estimates will be included in the annual summaries along with a discussion of benefits to water quality, recreational uses and farmers.

Task Outputs:

- Sign-off on farmer receipts re cost-share reimbursement by February 1 of each year

- Annual summary of IWM program/results

- Projections of farm practice effects on nutrient loads in each yearly summary

- Projections of nutrient load effects on water quality in each yearly summary

- Evaluation of benefits to water quality and farmers in each yearly summary

Task 6 Information and Education

Results of the post project IWM program and related lake and watershed monitoring activities will be communicated to the public as well as to participants. The on-farm fertilizer and irrigation water management part of the program will be communicated in at least four ways. The first of these methods will be via one-on-one conversations during the irrigation season between field technicians and participating farmers; the second will be through group meetings during the off-season with both participating farmers and other farmers interested in the program. These farmer oriented meetings will include discussions of project activities, results and projected benefits, and will provide a forum for obtaining additional data, comments or testimonials. A third aspect of the information and education (I & E) program will be annual summary reports prepared for distribution to interested individuals in public meetings and at appropriate public contact points such as the Grant County Fair. The fourth planned aspect of the I & E program includes intermittent press releases, TV coverage and speaking engagements within as well as beyond the Moses Lake Clean Lake project area.

Task Outputs:

- Public information meetings with farmer participants and others re project activities/results each winter

- Summaries (per task 5) to be handed out to participants/ others

- Press releases and informational talks to groups in the project area

Task 7 Project Management and Administration

Post project activities will require close coordination and management/administration. This aspect includes accounting and related administration of the remaining EPA cost-share monies as well as coordination of the various agencies and other participants involved in the technical aspects of the on-farm and monitoring activities. A quarterly review of the status of cost-share disbursements and budgets should be provided. The large number of potential participants requires a coordinator/manager to assure budgets and schedules are met and that technical tasks are being carried out to an appropriate level of effort consistent with project resources.

Task Outputs:

- Quarterly cost-share program disbursement/budget status reviews

- Coordination meetings between technical/management staff and with funding agency representatives

Task 8 Weather Station/Lake Temperature Recorder

A weather station with satellite communication capabilities will be selected, purchased and installed at a site to be located in the Block 40/41 vicinity. This will be a remote, automatic station that monitors rainfall, wind, solar radiation, relative humidity, air temperature and other conditions. Data transmission will be by UHF to a stationary satellite. Station purchasing and maintenance details will be coordinated with the U.S. Bureau of Reclamation, Bonneville Power Administration and the Grant County PUD with a view to working out joint operating arrangements. A temperature recorder capable of monitoring lake water temperature will be selected, purchased and installed in a suitable secure location to provide in-lake temperatures for future correlation with weather data, dilution releases and lake operations.

Task Outputs:

- Selection/purchase of Weather Station Package

- Installation of Weather Station by March 1988

- Selection/purchase of Lake Temperature Recorder

- Installation of Lake Temperature Recorder by March 31, 1988

Task 9 Final Report

A final technical report (100 copies) describing IWM activities, data and results will be prepared and distributed to interested agencies and individuals. This report will include an evaluation of the impact and benefits of IWM programs on Moses Lake water quality, and will provide the technical documentation of the program for future use in consideration of irrigation project developments and practices in the study area and in upstream areas such as the East High Canal service area. A summary report (500 copies) designed for less technical readers shall be prepared for general distribution.

Task Outputs:

- 100 copies of Final Report by March 1, 1990

- 500 copies of Final Report Summary by March 1, 1990.

Alternative Contracting Approaches

Long term contracts executed by MLIRD with individual farmers contain provisions for cost-share of operational items during 1987, 1988 and 1989. These operational items include irrigation water management (IWM) and fertilizer management (FM). IWM is eligible for cost share at a 75 percent rate OF $5 per acre for center pivot sprinklers and $7.50 per acre for wheelines and solid set sprinkler systems and $10.00 per acre for cablegation. Split fertilizer applications are eligible for 100% cost share for up to $5.00 per acre and soil tests related to fertilizer management are eligible for 75% cost share. These cost share monies are for the most part to be paid to the farmer on the basis of his performance and cooperation as determined by monitoring carried out by project staff.

The specifications which a farmer should meet in order to comply with his contract have been provided with the Water Quality Management Plan. A farmer may elect to carry out the IWM and FM specifications with minimal assistance from others or some level of technical assistance could be provided to him through the Moses Lake Conservation District (MLCD) working in conjunction with the U. S. Soil Conservation Service (SCS) or a private contractor retained specifically by the Clean Lake Project. Alternative Irrigation Water and Fertilizer Management (IW&FM) programs are described below which illustrate options available as regards scope, cost and funding sources for this on-farm operational phase of the project.

Alternative A - Full Service IW&FM and I/E Program

A fully developed IW&FM program has been proposed by the MLCD which provides for on-farm technical assistance by SCS, information/education and full time project management and administration. This program also includes a separable watershed monitoring component. Cost for the IW&FM, I/E and Project Management elements of the MLCD proposal have been estimated at $324,000 for a three year effort. Funding has been sought by MLCD through the Washington State Conservation Commission where 75% grants are available from the State Centennial Grant Fund. Local match could be from MLIRD.

Alternative B - Technical Service Oriented IW&FM Program

A condensed program emphasizing technical assistance to farmers including irrigation system performance testing and irrigation scheduling can be identified from the SCS input to the MLCD program. MLCD could provide administrative support and retain SCS for technical assistance similar to the arrangements used under Stage 1 of the Clean Lake Project where SCS provided the necessary management. Formal information/education activities would be limited to information exchanges in such forums as Block 40 meetings. This program would provide a lesser degree of information/education and part time project management. Estimated cost for this approach is $164,000 over three years. Funding could be sought from DOE by MLIRD from remaining project funds and referendum 39 monies available for 75% grants or as a 50% match from centennial monies available from DOE. MLCD could also seek funding from the Conservation Commission for this alternative.

Alternative C - Compliance & Assistance IW&FM Program

A third alternative emphasizing long term contract compliance monitoring and a limited technical assistance package has been identified using either a public sector contractor (MLCD) or a blend of public sector and private sector resources or a totally private sector approach. This alternative also assumes that 1987 activities would be conducted at a level consistent with funds left over from the Stage 3 project. Contract compliance and on-farm assistance in soil moisture testing and tensiometer maintenance should be provided by SCS personnel working through contracts with MLCD. If this is not feasible based on work loads or other factors, the contract compliance aspect could be made a private sector activity if the agency responsible for performance audits can establish clear guidelines for the contractor. Irrigation system performance testing and evaluation could be provided on a limited and as needed basis by private contractors. Irrigation scheduling assistance could be conducted by one or more private contractors on selected fields on individual farmer requests subject to available funding.

The 1987 season work would be carried out for up to $50,000 depending on the extent Moses Lake Clean Lake grant money is unexpended during Stage 3. Funding assistance in subsequent years (1988-89) would be requested from DOE by MLIRD using 1987 season experience as a basis for scoping the follow up work. Administration and part time project management would be provided by a private sector contractor who would also assemble the compliance forms and IW&FM project documentation and relate results to Clean Lake Project goals.

Ideally compliance with Moses Lake Clean Lake Handbook procedures for the long term contracts should be determined by SCS using input from their staff inspections and consultant information. On-farm technical assistance would be offered to the cooperating farmers who could utilize government technicians or one of two prequalified agriculture consultants for the IWM assistance depending on which contracting approach is taken. Such assistance would be provided at the request of any farmer cooperating but could be made mandatory for cost share eligibility after 1987 if farm inspections reveal sustained wasteful irrigation practices. Overall coordination with SCS and agricultural consultants and management and reporting of the 1987 IW&FM project could be by the Irrigation District's environmental engineering consultant.

Weather Station Installation

A solar-powered weather station with satellite hook-ups for data access is desirable for the project area and efforts would be made to secure such a station for the Block 40 acre. Realistically, such a station could not be installed for the 1987 season, however, one should be requested as part of a grant request for installation before the 1988 season. See Appendix for details on such a weather station and its use in irrigation water management.

IWM Program Evaluations

Definition of an IWM program and its implementation approach has been a major and sometimes controversial aspect of the Stage 3 project. The three alternatives described provide three different implementation concepts for three different levels of effort. Variables described include the level of involvement by the Conservation District (MLCD) which range from active management to administrative or clerical support and the extent of information and education and the level of the technical assistant effort on the 36 participating farms. Clearly a matrix of institutional and work scope arrangements is possible which includes a great number of valid possibilities for implementation.

Various criteria have been considered in discussions of IWM program alternatives. Budget availability is key to the final definition of scope, and agency continuity, flexibility and credibility are all keys to determining the implementing agencies, particularly as related to acceptance within the local farming community. These criteria have been among the major factors considered by the Moses Lake Irrigation and Rehabilitation District in working out their recommended IWM program.

Budget Availability. Discussions of budget availability have centered on two aspects. First is the immediate need to establish an IWM program for the 1987 season. This need focused attention on existing funding sources including availability of MLIRD funds to initiate the effort and monies which are projected to be left over from the existing DOE grant that might be applied to 1987 IWM work with minimal administrative delay. Second was the larger aspect of long term funding through 1989. Long term funding clearly will involve a grant request to obtain DOE funding, a process which will take time and entails competition with other state grant applications.

Project Continuity. Discussions of potential project participants have stressed a need for continuity within the participating agencies. This desire has stressed the need for some level of technical involvement by SCS within the IWM phase since the procedures for IWM and the cost-share program have been prepared by that agency. However, it has also been understood that local SCS personnel are currently committed to carrying out farm bill programs which leaves less time available for Clean Lake Project work as compared with past years. Continuity is also important for the information and education component. Fortunately, this aspect can be a shared responsibility so long as there is a coordinating center. The information exchange envisioned under IWM has at least four functions which can be carried out by different project participants. As discussed in the I & E task description, these functions range from one-on-one discussions with farmers during the irrigation season to group seminars in the off-season, to project reports and press releases. For example, one-on-one discussions with farmers will be initiated by field pesonnel in day-to-day technical assistance assignments. These technicians will be briefed by an I & E specialist to assure program continuity. Group meetings can be run by an I & E specialist with support from project technical staff. Project reports and informational handouts can be prepared by technical staff to meet I & E needs; whereas press releases and newsletters could be assigned to an I & E specialist. The I & E specialist could be provided by one of several agencies during the project. This function has been the responsibility of the Washington State University Cooperative extension in Stage 1 and the MLCD during Stages 2 and 3. Project report summaries used in the I & E effort were prepared by R. C. Bain.

Flexibility. Budget vagaries and uncertainties over the roles of participants (such as SCS staff commitments) have required that the evaluation include consideration of more alternatives. Agency willingness to work within the uncertainties of IWM contracting requirements was necessary since work scope and budget could not be precisely established. The need for an early start on IWM was felt and it was important that participants were prepared to work recognizing these constraints could alter or even terminate much of the program if long term funding were unavailable. This discussion led to discussions of various levels of effort as well as the possible need for private sector assistance to supplement SCS staff. Levels of effort were debated considering minimal compliance with long term contracts on the one hand and the larger goals of the program which emphasized IWM as the primary vehicle to change farming practices to reduce nutrient losses from the fields.

Credibility. The credibility of the Moses Lake Clean Lake Program was also discussed in evaluation sessions, particularly as related to early implementation for the 1987 irrigation season and to meet the project goals of reduction of nutrient loads to Moses Lake from the watershed. This factor has stimulated the IWM discussions and actually caused a recommendation to emerge which has concurrence of all participating agencies, despite the uncertainties of funding and agency staff involvement cited earlier.

Recommended IWM Program

The Moses Lake Irrigation and Rehabilitation District developed and approved a recommended IWM program in April 1987 following extensive deliberations with participating agencies. This program is outlined below in terms of participant roles and anticipated budget commitments. The nine tasks described earlier in this chapter describe the desired work elements for this IWM program.

The program is first described for the 1987 season and subsequent evaluation period. Similar recommendations are made for 1988 and 1989, however, additional program elements are included for these two years to support installation of a weather station with satellite data transmission, post project watershed monitoring and a final summary report.

Three proposals were received from the SCS in April 1987 describing different levels of their technical support effort for IWM programs ranging from $54,690 to $127,960. These were transmitted to MLIRD following a meeting between the SCS and the Moses Lake Conservation District (MLCD). The MLCD stated in an April 23, 1987 letter that a direct contracting arrangement between MLIRD and SCS was acceptable. The MLIRD accepted the SCS proposal for technical support at an intermediate funding level of $93,140. This intermediate (Level II) IWM program is included in the Appendix and fits within the programs described for 1987 and 1988-89 as described and budgeted in the following paragraphs.

1987 IWM Program. The recommended program budget for IWM is itemized below according to project tasks and participants. This program, as approved by the MLIRD directors, represents a maximum funding commitment of $80,000. Budget allocations are detailed by task and project participant in Table 8-1. It is anticipated that the program will start in May 1987 using MLIRD funds and that unexpended Stage 3 grant monies will be provided by DOE to support the remainder of the effort through 1987. If such funds do not support the recommended budget, there will be reduction of efforts in all but the long term contract compliance verification tasks (Tasks 1, 2 and 5) in order to balance the work load with available funding.

Table 8-1 Recommended 1987 Irrigation Water Management Program

		Recommended Budget	Participant/Role
Task 1	Irrigation System Operation Verification	$ 2,000	SCS to verify system is in place/ operating and prepare certification file. MLCD provides clerical support.
Task 2	Soil Test/Fertilizer Application Verification	3,000	SCS to review soil test and verify farmers' records of split fertilizer application. MLCD provides clerical support.
Task 3	Irrigation System Performance Testing	6,000	SCS to approve system testing by irrigation consultant(s) and review results. Infrared photos to be obtained to check participant fields.
Task 4	Irrigation Scheduling and Evaluation	26,000	SCS in lead with overview of technical field work by irrigation consultant(s). SCS and environmental consultant evaluate water and crop records. MLCD provides clerical support.
Task 5	Verification Records and Reporting	18,000	SCS and environmental consultant to prepare verification summary and annual report. MLCD provides clerical support to SCS.
Task 6	Information and Education	12,000	Team effort by SCS and environmental consultant; Cooperative Extension participation where possible.
Task 7	Management and Administration	10,000	Environmental consultant to coordinate task efforts; MLIRD accountant to provide administrative support.
	1987 IWM Project Total	$77,000	

Information/education is an important aspect of the IWM program.

1988-89 IWM Program. A DOE grant will be sought by the MLIRD to fund the 1988-89 IWM work and to cover the later portion of the 1987 season. This program will be similar to the 1987 program but may be modified to reflect experience gained in 1987. Additional program components in the 1988-89 program included construction of a weather station with satellite communication capabilities within or near the Block 40 or Block 41 area, and inclusion of a final report and summary describing the program and its results. This report would include descriptions of benefits to farmers and to Moses Lake water quality and would include results from in-lake monitoring and watershed monitoring programs described in subsequent sections of this chapter. The IWM work would be coordinated with the U.S. Bureau of Reclamation, and where feasible would be tailored to provide water conservation related data for possible use in the East High Environmental Impact Statement.

The recommended 1988-89 IWM program is described in Table 8-2 including tasks, budgets and participants. The watershed monitoring task included in this program is described later in this chapter.

Table 8-2 Recommended 1988-89 Moses Lake Clean Lake IWM Program

		Recommended Budget	Participant/Role
Task 1	Irrigation System Operation Verification	$ 3,000	SCS to verify system is in place/ operating and maintain certification file. MLCD provides clerical support.
Task 2	Soil Test/Fertilizer Application Verification	5,000	SCS to review soil test and verify farmers' records of split fertilizer application. MLCD provides clerical support.
Task 3	Irrigation System Performance Testing	5,000	SCS to approve system testing by irrigation consultant(s) and review results. Infrared photos to be obtained to check participant fields.
Task 4	Irrigation Scheduling and Evaluation	50,000	SCS in lead with overview of technical field work by irrigation consultant(s). SCS and environmental consultant evaluate water and crop records. MLCD provides clerical support.
Task 5	Verification Records and Reporting	36,000	SCS and environmental consultant to prepare verification summary and annual report. MLCD provides clerical support to SCS.
Task 6	Information and Education	24,000	Team effort by Cooperative Extension, SCS and environmental consultant.
Task 7	Management and Administration	20,000	Environmental consultant to coordinate task efforts; MLIRD accountant to provide administrative support.
Task 8	Weather Station/Lake Temperature Recorder	20,000	SCS and environmental consultant to install weather station with satellite communication and lake temperature recorder.
Task 9	Final Report	25,000	Environmental consultant to prepare and print final report and summary describing the Moses Lake Clean Lake IWM Program.
Total 1988-89 Monitoring Program		$188,000	

In-Lake Monitoring

The in-lake monitoring work began in mid 1986 and is expected to be complete by June 30, 1989. A contract has been signed between the MLIRD and the University of Washington for this work. Dr. Eugene Welch of the Civil Engineering Department is the principal investigator. The project involves water quality evaluations at 13 locations, primarily within Moses Lake itself. Water quality measurements will be made at the Wast Low Canal to characterize the dilution water source and at several tributary stations in the immediate vicinity of Moses Lake. This project emphasizes monitoring from March through September only and does not include monitoring up in the agricultural area of the watershed upstream of the USGS gauge on Crabcreek Road 7.

Objectives of the University in-lake monitoring contract are itemized as described in the contract scope of work.

1. Observe the appropriate water quality and algal growth controlling variables in Parker Horn, Pelican Horn, the main arm, and the lower lake to determine the effects of altered patterns and quantities of dilution water input to Moses Lake, including the effect of pumped dilution water into Pelican Horn.

2. Evaluate and map the extent of actual and potential macrophyte development in Moses Lake resulting from improved water clarity.

3. Develop a mathematical model using available data to predict the timing and maximum abundance of blue-green algal blooms in Parker Horn and Lower Moses Lake.

4. Using the model developed in Objective 3 and the water quality changes observed in Moses Lake due to higher and more consistent dilution water inflow, estimate the optimum inflow of dilution water necessary to achieve the desired water quality that will allow for a balance of water quality uses.

5. Evaluate the effect of sewage diversion expected to occur in early 1984 upon the water quality of Pelican Horn and Moses Lake proper.

The in-lake program data collection effort is summarized in Table 8-1. A final report will be issued in 1989 which includes a specific discussion and evaluation of the dilution water inflow from East Low Canal into Parker Horn and the effect of Clean Lake Project activities on water quality throughout Moses Lake. The report will address long term management of dilution water to optimize benefits to water uses and will evaluate the long term impacts of reductions of nutrient loads to Moses Lake water quality as a result of Clean Lake Project activities.

Watershed Monitoring Program

Water quality monitoring is a key element of the Moses Lake Clean Lake project. The project began in late 1982 with a year-long watershed monitoring program to determine nutrient loads entering Moses Lake from both surface and groundwater sources. The information gathered from the watershed monitoring effort was used to develop seasonal and annual nutrient budgets and to determine the relative importance of various nutrient sources. Work completed during Stage 1 of the project was reported in the March 1984 Stage 1 report and is summarized in Chapter 7 of the Stage 3 report.

Additional watershed monitoring was initiated in 1986 to provide additional background data and to assess initial effects of the Stage 3 programs. Results of the 1986-87 monitoring program are described in Chapter 7. It is anticipated that long term monitoring will be conducted after Stage 3 of the Clean Lake Project is completed in May 1987 to determine effects of Clean Lake Project activities, particularly the on-farm programs.

The post-project watershed monitoring program is described in the following pages in terms of monitoring stations, sample collection and analysis. Monitoring stations are identified in Table 8-3. The overall post-project watershed monitoring program is summarized in a matrix provided in Table 8-4.

Monitoring Stations

Stations selected for long term monitoring on a routine basis included five surface water stations, three springs and five wells. All but one of these were sampled regularly during the 1982-1983 Stage 1 monitoring program, and all were sampled during the 1986-87 Stage 3 program. The stations are listed in Table 8-1 with their location and Stage 1 designation where applicable.

The sampling points in the Crab Creek system are all in the lower portion of the watershed, upstream or upgradient from Moses Lake. The Crab Creek surface water stations include two upstream locations and one station downstream from the Rocky Coulee Wasteway as well as a station on the wasteway itself. Monitoring wells include three on the east side and two on the west side of Crab Creek. The two springs in the Crab Creek drainage are on the east side of the creek. A third spring (Magpie Springs) upgradient from Craig Spring will be monitored less frequently as a check on groundwater quality entering from further north in Block 40.

The Rocky Ford Creek system will be checked from its headwaters (Rocky Ford Spring) to the damsite in lower Rocky Ford Creek. The creek will be routinely monitored at the Highway 17 crossing and periodically checked at the damsite and the springs.

Table 8-3

Post Project Watershed Monitoring Stations

	Stage 1 Reference
Streams and Wasteways	
Crab Creek at Road 20	(S-5)
Crab Creek at Road 7 (USGS Gauge)	(S-4)
Crab Creek at Hwy 17/RR Bridge	(S-3)
Rocky Coulee Wasteway at Road K	
Rocky Ford Creek at Hwy 17	(S-2)
Rocky Ford Creek at Damsite	N/A
Springs	
Craig Spring	(SP-2)
Game Dept. Hatchery Spring	(SP-1)
Rocky Ford Spring	(SP-4)
Magpie Spring	(SP-3)
Wells	
PUD Well (Road 7 at Stratford Rd.)	(W-2)
Dean Black Well (Road 7 near Road M)	(W-11)
William Burman Well (Road K near Wasteway)	(W-14)
Jerry Newby Well (Stratford Road)	(W-4)
McIntosh Well (Harris Road)	(W-3)

Table 8-4

Watershed Monitoring Matrix

STATION	DESCRIPTION/LOCATION	FREQUENCY	ANALYSES
Streams			
CC-1	Crab Creek at Road 20	Semi-monthly	SS, TKN,
CC-2	Crab Creek at Road 7	"	NO_3, TP
CC-3	Crab Creek at Hwy. 17	"	on all
RC-1	Rocky Coulee at Road K	"	surface
RF-1	Rocky Ford Creek at Hwy. 17	"	samples
RF-2	Rocky Ford Creek at Dam Site	"	
Springs			
SP-1	Game Dept. Spring	Bi-monthly	NO_3, TP,
SP-2	Craig Spring	"	on all
SP-3	Magpie Spring	"	springs
SP-4	Rocky Ford Spring	"	and wells
Wells			
W1	Dean Black	Bi-monthly	NO_3, TP,
W2	William Burnian	"	on all
W3	PUD Well	"	springs
W4	McIntosh	"	and wells
W5	Jerry Newby	"	

More frequent checks will be made if nutrient values are dissimilar.

Other short term monitoring work is anticipated after 1987 to obtain supplemental information to evaluate effectiveness of controls. For example, once the proposed Rocky Ford Creek impoundment pond is built and carp are erradicated, there will be periodic assessments of the pond performance and response in upstream areas to determine if vegetation is being restored once the stream bottom becomes stabilized. Much of this part of the evaluation will need to be after May 1987; however, background conditions for lower Rocky Ford Creek will need to be documented during the first months after pond construction and again after carp are removed by the Department of Game. This information can be used later to evaluate the longer term changes in water quality entering Moses Lake as well as the changes in the stream character which are expected to result. Stabilization of the stream, including establishment of aquatic vegetation in the stream itself, will be important since these changes are expected to reduce phosphorus loads to Moses Lake.

Sample Collection and Analysis

Samples will be obtained by the grab method using sample containers furnished by the testing laboratory, Laucks Labortories of Seattle. Preservatives (acid) will be used for appropriate parameters where there are significant delays in getting samples to the laboratory. All samples will be iced following collection and during transport.

Stream samples will be collected at least monthly during the irrigation season and monthly thereafter; well and spring samples will be collected every six to eight weeks over the sampling period.

Flow will be estimated or measurements will be obtained from USGS or USBR for those stations used in determining nutrient budgets for Rocky Ford Creek, Rocky Coulee Wasteway and Crab Creek.

Typically, surface water samples will be analyzed for total suspended solids, total Kjeldahl nitrogen, nitrate and total phosphate. Soluble reactive phosphate (filtered ortho phosphate) will be determined on selected surface water samples if particulates are high. All analyses are in accordance with the EPA Methods for Chemical Analysis of Water and Wastes (1983). Total suspended solids will be measured by the gravimetric method (EPA Method 160.2). Total Kjeldahl nitrogen will be measured by the ion selective electrode method following digestion (EPA Method 351.4). Nitrate will be measured in filtered aliquots using cadmium reduction on the Auto Analyzer (EPA Method 353.2).

Total phosphate will be measured according to the ascorbic acid method on unfiltered samples following persulfate digestion

(EPA Method 365.2). Soluble reactive phosphate will be based on the ascorbic acid method using a filtered sample when this analysis is required.

No funding for post-project watershed monitoring has been identified. Post-project monitoring could be funded through future groundwater managment studies in the Grant County area or as a specific Clean Lakes Project grant. Some surface water stations (e.g. Crab Creek at USGS gauge and Rocky Ford Creek at Highway 17) are being checked through the in-lake monitoring program; however, groundwater sources (springs or wells) in the Crab Creek watershed are not being monitored. Changes in groundwater quality resulting from watershed activities (such as the IWM program) will occur slowly. Accordingly, some delay in post-project monitoring of groundwater is acceptable. It is recommended that such monitoring begin in October 1988 and extend through the 1989 water year as a minimum. Results could then be provided for use in the final report on the IWM program.

APPENDIX

APPENDIX A

TECHNICAL PAPER DESCRIBING MOSES LAKE CLEAN LAKE PROJECT

NONPOINT POLLUTION CONTROL STRATEGIES FOR MOSES LAKE, WASHINGTON

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ABSTRACT

Nutrient sources influencing eutrophication of Moses Lake, Wash., have been evaluated in a multistage investigation of urban and agricultural land uses in the watershed. Nutrient loadings from surface and groundwater contributions were quantified in a year-long monitoring program. Subsequent studies have assessed effectiveness of various control techniques to reduce nutrient input to the lake. These recent (1984) investigations include full-scale field demonstrations of agricultural irrigation practices involving cablegation, wheel line, and center pivot systems monitoring nutrient and water movement through coarse native soils. Over 75 percent of local farmers are trying control measures under a unique agricultural cost-sharing program. Other nutrient sources and controls evaluated and ranked for nutrient removal effectiveness include shallow detention ponds to enhance nutrient trapping, local septic tank management policies, animal waste and fish hatchery controls, and miscellaneous in-lake improvements affecting circulation, water depth, and macrophyte harvesting. This paper describes the proposed control strategies and the prioritizing system used to implement and fund them.

INTRODUCTION

Moses Lake, Wash., is the receiving body for a 6,255 km² watershed, much of which is used agriculturally. Irrigated grain and vegetable production and pasturing predominate near the lake, with substantial area in the watershed devoted to dryland wheat farming and rangeland. Septic tanks are commonly used in the coarse, shallow soils in urbanizing areas of Grant County near the city of Moses Lake.

For over two decades, Moses Lake's extensive algal growth has diminished its recreational use (Sylvester and Oglesby, 1964; Welch et al. 1973; Patmont 1980; Brenner, 1983). Nuisance levels of blue-green algae form unsightly floating mats in the summer. Aquatic weed growth is also a problem in some shoreline areas.

Both phosphorus and nitrogen contribute to Moses Lake's overfertilization. Prior to 1980, nitrogen most frequently limited phytoplankton biomass (Patmont, 1980; Welch and Patmont, 1980; Welch and Tomasek, 1981). Coincident with the formation of an ash layer on the lake sediments and continuing washoff to the lake in tributary flow following the Mount St. Helens eruptions, phosphorus temporarily became limiting. Moses Lake appeared to return to nitrogen limitation by the summer of 1982 (Welch et al. 1984).

Moses Lake has been studied since the early 1960s to determine the causes of the algae blooms and to develop algae control strategies. Since the late 1970s, low-nutrient water has been added to dilute a portion of the lake (Welch and Patmont, 1980; Welch and Tomasek, 1981; Welch et al. 1982; Carlson and Welch, 1983; Welch et al. 1984). Although this has reduced algal blooms locally and temporarily, nutrient-poor water is not always available.

The Moses Lake Clean Lakes Project was initiated in 1982 as part of an effort by a number of public and private agencies to improve lake water quality. The project's intent is to prevent further enrichment of Moses Lake through watershed nutrient controls. The first stage of the project (1982–83) involved on-farm monitoring of the agricultural sources of nutrients and their transport through the watershed to the lake (Brown and Caldwell Engineers and Horner, 1984; Horner et al. 1984). The second stage (1984–85) emphasized analyzing the feasibility of nutrient control strategies and demonstrating the most promising techniques (Bain and Moses Lake Conserv. Distr., 1985). After summarizing the first stage, this paper will discuss the system for selecting controls and the proposed methods for implementing the selected controls. A third stage of the Moses Lake Clean Lakes Project, running from 1985 to 1987, will implement and evaluate the controls.

STUDY AREA

Moses Lake is a large, shallow lake of 2,790 ha surface area centrally located in Washington state. The lake is regulated as part of the Columbia Basin Project, which supplies water stored behind Grand Coulee Dam to over 200,000 ha of farmland. Moses Lake 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 (Fig. 1).

The 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 major Moses Lake tributaries are Rocky Ford Creek and Crab Creek. Rocky Ford Creek 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 in the southeastern portion of the lake. Despite the disparity in catchment areas, the contributions of the two streams to the lake water balance are similar

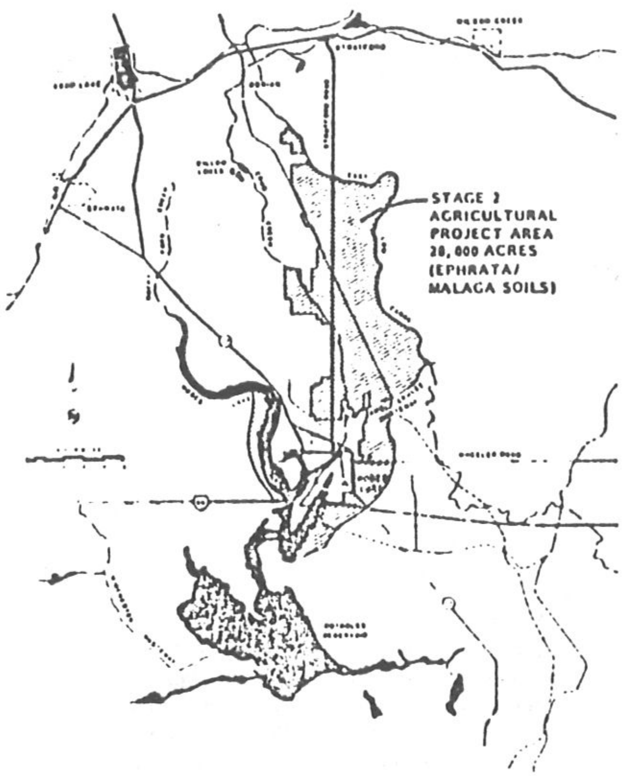

Figure 1.—Moses Lake and Stage 2 agricultural project area.

(Horner et al. 1984).

The city of Moses Lake, the major urban center in the watershed, is located on a peninsula separating Parker and Pelican Horns. The city and surrounding urban fringe have 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. Sewer systems serve Moses Lake, Ephrata, and Soap Lake, although much of the urban fringe and all of the rural population are unsewered.

The watershed consists mainly of two physiographic areas, the loess-mantled uplands and the channeled scablands. Soil in the channels formed in sand and gravel, glacial outwash, or basalt with a thin mantle of loess. The Ephrata and Malago soils predominant in the irrigation area near Moses Lake consist of gravelly glacial outwash material; extremely gravelly sand occurs within one meter of the surface.

NUTRIENT SOURCES AND TRANSPORT TO MOSES LAKE

Stage 1 of the Moses Lake Clean Lakes Project involved monitoring water quality and inventorying existing farming practices in the watershed. Water monitoring included measuring nitrogen and phosphorus in area streams and ground waters and in the soil profile of irrigated farms. The farm practice inventory primarily surveyed cropping patterns, acreage farmed, irrigation methods, and fertilizer application.

Data collected during Stage 1 indicated that farms over-irrigate in the area near Moses Lake, 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 26.3–29.4 kg/ha (Brown Caldwell Eng. and Horner, 1984). Historical Crab Creek water quality data showed that average nitrate values rose in years of high fertilizer use and fell with low fertilizer application.

At least 11,000 ha of land are irrigated in this area, with approximately 81 percent served by sprinkler irrigation and 19 percent by furrow irrigation. Although furrow irrigation accounts for less than one-fifth of the irrigated acreage, it contributes over one-quarter of the nitrogen leached by deep percolation (Brown Caldwell Eng. and Horner, 1984). Other sources of nutrients identified during Stage 1 included 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 nutrient transport monitoring program were used to develop nutrient budgets for the lake. The two greatest sources of nitrogen were Crab Creek and ground water, both linked to agricultural uses between Stratford and Moses Lake. The major sources of phosphorus included Rocky Ford Creek, the city of Moses Lake sewage effluent, which discharged to Pelican Horn until early 1984, Crab Creek, and ground water.

Stage 1 monitoring revealed that springs feeding Rocky Ford Creek were exceptionally high in phosphorus compared with those in the Crab Creek catchment (Fig. 2) (Horner et al. 1984). The source of this high phosphorus load from Rocky Ford Creek was further investigated in Stage 2. Much of it enters the groundwater basin from the Brook Lake–Adrian area along Crab Creek to the east where impoundments such as Brook Lake trap much of the phosphorus from the upper Crab Creek Watershed.

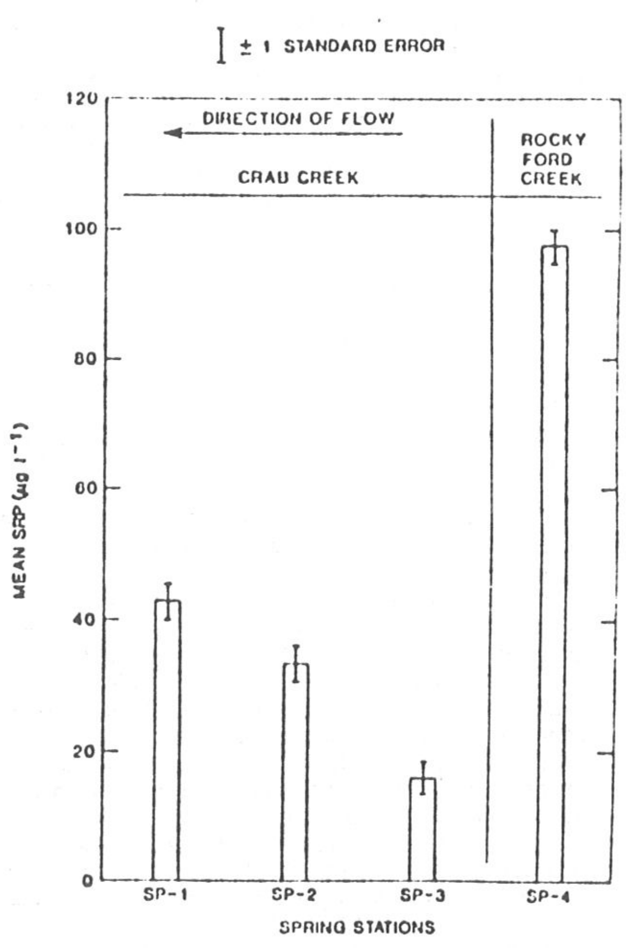

Figure 2.—Mean SRP concentrations in four Moses Lake area springs (1982–83).

Surface waters from this area recharge the groundwater basin tributary to Rocky Ford Creek (Bain and Moses Lake Conserv. Distr., 1985).

DEVELOPMENT OF NUTRIENT CONTROL STRATEGIES

Stage 2 of the Moses Lake Clean Lakes Project focused on identifying nutrient controls and evaluating the effect of these controls on Moses Lake water quality. This effort demonstrated the best management practices (BMP's) involving irrigation and fertilizing techniques on local farms and a variety of other nutrient control approaches in the watershed and within the lake itself. These measures are described separately as on-farm and off-farm nutrient controls. Following definition, alternatives in both categories were subjected to analysis to guide final selection.

ON-FARM NUTRIENT CONTROLS

Farm practices were analyzed in demonstration programs on four farms near Moses Lake during the 1984 irrigation season that involved a combination of changes in both irrigation equipment and in the management of irrigation water and fertilizer. Each demonstration field was monitored to determine the effect of these changes on nutrient loss, irrigation water use, and crop yield.

The practices demonstrated were as follows:

	Crop	Practice Demonstration
Matheson Farm	corn	furrow versus cablegation
Bellomy Farm	wheat	furrow versus cablegation
Schmidt Farm	wheat	center pivot management
Reffett Farm	alfalfa	wheel line management

Furrow and wheel line irrigation are manually controlled processes that tend to overuse water, especially furrow. The center pivot system is automated but relatively expensive. Cablegation is a fairly new, automated furrow irrigation method that is simple and inexpensive. A pipe perpendicular to the furrows contains a series of outlets positioned near the top of the pipe so that the level of free-flowing water remains below the level of the outlets. A plug traveling in the pipe backs up the flow and forces it through nearby outlet holes. Irrigation water flow rate depends on pipe size and slope, supply rate, outlet size, and plug travel speed. The latter is controlled by a speed regulator on a cable reel to which the plug is attached.

Subsurface water movement beneath agricultural fields was measured using neutron probes. The probes detect hydrogen atoms in soil water through neutron emissions from an americium isotope. The data were used in conjunction with results from a fertilizer application inventory and a regression equation developed by Pfeiffer and Whittlesey (1978) to estimate nitrogen leached to ground water.

Figure 3 depicts the total deep percolation quantities of

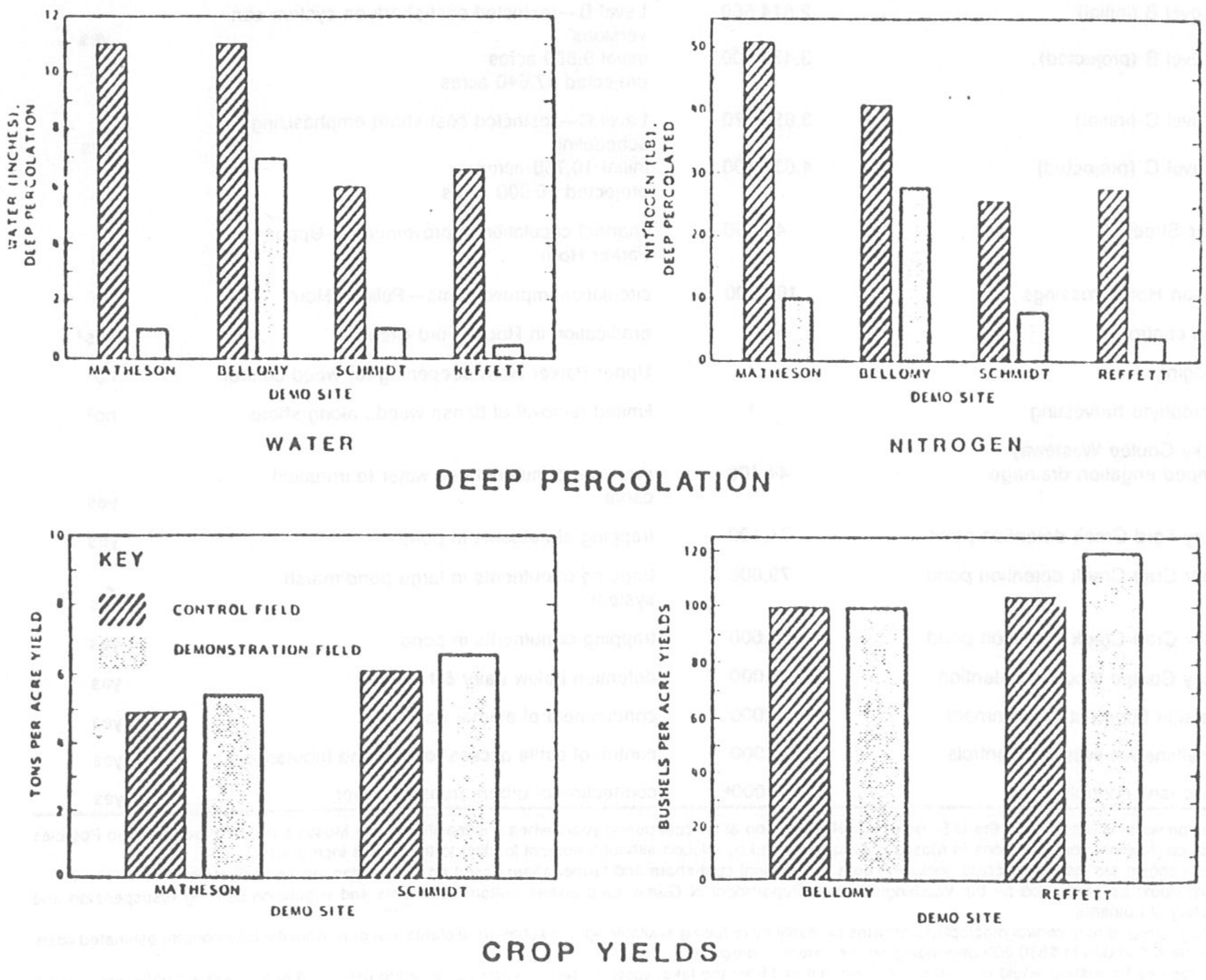

Figure 3.—Farm demonstration project results.

water and nitrogen over an irrigation season at the four demonstration sites, along with crop yields. Compared to adjacent reference fields, the demonstration fields all saved substantial water and nitrogen with equal or slightly improved crop yields.

Results from the demonstrations were then used to estimate their potential watershed-wide effects. Farmers in the approximately 11,000 ha irrigation area near Moses Lake were asked whether they were willing to implement structural and management changes on their farms; farmers representing 77 percent of the project area were. Ten model farm plans, or water quality management plans, were then developed from a representative sampling of these volunteers. In each plan, the farmer worked with the project staff to evaluate alternatives before deciding on practices that would meet his farming needs and the Clean Lakes Project's criteria. The farm plans described appropriate changes in equipment and management practices.

Following plan development, average costs of implementing the measures were established. Nitrogen-loss reductions, water savings, and crop yields for three levels of implementation (A, B, and C) were then estimated from the deep percolation and yield data previously accumulated. Level A represents full use of all practices identified in the plans, including major structural programs such as conversion to center pivot systems. In Level B, 2 of the 10 model farms would not convert from wheel lines to center pivots and thus would no longer participate. With Level C all wheel lines would remain and improvements would be gained primarily by conversion of furrow irrigation to cablegation or center pivots and changes in irrigation

Table 1.—Summary of control alternatives.

CONTROL SYSTEM	ESTIMATED COST ($)	CONTROL APPROACH	NUTRIENT LOAD REDUCTION
Dilution	N/A[1]	low nutrient release from USBR East Low Canal	no[1]
Irrigation controls[2]		improved irrigation water and fertilizer systems and management	
Level A (initial)	4,566,480	Level A—full cost share program	yes
Level A (projected)	5,521,200	initial 12,720 acres projected 21,560 acres	
Level B (initial)	2,814,560	Level B—restricted cost-share on system conversions	yes
Level B (projected).	3,479,800	initial 9,880 acres projected 17,640 acres	
Level C (initial)	3,859,970	Level C—restricted cost-share emphasizing scheduling	yes
Level C (projected)	4,634,100	initial 10,750 acres projected 16,900 acres	
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[3]	eradication in Rocky Ford Creek	yes[3]
Dredging	[4]	Upper Parker Horn deepening for weed control	no[4]
Macrophyte harvesting	[5]	limited removal of dense weeds along shore	no[5]
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[6]	connection of urban areas to sewer	yes

[1] 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.

[2] Costs shown are initial total costs, including both government cost-share and farmer share based on Model Plan level participation.

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

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

[5] Macrophyte 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.

[6] Septic tank control cost based on sewering assumptions described by Bain and Moses Lake Conservation District (1985); septic tank policy development cost is $5,000 of staff time.

scheduling.

OFF-FARM NUTRIENT CONTROL

Miscellaneous nutrient controls not involving irrigated crops were evaluated, including:

1. Construction of detention ponds to trap phosphorus in several tributaries.
2. Control of surface runoff from livestock operations.
3. Dredging for removal of rich sediments in shallow areas.
4. Macrophyte harvesting in selected areas of the lake.
5. Carp eradication from selected local tributaries.
6. Circulation improvements around existing causeways and bridges.
7. Development of buffer areas to prevent livestock access to surface water.
8. Development of more stringent septic tank and sewering policies.

The eight alternatives were analyzed to establish the costs of implementation and estimated reductions in lake nitrogen and phosphorus loadings. With respect to the eighth measure, a complete policy was drafted for consideration by the city of Moses Lake and the surrounding county that would restrict using septic tank systems in a defined lake-sensitive zone. The policy recommends horizontal and vertical spacings between septic tank drainfields and the lake or its tributaries and the use of fine sand filter beds beneath drainfields in some circumstances.

Prioritizing Alternatives

Table 1 summarizes all on-farm, off-farm, and in-lake control strategies considered and estimated costs. Most measures would reduce lake nutrient loadings, but some would favorably modify lake morphometry, circulation, or water exchange. For the irrigation controls, two degrees of participation were considered for each level of implementation. The two degrees reflect the increased acreage expected to enter the program as acceptance increases:

	% of Total Project Area Acreage	
Level	Initial	Projected
A	45	77
B	32	63
C	38	60

Control alternatives that decrease lake nutrient loading were evaluated to express their cost-effectiveness in \$/kg of nitrogen or phosphorus estimated loading reduction (Table 2). No phosphorus reduction credit was taken for the irrigation controls, because monitoring evidence indicated that deep percolation of phosphorus is minimal (Brown Caldwell Eng. and Horner, 1984).

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

	Nitrogen Control	Phosphorus Control
1.	Rocky Ford Creek detention	Rocky Ford Creek detention
2.	Lower Crab Creek detention	Miscellaneous livestock controls
3.	Miscellaneous livestock controls	Lower Crab Creek detention
4.	Level B irrigation controls (projected)	Westside feedlot containment
5.	Level A irrigation controls (projected)	Rocky Coulee tributary detention

The first five phosphorus control approaches were clearly more cost effective than other schemes, with the unit cost/kg of phosphorus rising from \$38.46 for the fifth-ranked alternative to \$555 for the sixth-ranked. Nitrogen control rankings did not reach a clear break point until the tenth-ranked alternative (upper Crab Creek detention) passed the \$250/kg level. The irrigation control alternatives were not cost rated for phosphorus control, but any level would have far exceeded \$250/kg. The fourth- and fifth-ranked phosphorus control measures were also rea-

Table 2.—Summary of cost-effectiveness evaluation of watershed nutrient controls.

CONTROL SYSTEM	TOTAL PROJECT COST[1]	NUTRIENT REDUCTION N (KG)	NUTRIENT REDUCTION P (KG)	COST-EFFECTIVENESS N (\$/KG)	COST-EFFECTIVENESS P (\$/KG)
Irrigation controls:					
Level A–initial	\$4,566,480	137,360	–	33.24	–
projected	5,521,200	228,260	–	24.19	–
Level B–initial	2,814,560	94,590	–	29.76	–
projected	3,479,840	169,180	–	20.57	–
Level C–initial	3,859,970	93,840	–	41.13	–
projected	4,634,100	146,620	–	31.61	–
Rocky Coulee drainage	44,400	950	80	46.74	555.00
Detention ponds:[2]					
Rocky Ford Creek	74,100	12,610	4,910	5.88	15.09
Upper Crab Creek	79,800	310	30	257.42	2,660.00
Lower Crab Creek	29,600	2,820	830	10.50	35.66
Rocky Coulee tributary	5,000	180	130	27.78	38.46
Westside feedlot containment	10,000	310	260	32.26	38.46
Miscellaneous livestock controls	30,000	2,730	910	10.99	32.97
Septic tank controls and sewering	8,650,000	10,360	3,950	834.94	2,189.87

[1] Total project cost includes engineering design and construction.
[2] Detention pond nutrient reduction estimates are based on 37.5 percent trapping efficiency for phosphorus and 8.4 percent for nitrogen, representing the combined effect of carp control and sedimentation or other water column removal process.

sonably cost effective for nitrogen control at $38.46/kg reduction each.

On a watershed loading basis, the greatest impact is accomplished by Level B irrigation for nitrogen control, and Rocky Ford Creek detention and related carp eradication for phosphorus control. Septic tank controls are a close second for phosphorus, but too costly if nutrient controls alone are the justification for sewering. Nevertheless, local agencies recognizing its potential importance have adopted the draft policy on septic tank use mentioned earlier and recommended developing a comprehensive sewerage plan for the greater Moses Lake area, and possibly establishing a sewer district.

Other controls that do not reduce nutrient loading from the watershed but potentially benefit water quality include, foremost, continuing the program of dilution water release from East Low Canal and subsequent channeling of the water to Parker and Pelican Horn, and dredging, weed harvesting, and alterations of causeways.

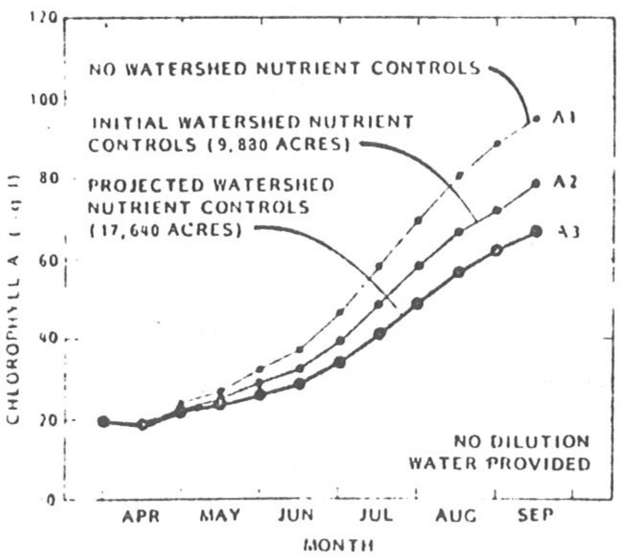

Figure 4.—Predicted chlorophyll *a* concentrations with watershed nutrient controls.

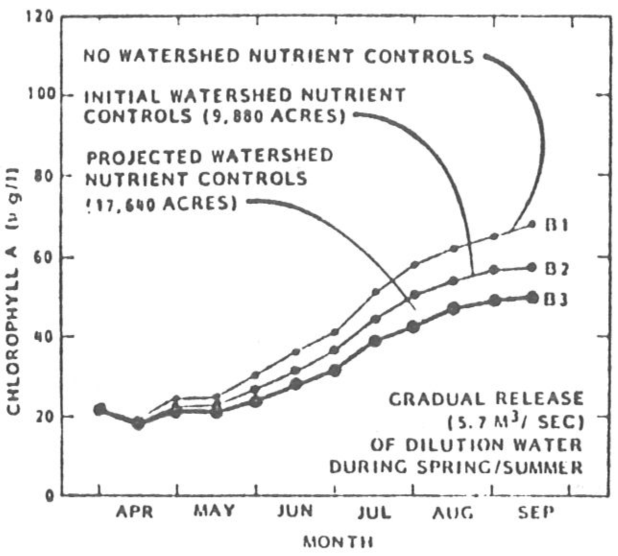

Figure 5.—Predicted chlorophyll *a* concentrations with dilution water release and watershed controls.

Table 3.—Monetary benefits of watershed controls to the Moses Lake area farms.

	($/YEAR)	
BENEFIT	INITIAL WATERSHED CONTROLS	PROJECTED WATERSHED CONTROLS
Fertilizer savings	$ 52,000	$ 93,000
Irrigation water savings	43,200	77,400
Crop yield increase	444,600	793,800
Totals	$539,800	$964,200

Project Benefits

Project benefits include Moses Lake water quality improvements, savings in farming costs, and increased crop yields. A mathematical model developed specifically for Moses Lake was used for the water quality analysis (Marquis, 1985). This model describes algal biomass changes in terms of chlorophyll *a* in response to nitrogen-limited phytoplankton growth kinetics and wind-induced vertical mixing.

Figure 4 depicts the model output for initial and projected nutrient control levels. Chlorophyll *a* content was forecast to drop 17 and 30 percent, respectively, as a result of initial and projected nutrient controls. As shown by Figure 5, greater improvements were predicted when watershed nutrient controls were supplemented with dilution water releases. The value of these water quality improvements was estimated to be in the $250,000 to $500,000 per year range.

Farm-related benefits, including savings in nitrogen fertilizer and irrigation water and increased crop yields, are summarized in Table 3 for the initial and projected degrees of participation. With the majority accruing from increased crop yields, these benefits eventually are expected to total nearly $1 million annually.

IMPLEMENTATION

Stage 3 of the project, which began implementation in spring 1985, includes a unique on-farm cost-sharing program funded by the U.S. Environmental Protection Agency (EPA) and the Agricultural Stabilization and Conservation Service (ASCS). Off-farm projects were also supported by the Washington State Department of Ecology, the Moses Lake Irrigation and Rehabilitation District, and EPA. Figure 6 shows Stage 3 project locations. The three-year budget for Stage 3 exceed $2 million, most of it for on-farm cost-sharing.

Farmers who participate in the cost-sharing program will be rated according to their contribution to Moses Lake nutrient loadings. Funding will be provided for technical assistance and for implementing management and structural practices to reduce the on-farm deep percolation of water and nutrient loading of groundwater irrigation operations. Livestock controls are also eligible for cost-sharing.

Eligible structural improvements, such as irrigation system conversions from furrow practices to cablegation or sprinklers and pipeline or pumping improvements, will be 50 percent reimbursed.

Management practices such as installation and use of soil moisture testing equipment and soil sampling for nutrients will be employed in determining quantities and scheduling irrigation water and fertilizer applications (75 percent reimbursable). The maximum funding per farmer is $50,000 from EPA and $3,500 from ASCS.

Off-farm programs currently being implemented include

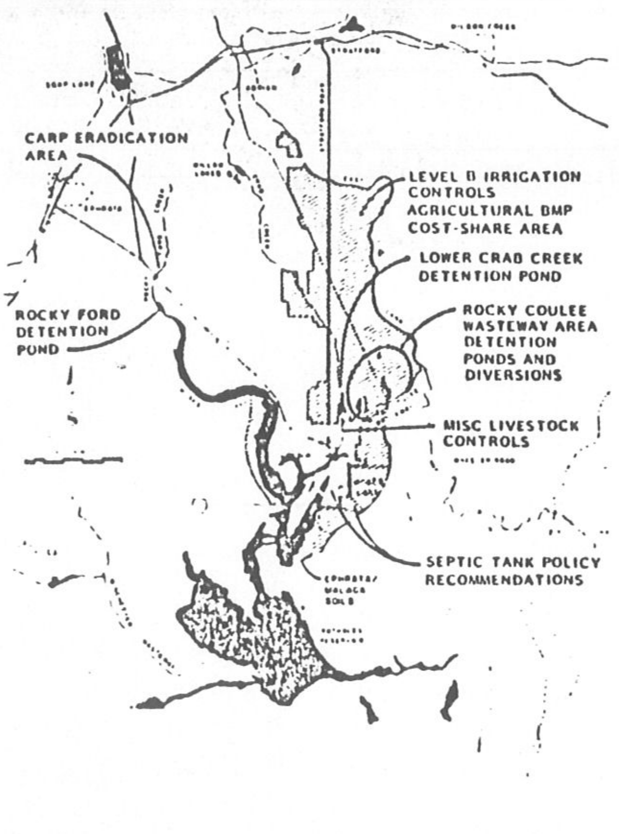

Figure 6.—Recommended Stage 3 watershed nutrient controls.

(1) design of detention pond structures and negotiation for pond sites, easements, and permits; (2) development and subsequent adoption of a septic tank control policy with comprehensive sewerage planning; (3) design of a project to remove macrophytes and debris in an area of poor circulation; and (4) continued use of a macrophyte harvester.

The Moses Lake Clean Lakes project represents a significant commitment by the various participating agencies. Public awareness of the problems and causes of lake eutrophication has resulted from meetings, publications, signs, the media, individual contact, even bumper stickers and hats.

Probably the most unusual feature of the project, however, is the significant agricultural cost-sharing program made possible by scientific findings that agricultural fertilizers are leaching from the farms to the lake in ground water. By changing farming practices, the farmers could achieve cost savings in their fertilizer and water management and actually increase crop yields, while improving water quality.

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APPENDIX B

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. <u>IMPROVING AN IRRIGATION WATER MANAGEMENT SYSTEM.</u> (MLCL/BMP-1)

A. <u>The Purpose</u> 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. <u>Apply</u> 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. <u>Policies</u> 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. <u>FERTILIZER MANAGAGEMENT.</u> (MLCL/BMP-3)

A. <u>The Purpose</u> 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. <u>Apply this practice</u> on farmland which significantly contributes to the water quality problems, as determined by the priority rating system.

C. <u>Policies</u> 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 <u>not</u> 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. <u>Specifications.</u>

Will be in accordance with applicable MLCL Standards and Specifications.

E. <u>Technical Responsibility.</u>

Is assigned to MLCL Project Staff.

F. <u>Maximum Cost-shares.</u>

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. <u>Technical responsibility</u> is assigned to the MLCL Project Staff.

F. <u>Maximum Cost-shares.</u>

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 C

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 Inlet structure with trash kicker	1 ea.	1500	50	$ 750					
2	1	MLCL/BMP - 2 Flow meter	1 ea.	685	50	$ 343					
3	1	MLCL/BMP - 2 Pipeline	300 ft.	4.20	50	$ 630					
		Underground low pressure pipeline (Job Sheet #1)									
4	2	MLCL/BMP - 2 Cablegation - control box	1 ea.	2000	50	$ 1000					
5	2	MLCL/BMP - 2 Cablegation - gated pipe	1500 ft.	3.20	50	$ 1725					
6	2	Gated pipe	700 ft.	N/C		700					
7	2	MLCL/BMP - 2 Pipeline	850 ft.	3.50	50	$ 1488					
		Underground low pressure pipeline (Job Sheet #1)									
8	3	MLCL/BMP - 2 Cablegation - control box	1 ea.	2000	50	$ 1000					
9	3	MLCL/BMP - 2 Cablegation - gated pipe	1300 ft.	2.30	50	$ 1495					
10	6	Gated pipe	500 ft.	N/C		500					
11	6,4	MLCL/BMP - 2 Pipeline	800 ft.	2.80	50	$ 1120					
		Underground low pressure pipeline (Job Sheet #1)									
12	4	MLCL/BMP - 2 Cablegation - control box	1 ea.	2000	50	$ 1000					

* FOR NONCOST-SHARE ITEMS SHOW N/C

NOT-

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 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 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	
		percolation 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 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) 19 85	19 86	19 87	19 88	19 89	REFERENCE NO.
		TOTAL ESTIMATED COST-SHARE				$11406	$ 299	$ 299	$ 276		$12280

* 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.

CONSERVATION PLAN MAP

pared by UNITED STATES DEPARTMENT of ICULTURE ★ SOIL CONSERVATION SERVICE
cooperating with

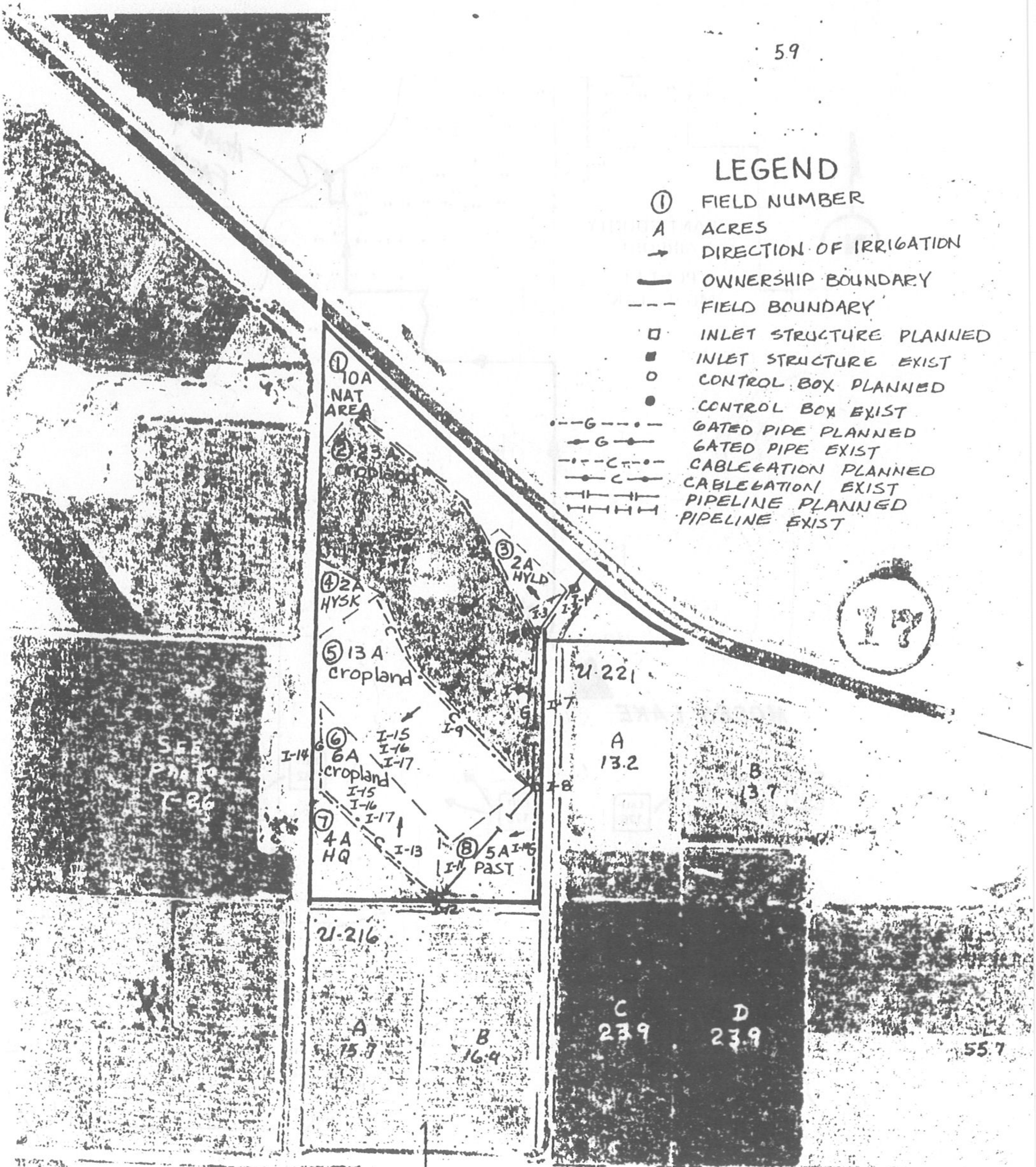
MOSES LAKE
S.C. DISTRICT

BLK 40

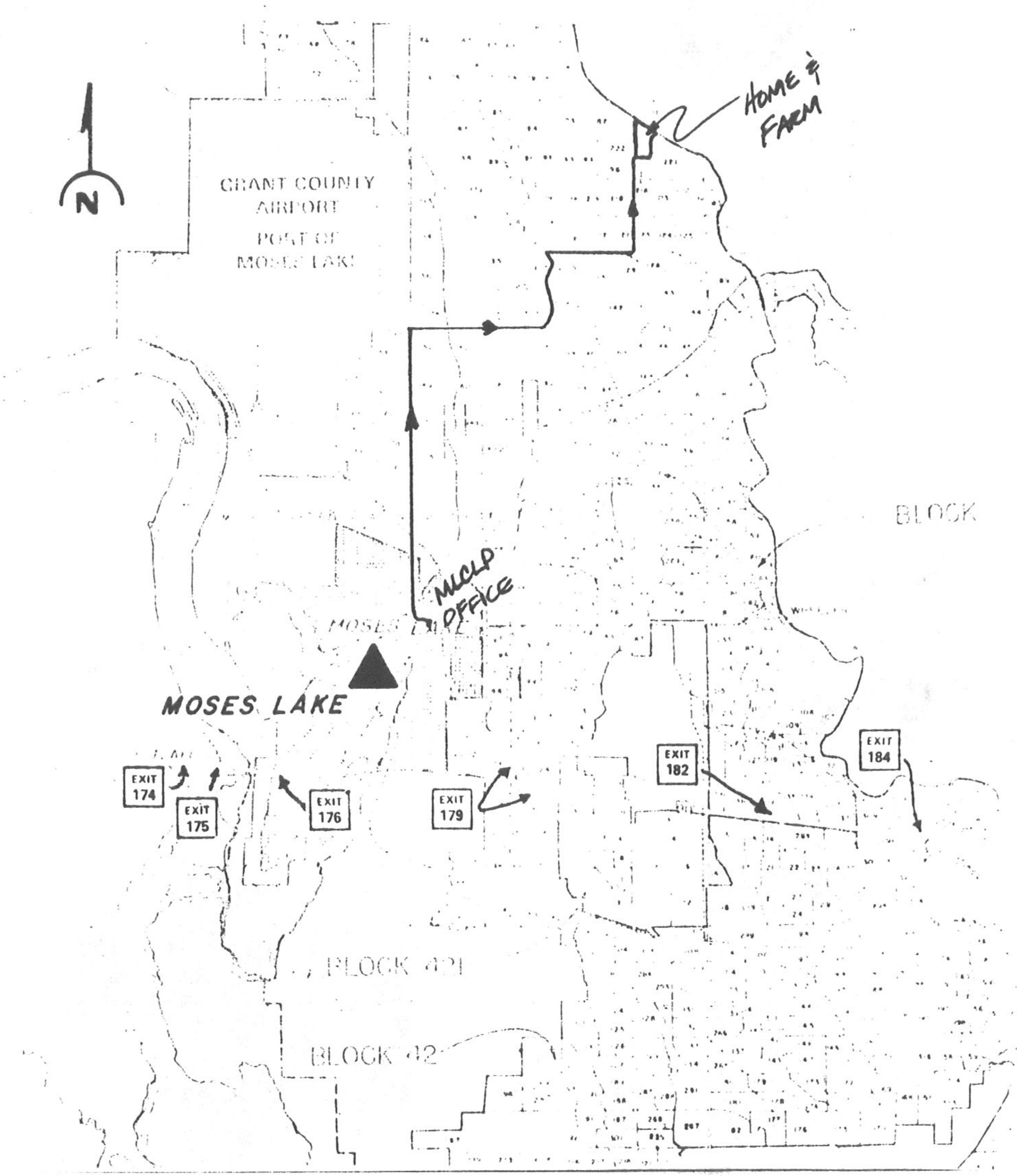
OWNER .... FARM No. 222 B DATE 11-1-84

OPERATOR SAME SCALE 1" = 660' ACRES
APPROXIMATE

GRANT , WASHINGTON PHOTO No.
COUNTY STATE



LOCATION MAP



APPENDIX D

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 on-going 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 MLCL 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 E

MOSES LAKE CLEAN LAKE PROJECT 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 specifified 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.

§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/ -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.

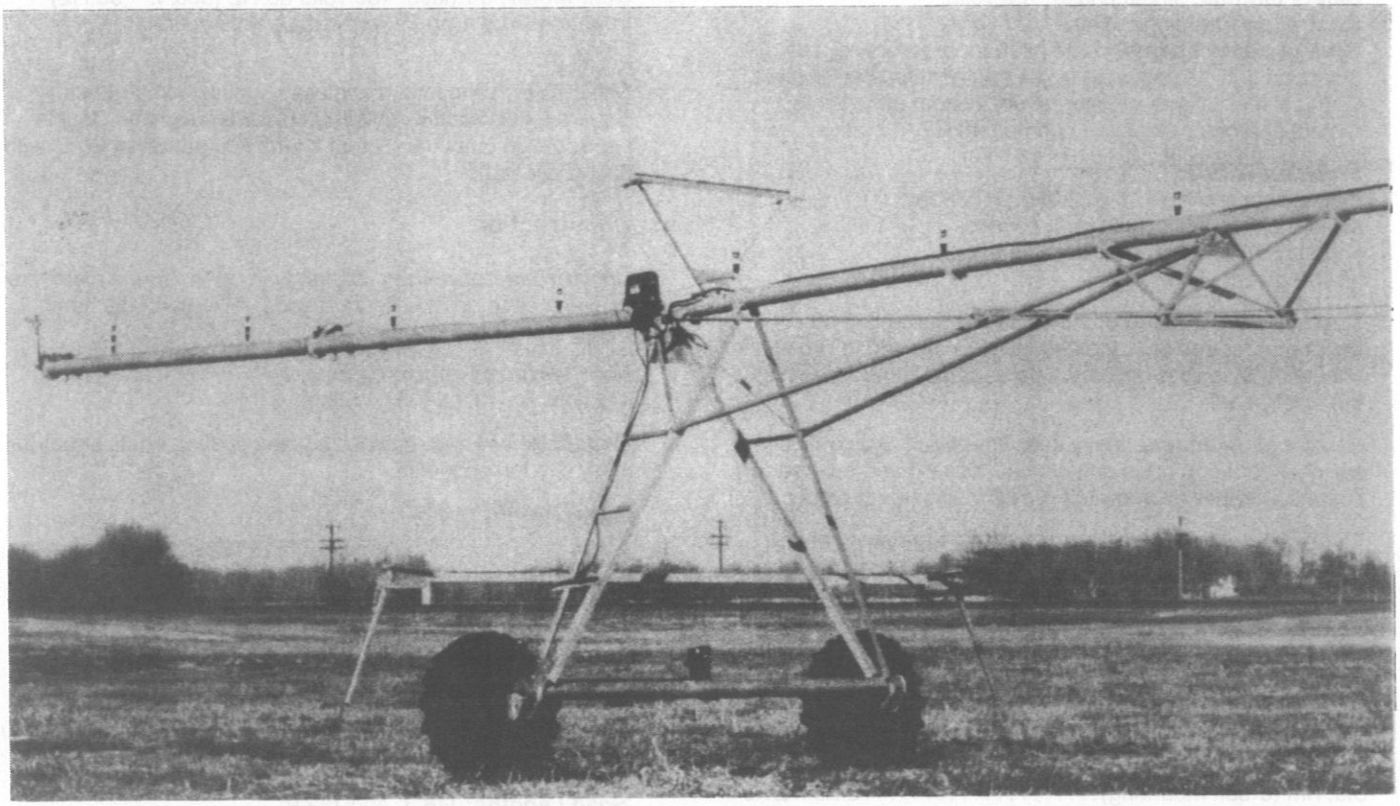
Applications for cost-share payments for practices or components not carried out or that do not meet required specifications constitute false applications. Participants filing false or fraudulent applications are subject to a fine of not more than $10,000.00 or imprisonment of not more than 5 years or both.

APPENDIX F

TYPICAL CENTER PIVOT
IRRIGATION SYSTEM EQUIPMENT DESCRIPTION

Model 4765

VALLEY® ELECTRIC CENTER PIVOTS



Features

New modular design spans and drive units allow greater interchangeability of pipe, truss rods and trusses. Spans are built with pipe lengths of 36 ft. and 18 ft. Two new spans for 6⅝″ pipe have been designed to accommodate 183 ft. and 146 ft. drive unit spacing.

Span integrity The fatigue life of the spans has been increased two times over current systems. The loads generated by wheel tracks and ridges are more evenly distributed into the pipeline in a new special double truss design. The truss attachment ears have been enlarged and have more welded surface to spread the load throughout the pipeline. All truss rods are manufactured by the hot-heading process which maintains precise length and assures a uniform-shaped crown for all the spans. The truss rod attachment brackets at both ends of the span has been designed for greater load bearing.

Drive Unit Strength The ultimate load carrying capacity of the drive unit has been increased. Gearbox mounting brackets have wider spacing to reduce stresses in the base beam, and the drive unit legs attach directly to gearbox mounting brackets drastically reducing torsional stress in the base beam. Drive units have four main structural members which spread the load out onto the pipeline. Diagonal braces on both sides of the drive unit increase the strength and stability of the entire structure.

Electric circuitry is manufactured from top-grade electrical components for safety and performance. Components are wired and factory tested by Valmont. Special suppressor circuits increase switch life. Suppressor circuits are standard and provide extra protection against peak voltage problems. Special microswitches and alignment controls permit motors to run for longer intervals, extending motor life. A three-second auto-restart eliminates nuisance shutdowns brought on by momentary power loss.

Automatic collector rings are standard. The main power cable is fed through a sealed stainless steel conduit from the main control box to the pivot. Power is transferred using eleven sliding contacts rated 600 V., 30 amps.

Valmont electric gear motors are designed to provide long life under peak loads. They're engineered for high starting torques at a low current draw, giving needed muscle in handling deep furrows or steep inclines.

Greaseless U-Joints have a flexible urethane insert that absorbs shock and stress during operation, helping to extend the life of costly power train parts.

Valmont heavy duty gear cases, at the wheel, absorb 60,000 in./lbs. torque from the motor. Special high test worms and gear angles allow 40% greater wear life. Larger bearings mean longer life and greater load capacity. Condensation problems are eliminated with a rubber diaphragm expansion chamber on top of the gear case that allows the case to be filled with oil.

Multidirectional tower flex joints meet the need for consistent durability, strength, and flexibility regardless of travel direction. The coupling is a heavy 2″ (5cm) ball and socket that not only moves up and down and back and forth, but twists to take torsion stresses common on rough ground.

Rough ground capabilities are outstanding. The multidirectional flexing assures that the system will operate through slope changes up to 30% or go over terraces or other rough ground with ease. It's built rugged to handle terrain that is difficult to irrigate any other way.

Specifications — Model 4765

Electrical System

Safety circuits: single phase, 120 volts.
Control circuit: single phase, 120 volts.
System control panel: contains manual reversing and 3-second auto-restart standard equipment located at pivot. Optional low voltage monitor: shuts system off to protect motors and other electrical components.

Shielded Wiring:
main power leads — 10 g (2.05mm) copper;
safety control — 14 g (1.3mm) copper;
end gun circuit — 14 g (1.3mm) copper;
all fittings are watertight.

Speed control: speed of the system is controlled by the percentage of time the end tower is allowed to run each minute. This is controlled by a percentage timer located in the pivot panel.

Electrical Switches: heavy duty ten-million-cycle micro-switches for each drive unit provide forward and reverse run circuits. Another microswitch provides alignment safety.

Over-watering safety: timer in next-to-last tower control box shuts system down if it fails to move after pre-selected time.

Drive Unit

Gear Motor: 3-Phase, 480 volts 60 HZ (380 V. – 50 HZ) Irrigation Duty, 1 hp 29 rpm output, plus optional 1½ hp, 58 rpm.

Drive Train: Valmont Greaseless U-Joints, ⅞″ (2.22 cm) Square Drive Shaft — shielded. Gear Boxes have Double Lip Seals on output and input shafts, Output Shaft 2.25″ with 52:1 Gear Ratio.

Construction

Undertruss: "bowstring" design with up to 7 truss members between each drive unit. Truss rods ¾″ (1.9cm) diameter, with integral hot formed heads.

Main Vertical Support Members
4″ x 3″ x ¼″ (10.1 x 7.62 x 63cm)

Protective coating: galvanized zinc coating on all structural members for longer life.

Pipe Diameter 6⅝″

Tire & Rim Sizes:

Std. tire special irrigation retread (274 in^2 (1768cm^2) contact area)* . . . . . 11x 24.5″
Std. rim (8-bolt mounting) . . . . . 8.25 x 24.5″

Opt. high flotation tire (417 in^2 (2690cm^2) contact area)* . . . . . 14.9 x 24″

Rim (8-bolt mounting) . . . . . 12.0 x 24″

Opt. Maxi-float (491 in^2 (3168cm^2) contact area)* . . . . . 16.9 x 24″
Rim (8-bolt mounting). 15.0 x 24″
*Contact area at 3″ soil penetration.

Typical Quarter Section Systems:

7 Tower: 7-182.9 plus 18.1′ OH . . . . . = 1298′
8 Tower: 3-182.9, 5-146.3 plus 18.1′ OH . . . . . = 1298′

Span Lengths: 146.3′ and 182.9′.

Standard Pivot adds 1.5′ to first span length.
Pivot Flex option adds 2.3′ to first span length.

Overhang Lengths: 18.1′, 27.4′, 36.2′, 54.9′, 63.7′, 82.3′

Maximum Height of Overhang Support Trusses:
16.2′ with 18.1′, 27.4′, and 36.2′ overhang lengths.
23.5′ with 54.9′, 63.7′, and 82.3′ overhang lengths.

DESCRIPTION — MODEL 4765

System Size/Quarter Section:
Length . . . . . 1298′
Drive Units 7

Rotation Time: (Approx. w/480 V — 60 HZ motor)
Standard Speed (29 rpm) . . . . . 22.5 hrs.
High Speed (58 rpm) . . . . . 12.0 hrs.

Pipe Size: 12 Gauge Wall
6⅝″ w/9.14′ coupler spacing (16.8cm w/2.8m) X

Maximum Slope Limitations:
Climbing (std. and low profile lower height)
0-6″ ridges (0-15.2cm) 8%
6-12″ ridges (15.2cm-30.4cm) 5%
Maximum slope absorption at Drive Unit 30%

Span Lengths & Weights with Water:
147′ x 6⅝″ (44.8m x 16.8cm) — 5 trusses/span . . 5800 lbs.
183′ x 6⅝″ (55.8m x 16.8cm) — 7 trusses/span . . 6900 lbs.

Options & Accessories

High-speed motors provide faster revolution time of the Center Pivot system. Example: A quarter section standard-speed system will make a revolution in approximately 20-23 hours; with high-speed motors it will make a revolution approximately every 10-12 hours.

Flotation Tires minimize rutting problems. Available sizes are: 14.9" x 24" (37.8 x 61cm), or 16.9" x 24" (42.9 x 61cm).

Pivot flex is required for systems where the first drive unit is 4% above or below the level of the pivot pad.

Heavy duty pivot available for longer systems. (Recommended on systems 1500' to 1999'. Standard on systems 2000' to 2800'.)

Long pivot alignment available on longer systems that operate over rolling or choppy terrain and/or operate in both directions. (Recommended on systems 1500' to 1999' — standard equipment on systems 2000' to 2800'.)

Booster transformers available to increase system voltage for long systems and/or systems with larger electrical loads.

45-amp package available when required for high system amperage loads.

Automatic reverse automatically reverses at any predetermined point in the field such as a field boundary on a part circle machine.

Pivot stop-in-slot allows you to automatically stop your Valley Center Pivot at any preset area that you select, such as pivot road.

Automatic end gun shutoff turns on or off automatically at any preset area in the field.

End-of-field stop can be located on any drive unit, allowing the system to be stopped at preset points such as farm buildings, fence lines, etc.

Low-pressure shut-off shuts off the center pivot if there is a loss of water pressure while the system is operating.

Lightning arrestor helps protect the system from lightning and voltage spikes.

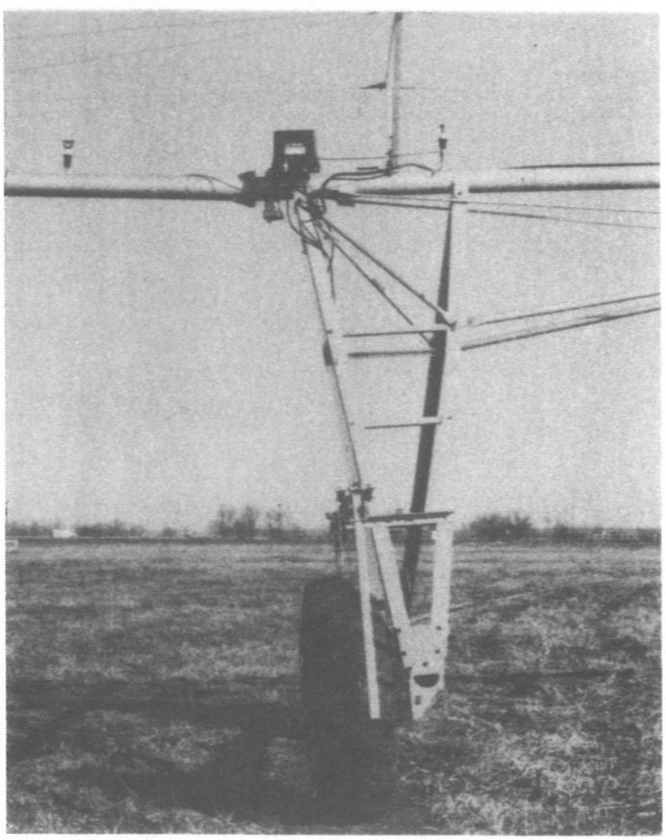
Running light allows the system to be monitored — light on/system operating. The running light can be located at the pivot or on the end drive unit. It may be wired to be on continually when the system is operating or turn on and off as the last drive unit starts and stops.

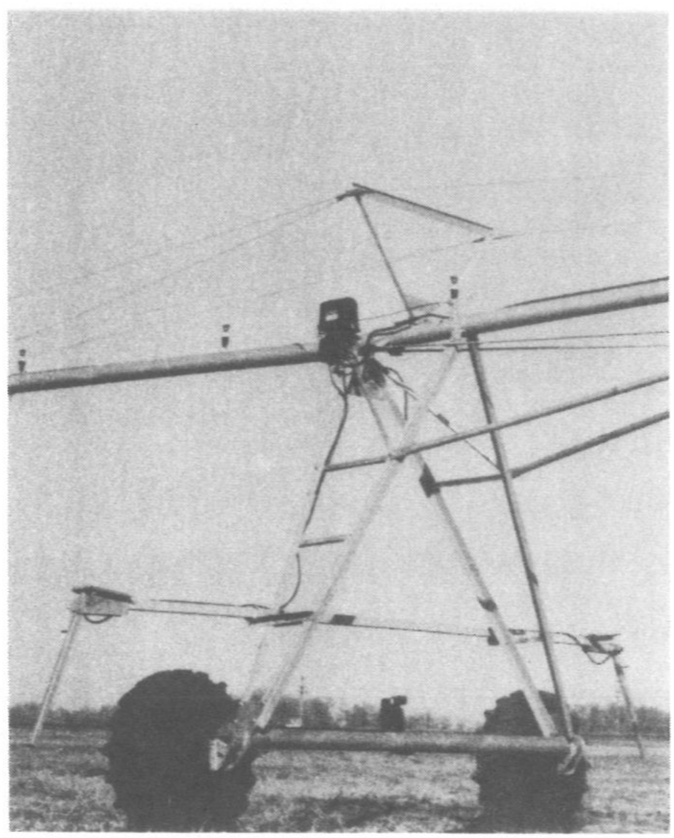
Low-Voltage Monitor shuts the system off, if the voltage supply drops, to protect motors and other electrical components.

High-volume end guns available are Rainbird #65, #85 and #103 also the Nelson PC100HD and SR100.

Booster pump can be added to low-pressure systems to increase the end gun coverage.

Eight Sprinkler Packages
Valley offers eight types of water distribution configurations. Each features a design to take advantage of the needs of specific crops, soil type, land contour and energy costs. Tested Valley water patterns consistently achieve a high coefficient of uniformity, far superior to many other sprinkler techniques which perform in the 60% to 80% range.





APPENDIX G

CABLEGATION IRRIGATION SYSTEM DESCRIPTION

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.

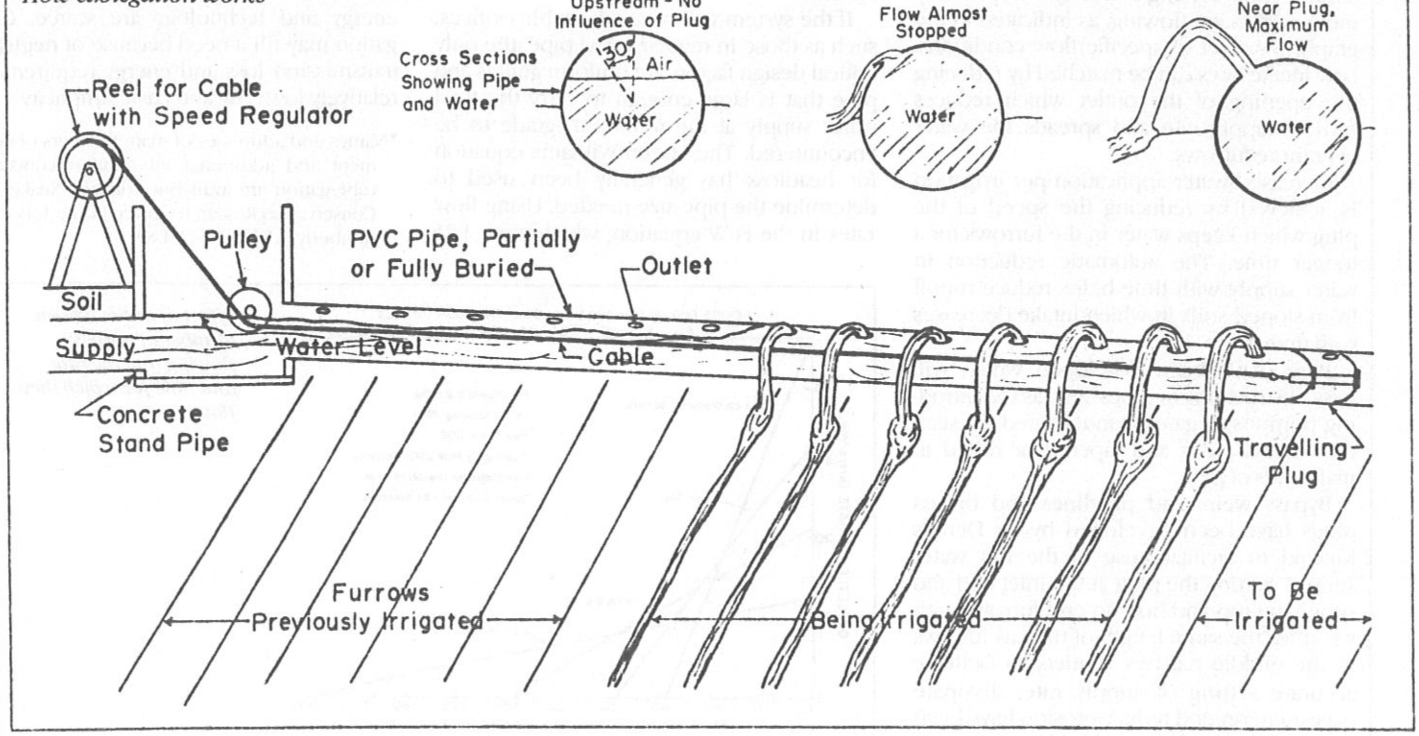
The number of outlets flowing depends on the pipeline size and grade, supply rate, and outlet size. Time for which water is supplied to a furrow depends on the number of outlets emitting water and how fast the plug moves down the pipe. Water pressure pushes the plug down stream and its rate of travel 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

How cablegation works



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.

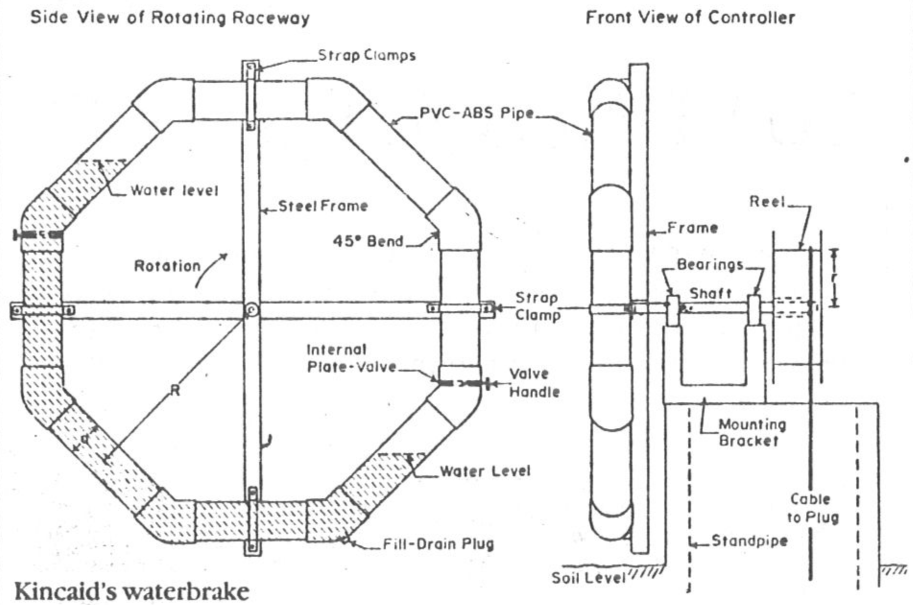
If the operator of a system supplying water to bordered strips desires all the water to flow to one strip at a time, the outlet (and riser) must be large. Reducing the outlet size decreases flow rate in the outlet next to the plug, increases the hydraulic head in the pipe and causes water to come out 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.

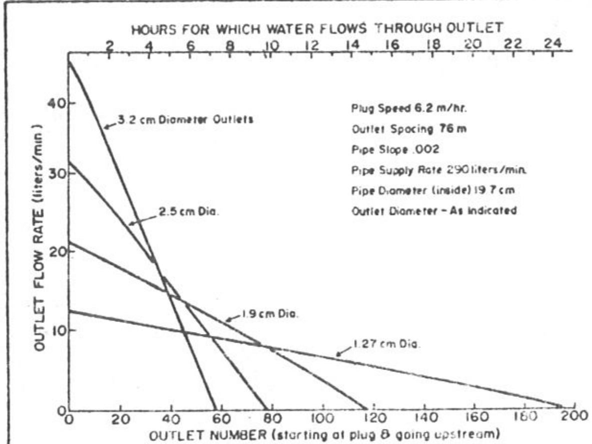
A computer model has been developed and verified to make these calculations. Dimensionless graphical plots of the computer solution are available to enable those without computers to design cablegation systems.

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.

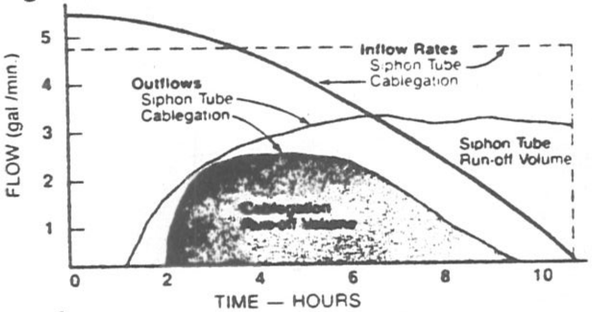
*Names and addresses of manufacturers of equipment and additional information concerning cablegation are available from the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho 83341, USA.



Effect of outlet size on number of outlets flowing and the rate and time for which they flow

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

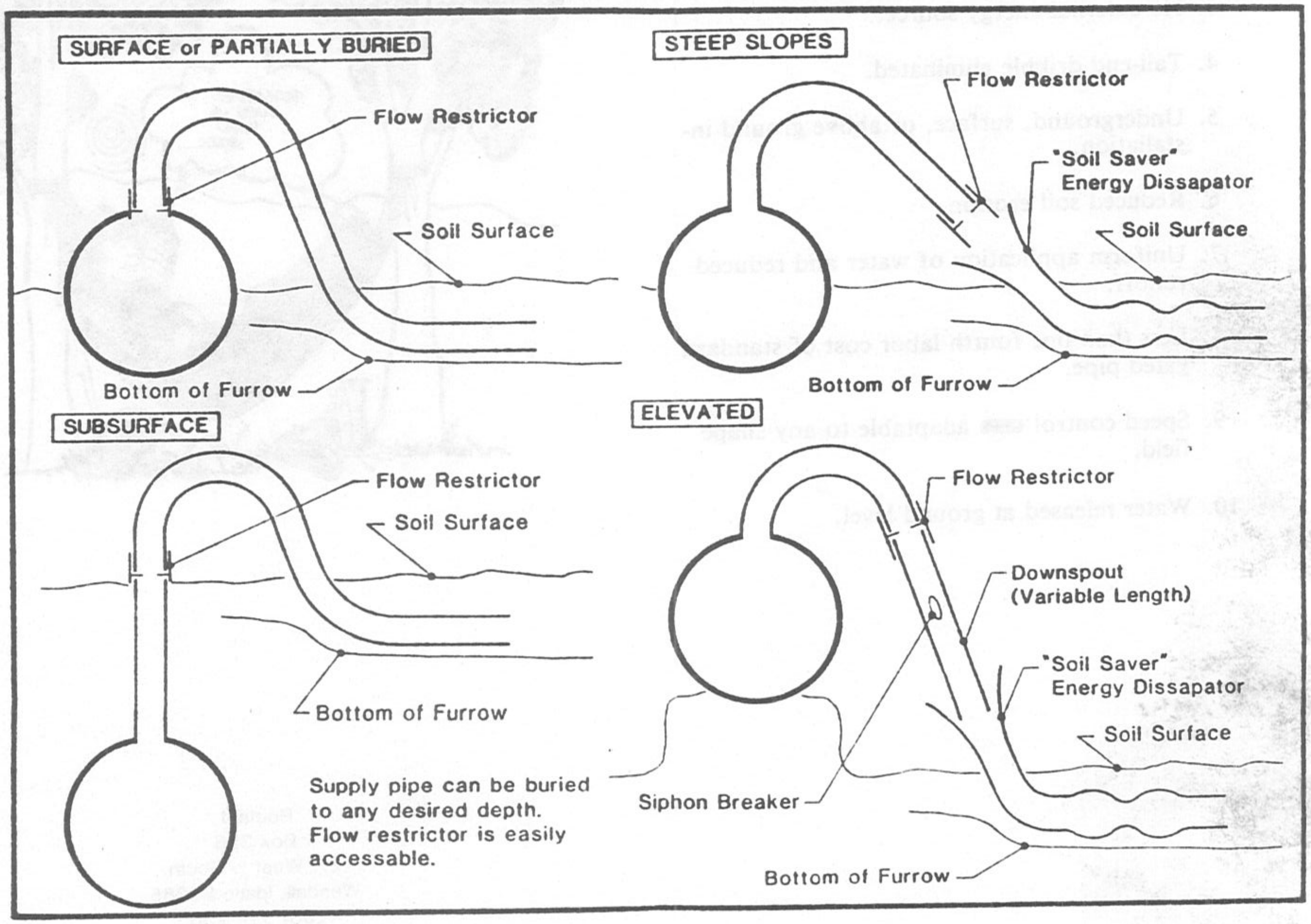
We are manufacturing equipment to adapt cablegation to almost any field situation, and to help control the soil erosion associated with gated pipe irrigation.

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.

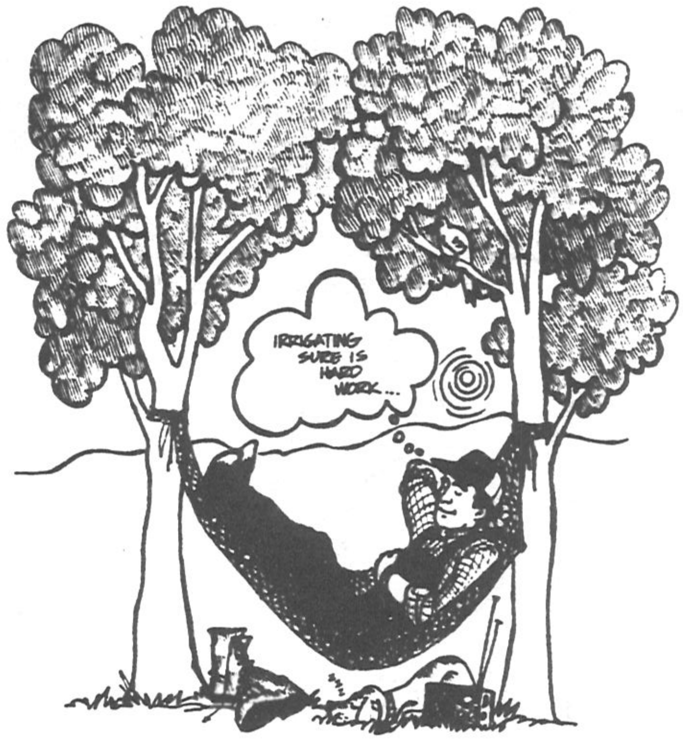
A small flow of water runs a timer which regulates an escapement mechanism, allowing the cable to unwind from the reel. A pressure head of only about 6 inches is required to operate the timer and an average of 5 gallons of water per hour is spilled.

INSTALLATION METHODS



ADVANTAGES OF OUR SYSTEM

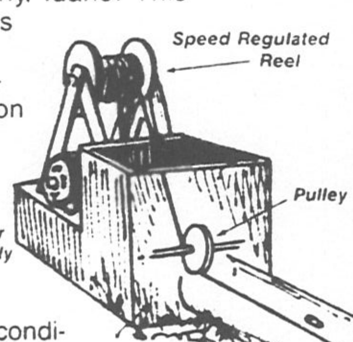
1. Automatic control of plug travel speed.
2. The control mechanism is portable and can be used on separate fields, greatly reducing irrigation equipment costs.
3. No external energy source.
4. Tail-end dribble eliminated.
5. Underground, surface, or above ground installation.
6. Reduced soil erosion.
7. Uniform application of water and reduced runoff.
8. Less than one fourth labor cost of standard gated pipe.
9. Speed control [redacted] adaptable to any shape field.
10. Water released at ground level.

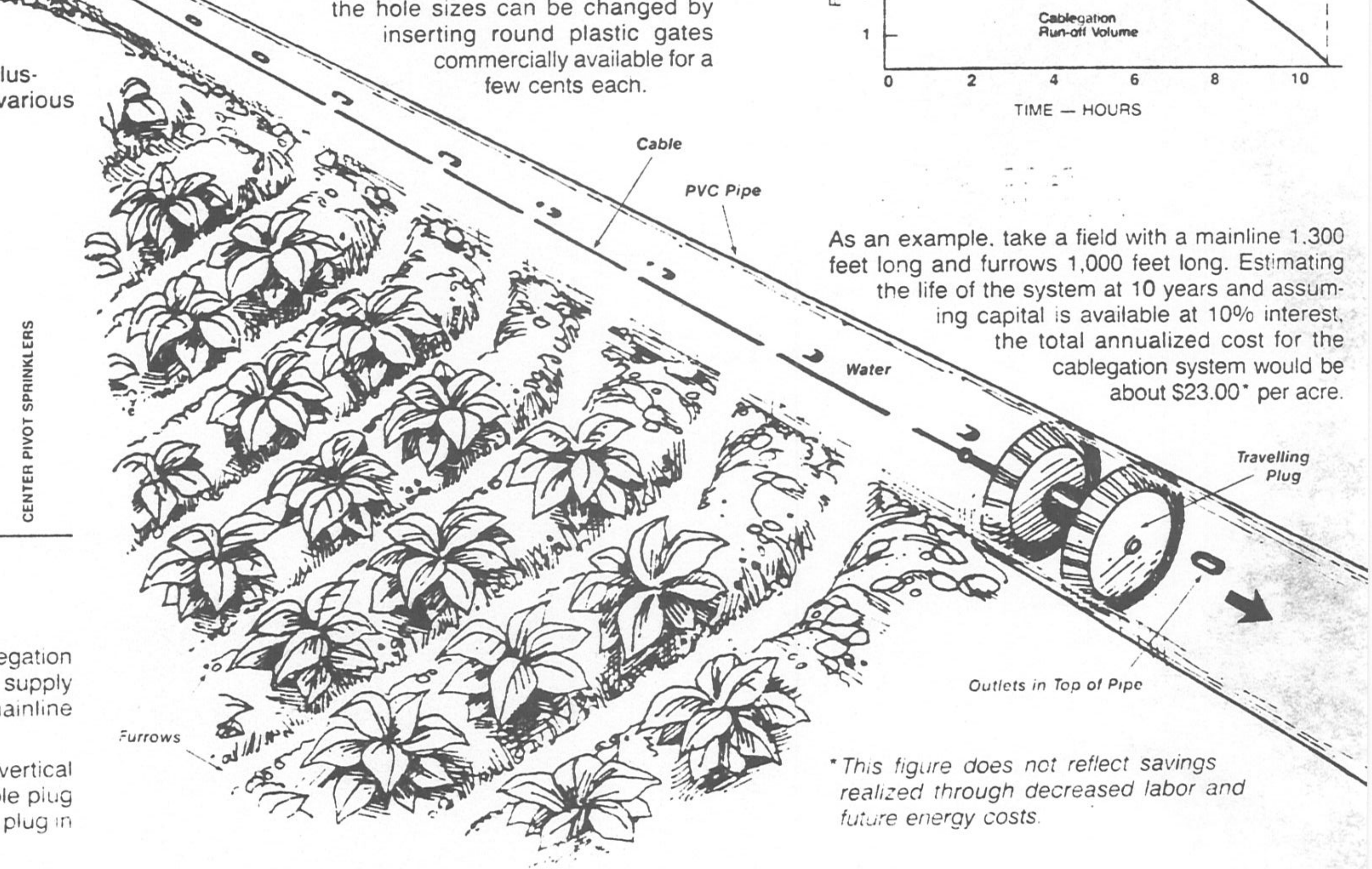


Route 1
Box 356
2½ West ½ South
Wendell, Idaho 83355
(208) 536-2365

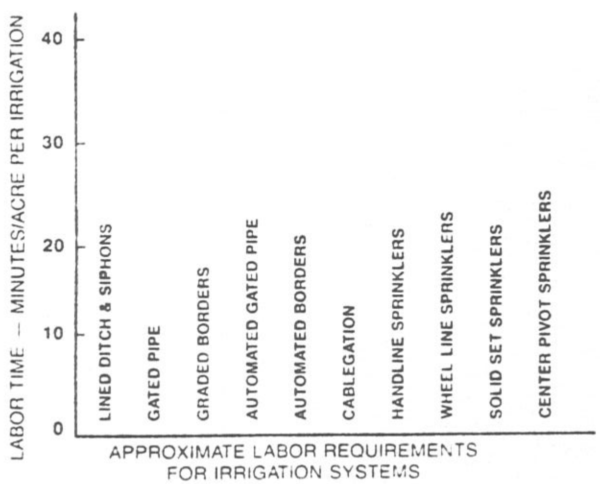
Are you surface irrigating and looking for ways to reduce labor and runoff?

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 run-off 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

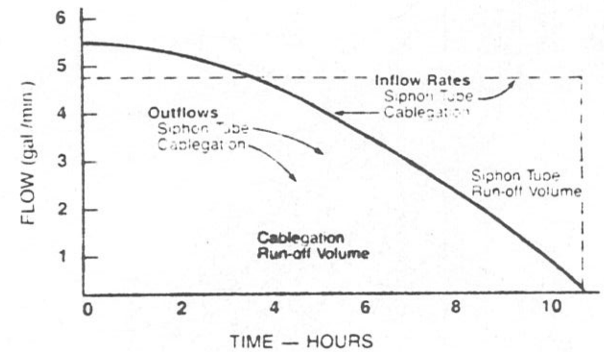
As with other gated pipe systems, the cablegation system uses a single PVC pipe as both the supply and distribution line. Installation of the mainline pipe to assure proper slope is critical.

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.

APPENDIX H

WEATHER STATION DESCRIPTION

COVER STORY

Weather Station Aids Irrigation Scheduling

By Mike Wohld

A small, automated, solar-powered weather station located at the edge of a field about 10 miles southeast of George in Grant County is providing data which is helping some farmers, such as Rex Calloway of Quincy, do a more precise job of scheduling irrigation.

The remote, automatic station monitors rainfall, wind, solar radiation, relative humidity, air temperature and other conditions. Each station is protected by a padlocked, two-layer steel jacket to discourage vandalization. Cost is about $10,000.

The data is transmitted by UHF to a stationary satellite about 23,000 miles above the earth and then on to the Bureau of Reclamation office at Boise, where it is summarized and stored in a computer. Funds to buy, install and maintain the system are provided by the Bonneville Power Administration. The Bureau of Reclamation is responsible for the actual servicing of the system and provides the information to growers.

BPA and the Bureau of Reclamation have been encouraging farmers to use the weather data in combination with known crop water consumption factors, irrigation system efficiencies and other factors to help make decisions on irrigation scheduling.

Computers are used to make the complicated calculations and summarize and store the various data. Incentives to use the computerized irrigation scheduling data include, in some cases, the hiring of qualified agricultural consultants to assist farmers and demonstrate how it can be utilized in irrigation scheduling.

An automatic, solar-powered weather station located southeast of George in Grant County.

The automatic weather stations provide accurate, up-to-date weather information which helps to estimate the evapotranspiration rate. This rate reveals how much water is evaporating from the soil and how much is actually being utilized by the plant.

This knowledge, along with actual measurements of current soil moisture in the field, the crop's moisture requirements at various stages of growth, and how much water an irrigation system will deliver over a period of time, is analyzed in coming up with estimates of how much water to apply the next week and how long to run each system to achieve this amount of water, according to Vaughn Hunsaker, soil chemist and co-owner of Soiltest Farm Consultants, a BPA contractor.

Vaughn Hunsaker, Moses Lake

Hunsaker, who holds a doctorate in soil science, has been involved in private consulting and irrigation scheduling in the Columbia Basin Project for about 10 years. He started when the primary aid was only an evaporation pan, which he indicated is still a useful guide in estimating irrigation needs.

"Weather determines irrigation," Hunsaker pointed out. Consequently, without accurate weather data, it is impossible to do a good job of scheduling irrigation.

The automatic weather station southeast of George is supposed to gather weather data fairly representative of an area within about a 25-mile radius of the unit, he said. The station was located in the Black Sands area because timely water application is particularly critical in this very sandy soil in which many potatoes are grown. Precise irrigation scheduling has reduced water consumption by as much as 25% in potato fields, where it has been used in the Black Sands area, he estimated.

Among the farmers who are using computerized irrigation scheduling, based in part on data from the George weather station, is Rex Calloway, 27, of Quincy. He farms with his father, Damon, and younger brother, Ross, 24, about 17 miles from the George weather station. The farm is outside the Black Sands area but within the Columbia Basin Irrigation Project.

Fields are mostly sandy loam, Rex said. They grow potatoes, sweet corn, dry corn, wheat and a small amount of alfalfa on about 750 acres.

Rex's grandparents, Roy and Pauline, came to the basin around 1950 from Oklahoma. Roy was about 55 years old at the time. He had heard about Grand Coulee Dam and the irrigation project, came out, looked it over and decided there was opportunity there. So, he and his wife sold their Oklahoma wheat and cattle farm and came to the Columbia Basin with their three sons and three daughters. All three sons — including Rex's father, Damon, David and Jerry — farm today in the Columbia Basin Project. "Dad always talks about how Grandpa was a man of great foresight," Rex noted.

The data has been amazingly accurate, Rex Calloway indicated during an irrigation workshop at which he was a speaker last winter at Moses Lake. For example, cumulative weekly estimates provided in computer printouts by Hunsaker on how much water the potatoes in one of the Calloway fields consumed last year totaled 29.3 inches per acre. The week-by-week recommendations by Hunsaker on how much water should be applied added up to a little over 28 inches. "We actually applied 29.7 inches," Calloway said.

Rex Calloway, Quincy

"We use it [computerized irrigation scheduling recommendations] as another tool," Rex said in a later on-farm interview. "We do not rely on it totally. We are out in the field every day with a soil probe and spade, digging and looking."

The irrigation scheduling program the Calloways are using is based on constant field inspection by the Calloways along with the computerized George station evapotranspiration data, crop consumption data and weekly soil moisture measurements at the same locations with a neutron probe by the Soiltest Farm Consultants. In addition, there are also calculations by the consultant on the number of passes and at what percent setting the center pivots must operate during the week to provide the desired amount of water.

All of this "helps us in applying the right amount of water," said Rex. Potatoes are particularly sensitive to the right amount of water at the right time, and quality is greatly influenced by appropriate moisture levels, he noted.

The primary advantage of the irrigation scheduling program has been in influencing potato quality, Rex indicated. "Quality is something we strive for. Quality is what you get paid for," he said. A shipment about the time of the interview graded 88% to 91% No. 1's and No. 2's, he noted.

"We are staying away from overirrigation," Calloway also pointed out. "We are probably using 3 to 4 inches less water now," he said.

The Calloways also use the irrigation scheduling program on their sweet corn and dry corn.

Computers and weather sensors like the one southeast of George can greatly assist precise scheduling of irrigation, indicated Hunsaker. He predicted increased use of this technology in the future. Advantages include improved crop quality and, in many cases, reduced water consumption, which can lower power costs. It can also reduce leaching of fertilizer, which offers the potential of great dollar savings, Hunsaker noted.

This technology, however, is only a supplement to experience and close personal monitoring of soil moisture in the field, both agriculturists also indicated.

Furthermore, the system is complicated and considerable patience and study are required to understand it and utilize the information it provides.

Fact Sheet: Automatic Remote Ag Weather Stations
USBR/BPA Ag Weather Network

Measures:

- Air temperature
- Relative humidity
- Solar radiation
- Precipitation
- Wind run
- Wind speed
- Wind direction
- Soil temperatures

Data collected at fifteen minute intervals and stored in station microprocessor. Then transmitted at established intervals via GOES West Satellite to Vax computer at Bureau of Reclamation office in Boise, Idaho.

Calculates on a Daily Basis:

- Minimum air temperature
- Maximum air temperature
- Dew point temperature
- Accumulated precipitation
- Wind run in miles
- Solar radiation in langleys
- Average wind speed
- Average wind direction
- Evapotranspiration

Sensors:

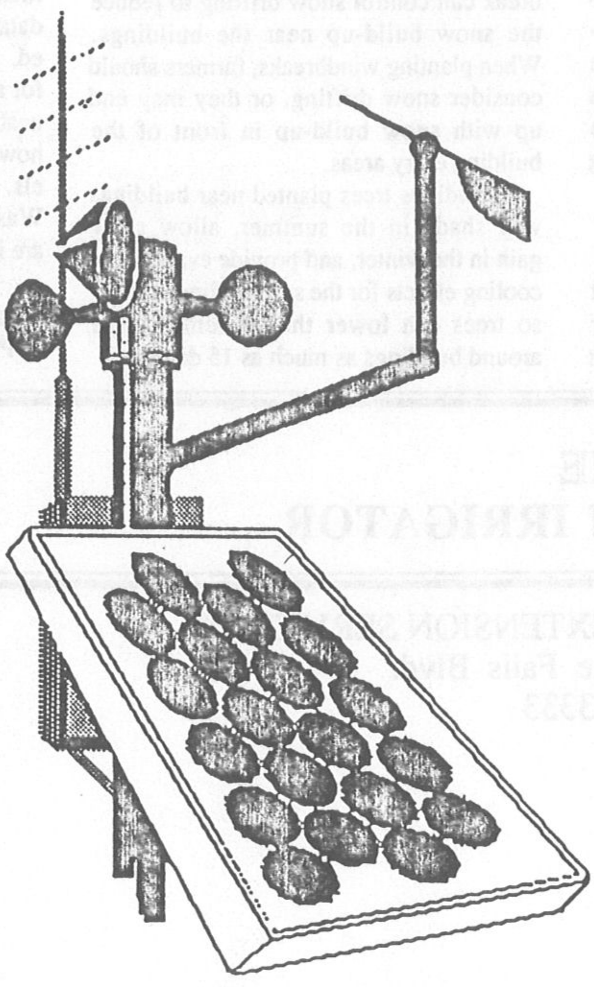
- R.M. Young	Free Flow Temperature Shield #41002
- R.M. Young	Wind Monitor #05103
- Texas Electronics	Relative Humidity Sensor, Model 2013A
- Qualimetrics	Contact Anemometer, Mode 2510
- Qualimetrics	Tipping Bucket Rain Gage, Model 6010
- Li-Cor	Pyranometer, Model LI-205B
- Yellow Springs Inst.	Thermistor, YSI#44212

Station Locations	Installed
Hermiston, Oregon	5/83
Lind, Washington	5/83
Malta, Idaho	6/83
Odessa, Washington	4/84
Madras, Oregon	5/84
Hamilton, Montana	4/84
Oroville, Washington	3/85
Christmas Valley, Oregon	4/85
Cedarville, California	4/85
Bandon, Oregon	5/85
Parma, Idaho	3/86
George, Washington	5/86
Wapato, Washington	6/86
Legrow, Washington	7/86

An Automated Weather Data Network for Washington

by Tom Ley and Mike Nelson

Over the course of the past year we have actively been gathering information and laying the groundwork for creating an automatic weather data collection system to serve Washington agriculture. The concept is simple but takes advantage of tremendous advances in electronic remote sensing and communications technology. The proposed system is composed of several carefully located automatic weather stations. They would all be linked together through any of three possible communications links to one or more central computer faciities. These computer facilities would automatically collect the weather data from the remote sta'ions, check the data, analyze it, and save it in an archive file. Most importantly the data would be utilized in a variety of tested agricultural computer models which have been developed to assist decision-making in crop production, helping to make many important operations more efficient and timely. Producers would have access to the information generated by telephone modem link from their personal computers, through WSU Cooperative Extension offices, through toll-free telephone lines, from the National Weather Service and various other sources and media. For some uses, such as frost monitoring and protection, the proposed system design will allow growers with microcomputers and the appropriate hardware to automatically receive weather data transmissions made by radio telemety from weather stations in their areas. This concept is not a new one. In fact, systems such as these have been operating in Nebraska for nearly ten years, and in California for over five years. Many states, seeing the advantages, are in the process of installing such systems for different purposes, but mostly for agricultural and water resources related uses. Documented costs and benefits of these installed networks generally show the systems pay for themselves relatively quickly, within three years in one case. We have proposed a network of 45 automatic weather stations which would report to up to 6 central computer facilities for Washington State. The system as proposed was a 5 year project. It was estimated that all the necessary equipment, as well as all operating and maintenance costs, plus a strong educational program on how to use the information would cost about $1.68 million over the 5 years. Very conservative estimates of the benefits accruing



just from the reduction of annual irrigation pumping costs to growers due to scientific irrigation scheduling are $2.58 million.

We have studied other systems in other states and collected information on the types of climate dependent agricultural crop production and protection models available. Since the weather data collected by this system would be available almost immediately to anyone, decisions about crop and pest management as affected or constrained by current weather conditions can be made more efficiently. The weather data system would greatly enhance a very valuable fruit frost monitoring and protection system in the major fruit producing regions in the state. The data would make pest development monitoring and pest management decisions more efficient. Fertilizer use efficiency would increase as a benefit of irrigation scheduling and the reduction of overirrigation. The benefits to agriculture are tremendous. We have made a conservative estimate of the benefits to agriculture of the entire statewide system to be on the order of $26 million annually. The benefits to the public in general would also be of economic importance.

The original proposal was to the POWER WASHINGTON committee, the group appointed by the Governor to determine the best allocation of about $46 million being refunded to the State by oil enterprises because of overcharges during the 70's. It appears at this point that the proposal will have to wait. We are still striving to obtain some level of funding to achieve partial or phased in implementation of the project. A hearing before the Fruit and Vegetables Subcommittee of the State House Agriculture Committee was held in Olypmia on February 19. The purpose was to provide more information to the committee members about the concept, how the data would be used and the expected benefits. Various funding alternatives were discussed. The Bonneville Power Administration and the U.S. Bureau of Reclamation are currently collaborating on a network of automatic weather stations for irrigation scheduling in the Pacific Northwest. There are currently 6 of their weather stations in Washington. They report their data via radar telemetry and a geo-stationary sattalite to the Bureau of Reclamation computer in

continued p. 4

Saving energy on the farm through careful site planning.

There are many ways that farmstead managers can reduce energy costs. Careful planning provides the largest potential for energy savings. Building design, landscaping and orientation can take advantage of enviornmental factors to reduce energy needs. Energy efficient buildings minimize heat loss, maximaze solar gain and natural ventilation, thereby reducing energy costs.

Site Features

New buildings should be oriented so that natural site features are used to the best advantage. Building into hillsides or near natural windbreaks can protect structures from winter winds and drifting snow. Open-front livestock buildings should be oriented away from the cold winter winds and still be able to capture the summer breezes which remove heat. All buildings should be designed so that natural ventilation can occur.

Landscaping

Landscaping can provide a great deal of protection from winter winds, snow drifting, soil erosion and hot summer sunshine. Three to five rows of trees or shrubs will provide an effective windbreak to stop cold air from blowing into the home or farm buildings. This same windbreak can control snow drifting to reduce the snow build-up near the buildings. When planting windbreaks, farmers should consider snow drifting, or they may end up with snow build-up in front of the building entry areas.

Decidious trees planted near buildings will shade in the summer, allow solar gain in the winter, and provide evaporative cooling effects for the surrounding area also trees can lower the air temperature around buildings as much as 15 degrees.

Weather Network continued

Boise, ID. The data is obtained locally via computer to telephone modem hookup to the Boise computer. With careful cooperation and design, this system could meet the constraints and needs of our proposed system. We envision a need for more weather stations than are planned by the BPA. We also desire local weather data radio telemetry to meet the needs of the fruit growers. A more comprehensive data analysis and usage plan is needed. In other words, use the data in a variety of other agricultural crop management models. Finally, a more efficient data dissemination/delivery plan is needed. We need the local computer facilities for assisting this. Plus, a considerable educational effort is needed to teach growers how to make use of the data and the models. WSU Cooperative Extension and Washington Energy Extension Servoce are ideally suited for these jobs.

If you would like more information on the proposal please contact Tom Ley in Prosser (509) 786-2226.

THE
WASHINGTON IRRIGATOR

WASHINGTON ENERGY EXTENSION SERVICE
Room 627, W. 808 Spokane Falls Blvd.
Spokane, Washington 99201-3333

BULK RATE
U.S. POSTAGE
PAID
Seattle, Wa.
Permit 1221

USDA
Soil Conservation Service
316 A S. Chestnut St.
Moses Lake, WA 98837

APPENDIX I

URBAN WASTEWATER DISPOSAL RESOLUTIONS

MOSES LAKE IRRIGATION & REHABILITATION DISTRICT

COPY

RESOLUTION NO. 85-1

RESOLUTION CONCERNING THE DEVELOPMENT OF A CITY/COUNTY PLAN TO REDUCE THE IMPACT OF ON-SITE SEWAGE DISPOSAL SYSTEMS ON THE BODY OF WATER, MOSES LAKE.

RECITALS:

1. The Moses Lake Clean Lake Project was initiated in 1982 as part of an effort by a number of agencies to improve Moses Lake water quality. These agencies included the Moses Lake Conservation District, the Moses Lake Irrigation & Rehabilitation District, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency.

2. The greater Moses Lake area has experienced extensive population growth and subsequent pollution increases over the past two decades, which results in diminished recreational use and increasing numbers of complaints concerning odors, degradation and aquatic weed growth.

3. The Moses Lake Clean Lake Project Phase I study indicates nitrogen and phosphorus are the major nutrients causing over-fertilization of the lake. Septic tank effluent contains significant amounts of these nutrients and under certain conditions may contribute significantly to the nutrient load of the lake. These conditions include: malfunctioning systems, improperly designed systems, overloaded systems, and systems installed in excessively permeable soils or where groundwater is shallow and unconfined.

4. Soil Conservation Service data indicates underlying soils in the vicinity of the lake are considered to be excessively permeable and groundwater is shallow, which allows nutrients to rapidly move toward Moses Lake.

5. The Moses Lake Clean Lake Project Stage II report states, "at best, the septic tank/drainfield increases the total dissolved mineral content of local groundwaters. At worst, it may introduce bacteria, viruses and degradeable organic matter as well. Rationally, it would seem undesirable to concentrate 2,000 - 15,000 septic tank systems along the margin of a recreational lake". Presently, there are an estimated 3,000 septic tank/drainfield systems in the immediate area of Moses Lake.

6. It is in the best interest of the residents of the Moses Lake area and for the general good, health and welfare of the community to urge the elimination of on-site sewage disposal in the vicinity of Moses Lake.

IT IS THEREFORE RESOLVED:

1. The Moses Lake Irrigation & Rehabilitation Board of Directors encourages the establishment of a plan to eliminate present and future use of on-site sewage disposal systems in the vicinity of Moses Lake. This plan should be developed as a Comprehensive Waste Water Management Plan for the greater Moses Lake area and include a sewage collection and treatment system which will be administered by an appropriate public entity.

2. The Moses Lake Irrigation and Rehabilitation District Board of Directors pledges its support to the applicable agencies involved with the development of such a plan and the eventual elimination of on-site sewage systems which adversely affect the lake.

3. The Moses Lake Irrigation & Rehabilitation District Board of Directors presupposes that any development in the greater Moses Lake area will be in accordance with the Comprehensive Waste Water Management Plan, following its adoption.

Passed by the Moses Lake Irrigation & Rehabilitation District Board of Directors on the 8 day of Oct, 1985.

Constituting the Moses Lake Irrigation and Rehabilitation District Board of Directors.

MOSES LAKE

CLEAN LAKE PROJECT

SPONSORING AGENCIES:
Moses Lake Irrigation & Rehabilitation District
Moses Lake Conservation District
Upper Grant Conservation District

PROJECT OFFICE:
316 A Chestnut Street
Moses Lake, WA 98837
509-765-3261

RESOLUTION 85-1

RESOLUTION CONCERNING THE DEVELOPMENT OF SEWER SYSTEM EXTENSIONS TO ELIMINATE EFFLUENTS FROM IMPACTING THE WATER QUALITY OF MOSES LAKE

WHEREAS, the MLCD is aware the lakeshore of Moses Lake is becoming more urbanized and densely populated, and

WHEREAS, the area in the vicinity of Moses Lake will continue to become more urbanized as lands are developed into residential areas, and

WHEREAS, it is estimated that 3,000 septic tank/drainfield systems already exist in the immediate area of Moses Lake and its tributaries, and

WHEREAS, soils in the Moses Lake area are of glacial origin and are considered to be excessively permeable which allows contaminants and nutrients to move readily underground, and

WHEREAS, ground water is generally shallow and flows toward Moses Lake, and

WHEREAS, older septic tank systems may have exceeded their useful lives and be significantly contributing to the nutrient loading of the lake.

NOW, THEREFORE, IT IS HEREBY RESOLVED that the Moses Lake Conservation District Board of Supervisors establishes a policy to proceed with the elimination of the use of on-site sewage disposal systems along the lakeshore of Moses Lake and any of its tributaries where pollutants and nutrients might reach the lake.

BE IT FURTHER RESOLVED, that the MLCD encourages the establishment of a moratorium which may be adopted by applicable agencies to stop future placement of on-site sewage disposal systems in the vicinity of Moses Lake.

BE IT FURTHER RESOLVED, that the MLCD through its involvement in the Moses Lake Clean Lake Project wishes to be instrumental in bringing together governmental agencies and interested persons to discuss the problems of on-site sewage disposal systems and to address possible solutions to those problems,

COOPERATING AGENCIES:
Grant-Adams Area Cooperative Extension
Soil Conservation Service
Washington State Conservation Commission
Washington State Department of Ecology
Environmental Protection Agency

BE IT FURTHER RESOLVED, that the MLCD assist in finding any funds local, state, and federal which may be available to use for the development of sewer systems near Moses Lake,

BE IT FURTHER RESOLVED, that the MLCD encourage conversion from existing on-site sewage disposal systems in use near the lake to approved off-site sewage treatment facilities,

BE IT FURTHER RESOLVED, that the MLCD accomplish all of the above with as little disruption and as much public support as possible.

PASSED by the Board of Supervisors of the Moses Lake Conservation District this 11th day of Sept., 1985.

Clifford J Elder
Clifford (Tom) Elder, Chairman

Wm J Bellomy
Wm. J. Bellomy, Jr.

Dan Roseburg
Dan Roseburg

Dale P Walker
Dale P. Walker, Vice-Chairman

Constituting the Board of Supervisors of the Moses Lake Conservation District.

RESOLUTION NO. 85- UGCD 1 **COPY**

RESOLUTION CONCERNING THE DEVELOPMENT OF A COMPREHENSIVE WASTEWATER MANAGEMENT PLAN FOR THE GREATER MOSES LAKE AREA

RECITALS:

1. The greater Moses Lake area has experienced extensive population growth and subsequent increases in amounts of wastewater which impacts area groundwater.

2. The U.S.D.A. Soil Conservation Service, Grant County soil survey indicates that many of the underlying soils in the Moses Lake area are excessively permeable which allows water, contaminants and nutrients to enter unconfined groundwater.

3. U.S. Bureau of Reclamation data indicates groundwaters in the Moses Lake area generally flow toward the lake.

4. Groundwater can be adversely affected by the addition of pollutants and nutrients.

5. It is in the best interest of the residents of the Moses Lake area and for the general health, safety, and welfare of the community to address the environmental impacts of the use of on-site sewage disposal systems.

IT IS RESOLVED:

1. The Upper Grant Conservation District Board of Supervisors endorses the concept to develop a Comprehensive Wastewater Management Plan for the greater Moses Lake area.

2. The Upper Grant Conservation District Board of Supervisors agrees that it is essential for applicable agencies to become involved in the development of such a plan and hereby expresses its willingness to offer input to the development of such a plan.

3. The Upper Grant Conservation District Board of Supervisors concurs with the general concept of the development of a Comprehensive Wastewater Management Plan, although this concurrence does not obligate the Upper Grant Conservation District financially nor to any specific feature that may be adopted in such a plan.

Passed by the Upper Grant Conservation District Board of Supervisors on the 25 day of Oct, 1985.

Lance Stadelman

[illegible]

[illegible] Roberts

[illegible] Dormaier

R. Edward Boston

Constituting the Upper Grant Conservation District Board of Supervisors

received
9/26 djb

STATE OF WASHINGTON

DEPARTMENT OF GAME

EPHRATA OFFICE: P.O. BOX 1237 - 1540 ALDER ST. NW EPHRATA, WA 98823 PHONE: (509) 754-4624

September 25, 1985

Moses Lake Clean Lake Project
316 A Chestnut Street
Moses Lake, WA 98837

To whom it may concern:

The recent passage of Resolution 85-1 by the Moses Lake Conservation District is a commendable and needed step in solving water quality problems associated with Moses Lake. Moses Lake is a valuable resource not only to residents of Grant County, but to people throughout Washington. This resource must be improved and protected.

The Washington Department of Game, Region 2 Office, supports the proposal to develop off-site sewage treatment facilities which would service all present and future development along the lake. Such a system would decrease pollutants and nutrient loading and improve water quality. Improved water quality would be beneficial to fish and wildlife production which would generate additional income and jobs for the community of Moses Lake through greater recreational use.

Thank you for allowing us to comment on the proposal. We welcome the opportunity to participate in planning for a cleaner Moses Lake.

Respectfully,

THE WASHINGTON DEPARTMENT OF GAME

Joseph H. Foster /EH

Joseph H. Foster
Acting Regional Administrator

JHF:eh

cc: Ray Duff

United States Department of the Interior

BUREAU OF RECLAMATION
COLUMBIA BASIN PROJECT
P.O. BOX 815
EPHRATA, WASHINGTON 98823

IN REPLY REFER TO 430
511.-Moses Lake

NOV 2 1 1985

Moses Lake Clean Lake Project
316 A Chestnut Street
Moses Lake, WA 98837

Ladies and Gentlemen:

This is in response to your letter of October 31, 1985, concerning a Comprehensive Wastewater Management Plan for Moses Lake, Washington.

Your letter sufficiently explains your reasons for developing a Comprehensive Wastewater Management Plan. However, we are not adequately prepared to recommend or support the need for the plan itself. Certainly the concepts for the improvements of the quality of the lake are good.

In this regard the Columbia Basin Project and the East Columbia Basin Irrigation District will continue to cooperate in programming feed water to Potholes Reservoir through Moses Lake when necessary to meet the downstream irrigation needs. The Clean Lake Project's desired flow rates will certainly be considered whenever possible.

Thank you for keeping us informed of your activities in Moses Lake, and we look forward to continuing to work with the agencies and people who are involved.

Sincerely yours,

Jim Cole

James V. Cole
Project Manager

cc: Mr. Clinton Connelly, Moses Lake Irrigation and Rehabilitation District, 2131 W. Broadway, Moses Lake, WA 98837

Mr. Dick Bain, Brown and Caldwell Consulting Engineers, 100 West Harrison St., Seattle, WA 98119

East Columbia Basin Irrigation District, Othello, WA

RESOLUTION CONCERNING THE DEVELOPMENT OF A COMPREHENSIVE WASTE WATER MANAGEMENT PLAN FOR THE GREATER MOSES LAKE AREA.

WHEREAS, the purpose of the Moses Lake Area Chamber of Commerce, in part, is to work toward the advancement of industrial, commercial, agricultural, civic and general interest of the City and Port of Moses Lake, and

WHEREAS, by order of the Board of Directors, the Moses Lake Area Chamber of Commerce has long endorsed a clean lake for the enhancement of recreational development, and

WHEREAS, it is in the best interest of the residents of the Moses Lake area, for their general health, safety and welfare, to address the environmental impacts of water quality.

NOW, THEREFORE BE IT RESOLVED, that the Moses Lake Area Chamber of Commerce endorses the concept of the development of a Comprehensive Waste Water Management Plan for the Greater Moses Lake area.

BE IT FURTHER RESOLVED that the Plan be allowed the appropriate review process by associated agencies and all other interested parties.

PASSED this 14th day of January, 1986.

JOHN F. DIETZEN, PRESIDENT

Karen Gordon Wagner

KAREN GORDON WAGNER, MANAGER

MOSES LAKE-OTHELLO BOARD OF REALTORS

REALTOR®

received
12/17 ·d ·B

MOSES LAKE, WASHINGTON 98837

Moses Lake
Clean Lake Project
316A Chestnut St.
Moses Lake WA 98837

December 13, 1985

To whom it may concern:

The Moses Lake-Othello Board of Realtors endorses the developement of a Comprehensive Wastewater Management Plan for Moses Lake. This plan should address water quality and other issues affecting Moses Lake.

We support the rights of all private property owners. We feel that before any significant action is taken to affect water quality in Moses Lake, the Comprehensive Plan must be developed so that all issues can be faithfully and reasonably addressed. The problem appears to be extremely complex. Some of the solutions appear to be enormously expensive, possibly prohibitively so, for some property owners. We are the hub of a major agricultural area and any solution affecting agriculture must be thoroughly analyzed. The solutions would seem to be beneficial to all in the long term. Short term affects should be considered as well.

A comprehensive plan will provide the vehicle for solutions to most of the problems.

Please consider our support in the plan developement. We would like to remain appraised of developments.

Sincerely,

Bill Bailey
Vice President

BB/bb

COPY

RESOLUTION NO. 85- 1238

RESOLUTION CONCERNING THE DEVELOPMENT OF A COMPREHENSIVE WASTE WATER MANAGEMENT PLAN FOR THE GREATER MOSES LAKE AREA

RECITALS:

1. The greater Moses Lake area has experienced extensive population growth and subsequent increases in amounts of wastewater which impacts area groundwater.

2. The U.S.D.A. Soil Conservation Service, Grant County Soil Survey indicates that many of the underlying soils in the Moses Lake area are excessively permeable which allows water, contaminants and nutrients to enter unconfined groundwater.

3. U.S. Bureau of Reclamation data indicates groundwaters in the Moses Lake area generally flow toward the lake.

4. Groundwater can be adversely affected by the addition of pollutants and nutrients.

5. It is in the best interest of the residents of Moses Lake area and for the general health, safety, and welfare of the community to address the environmental impacts of the use of on-site sewage disposal systems.

IT IS RESOLVED:

1. The City of Moses Lake City Council endorses the concept to develop a Comprehensive Wastewater Management Plan for the greater Moses Lake area.

2. The City of Moses Lake City Council agrees that it is essential for applicable agencies to become involved in the development of such a plan and hereby expresses its willingness to offer input to the development of such a plan.

3. The City of Moses Lake City Council concurs with the general concept of the development of a Comprehensive Wastewater Management Plan, although this concurrence does not obligate the City of Moses Lake financially nor to any specific feature that may be adopted in such a plan.

Adopted by the City Council on October 22, 1985.

Norman J. Johnson

Mayor

ATTEST:

Walter Fry

City Clerk

CITY OF MOSES LAKE
WASHINGTON

City Manager........766-9201
City Attorney.........766-9203
Community Dev....766-9235
Finance Dept.......766-9246
Fire Dept.............765-3811
Municipal Serv......766-9217
Municipal Court....766-9212
Parks & Rec.........766-9240
Police Dept..........765-4511

September 5, 1985

Honorable Mayor and
Moses Lake City Council

Gentlemen:

Attached for your consideration is a draft of a resolution setting forth a policy with regard to septic tanks usage and sewer hook-ups. This resolution is drafted pursuant to Council direction. The matter was discussed by City Council and City Staff at the City Council/Staff retreat.

If this type of resolution is agreeable to the Council, I will bring it back at the next City Council meeting for formal consideration. There are some details which should be discussed, such as the date when the City Council would feel all septic tank usage in the City of Moses Lake should cease, if the City wishes to participate financially in the installation of any sewer improvements, how much money would be allocated for such purpose, and to what degree the City would participate if financial assistance was provided, and if there would be any waivering from this type of a policy to take into account any new developments in the disposal of solid waste through small private systems.

Also when this resolution is brought back for formal consideration, I will present amendments to the two ordinances currently on the city's books with regard to sewer hook-ups in order to eliminate confusion in the city's written direction. Those ordinances were discussed also with the City Council at the last City Council/Staff retreat.

Respectfully submitted,

JOSEPH K. GAVINSKI
City Manager

JKG:mdp

Attachment

SOUTH 321 BALSAM STREET ■ POST OFFICE DRAWER 1579 ■ MOSES LAKE, WASHINGTON 98837 ■ A.C. 509 766-9214

Change S.T. to On-Site Sewage Disposal Systems

RESOLUTION NO. _______

RESOLUTION SETTING FORTH A POLICY WITH REGARD TO SEPTIC TANKS AND SEWER HOOK-UPS

RECITALS:

1. The water quality of Moses Lake has been a concern of many citizens and public and private agencies and organizations over the last several years.

2. The Moses Lake Clean Lakes Project was initiated in 1982 as part of an effort to improve the water quality of Moses lake. Involved in the effort is the United States Environmental Protection Agency, the Washington State Department of Ecology, Moses Lake Irrigation and Rehabilitation District, and the Moses Lake Conservation District.

3. The Clean Lakes Project, through its endeavors, identified high levels of nitrogen and phosphorous in the waters of Moses Lake. This has been considered part of the cause for the algae growth in Moses Lake which effects the water quality of Moses Lake. The high levels of nitrogen and phosphorous in turn is caused in part by septic tank leachate.

4. Furthermore, the septic tank leachate in the future could affect the quality of drinking water for those people served by the City of Moses Lake's water utility, people served by private water utilities, and people served by private wells. The effect could be felt not only by those people residing within the corporate limits of the City of Moses Lake but also by those people residing in the areas surrounding the City of Moses Lake.

5. It is in the best interests of the citizens of the City of Moses Lake and the citizens in the areas surrounding the City of Moses Lake and generally for the public good, health and welfare if the usage of septic tanks was eliminated within the corporate limits of the City of Moses Lake.

6. Also, since it is in the best interests of the citizens of the City of Moses Lake and the citizens in the areas surrounding the City of Moses Lake and generally for the public good, health and welfare, to eliminate the usage of septic tanks within the corporate limits of the City of Moses Lake, the City should participate financially in partnership with those citizens, companies, corporations, etc. who wish to hook up to the city's sewer system. This financial assistance would be made available for those utilizing the LID or ULID process.

IT IS RESOLVED:

1. All structures with sanitary facilities within the corporate limits of the City of Moses Lake shall be hooked up to the city sewerage system as of ________________. Also, as of the same date all septic tank usage in the City of Moses Lake shall cease and structures with sanitary facilities shall not be allowed to discharge the sanitary waste water to a septic tank system.

2. The City of Moses Lake shall make available ____________________ for the years _____________________ to be used to partially fund the cost of installing sewer mains and laterals. The money of the City of Moses Lake, derived from the city's water/sewer enterprise fund, will fund _____ % of the cost of installing the improvements when such installation is done by an LID or ULID.

PASSED by the City Council on the _____ day of ________________, 1985

ATTEST:

____

City Clerk

____

MAYOR

ORDINANCE NO. 1187

AN ORDINANCE AMENDING CHAPTER 13.04 OF THE MOSES LAKE MUNICIPAL CODE ENTITLED "SEWER REGULATIONS"

THE CITY COUNCIL OF THE CITY OF MOSES LAKE, WASHINGTON DO ORDAIN AS FOLLOWS:

Section 1. Moses Lake Municipal Code Chapter 13.04 entitled "Sewer Regulations" is amended to provide as follows:

13.04.045 Private Systems: Private sewer systems, septic tanks, and on-site sewage disposal systems are prohibited.

13.04.150 Installation and Connection to Toilet Facilities With Sewer: The owner of all houses, buildings, or properties used for human occupancy, employment, recreation, or other purpose, situated within the city and abutting on any street or alley in which there is constructed and now located or within two hundred feet (200') of any street or alley in which there is constructed and now located a public sanitary or combined sewer of the city, is required at his expense to install suitable toilet facilities therein and to connect such facilities directly with the public sewer in accordance with the provisions of this chapter and as permitted by RCW 35.24.290(4) as now in effect or hereinafter amended, within six (6) months after the date of official notice to do so.

Section 2. Section 13.04.045 shall take effect and be in force five (5) days after its passage and publication as provided by law. Section 13.04.150 shall take effect and be in force on January 1, 1987.

Adopted by the City Council and signed by its Mayor on October 22, 1985.

s/ Norman Johnson
Mayor

ATTEST:

s/ Walter Fry
City Clerk

APPROVED AS TO FORM:

s/ James A. Whitaker
City Attorney

Publish: October 30, 1985

APPENDIX J

MOSES LAKE MANAGEMENT MODEL

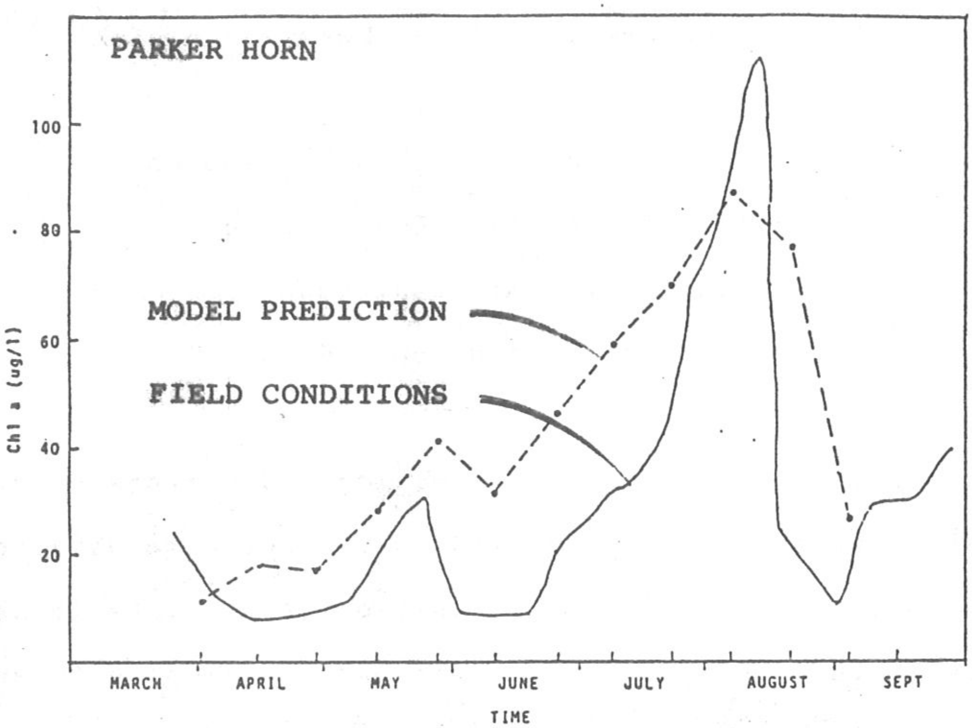
A wind-phytoplankton model for the water quality management of Moses Lake

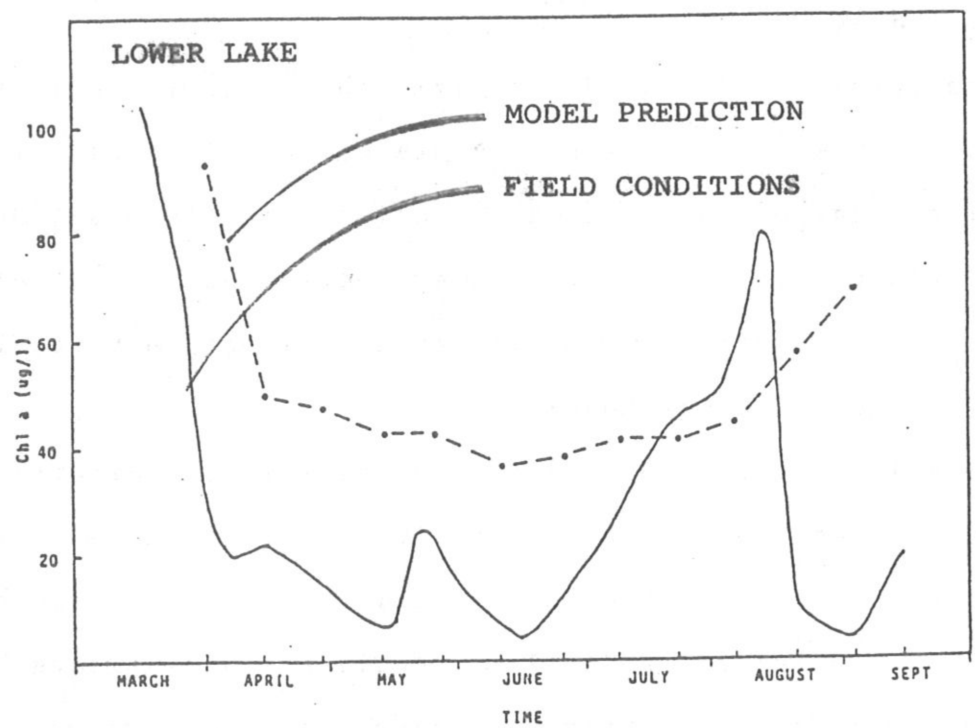
S.L. Marquis, B.W. Mar and E.B. Welch
Department of Civil Engineering
University of Washington
Seattle, Washington 98195

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.

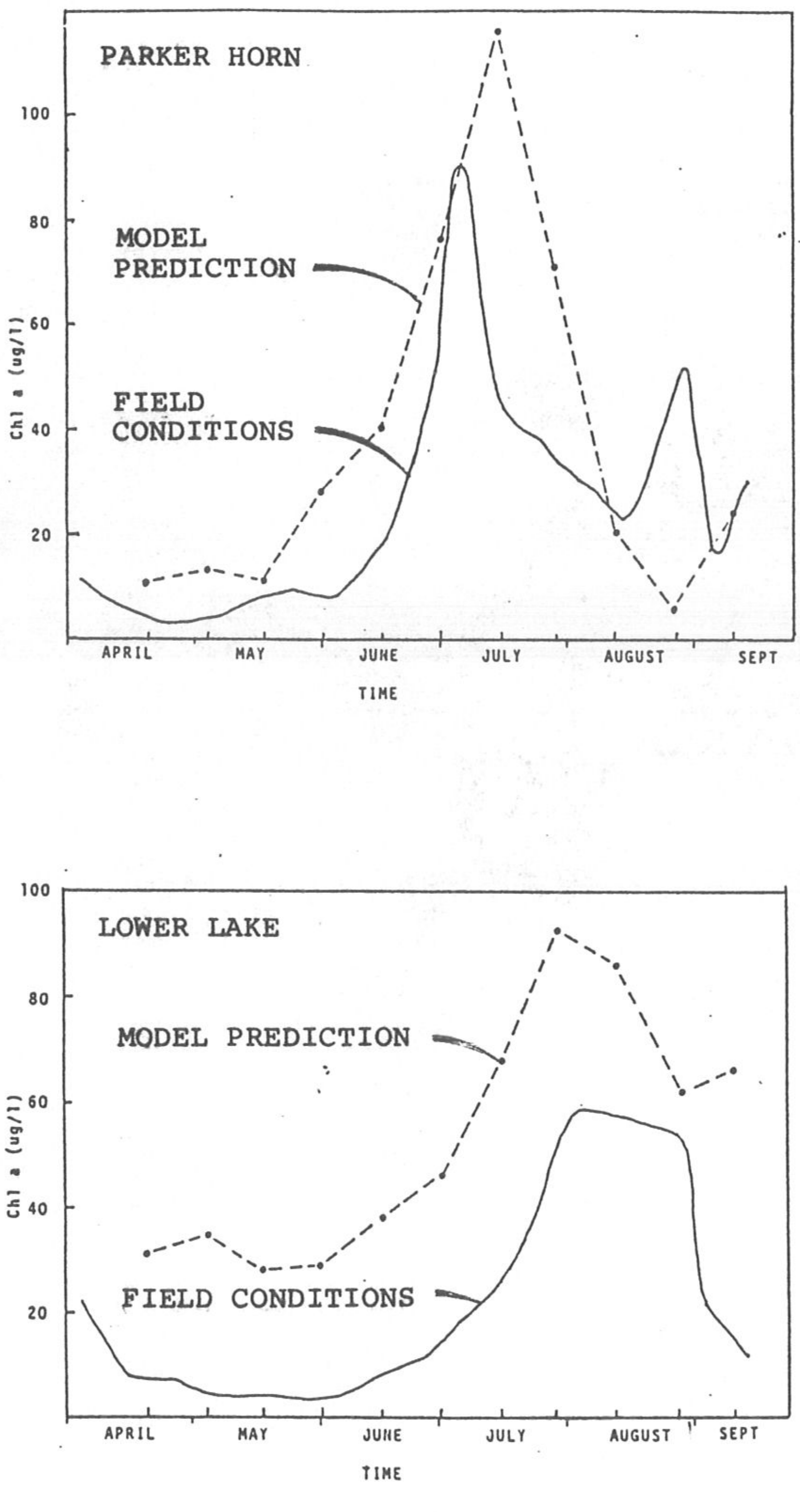
The management model predicts total chlorophyll a over two week time periods for each sub-basin of Moses Lake, excluding Pelican Horn. It was calibrated and verified with limitations (figures 1 and 2). While the model predicts the timing of blooms and the pattern of algal concentration fluctuations well, 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 K

ROCKY FORD CREEK DETENTION POND OPERATION AND MAINTENANCE

Rocky Ford Creek Detention Pond
Operation and Maintenance Manual

The Rocky Ford Creek Detention Pond is located on lower Rocky Ford Creek in the southeastern quarter of Section 8, T 20 N, R 27 e and can be reached by an access road off Nepel Road near State Highway 17. See Location on Fig. 6-5 in final report.

Description of Detention Structure

The Rocky Ford Creek Detention Pond Structure consists of an earthen dike and a concrete spillway structure. Specific details are provided on as built drawings prepared by Boundary Engineers which are incorporated into this operations and maintenance manual by reference. The structure is protected by basalt rock rip rap in areas subject to water erosion. There is a concrete fuse plug in the western dike which is designed to allow the western-most portion of the dike to wash out in the event of an extreme flood. Non-extreme flood flows are handled by the spillway structure which is equipped with removable wooden (4X6) stop logs to allow adjustment of pool elevation over a three foot range.

Operation and Maintenance

The primary purpose of the structure is to improve water quality by enhancing sedimentation of incoming suspended matter within the reservoir, nutrient trapping by emergent and benthic vegetation and blockage of carp migration into upper Rocky Ford Creek. To these ends the structure is needed and its integrity should be assured through periodic inspections of the dike and spillway area as well as conditions in the reservoir and areas immediately downstream of the structure. The following specific inspections and activities should be conducted:

1. Periodic routine inspections should be made to evaluate the condition of the structure, these inspections should be made on a regular (e.g. weekly) basis during the first year of operation to establish a baseline for future reference. Factors to be checked on these routine inspections include:
   a. Condition of access gate, signs and locks, condition of catwalk, gates, locks and signs at the dam.
   b. Condition of the access road, pot holes, obstacles such as large rocks or other impediments to travel.
   c. Water level in pond, number and condition of stop logs in place*, height of water coming over stop logs.
   d. Debris accumulations at spillway or on spillway apron, remove debris which affects water passage.
   e. Check water drainage from high groundwater area on west side of dam, estimate flow.
   f. Check for water seepage conditions along entire downstream side of dike, report any unusual seepage to MLIRD Board.
   g. Check vegetation on dike, below dike, and within

ponded area, photograph vegetative cover once established for future reference.

h. Check for presence of carp in below spillway area, remove dead carp from vicinity of structure.

i. Document water or shoreline use activities by visitors to the site, report any activities of concern to MLIRD Board. Warn visitors to stay away from spillway apron or catwalk.

2. Non-routine inspections should be made to evaluate conditions following significant storms or snow melt events. All of the routine inspection items listed above should be considered along with the following:

a. Evaluation of maximum water level reached during event.

b. Special evaluation of west side of structure, west of fuse plug to assess if any wash out had occurred or if preliminary signs of wash out were evident.

3. Precautionary visits should be made when significant snow accumulations are present or when major storms are expected. Precautions to be taken where major runoff is anticipated include:

a. Removal of stop logs to draw pool level down. Spillway capacity is increased by approximately cfs for each 6 inces the stop log weir is lowered.

b. Stop logs removed should be stored in a secure location. Stop log pullers have been designed to fit over steel dowels at the ends of each log. Stop log removal requires two men as a minimum.

4. Periodic (routine) inspections cited in item 1 maybe less frequent after the first year but should be no less than monthly and should be attentive to non-routine events or activities, including reports of increased visitation to the structure. Liability of the MLIRD should be a paramount concern and any unusual or potentially dangerous activities should be reported to MLIRD and discouraged signage or other measures.

5. Reservoir inspection should be conducted annually and silt deposits should be noted. Water clarity should permit visual inspection of the pond bottom. Silt build up will take many years before silt removal will be necessary unless some unusual event occurs in the watershed. Cleaning by drag line or other dredging methods may be required at sometime in the future. Spoils may be deposited above the high water line and should be used to build soil in thin soil areas such as the construction borrow pit on the east side of the pond.

6. Water samples should be taken during flood events to assess suspended solids and nutrient trapping within the pond. Samples should be taken from the creek entering the pond and from the spillway discharge and analyzed for suspended solids total phosphorus and total nitrogen when such opportunities arise.

*Extra stop logs are stored at Airman's Beach Park should a stop log be lost or broken.

APPENDIX L

PUBLIC INFORMATION

Moses Lake Clean Lake Project
Information/Education Program Summary

The 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 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.

Activities Summary (Stage 2 and Stage 3)

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 designated 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 everybody 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 Camero Recordings - Hundreds of 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 and Rehabilitation District as well as other persons in leadership positions within the community. These demonstrations were provided through a coordinated effort by the Information/Education section to show the elected Moses Lake Irrigation and Rehabilitation District Commissioners and their constituents how

Activities Summary (Stage 2 and Stage 3) - continued

Weed Harvester Demonstrations (continued) - 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. Weed Harvesters were subsequently leased from Seattle Metro and used on the Lake in 1985 and 1986.

News Media, Press Releases, and Stories - Numerous 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 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, one information letter was sent to the nearly 300 landowners in the project area as an informational item.

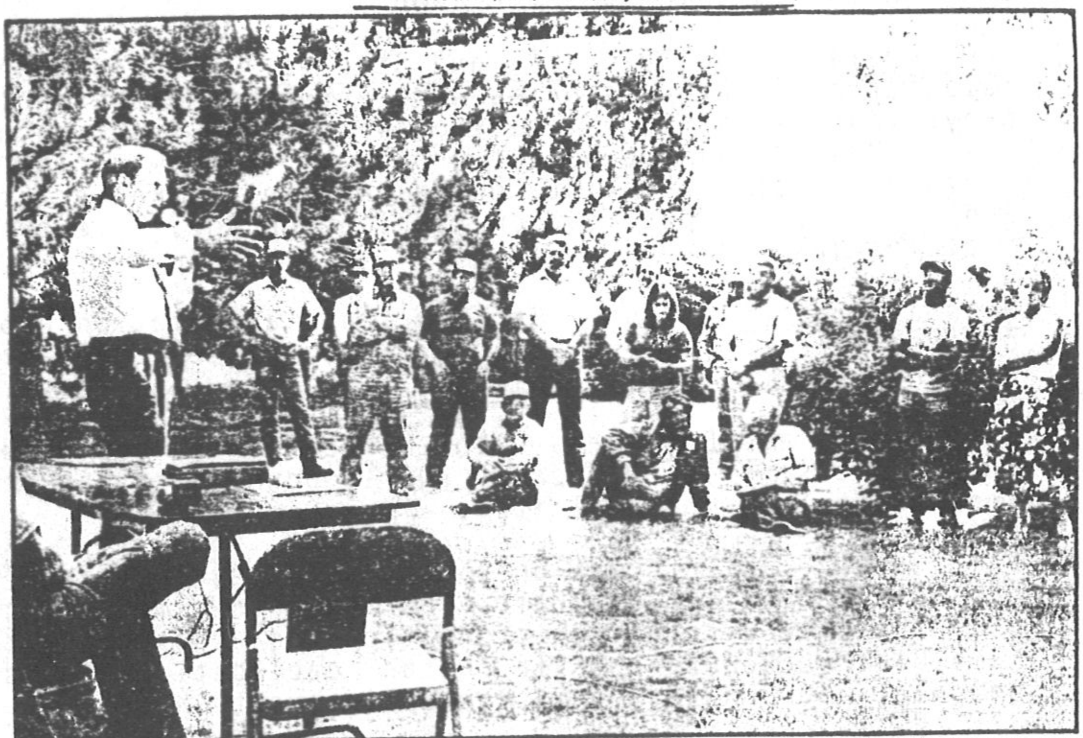
Fair Booth - An informational booth was developed and staffed during the Grant County Fair. During this time, nearly 85,000 people were given information and exposure to the Moses Lake Clean Lake Project via photos, cablegation demonstrations, pamphlets, brochures, and sign-up interest sheets.

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. This effort was repeated with equal success in 1985 and 1986.

Farm Tours - Numerous tours of project area farms occurred to educate the interested public and to provide publicity on the project. A highlight tour occurred in the summer of 1986 which featured Congressman Sid Morrison as an honored guest. At that time Congressman Morrison passed out cost-share checks to several farmers in a formal presentation at one of the farms.

National Recognition - The North American Lake Management Society awarded a special technical excellence award to the Moses Lake Project in their 1986 annual meeting in Portland, Oregon.

CBH. Moses Lake, Wa., Thurs., July 10, 1986



Congressman Sid Morrison is pictured making a point to other guests on a tour of the Moses Lake Clean Lake Project on Wednesday. Morrision commended the efforts of project manager Don Beckley and his colleagues in promoting the enhanced methods of irrigation which improve farm operations and reduce energy costs. Morrison said the project should be continued, and pledged his support.

—Herald photo

Clean Lake Project

Morrison commends water program

The Moses Lake Clean Lake Project is an "investment worth sponsoring and worth continuing," Congressman Sid Morrison told a gathering of government and farming leaders Wednesday during a project-sponsored water quality tour.

The tour centered in the Block 40 area, where project efforts and matching money for new irrigation equipment are designed to reduce agricultural fertilizer runoff which pollutes Moses Lake.

More than 70 local politicians and agribusiness people were on the tour, which shuttled from site to site by bus.

"You don't know how good this makes an old irrigation farmer feel," Morrison said at the tour's last stop, the Hartvig and Isabel Roseberg farm.

"We're seeing actual on-ground examples of better management applications. All these thing demonstrate progress, progress we can be proud of."

Merely running more Columbia River water through the canal system into the lake won't solve the problem that starts from a variety of pollution sources, Morrison said.

"Dilution is not the solution to pollution. The non-point problem is part of what we say today.

"A lot of us have stayed on the farm because we want something to pass on to our children.

"But we want to pass on something better than the way we found it."

Money that comes directly from the nation's capitol doesn't always make it to its target.

But the Clean Lake Project blend of several agencies working together has produced the desired result, Morrison said.

"It's an awfully leaky bucket between here and Washington, D.C. I like the Clean Lake Project.

"These dollars are better spent because of local involvement."

TECHNICAL EXCELLENCE
AWARD

presented to

MOSES LAKE IRRIGATION &
REHABILITATION DISTRICT

1986

In recognition of outstanding achievement

in lake restoration, protection and management

NORTH AMERICAN
LAKE MANAGEMENT SOCIETY

Mostly sunny
Highs mid 70s-80s, lows 50-60. Details on Page 8.

THE WENATCHEE WORLD

Published in the Apple Capital of the World and the Buckle of the Power Belt of the Great Northwest
Wenatchee, WA 98801

Tuesday
Sept. 2, 1986
82nd year, No. 53
35¢

Dream to preserve Rocky Ford Creek coming true

By PATRICIA WREN
Columbia Basin staff writer

RON BALLINGER

ROCKY FORD — A self-employed Ephrata carpenter is seeing a long-time dream come true this summer as funding begins to fall into place for acquisition of most of lower Rocky Ford Creek, southeast of Ephrata.

With the impetus supplied by member Ron Ballinger, the Grant County Centennial Committee last summer adopted acquisition of the historic ford as its pet project.

With that impetus, the state Department of Game has placed its highest priority on buying 3.25 miles of Rocky Ford stream and shoreline — a $510,000 project — and the Department of Natural Resources announced late last week it is kicking in another $75,000.

Also in the works is a proposed dam and 19-acre pond at the lower end of the creek, funded with some $100,000 by the Moses Lake Irrigation District. The district and the Moses Lake Clean Lake Project also are considering tossing in acquisition money.

The Game Department's project was endorsed at a July meeting in Wenatchee by the Interagency Committee for Outdoor Recreation. If approved by the state Legislature in January, it could be funded for the 1987-89 biennium.

That proposal is considered the key for bringing the entire area back into public hands and restoring the traditional meeting place of Indians and pioneers.

The area at present is in the hands of a land developer, and there is keen private interest in buying the creek-front property.

Once the largest trading site in the Northwest — after The Dalles — Rocky Ford is where the early day military road from Fort Walla Walla to Camp Chelan crosses the steep-sided gulch.

One man's dream...

For centuries, the ford also was a summer meeting place for the Sinkiuse, Okanogans, Wenatchees, Chinooks, Yakimas and Nez Perce as well as other Indian bands from across the snow-covered Rockies.

Outstanding features at the site include a historic trading rock, a boulder with a mysterious ancient pictograph and numerous pit-house depressions and Indian graves.

Signs of early Indian habitation are not just abundant in the area, they are everywhere — despite huge boxfuls of artifacts carried off by pothunters since the late 1800s.

As a para-professional archaeologist, former state Legislator Nat Washington, Ephrata, has been combing the area between the ford itself and the proposed dam to put red flags at sites of particular interest for archaeologists from Washington State University.

Washington describes the area as extremely rich in artifacts dating back to approximately 3,000 B.C.

The low carp-barrier dam would flood only a small part of the ancient camp area south of the stream riffles where wagons once forded the creek, according to Ballinger and Washington.

The dam would restore the creek to a quality trout stream. With the carp gone, says Game Department biologist Steve Jackson, resident fish, waterfowl, non-game birds and fur-bearers also would increase.

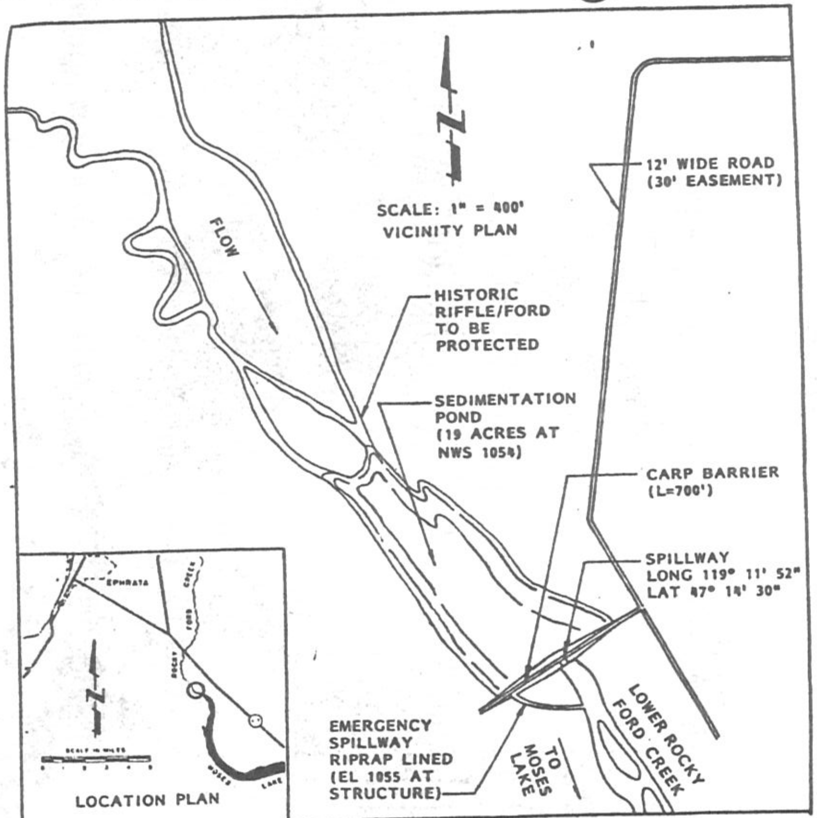
"Carp virtually destroy the habitat in aquatic areas," Jackson said. Cattle and sheep run in the area for many years also harmed the land.

What the Game Department plans to do is revegetate the area and restore the creek to a narrow stream with pools and riffles and make it a public fishery.

Farther down the road, it would create interpretive centers around the stream area to encourage birdwatching and wildlife photography.

Ballinger also envisions winding asphalt foot and vehicle trails punctuated by signs identifying the grave circles, pit houses, the trading rock and other pertinent sites, and shaded, grassy picnic areas, campgrounds and vantage points overlooking the wide gulch.

He would also like to see an observatory on the ridge above and a full-fledged archaeological museum containing artifacts from ongoing digs and the collections of their dusty boxes of stones.



PLANS FOR HISTORIC PRESERVATION AND NATURAL ENHANCEMENT

The Grant County Centennial Committee last summer was offered a sizeable bequest by an Ephrata woman who also would like to see the county have its own archaeological museum, Ballinger said.

According to Jackson, the Game Department is negotiating a cooperative agreement with Ed McCleary, owner of Trout Lodge Fish Hatchery, north of the ford, trout and allow McCleary to increase his hatchery production farther upstream.

In exchange for a bigger hatchery area, McCleary would give the department fish to plant elsewhere in the Columbia Basin, Jackson said.

The Game Department also would ensure that all carp are removed from the entire seven miles of Rocky Ford Creek, including the springs that feed it.

EDITION

— See story in Sports, Page 15

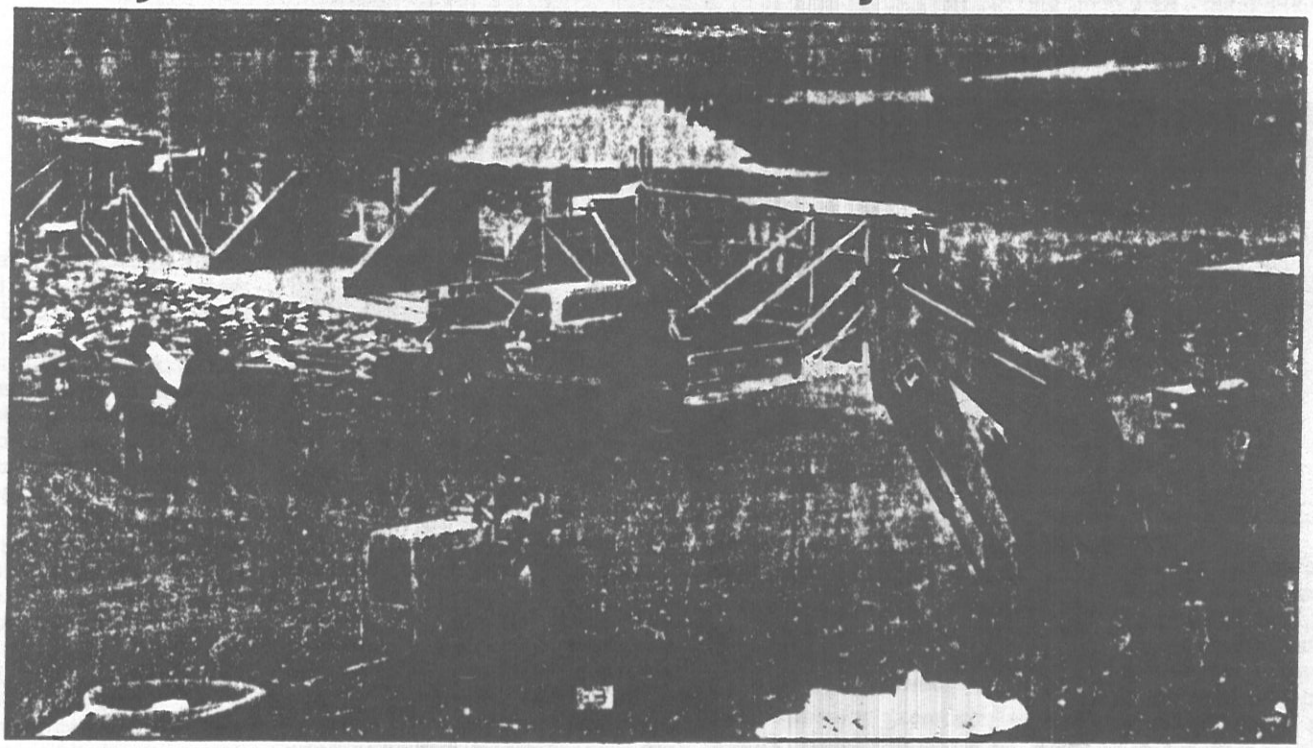
Cloudy
Chance of showers. Highs 70s. Lows 50-60. Details on Page 11.

THE WENATCHEE WORLD

Published in the Apple Capital of the World and the Buckle of the Power Belt of the Great Northwest
Wenatchee, WA 98801

Tuesday
April 28, 1987
82nd year. No. 256
35¢

Rocky Ford Creek — a success story



WORK CONTINUES ON THE DAM THAT WILL HELP TURN ROCKY FORD CREEK INTO A PRIME TROUT STREAM

Murky carp hovel to become challenging trout haven

By DAVE REA
Columbia Basin bureau

EPHRATA — With an 8-foot dam, a new hatchery agreement and the prospect of a major land acquisition, state officials here are dreaming about trout fishing — in what could become the most challenging stream in North Central Washington.

Murky, carp-infested Rocky Ford Creek, running down a wide gully of grass and sagebrush six miles east of here, is the unlikely site for the enterprise.

In the sprawling scablands between Ephrata and Moses Lake, it's strange enough just to find a creek that flows year-round.

But Indians from all over the region once gathered by the thousands along Rocky Ford Creek to trade. Near their lucky "trading rock" stands the home of an early cattle baron who rambled the dusty Columbia Basin in a fancy coach.

Now officials of the state Department of Game see something else that's special about the seven-mile, spring-fed creek.

"Lowland spring creeks are kind of unique," said Steve Jackson, fish biologist.

Rocky Ford Creek, he said, has the nutrients, vegetation and steady temperature to produce fighting 6-pound trout. Through its clear water, a wild game fish could get an honest look at a fly or lure, putting a fisherman's "presentation" and skill to the test.

Accounts by early settlers describe that kind of fishing.

But for years, Rocky Ford has been a wallow for cattle and a haven for carp.

Where Indians gathered each spring — perhaps for thousands of years — souvenir hunters gradually are carrying off artifacts and even disturbing graves.

(Continued on Page 24, Col. 1)

Nearly 80 farmers sign for project

Project manager Don M. Beckley announced today that the second and final sign-up period for the Moses Lake Clean Lake Project has been completed, and to date, nearly 80 farmers in the watershed area have completed applications to participate in the program.

The spring sign-up initially attracted 46 farmers, with the remainder coming in under the fall sign-up. Beckley said "Now that the figure has reached 80, we have the majority of the farmers participating in the program and upon completion of all improved systems and management practices, the 'on farm' area of concern will be improved through these actions." The project's next step is to complete the plans for improving irrigation systems with the farmers, and getting them approved by the Moses Lake Clean Lake Council. As these occur, contracts will then be signed with the individual farmers and the new systems will then be installed in late fall of 1985 and spring of 1986.

Along with the completion of the on-farm portion of this project, the Moses Lake Clean Lake Project will also be attempting to create a sewer system extension to all suburban population areas of the lakeshore and this portion of the Moses Lake Clean Lake Project is just beginning. Beckley added, "At this point the cooperation and positive attitudes of all the agencies and the farmers involved have made the project successful. The dollars involved show the seriousness of the water quality problems of a community. When agencies such as the Environmental Protection Agency, the State Departmenc of Ecology, and the Moses Lake Irrigation and Rehabilitation District are willing to put thse kinds of funds into our community, it is then up to our local leaders and administrators to distribute these funds in an honest, fair and equitable way to the extent that the dollars are spent to obtain the most effective results.

"Moses Lake's quality of life involves everybody and it is much more important in these matters to work on the solution then continue to define the problem. We know the pollution problem is there, but it's difficult to quanify. We just need to roll up our sleeves and do everything we can to stop pollution," Beckley said.

Clean Lake checks

The first three recipients of reimbursement checks to farmer participants in the Moses Lake Clean Lake program were given Wednesday. The checks represent payment for conversions of old irrigation systems which were contributing to the leaching of nutrients into the Moses Lake watershed water table. Participants are reimbursed for 50 percent of actual cost up to a maximum of $50,000 per farm. Presentors and recipients included, from left to right: Soil Conservation Service resource technician Bernie Kanoff and Isabel Roseburg, who received the check for Roseburg Farms; soil conservationist Jerry Gilmore and Ron Hanson, who received the check for his landlord, Hazel Brown of Fairbanks, Alaska; and Grover Black of Grover Black and Sons, who received his check from the Clean Lake Project's Don Beckley.

—Herald photo

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.

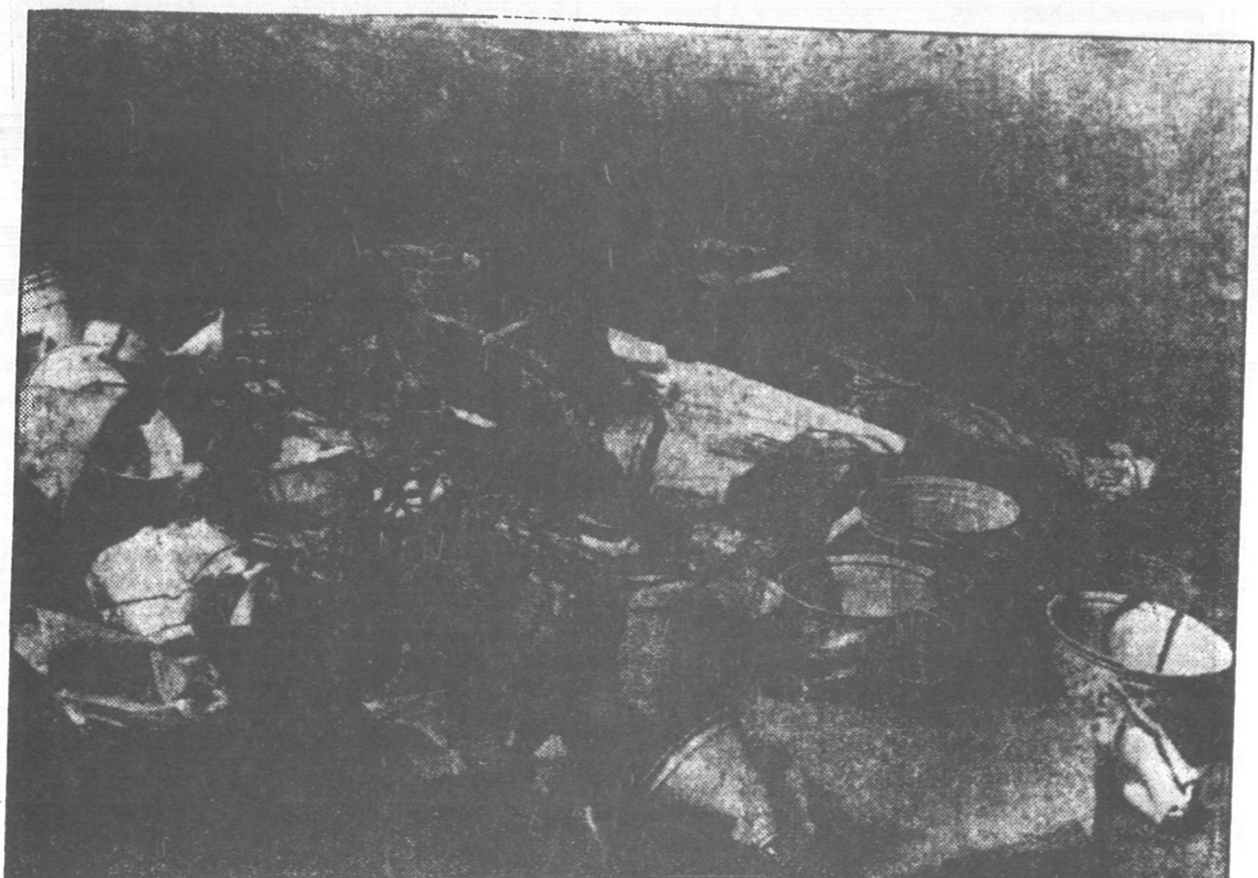
The cleanup project needs people who'll volunteer the use of and operate small boats to pick up and shuttle garbage to designated spots along the lake. Pickup and truck owners are needed to carry trash.

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

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 La e and said final clea o of the l e is a long-term pro t which going to have to nvolve "everyo e."

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.

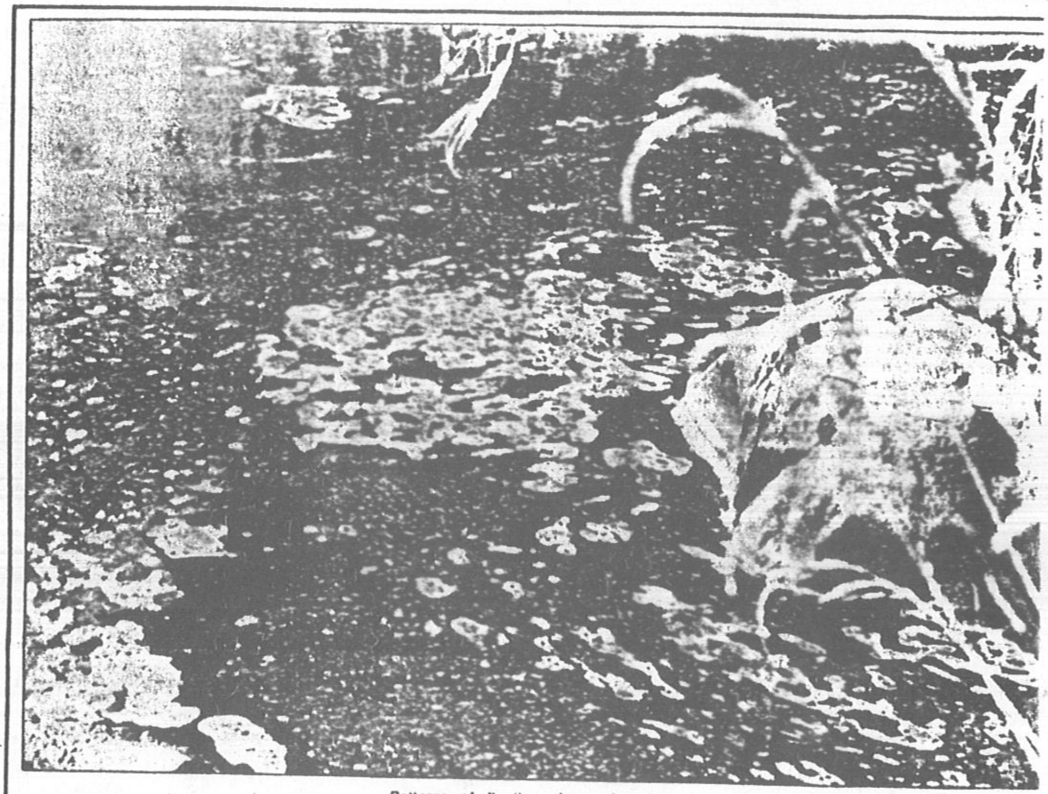
Larry Matheson.

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 drainfields 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[illegible]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 encoura hookups to the city's sewer treatment plant, planners said. Still, city ficials are reviewing their procedures on how to evaluate and cont new septic systems in cooperation with the county's environmen 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 regio 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. Lak 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 Distric "We all have to take responsibility for cleaning up the lake."

Connelly, acknowledged as one of the prime movers in clean lake e 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 maki progress."

APPENDIX M

LIST OF PROJECT REPORTS

MOSES LAKE CLEAN LAKE PROJECT REPORTS

Reports by Brown and Caldwell, Consulting Engineers

June 1978	Moses Lake 1977 Pilot Project Vol. I (Restoration Plan)
June 1978	Moses Lake 1977 Pilot Project Vol. II (Dilution Evaluation)
July 1980	Moses Lake Restoration Project Draft Environmental Impact Statement
January 1981	Moses Lake Restoration Project Agricultural Best Management Practices
July 1981	Parker Horn Pumping Station and Pipeline Drawings and Specifications
March 1984	Moses Lake Clean Lake Project Stage I Report
April 1984	Moses Lake Dilution Projects

Reports by Richard C. Bain, Jr., Consulting Engineer

March 1985	Moses Lake Clean Lake Project Stage 2 Report
March 1985	Moses Lake Clean Lake Project Stage 2 Summary
March 1986	Moses Lake Clean Lake Project 1985 Annual Report
May 1986	Moses Lake Clean Lake Project Urban Wastewater Disposal Report
May 1987	Moses Lake Clean Lake Project Stage 3 Report
May 1987	Moses Lake Clean Lake Project Stage 3 Summary Report

APPENDIX N

COST SHARE PROGRAM SUMMARY REPORT

REPORT DATE: 04/30/87

CLEAN LAKES PROJECT CONTRACT ACCOUNTS

REF NO.	NAME	CONTRACT NUMBER	TOTAL COMM/OBL	TOTAL DISBURSED	TOTAL REMAINING	COMMITTED/OBLIGATED STRUCTURE	COMMITTED/OBLIGATED MANAGEMENT	DISBURSED STRUCTURE	DISBURSED MANAGEMENT	REMAINING STRUCTURE	REMAINING MANAGEMENT
10	MATHESON, CHRIS	MLCL-85-1	$50,000	$50,000.00	$0.00	$48,390	$1,610	$48,390.00	$1,610.00	$0.00	$0.00
13	BLACK & SONS	MLCL-85-2	$50,000	$46,175.13	$3,824.87	$44,583	$5,417	$44,583.00	$1,592.13	$0.00	$3,824.87
17	ROSEBURG, HARTVIG	MLCL-85-3	$47,622	$42,798.99	$1,823.01	$41,731	$5,891	$41,729.39	$1,069.60	$1.61	$4,821.40
1	BROWN, HAZEL	MLCL-85-4	$8,960	$5,995.43	$2,964.57	$5,498	$3,462	$5,497.48	$497.95	$0.52	$2,964.05
7	SIRCIN, VICKI (CAFO-42)	MLCL-85-5	$25,276	$23,382.12	$1,893.88	$21,869	$3,407	$21,867.96	$1,514.16	$1.04	$1,892.84
5	SIRCIN, ALLEN (CAFO-40)	MLCL-85-6	$25,977	$23,708.99	$2,268.01	$22,846	$3,131	$22,845.49	$863.50	$0.51	$2,267.50
14	BELLONY, BILL	MLCL-85-7	$50,000	$50,000.00	$0.00	$49,000	$1,000	$49,000.00	$1,000.00	$0.00	$0.00
33	DUVALL, CRAIG	MLCL-85-8	$32,223	$27,924.76	$4,298.24	$27,188	$5,035	$27,187.11	$737.65	$0.89	$4,297.35
41	ISAAK BROS.	MLCL-86-9	$42,558	$40,672.81	$1,885.19	$37,888	$4,670	$37,888.00	$2,784.81	$0.00	$1,885.19
6	WATSON, R & T (CAFO-51)	MLCL-86-10	$21,381	$17,301.70	$4,079.30	$16,552	$4,829	$16,552.00	$749.70	$0.00	$4,079.30
62	DILLING, ROLF	MLCL-86-11	$43,549	$38,241.58	$5,307.42	$30,556	$12,993	$30,555.63	$7,685.95	$0.37	$5,307.05
3	TURNER, GEO (TNT ENTERPRISE)	MLCL-86-12	$46,237	$22,117.89	$24,119.11	$18,820	$27,417	$12,001.85	$10,116.04	$6,818.15	$17,300.96
9	SLOOP, P (MITCHELL FARMS)	MLCL-86-13	$39,439	$34,710.12	$4,728.88	$34,086	$5,353	$34,085.27	$624.85	$0.73	$4,729.15
49	WEITMAN, DICK	MLCL-86-14	$41,448	$39,634.93	$1,813.07	$36,107	$5,341	$36,105.85	$3,529.08	$1.15	$1,811.92
54	CAMERON, WM	MLCL-86-15	$35,561	$33,901.50	$1,659.50	$33,381	$2,183	$33,380.44	$524.06	$0.56	$1,658.94
67	OSBORNE, DON	MLCL-86-16	$39,744	$35,033.97	$4,710.03	$31,175	$8,569	$31,173.95	$3,860.02	$1.05	$4,708.98
72	BALLIET, STEVE	MLCL-86-17	$40,175	$35,326.43	$4,848.57	$20,335	$19,840	$20,333.82	$14,992.61	$1.18	$4,847.39
0	RILEY, CECIL	MLCL-86-18	$19,307	$15,755.34	$3,551.66	$11,363	$7,944	$11,363.00	$4,392.34	$0.00	$3,551.66
57	COLE, VERLYN	MLCL-86-19	$50,000	$21,427.85	$28,572.15	$47,212	$2,788	$20,623.30	$804.55	$26,588.70	$1,983.45
6	DUVALL, DEMAR	MLCL-86-20	$50,000	$50,000.00	$0.00	$43,562	$6,438	$43,562.00	$6,438.00	$0.00	$0.00
9	DILLS, JOHN	MLCL-86-21	$21,402	$16,820.82	$4,581.18	$16,445	$4,957	$16,445.00	$375.82	$0.00	$4,581.18
3	WITTENBURG, WILLIAM	MLCL-86-22	$27,626	$24,421.58	$3,204.42	$23,898	$3,728	$23,897.52	$524.06	$0.48	$3,203.94
11	REFFETT, ANNA	MLCL-86-23	$13,146	$11,538.02	$1,607.98	$11,538	$1,608	$11,538.00	$0.02	$0.00	$1,607.98
01	MARTINEZ, TOM	MLCL-86-24	$1,279	$750.53	$528.47	$83	$1,196	$82.97	$667.56	$0.03	$528.44
32	HIGGINS, PETE	MLCL-86-25	$10,270	$8,592.95	$1,677.05	$7,998	$2,272	$7,997.94	$595.01	$0.06	$1,676.99
3	KRUG, JEFF	MLCL-86-26	$16,391	$14,608.84	$1,782.16	$10,633	$5,758	$10,632.90	$3,975.94	$0.10	$1,782.06
51	KNOPP, RICKI	MLCL-86-27	$5,941	$1,198.63	$4,742.37	$1,199	$4,742	$1,198.63	$0.00	$0.37	$4,742.00
2	WESTERN FARMS	MLCL-86-28	$29,548	$24,434.79	$5,113.21	$12,669	$16,879	$12,669.00	$11,765.79	$0.00	$5,113.21
75	ROSEBURG, DAN	MLCL-86-29	$16,506	$12,423.50	$4,082.50	$4,950	$11,556	$4,950.00	$7,473.50	$0.00	$4,082.50
38	HENDRICKSON, JERRY	MLCL-86-30	$34,802	$27,657.44	$7,144.56	$29,195	$5,607	$27,210.87	$446.57	$1,984.13	$5,160.43
1	MERTES, KEN & JOYCE	MLCL-86-31	$7,236	$4,627.26	$2,608.74	$2,380	$4,856	$2,378.71	$2,248.55	$1.29	$2,607.45
9	CHANDLER, GLYN	MLCL-86-32	$9,378	$6,301.89	$3,076.11	$2,634	$6,744	$2,633.53	$3,668.36	$0.47	$3,075.64
0	MOSES LAKE SCHOOLS	MLCL-86-33	$12,469	$11,098.34	$1,370.66	$8,737	$3,732	$8,736.27	$2,362.07	$0.73	$1,369.93
59	MATHESON, MITCHELL	MLCL-86-34	$32,937	$30,026.80	$2,910.20	$29,126	$3,811	$29,126.00	$900.80	$0.00	$2,910.20
1	FODE, ROY	MLCL-86-35	$50,000	$31,043.48	$18,956.52	$39,406	$10,594	$27,571.91	$3,471.57	$11,834.09	$7,122.43
	FODE, RON	MLCL-86-36	$50,000	$46,069.19	$3,930.81	$37,732	$12,268	$37,730.16	$8,339.03	$1.84	$3,928.97
			$1,098,391	$925,726.60	$172,664.40	$860,765	$237,626	$813,524.95	$112,201.65	$47,240.05	$125,424.35

DISBURSEMENT FIGURES INCLUDE WAITING PAYMENTS

AND WAITING SIGNATURES FROM EXPENDITURE REPORT.

REPORT DATE: 04/30/87

CLEAN LAKES PROJECT WQMP 3 ACCOUNT

REF NO.	NAME & CONTRACT NUMBER		WQMP REQ	PRIORITY NO.	PRIORITY RATE	WQMP'S P	WQMP'S A	WQMP'S C	COMP STNG	ACRES PLND	# NUTR SAV (EL)	EST. 3rd SIGN UP C/S	TOTAL COMM/OBL	TOTAL DISBURSED	COMMITTED/OBLIGATED STRUCTURE	COMMITTED/OBLIGATED MANAGEMENT	DISBURSED STRUCTURE	DISBURSED MANAGEMENT	AVAILABLE STRUCTURE	AVAILABLE MANAGEMENT
1	FODE, ROY	MLCL-86-35	F 86	66	HIGH	1				859	16321		$50,000	$31,043.48	$39,406	$10,594	$27,571.91	$3,471.57	$11,834.09	$7,122.43
2	FODE, RON	MLCL-86-36	F 86	62	HIGH	1			1	835	18360		$50,000	$46,069.19	$37,732	$12,268	$37,730.16	$8,339.03	$0.00	$3,928.97
3	JONES, CRAWFORD		F 86	60	HIGH					462	14570	$50,000					$0.00	$0.00	$0.00	$0.00
4	PEARCE, LEELOYD		F 86	57	HIGH					275	9653	$32,450					$0.00	$0.00	$0.00	$0.00
5	SIRCIN, ALLEN (CAFO-40)(P)	MLCL-85-6	SP 85	56	HIGH	1	1		1	192	4380		$25,977	$23,708.99	$22,846	$3,131	$22,845.49	$863.50	$0.00	$2,267.50
6	WATSON, R & T (CAFO-51)	MLCL-86-10	SP 85	56	HIGH	1	1		1	164	4100		$21,301	$17,301.70	$16,552	$4,829	$16,552.00	$749.70	$0.00	$4,079.30
7	SIRCIN, VICKI (CAFO-42)(P)	MLCL-85-5	SP 85	56	HIGH	1	1		1	149	5642		$25,276	$23,382.12	$21,869	$3,407	$21,867.96	$1,514.16	$0.00	$1,892.84
8	BERNETT, BOB (CAFO-20)		SP 85	56	HIGH					78	1000	$9,201	0	$0.00					$0.00	$0.00
9	McCOWAN, NICK (CAFO-37)		F 85	56	HIGH								0	$0.00					$0.00	$0.00
10	MATHESON, CHRIS (P)	MLCL-85-1	SP 85	55	HIGH	1	1			261	4944		$50,000	$50,000.00	$48,390	$1,610	$48,390.00	$1,610.00	$0.00	$0.00
11	REFFETT, ANNA (2)	MLCL-86-23	SP 85	54	HIGH	1	1		1	163	13077		$13,146	$11,538.02	$11,538	$1,608	$11,538.00	$0.02	$0.00	$1,607.98
12	LEISHMAN, ARLO		F 85	54	HIGH			1		90	3760	$10,620	0	$0.00					$0.00	$0.00
13	BLACK & SONS	MLCL-85-2	SP 85	50	HIGH	1	1		1	268	9087		$50,000	$46,175.13	$44,583	$5,417	$44,583.00	$1,592.13	$0.00	$3,824.87
14	BELLOMY, BILL	MLCL-85-7	SP 85	50	HIGH	1	1		1	348	12180		$50,000	$50,000.00	$49,000	$1,000	$49,000.00	$1,000.00	$0.00	$0.00
15	REFFETT, DICK (H)		SP 85	50	HIGH	1	1			288	6325		$0	$0.00	$0	$0			$0.00	$0.00
16	JONES, TREN (H2)		SP 85	49	HIGH	1	1			122	5246		$0	$0.00	$0	$0			$0.00	$0.00
17	ROSEBURG, HARTVIG (P)	MLCL-85-3	SP 85	49	HIGH	1	1		1	238	7890		$47,622	$42,798.99	$41,731	$5,891	$41,729.39	$1,069.60	$0.00	$4,821.40
18	HENDRICKSON, DOUG (H)		SP 85	49	HIGH	1	1			468	6096		$0	$0.00					$0.00	$0.00
19	SHARP, MILT		SP 85	49	HIGH			1					$0	$0.00					$0.00	$0.00
20	PISTER, RON (H)		F 85	48	HIGH	1	1			250	7000		$0	$0.00					$0.00	$0.00
21	ISAAK LAND GENERAL PARTNERS		F 86	48	HIGH					153	5432	$46,434								
22	BERNARD, BOB (H)		F 85	47	HIGH	1	1			31	1426		$0	$0.00					$0.00	$0.00
23	HIRZ, NED (H)		SP 85	46	HIGH	1	1			290	7101		$0	$0.00					$0.00	$0.00
24	KNOPP, HOWARD (H2)		SP 85	46	HIGH	1	1			7	253		$0	$0.00	$0	$0			$0.00	$0.00
25	FORYAN, STEVE		F 86	46	HIGH					512	6382	$34,714								
26	POST, GLENN & LESLIE		F 86	46	HIGH					150	3645	$27,625								
27	PISTER, JAKE (H)		F 85	45	MED	1	1			91	1820		$0	$0.00					$0.00	$0.00
28	ESSEX, ELDON		F 86	45	MED					147	3822	$17,346								
29	BATOR, ED		SP 85	44	MED			1					$0	$0.00					$0.00	$0.00
30	ARGERSINGER, BILL (JACK BROWN) (H2)		F 85	44	MED	1	1			116	2320		$0	$0.00	$0	$0			$0.00	$0.00

REPORT DATE: 04/30/87

CLEAN LAKES PROJECT WQMP 3 ACCOUNT

REF NO.	NAME & CONTRACT NUMBER		WQMP REQ	PRIORITY NO.	RATE	WQMP'S P	A	C	COMP STNG	ACRES PLND	# NUTR SAV (EL)	EST. 3rd SIGN UP C/S	TOTAL COMM/OBL	TOTAL DISBURSED	COMMITTED/OBLIGATED STRUCTURE	MANAGEMENT	DISBURSED STRUCTURE	MANAGEMENT	AVAILABLE STRUCTURE	MANAGEMENT
31	HICKMAN, TOM (H)		F 85	44	MED	1	1			143	6435		$0	$0.00					$0.00	$0.00
32	WOLFE, FRED & ARLENE		SP 85	43	MED	1	1	1		337	7414		$0	$0.00					$0.00	$0.00
33	DUVALL, CRAIG (H2)	MLCL-85-8	SP 85	43	MED	1	1		1	238	5606		$32,223	$27,924.76	$27,188	$5,035	$27,187.11	$737.65	$0.00	$1,297.35
34	CRAIG, HAROLD		F 86	42	MED					225	4770	$40,467								
35	TURNER, GEORGE		F 86	42	MED					241	6435	$28,438								
36	DUVALL, DEMAR	MLCL-86-20	SP 85	41	MED	1	1		1 1	148	4884		$50,000	$50,000.00	$43,562	$6,438	$43,562.00	$6,438.00	$0.00	$0.00
37	COLE, VERLYN	MLCL-86-19	SP 85	41	MED	1	1			126	4914		$50,000	$21,427.85	$47,212	$2,788	$20,623.30	$804.55	$26,588.70	$1,983.45
38	HENDRICKSON, JERRY	MLCL-86-30	SP 85	41	MED	1	1			304	6096		$34,802 *	$27,657.44	$29,195	$5,607	$27,210.87	$446.57	$1,984.13	$5,160.43
39	HENDRICKSON, DAN (H)		SP 85	41	MED	1	1			176	3637		$0	$0.00					$0.00	$0.00
40	JENSEN, ELSA (H)		SP 85	41	MED	1	1			156	4032		$0	$0.00					$0.00	$0.00
41	ISAAK BROS. (P)	MLCL-86-9	SP 85	41	MED	1	1		1	159	5565		$42,558	$40,672.81	$37,888	$4,670	$37,888.00	$2,784.81	$0.00	$1,885.19
42	SCHMID, TRACY (H)		SP 85	41	MED	1	1			193	4053		$0	$0.00					$0.00	$0.00
43	ROSEBURG, DON		F 85	41	MED			1					$0	$0.00					$0.00	$0.00
44	HIRZ, JIM (H)		F 85	41	MED	1	1			264	3960		$0	$0.00					$0.00	$0.00
45	FINDLAY, RICHARD		F 85	41	MED			1					$0	$0.00					$0.00	$0.00
46	GOODWIN, DON		F 85	41	MED	1		1		111			$0	$0.00					$0.00	$0.00
47	SNAP, LAWRENCE		F 85	41	MED			1					$0	$0.00					$0.00	$0.00
48	EDDIE, JAMES		F 86	41	MED					117	2668	$9,490								
49	WEITMAN, DICK	MLCL-86-14	SP 85	40	MED	1	1		1	122	3030		$41,448	$39,634.93	$36,107	$5,341	$36,105.85	$3,529.08	$0.00	$1,811.92
50	RILEY, CECIL	MLCL-86-18	SP 85	40	MED	1	1			182	2366		$19,307	$15,755.34	$11,363	$7,944	$11,363.00	$4,392.34	$0.00	$3,551.66
51	KNOPP, RICKI	MLCL-86-27	SP 85	40	MED	1	1		1	120	2160		$5,941	$1,198.63	$1,199	$4,742	$1,198.63	$0.00	$0.00	$4,742.00
52	HIGGINS, PETE	MLCL-86-25	F 85	40	MED	1	1			46	920		$10,270	$0.00	$7,998	$2,272	$0.00	$0.00	$7,998.00	$2,272.00
53	TURNER, GEO (THT ENT) (P)	MLCL-86-12	SP 85	39	MED	1	1			298	6854		$46,237	$22,117.89	$18,820	$27,417	$12,001.85	$10,116.04	$6,818.15	$17,300.96
54	CAMERON, WM	MLCL-86-15	SP 85	39	MED	1	1		1	127	4699		$35,564	$33,904.50	$33,381	$2,183	$33,380.44	$524.06	$0.00	$1,658.94
55	ROBERTS, PAUL (H2)		F 85	39	MED	1	1			65	2210		$0	$0.00	$0	$0			$0.00	$0.00
56	McKEAN, LUKE		F 85	39	MED			1					$0	$0.00					$0.00	$0.00
57	WELCH, DARALD		SP 85	38	MED			1					$0	$0.00					$0.00	$0.00
58	DOWERS, T		SP 85	38	MED	1	1	1		97	2037		$0	$0.00					$0.00	$0.00
59	MATHESON, MITCHELL	MLCL-86-34	F 85	38	MED	1	1		1	109	2867		$32,937	$30,026.80	$29,126	$3,811	$29,126.00	$900.80	$0.00	$2,910.20
60	PRENTICE, DON		F 86	38	MED					229	5198	$30,404								

REPORT DATE: 04/30/87

CLEAN LAKES PROJECT WQMP 3 ACCOUNT

REF NO.	NAME & CONTRACT NUMBER		WQMP REQ	PRIORITY NO.	PRIORITY RATE	WQMP'S P	WQMP'S A	WQMP'S C	COMP STNG	ACRES PLND	# NUTR SAV (EL)	EST. 3rd SIGN UP C/S	TOTAL COMM/OBL	TOTAL DISBURSED	COMMITTED/OBLIGATED STRUCTURE	COMMITTED/OBLIGATED MANAGEMENT	DISBURSED STRUCTURE	DISBURSED MANAGEMENT	AVAILABLE STRUCTURE	AVAILABLE MANAGEMENT
91	TEBOW, DELBERT		F 86	30	LOW					151	1359	$16,971								
92	WESTERN FARMS (H2)	MLCL-86-28	SP 85	29	LOW	1	1		1	270	5420		$29,548	$24,434.79	$12,669	$16,879	$12,669.00	$11,765.79	$0.00	$5,113.21
93	KRUG, JEFF	MLCL-86-26	SP 85	29	LOW	1	1		1	88	1848		$16,391	$14,608.84	$10,633	$5,758	$10,632.90	$3,975.94	$0.00	$1,782.06
94	SAUNDERS, KEN		SP 85	29	LOW			1					$0	$0.00					$0.00	$0.00
95	FULLER, HUCK		F 86	29	LOW					9	185	$944								
96	THOMASON, E		SP 85	28	LOW								$0	$0.00					$0.00	$0.00
97	FODE, BOB (H)		SP 85	26	LOW	1	1			126	2646		$0	$0.00					$0.00	$0.00
98	BURMAN, WILLIAM C.		F 86	25	LOW					18	140	$3,856								
99	DOW, ERWIN		F 86	25	LOW					5	22	$590								
100	EIDE, PAUL		F 86	24	LOW					15	315	$1,770								
101	MARTINEZ, TOM	MLCL-86-24	SP 85	22	LOW	1	1		1	16	144		$1,279	$750.53	$83	$1,196	$82.97	$667.56	$0.00	$528.44
102	McOMBER, CAL		F 85	20	LOW			1					$0	$0.00					$0.00	$0.00
103	MORGHER, ROBERT		F 86	19	LOW					9	189	$1,062								
104	MORGAN, ORVIN		SP 85	15	LOW			1					$0	$0.00					$0.00	$0.00
				TOTALS		60	57	18		14,955	343,696	$508,361	$1,098,391	$902,629.20	$860,765	$237,626	$796,790.74	$105,838.46	$63,960.07	$131,787.54

APPENDIX O

SCS IWM PROPOSAL

(LEVEL II)

Moses
Lake
Irrigation and
Rehabilitation
District

April 29, 1987

Mr. Byron Fitch
Soil Conservation Service
316 South Chestnut
Moses Lake, WA 98837

Dear Byron,

This letter is to inform you that on April 28, 1987 the Moses Lake Irrigation and Rehabilitation District approved a post project monitoring program and budget covering the years 1987-1989. Irrigation water management (IWM) is a major component of this approved program.

Our District has also approved your agency's involvement in the IWM program at a level consistent with your intermediate (Level II) budget proposal at a cost of $33,540 for 1987 and $93,140 for your portion of the total program. This letter provides formal notification to your agency of our District's intent to enter into a contract covering IWM activities. Work should start immediately so please consider this letter as notice to proceed using your proposed Level II work plan and the attached description of the IWM program as a guide.

We will formalize work scope and contract details in the coming weeks. We understand that you may contract clerical services to the Moses Lake Conservation District.

We have advertised for irrigation consultant qualifications and expect to have several statements of qualification available for review by May 4, 1987. We welcome your use of qualified private sector specialists for system testing or irrigation scheduling work to supplement your staff in field assignments during the peak activity of the irrigation season. We need to reach some early agreement on the extent such specialists will be engaged during the 1987 season.

Moses Lake Irrigation and Rehabilitation District 521 CASTLE DRIVE MOSES LAKE, WA 98837 (509) 765-4545

As we envision the program you will be working closely with our engineering consultant over the three year time period. We hope this team effort will also involve the Cooperative Extension in the important information-education phase. We are requesting grant funding from the Department of Ecology; however, near term IWM activities carried out prior to grant award will be covered by District funds.

Very truly yours,

Clinton J. Connelly

CJC/rdb

Enclosure

cc: Dan Roseburg, MLCD
Elbert Moore, EPA
Charles Carelli, DOE
Dick Bain

PROPOSED IRRIGATION WATER MANAGEMENT WORK PLAN

The IWM program will consist of the following parts.

1. Helping the farmer apply IWM to the land--the WHOLEISTIC APPROACH.

2. Development of farmer specific water management plans for each farmer who has a WQMP.

3. Provide technical evaluations of installed systems to ensure that the systems that received cost share monies are performing according to design. This involves the use of the Soil Conservation Service IRRIGATION GUIDE and Soil Conservation Service computer programs for center pivot analysis based upon the technical evaluations.

4. SUPPORT WORK and end of year REVIEWS, & ANALYSIS.

a) Reviews and Analysis-- provide year end reviews of work to M.L.I.R.D. for their on going monitoring program, and to provide data for other reports MLIRD or others may have.
ANALYSIS would be done on water savings, nutrient savings (using the same equations used for the development of the project), and some selected farmer specific economic evaluations.***1

ALL THE WORK IN THIS PLAN WOULD BE DONE WITH THE FARMER DIRECTLY INVOLVED TO THE EXTENT THAT THE FARMERS TIME WILL ALLOW. COPIES OF ANALYSIS AND OTHER DATA OF INTEREST WILL BE PROVIDED TO THE FARMER. RECORDS THE FARMER MAY WISH KEPT CONFIDENTIAL, WILL BE.

(PART 1) HELPING THE FARMER TO APPLY IWM TO THE LAND

This part of the IWM plan is more of a philosophy than a separate task within the plan. After infra-red photos are done, every effort will be made to take up at least 30 minutes per contact of the farmers time to work with him on carrying out his water management plan. Frequent contact in the first three years of operation will be necessary to insure that the water management plan translates to a way of irrigating for the farmer. These contact opportunities will be used to go over the test results, how to do the tests "on your own", use of tensiometers, up keep of the IWM notebooks, analysis of records, water saving , fertilizer

DRAF

use records, changes needed in the cultural practices compliance with WQMP CONTRACTS MANAGEMENT PRACTICES.

(this section deleted for LEVEL II proposal)

Incorporated into the work outlined above will be checking for and assisting with compliance to fertilizer requirements of the WQMP's.

This task will take 720 hours per year.

(PART 2) FARMER SPECIFIC WATER MANAGEMENT PLANS

The irrigation systems installed as part of the Moses Lakes Clean Lakes program were largely of the center pivot type. A small percentage of the contracts resulted in wheel line systems and there were a few "other" types such as cablegation. The systems were designed to apply water at a rate that would meet the peak consumptive use of the most demanding crop while minimizing excess water use. However having the plumbing in place does not guarantee proper application of of the water that can be delivered to the crop through the system. Management of the irrigation water/crop/soil/fertilizer/cultural/and crop interactions are needed to minimize deep percolation of water which is carrying nutrients with it into the ground waters and thus into the lake.

To assist the farmer in this management task, a farmer specific water management plan will be developed for each farmer having a contract. This plan will be worked out with the farmers full input as the farmer is the one who has to carry it out.

This plan will provide written detail of the following at a minimum.

A. A description of the physical mechanical system in place and its design parameters that are pertinent to the proper delivery of water to the crop.

B. A brief description of the soil of the farm involved and the soils limitations to holding water.

C. Data and literature pertinent to scheduling from TENSIOMETERS. Proper use of these will be described in order to provide reliable soil moisture data so the farmer can make management decisions regarding irrigation. Methods of cross checking the tensiometers will be provided to minimize risks of crop failure.

DRAFT

Methods of avoiding under irrigation from center pivots will be explained.

Further changing from rill irrigation to sprinkler irrigation will cause the farmer to ultimately look at and change his tillage and other cultural practices to adapt to the different water intake curves. This will be discused in the IWM plan.

These and additional items as needed will constitute the farmer specific water management plan.

(PART 3) PROVIDE TECHNICAL EVALUATIONS OF INSTALLED SYSTEMS

With state of the art design there still is room for error and the design parameters are not so precise as to be perfect. Therefore a screening process using infra red photography to determine which systems will require adjustment will be used. "Can" tests will NOT BE DONE BY SCS. INFRA RED PHOTOGRAPHY WILL BE FLOWN TWICE FOR EARLY AND LATE PLANTED CROPS WITH TWO PRINTS PER CIRCLE PER FLIGHT. THIS WAS ALSO ASSUMED FOR LEVEL I. FARMERS MAY BE ASSISTED IN DOING THEIR OWN CAN TESTS.
The information FROM THE FLOW METERS will BE UDED FOR the "before" and "after" water savings. The PFIEFFER-WHITTLESY equation will then be used to determine the ACTUAL before and after nutrient savings. This will allow comparison of project "planned " results with "accomplished" results.

In connection with the technical evaluations, OPERATION AND MAINTENANCE needs by way of fact sheets or lists would be developed.

(PART 4) SUPPORT WORK and end of year REVIEWS & ANALYSIS

As a result of the IWM work outlined in this proposal, a report would be created that would make the information readily available to the project farmers, MLIRD, EPA, and others who are involved. This report would include at a minimum:
1. a summary of tensiometer and flow meter readings for each farm site with WQMPS.
2.Infra red photos of problem cases.

4. Estimated water and nutrient savings by farm and for the project.
5.Time the farmer spent doing IWM, and FERT. MANAGEMENT.
6.Estimated dollar benefits to farmer by being involved in IWM and FERT. MGT.
7.(deleted from level I)

DRAFT

It is assumed that the report would be less than 20 pages and would cover only on farm IWM and FERT. MANAGEMENT subjects.

Included in the budget for this item is printing and technical review costs within SCS. Such a report could not be released without appropriate approval from higher levels within SCS.

Some additional budget will be required for anticipated involvement in conferences and I&E work by others.

DRAFT

COSTS: IWM PROPOSAL; 4/28/87 LEVEL II

Technical Personnel: Salaries plus overhead

1987--	1722 hrs.	= $28,240	(weighted cost 1 FTE)
1988--	1494 hrs.	= $24,500	(" " " ")
1989--	1494 hrs.	= $24,500	(" " " ")
		$ 77,240	

Misc. Costs (vehicle allowance, office, phone, etc.) based upon last 6 months of phase 3 of miclp is $7,000 per year or $21,000 total. FOR LEVEL II THIS IS ESTIMATED TO BE REDUCED TO $5300 PER YEAR OR $15,900 TOTAL.

Total cost for LEVEL II PROPOSAL -- $93,140

Byron Fitch
District Conservationist
Moses Lake, SCS

(footnote work deleted for LEVEL II)

Table 8-1

$35,000 vs. $28 240

Irrigation Scheduling

The main purpose for irrigating is to supply needed water for crops. Plant growth is dependent on photosynthesis. While the plant exchanges gases with the air for photosynthesis, some water evaporates. Water is taken up from the soil by plant roots to replace this water. The water leaving the plant is called *transpiration*.

An illustration of a water balance is shown in figure 1. The combination of transpiration and evaporation is called *evapotranspiration* (ET) and is considered as the crop water use. The process of water being used

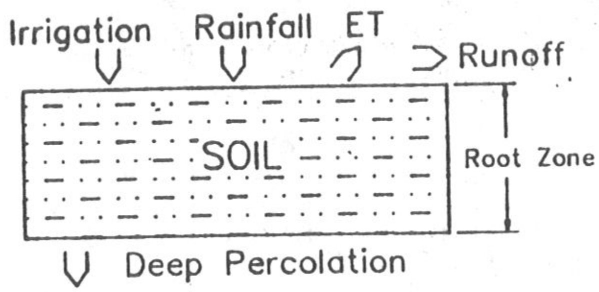


Figure 1.—Schematic representation of the root-zone water-balance components.

by the plant and replaced by irrigation is sometimes compared to a checkbook because of the similarity to withdrawals and deposits. Water taken out of the soil must be made up with either rainfall or irrigation, or the soil reservoir will become dry.

Good irrigation scheduling means applying the right amount of water at the right time—in other words, making sure water is available when the crop needs it. Scheduling maximizes irrigation efficiency by minimizing runoff and percolation losses. This often results in lower energy and water use and optimum crop yields, but it can result in increased energy and water use in situations where water was not being properly managed.

Crop water use

Research has provided information on how much and when a crop needs water. Crop water use can be estimated by a number of methods: evaporation pans, weather data, or soil-moisture monitoring. This information may be available via telephone, radio reports, newspapers, or computers.

Measurements of temperature, wind, solar radiation, and humidity with a weather station can be used to estimate crop water requirements. A network of automated weather stations is being installed in the Pacific Northwest to make this information readily available via computers.

An example of crop water use over a season for alfalfa being grown at an elevation of about 3,000 feet is shown in figure 2. Note that water use is less during the cooler parts of the year and peaks in midsummer. Each cutting temporarily decreases crop water use until the alfalfa has grown back enough to completely cover the ground (called *full cover*). Other crops have water use curves with different shapes.

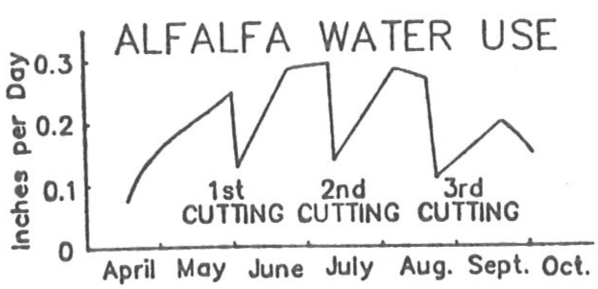


Figure 2.—Typical growing season crop water use by alfalfa.

Irrigation amount

An irrigation system is usually designed to deliver a steady flow of water to an irrigated field at a rate sufficient to meet peak irrigation requirements. If the system is operated continuously as shown in figure 3,

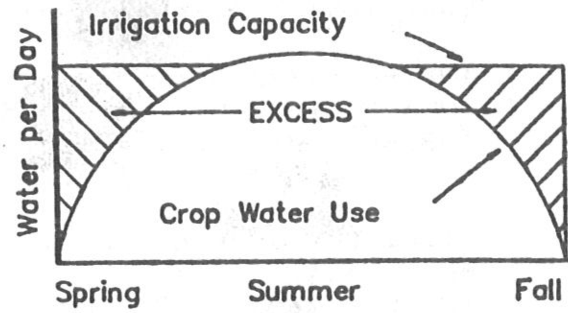


Figure 3.—Comparison of crop water use during growing season and potential overapplication of water when irrigation system is operated with equal settings every irrigation pass.

excess water will be applied both early and late in the season. Irrigation scheduling is a management tool which can help avoid such overirrigating.

The gross application of water that can be delivered by an irrigation system in a 24-hour day can be determined by:

$$\text{Gross application (in/day)} = \frac{\text{gpm} \times 0.053}{\text{acres}}$$

Net irrigation is used to meet crop water needs instead of gross irrigation since not all of water applied is available for plant use. Some water may be lost to deep percolation, runoff, wind drift, and evaporation. An estimate or measurement of the efficiency of application of the irrigation system is needed to determine the net application. Table 1 lists representative application efficiency factors to be used in calculating net irrigation. Multiply gross application by these factors to find net application to be used in scheduling.

Every effort should be made to assure the most uniform irrigation possible. Irrigation systems with distribution problems may have substantially lower efficiencies than those in table 1.

It is important to measure the flow rate (gpm) of water being delivered for irrigation. Water cannot be well-managed without knowing the volume applied.

A good quality rain gauge at each field is important because wide variations in rainfall can occur over relatively short distances. Rainfall which runs off the field should not be counted as useful moisture. In general, about 75% of rainfall is stored in the soil.

Soil-water relationships

The texture of soil to be irrigated is very important in determining when and how much to irrigate. Table 2 lists abilities of different soil types to store water.

The plant root zone determines soil depth from which the crop can draw moisture. Table 3 shows the root zones that mature crops depend on for 90% of their water needs. Early in the season, annual crops have

Table 1.—Application efficiency factors

Conditions	Center pivot	Hand move, side roll, solid set	Big gun
Daytime, wind under 10 mph	0.9	0.8	0.7
Daytime, wind over 10 mph	0.8	0.7	0.6

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Table 2.—Soil water storage capacities*

Soil		Readily available moisture/ft.
General descrip.	Texture class	
Light, Sandy	Coarse Sand	0.7 inches
	Fine Sand	0.9
Medium, Loamy	Fine Sandy Loam	1.5
	Silt Loam	2.0
Heavy, Clay	Clay Loam	2.3
	Clay	2.0
	Peats and Mucks	2.5

*Values given are for deep, uniform soil profiles. Layering and changes in soil texture within the profile may increase or decrease effective available water.

Table 3.—Root-zone depths for selected crops

Crop	Root zone* (ft)	Time to reach mature root zone	Allowable depletion %
Alfalfa	4.0	0	60
Beans	2.5	50 days after planting	50
Corn	3.0	10 days after tasseling	50
Grapes	3.0	0	65
Orchard	6.0	0	50-65
Potatoes	2.0	80 days after planting	30-40
Pasture/Turf	2.0	0	60
Small Grains	3.0	heading	50
Sugar Beets	3.0	10 days after planting	50

*The root zone can be limited by shallow soils, compaction layers, and dry soil—all of which reduce amount of water available to crop, thus requiring more frequent irrigations.

shallow root zones and approach the values in table 3 only when they reach full cover.

Plants will show signs of wilting and drought stress before they use all available water stored in the soil. Table 3 shows percent of total available moisture that different crops can withdraw without suffering yield loss.

Soil moisture should be measured initially and monitored regularly to determine the available soil moisture. Soil moisture blocks, neutron probes, tensiometers, or the feel method with soil probing will all work. Some methods work better than others with different soil types.

Scheduling

Irrigation could be scheduled by continuously monitoring the soil moisture as shown in figure 4 and starting irrigation when measurements so indicate. Because soil moisture monitoring entails a lot of work and an irrigation cannot be completed instantly, this is not a practical approach. Instead, soil moisture is usually measured infrequently and the "checkbook" method is used to estimate the soil moisture condition between measurements.

The root zone should be filled with moisture just before the period of peak crop water use. The amount of usable water available in the root zone and the rate at which water is being used by the crop determines irrigation timing. When the soil moisture profile is full, multiply depth of root zone (table 3) by available moisture-holding capacity per foot of soil (table 2) and that product by the percent allowable depletion (table 3) to determine available water in storage that can be used by crops between irrigations. The maximum number of days before the next irriga[illegible] be applied is calculated by dividing available soil moisture by t[illegible] mated daily crop water use.

Example: Alfalfa on a deep clay loam soil, where root zone is 4.0 ft (table 3); available moisture is 2.3 in/ft (table 2); and allowable depletion is 60% (table 3). Our equation is:

Usable moisture = Root zone × Avail. moist. × Allow. depletion
= 4 × 2.3 × .60
= 5.5 inches

Assume the crop water use averages 0.3 inch per day:

$$\frac{\text{5.5 inches of usable soil moisture storage}}{\text{0.3 inch per day}} = \text{18 days}$$

The next irrigation must be applied within 18 days. As a full irrigation cycle must be completed in 18 days, irrigation must be started early enough to reach the last set by the 18th day. It is important not to overestimate the number of days between irrigations.

The strategy used to manage irrigation systems varies with type of system. For systems that apply very large applications of water infrequently (surface systems and some side-roll and hand-line sprinkler systems), the irrigation cycle should be timed so it is completed and refills the soil profile before all usable soil moisture in the root zone is depleted. Do not let the irrigation schedule be determined by the driest portion of the field (for example, the portion with shallowest soil or coarsest texture) unless it represents a significant area.

Often, irrigation systems that must apply heavy applications must begin the irrigation cycle before there is room in the soil profile to store the full irrigation. The irrigation application should be limited when possible so that the root zone is not overfilled. Controlling the amount of irrigation applied and improving application uniformity may be the only possible way to better manage water that is delivered on a fixed calendar schedule. A timer can sometimes be used with hand-line and side-roll sprinklers to limit the application to only that amount which can be stored in root zone.

For irrigation systems that can apply light irrigations frequently (center pivots, solid set sprinklers, moving sprinkler systems, and drip systems), the system should be started when there is enough room in the soil profile to store the minimum application.

In some cases, it may be desirable to begin cutting back on irrigation late in the season and use most of the available soil moisture by the end of the growing season unless there is a crop on the field which may suffer from fall drought or winter kill. This practice will allow the capture of as much off-season precipitation as possible.

Summary

Knowing when crops need water and how much they need are the keys to good water management. With some basic knowledge of the soil type and crop water use information, an irrigator can easily learn to schedule more scientifically and be able to anticipate irrigation demands. County Extension or Soil Conservation Service offices can provide more information on scheduling.

Computer programs for irrigation scheduling have been developed to help provide timely and precise scheduling techniques. Irrigation consulting and scheduling services are available in many areas to perform the technical tasks required to schedule irrigations in order to save both water and energy.

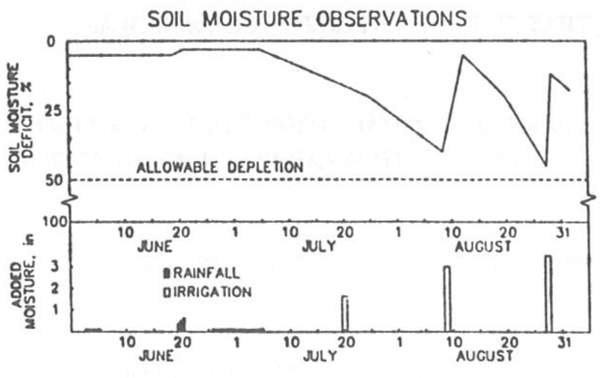

Figure 4.—Typical soil-moisture monitoring chart for a full growing season.

Prepared originally for the Bonneville Power Administration by Walter L. Trimmer, Extension irrigation specialist, and Hugh J. Hansen, Extension agricultural engineer, Oregon State University.

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SOIL MOISTURE BUDGET ACCOUNTING

FIELD ID__________________ SOIL TYPE____________________CROP_________________________ SOIL WATER HOLD. CAP. (IN/FT)__________MAX. ROOT DEPTH (FT)________SOIL DEPTH (FT)________
MAX. ALLOWABLE DEPL. (%)_____ TOTAL AVAIL. SOIL MOIST. (IN)___USABLE SOIL MOIST. (IN)_____

(1)	(2)	(3)	(4)	(5)	(6)	
DATE PAN EVAP. (IN)	PAN/CROP FACTOR (IN)	EST. CROP WATER USE (IN)	RAIN (IN)	NET IRRIG. (IN)	REMAINING USABLE SOIL MOISTURE (IN)	NOTES

(1) DAILY US WEATHER BUREAU CLASS A PAN EVAPORATION READINGS ARE LISTED IN THE WEATHER SECTIONS OF MANY LOCAL NEWSPAPERS IN IRRIGATED AREAS OF WASHINGTON DURING THE GROWING SEASON FROM APRIL 1 THROUGH SEPTEMBER 30.

(2) THE PAN/CROP FACTOR IS A CROP COEFFICIENT RELATING THE PAN EVAPORATION TO CROPWATER USE FOR A SPECIFIC CROP AND STAGE OF GROWTH. THESE ARE AVAILABLE FROM THE WSU COOPERATIVE EXTENSION SERVICE.

(3) ESTIMATED CROP WATER USE IS DETERMINED BY MULTIPLYING THE PAN EVAPORATION READING IN COLUMN LABELED (1) BY THE PAN/CROP FACTOR IN COLUMN LABELED (2). IN SOME AREAS, CROP WATER USE ESTIMATES ARE AVAILABLE BASED ON WEATHER DATA MODELS, IN WHICH CASE, THAT VALUE IS ENTERED IN COLUMN (3) AND COLUMNS (1) AND (2) CAN BE IGNORED.

(4) ON BARE SOILS RAINFALL AMOUNTS LESS THAN 0.25 INCH CAN BE IGNORED. WHEN THE CROP IS NEAR FULL EFFECTIVE COVER PROVIDING SHADING OF AT LEAST 70% OF THE SOIL SURFACE THEN THE ENTIRE RAINFALL AMOUNT IS ENTERED.

(5) THE NET IRRIGATION AMOUNT EQUAL TO THE GROSS IRRIGATION AMOUNT MULTIPLIED BY THE IRRIGATION APPLICATION EFFICIENCY IS ENTERED IN THIS COLUMN.

(6) THE REMAINING USABLE MOISTURE IS CALCULATED BY TAKING THE PREVIOUSLY KNOWN VALUE FROM COLUMN (6) AND ADDING ANY RAINFALL (COLUMN 4) AND NET IRRIGATION (COLUMN 5) AMOUNTS AND THEN SUBTRACTING THE CROP WATER USE AMOUNTS IN COLUMN 3. TO START THE PROCESS AT THE BEGINNING OF THE SEASON, THE USABLE SOIL MOISTURE MUST BE MEASURED OR ESTIMATED BY SOIL SAMPLING.

Fact Sheet

What is Irrigation Water Management

March 1984

United States Department of Agriculture

Soil Conservation Service

What

Simply, irrigation water management is knowing when to irrigate and how much water to apply.

Key Considerations

Key considerations in irrigation water management include soil, water quantity and quality, crops, climate, available labor, and economics. These factors are all interrelated.

Soil. The soil provides physical support for the plant and serves as a reservoir for nutrients and water. The chosen irrigation method must suit the soil intake rate. For example, soils with a very high intake rate are difficult to irrigate with surface methods, and soils with very low intake rates are more difficult to sprinkle. The soil must be capable of storing enough moisture between irrigations so that the plant will not suffer from lack of water, and deep enough so that the plant can develop an adequate root system. There are several methods for monitoring soil moisture. All require experience with soils and crops before accurate decisions can be made about when to irrigate and how much water to apply.

Water Supply. Adequate water to meet crop needs throughout the irrigation season and during periods of peak use by crops is another consideration. The water supply may limit the acreage irrigated.

Water Quality. Quality of water can have a serious affect on crop production and soil performance. For example, water containing chlorides sprinkled on some crops may cause leaf burn. Water quality also can influence the way plants use fertilizer. A water analysis and proper interpretation are important tools for water management.

Crops. Each crop needs different amounts of water; the amounts vary with the length of the growing season and what portion of the plant is harvested. Root systems need to be considered, too. Shallow-rooted crops will require more frequent but lighter irrigations than deep-rooted crops. By understanding the crops need for water at various stages, you can schedule irrigations to more accurately meet the crop's water demands. For example, in the first quarter of a crop's growing season, the plant's use of water is low. The need for air around the roots is high because root development is critical at this stage. Over-irrigation reduces both the volume and depth of the root growth. The flowering and pollinating stage is also a critical time. The roots are more fully developed and must supply adequate water to the plant. As a plant matures and fruit or grain is set, the demand for water may decrease.

Climate. Climate determines the need for water and the crops grown and influences the choice of irrigation methods. Climate includes the amount of precipitation in an area and how it is distributed throughout the year. Areas with good spring and early summer rains may require only supplemental water. In arid areas, irrigation may be necessary to meet all the plant's water needs. Temperature and wind directly affect plant requirements, although it may be possible to modify these factors through irrigation. For instance, sprinkler irrigation has been used for crop cooling to protect sensitive crops during frost.

Economics. Economics is an important consideration in deciding how to improve your irrigation management. The cost of water, labor, and energy will influence what you do. Your decision will require an analysis of your operation. Improving the management of your existing system is usually more economical that changing types of systems. A profitable operation—part of irrigation water management's basic goal—produces the best crop yields per acre with the available water.

For more information Contact your local office of the Soil Conservation Service.

Fact Sheet

Irrigation Scheduling

March 1984

United States Department of Agriculture

Soil Conservation Service

What

Irrigation scheduling is simply deciding when or how long to apply irrigation water. The increased cost of irrigation water, coupled with decreasing water supplies, has made scheduling important in the management of every irrigated farm.

Kinds of Scheduling

What method of scheduling you use will depend on the availability of irrigation water. If adequate irrigation water is available throughout the growing season, more precise methods of scheduling are possible. If water is limited, your scheduling objective is to get the best crop yield per inch of water you apply. Your scheduling method may be one or a combination of the following:

Checkbook method. This method requires that the landowner know how much water is applied at each irrigation. Based on normal daily withdrawal rates by the crop, or current published rates, the landowner merely "checks off" the daily crop use until the moisture reaches a predetermined deficit level. When the soil moisture "bank account" reaches this level, the next irrigation is started. Rainfall or other climatic conditions that affect water use of the crop can be inserted into this method. Check the balance occasionally for accuracy. Soil moisture content is necessary for the "checkbook balance."

Actual use methods. These methods work best with the "checkbook method." Instead of having the landowner use a normal daily water withdrawal rate, actual use methods measure the water use of the crop by some type of field determination. These can measure either actual soil moisture or actual in-field evaporation. With simple bookkeeping procedures or complex computer programs, the data can give the landowner a "crop's eye" view of water use.

Crop growth stages. This method concentrates on irrigating crop growth; it is used most often by farmers who have a limited supply of water to meet the total water needs of the crop. Irrigating at certain stages of crop growth will maximize the yield per inch of water applied and make the most effective use of irrigation water available. These stages of growth vary from crop to crop, but generally, the stages at which irrigation water should be applied to achieve the optimum crop response are flowering stage, grain or fruit production stage and grain or fruit filling stage.

The Soil Conservation Service has guidelines tailored to the various crops grown in the state. These delineate the stages of growth at which irrigations should be applied to optimize yield per acre inch of water applied.

Summary

Regardless of the type of irrigation scheduling system used, a landowner should realize that scheduling is just one part of the farm's overall irrigation water management system. To make any scheduling effective, the landowner must be able to make decisions regarding the amount of irrigation water applied and the effectiveness and uniformity of the current water application method

For More Information

Contact your local office of the Soil Conservation Service.

Fact Sheet

Soil Moisture Measurement

March 1984

United States Department of Agriculture

Soil Conservation Service

What

Soil moisture measurement is an important tool in managing an irrigation system. It helps to determine how much water to apply and when to irrigate. Soil moisture measurement is the physical process of determining how much water is stored in the soil.

Why

Soil moisture measurement helps you decide if an irrigation was adequate, if water was applied uniformily, as well as when to irrigate and how much water to apply.

Soil moisture is critical to crop growth. By maintaining moisture within a certain range for a given soil and crop, the best growing conditions can be achieved. Frequent irrigations slow crop growth by forcing air out of the soil. On the other hand, if a crop is under-irrigated and soil moisture falls below a certain level, plant stress reduces crop yields. This level varies from crop to crop and from soil to soil. Therefore, measuring soil moisture provides a method of controlling this important element and using only the amount of water needed to produce a crop.

Measurement Methods

There are five ways commonly used to measure soil moisture. Each one must be carefully used and correlated to the soil texture.

1. The "feel" method—In this method, the irrigator obtains a handful of soil from the crop's root zone and by squeezing the sample estimates the moisture it contains.

2. Electrical resistance blocks—These show soil moisture changes by measuring electrical resistance changes in a porous block placed in contact with the soil.

3. Tensiometers—These show soil moisture changes by measuring the changes of vacuum created by water movement through their ceramic tip as soil moisture changes.

4. Neutron probe—These instruments measure soil moisture by emitting neutrons and counting the number of returning neutrons.

5. Gravimetric—Soil moisture is measured in this method by weighing a soil sample before and after it is dried.

These methods are compared in a table on the back.

For More Information

Contact your local office of the Soil Conservation Service.

Methods of measuring soil moisture

Method	Equipment needs	Estimated cost	Advantages	Disadvantages
"Feel"	Soil probe Soil auger	$30 $100	Quick & inexpensive May be done anywhere in a field at anytime.	Experience needed to develop confidence or proficiency.
Electrical resistance blocks	One block for each spot and depth to be monitored. Resistance or Ohm Meter	$10 $225-$250	Some meters can measure soil temperature. Work well with low to medium water requirement crops. Moderately fast use. Works within wide moisture range.	Blocks deteriorate rapidly in sandy, wet or high shrink-swell soils. Less accurate in high-moisture requiring crops. Lag between moisture changes in the block and that in the soil. Adversely affected by soil salinity. Must have soil-moisture release curve to convert readings to inches of water. Must be carefully installed. Limited to those spots where blocks are installed.
Tensiometers	One instrument for each location and depth.	$35	Quick to read.	Protect from freezing. Limited in clay and very coarse sand. Require regular maintenance. Doesn't work if soil becomes too dry Works within narrow moisture range near wet end of scale. Must be carefully installed.
Neutron Probe	Access tube for each location Probe	$5-10 $3,500	Usable on all soils and moisture ranges. Rapid readouts. Highly accurate if properly calibrated.	Initial cost. Need to calibrate for each location. Access tubes need to be well-marked. Users must be certified. Special storage required.
Gravimetric	Probe; oven and tins for drying soil samples. Other soil drying method	$5, if home oven used $550-600	Use anywhere.	Slow. Need table to convert readings to inches of water.