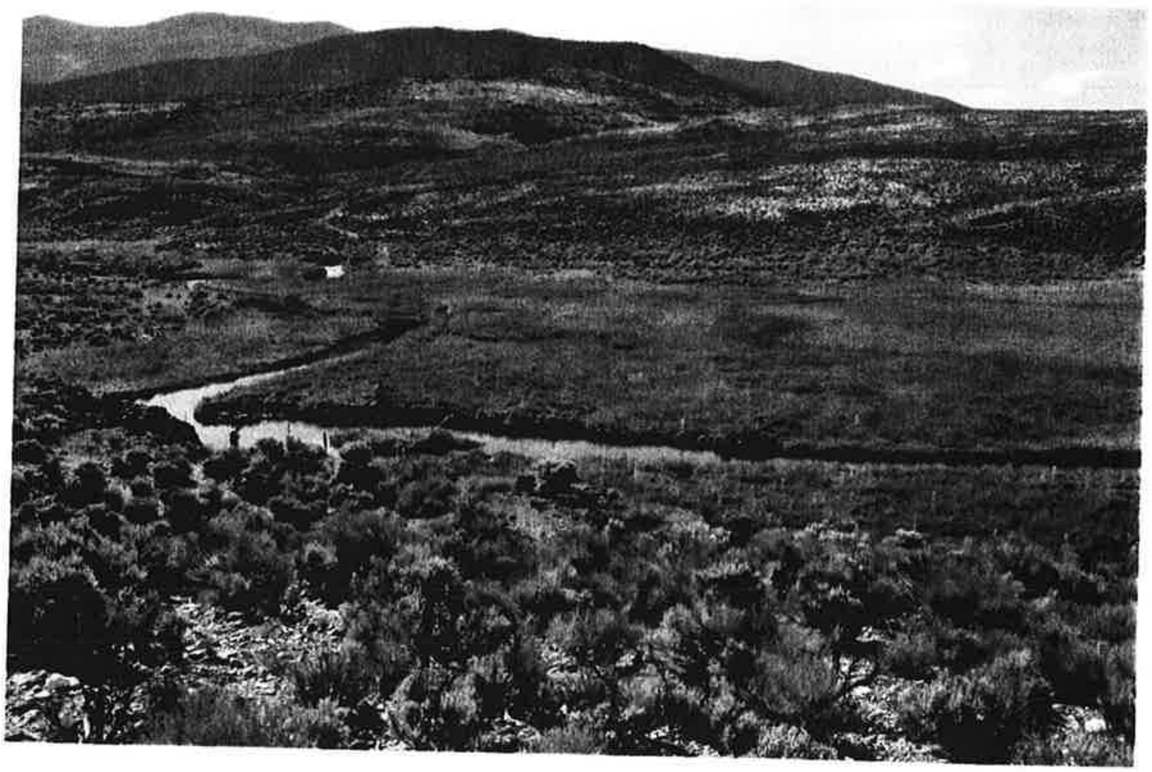
Utah Department of Environmental Quality
Division of Water Quality
TMDL Section
Otter Creek Watershed TMDL

Waterbody ID	**Otter Creek**
Location	**Piute and Sevier Counties, Central Utah**
Pollutants of Concern	**Total Phosphorus, Sediment, Dissolved Oxygen, Coliforms**
Impaired Beneficial Uses	**Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.**
Loading Assessment	**93,000 tons/y sediment reduction (federal and non-federal rangeland)** **Decease sediment along 30 miles of streambank/ channel** **25% decrease in nutrient loading**
Defined Targets/Endpoints	**- Restore trout fishery to full potential commensurate with use classification** **- Increase fish production to 150-200 pounds/acre in Otter Creek** **- Shift from sediment and organic enrichment tolerant macroinvertebrates in Otter Creek** **- 500 coliform count/100 ml**
Implementation Strategy	**Stabilize streambanks and stream channel** **Revegetate riparian and upland range land** **Implement BMP's for grazing and irrigation**

This document is identified as a TMDL for waters in the Otter Creek drainage and is officially submitted to U.S. EPA to act upon and approve as TMDLs for those waters.

STATE OF UTAH

NONPOINT SOURCE INTERAGENCY MONITORING WORKGROUP



1993-1998 Field Evaluations and Progress Report
OTTER CREEK
May 14, 1999

Utah Department of Environmental Quality
Utah Department of Natural Resources
USDA Natural Resources Conservation Service
Utah Department of Agriculture and Food
Utah State University Extension

King = Above Narrows Treatment

Blood = Angle Site

Nielson = Above Narrows Untreated

NPS INTERAGENCY MONITORING WORKGROUP

1993-1998 Field Evaluations and Progress Report

OTTER CREEK

May 14, 1999

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Table of Contents

Table of Contents

STATE OF UTAH NPS INTERAGENCY MONITORING WORKGROUP

INTRODUCTION

In fiscal year 1990, Congress began appropriating funds to implement a state nonpoint source management plan. Utah is using these funds to create a balanced nonpoint source (NPS) program of state staffing, watershed projects, information and education projects, training, technology transfer, groundwater assessment, and other elements needed for an effective state program. Some of this funding is being used to support a coordinated effort to identify and treat nonpoint source pollution problems in the Otter Creek, Little Bear River, Chalk Creek, Beaver River, and Mill Creek watersheds in Utah. These projects target the entire watershed area that feeds the main channel for special inventory, planning, and practices to correct water quality problems. Federal and stage agencies have been working in a cooperative effort to assist landowners in making management, structural, and vegetative changes to improve water quality.

CHAPTER ONE: INTERAGENCY NPS MONITORING WORKGROUP

During FY93, an Interagency NPS Monitoring Workgroup was organized to evaluate the effectiveness of BMP practices and 319 watershed restoration projects in Utah to provide technical assistance and interpretation of data to NPS planners and user groups. The current workgroup membership is made up of representatives from the Utah Division of Wildlife Resources (DWR), Natural Resources Conservation Service (NRCS), Utah State University Extension, and Utah Department of Agriculture (UDA) with Chairmanship provided by the Utah Department of Environmental Quality, Division of Water Quality. As workgroup efforts focus on an individual watershed or project, additional members are invited on a project specific basis. These may include watershed project coordinators or managers, representatives of Federal land management agencies, regional resource people from DWR, and research interests from Universities.

The primary objective of the workgroup is to investigate and employ monitoring of surrogate parameters to compliment DEQ's concurrent chemical and physical water column chemistry data. The monitoring of channel morphology, riparian vegetation recovery, fish population/productivity, and habitat quality together with implementation of photopoint documentation of projects will provide data on the success of selected BMP's and time frames for expected biological response.

Mission Statement and Objectives

Specifically, the mission statement and objectives of the Workgroup are:

Mission Statement

The mission of the NPS Interagency Monitoring Workgroup is to coordinate evaluation and monitoring of stream habitat/biological/physical conditions and *response to Resource Management Systems*

Objectives

1. *Conduct effectiveness monitoring of Resource Management Systems and BMPs in Section 319 funded watershed projects*

2. *Evaluate, develop, and adopt Statewide watershed monitoring protocols and quality assurance plans for BMP effectiveness monitoring*

The objectives at this time are intentionally limited and focused. We anticipate that the objectives will be broadened as the Workgroup and NPS program develops, especially in the area of project scoping/basin inventories and training and coordination for similar monitoring efforts.

Progress of the Interagency NPS Monitoring Workgroup

During the period March 1993 through March of 1994, the Interagency Monitoring Workgroup met several times and accomplished the following: 1) monitoring methodologies were reviewed and selected, 2) workgroup purpose was discussed and an outline of monitoring workgroup goals and immediate agenda drafted, 3) formats for standard operating procedures (SOPs) and quality assurance measures (QA) were selected, 3) Eight draft SOPs for monitoring methods were prepared, and 4) representatives from the workgroup attended training on Stream Classification and Application by D.L. Rosgen and W. S. Platts. In 1996, Interagency Monitoring Workgroup attended a training session on Stream Assessment and Monitoring taught by D.L. Rosgen and William Emmett.

Pilot studies were implemented on Otter Creek, Mill Creek, and the Little Bear River during July, August and early September of 1993 to test the methodologies and SOPs. The Otter Creek sites were monitored in 1994, 1995, and 1998; Mill Creek was monitored in 1994, 95, 96, and 98. The Little Bear River was revisited in 1994, 1995 (one site), 1996 (one site), and 1997.

In Northern Utah, a study site was established on Chalk Creek, located in the Weber Basin, in 1994 with continued monitoring in 1995, 96, and 98. Baseline data was collected at a second site on Chalk Creek in 1998. Huff Creek, also located in the Weber Basin and a tributary to Chalk Creek, had a project implemented in 1995 with monitoring through 1997. In Central Utah, a project on the Beaver River was implemented in 1997 with a survey completed in 1998, and scheduled for 1999. Data evaluation for some aspects of these pilot studies are still in progress.

The workgroup made significant progress in the first year by drafting a report that represents a foundation for future monitoring and reporting of Best Management Practices effectiveness in these project watersheds. The report also establishes and documents the workgroup activities to provide for consistency and facilitate the continuance of the monitoring during possible staff and program changes. Permanent monitoring reaches have been monumented in the field and the basis for future evaluation and project observation has been established. Interest and participating agency commitment to the workgroup activities is high.

Since 1993 the workgroup has focused on evaluating existing sites, monitoring and establishing new projects, and completing progress reports. The document described above is the foundation for this Otter Creek report and will be used for additional progress reports on Chalk Creek, Mill Creek, and the Little Bear River, and Beaver River. This Otter Creek progress report includes a watershed project description, basin and site project implementation, methodology, study reaches and design, monitoring results, and conclusions.

NPS Interagency Monitoring Workgroup Future Activities

Work plans for the group for the coming year include development of additional SOPs if needed, amending existing project implementation plans (PIPs) to include project specific sampling plans, and conducting project monitoring during the 1999 field season. Study sites on the East Fork Little Bear River, Beaver River, and Chalk Creek (2 reaches) will be revisited and surveyed. Baseline study reaches will be established in the Chalk Creek project area in close cooperation with the project coordinator during finalization of the Coordinated Resource Management Plan.

If NPS activity increases in the Beaver River drainage with a demonstration project, the workgroup will explore establishing appropriate baseline studies. Opportunity may exist for coordination with Utah State University in some proposed watershed studies in these basins. Study plans and literature reviews for the studies are anticipated to be drafted.

Data evaluation and summary is ongoing for: geomorphic indices (width/depth ratios, mean depth, etc.) for the channel cross-sections; Mill Creek riparian evaluation (USFS will author); longitudinal profiles plots and planimetric views for all reaches; integration of USU study data for future baseline studies and control reaches on the Little Bear; complete Utah riparian classification (Peterson, et.al, 1991) for all reaches; and complete miscellaneous figures (watersheds, reach locations, etc.) and editorial details for future reports. Interagency Monitoring Workgroup will complete the analysis of data and prepare a report for the Little Bear River Watershed in 2000.

Project coordinators in each basin will be contacted and plans developed to track and document intensely the specific implementation of BMPs (type, timing, and concerns) in study reaches to allow full evaluation and interpretation of the data collected by the workgroup.

The Methods section presented in this report is brief for some methodologies, however, the workgroup is authoring or revising final Standard Operating Procedures (SOPs) and efforts to author special narratives for those methods at this time was decided to be redundant. Future annual reporting will simply reference these procedures and document any necessary departures from the SOP for the specific monitoring period. SOPs were finalization in early June 1994. The workgroup is also exploring "Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Stream" (EPA, Region 10, 1993) for applicability to meeting our goals.

Conclusions

The workgroup observations during 1993 showed stream systems with lower ecological status, fish populations that could be improved, and many wide and shallow stream configurations. We observed cut banks and deposition of sediments on substrates, low values for shade and riparian canopy, and riparian zones with great potential for improvement. The workgroup consensus is that these pilots studies were very successful and the data collected is suitable to be used as solid baseline data for future monitoring work and trend observation.

As the projects are successfully implemented and maintained, we are confident we will see lower width/depth ratios, lower fine sediments on the channel substrate, improvement in reach habitat scores and fish populations, and increased shade and riparian vegetation health as we move toward the goals of the Clean Water Act. Realizing, however, that in some reaches upstream influences may mask the effects of the BMPs in the immediate study reach. In some cases, full success may not be manifested by these studies until the entire watershed is adequately treated and stabilized.

CHAPTER TWO: THE OTTER CREEK WATERSHED PROJECT

Introduction

The Otter Creek Watershed is located in south-central Sevier County and the eastern part of Piute County, Utah (Figure 2.1) and is a tributary to the East Fork of the Sevier River. It encompasses 240,000 acres (375 sq mi) and approximately one-third of it lies within Sevier County and two-thirds in Piute County. The topography includes mountains, mountain valleys and plateaus; and the elevation ranges from 6,270 feet near Otter Creek Reservoir to 11,613 feet at the top of Mt. Marvine. Otter Creek drains the east slope of Parker Mountain and the west slope of Monroe Mountain. The watershed lies between longitude -112° 5' 34" (west) and -111° 41' 49" (east), and between latitude 38° 42' 29" (north) and latitude 38° 7' 42" (south). The watershed is approximately 39 miles long and 12 miles wide and runs along a north-south axis (Figure 2.2).

According to the U.S. Soil Conservation Service and the Utah Department of Agriculture (1992), ninety-five percent (228,000 acres) of the land is classified as range/wildlife and the remaining 12,000 acres (5%) includes irrigated pasture, cropland, and wet pasture land. The soil types are deep, loamy in the valley bottoms; deep gravelly and cobbly on the alluvial fans and foothills, and usually shallow soils on the steep mountainsides and escarpments. Average precipitation ranges from 9.6 inches per year at the lower elevations to 20 inches per year in the mountains.

Otter Creek Reservoir is located at the mouth of Otter Creek near the town of Angle and Koosharem Reservoir is in the upper portion of Grass Valley above Burrville. These reservoirs have beneficial use classifications of 2B, 3A, and 4 as given by DEQ in the Standards of Quality for Waters of the State. The 2B beneficial use designation is "protected for boating, water skiing and similar uses, excluding swimming". Class 3A designation is for "cold water species of game fish and other cold water aquatic life including the necessary aquatic organisms in their food chain" and Class 4 is for "agricultural uses including irrigation of crops and for livestock watering".

Watershed Description

The Otter Creek Watershed from Otter Creek Reservoir to its headwaters contains 121 miles of perennial streams and 281 miles of intermittent streams. Otter Creek is the main stream channel with 6 to 8 tributaries feeding it. There are approximately 21 miles of ditches and canals located within the watershed. Otter Creek and its tributaries have beneficial use designations of 3A, cold water fishery; and 4, agricultural water for irrigation and stock watering. Two reservoirs, Otter Creek and Koosharem, are located within the basin.

Otter Creek is a third order stream and is generally an unconfined, high sinuosity, low gradient stream. It has moderate to high width/depth ratios. Its bed materials are primarily small gravel, sands, silts, and clays, but there are significant areas with gravel bed materials. Otter Creek has formed its channel in low river terraces and is derived from cobble and gravel sized alluvium and from eolian, residual, and other typically sand sized materials. Limited reaches of the stream have or are at risk of becoming entrenched.

Soils below the 8,000 foot elevation are shallow to deep gravel and cobble loams underlain with sandstone and shale bedrock. These soils are well drained, and permeability is moderate to slow. Runoff is medium and sediment production is moderate. Principle vegetation is big sagebrush, oakbrush, pinion pine, and associated grasses, forbs, and shrubs (Figure 2.3). Soils above 8,000 feet are moderately deep to deep acidic loam, silt lam, and clay loams underlain by bedrock. Depth to bedrock varies from 0 to 60+ inches. Soils are well drained with permeability ranging from slow to rapid. Vegetation consists of aspen, spruce, fir, grasses, forb, and shrubs (SCS, 1992).

Climate in the watershed is temperate. Temperatures range between a mean minimum 5.7° Fahrenheit (F) in January, to a mean maximum of 83.5 F in August. Temperatures have reached 99° F and minus 30° F. The average annual air temperatures is 44 degrees. Mean annual precipitation is 20 inches in the higher mountain areas, and less than 10 inches in the lower valleys. Approximately 5.4 inches comes as rain in May through September. The remaining 4.2 inches comes during October through April mostly as snow.

The SCS (1992) classified 90 percent of Otter Creek as a C-4 stream type (after Rosgen). This stream type consists of a sand-bed channel formed in low river terraces that are derived from alluvium, eolian, residual and other sand-size material. The gradient is gently sloping to 0.1 - 0.3%. Sinuosity is 2.8 and the width to depth ratio is >5. Channel material consists of sand with a mixture of gravel and silt, or some silts and small gravel. The channel is moderately entrenched and slightly confined. The remaining 10 % of Otter Creek is a C-3 stream type. This stream type consists of a gravel-bed channel formed in low river terraces derived from fine textured banks, gravel beds, and unstable banks. The gradient is gently sloping 0.5 - 1.0% . Sinuosity is 1.8 - 2.4 and the width to depth ration is >10. Channel material consists of a gravel bed with mixture of small cobbles and sand. This stream is moderately entrenched and slightly confined.

The Hydrologic Unit Plan for Otter Creek (SCS, 1992) presents the following riparian classification for Otter Creek:

1. Physiographic Region - MLRA D 28 and E 47.
2. Temperature Regime - Cryic to Frigid.
3. Water Chemistry - Fresh (800 umhos specific conductance).
4. Geologic district - Broad, generally flat to gently slopping valley bottoms composed of alluvial materials (sand, silt, and clays).
5. Associated Aquatic Ecosystem Type - Stream (riparius).
6. Riparian Complex - *Carex Rostrate, Saliz Geyeriana/Carex Rostrate, Juncus Balticus, Populus Angustifolia/Carex Rostrate.*
7. Hydrologic Moisture Regime - Hydroriparian and Mesoriparian.

South Narrows Allotment, Otter Creek
Piute County, Utah

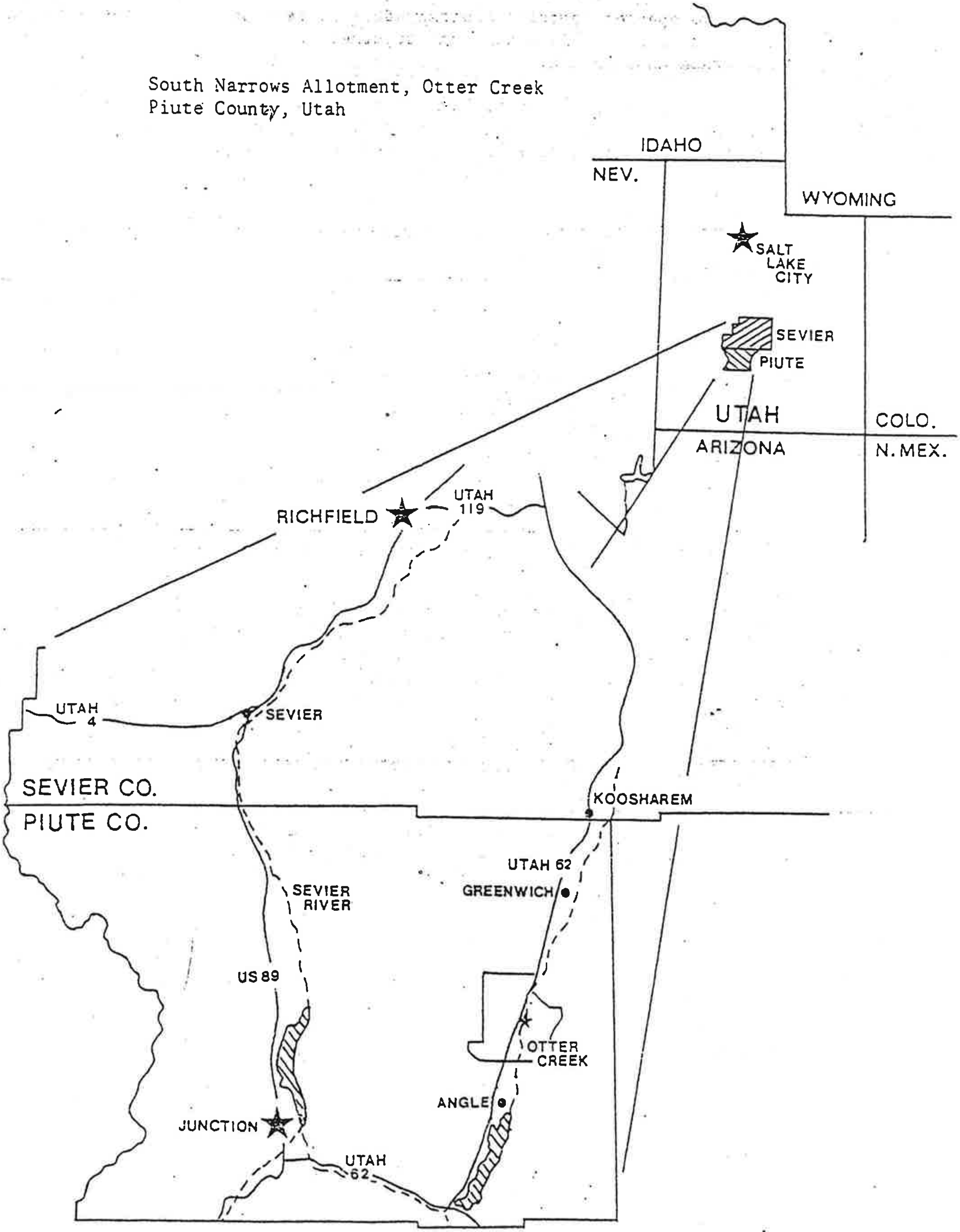

Figure 2.1 Otter Creek monitoring site location (Platts, 1980).

8. Range Sites - Wet Fresh Streambank, Wet Fresh Meadow, Semiwet Fresh Streambank, Semiwet Fresh Meadow, and Loamy Bottom.
9. Ecological Condition Class - Early Seral to Mid and Late Seral Stage.
10. Community Type - *Juncus Balticus/Poa Pretenses.*

Riparian areas of the watershed are generally in poor condition. Most of the willows are gone, and the deep rooted grass and grasslike plants have been replaced with shallow rooted sod-forming grasses. The potential for recovery of these riparian areas is very good. There are local sources of plants to replace those that have been lost, and with improved management these areas will recover.

General range site conditions of the watershed vary from poor to good. Rangeland in good condition accounts for 20% of the total range acreage. This range is typically located on steep slopes and includes rangeland that is too far from water to be utilized by livestock. Approximately 30% of the rangeland is in poor condition. Approximately 50% of the range is in fair condition. This area includes most of the region located approximately 2 to 2.5 miles from water sources. Five percent (5%) of the total watershed range consists of wetland and riparian areas. Range site condition and percentage of the wetland and riparian area covered is as follows: poor condition - 5%, fair condition - 80%, good condition - 15%. Wetland and riparian range sites in poor condition are also identified as critically eroding areas. Critically eroding areas usually start at the outer edge of the wetland and riparian areas, and extend upslope approximately 2 miles from the creek.

Average maximum daily flow occurs in the month of May with a flow rate of 78 cfs. The average minimum daily flows (8 cfs) occur in September. These averages are based on data from three different sites on Otter Creek. These sites are located at the upper end (north), midway, and lower end (south) of Otter Creek.

Land Ownership

About 109 farm owners live in the watershed and an additional 30 to 35 live in surrounding communities of Burrville, Koosharem, Greenwich, and Angle. The BLM owns over fifty percent of the watershed, followed by the Forest Service, private holdings, and State land (Figure 2.4). An estimated 2800 acres of irrigated pasture/hayland and 3100 acres of wet meadows are located adjacent to the Otter Creek channel. Approximately 90% of this land is privately owned. Heavy livestock concentrations in these areas have created a situation that contributes to sediment, nutrient, and coliform loading of the stream. Animal concentrations are heavier during winter, fall and spring months. Pollutant delivery occurs mainly during spring snowmelt runoff and during intense summer convection storms. Large amounts of animal waste are also washed into Otter Creek and Otter Creek Reservoir during the irrigation season in the spring and summer months.

There are approximately 8900 acres of privately owned irrigated land that includes alfalfa, small grains and meadow pasture. Crop rotations in the watershed include alfalfa for 6 to 8 years, and small grains for 2 to 3 years. Irrigated pastures are used for livestock grazing and production of grass hay.

The major source of income is from livestock production, with many families obtaining additional income from off-farm sources in the larger neighboring communities. Cattle, sheep and horses are the major livestock produced in the watershed. Livestock are grazed on both private and state ground in coordination with BLM and US Forest Service allotments.

Land Ownership (NRCS, 1992):

Owner	Percent	Acres
BLM	50%	120,000
Forest Service	35%	84,000
Private	10%	24,000
State	5%	12,000

Water Quality Concerns

Historically, Otter Creek was considered a good fishery, but has declined over the past decade due to nutrient loading, loss of riparian habitat, extensive aquatic vegetation growth, and sediment loading. In 1991, whirling disease was discovered in a private fish hatchery in the watershed and the State Division of Wildlife Resources decided to remove all fish from the stream in an attempt to control the spread of the disease. Rotenone was used to kill trout in 1991, 1992 and 1993 in an attempt to eliminate the disease. The stream will be restocked after treatment. However, the habitat problems that were impacting the fishery before whirling disease was discovered will have to be addressed before Otter Creek can become a good fishing stream again.

Stream channel erosion has had an adverse affect on riparian conditions by lowering the watertable in some areas. As a result there has been a reduction in quality and quantity of vegetation essential for protection of the stream channel and streambanks. There is a distinct lack of shrubby vegetation along most of Otter Creek's channel. The final result from these impacts is an impaired watershed with limited ability to perform its function as a filter zone to prevent pollutants from entering the stream and being transported to the reservoirs.

Streambanks are unstable at many locations along Otter Creek due to damage sustained during extensive spring runoff in 1983 - 1984 and from animals trampling banks as they use the stream for drinking water. Pollutants associated with this type of damage occurs throughout the year, but is more pronounced during spring through fall months.

Otter Creek and Koosharem Reservoirs receive heavy recreational use, including fishing and boating. The fishery in both reservoirs has degraded and the recreational benefits are being impacted by aquatic vegetation growth. The primary cause is nutrients entering the reservoirs from the streams in the basin.

Koosharem is one of only four hypereutrophic lakes in Utah and Otter Creek is classified as eutrophic. Koosharem's beneficial uses are moderately to severely impacted by nuisance algal blooms, extensive rooted aquatic vegetation, and high temperatures. Otter Creek Reservoir's beneficial uses were also impacted by high temperatures and low dissolved oxygen levels. (DWQ, 1992).

Water Quality Assessment

Water quality data for the period from May, 1990 through December 1992, for eight (8) stations were collected by the Division of Water Quality, Department of Environmental Quality in the Otter Creek watershed. The Water Quality Assessment: Otter Creek, Piute and Sevier Counties, Utah (DWQ, 1994) summarizes the investigation from which the information contained herein was drawn. DEQ has continued monitoring the Storet sites throughout the watershed. The reader is referred to that report for details on sampling, field techniques and analytical methods.

Several stream segments in Otter Creek do not meet the water quality criteria for supporting a cold water trout fishery because of low dissolved oxygen levels and the presence of iron above Koosharem Reservoir. The number of samples that exceeded the State pollution indicator value for phosphorus indicated the impact of agricultural practices in the area. In addition, Koosharem Reservoir acts as a sink for nutrients and releases them whenever water is released from the reservoir. In general, it appears that restoration of the riparian habitat and an improvement in agricultural practices within the watershed would improve the water quality as well as the fisheries habitat. A total maximum daily load analysis for phosphorus would help determine where the major portion of the phosphorus is entering the system and how much is entering Koosharem and Otter Creek Reservoirs. This information would assist in pinpointing the most critical areas of the watershed and help in the design and implementation of projects to improve water quality.

Total Phosphorus-- Nutrients, such as phosphorus, stimulate plant growth in water in the same way they stimulate growth of crops in a field. Generally levels of phosphorus above 0.05 mg/l are considered unacceptable in streams and 0.025 mg/l in lakes and reservoirs and as such the State of Utah has adopted these concentrations as pollution indicators as part of its water quality standards. Total phosphorus concentrations exceeded the State's pollution indicator value of 0.05 mg/l in 90%, 44%, 41%, 68%, 65%, 100%, 89%, and 54% of the samples collected at the 8 stations.

Mean concentrations ranged from 0.049 mg/l to 0.168 mg/l. The highest mean concentration occurred at the station immediately below Koosharem Reservoir (station 6) and was significantly greater than the other stations. Koosharem Reservoir acts as a retention basin for phosphorus and then it is released when water is released from the reservoir. Station 1 located above Otter Creek Reservoir had the next highest mean concentration of total phosphorus. High concentrations of phosphorus at this station were caused by return irrigation flows, runoff from a feedlot and poor riparian habitat that allowed surface runoff to enter the stream. Phosphorus levels below Station 6 were lower and then increased significantly downstream near the town of Angle. This also indicated the impact of return irrigation flows and surface runoff from the feedlot above this station.

Dissolved Nitrate-Nitrites-- The mean concentrations ranged from 0.047 mg/l to 0.628 mg/l. The concentration at the lowest station was significantly higher than those at the other stations. The higher concentration found at this station indicated that the water was being affected by the wastes from the feed lot near it.

Ammonia-- Ammonia levels were not very high throughout the basin with 84% of the concentrations being below the laboratory detectable limit of 0.05 mg/l. Of those that exceeded the minimum detectable limit, 41% of them occurred from samples immediately below Koosharem Reservoir. The mean concentration of ammonia at this station was 0.189 mg/l and was more than 3 times greater than at any other station.

Temperature--_Cold water fish, like trout, do best between 10 ^{0}C and 15 ^{0}C and temperatures above 39 ^{0}C can be harmful. Utah has set the maximum temperature standard for a Class 3A stream (cold water game fishery) at 20 ^{0}C to protect the trout and the necessary supporting biological communities such as benthic macroinvertebrates. This standard was exceeded seven times during the study period. These exceedances occurred in the months of June, July, and August. Boobe Hole Creek and its tributaries were determined to be partially supporting their cold water fishery beneficial use classification because the temperature standard was exceeded about 15% of the time.

Dissolved Oxygen-- Dissolved oxygen (DO) normally ranges between 8 and 15 mg/l in rivers and streams. Since oxygen requirements vary among aquatic organisms, Utah has set a minimum level of 6.5 mg/l for a cold water fishery and 5.5 mg/l for a warm water fishery. Dissolved oxygen levels in Otter Creek ranged from 1.1 mg/l to 12.8 mg/l and the means ranged from a low of 8.0 mg/l to a high of 9.5 mg/l. Overall the oxygen levels were high enough at most of the stations, but the 1.1 mg/l concentration at Station 1 (Blood project reach) would not be adequate for trout to survive. In addition, the oxygen levels recorded at Station 1 were less than the State standard 27% of the time that samples were collected. The low levels have been attributed to low flows and the biological oxygen demand caused by animal wastes that enter the stream in the reach. Under the criteria used for evaluating use support, Otter Creek in the lower reach would be designated as partially supporting the beneficial use classification as a cold water fishery because the DO criterion was not met in 23% of the samples. A mid-basin stream reach would be designated as partially supporting because DO concentration were less than 6.5 mg/l 14% of the time.

Total Suspended Solids-- Total suspended solids (TSS) ranged from a low 3 mg/l at all but one of the stations to a high of 394 mg/l at Station 2. The means ranged from 14.5 mg/l to 17.2 mg/l The levels of TSS at lower basin stations were somewhat seasonal with the higher levels occurring during spring runoff. The TSS concentrations were not extremely high for a stream, but the amount of sediment loading needs to be calculated to determine the amount of sediment that is entering the stream to determine the overall effect of sediment on the stream. Sediment loading could be reduced by improving the riparian habitat of the stream.

Specific Conductance-- Specific conductance (conductivity) is a quick method of measuring ion concentration which affects the osmotic pressure on aquatic organisms. In general, streams that have a specific conductance between 150 umhos/cm^3 and 500 umhos/cm^3 support a good mixed fish fauna although levels higher than can be tolerated by fish in areas where the water has a higher alkalinity. The mean conductivity values were higher below Koosharem Reservoir indicating the presence of return irrigation flows or groundwater intrusion as one descends Otter Creek. The means ranged from 218 umhos/cm^3 to 570 umhos/cm^3. The mean conductivity at lower basin stations were lower than those in mid-basin, but the mean conductivity increased to 540 umhos/cm^3 at the station near Otter Creek Reservoir. The increase at this station was attributed mainly to higher return irrigation flows and the effects of animal wastes that wash into the stream at or upstream of this station.

pH-- The pH of water indicates whether it is basic, neutral or acidic. Most natural waters are buffered by minerals like bicarbonates that keep the range of values between 6.5 to 9.0. Utah has adopted this range as the pH standard as 6.5-9.0 to protect the fish and benthic macroinvertebrate populations. The median pH ranged from 7.6 to 8.5. The maximum pH was exceeded three times during the 2 year period. The pH of the water was well within the range required for a cold water fishery and the supporting biological communities necessary to support one.

Benthic Macroinvertebrates-- Benthic macroinvertebrates are used to indicate the quality of water. A healthy stream has a diverse community of macroinvertebrates, including some pollution tolerant species. As the water quality degrades the community structure is reduced to a few kinds of organisms that are more tolerant of pollution. All three benthic sites, Stations 1, 3, and 6, were dominated by sediment and organic enrichment tolerant taxa. The Biotic Condition Index ranged from 50 to 56. These values indicated that the benthic community at all the stations sampled were stressed (Mangum, 1993). Indications are that the benthic macroinvertebrate community would change with improvement in the riparian habitat, and a reduction in nutrients and total suspended sediments in the stream. However, the diversion of water for irrigation would still impact the community in the summer.

State Water Quality Criteria-- In addition to the parameters already mentioned in the report, the criterion for iron was exceeded in 3 of the 8 samples analyzed from Boobe Hole Creek. Boobe Hole Creek and its tributaries would be classified as not supporting the cold water fishery beneficial use based upon this data. The source of the iron is not known, but it may be coming from the soils located in the drainage above Koosharem Reservoir.

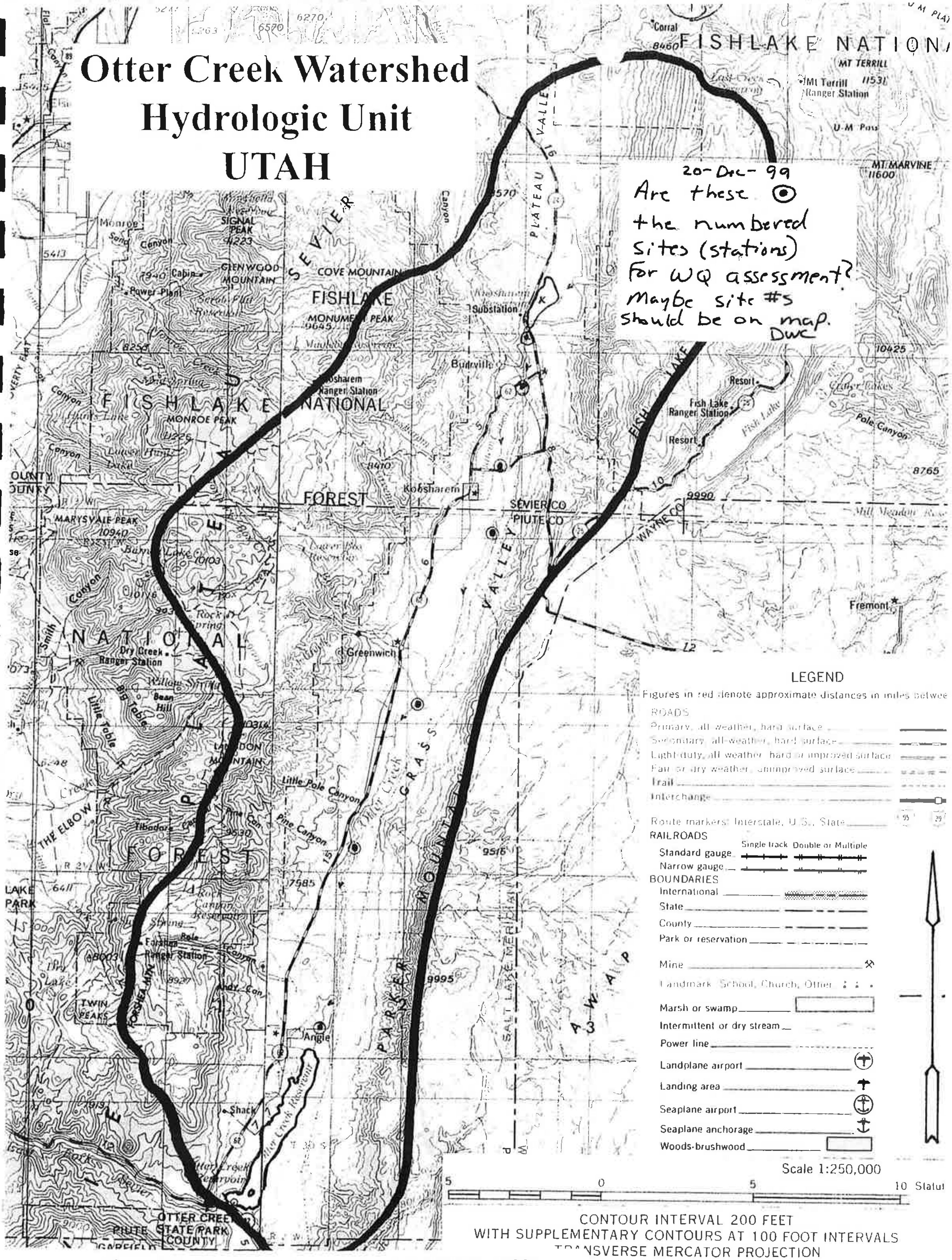

Figure 2.2 Otter Creek Hydologic Unit (NRCS, 1992).

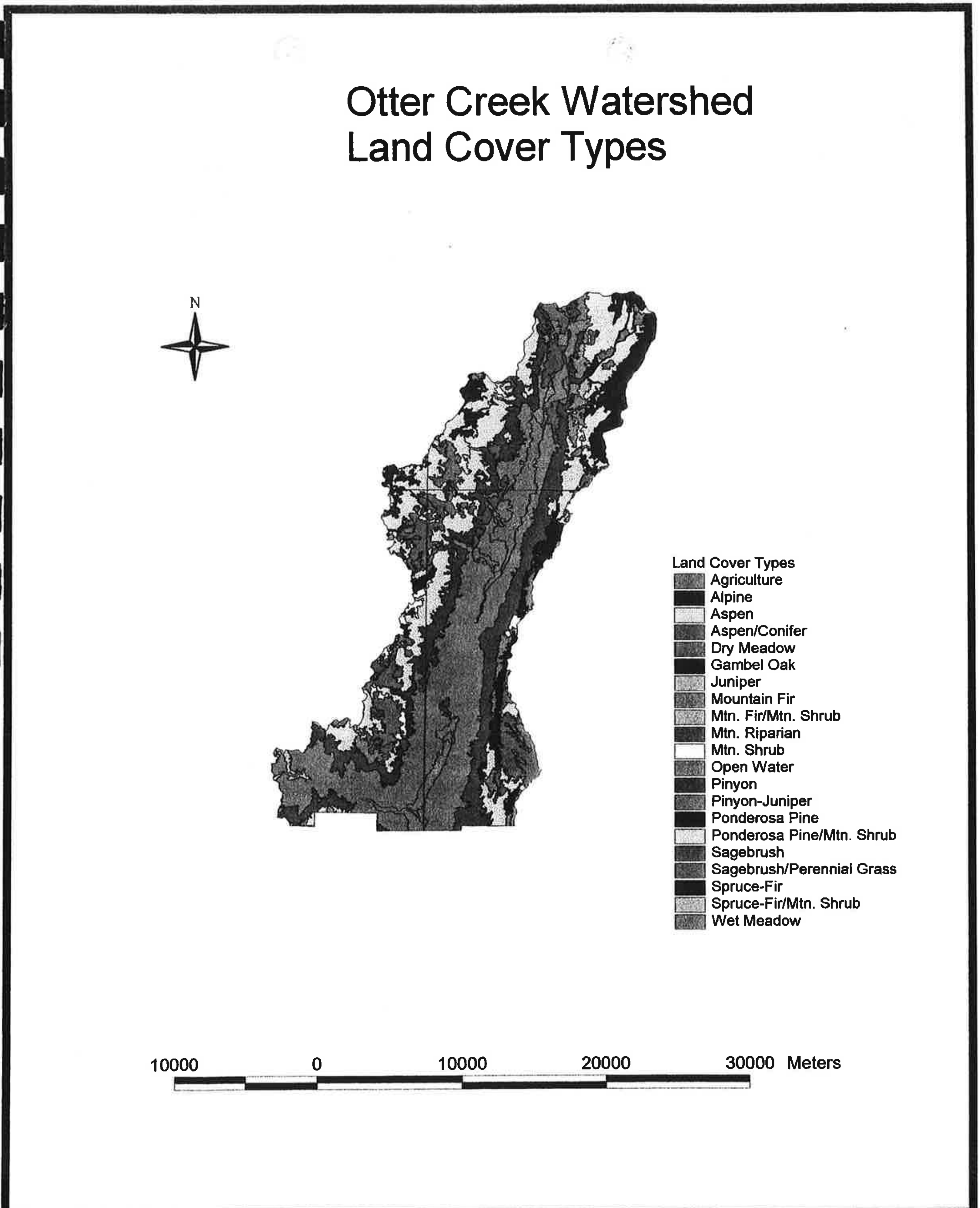

Figure 2.3 Otter Creek Watershed Land Cover Types.

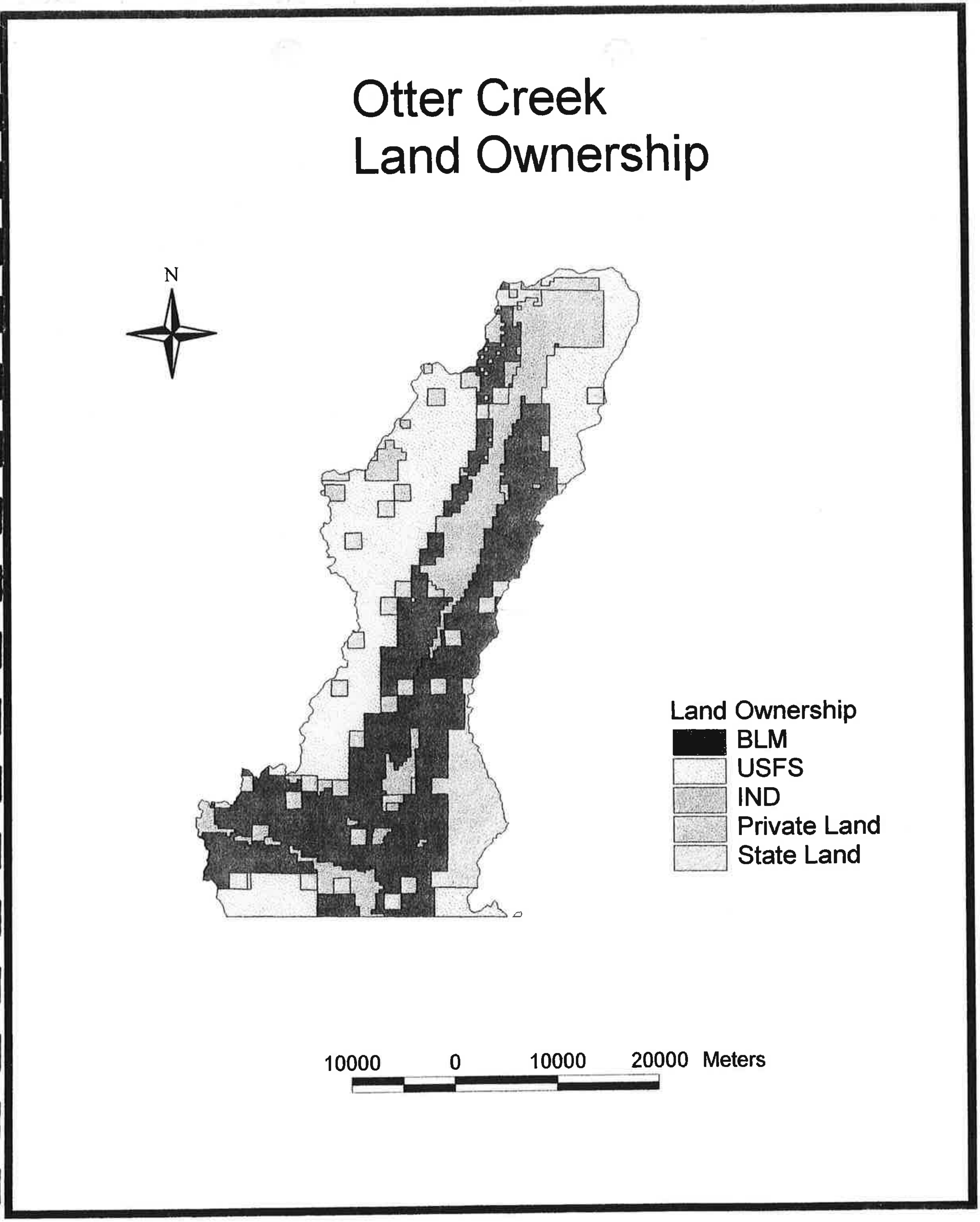

Figure 2.4 Otter Creek Watershed Land Ownership.

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CHAPTER THREE: OTTER CREEK WATERSHED NPS PROJECT IMPLEMENTATION

Introduction

Otter Creek is one of five nonpoint source projects that have been implemented within Utah. As part of that implementation process, the following items have been accomplished: Steering and Technical Advisory Committees were formed and have met on a regular basis, several demonstration projects were started which included livestock watering improvements, pastureland improvement and seeding, and sprinkler irrigation. Proposed projects include rehabilitation of the riparian habitat, improved livestock management, rangeland reseeding and improved grazing management, and improved irrigation and stockwatering systems.

Previous to the NPS 319 funding, Otter Creek Watershed received project funding from the US Department of Agriculture HUA funding. This included cost share agreements with the Farm Service, technical services from the Natural Resource Conservation Service (NRCS), and I & E from Extension Service. The following information is a progress narrative, based on the Coordinated Resource Management Plan (CRMP), of projects funded with 319 funds in the Otter Creek/Koosharem watershed since 1991. This includes the project description and status. Project grants were awarded for FY 91 through FY 95, and continuation projects were funded from those grants for FY 96 through FY 98. USDA funded NRCS technical assistance and ES for I & E from 1991 through 1999. USDA funded cost share assistance from 1991through 1993.

NPS Projects in Otter Creek/Koosharem Watershed

At this date the Otter Creek Watershed has received approval from EPA for the use of $525,000 of Section 319 Nonpoint Source Water Quality funds. An additional $75,000 of FY97 319 funds have been requested but, have not yet been received. These funds have been and will continue to be used to implement best management practices (BMPs) that will help improve water quality within the watershed. Twenty six (26) conservation plans of operation (CPOs) have been developed with landowners in the watershed to address water quality problems on their farms and rangeland. These plans are in the process of being implemented. All funds approved to date have been committed in formal contracts for specific projects. Requests have been received for FY96 funds and technicians are in the process of developing individual CPOs and contracts. Contracts have been signed for FY 91 through FY 96. Included in these CPOs is the treatment of all high priority acres identified in the PSIAC study.

The following is an explanation by program year, of approved 319 projects.

FY 1991
(EPA 319 funding = $30,000, Matching funds = $20,000)

The best management practices implemented in 1991 include building drop structures, inserting barbs in critical areas along the channel and adding dormant stump plantings along the banks to prevent accelerated bank erosion and channel headcutting while vegetative cover is being established. Disking reduces competition for moisture from undesirable vegetation and to prepare suitable seedbed for seeding grass. Livestock watering facilities provide for better distribution of livestock grazing to protect ground cover and reduce animal manure and sediment input to Otter Creek. Seeding pasture land provides better protective ground cover. Fencing protects vegetative cover and reduce soil erosion with uniform distribution of livestock by controlled grazing. Land leveling provides uniform distribution of irrigation water and reduces runoff.

Tasks Planned (91):
1. Stream channel stabilization and protection - 3,470 feet
2. Brush management- 380 acres by disking
3. Livestock watering facilities - install three troughs and 5,280 feet of pipeline
4. Improved pastures- seed 215 acres
5. Fencing- 27,350 feet
6. Land leveling - 200 acres.

Tasks Completed (91):
A total of $30,000 of FY 91 EPA 319 funds have been spent to date along with $20,000 of matching private funds for the following:

1. Stream channel and streambank stabilization - 3334 feet
2. Brush management - 380 acres
3. Livestock watering facilities - installed 3 watering troughs and 4,500 feet of pipeline
4. Improved pastures - 200 acres
5. Fencing - installed 27,350 feet
6. Land leveling - none
7. Installing irrigation sprinkling system on 155 acres (replaces task #6)
   Pipeline - 5039 feet of pipe

Tasks To Be Completed (91):
All 319 funds have been paid out.

FY 1992
(EPA funds = $62,000, Matching funds = $41,500)

BMP projects planned for FY 92 include disking sagebrush infested rangeland to prepare for seeding more protective vegetative cover, seeding desirable species of grasses and browse, installing dormant stump willow plantings, and creating a wetland area to prevent waste produced by a fish farming operation from entering Otter Creek.

Tasks Planned (92):
Range Improvements:
1. Fencing - 9,000 feet
2. Brush management - disk 620 acres
3. Seed - 620 acres of rangeland

Stream Improvement:
4. Stream channel protection - 1,000 feet
5. Streambank protection - install 1,592 feet

Created Wetland:
6. Waste management - 1 waste management system
7. Created wetland - created 3 acres

Tasks Completed (92):

A total of $62,000 of FY-92 EPA 319 funds along with $41,500 matching funds have been used to complete the following improvements:

1. Fencing - 9,000 feet.
2. Brush management - 622 acres.
3. Seeding rangeland - 622 acres.
4. Stream channel protection - none.
5. Streambank protection - 1592 feet.
6. Waste management system - 1 ea.
7. Created wetland - 3 acres.

Tasks To Be Completed (92):
1. Stream channel protection - 1,000 feet

FY 1993
(EPA 319 funding of $98,500 and Matching funds of $65,667)

Tasks Planned*(93):
1. Brush mgmt - 640 acres
2. Range reseeding - 640 acres
3. Fencing - 6.4 miles
4. Livestock water develop - 8 each
   Pipeline - 8 miles
   Troughs - 8 each
5. Streambank protection - 11,000 feet
6. Stream channel (veg) stabilization - 11,000 feet
7. Pasture & hayland plant - 200 acres
8. Pasture & hayland mgmt - 200 acres
9. Deferred grazing - 640 acres
10. Proper grazing use - 640 acres
11. Planned grazing system - 640 acres
12. Irrigation water mgmt - 200 acres
13. Wildlife upland habitat mgmt - 200 acres
14. Fish Raceway/waste mgme. structure - 1 each

15. NRCS Technical Assistance - 1 each

*Tasks 1-6, 9-11, and 13 are BLM and private land projects, and tasks 7-8, 12, and 14 are private land projects.

Tasks Completed (93):
1. Brush mgmt - 396 acres
2. Range reseeding - 755 acres
3. Fencing - 76,290 feet
4. Livestock water develop - 4 each
   Pipeline - 4 miles
   Troughs - 4 each
5. Pasture & hayland plant - 200 acres
6. Pasture & hayland mgmt - 200 acres
7. Deferred grazing - 640 acres
8. Proper grazing use - 755 acres
9. Planned grazing system - 755 acres
10. Irrigation water mgmt - 200 acres
11. Wildlife upland habitat mgmt - 200 acres
12. Fish Raceway/waste mgme. structure - 1 each
13. NRCS Technical Assistance - 1 each

Tasks To Be Completed (93):
1. Streambank protection - 11,000 feet
2. Streamchannel (veg) stabilization - 11,000 feet

All contracts are in place for the use of FY 93 funds. All funds have been committed in formal contracts and the implementation of BMPs is in process. To date, $97,068 has been spent, with $1,432 remaining on current contracts.

FY 1994
(EPA 319 funding of $112,000 and Matching funds of $74,666)

The 1994 continuation PIP for Otter Creek requested $112,000 of EPA 319 funding for the purpose of implementing BMPs on both private and Bureau of Land Management (BLM) lands that will accomplish the following:

Tasks Planned* (94):
1. Pasture planting - 750 acres
2. Fencing - 31,600 feet
3. Stock water pipeline - 7,350 feet
4. Stock watering troughs - 6 each
5. Irrigation systems improved - 2 each
6. Brush management - 320 acres

7. Range seeding - 320 acres
8. Critical area planting - 66 acres
9. Erosion control structures - 5 each
10. Range management - 5,000 acres
11. Channel vegetation with dormant stump planting - 2,000 feet
12. Streambank protection - 1,000 feet
13. Stream channel stabilizing structure - 1 each
14. Streambank stabilization - 300 feet
15. Brush management - 600 acres
16. Range seeding - 600 acres
17. Fencing - 5,000 feet
18. Stock water pipeline - 1,500 feet
19. Stock water trough - 1 each
20. Range management - 10,000 acres

*Tasks 1-14 are on private land and 15-20 are on BLM land.

The contract for dispersement of 319 funds has been finalized between Division of Water Quality (DEQ), UDA (Utah Department of Agriculture) and UACD (Utah Association of Conservation Districts). Funding has been committed and contracted in each cooperator's conservation plan of operation.

Tasks Completed (94):
1. Fencing - 7,260 feet
2. Brush Mgmt. - 2440 acres
3. Troughs - 6 each
4. Range seeding - 799 acres
5. Grazing management - 3418 acres
7. Prescribed grazing - 24,365 acres
8. Struct (water control) - 70 each
9. Waste Mgmt structure - 1 each

EPA 319 Funds used = $88,000 Matching Funds used = $58,700 Other Federal Funds used = $291,000. FY 94 funds remaining=319 $14,000, Matching funds $9,400.

FY 1995

Since EPA did not grant the FY-95 Proposal request for continued funding to the Otter Creek Watershed the Utah Department of Environmental Quality (UDEQ) requested EPA's permission to transfer $80,000 of FY 1995 319 funds from the Little Bear River Project to the Otter Creek/Koosharem Watershed Project. This request to transfer funds was to maintain the program continuity in the watershed, ensure continued progress, and to maintain local interest at a high level.

Private landowners are not only interested in implementing water quality improvement practices on their land but, but also interested in improving protective cover on federal allotment land. Both BLM and the Forest Service are interested in improving the vegetative cover within the watershed. All funds previously approved have been allocated to individual projects and the contracts have been signed. Adjustments were made by the NPS Technical Advisory Committee in the 1996 funding process to return $80,000 to the Little Bear River Watershed Project.

CPOs have been prepared, with cooperators, that will require an additional $176,000 above the amount currently approved for the watershed project to implement needed BMPs.

Tasks Planned (95):
South Narrows Area
1. Brush management - 2,120 acres
2. Range reseeding - 2,120 acres
3. Watering facilities
    - Pipeline - 4 miles
    - Water tanks - 2

Plateau Area
1. Brush management - 2,200 acres
2. Range reseeding - 2,200 acres
3. Watering facilities - install 6 water catchments with troughs

Tasks Completed (95):
South Narrows Area:
1. Brush Management - 645 acres
2. Range seeding - 645 acres
3. Watering facilities

Plateau Area:
None

In addition to the 319 funds requested from EPA, BLM will provide $50,000 from their demonstration project fund. These funds will be used for the following activities within the watershed: Utah Division of Wildlife Resources will receive $9,000 for an Elk Telemetry Study, $5,000 will be used for the Koosharem Wetland Area Fence Project and $36,000 will be used for the Pine Canyon Watershed/Big Game Habitat Enhancement Project. All operation, maintenance and management practices related to these projects will be implemented by the participants. All planned practices are on schedule and will be fully implemented by the end of November 1995.

The BLM is aggressively pursuing additional funding for improvements. The recent successful brush management and grass seeding on the Narrows allotment has contributed greatly to this increased interest. The Forest Service is also pursuing funding for vegetative improvements as well.

FY 1996
(EPA 319 funds = $150,000, Matching funds = $205,600, Other Federal funds = $152,000)

The proposal submitted for FY96 funding requested $209,400 of 319 funds. However, due to the shortage of 319 funds available at this time, and by the decision of the State TAC, the amount requested in the final FY 1996 PIP was for $150,000. These funds are planned to be used to implement the following:

Tasks Planned (96):
Irrigated & meadow pasture:
1. Pasture seeding - 580 acres
2. Fencing - 6,750 feet
3. Watering facilities - 3 livestock & wildlife watering facilities

Critical range treatment:
4. Brush management - 1,120 acres
5. Seeding - 1,120 acres
6. Fencing - 21,120 feet on rangeland
7. Watering facilities - 2 livestock & wildlife watering facilities
8. Erosion control - 2 erosion control structures

Range condition improvement:
9. Brush management - 2,200 acres
10. Range seeding - 2,200 acres
11. Fencing - 11,00 feet
12. Watering facilities - 2 livestock & wildlife watering facilities

Vegetative Stream bank Stabilization/Riparian Area
13. Stream bank stabilization - 6,070 feet
14. Fencing - 20,000 feet
15. Watering facilities - 2 livestock & wildlife watering facilities
16. Channel Stabilization - 4 stream channel structures
17. Other bank stabilization - 1010 feet

Contract & Tracking and Record Keeping
18. Contract and tracking
19. Record keeping

Tasks Completed (96):
18. Contract & Tracking - $2405.29

Six additional Conservation Plans of Operation (CPOs) have been planned with land owners and need $236,900 of 319 funding. Four more prospective participants have requested planning assistance and are waiting for CPO development. All funding has been allocated to projects and the remaining projects will be completed in the near future.

Transfer of FY 1995 funding from Little Bear River to Otter Creek Watershed.

EPA authorized a transfer of $80,000 of 319 funds from the FY95 Little Bear River (LBR) allocation to the Otter Creek/Koosharem Watershed. This $80,000 was returned to the LBR Watershed from 319 funds that were allocated to Utah in FY96. In addition, $70,000 was awarded from the FY96 319 Proposal request for Little Bear River.

FY 1997 FUNDING
(EPA 319 funds = $75,000, other federal funds available = $152,000, state & local matching funds required = $50,000)

Tasks Planned (97):
Critical Range Treatment
1. Brush management - 500 acres
2. Seeding rangeland - 500 acres
3. Fencing - 2 miles
4. Watering facility- livestock & wildlife - 1 each

Range Condition Improvement
5. Brush management - 1,000 acres
6. Rangeland seeding - 1,000 acres
7. Fencing - 1 mile
8. Watering facility- livestock & wildlife - 1 each

Contract and tracking
9. Contracting & tracking

Tasks Completed (97):
Funding has not been received at this date.

FY 1998 FUNDING REQUESTED
(EPA 319 funds = $75,000, potential other federal funds = $ 133,500, state and local matching funds required = $50,000)

Task Planned (98):
Irrigated and Meadow Pasture Practices:
1. Riparian pasture planting - 250 acres
2. Fencing - 1.5 miles
3. Pipeline for livestock water - 200 feet
4. Water trough - 1 each

Critical Range Treatment
5. Brush mgmt. - 320 acres

6. Range seeding - 320 acres
7. Fencing - 3 miles

Range Condition Improvement
8. Brush management - 275 acres
9. Range seeding - 275 acres

Streambank Protection
10. Critical area planting - 1320 feet (1.5 acres)
11. Vegetative protection - 5280 feet

Contract and Tracking
12. Contract and tracking

Continuation Plan:
This 1998 Continuation Plan will remain the same as the 1997 Continuation Plan except for the budget section. That will shows the current 1998 budget items that will be implemented using fiscal 98 funds.

OTHER FEDERAL FUNDING:
Bureau of Land Management (BLM):

FY 1993	Seed and drilling	=	$ 50,000
	Tech Assist	=	11,400
	Total	=	$ 61,400
FY 1994	Tech Assist	=	$ 60,000
FY 1995	Disking & seed	=	$ 50,000
	Tech Asst	=	29,000
	Total	=	$ 79,000
FY 1996	Seed & drilling	=	$ 45,000
	Tech Asst	=	40,000
	Total	=	$ 85,000

Forest Service (USFS):

Prior to 1994.	None		
FY 1994	Technical Assistance	=	$ 96,000
FY 1995	Technical Assistance	=	$ 96,000
FY 1996	Technical Assistance	=	$ 96,000
Total		=	$288.000

Farm Services Administration (FSA):

ACP funding	=	$359,000 for FY 91 - FY 93
WQIP funding	=	$ 94,700 for FY 92 - FY 94
HUA funding	=	$339,701 for FY 91 - FY 93
Total	=	$793,401

Natural Resources Conservation Service (NRCS):

HUA funding	=	$1,013,000 for FY 91 - FY 96
Regular CO-O1 funding	=	$ 56,000 for FY 92 - FY 96
Total	=	$1,069,000

Cooperative Extension Service (CES):

HUA I&E funding	=	$180,000 for FY 91 - FY 95

OTHER funding:

UDA ARDL(State Loan)	=	$163,280 for FY 92 - FY 95
Rocky Mountain Elk Foundation	=	$ 45,000 FY 93 - FY 96
Utah DWR	=	$ 41,500 FY 94 - FY 96
Utah DWR (Tech Asst.)	=	$ 14,000 FY 96
Total	=	$263,780

REFERENCES

U.S. Natural Resource Conservation Service and Utah Department of Agriculture. 1993 Coordinated Resource Management Plan for Otter Creek Wateshed.

U.S. Natural Resource Conservation Service and Utah Department of Agriculture. 1993-1998. Continuation PIP for Otter Creek Watershed.

CHAPTER FOUR: METHODOLOGY

Substrate Particle Size Distribution

Streambank destabilization and erosion can increase the amount of fine sediment on stream substrates. Such increases in substrate can impair aquatic food production and salmonid survival (Bauer, 1994). The fine sediments can cover spawning substrates and block intragravel oxygen delivery to developing salmonid embryos. The proportion of fine sediments on the substrate surface of a stream provides a good estimate of substrate habitat quality for salmonids. Fines that reduce embryo survival and impede emergence have been defined as particles less than 6.4 mm (Torquemada and Platts, 1988). The substrate particle size distribution for Otter Creek was determined using the methodology suggested by Wolman (1954).

Pebble counts are a systematic method of sampling the material on the surface of the stream bed. At the selected transects for each reach, the pace method was used to obtain a minimum of 100 pebble measurements. To obtain 100 counts in four crossings, the stream width is estimated and divided by 25 to obtain the distance between samples[1]. The observer paces the transect and collects a substrate pebble by reaching to the tip of the boot and extending the index finger and selecting the first particle touched by the finger. The observer must look up to prevent bias in the selection of the particle. Fines thinly coating the surfaces of larger gravels, pebbles and boulders are not counted in the tally.

[1] Departure from this approach was used at the Angle reach. Here 100 particles were sampled within the reach, but were not tied to a permanent transect.

The particles intermediate axis is measured and the size is tallied according the size classes given in Table . The intermediate diameter is found by observing the longest diameter, and then the shortest diameter of the particle. The intermediate diameter should be found perpendicular to these axes. The intermediate diameter is the axis which would allow the particle to fall through a sieve as it was agitated on the upper sieve surface (Bauer, 1994). A minimum of 100 particles are sampled, measured and tallied and recorded with the site and transect location, observer(s), and date.

The tallies for each particle size class are summed and a cumulative distribution determined. The distribution is plotted as semi-logarithmic with the y-axis the particles size class and the x-axis the cumulative percent finer for the class. The d_{50} particle size (particle size corresponding to 50 percent on the x-axis) and the percent fines less than 6 mm are determined from the plot and recorded.

Table 4.1 Classification of bed material by particle size (from MacDonald, 1991)

Class name	size (mm)	size (in.)
silt/clay	less - .062	less - .0025
very fine sand	.062 - .125	.0025 - .005
fine sand	.125 - .25	.005 - .01
medium sand	.25 - .50	.01 - .02
coarse sand	.50 - 1.0	.02 - .04
very coarse sand	1.0 - 2.0	.04 - .08
very fine gravel	2.0 - 4.0	.08 - .16
fine gravel	4.0 - 6.0	.16 - .24
	6.0 - 8.0	.24 - .31
medium gravel	8.0 - 12	.31 - .47
	12 - 16	.47 - .63
coarse gravel	16 - 24	.63 - .94
	24 - 32	.94 - 1.26
very coarse gravel	32 - 48	1.26 - 1.9
	48 - 64	1.9 - 2.5
small cobble	64 - 96	2.5 - 3.8
	96 - 128	3.8 - 5.0
large cobble	128 - 192	5.0 - 7.6
	192 - 256	7.6 - 10
small boulder	256 - 384	10 - 15
	384 - 512	15 - 20
medium boulder	512 - 1024	20 - 40
large boulder	1024 - 2048	40 - 80
very large boulder	2048 - 4096	80 - 160

Stream Shade and Temperature

Riparian vegetation functions to control the amount of solar radiation reaching the stream and therefore, largely determines the potential for elevating stream temperatures. Increased water temperatures can adversely affect salmonid growth rates and survival, increase primary production in the stream and reduce dissolved oxygen values.

Canopy Density

During the field studies of 1993-1998 conducted in Otter Creek, Little Bear River, Beaver River, and Mill Creek, data was collected for selected reaches for canopy density and solar input to the stream surface. Canopy density data was collected using a spherical canopy densiometer (convex) after a protocol suggested by Platts, et. al. (1987). The densiometer consists of a convex mirror surface with etched grid (37 intersections) that reflects vegetation and other obstructions above the stream channel. Due to the curved reflecting surface, the observed area at any given point will result in an overlap of observed area. Modifications suggested by Strichler (1959) were adopted which reduces the observed grid intersections in any of four cardinal directions to 17. A right angle is taped on the mirror to define the 17 intersection points.

At each permanent transect, readings were taken at four points along the line transect: 1) at left and right streambanks, 12 " from water surface and 12" from shoreline; 2) at stream center facing upstream and 3) at stream center facing downstream. The densiometer is held away from the observer with the bottom of the taped V pointed to the observer (Figures 4.2, 4.3). The observers head reflection should almost touch the top of the gridline and the densiometer is leveled using the bubble level on the instrument. The number of intersections that are intercepted by vegetation is counted and recorded for each of the four readings.

The points intercepted for each reading are totaled and multiplied by 1.5 to estimate canopy density. The average of all density measurements for the reach are averaged to obtain the percent canopy density for the reach. A correction factor of 1% is deducted from scores between 30 and 65 percent, and 2% is deducted for scores greater than 66 % to determine the reach mean canopy density in percent. No correction is necessary for scores between 0 and 29%.

Solar Pathfinder™

Thermal input to the water column is a function of the percent of stream surface shaded by riparian vegetation or topography, the average stream width, the orientation of the stream relative to the angle of sunlight, and the vertical angle of the sun's rays as influenced by latitude, time of day and time of year. To estimate the thermal input to the stream for the study reaches, a Solar Pathfinder™ was used at each of the permanent transects. The methodology is described by Platts, et. al. (1987). The solar pathfinder records all obstacles providing shade and these can be compared with future measurement of shade to document change. The solar pathfinder measurements were taken at stream midpoint for each transect.

The solar pathfinder is used by observing the reflected image of the surrounding obstacles

Figure 4.2 The concave spherical densiometer Model B (Platts, 1987).

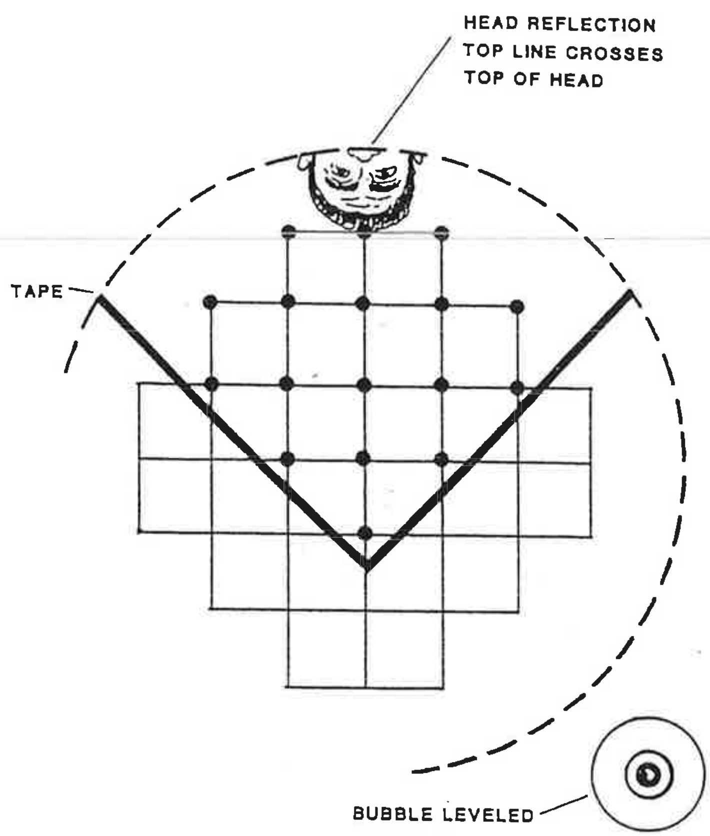

Figure 4.3 Densiometer with placement of head reflection (Platts, 1987).

relative to monthly horizontal sunpath diagrams (Figures 4.4, 4.5). The observation is made by looking directly down into the dome of the instrument. The appropriate sunpath diagram is inserted into the operating face of the instrument. The sunpath diagrams have been prepared to correspond to the latitude requirements of the selected study area. For Otter Creek, the Little Bear River, and Mill Creek, a diagram for latitude 37 - 43 degree N. was used. The instrument is oriented to true south, in contrast to magnetic south. The declination for the study area is obtained from a U.S.G.S. topographic quadrangle and the sunpath diagram is adjusted for this angle. The instrument is leveled using the bubble level within the base support and the south seeking compass needle is pointed directly at the south reference point. The observation is made by viewing the reflected image between 12 and 18 inches from the dome and within 10 to 15 degrees of vertical.

The boundary between the unobstructed sky and all intercepting objects that appear on the horizon is observed or traced on the diagram. The sunpath for the month of August was used for this study because high solar angles and low stream flows present the highest potential for stream temperature increases. The average percentage of monthly total radiation that will fall on the selected area is taken directly from the diagram by summing the unshaded ½ hour values on the diagram or subtracting the shaded values from 100. This value is recorded with the reach identification and transect label. The reach mean solar radiation percentage is obtained by averaging the values for all transects in the reach.

Stream Bank Angle

Removal of streambank/riparian vegetation along with mechanical bank damage reduces the structural stability of the stream channel with several resultant negative impacts to fish productivity (Platts, 1990). Undercut banks provide valuable habitat and are a good indicator of general channel condition. Channel cross-section data collection techniques can artificially mask the presence/absence of undercut bank features. Measuring the channel-bank angle is effective for monitoring land uses that can change the morphology and relative location of the streambank (Platts, et. al., 1987). Additionally streambank vertical profiles and bank erosion pins, referenced to permanent monuments, can be monitored through time to detect rates of lateral migration and bank loss.

Bank angle measurements were taken at each (left and right) bank on the permanent channel cross-section transects. The measurement is taken by using a clinometer and rod to measure the angle formed by the downward sloping streambank as it meets the more horizontal streambank (Platts, et. al., 1987). An undercut streambank angle will be less than 90 degrees. For undercut banks, the angle is determined directly from the clinometer placed on the top of the rod as it forms the angle determined by the protruding edge of the bank to the midpoint of the dominant undercut along the transect. For banks with no undercut, the angle is greater than 90 degrees, and is measured with the clinometer and rod aligned parallel to the streambank along the transect. That reading is subtracted from 180 degrees to obtain the bank angle. Platts (1987) reports good year-to-year precision and accuracy and narrow confidence limits (95% C.I., +/- 4.4 %) with this method. The bank angle is recorded with the site, transect and left/right bank designations.

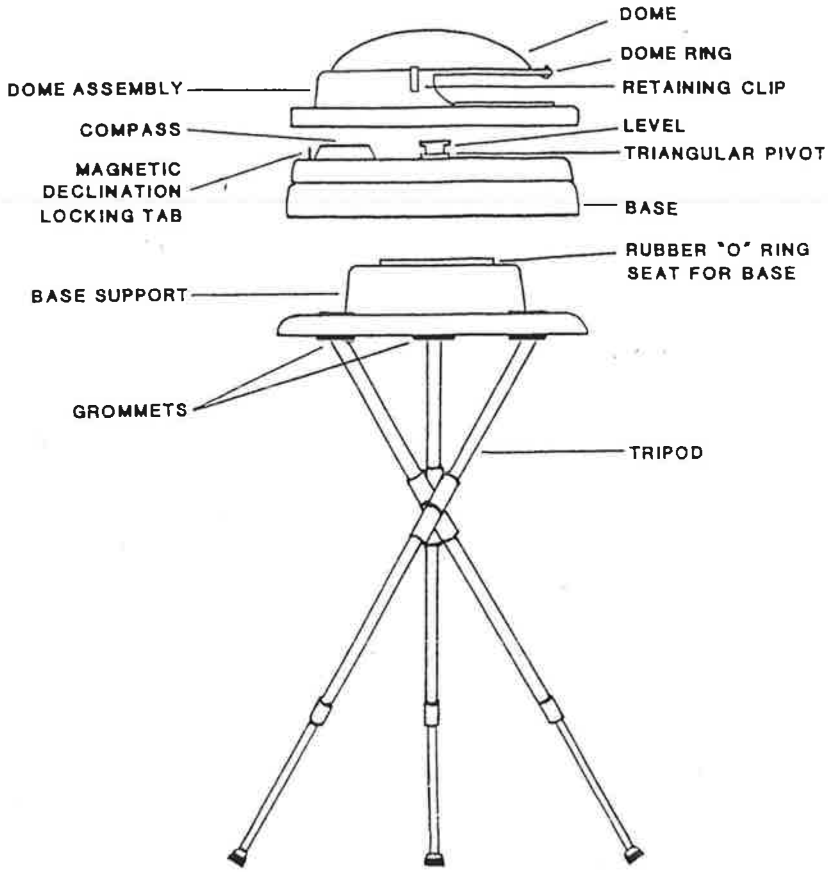

Figure 4.4 Schematic drawing of the Solar PathfinderTM (Platts, 1987).

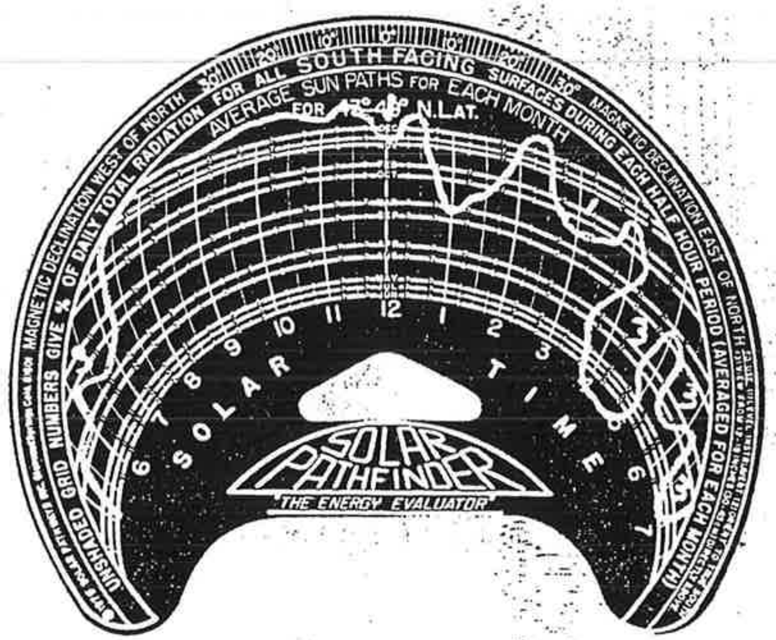

Figure 4.5 Solar Pathfinder angle estimator graph and sky obstacle border.

Photopoints

Photographs generally were taken at each permanent geomorphic transect. A 35 mm camera fitted with a 28 mm lens was used for each photograph with color transparency film. Film canisters were labeled at film changes and noted in the field log. At each transect, photographs were taken of the transect line from the appropriate bank(s) and upstream and downstream from the channel greenline. Photographs were also taken of the transect from upstream and/or downstream. Where topography allowed ridge photographs were taken of the reach or reach segments. A photolog for all photographs documents each slide location, date, and view perspective. Slides are on file at the Division of Water Quality.

Riparian Vegetation Survey

Riparian vegetation is evaluated according to standard operating procedures (SOP) for monitoring and evaluation of riparian vegetation developed by the Work Group. This includes three to seven vegetation cross-section transections, one to three green-line transections, and a woody vegetation transection along each green-line transection. Along each transection, the number of feet of each vegetation community is recorded. The transections are totaled and the percent of each vegetation community is computed. Riparian vegetation communities are classified using the riparian classification system developed by Petersen and Sennett (1996). This is a hierarchical classification system that was developed for the Utah Riparian Management Coalition.

Photo points are established at each end of each cross-section and green-line transection. At each end of a green-line transection, a photo is taken of the green-line along each bank. At the intersection of each cross-section and the stream, a photo is taken from each bank of the opposite bank.

Channel Geomorphology Survey

Monitoring geomorphic trend over time was done by establishing permanent benchmarks and channel cross sections at each reach (Harrelson, et al). Benchmark monuments are steel rods (mine roof bolts or ½ inch rebar) set in concrete, which are often used as the right or left endpoint of a transect and were located outside the channel on a terrace. In the case where monuments were not used as transect endpoints, rebar was used for the right and left pins. These transects were documented by a compass bearing from the monument. Survey data was collected with a laser level (1993), a Sokkia total station (1995-98) and data logger, line tape, and stadia rod. The total station instrument was set up over a known point, either a monument or rebar pin, with a backsight taken to a second known point to establish the location in the same coordinate plane as previous year(s).

The reach was defined by one full meander length or 20 bankfull channel widths. Within the reach, cross sections were selected to include a pool and "cross-over" feature to develop the at-a-station channel geometry. The cross sections were set perpendicular to the direction of stream flow (Harrelson, et al.).

A minimum of five cross sections were surveyed by starting at the upstream-most transect on the right bank (looking downstream) progressing to the left bank. A fiberglass tape was stretched horizontally across the channel and topographic features such as terraces, slope breaks, floodplains, cut banks, bankfull, water surfaces, thalweg, and channel bars were measured along each cross section. Longitudinal profiles were surveyed to collect channel bed/thalweg elevation, water surface slope, and bankfull indicators. Profiles started at the top of the reach section, or a the upstream-most transect, and continued downstream at least to the downstream-most transect in the reach.

Evaluating Bankfull

As part of the channel geometry and longitudinal profile data, bankfull indicators were surveyed. As defined by Dunne and Leopold, bankfull stage occurs when the water fills the channel completely or its surface is level with the floodplain. The crew used the following bankfull indicators (Dunne and Leopold, 1978) and (Harrelson, et. al. 1995).

1. Elevation of topographic breaks from vertical bank to flat floodplain.
2. Slope breaks from steep bank to gentle slopes.
3. Change in vegetation characteristics.
4. Change in substrate texture of deposited material (clay to sand, sand to pebbles)
5. Highest elevation below which no fine debris of leaves, needles, occur; sometimes it is the upper limit of this fine debris.
6. Undercuts in the bank, which usually reach an interior elevation just below bankfull stage.

Finding bankfull indicators varies among stream types, and can be difficult in recently disturbed streams or areas where floodplains are poorly defined. Identifying this attribute using several of the criteria above, and other surrogate indicators, was discussed at length among the survey crew members. Bankfull measurements were taken at the cross sections, and down the right and left banks as measurements of the longitudinal profile.

Fish Population Survey

Trout population parameters were evaluated according to standard operating procedures (SOP) developed and approved for such purpose.

The procedure requires identifying and measuring 1/10 th of a mile (530 feet) of stream reach within the study site. The reach included pool, riffle, run, and glide habitat types. Reach length varied due stream size, flow, and habitat types. Electrofishing work was done during low flow, which occurs in Utah streams from mid-August to mid-October. Subsequent year sampling was done within a comparable two week calendar time frame.

Two pass depletion sampling (Zippon, 1958) was done using a backpack shocker or canoe rigged shocker to adequately provide data to determine standing crop, species composition and age structure. Block nets were set at the top of the reach, and the first pass was done starting at the downstream end walking upstream. The same procedure was repeated for the second pass upon reaching 70% depletion. A third pass was recommended if the 70% depletion rate was not attained on the second pass. Each pass was conducted under the same amount of time and effort. Fish were kept separate by corresponding passes, and removed from the survey area until all electrofishing passes were completed. During the sampling period, captured fish were kept in live wells away from the sampling area.

For each pass, fish were identified, weighed, and measured. At a minimum, one hundred fish of each species should be measured if more than that many individuals are collected. A total and separate count of all fish from each pass was tallied. Fish were returned to the stream in the area of their capture.

Habitat Quality Index

A habitat quality index (HQI) was developed for each study reach by. Eleven aquatic habitat attributes were measured according to the SOP described in Binns (1982). These attributes provide an evaluation of the existing stream reach potential for supporting trout. A summation of these measurements, when compared with an electrofishing survey, provide a comparison between the predicted standing crop (lbs/acre) of trout to actual standing crop (lbs/acre).

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CHAPTER FIVE: STUDY REACHES AND DESIGN

Introduction

Three study reaches were selected for study in the watershed. These are referred to as Otter Creek at Angle, Otter Creek above Narrows-Treated, and Otter Creek above Narrows-Untreated. Study layout for each reach consists of permanently monumented transects for the collection of data and location of photopoints. Five cross-section transects were established on the three sites. Transects were established on riffles, runs and pools for each reach. It should be noted that transect G-0, at the Untreated reach, bisects two river meanders and resulted in three channel cross-sections. Habitat Quality Index (HQI) and riparian vegetation surveys (Greenline) are referenced to the permanent transects. Substrate counts (Wolman method), bank angles, solar input and canopy density measurements are also tied to the transect locations. Photos were taken at each of the transects and a series of reach overview photos were taken from the ridge to the north and west at the Treated and Untreated reaches. Opportunity for ridge photographs was not possible for the Angle location.

OTTER CREEK AT ANGLE SITE

Site location

Specific site location directions are as follows:

Otter Creek at Angle: South of Koosharem City, approximately 17 ½ miles on Utah State Highway 62, you will come to a road sign indicating the village of Angle. Go one mile east on this oil road until you come to the creek. There is a gate on the south side of the road that gives you access to the west side of Otter Creek. The creek flows through a large culvert at this location. The westbank G-0 monument pin is located approximately 25 yards south of the road on the west side of the stream near the top of the high bank.

Study Site Description

Otter Creek at Angle (Figure 5.1) is located in T. 29 S., R. 2 W., section 36 (U.S.G.S. Angle quadrangle), just upstream from Otter Creek Reservoir (elevation 6380 ft). The Angle project is in mid-implementation stage with some channel work completed.

The Angle project is located at a small (30-50) head dairy with cropping of hay and small grains. The channel reach has been dredged three times since the construction of Otter Creek Reservoir in the late 30's. The last dredging occurred in 1984. Cattle have historically had access to the entire channel reach. The project implementation includes reconstruction of channel geometry, establishment of permanent pasture, riparian vegetation enhancement, and off-channel water supply.

In 1990, the land owner straightened approximately 3800 feet of Otter Creek below the bridge at Angle. This action resulted in an extremely unstable channel with severe streambank and channel erosion Livestock had season long access to the stream and riparian vegetation was over grazed and in poor ecological condition. The milk barn and holding corrals were located on a shallow water table area just west of the stream. Dairy cows in one of the holding corrals had direct access to the stream. Drainage from the corrals flowed directly in to the stream. Riparian vegetation was very sparse with no woody vegetation on the stream banks.

In 1992, the landowners, with technical assistance from NRCS and financial assistance from USDA and EPA, installed meanders and approximately 3300 feet of streambank protection. Willows were planted, but success was poor because of low water table conditions and lack of adequate protection from grazing. Stock water was developed and the corral that was closest to the stream and drained directly into the stream was fenced to eliminate direct access of livestock to the stream. Ten acres of pasture along the stream was planted to improved pasture . The land owner is currently working on a plan that will include moving the dairy barn and corrals away from the stream, implementing a comprehensive nutrient management system, and reclaiming the old barn site.

Practices that have been installed in the watershed affecting this monitoring site include: 10,360 acres of brush management and range seeding, 23 miles of fencing,, three (3) stock water developments, 27,250 feet of livestock/wildlife water pipeline, 10 troughs, and prescribed grazing on 96,060 acres.

These practices have resulted in a reduction of approximately 12,740 tons/year of soil loss from upland erosion and 500 tons/year of soil loss from streambank erosion above this site. This results in a reduction of about 3,000 tons/year of sediment passing through the monitoring site.

OTTER CREEK ABOVE NARROWS (Treated) SITE

Site Location

Specific site location directions are as follows:

Otter Creek above Narrows - Treated: Approximately 10 1/4 miles south of Koosharem City, on Utah State Highway 62, there is an unimproved trail on the east side of the highway. Immediately after turning off the highway at this point there is a leveled off area that is used by the Utah Department of Transportation for occasional stockpiling of gravel. The unimproved trail continues on past this leveled out area approximately 200 yards down to a gate. After proceeding through the gate one should immediately turn right and follow closely to the fence line, for 100 yards, until you reach the creek. The rightbank G-99 monument pin is about 15 yards to the left of the fence and of similar distance north of the creek.

Study Site Description

Otter Creek above Narrows-Treated project reach (Figure 5.3) is located in T. 28 S., R. 1 W., section 19 immediately downstream of the Untreated reach (elevation 6660 ft). The Treated reach data is preproject data (baseline) with BMP implementation scheduled for 1994 (Figure 5.4).

The land owner has 480 acres of private land that is located along Otter Creek. The BLM South Narrows Allotment surrounds this private land. Historically, the area has been utilized by cattle and sheep. Prior to treatment, 95 percent of the actual grazing use within this grazing allotment were obtained from the private lands along the stream. The season of use has been November through December and April 15 to June 15 with 75 head of cattle. Grazing use of the riparian area was heavy and the riparian vegetation was in an early seral state. Stream banks were eroding excessively.

In 1992, a conservation plan was developed for the South Narrows Allotment, which includes the private lands along the stream. Implementation of the plan began in the fall of 1992. To date, the following BMP's have been installed on the private lands along the stream: fencing to divide the area into three (3) riparian pastures; and 295 acres of brush management and range seeding. The following practices have been installed on the BLM administered land in the allotment: 2100 acres of brush management and range seeding; five (5) miles of fence to divide the rangeland into three (3) pastures; stock water pipeline and troughs; and 1320 feet of streambank protection. With these practices in place, a rest-rotation grazing system will now be implemented on this allotment.

Practices installed in the watershed affecting this monitoring site include: 8,000 acres of brush management and range seeding, 23 miles of fencing,, three (3) stock water developments, 27,250 feet of livestock/wildlife water pipeline, 10 troughs, and prescribed grazing on 69,660 acres.

These practices have resulted in a reduction of approximately 9,000 tons/year of soil loss from upland erosion and 400 tons/year of soil loss from streambank erosion above this site. This results in a reduction of about 2,400 tons/year of sediment passing through the monitoring site.

OTTER CREEK ABOVE NARROWS (Un-treated) SITE

Site Location

Specific site location directions are as follows:

Otter Creek above Narrows - Untreated: Approximately 10 miles south of Koosharem City, on Utah State Highway 62, there will be an unimproved trail on the east side of the highway. This trail goes a short distance and then forks. To reach the site take the right fork until the trail is right adjacent to the barbwire fence. The study reach is located just over the ridge to the east. One must walk to the site from the fence line as vehicular access is not available. The rightbank G-0 monument pin is located near the base of the rock cliff at his location.

Study Site Description

The third reach, Otter Creek above Narrows-Untreated reach (Figure 5.3), is located in T. 28 S., R. 1 W., section 20 (U.S.G.S Parker Knoll Quadrangle) and is considered to be an untreated management reach for data analysis. Figure 5.5 illustrates the study reach. The site elevation is 6660 feet.

The land owner has 200 acres of private land that is located along Otter Creek to the north of the Treated property. Prior to about 1989, this riparian area was used for spring grazing from April to June. Grazing use of the riparian area was heavy and the riparian vegetation was in an early seral state. Stream banks were eroding excessively. In about 1989, the season of use was changed to winter grazing from December to February and the grazing use has been moderate to heavy. Although there had been some improvement, the riparian vegetation was still in an early seral state when monitoring began in 1993. No additional changes in grazing management have been implemented since the season of use change in about 1989.

Practices installed in the watershed affecting this monitoring site include: approximately 8,000 acres of brush management and range seeding, 18 miles of fencing, stock water developments, and prescribed grazing on 54,830 acres.

These practices have resulted in a reduction of approximately 9,000 tons/year of soil loss from upland erosion and 400 tons/year of soil loss from streambank erosion above this site. This results in a reduction of about 2,400 tons/year of sediment passing through the monitoring site.

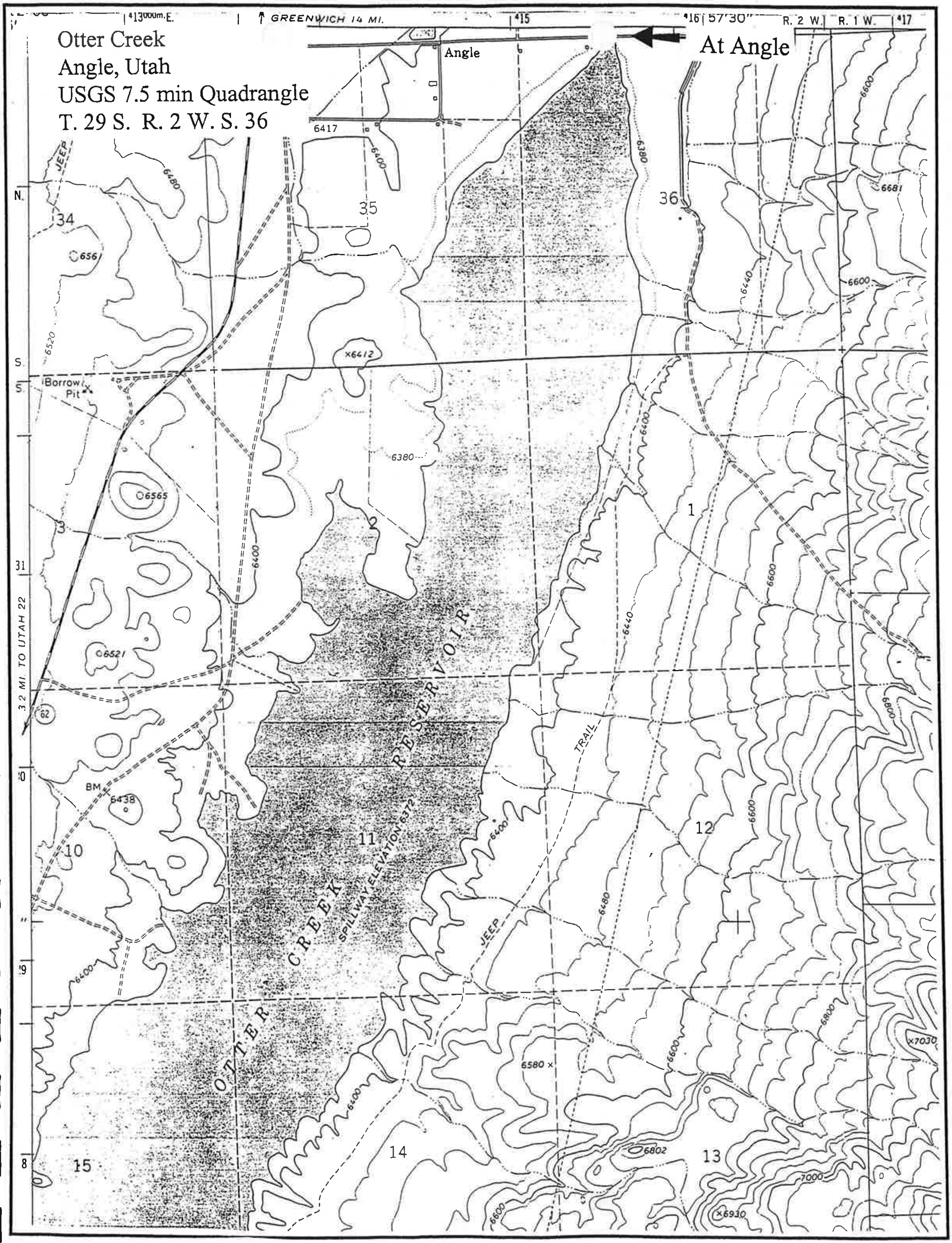

Figure 5.1 Otter Creek at Angle

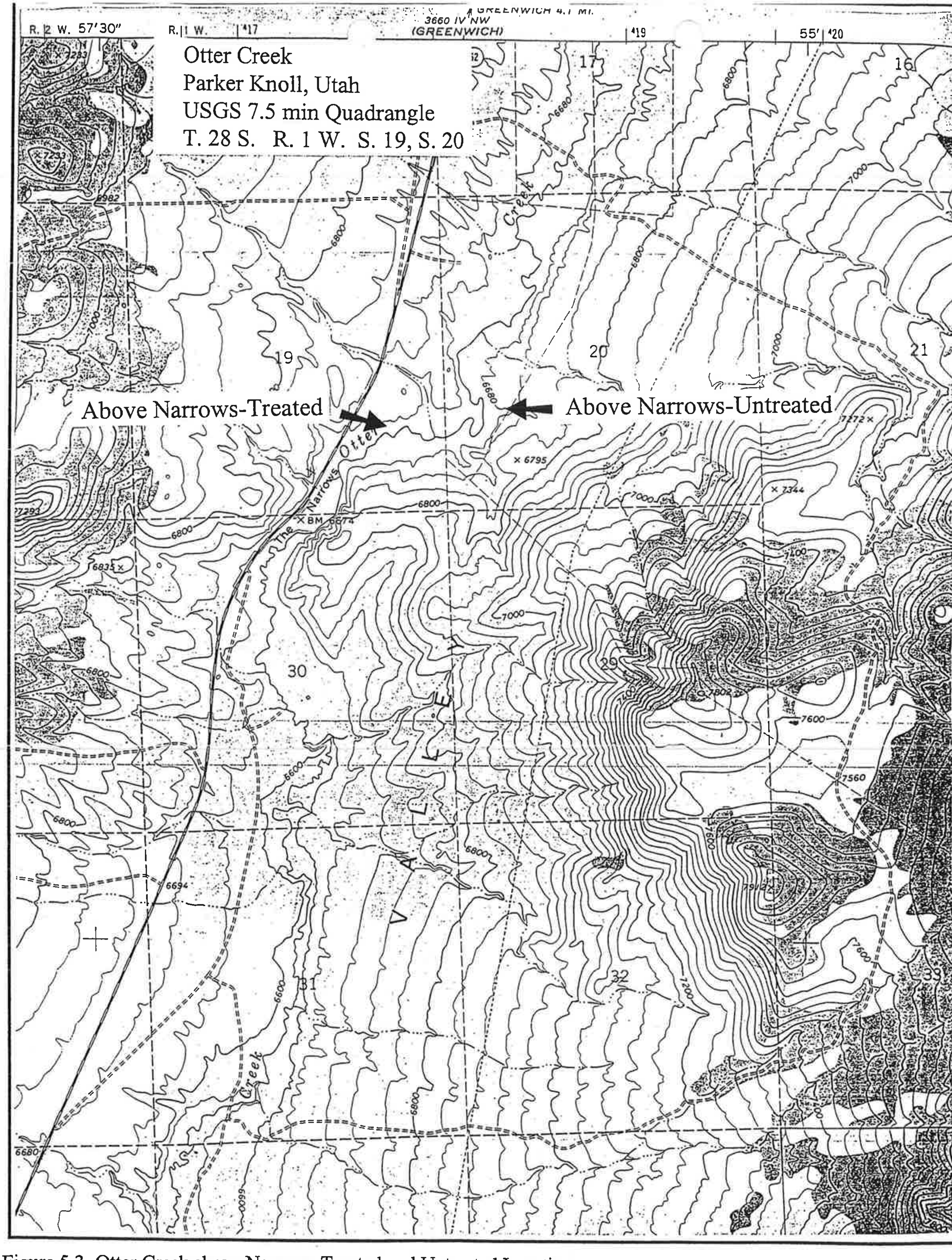

Figure 5.3 Otter Creek above Narrows-Treated and Untreated Locations.

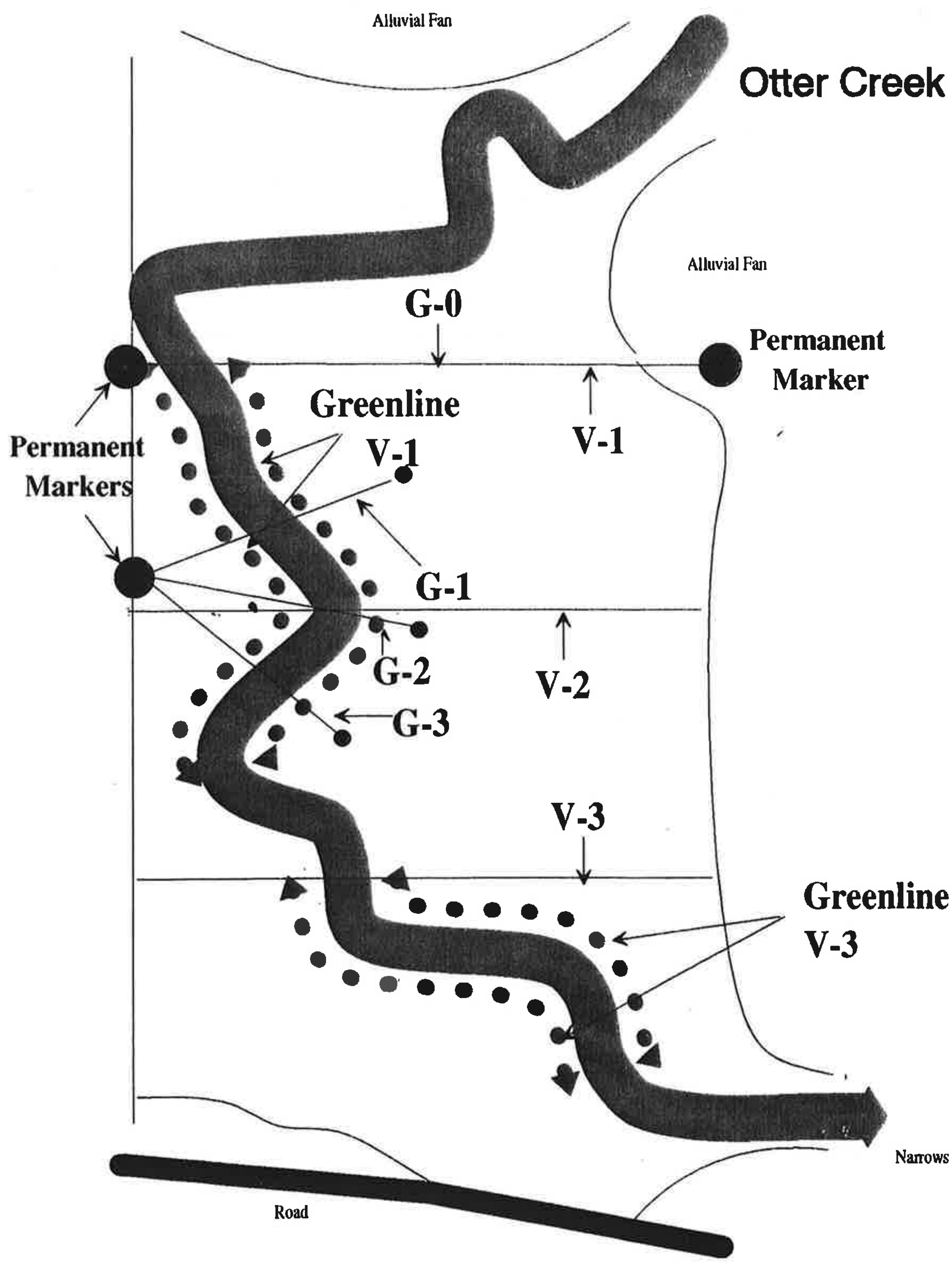

Figure 5.4 Above Narrows-Treated Study Reach Diagram.

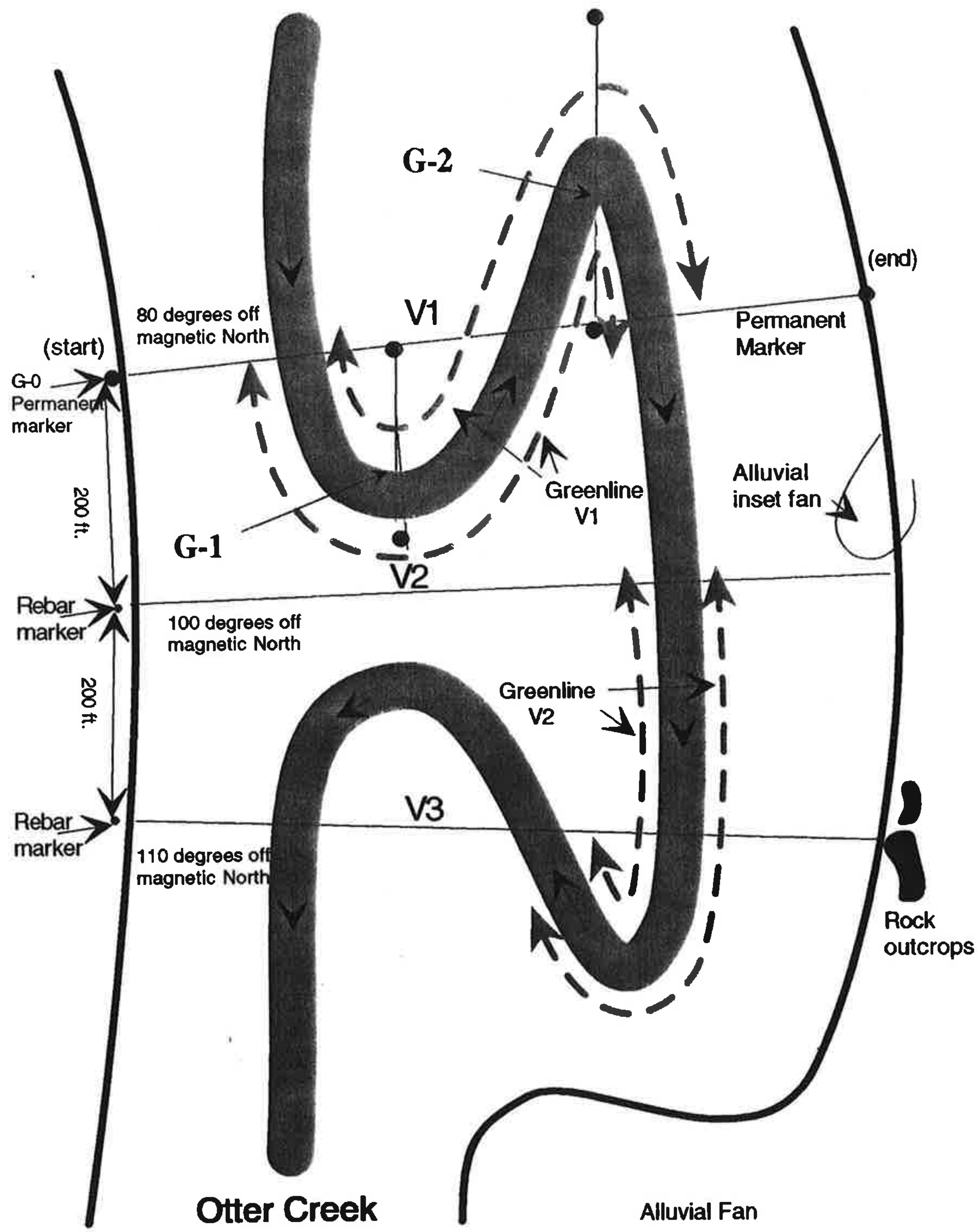

Figure 5.5 Above Narrows-Untreated Study Reach Diagram.

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Monitoring Report
NPS Interagency Monitoring Workgroup
CHAPTER SIX: CHANNEL GEOMORPHOLOGY
Otter Creek Watershed

Introduction

The NPS Interagency Monitoring Workgroup conducted a field study on three reaches of Otter Creek, Piute County, Utah in August 1993, 1994, 1995, and 1998. As part of these monitoring studies, channel geomorphology data was collected by surveying permanent channel cross sections and longitudinal profiles. In 1993 a laser level and tape were used, and in subsequent years a Total Digital Station and data logger were used to survey topographical features of the transects.

The Angle reach represents a site that had mechanical alterations made to the stream; at the Above Narrows-Treated location, grazing strategies were the main focus of the treatment; and at the Above Narrows-Untreated site, there was no specific agency/cooperative management strategy implemented. The management practices for each site are described in detail in Chapter Five: Study Reach and Design.

The channel survey is used to characterize physical attributes of the stream. Through repeated measurements, changes can be observed over time. Permanent benchmarks and cross sections were established at each reach to ensure a long-term monitoring effort. The objective was to measure a baseline of existing physical condition and monitor the trends of the physical characteristics with implemented management practices. (Harrelson, et. al. 1996).

Otter Creek at Angle

Summary

1. The planview of the survey is given in Figure 6.1.

2. Channel cross sections for transects G0-G4 are plotted in Figures 6.2-6.26. For each transect, the first plot compares the cross section geometry on a single graph. The second page shows the cross section in a four plot series from 1993 through 1998. These plots demonstrate channel narrowing and point bar building at G0, G2, and G3.

3. The longitudinal profiles for all four years are plotted in Figures 6.27-6.30. The water surface slopes and bed slopes are included with the graphs.

4. Width to depth ratios at bankfull have decreased over time. Table 6.1 shows the values measured at each transect.

Table 6.1 Width to Depth Ratios

	1993	1994	1995	1998
G0	42	32	38	7
G1	34	66	48	19
G2	26	12	21	6
G3	---	---	34	34
G4	---	36	62	12

Otter Creek above Narrows-Treated

Summary

1. The planview of the survey is given in Figure 6.31.

2. Channel cross sections for transects G99-G3 are plotted in Figures 6.32-6.36. For each transect the plot compares the cross section geometry for all the years on a composite graph. There was no significant channel change observed at the Treated reach. Transect G99 was added in 1994 and is located upstream of G0.

3. The longitudinal profiles for all four years are plotted in Figures 6.37-6.40. The water surface slopes and bed slopes are included with the graphs.

4. Width to depth ratios at bankfull have not changed significantly over time. Table 6.2 shows the values measured at each transect.

Table 6.2 Width to Depth Ratios

	1993	1994	1995	1998
G99	---	---	9	10
G0	11	13	13	13
G1	7	9	7	7
G2	---	7	8	9
G3	---	17	44	18

Otter Creek above Narrows-Untreated

Summary

1. The planview of the survey is given in Figure 6.41.

2. Channel cross sections for transects G0a, b, c, G1 and G2 are plotted in Figures 6.42-6.47. The composite plots compare the cross section geometry for each transect for all years. There was no significant channel change observed at the Treated reach.

3. The longitudinal profiles for all four years are plotted in Figures 6.48-6.51. The water surface slopes and bed slopes are included with the graphs.

4. Width to depth ratios at bankfull have not changed significantly over time. Table 6.3 shows the values measured at each transect.

Table 6.3 Width to Depth Ratios

	1993	1994	1995	1998
G0a	---	17	12	14
G0b	---	14	12	14
G0c	---	13	13	13
G1	---	14	17	15
G2	---	14	15	12

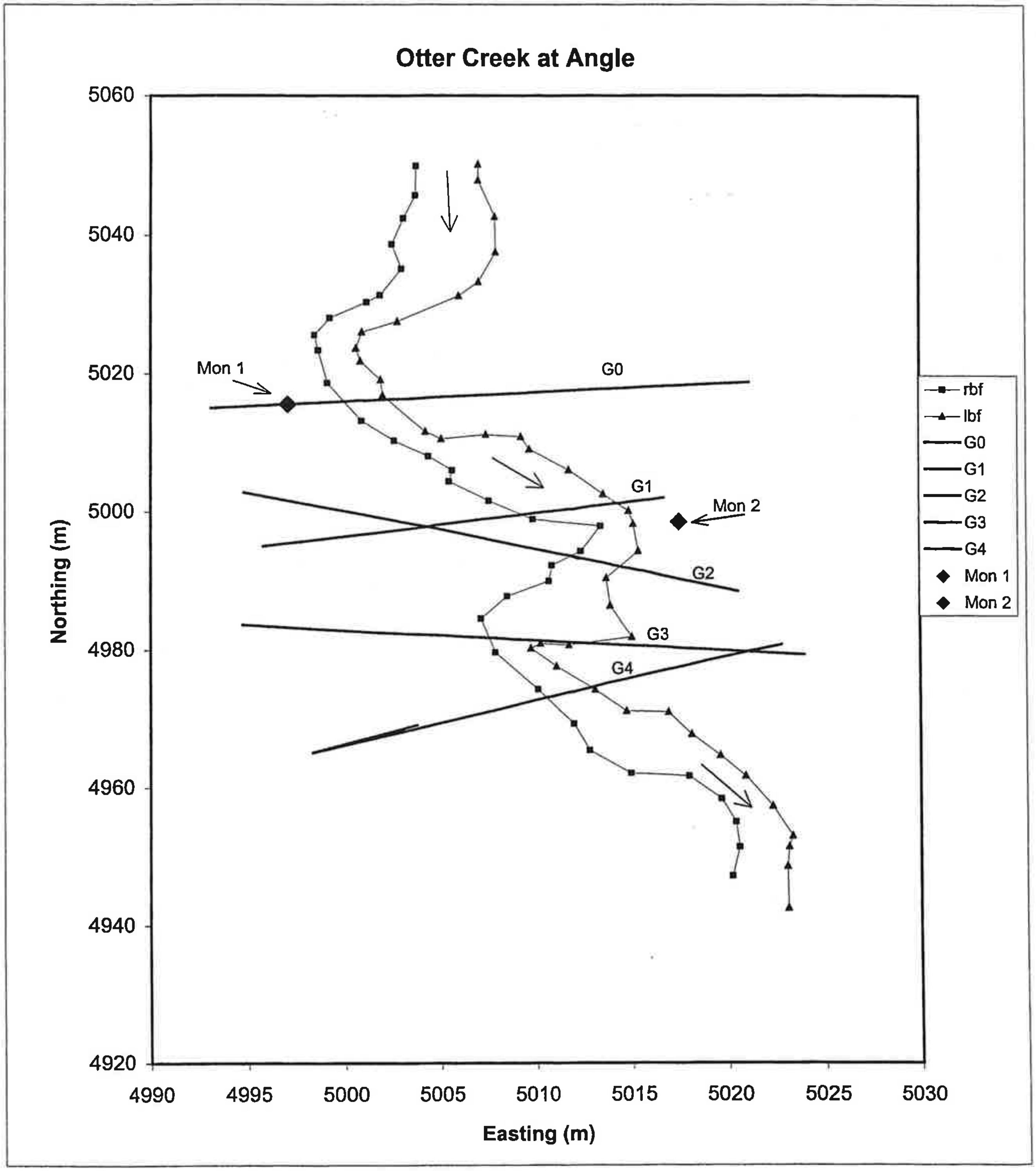


Figure 6.1 Otter Creek at Angle.

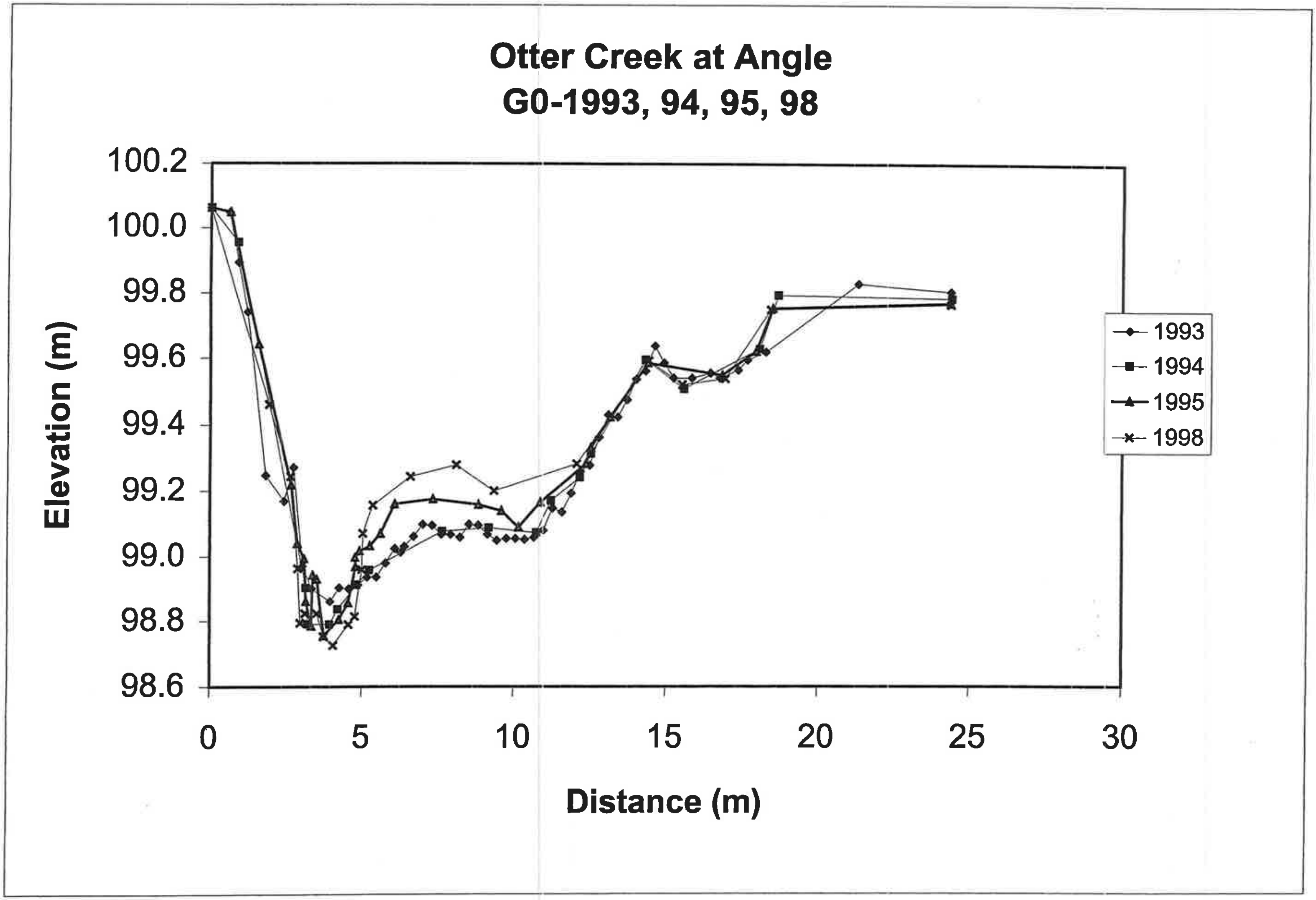


Figure 6.2 Composite graph of G0, 1993-98.

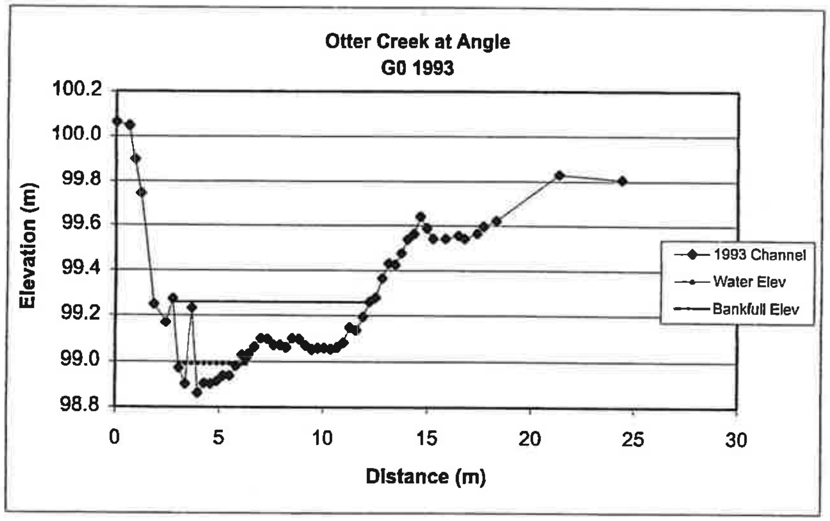


Figure 6.3 G0 1993.

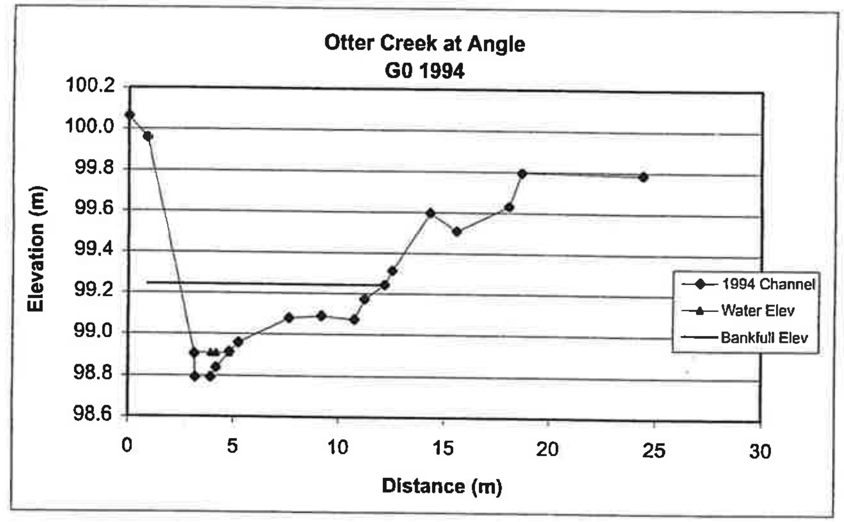


Figure 6.4 G0 1994.

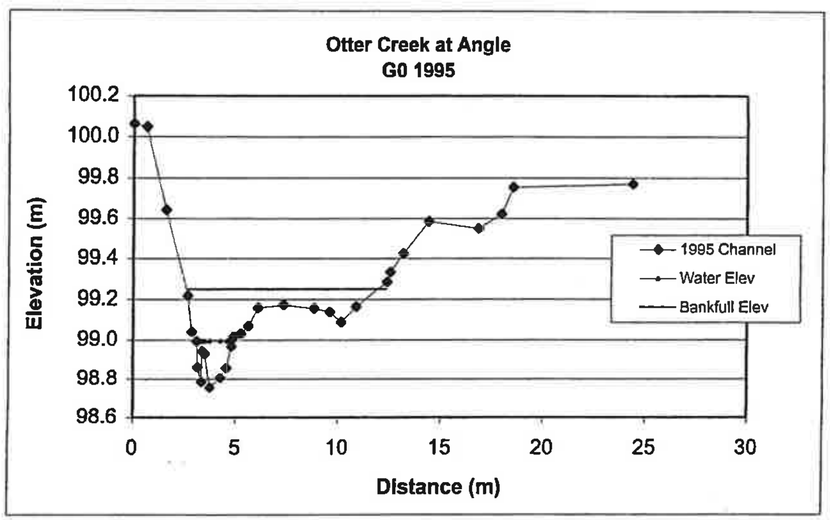


Figure 6.5 G0 1995.

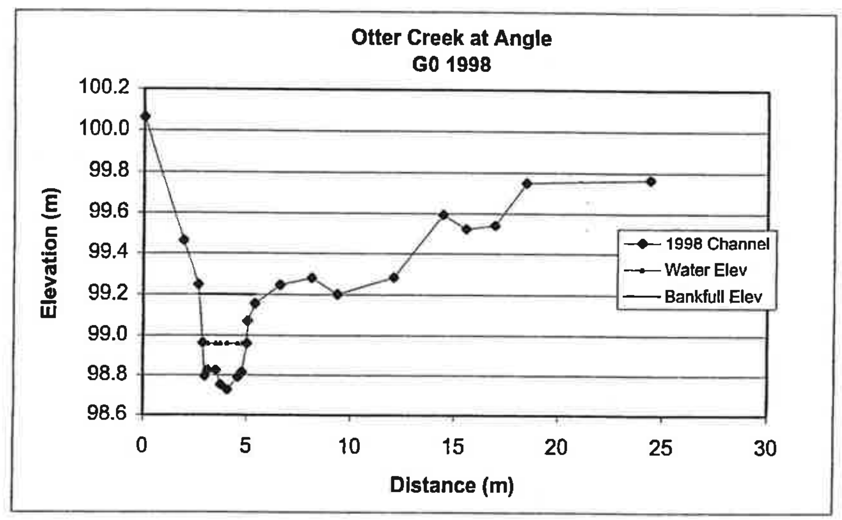


Figure 6.6 G0 1998.

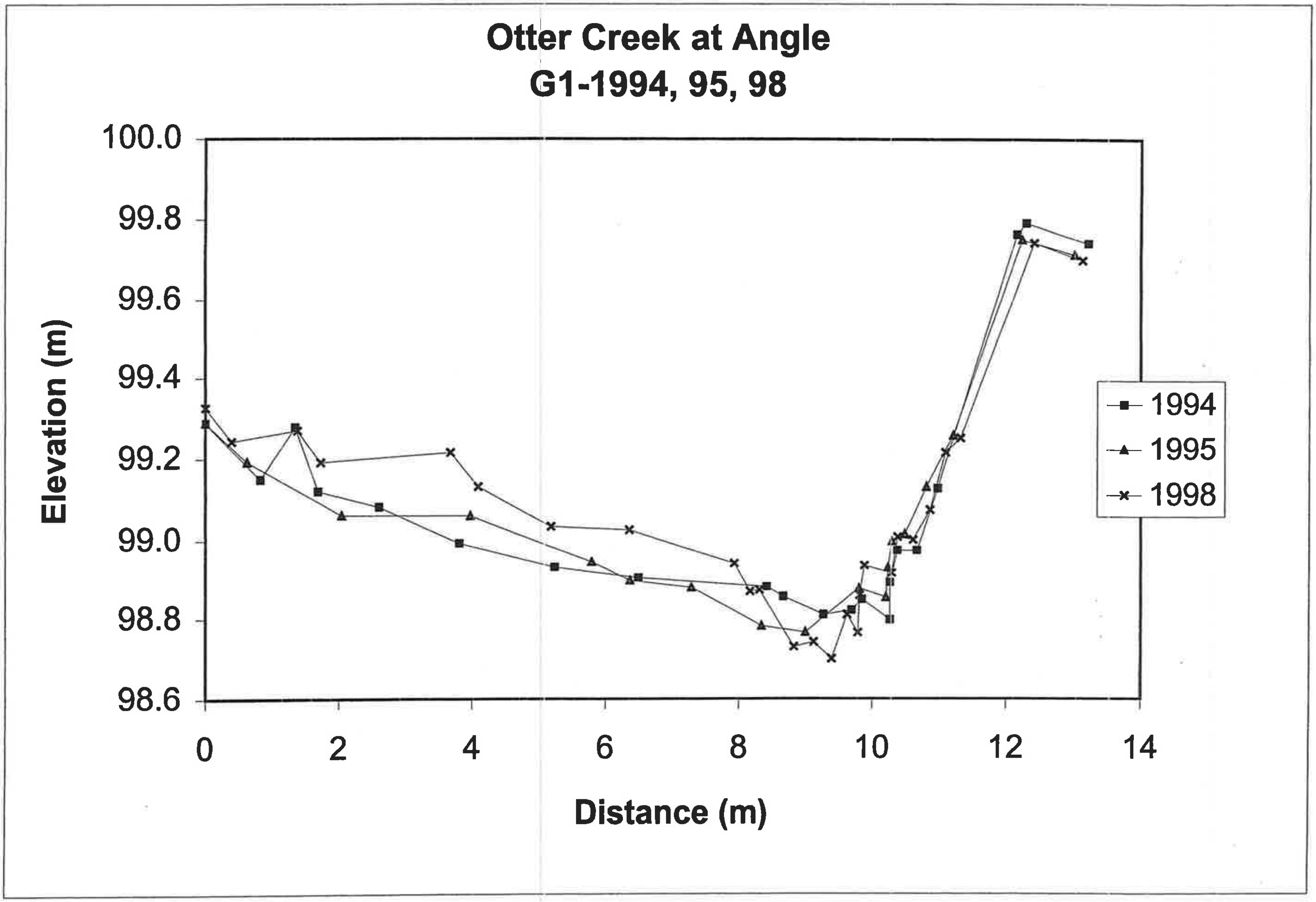


Figure 6.7 Composite graph of G1, 1994-98.

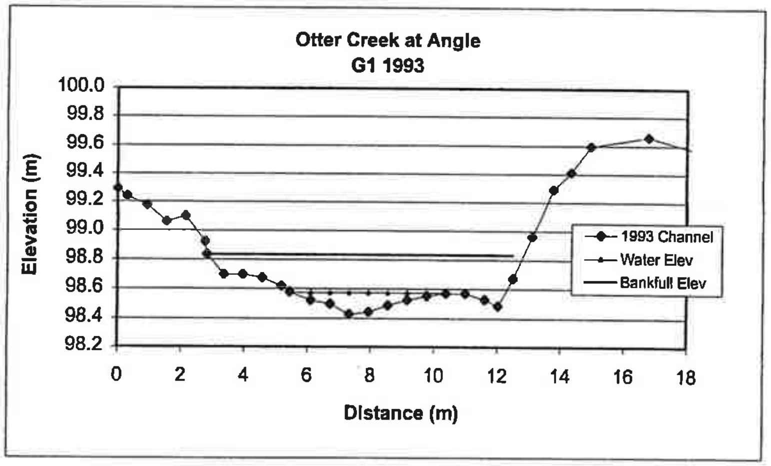


Figure 6.8 G1 1993.

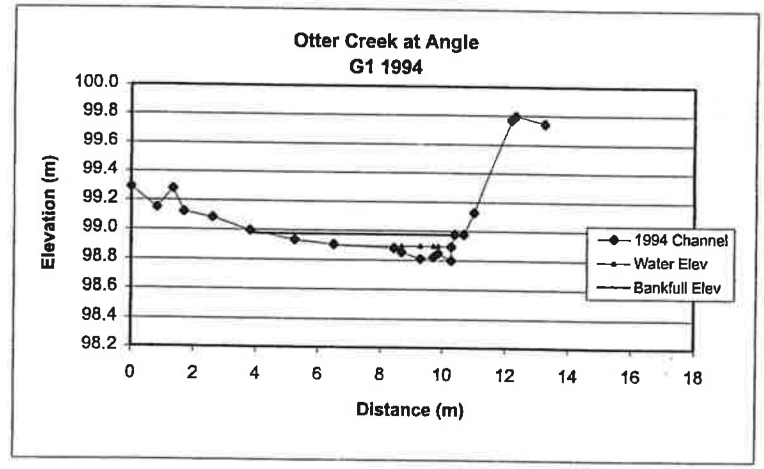


Figure 6.9 G1 1994.

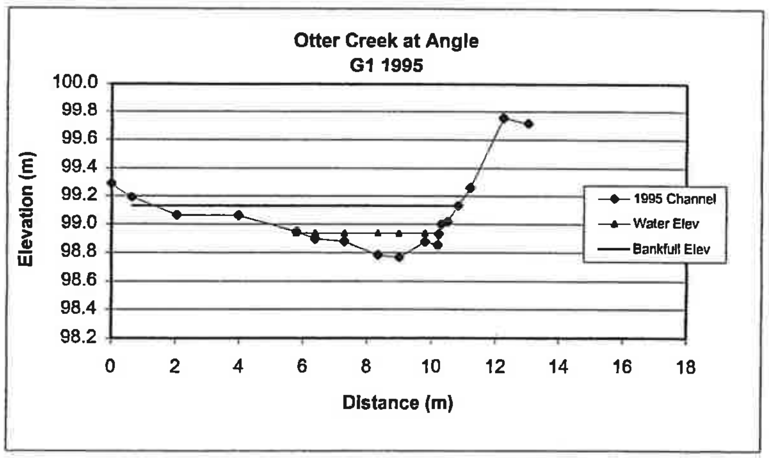


Figure 6.10 G1 1995.

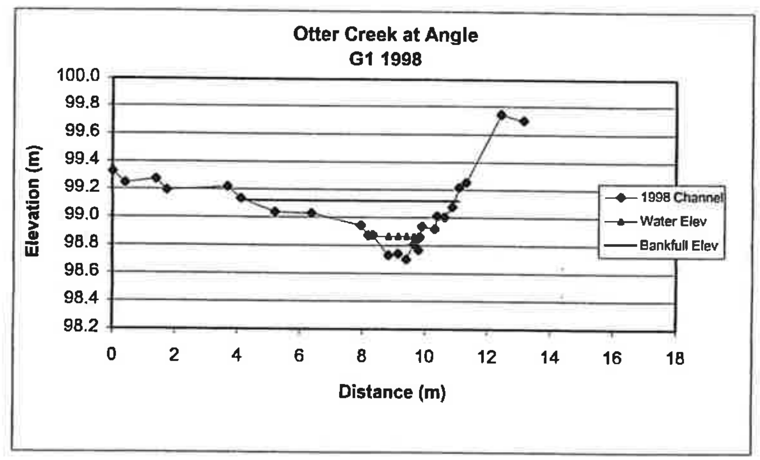


Figure 6.11 G1 1998.

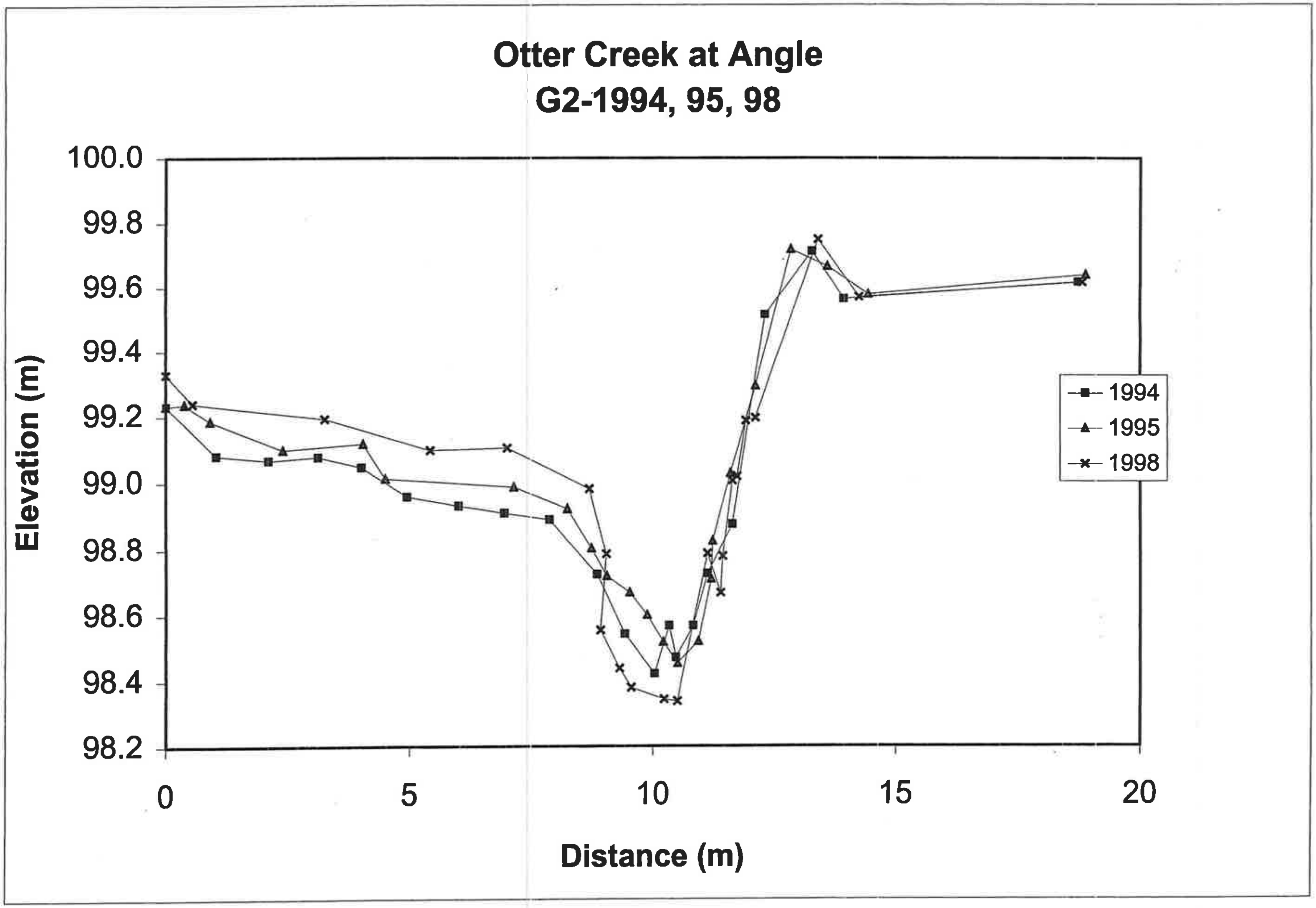


Figure 6.12 Composite graph of G2, 1994-98.

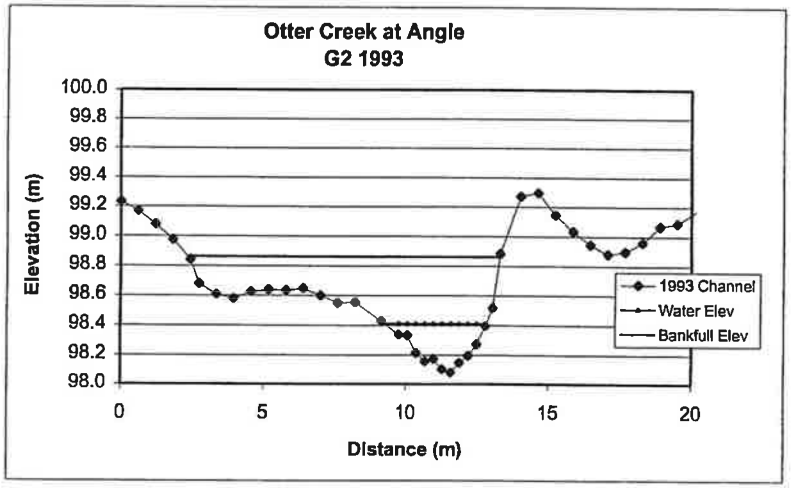


Figure 6.13 G2 1993.

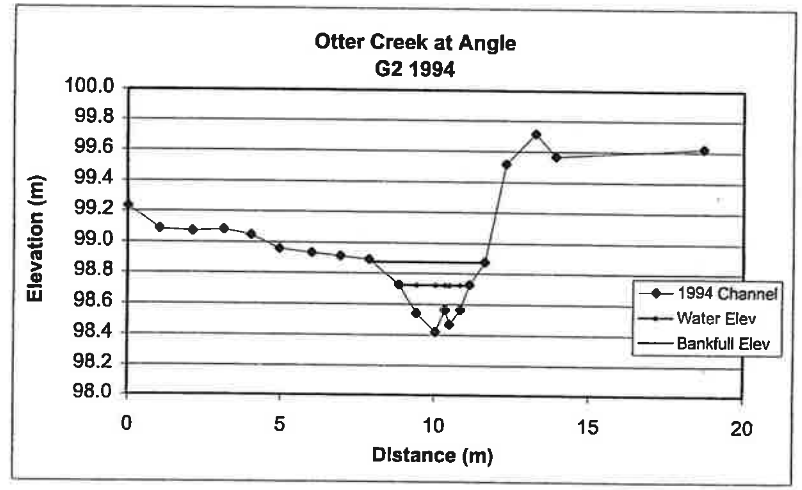


Figure 6.14 G2 1994.

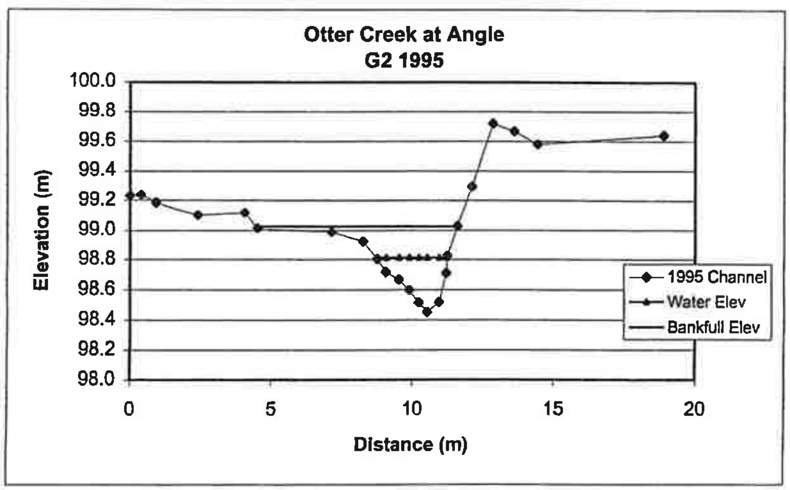


Figure 6.15 G2 1995.

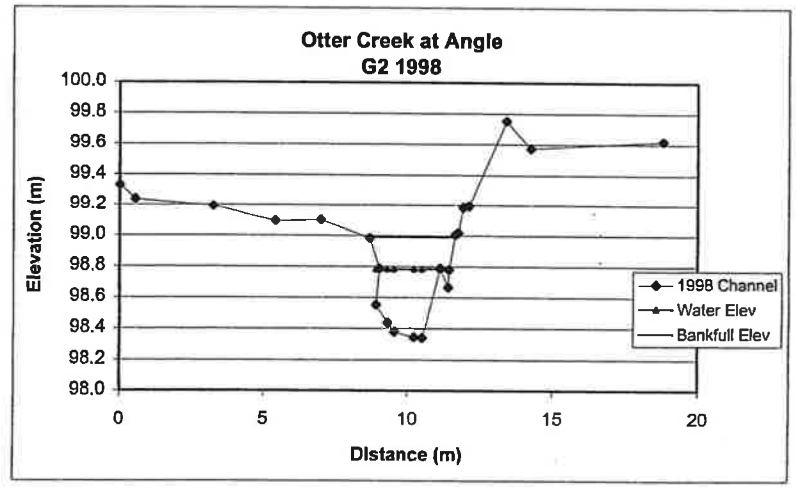


Figure 6.16 G2 1998.

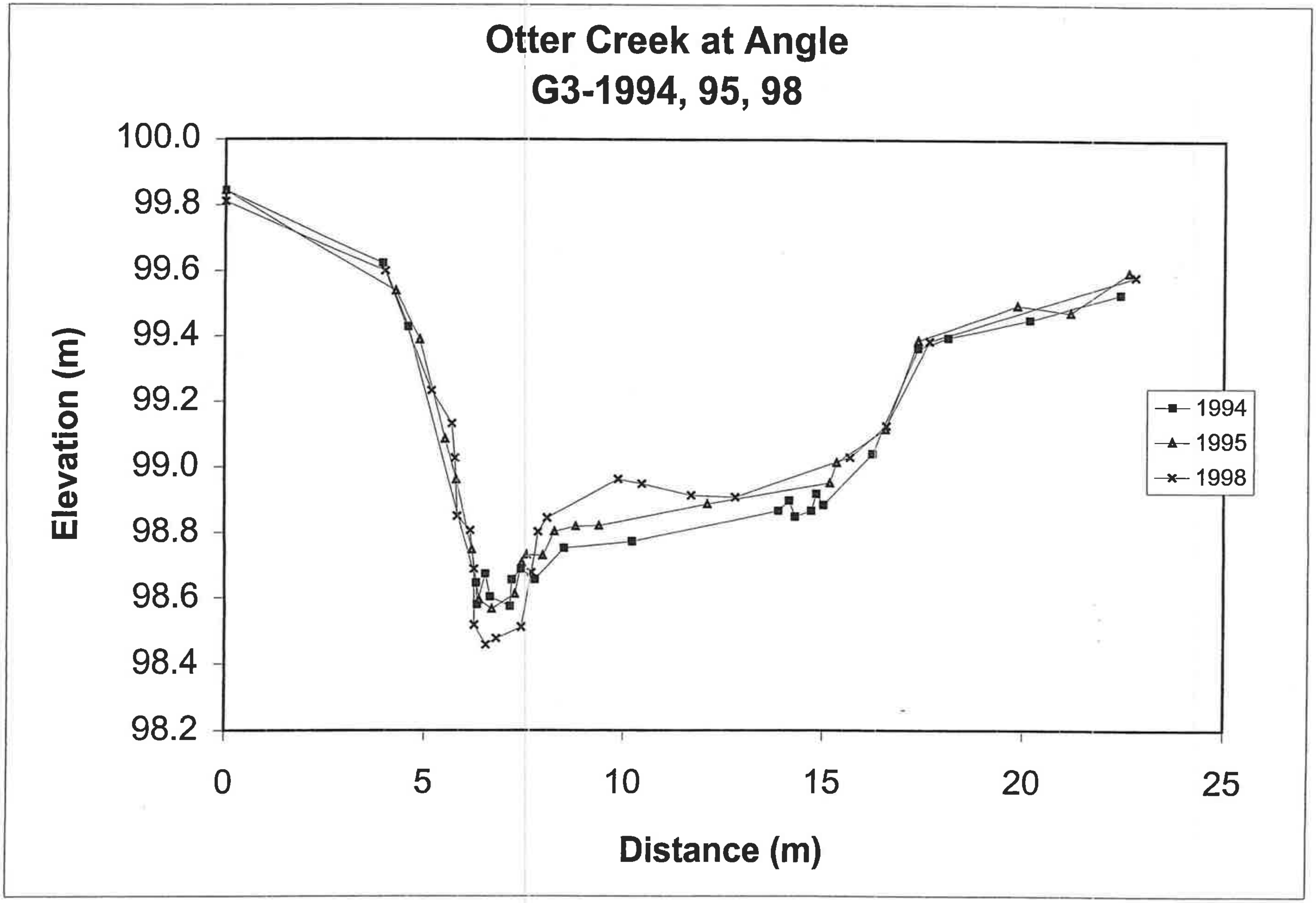


Figure 6.17 Composite graph of G3, 1994-98.

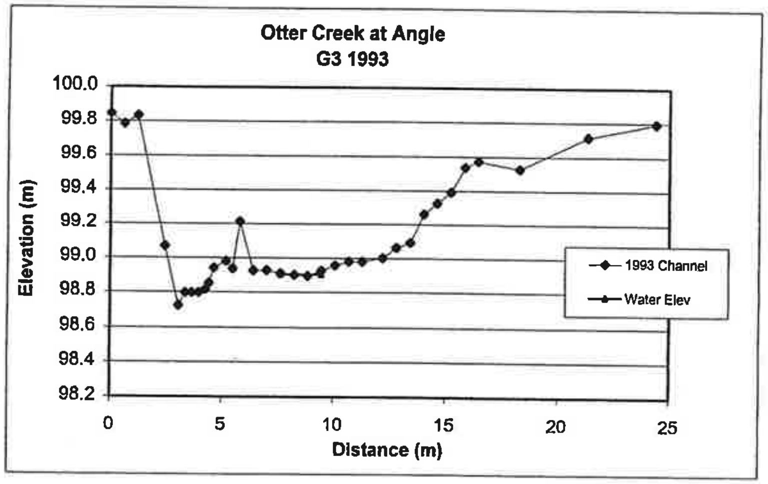
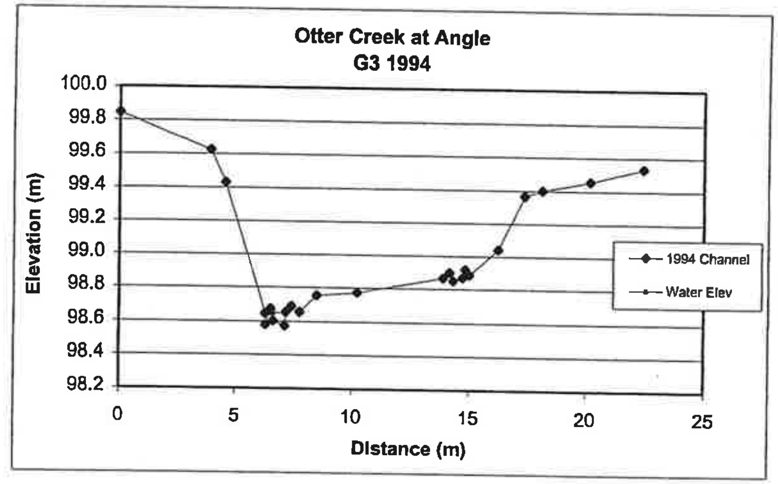


Figure 6.18 G3 1993.



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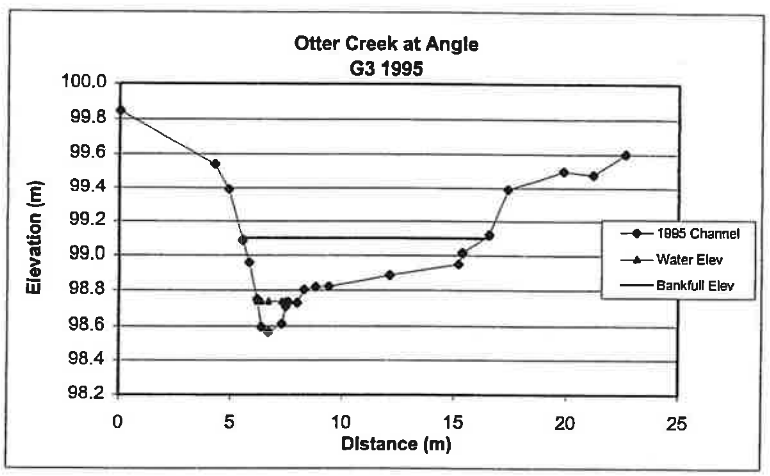


Figure 6.20 G3 1995.

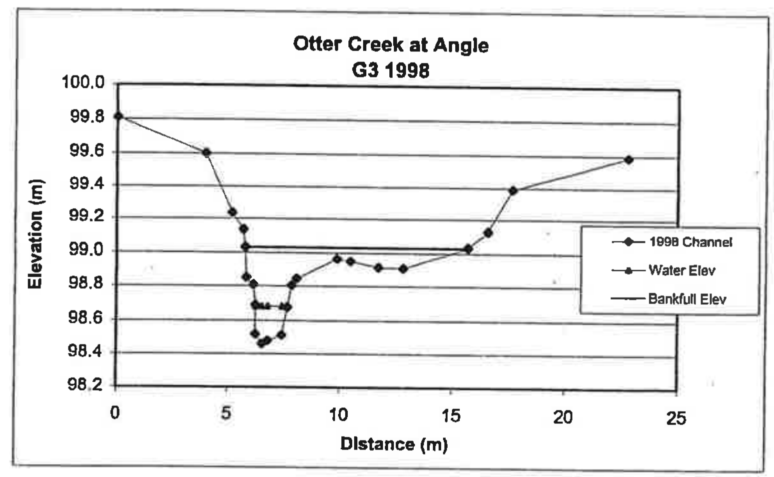


Figure 6.21 G3 1998.

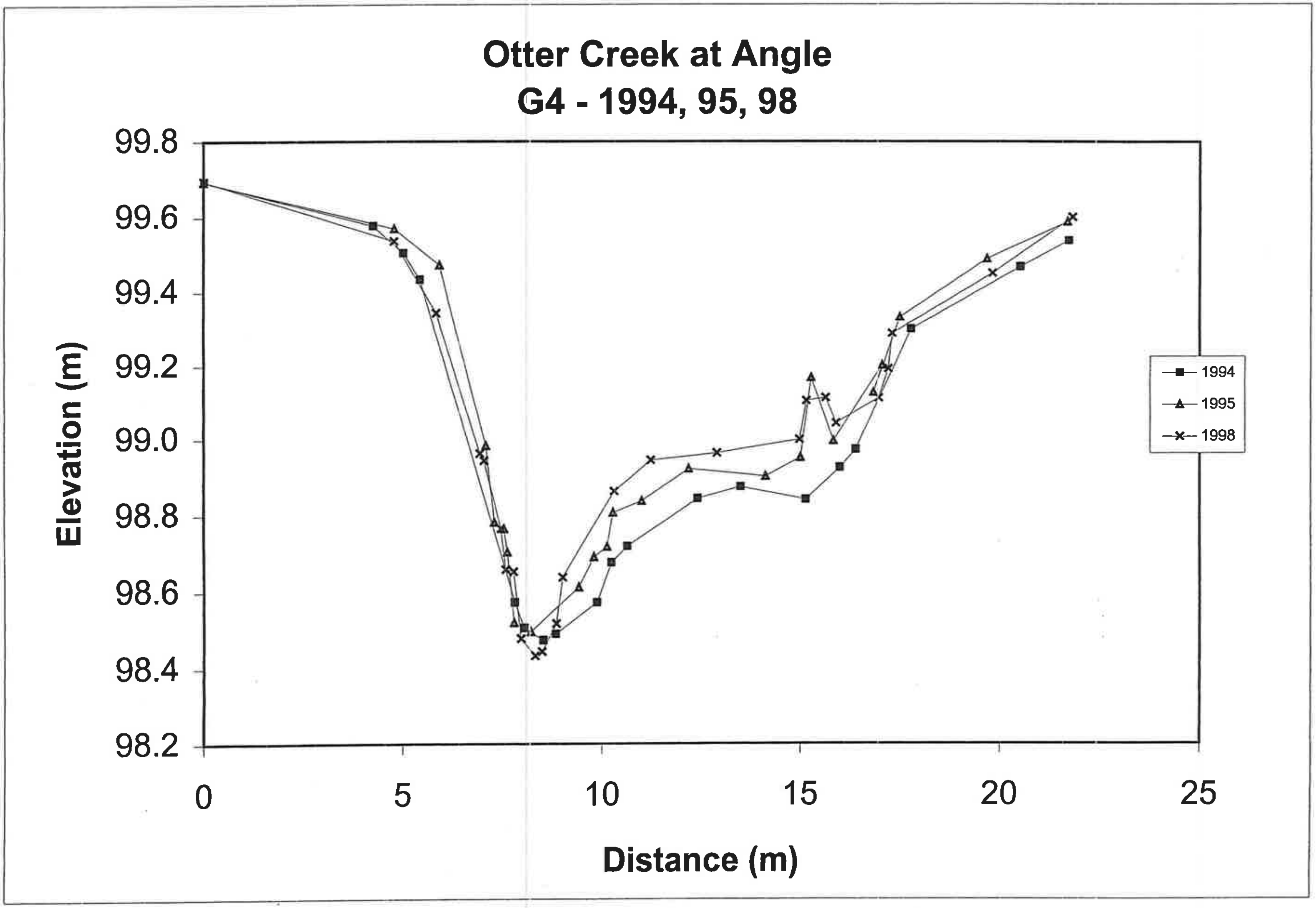


Figure 6.22 Composite graph of G4, 1994-98.

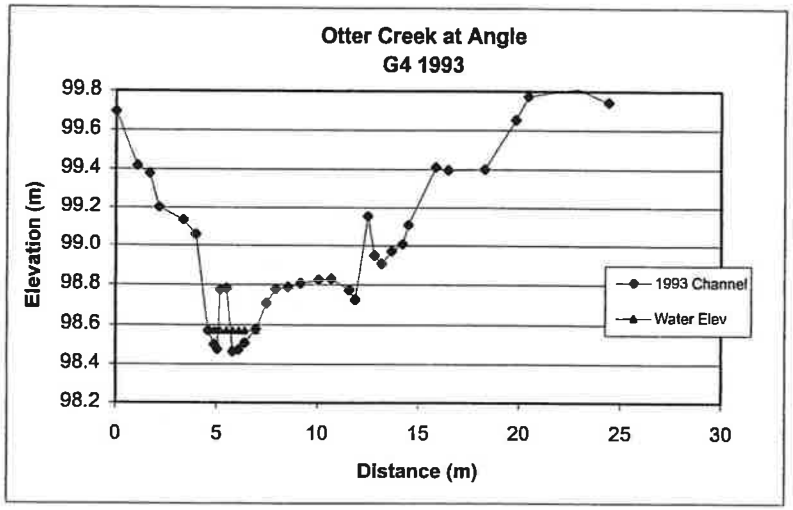


Figure 6.23 G4 1993.

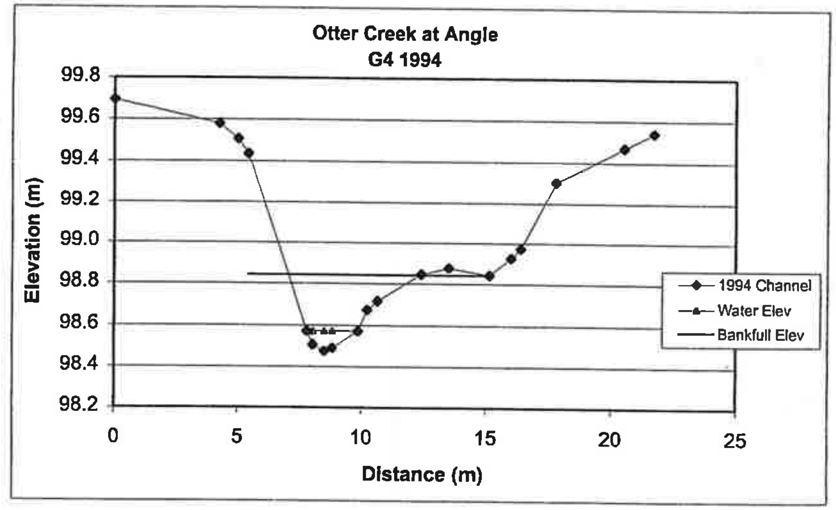


Figure 6.24 G4 1994.

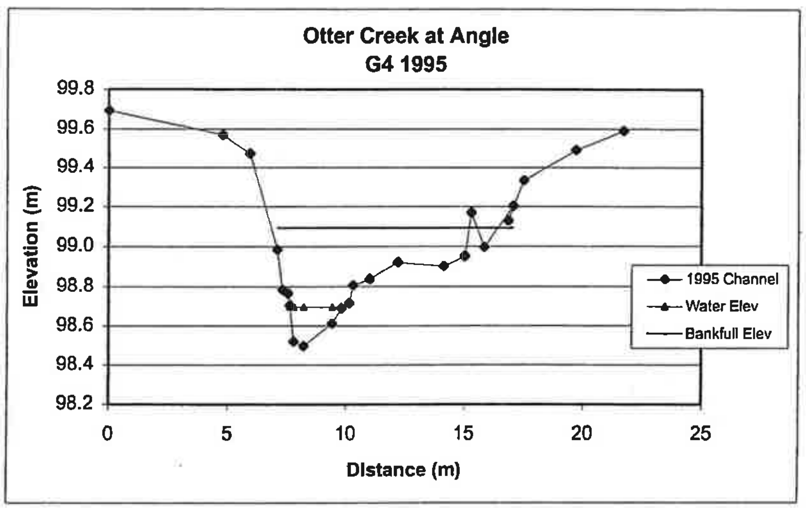


Figure 6.25 G4 1995.

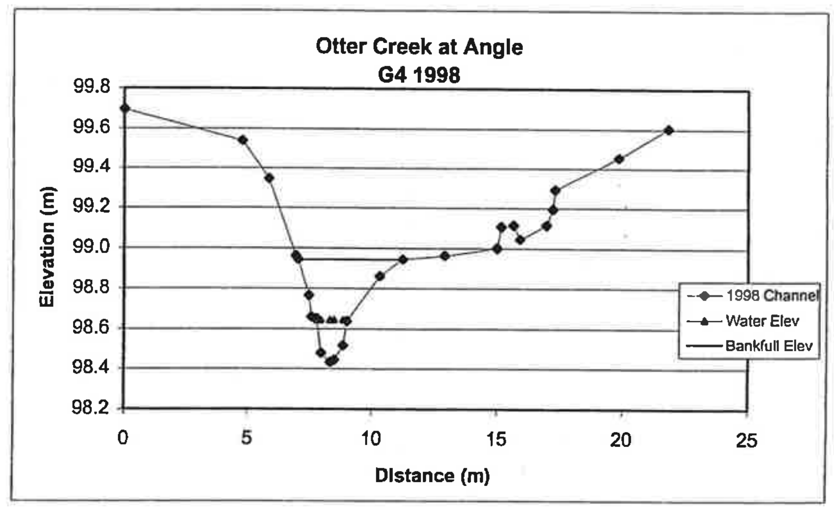
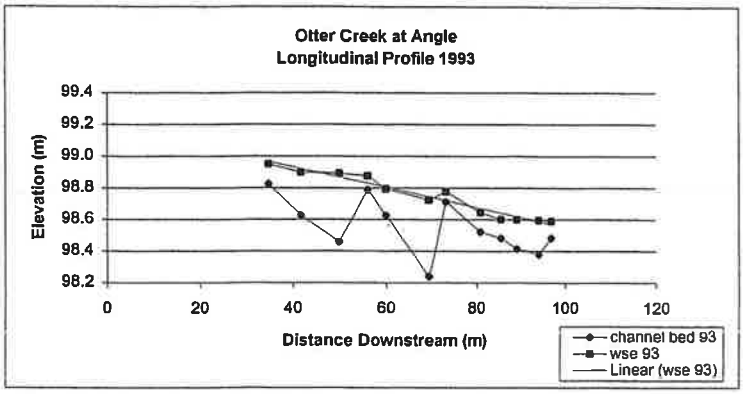
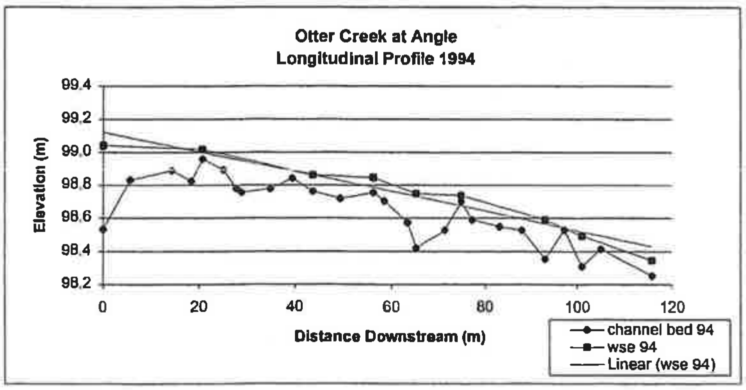


Figure 6.26 G4 1998.



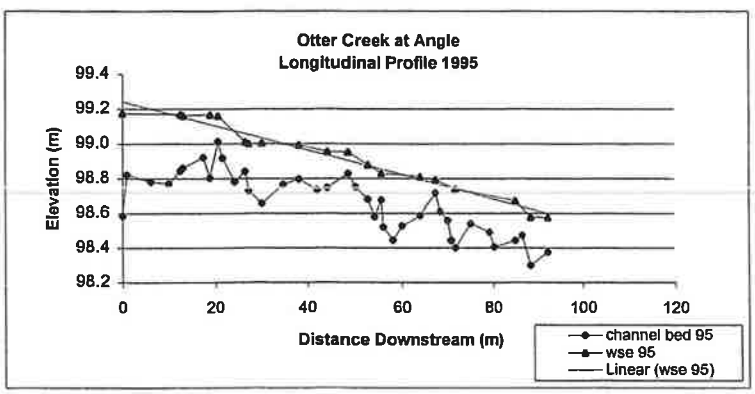
water surf slope 93	-0.0064
channel bed slope 93	-0.0049
avg bed elevation 93 (m)	98.546

Figure 6.27: 1993 Longitudinal Profile



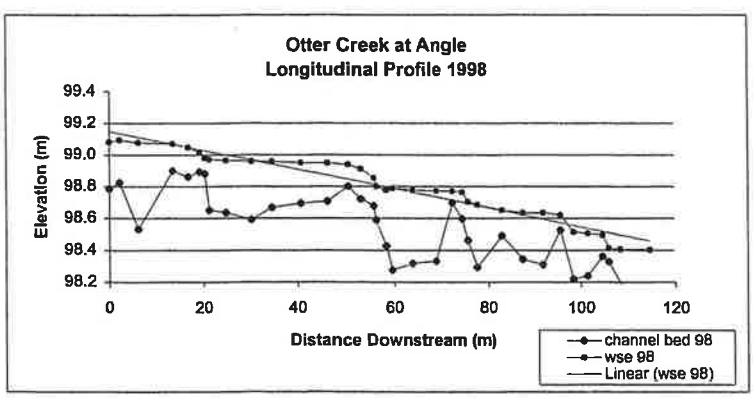
water surf slope 94	-0.0059
channel bed slope 94	-0.0047
avg bed elevation 94 (m)	98.644

Figure 6.28: 1994 Longitudinal Profile



water surf slope 95	-0.0070
channel bed slope 95	-0.0053
avg bed elevation 95 (m)	98.659

Figure 6.29: 1995 Longitudinal Profile



water surf slope 98	-0.0060
channel bed slope 98	-0.0057
avg bed elevation 98 (m)	98.535

Figure 6.30: 1998 Longitudinal Profile

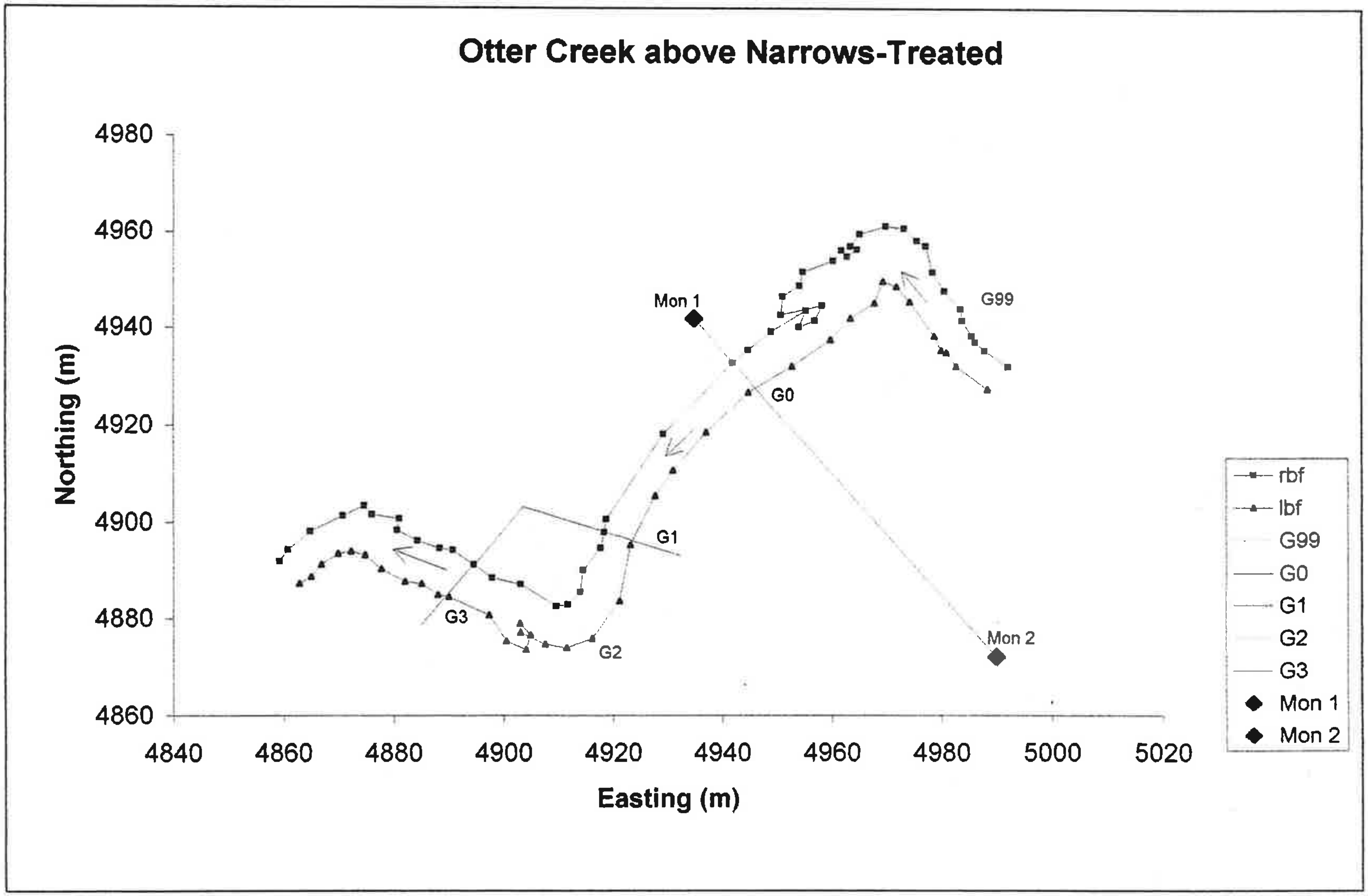


Figure 6.31 Planview of Above Narrows-Treated Site.

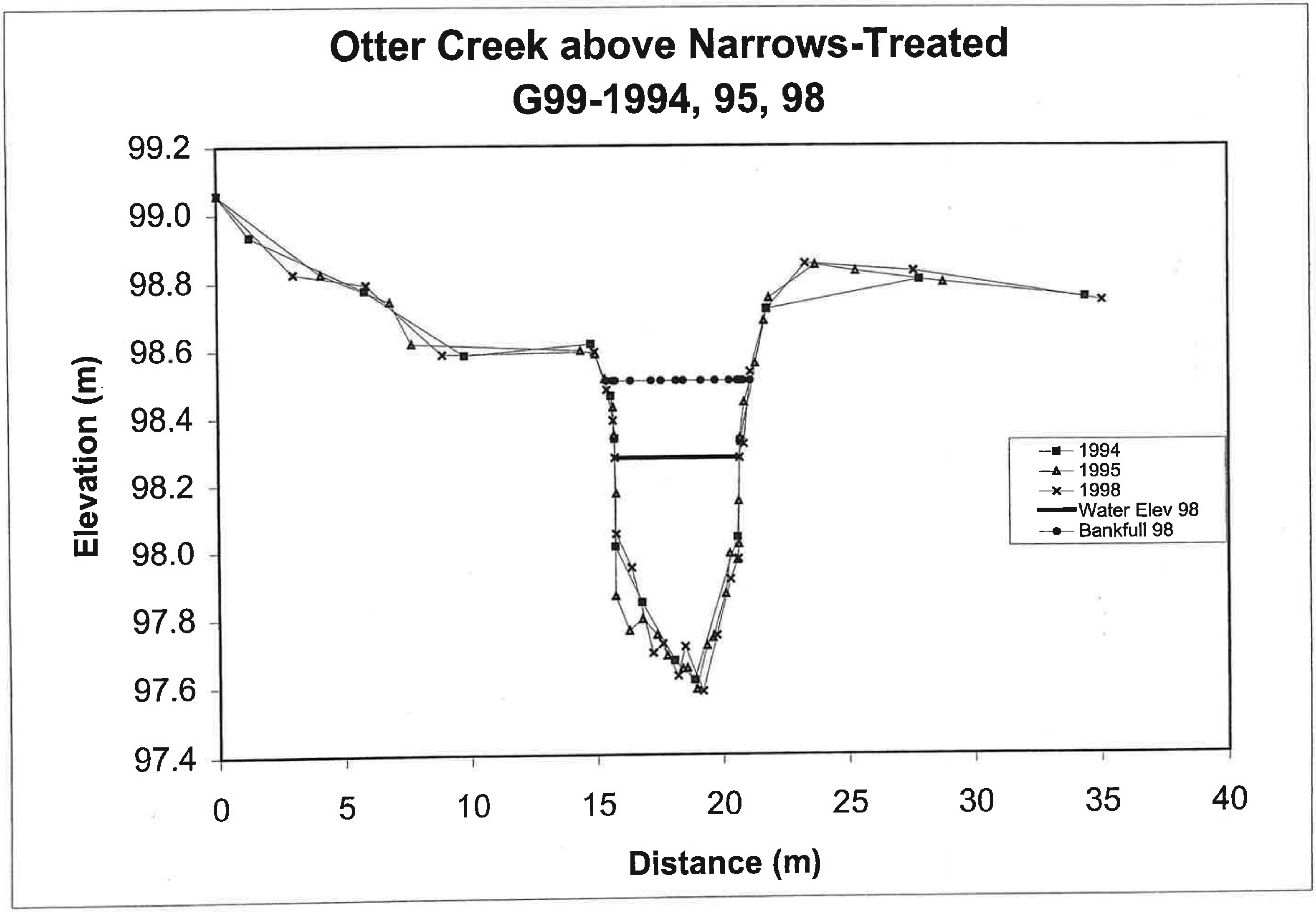


Figure 6.32 Composite graph of G99, 1994-1998.

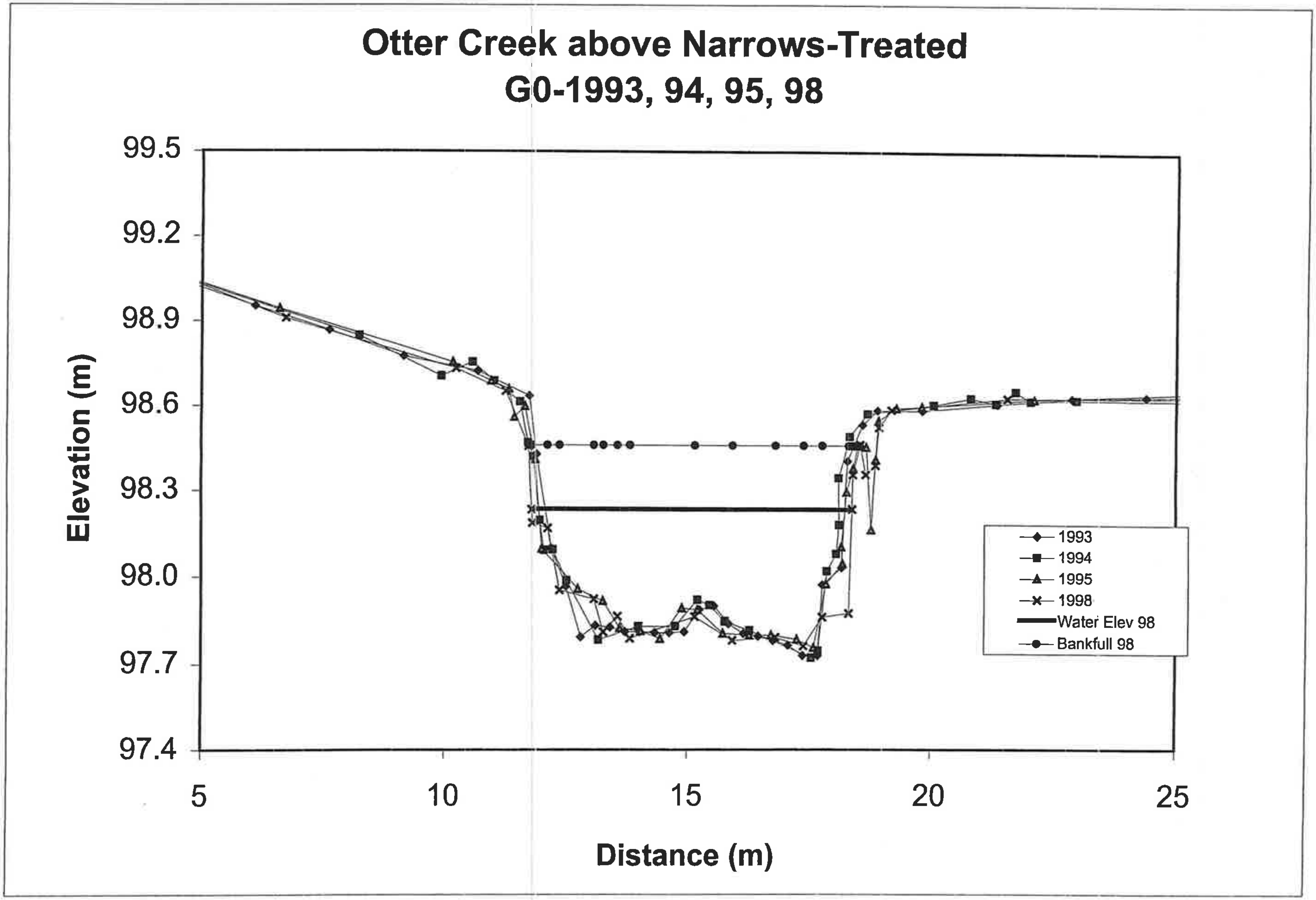


Figure 6.33 Composite graph of G0, 1993-1998.

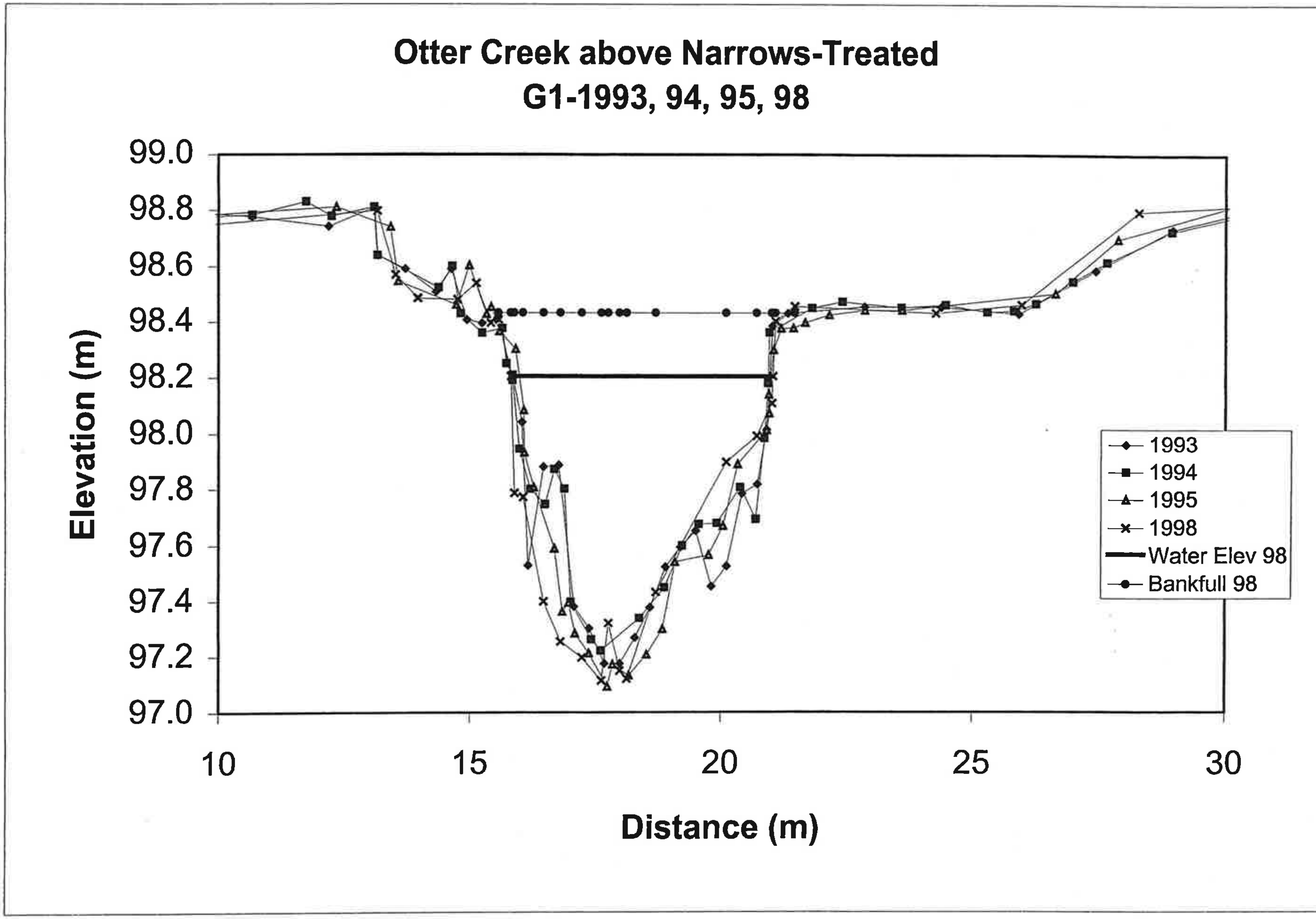


Figure 6.34 Composite graph of G1, 1993-1998.

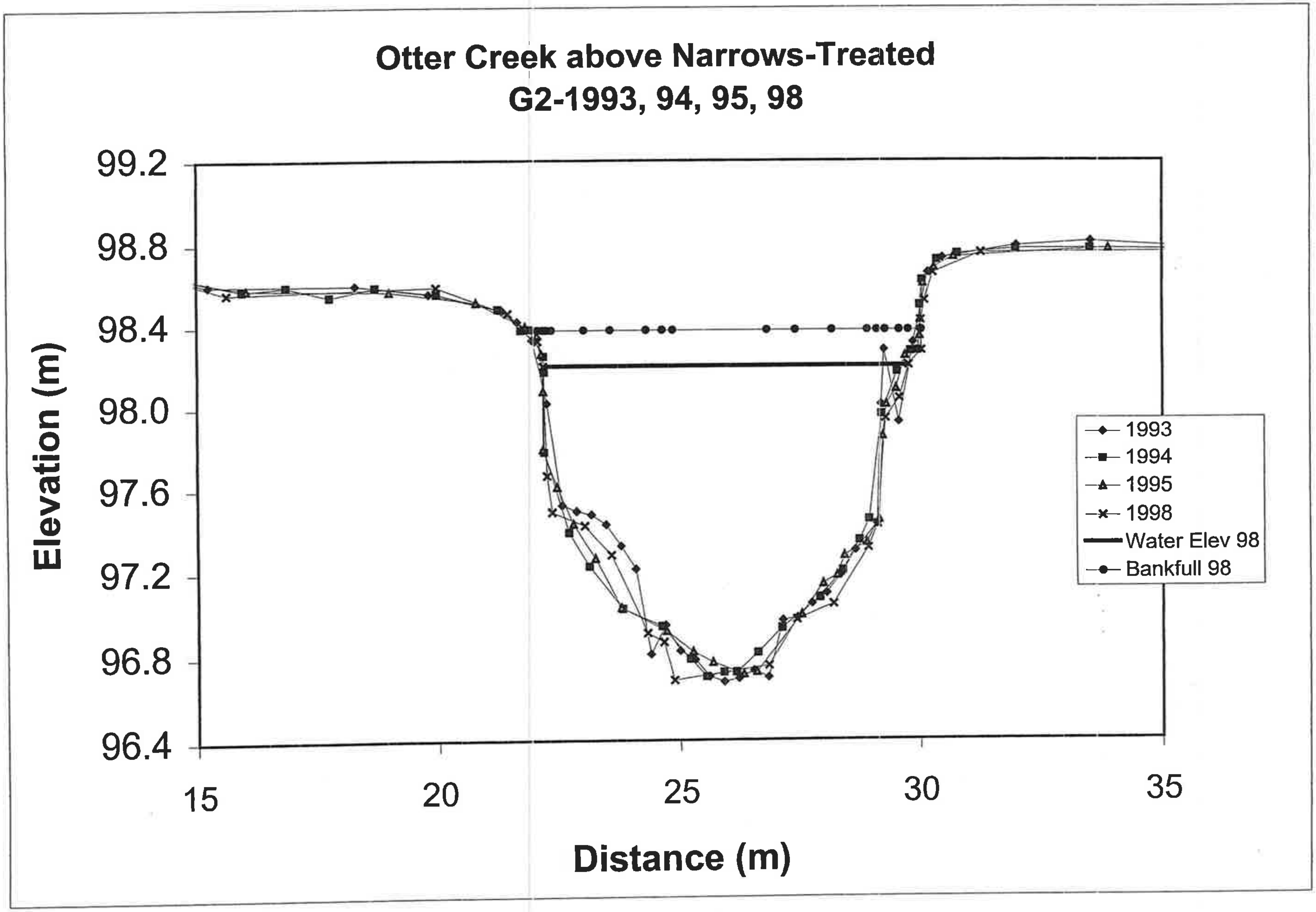


Figure 6.35 Composite graph of G2, 1993-1998.

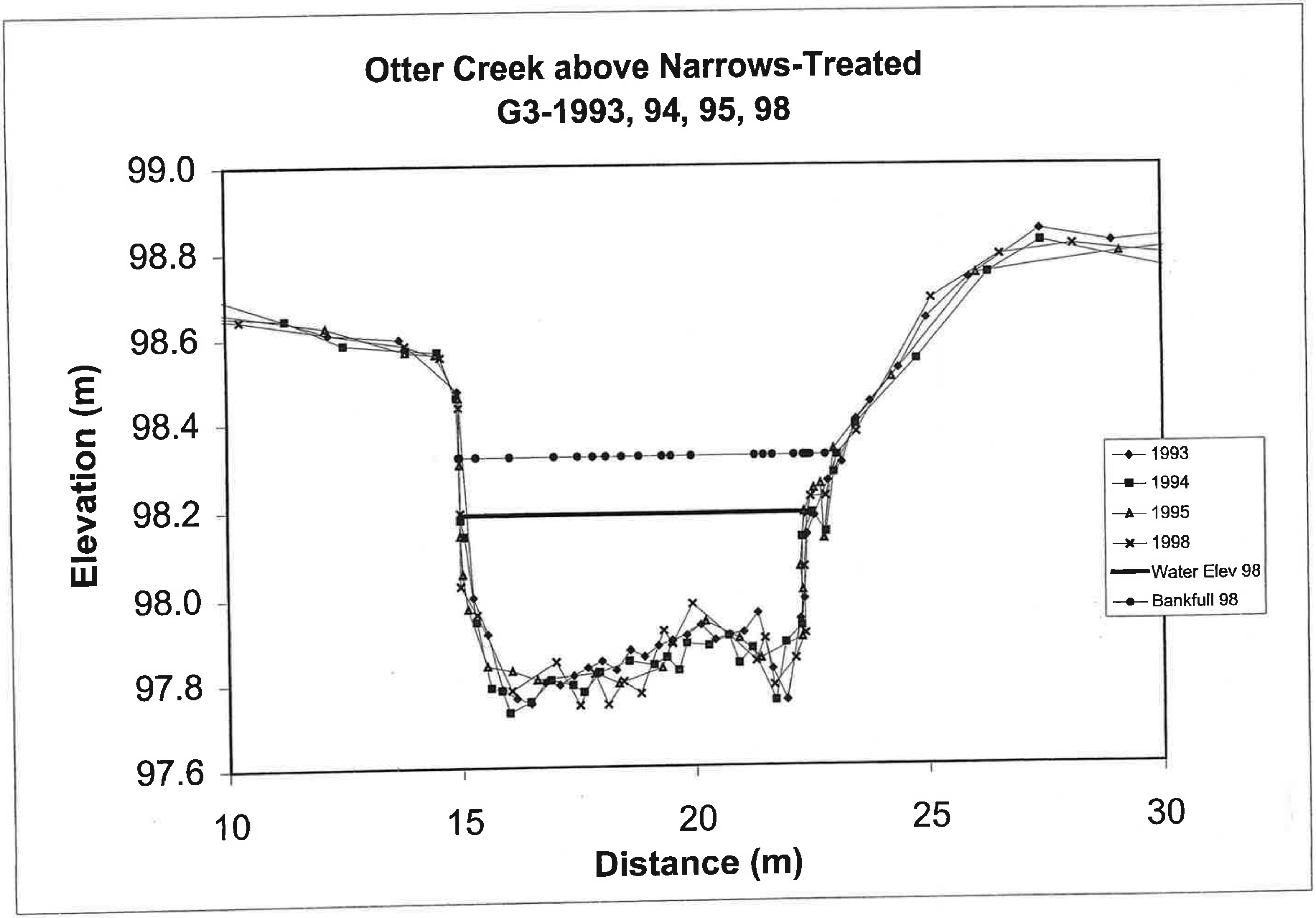
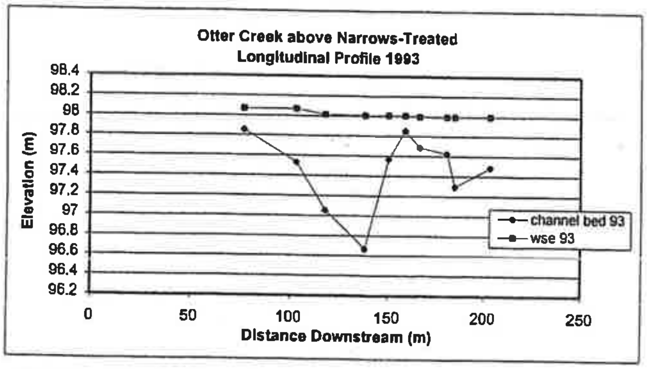
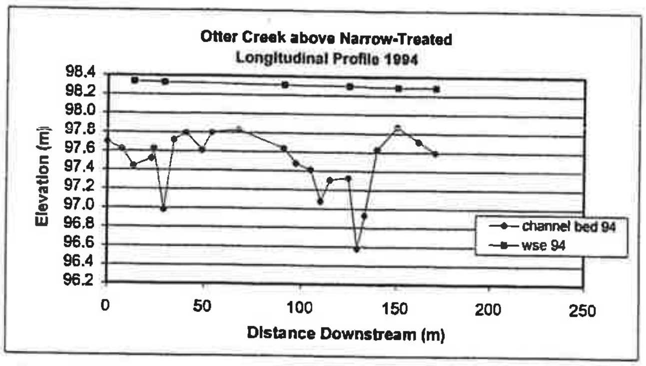


Figure 6.36 Composite graph of G3, 1993-98.



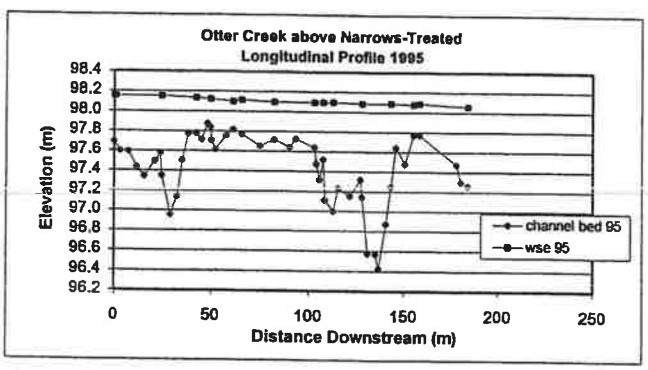
water surf slope 93	-0.00063
channel bed slope 93	-0.00014
avg bed elevation 93 (m)	97.461

Figure 6.37: 1993 Longitudinal Profile



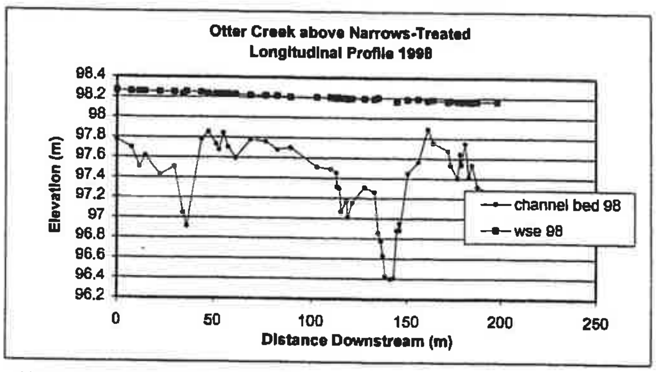
water surf slope 94	-0.00033
channel bed slope 94	-0.00130
avg bed elevation 94 (m)	97.486

Figure 6.38: 1994 Longitudinal Profile



water surf slope 95	-0.00050
channel bed slope 95	-0.00238
avg bed elevation 95 (m)	97.432

Figure 6.39: 1995 Longitudinal Profile



water surf slope 98	-0.00056
channel bed slope 98	-0.00340
avg bed elevation 98 (m)	97.467

Figure 6.40: 1998 Longitudinal Profile

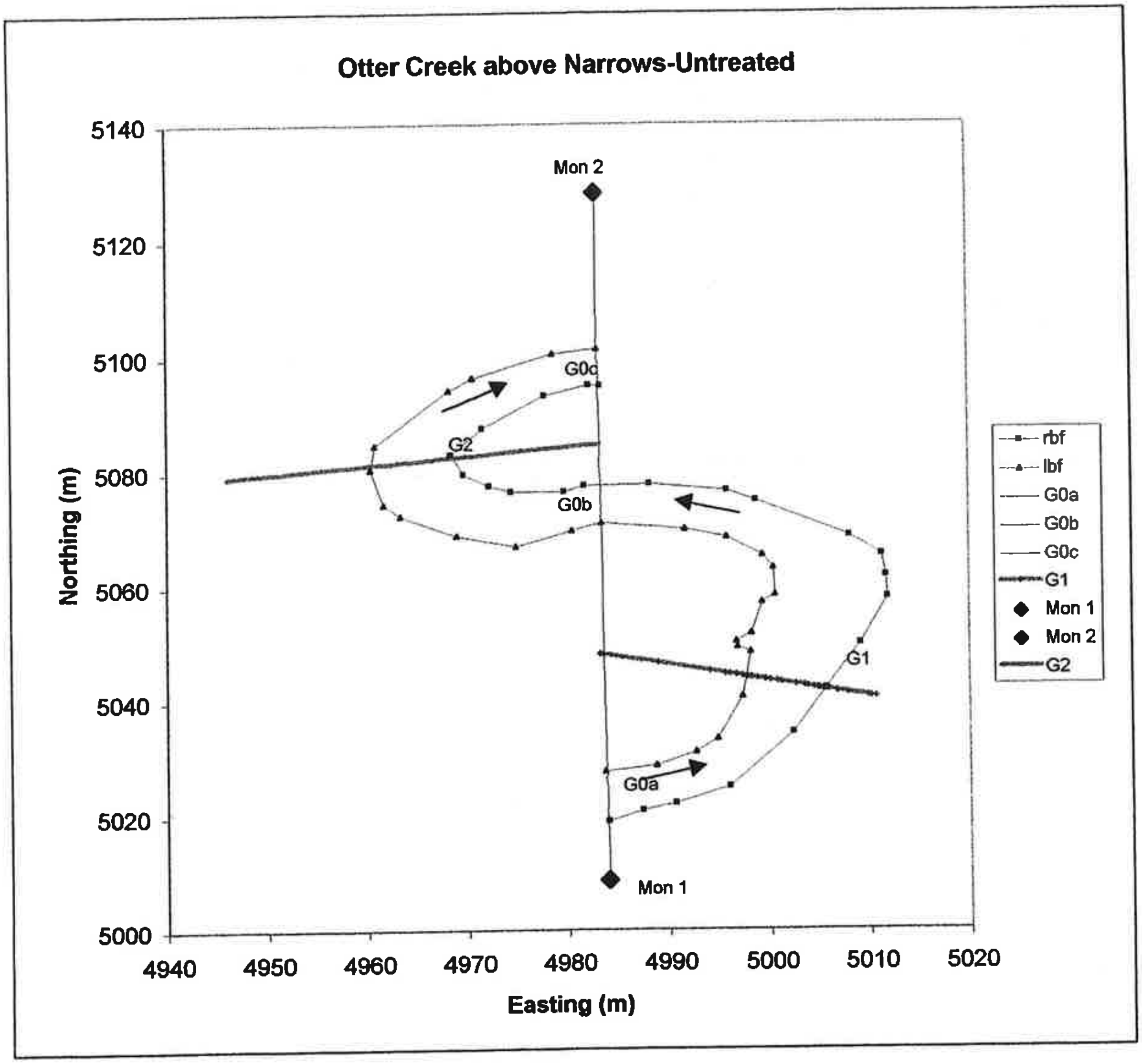


Figure 6.41 Planview of Above Narrows-Untreated Site.

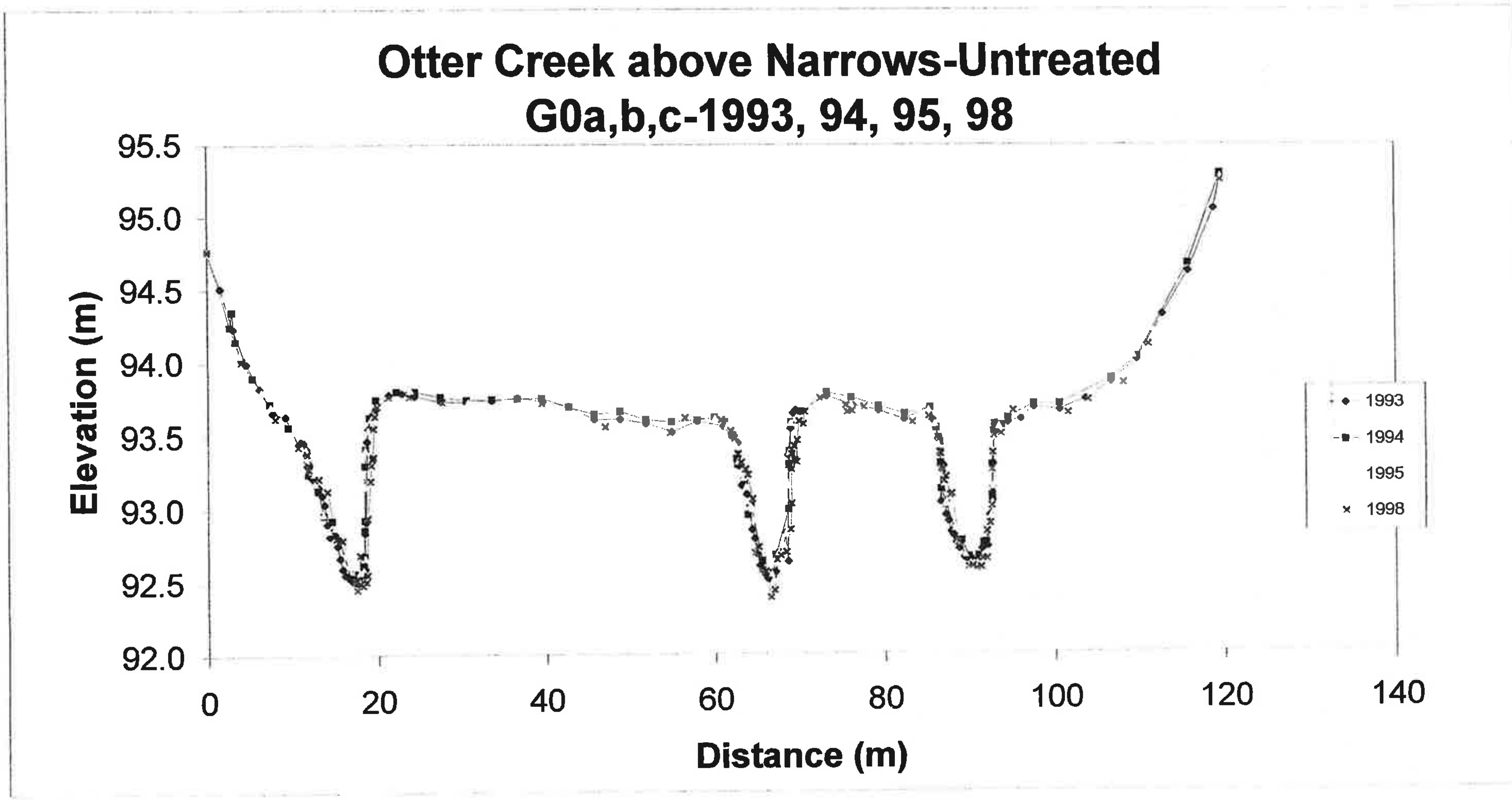


Figure 6.42 Composite graph of G0a,b,c from West monument to East monument, 1993-98.

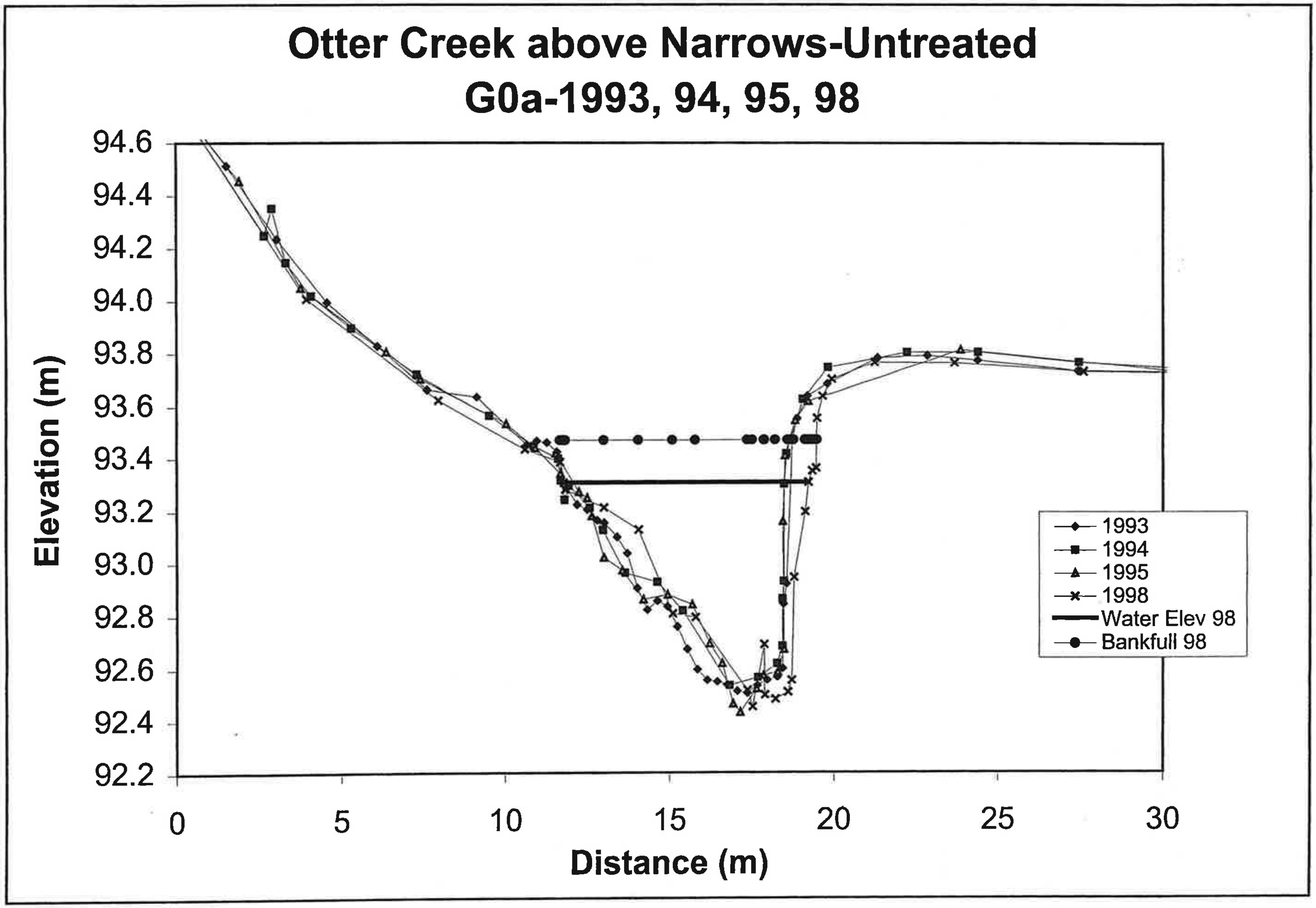


Figure 6.43 Composite graph of G0a, 1993-98.

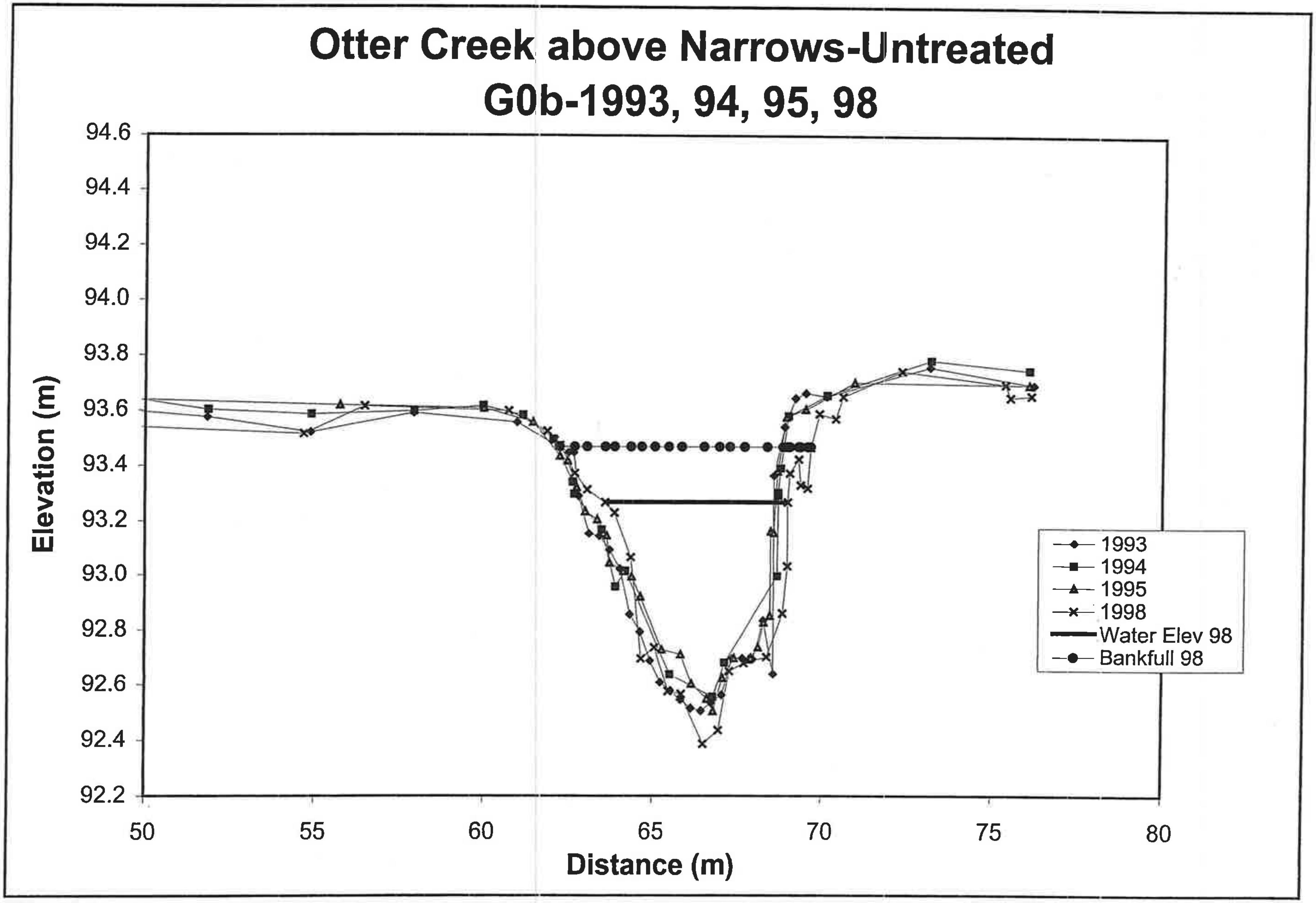


Figure 6.44 Composite graph of G0b, 1993-98.

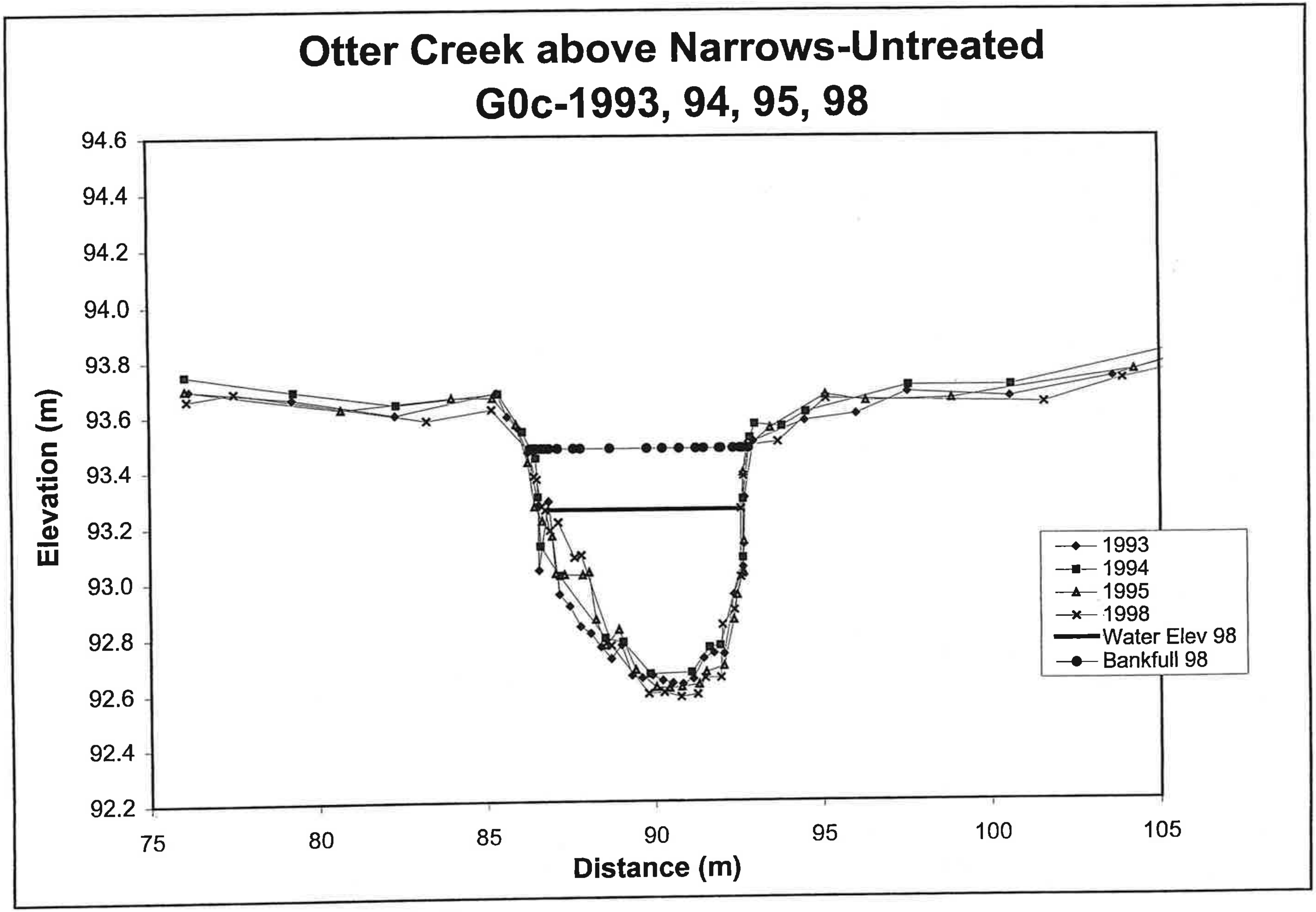


Figure 6.45 Composite graph of G0c, 1993-98.

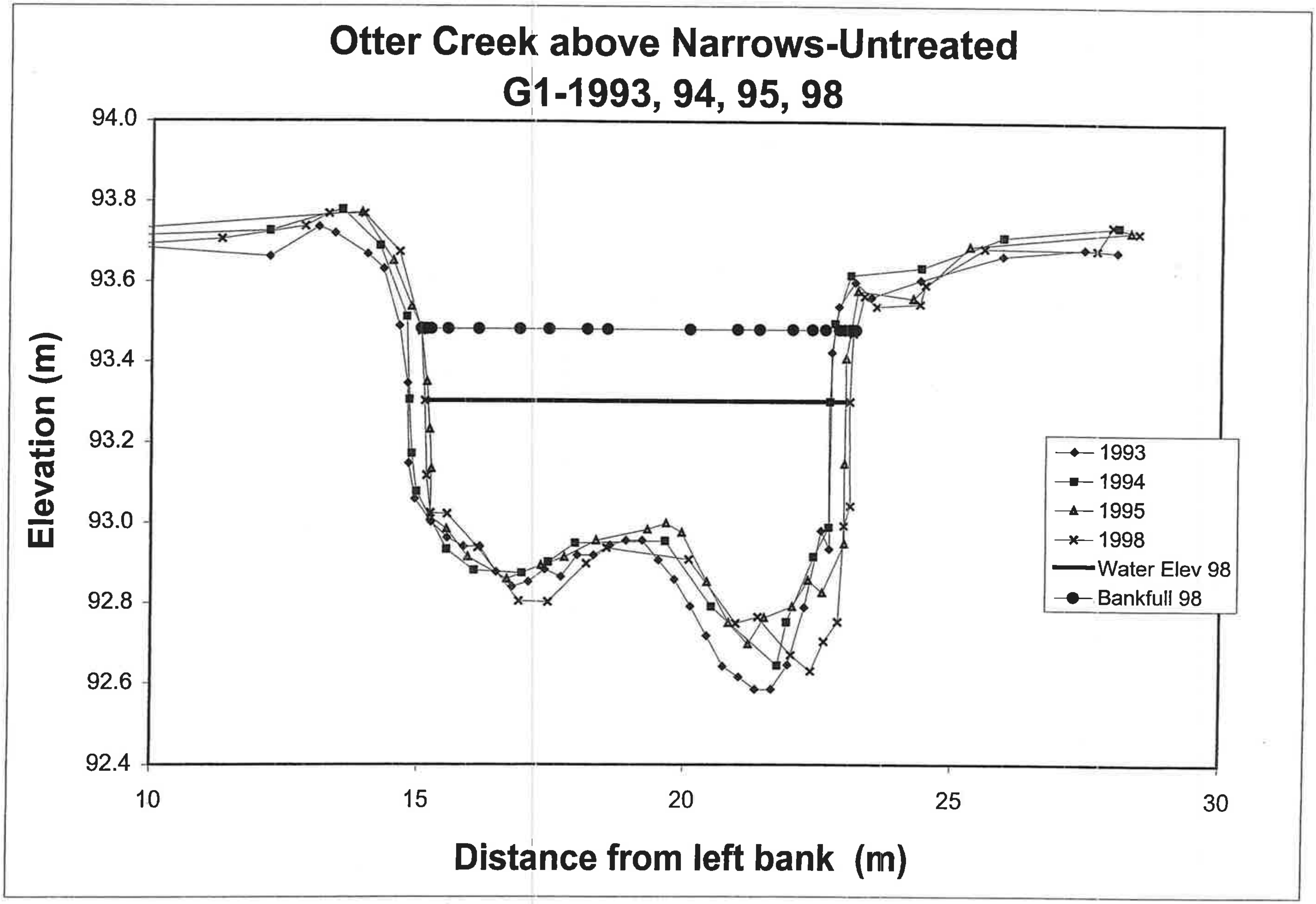


Figure 6.46 Composite graph of G1, 1993-98.

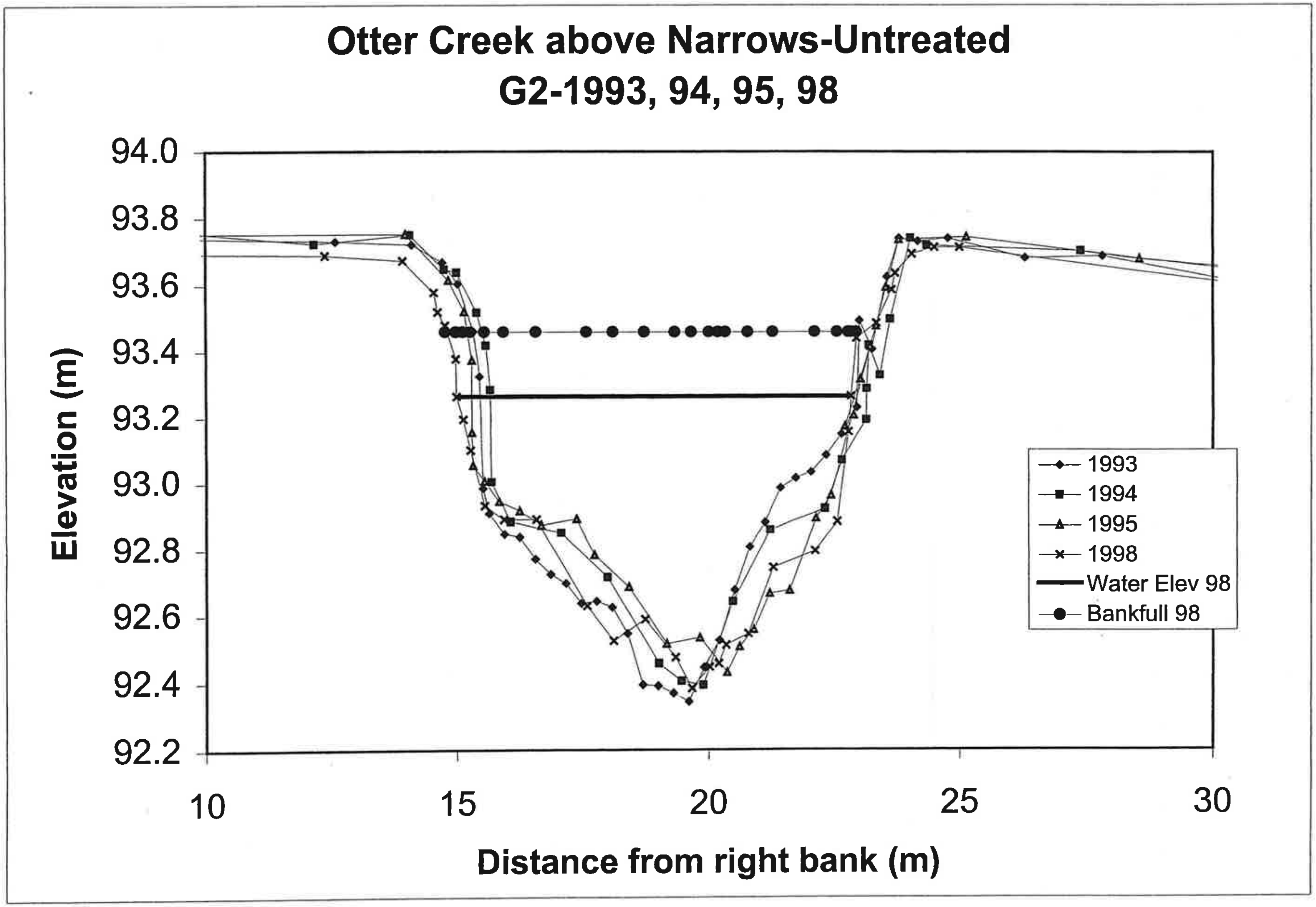
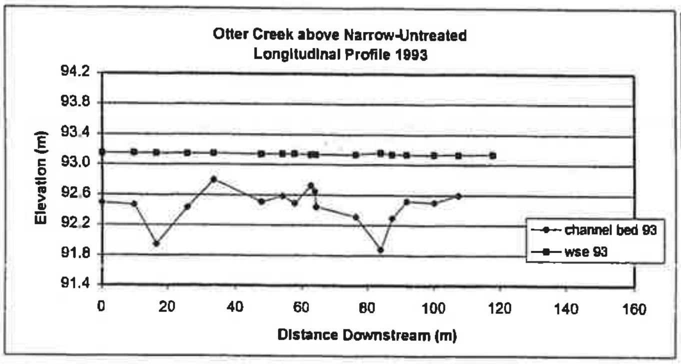
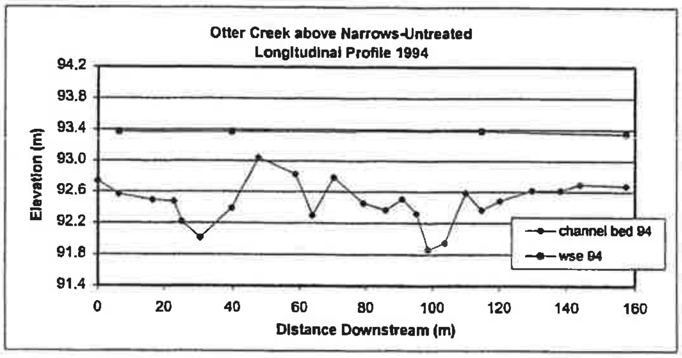


Figure 6.47 Composite graph of G2, 1993-98.



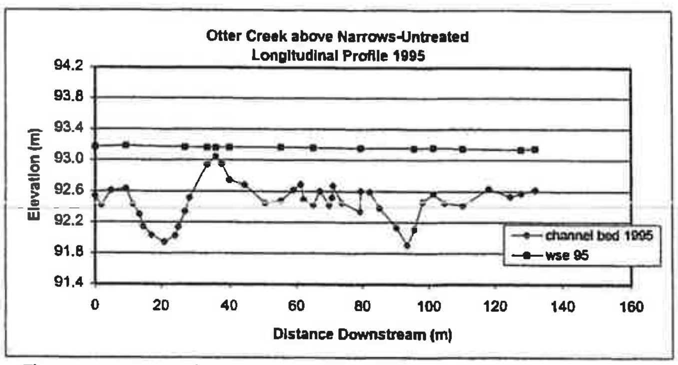
channel bed slope 93 0.00046
water surface slope 93 -0.00015
avg bed elevation 93 (m) 92.456

Figure 6.48: 1993 Longitudinal Profile



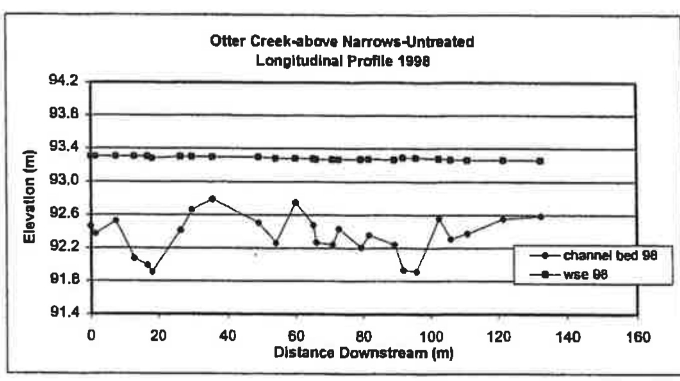
channel bed slope 94 0.00008
water surface slope 94 -0.00011
avg bed elevation 94 (m) 92.472

Figure 6.49: 1994 Longitudinal Profile



channel bed slope 95 0.00041
water surface slope 95 -0.00025
avg bed elevation 95 (m) 92.417

Figure 6.50: 1995 Longitudinal Profile



channel bed slope 98 0.00024
water surface slope 98 -0.00035
avg bed elevation 98 (m) 92.352

Figure 6.51: 1998 Longitudinal Profile

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Harrelson, Cheryl C., Rawlins, C.L., and John P. Potyondy. 1996. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado. General Technical Report RM-245.

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Bill Bradwisch, Division of Wildlife Resources
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Report by: Tracie Kirkham
Rick Summers

Monitoring Report

NPS Interagency Monitoring Workgroup

CHAPTER SEVEN: SUBSTRATE AND STREAM SHADE EVALUATION

Otter Creek Watershed

Introduction

The NPS Interagency Monitoring Workgroup conducted a field study on three reaches of Otter Creek, Piute County, Utah in August of 1993,1994, 1995, and 1998. As part of these studies, data was collected for channel substrate using the Wolman pebble count method (Wolman, 1954) and stream shade/solar input using a Solar PathFinder™ and spherical canopy densiometer. The field trial of these methods also was conducted to assist in finalization of standard operating procedures (SOPs) for each technique. Preliminary results of the shade evaluation are included in this report. This report presents and summarizes the data for the three reaches described as Otter Creek at Angle, Otter Creek above Narrows-Treated, and Otter Creek above Narrows-Untreated.

Each reach is permanently monumented with four or five surveyed transects. At each transect, measurements were taken with the densiometer and Solar PathFinder™ as described in Chapter Four: Methods. Solar PathFinder™ values represent average August percent daily radiation reaching the stream surface. Study site layout and descriptions for each reach as described in more detail in the Watershed Description. The reaches represent an untreated site, Otter Creek above Narrows-Untreated, where no specific management plan was to be monitored, baseline data, Otter Creek above Narrows-Treated, where a specific management plan was to be followed, and mid-implementation of a mechanical treatment, Otter Creek at Angle. Further descriptions of BMP implementation are included in chapter three and chapter five.

Pebble counts were taken at the Angle and Above Narrows-Treated in 1993, 1994, 1995, and 1998. Unforeseeable circumstances prevented collection at the Above Narrows-Untreated reach in 1993, but counts were taken in 1994, 1995, and 1998. Approximately 100+ pebbles were tallied for each count. Counts were taken at G-3 for the Treated reach, between G-1 and G-3 for the Angle reach (est. 70% of counts in riffle and 30% in pool), and at G1 at the Untreated reach.

<u>Otter Creek at Angle</u>

Summary

1. Tabled values for the particle size distributions are given in Tables 7.1-7.4.

2. Figure 7.1 shows the cumulative percent finer distribution for the Angle project.

3. Data were summarized using d_{50} values for each distribution and percent fine sediment (Table 7.5). It was assumed that fine sediment is represented by the size fraction less than 6 mm in diameter. The d_{50} for the Angle reach is 11 mm with 35% fine sediment in 1993, 15.5 mm with 23% fines in 1994, 9.5 mm with 46% fines in 1995, and 9.3 mm with 40% fines in 1998. This reach indicates excessive fine sediments. There was an increase in sediment size in 1994, and then a

decrease in size in 1995, and 1998.

In 1993 the existing channel shape was wide and shallow, by 1998 the channel has narrowed and deepened with a defined thalweg. There is also evidence of a "point bar" or low floodplain development (Chapter Six: Geomorphology). Fine sediments are being deposited on this "point bar" feature causing the 1995 and 1998 lines to flatten and show an increase in percent fines and a slightly, although not necessarily significant smaller d_{50}. As this feature and the channel become more stable, over time there should be a reduction in the percent fine sediment and an increase in the d_{50}.

Table 7.5 Angle Site

	Particle Size Distribution			
	1993	1994	1995	1998
D_{50} (mm)	11	15.5	9.5	9.3

4. There was a slight increase in percent shade at the Angle site based on the solar pathfinder measurements. Three percent shade was observed at two of the cross sections and six percent measured at another, which is an improvement from zero measured in the previous years. The densiometer showed no shade measured over the monitoring period.

5. Copies of field data are available from DEQ/DWQ files.

Otter Creek above Narrows-Treated

Summary

1. Tabled values for the particle size distributions are given in Tables 7.6-7.9.

2. Figure 7.2 shows the cumulative percent finer distribution for the Above Narrows-Treated project.

3. Data were summarized using d_{50} values for each distribution and percent fine sediment (Table 7.10). It was assumed that fine sediment is represented by the size fraction less than 6 mm in diameter. The d_{50} for the Above Narrow-Treated reach is 2.4 mm with 73% fine sediment in 1993, <1 mm with 81% fines in 1994, <1 with 84% fines in 1995, and <1 mm with 81% fines in 1998. This reach indicates excessive fine sediments.

Table 7.10 Treated Site

	Particle Size Distribution			
	1993	1994	1995	1998
D_{50} (mm)	2.4	<1	<1	<1

4. There was no increase in shade above the stream channel based on solar pathfinder and densiometer measurements.

5 . Copies of field data are available from DEQ/DWQ files.

Otter Creek above Narrows-Untreated

Summary

1. Tabled values for the particle size distributions are given in Tables 7.11-13.

2. Figure 7.3 shows the cumulative percent finer distribution for the Otter Creek above Narrows-Untreated project.

3. Data were summarized using d_{50} values for each distribution and percent fine sediment (Table 7.14). It was assumed that fine sediment is represented by the size fraction less than 6mm in diameter. The d_{50} for the Untreated reach was<1 mm with 95% fine sediment for 1994, <1 mm with 97 % fines in 1995, and <1 mm with 86% fines in 1998. This reach indicates excessive fine sediments.

Table 7.14 Untreated Site

	Particle Size Distribution		
	1994	1995	1998
D_{50} (mm)	<1	<1	<1

4. There was no increase in shade above the stream channel based on solar pathfinder and densiometer measurements.

5. Copies of field data are available from DEQ/DWQ files.

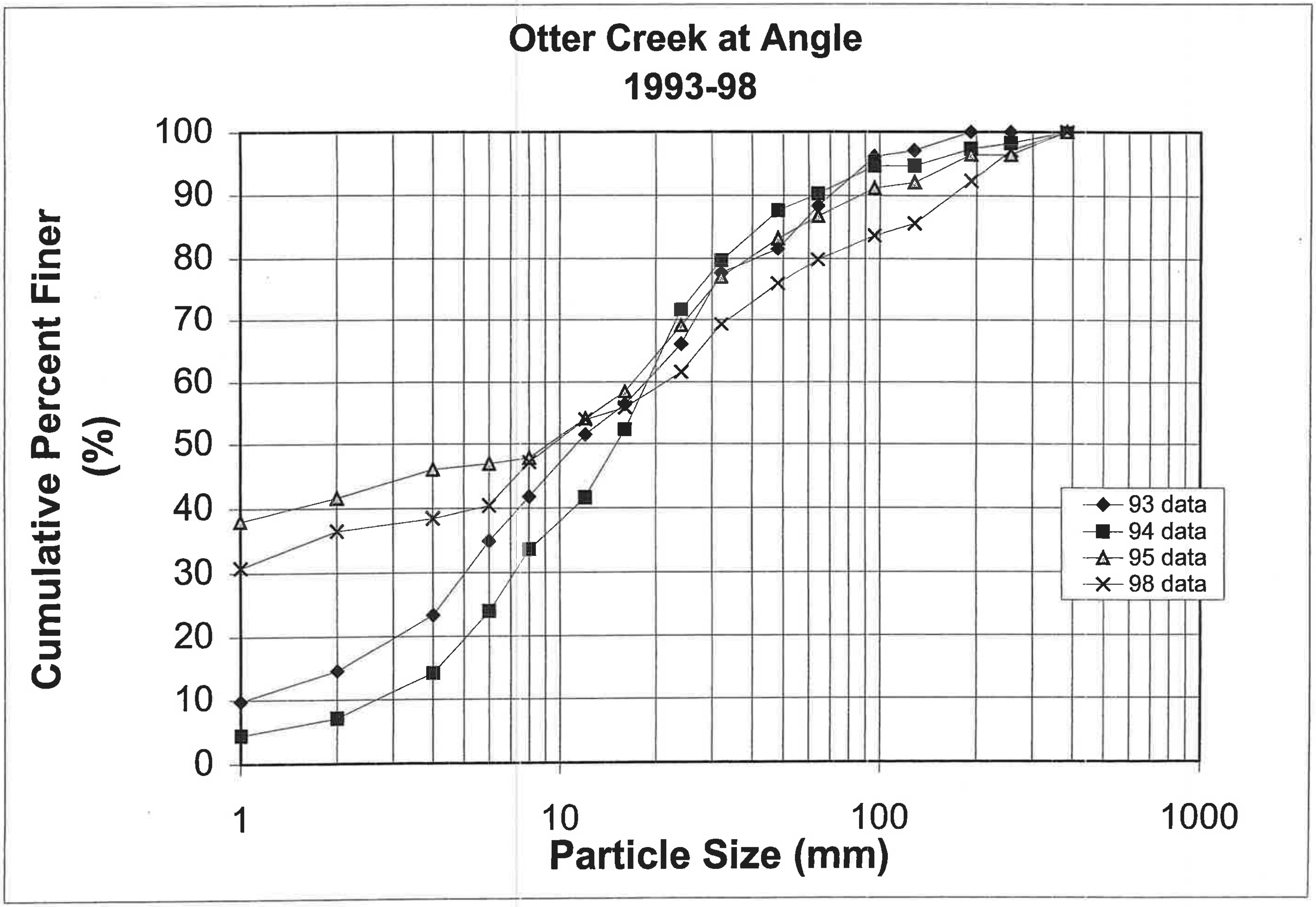

Figure 7.1 Particle size distribution at Angle, 1993-1998.

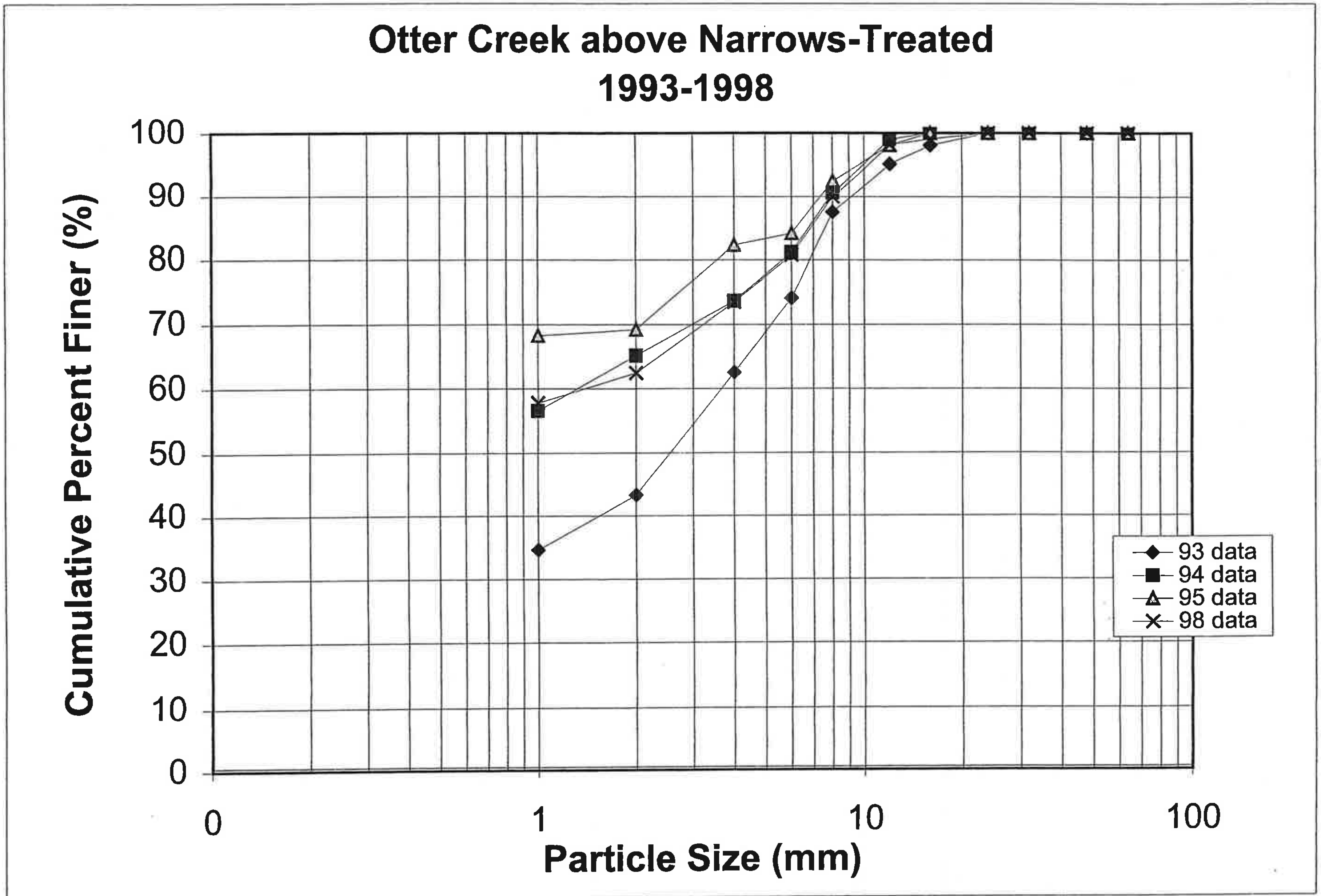

Figure 7.2 Particle size distribution at Treated Site, 1993-1998.

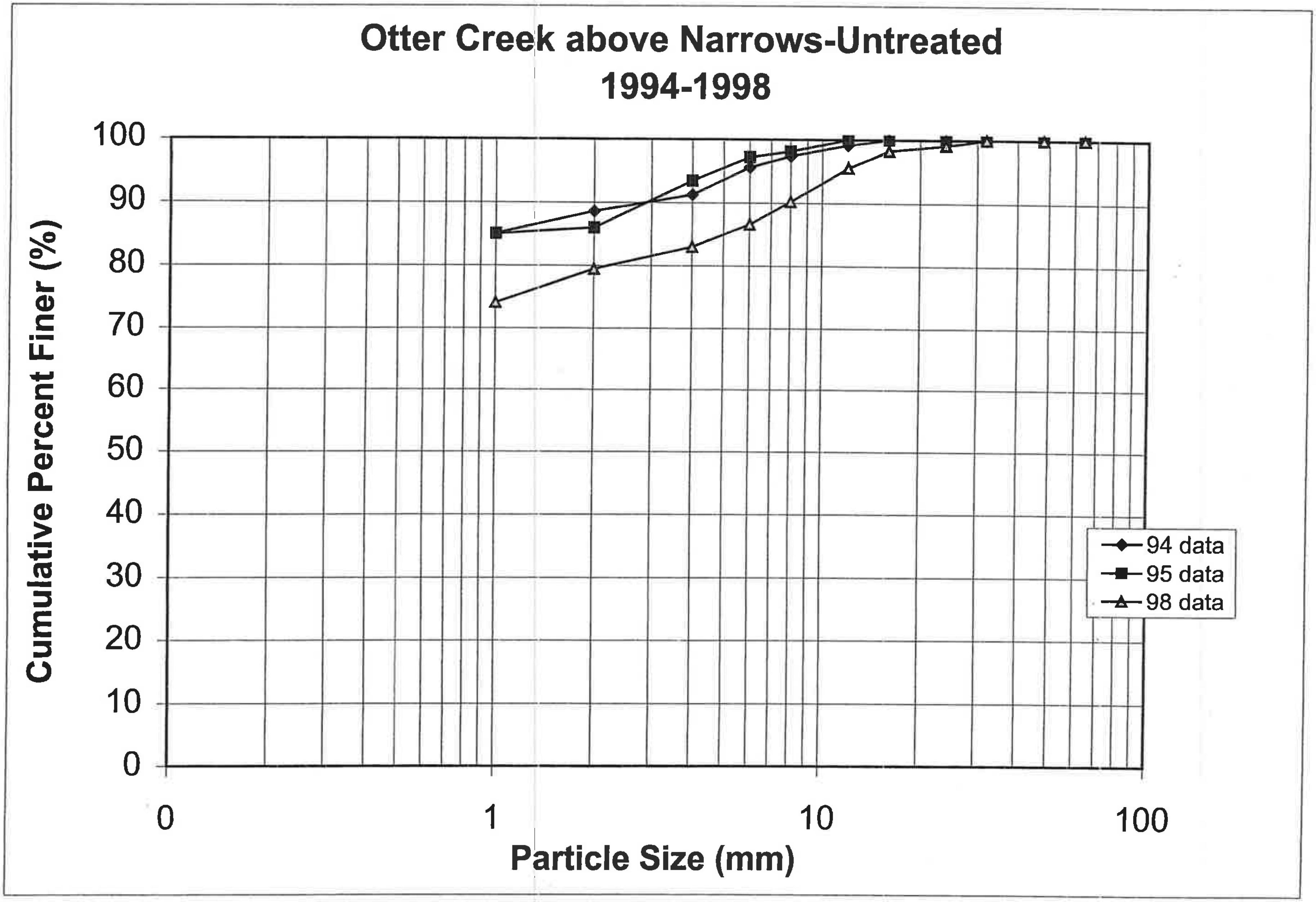

Figure 7.3 Particle size distribution at Untreated Site, 1994-1998.

Otter Creek at Angle
Pebble counts taken btwn G1&G3

Table 1. 1993 Pebble Count Data

1993 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256	0	100.000
192	0	100.000
128	3	100.000
96	1	97.087
64	8	96.117
48	7	88.350
32	4	81.553
24	12	77.670
16	10	66.019
12	5	56.311
8	10	51.456
6	7	41.748
4	12	34.951
2	9	23.301
1	5	14.563
0.5	10	9.709
TOTAL	103	

Table 2. 1994 Pebble Count Data

1994 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256	2	100.000
192	1	98.230
128	3	97.345
96	0	94.690
64	5	94.690
48	3	90.265
32	9	87.611
24	9	79.646
16	22	71.681
12	12	52.212
8	9	41.593
6	11	33.628
4	11	23.894
2	8	14.159
1	3	7.080
0.5	5	4.425
TOTAL	113	

Table 3. 1995 Pebble Count Data

1995 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256	4	100.000
192	0	96.460
128	5	96.460
96	1	92.035
64	5	91.150
48	4	86.726
32	7	83.186
24	9	76.991
16	12	69.027
12	5	58.407
8	7	53.982
6	1	47.788
4	1	46.903
2	5	46.018
1	4	41.593
0.5	43	38.053
TOTAL	113	

Table 4. 1998 Pebble Count Data

1998 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256	3	100.000
192	5	97.115
128	7	92.308
96	2	85.577
64	4	83.654
48	4	79.808
32	7	75.962
24	8	69.231
16	6	61.538
12	2	55.769
8	7	53.846
6	7	47.115
4	2	40.385
2	2	38.462
1	6	36.538
0.5	32	30.769
TOTAL	104	

Otter Creek above Narrows-Treated
Pebble counts taken at G0

Table 6. 1993 Pebble Count Data

1993 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.00
192.00	0.00	100.00
128.00	0.00	100.00
96.00	0.00	100.00
64.00	0.00	100.00
48.00	0.00	100.00
32.00	0.00	100.00
24.00	0.00	100.00
16.00	2.00	100.00
12.00	3.00	98.08
8.00	8.00	95.19
6.00	14.00	87.50
4.00	12.00	74.04
2.00	20.00	62.50
1.00	9.00	43.27
0.50	36.00	34.62
TOTAL	104.00	

Table 7. 1994 Pebble Count Data

1994 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.000
192.00	0.00	100.000
128.00	0.00	100.000
96.00	0.00	100.000
64.00	0.00	100.000
48.00	0.00	100.000
32.00	0.00	100.000
24.00	0.00	100.000
16.00	0.00	100.000
12.00	1.00	100.000
8.00	9.00	99.057
6.00	10.00	90.566
4.00	8.00	81.132
2.00	9.00	73.585
1.00	9.00	65.094
0.50	60.00	56.604
TOTAL	106.00	

Table 8. 1995 Pebble Count Data

1995 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.000
192.00	0.00	100.000
128.00	0.00	100.000
96.00	0.00	100.000
64.00	0.00	100.000
48.00	0.00	100.000
32.00	0.00	100.000
24.00	0.00	100.000
16.00	0.00	100.000
12.00	2.00	100.000
8.00	6.00	98.131
6.00	9.00	92.523
4.00	2.00	84.112
2.00	14.00	82.243
1.00	1.00	69.159
0.50	73.00	68.224
TOTAL	107.00	

Table 9. 1998 Pebble Count Data

1998 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.00
192.00	0.00	100.00
128.00	0.00	100.00
96.00	0.00	100.00
64.00	0.00	100.00
48.00	0.00	100.00
32.00	0.00	100.00
24.00	0.00	100.00
16.00	1.00	100.00
12.00	1.00	99.08
8.00	9.00	98.17
6.00	10.00	89.91
4.00	8.00	80.73
2.00	12.00	73.39
1.00	5.00	62.39
0.50	63.00	57.80
TOTAL	109.00	

Otter Creek above Narrows-Untreated
Pebble counts taken at G1

Table 11. 1994 Pebble Count Data

1994 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.00
192.00	0.00	100.00
128.00	0.00	100.00
96.00	0.00	100.00
64.00	0.00	100.00
48.00	0.00	100.00
32.00	0.00	100.00
24.00	0.00	100.00
16.00	0.00	100.00
12.00	1.00	100.00
8.00	2.00	99.12
6.00	2.00	97.37
4.00	5.00	95.61
2.00	3.00	91.23
1.00	4.00	88.60
0.50	97.00	85.09
TOTAL	114.00	

Table 12. 1994 Pebble Count Data

1995 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.00
192.00	0.00	100.00
128.00	0.00	100.00
96.00	0.00	100.00
64.00	0.00	100.00
48.00	0.00	100.00
32.00	0.00	100.00
24.00	0.00	100.00
16.00	0.00	100.00
12.00	2.00	100.00
8.00	1.00	98.13
6.00	4.00	97.20
4.00	8.00	93.46
2.00	1.00	85.98
1.00	91.00	85.05
0.50		
TOTAL	107.00	

Table 13. 1994 Pebble Count Data

1998 Particle Size (mm)	Count (#)	% Cumulative Finer Than
256.00	0.00	100.00
192.00	0.00	100.00
128.00	0.00	100.00
96.00	0.00	100.00
64.00	0.00	100.00
48.00	0.00	100.00
32.00	0.00	100.00
24.00	1.00	100.00
16.00	1.00	99.11
12.00	3.00	98.21
8.00	6.00	95.54
6.00	4.00	90.18
4.00	4.00	86.61
2.00	4.00	83.04
1.00	6.00	79.46
0.50	83.00	74.11
TOTAL	112.00	

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Report by: Rick Summers, Hydrologist, Division of Water Quality
Tracie Kirkham, Division of Wildlife Resources

Monitoring Report
NPS Interagency Monitoring Workgroup
CHAPTER EIGHT: RIPARIAN VEGETATION
Otter Creek Watershed

INTRODUCTION

NPS Interagency Monitoring Work Group is conducting monitoring field studies on reaches of Otter Creek (Sevier River Basin), in Utah. The purpose of this part of the monitoring study is to establish baseline data and evaluate changes in riparian vegetation as a result of BMP implementation in the watershed.

Monitoring sites being studies and the years data has been collected at each site are as follows:

Monitoring Site	1993	1994	1995	1998
Otter Creek At Angle	x	x	x	x
Otter Creek Above Narrows (treated)	x	x	x	x
Otter Creek Above Narrows (untreated)	x	x	x	x

MONITORING RESULTS

OTTER CREEK AT ANGLE SITE

Riparian Classification

Riparian vegetation are classified using the riparian classification system developed by Petersen and Sennett (1996). The study site riparian area is located in the Utah Plateaus (E47B) major land resource area. It is a fresh water, riverine system in a confined alluvial valley with a frigid temperature regime. The riparian complex has an estimated potential to be about 80 percent hydroriparian made up of Yellow willow (*Salix lutea*), Coyote willow (*Salix exigua*) and Nebraska sedge (*Carex nebrascensis*) communities; and about 20 percent mesoriparian made up of Yellow willow (*Salix lutea*) and Saltgrass (*Distichlis spicata*) communities.

Riparian Vegetation Green-Line Data Summary

Data was collected from one (1) green-line transection.

Changes in percentage of plant communities along the green-line can indicate a trend in stability and ecological status.

Some of the most significant composition changes along the green-line are shown in the following table.

	Percent of Green-Line Transections			
	1993	1994	1995	1998
Wetland Communities	29	64	64	93
Other (Riprap, Bare Ground, etc.)	61	28	20	7

Another indicator of trend in the green-line is a change in hydrologic moisture regime. An increase in hydroriparian (riparian wetland) can indicate that the stream channel is narrowing or that the water table is rising. Following is a summary of changes in hydrologic moisture regime along the green-line:

	Hydrologic Moisture Regime Along Green-line (%)			
	1993	1994	1995	1998
Hydroriparian	29	64	64	93
Mesoriparian	3	8	6	0
Xeroriparian	7	0	10	0
Other (Riprap, Bare Ground, etc.)	61	28	20	7

Green Line Stability Rating

Data from the green line transections are used to compute a stability index which is an indicator of the ability of the present riparian vegetation to resist erosion forces and stabilize the stream banks. The green line stability index is on a scale of 1 to 10 with 1 being very poor and 10 being excellent. The green line stability index at the Angle site is summarized as follows:

Green-line Stability Index	1993	1994	1997	1998
Numeric	5.61	4.78	4.38	4.87
Descriptive	Moderate	Moderate	Low	Moderate

As indicated in the above table, there has not been a significant change in the stability index for this site since monitoring began in 1993. However, based on photos of the site taken in 1991, the estimated stability rating prior to treatment in 1992 was 2.3 or very poor. Streambank and channel erosion has been reduced to almost insignificant at this site by the treatment with rock riprap, but the green-line vegetation is still in an early seral state with a moderate stability index. The slight decrease in the numeric stability index in due to newly established plant communities on newly formed depositional features inside the constructed channel. This recruitment of vegetation forms a new green-line of early seral plant communities that has a lower stability index than the rock riprap behind it.

Riparian Vegetation Cross-Section Data Summary

Data were collected from five (5) cross-section transections.

Changes in percentage of plant communities in the riparian complex can indicate a trend in stability and ecological status. Because the cross-section transections extended across the entire riparian area, cross-section data can show changes in plant community composition within the riparian complex. Changes in plant communities can be used as indicators of changes in hydrologic moisture regimes within the riparian complex. It can also indicate changes in the ecological status of the riparian complex.

Changes in hydrologic moisture regime can indicate changes in stream channel width, and/or that the water table is rising or lowering in the riparian zone. At the Angle Site, there has been a significant increase of both hydroriparian and xeroriparian and a very significant decrease of bare ground and riprap along the green-line. This is the result of the stream channel narrowing and floodplain development inside the constructed channel and hydroriparian vegetation becoming established on these new depositional features. Xeroriparian vegetation has become established on what was previously bare ground on the upper banks. A summary of changes in hydrologic moisture regime along the cross-section transections is shown as follows:

Hydrologic Moisture Regime Along Cross-section (%)

	1993	1994	1995	1998
Hydroriparian	9	10	15	33
Mesoriparian	47	40	64	40
Xeroriparian	3	4	6	21
Other (Riprap, Bare Ground, etc.)	41	45	15	6

Estimated Ecological Status

Data from the cross-section transections can be used to estimate the ecological status of the riparian complex. The apparent trend in ecological status is summarized in the following table. Although no vegetation data was collected prior to 1993, the ecological status before treatment began in 1991 was estimated to be Very Early Seral using photos taken in 1991. The following summary shows that there has been no change in the estimated ecological status of the riparian complex at the Angle site.

Ecological Status Trends

	1993	1994	1995	1998
Ecological Status	Very Early	Very Early	Very Early	Very Early

Woody Species Regeneration

Woody species regeneration was measured along the green line transections. Shrubs and trees are tallied by age class to provide and indication of regeneration. There were abundant seedling of yellow willow and coyote willow in 1994 and 19995; however, none became established on the site. The trend in woody species regeneration is summarized as follows:

Woody Species Regeneration Trends

	1993	1994	1995	1998
Seedling	0	48	37	0
Young	0	0	0	4
Mature	0	0	0	0
Decadent	0	0	0	0
Dead	0	0	0	0

Photographic Documentation

Although photographs may not be used to provide quantitative data, they can be used to visually represent the data being collected, and as an aid in information transfer and understanding. Photographs (35mm color slides) were taken at 25 established photo-points in 1993, 1994, 1995 and 1998.

OTTER CREEK ABOVE NARROWS (Treated) SITE

Riparian Classification

Riparian vegetation are classified using the riparian classification system developed by Petersen and Sennett (1996). The study site riparian area is located in the Utah Plateaus (E47B) major land resource area. It is a fresh water, riverine system in a confined alluvial valley with a frigid temperature regime. The riparian complex has an estimated potential to be about 85 percent hydroriparian made up of Beaked sedge (*Carex rostrata*) and Nebraska sedge (*Carex nebrascensis*) communities; about 10 percent mesoriparian made up of Blackcreeper sedge (*Carex praegracilis*) and Baltic rush (*Juncus balticus*) communities, and about 5 percent Xeroriparian made up of Rubber rabitbrush (*Chrysothamnus nauseosus Var. consimilis*) and Saltgrass (*Distichlis spicata*) communities.

Riparian Vegetation Green-Line Data Summary

Data was collected from two (2) green-line transections.

Changes in percentage of plant communities along the green-line can indicate a trend in stability and ecological status. Some of the most significant composition changes along the green-line are shown in the following table.

	Percent of Green-Line Transections			
	1993	1994	1995	1998
Wetland Communities	83	77	90	95

Another indicator of trend in the green-line is a change in hydrologic moisture regime. An increase in hydroriparian (riparian wetland) can indicate that the stream channel is narrowing or that the water table is rising. A summary of changes in hydrologic moisture regime along the green-line is shown as follows:

	Hydrologic Moisture Regime Along Green-line (%)			
	1993	1994	1995	1998
Hydroriparian	83	77	90	95
Mesoriparian	17	23	10	5
Xeroriparian	0	0	0	0

Green Line Stability Rating

Data from the green line transections are used to compute a stability index which is an indicator of the ability of the present riparian vegetation to resist erosion forces and stabilize the stream banks. The green line stability index is on a scale of 1 to 10 with 1 being very poor and 10 being excellent. The green line stability index at the Above Narrows (Treated) site is summarized as follows:

Green-line Stability Index	1993	1994	1997	1998
Numeric	5.65	4.53	5.34	6.27
Descriptive	Moderate	Moderate	Moderate	Moderate

As indicated in the above table, there has been only a slight increase in the stability index for this site.

Riparian Vegetation Cross-Section Data Summary

Data were collected from three (3) cross-section transections.

Changes in percentage of plant communities in the riparian complex can indicate a trend in stability and ecological status. Because the cross-section transections extended across the entire riparian area, cross-section data can show changes in plant community composition within the riparian complex. Changes in plant communities can be used as indicators of changes in hydrologic moisture regimes within the riparian complex. It can also indicate changes in the ecological status of the riparian complex.

Changes in hydrologic moisture regime can indicate changes in stream channel width, and/or that the water table is rising or lowering in the riparian zone. At the Above Narrows (Treated) Site, there has been a significant increase in hydroriparian and a significant decrease in both mesoriparian and xeroriparian, which indicates that the drier part of the riparian area is becoming more moist. A summary of changes in hydrologic moisture regime along the cross-section transections is shown as follows:

Hydrologic Moisture Regime Along Cross-section (%)				
	1993	1994	1995	1998
Hydroriparian	13	20	32	53
Mesoriparian	67	59	49	37
Xeroriparian	20	21	19	10

Estimated Ecological Status

Data from the cross-section transections can be used to estimate the ecological status of the riparian complex. The apparent trend in ecological status is summarized as follows:

Ecological Status Trends				
	1993	1994	1995	1998
Ecological Status	Early Seral	Mid Seral	Mid Seral	Mid Seral

Woody Species Regeneration

No woody species were found on this site. It is not expected that woody species will be recruited into this site because stream gradient is so low.

Photographic Documentation

Although photographs may not be used to provide quantitative data, they can be used to visually represent the data being collected, and as an aid in information transfer and understanding. Photographs (35mm color slides) were taken at 20 established photo-points in 1993, 1994, 1995 and 1998.

OTTER CREEK ABOVE NARROWS (Un-treated) SITE

Riparian Classification

Riparian vegetation are classified using the riparian classification system developed by Petersen and Sennett (1996). The study site riparian area is located in the Utah Plateaus (E47B) major land resource area. It is a fresh water, riverine system in a confined alluvial valley with a frigid temperature regime. The riparian complex has an estimated potential to be about 85 percent hydroriparian made up of Beaked sedge (*Carex rostrata*) and Nebraska sedge (*Carex nebrascensis*) communities; about 10 percent mesoriparian made up of Blackcreeper sedge (*Carex praegracilis*) and Baltic rush (*Juncus balticus*) communities, and about 5 percent Xeroriparian made up of Rubber rabittbrush (*Chrysothamnus nauseosus Var. consimilis*) and Saltgrass (*Distichlis spicata*) communities.

Riparian Vegetation Green-Line Data Summary

Data was collected from two (2) green-line transections.

Changes in percentage of plant communities along the green-line can indicate a trend in stability and ecological status. The following summary shows that there has not been a significant change in wetland communities at the Above Narrows (Un-treated) site:

	Percent of Green-Line Transections			
	1993	1994	1995	1998
Wetland Communities	55	55	66	60

Another indicator of trend in the green-line is a change in hydrologic moisture regime. An increase in hydroriparian (riparian wetland) can indicate that the stream channel is narrowing or that the water table is rising. At the Above Narrows (Un-treated) site, there has not been a significant change in hydrologic moisture regime since monitoring began in 1993. A summary of changes in hydrologic moisture regime along the green-line is shown as follows:

	Hydrologic Moisture Regime Along Green-line (%)			
	1993	1994	1995	1998
Hydroriparian	55	55	66	60
Mesoriparian	45	45	34	40
Xeroriparian	0	0	0	0

Green Line Stability Rating

Data from the green line transections are used to compute a stability index which is an indicator of the ability of the present riparian vegetation to resist erosion forces and stabilize the stream banks. The green line stability index is on a scale of 1 to 10 with 1 being very poor and 10 being excellent.

The green line stability index at the Above Narrows (Un-treated) site is summarized in the following table.

Green-line Stability Index	1993	1994	1997	1998
Numeric	7.15	5.38	7.98	5.31
Descriptive	Good	Moderate	Good	Moderate

As indicated above, there has not been a significant change in the stability index for this site. Streambank and channel erosion not changed significantly at this site since monitoring began in 1993.

Riparian Vegetation Cross-Section Data Summary

Data were collected from three (3) cross-section transections.

Changes in percentage of plant communities in the riparian complex can indicate a trend in stability and ecological status. Because the cross-section transections extended across the entire riparian area, cross-section data can show changes in plant community composition within the riparian complex. Changes in plant communities can be used as indicators of changes in hydrologic moisture regimes within the riparian complex. It can also indicate changes in the ecological status of the riparian complex.

Changes in hydrologic moisture regime can indicate changes in stream channel width, and/or that the water table is rising or lowering in the riparian zone. At the Above Narrows (Un-treated) Site, there has been a slight decrease in mesoriparian and xeroriparian, and a slight increase in hydroriparian, which indicates that the drier part of the riparian area may be becoming more moist.

A summary of changes in hydrologic moisture regime along the cross-section transections is shown as follows:

Hydrologic Moisture Regime Along Cross-section (%)

	1993	1994	1995	1998
Hydroriparian	26	23	27	33
Mesoriparian	70	73	67	64
Xeroriparian	4	4	6	3

Estimated Ecological Status

Data from the cross-section transections can be used to estimate the ecological status of the riparian complex. The apparent trend in ecological status is summarized as follows and shows no change at the Above Narrows (Un-treated site):

	Ecological Status Trends			
	1993	1994	1995	1998
Ecological Status	Early Seral	Early Seral	Early Seral	Early Seral

Woody Species Regeneration

No woody species were found on this site. It is not expected that woody species will be recruited into this site because stream gradient is so low.

Photographic Documentation

Although photographs may not be used to provide quantitative data, they can be used to visually represent the data being collected, and as an aid in information transfer and understanding. Photographs (35mm color slides) were taken at 28 established photo-points in 1993, 1994, 1995 and 1998.

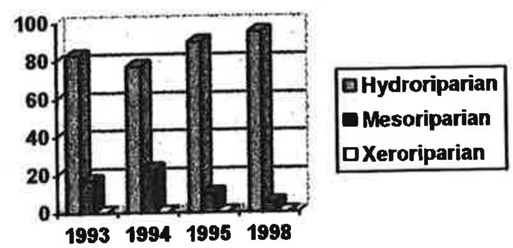
REFERENCES

Petersen, Mark M. and Sennett, Robert F. 1996. A riparian classification system for riparian areas in Utah. Utah Riparian Management Coalition, Technical Paper. 7p.

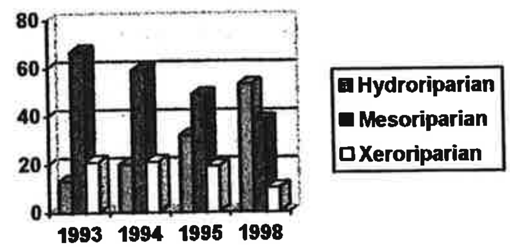
OTTER CREEK WATERSHED
CHANGES IN RIPARIAN WETLAND VEGETATION

OTTER CREEK ABOVE NARROWS Treated:

Green Line Vegetation

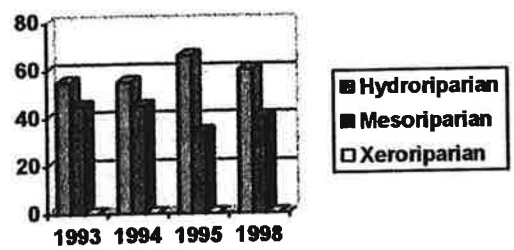


Cross-Section Vegetation

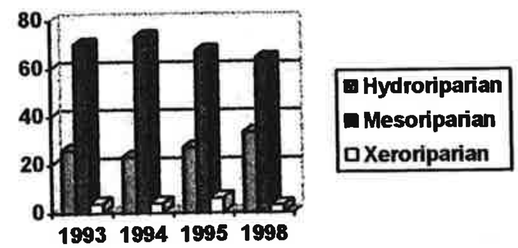


OTTER CREEK ABOVE NARROWS Untreated:

Green Line Vegetation

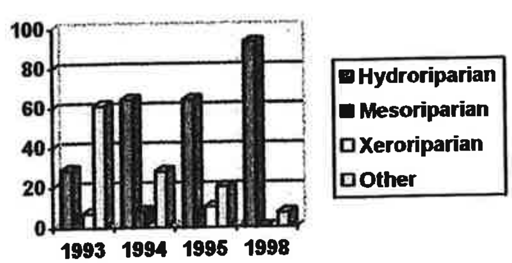


Cross-Section Vegetation

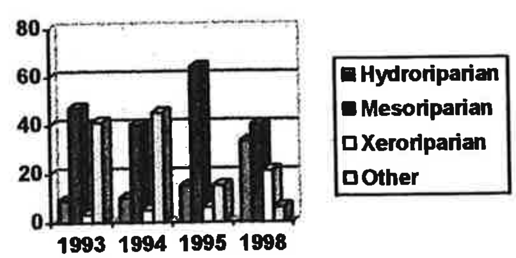


OTTER CREEK AT ANGLE:

Green Line Vegetation



Cross-Section Vegetation



Monitoring Report
NPS Interagency Monitoring Workgroup
CHAPTER NINE: AQUATIC HABITAT EVALUATION
Otter Creek Watershed

Introduction

The Otter Creek drainage, between Koosharem and Otter Creek Reservoirs, was subjected to four years (Nov. 7-9,1989; Oct. 18-20,1991; July 28-30,1992; and Oct. 19-20,1993) of treatment with liquid rotenone in late summer/early fall to eliminate all trout. This was done in effort to eliminate whirling disease (*Myxobolus cerebralis*) which had been documented in this area. Rotenone is an approved chemical, by the Environmental Protection Agency, for such use. The effect of these treatments was the eradication of all trout and an undetermined, but probable, impact on macroinvertebrate populations. Adult leatherside chub (*Gila copei*) were reintroduced into this area in 1994. Subsequently, fingerling brown trout (*Salmo trutta*) have also been stocked yearly from 1995 to 1998. No reintroduction of macroinvertebrates have occurred, nor are any planned.

The NPS Interagency Monitoring Workgroup conducted a field study on three reaches of Otter Creek, Piute County, Utah in August 1993, 1994, 1995, and 1998. As part of these studies, data was collected for fisheries habitat using Binns's Habitat Quality Index (Binns, 1982). The report presents and summarizes the data for three reaches described as Otter Creek at Angle, Otter Creek above Narrows-Treated, and Otter Creek above Narrows-Untreated. Supplemental data from DEQ Storet monitoring locations is included within this progress report for stream temperature, stream flow, and macroinvertebrate samples.

Otter Creek at Angle

Summary

1. Habitat Quality Index (Binns, 1982) results are summarized in Table 9.1.

Table 9.1 Otter Creek at Angle, Utah 1993-1998.

HQI Attribute	Data Value/Rating July 29, 1993		Data Value/Rating Aug. 3, 1994		Data Value/Rating Aug. 1, 1995		Data Value/Rating July 29, 1998	
Late summer flow (CPF/ADF) Percent of annual daily flow	1990-1993 Storet <10%	0	1990-1993 Storet <10%	0	1990-1993 Storet <10%	0	1990-1993 Storet <10%	0
Annual streamflow variation (peak to low flow)	1990-1993 Storet Peak flow is 53 times the low flow	2	1990-1993 Storet Peak flow is 53 times the low flow	2	1990-1993 Storet Peak flow is 53 times the low flow	2	1990-1993 Storet Peak flow is 53 times the low flow	2
Max summer stream temperature (F)*	Category: 55-65 F	4	Category: 55-65 F	4	Category: 55-65 F	4	Category: 55-65 F	4
Nitrate Nitrogen (mg/l)	0.37 mg/l	3	0.684 mg/l	2	0.47 mg/l	3	1.65 mg/l	1
Cover (ft^2)	17 ft^2, 1.02%	0	12 ft^2, 0.53%	0	463 ft^2, 17%	1	610 ft^2, 23%	1
Eroding Bank (ft)	178 ft, 105%	0	0 ft, 0%	4	52 ft, 17%	3	34 ft, 11	3
Fish food abundance (macros/ft^2)	field est. 250-500/ft^2	3	DEQ '94 data 2730/ft^2	4	9587/ft^2	4	9492/ft^2	4
Water velocity (dye tests)	0.36 ft/sec	1	0.38 ft/sec	1	1.14 ft/sec	3	1.0 ft/sec	3
Avg stream width (ft)	9.8 ft	2	7.5 ft	2	9.27 ft	2	8.66 ft	4
Habitat Quality Index	24.05		22.3		83.71		41.61	
Predicted Standing Crop (lbs/acre)	22.27		20.65		77.5		38.6	

*Max summer stream temperature is based on DEQ STORET monitoring records.

2. The HQI monitoring reach at Angle starts at the G-0 (geomorphology survey) transect and is 300 ft in length. There were eleven equally spaced transects temporarily placed to measure average wetted channel width. The average width, along with the length, was used to calculate the area of the reach. Based on this area, percent eroding bank and cover were measured. Average water velocity was measured using a timed-distance dye test, nitrate nitrogen was collected and preserved for lab analysis, and macroinvertebrates were collected in a riffle at G0. Stream flow records and maximum summer temperature data came from the Division of Water Quality's non point source monitoring records.

3. The parameters that significantly influenced the HQI score were the eroding banks, cover and nitrate nitrogen. Figures 9.1-9.4 shows the results of these measurements, followed by a brief discussion of the measured attributes.

Instream cover shown in Figure 9.1, exhibits considerable improvement at the Angle site with the BMP's implemented. Increased habitat cover was observed by measuring increased pool and pocket pool areas, overhanging grasses on the bank, and establishment of rooted instream vegetation.

Eroding bank data is shown in Figure 9.2. The Angle site shows considerable bank stabilization with the Best Management Practices (BMP's) implemented. Eroding banks decreased over the monitoring period from raw banks throughout the reach, to early stage vegetation species covering most bank area. Rip rap placement helped reduce erosion in the most severe areas. In addition, the restriction of livestock use at this site has contributed to stream bank stabilization.

Nitrate Nitrogen values are shown in Figure 9.3. The Otter Creek at Angle site exhibited the highest readings. Some of the variation in readings may be attributed to the application of chemical fertilizers within the watershed, but this attribute is highly variable. Stream flow at this location is largely dependent on return irrigation flows. Additional water chemistry data collected by the Division of Water Quality throughout the basin, provides a watershed perspective on water quality (DWQ, Water Quality Assessment: Otter Creek, Piute and Sevier Counties, Utah).

Water temperatures. The Otter Creek at Angle site appears to maintain temperatures well below 68 degrees F (20° C). The maximum stream temperature is best represented by category 4: 55-65 degrees F, based on our measured data (57F, 68F, 60F, and 60F) and Division of Water Quality Storet monitoring data. This may result from the contribution of subsurface return irrigation water.

Fish food abundance (macroinvertebrate samples). Macroinvertebrates were collected for the HQI evaluation using a Surber sampler to measure the number of individuals per square foot. In addition to that analysis, Fred Mangum's Forest Service lab used several indices to assess water quality. Due to the rotenone treatment during the early 1990's, a field estimation was done in 1993 and data from Water Quality was used for the HQI in 1994. In addition to the work group samples, supplemental data from the Division of Water Quality is included in Table 9.2.

Based on both DWQ and HQI samples, the Biotic Condition Index ranged from 49 to 57, which indicates the benthic communities were extremely stressed (Mangum, 1998). Biodiversity of taxa declined from 1995 to 1998. The Angle site was dominated by sediment and organic enrichment tolerant species, and cleanwater taxa were absent. A healthy stream should include a diverse community of macro-invertebrates, with some pollutant tolerant species and cleanwater taxa. As water quality degrades, the community structure is reduced to a few kinds of sediment, or pollutant, tolerant organisms.

HQI and Predicted Standing Crop are shown in Figure 9.4. The HQI shows an upward trend from the beginning of the project.

Otter Creek above Narrows-Treated

Summary

1. Habitat Quality Index (Binns, 1982) results are summarized in Table 9.3.

Table 9.3 Otter Creek above Narrows-Treated, Utah 1993-1998.

HQI Attribute	Data Value/Rating July 27, 1993		Data Value/Rating Aug. 2, 1994		Data Value/Rating July 31, 1995		Data Value/Rating July 30, 1998	
Late summer flow (CPF/ADF) Percent of annual daily flow	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4
Annual streamflow variation (peak to low flow)	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4
Max summer stream temperature (F)*	Category: 71-75 F	2	Category: 71-75 F	2	Category: 71-75 F	2	Category: 71-75 F	2
Nitrate Nitrogen (mg/l)	<0.02 mg/l	1	<0.02 mg/l	1	<0.02 mg/l	1	<0.1 mg/l	3
Cover (ft^2)	977.5 ft^2, 14%	1	4060 ft^2, 28%	2	1864 ft^2, 13%	1	6070 ft^2, 39%	2
Eroding Bank (ft)	571.3 ft, 150%	0	412 ft, 55%	1	161 ft, 21%	3	90 ft, 12%	3
Fish food abundance (macros/ft^2)	field est. 25-59 macros/ft^2	1	0 /ft^2, trmt	0	3857/ft^2	4	1771/ft^2	4
Water velocity (dye tests)	0.61 ft/sec	2	0.47 ft/sec	1	0.49 ft/sec	1	0.60 ft/sec	2
Avg stream width (ft)	18.61 ft	4	19 ft	4	19.4 ft	4	20.7 ft	4
Habitat Quality Index	20.6		10.6		49.1		163.6	
Predicted Standing Crop (lbs/acre)	19.1		9.8		45.5		151.5	

*Max summer stream temperature is based on DEQ STORET monitoring records.

2. The HQI monitoring reach Above the Narrows-Treated starts at G99 (geomorphology survey) transect and is 750 ft in length. There were eleven equally spaced transects temporarily placed to measure wetted width. The average width, along with the length, was used to calculate the area of the reach. Based on this area, percent eroding bank and cover were measured. Average water velocity was measured using a timed-distance dye test, nitrate nitrogen is collected and preserved for lab analysis, and macroinvertebrates were collected in a riffle at G3. Stream flow records came from the Division of Water Quality's non point source monitoring data, and the maximum temperature data was from a Hobo temperature recorder that was placed in the stream in late summer.

3. The parameters that significantly influenced the HQI rating Above the Narrows- Treated were the eroding banks, cover and nitrate nitrogen. Figures 9.5-9.8 shows the results of these measurements.

Instream cover shown in Figure 9.5, exhibits an overall increase in habitat cover from 1993 to

1998. There was an increase in pool and pocket pool area, undercut banks with overhanging grassy vegetation, and rooted macrophytes.

Eroding bank data is shown in Figure 9.6. The Treated site has shown considerable bank stabilization with Best Management Practices (BMP's) implemented. The establishment of stream bank grasses reduced the area of raw eroding banks.

Nitrate Nitrogen values are shown in Figure 9.7. The higher nitrate nitrogen value measured in 1998 significantly influenced the HQI score. This attribute usually remains low at this site, so 1998 could be an outlier measurement. Additional water chemistry data collected by the Division of Water Quality throughout the basin, provides a watershed perspective on water quality (DWQ, Water Quality Assessment: Otter Creek, Piute and Sevier Counties, Utah).

Water temperatures were recorded at the Otter Creek Above Narrows-Treated using a Hobo temperature data logger. The Hobo data logger recorded temperatures from July 29, 1998 through October 6, 1998 (Table 9.4). According to the HQI protocol, the critical time period is August 1 to September 15, so data from this time period was used (Binns, 1982). The maximum temperature of 68 F (20C) is the standard for a Class 3A, cold water game fishery, stream.

Fish food abundance (macroinvertebrate samples). Macroinvertebrates were collected for the HQI evaluation using a Surber sampler to measure the number of individuals per square foot. In addition to that analysis, Fred Mangum's Forest Service lab used several indices to assess water quality. Due to the rotenone treatment during the early 1990's, a field estimation was done in 1993 and data was not collected for the HQI in 1994. Supplemental data collected at the Narrows by the Division of Water Quality is included in Table 9.5.

Based on both DWQ and HQI samples, the Biotic Condition Index ranged from 51 to 57, which indicates the benthic communities were extremely stressed (Mangum, 1998). The Treated site was dominated by sediment and organic enrichment tolerant simuliids; cleanwater taxa were missing. High numbers of simuliids often reflect high organic nutrient loading. Low number of shredders indicate poor or unsuitable habitat conditions and spawning substrate in the riparian area. Conditions remained the stressed from 1995 to 1998.

HQI and Predicted Standing Crop are shown in Figure 9.8. The HQI is increased significantly from the beginning of the monitoring period.

Otter Creek above Narrows-Untreated

Summary

1. Tabled values of the Habitat Quality Index (Binns, 1982) are summarized in Table 9.6.

Table 9.6 Otter Creek above Narrows-Untreated, Utah 1993-1998.

HQI Attribute	Data Value/Rating July 28, 1993		Data Value/Rating Aug. 3, 1994		Data Value/Rating Aug 1, 1995		Data Value/Rating July 28, 1998	
Late summer flow (CPF/ADF) Percent of annual daily flow	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4	1990-1993 Storet >55%	4
Annual streamflow variation (peak to low flow)	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4	1990-1993 Storet Peak flow is 13 times the low flow	4
Max summer stream temperature (F)*	Hobo: 71-75 F measured: 75 F	2	Hobo: 71-75 F measured: 67 F	2	Hobo: 71-75 F measured: 68 F	2	Hobo: 71-75 F measured: 68 F	2
Nitrate Nitrogen (mg/l)	<0.02 mg/l	1	<0.02 mg/l	1	0.09 mg/l	2	<0.1 mg/l	3
Cover (ft^2)	1055 ft^2, 16%	1	2473 ft^2, 25%	1	3459 ft^2, 35%	2	5119 ft^2, 53%	3
Eroding Bank (ft)	53.5 ft, 16%	3	94 ft, 22%	3	60 ft, 14%	3	54 ft, 13%	3
Fish food abundance (macros/ft^2)	field est. <25 macros/ft^2	0	0 /ft^2	0	3293/ft^2	4	1909/ft^2	4
Water velocity (dye tests)	0.62 ft/sec	2	0.37 ft/sec	1	0.42 ft/sec	1	0.60 ft/sec	2
Avg stream width (ft)	20.1 ft	4	23.4 ft	3	23.8 ft	3	23 ft	3
Habitat Quality Index	11.5		10.6		79.3		167	
Predicted Standing Crop (lbs/acre)	10.6		9.8		73.4		154.7	

*Max summer stream temperature is based on DEQ STORET monitoring records.

2. The HQI monitoring reach Above the Narrows-Untreated starts at G0 (geomorphology survey) transect and is 420 ft in length. There were eleven equally spaced transects temporarily placed to measure wetted width. The average width, along with the length, was used to calculate the area of the reach. Based on this area, percent eroding bank and cover were measured. Average water velocity was measured using a timed-distance dye test, nitrate nitrogen is collected and preserved for lab analysis, eroding banks and cover were measured through the reach, and macroinvertebrates were collected at G1. Stream flow records came from the Division of Water Quality's non point source monitoring data, and the maximum temperature data was from a Hobo temperature recorder that was placed in the stream in late summer at the Treated site. The locations are in close proximity to one another, and it is reasonable to use the data for both Treated and Untreated sites.

3. The parameters that significantly influenced the HQI rating Above the Narrows-Untreated were the macroinvertebrate numbers, cover, eroding bank, and nitrate nitrogen. Figure 9.9-9.12 shows the results of these measurements.

Instream cover shown in Figure 9.9 increased from 1993 to 1998 at the Untreated site. The Untreated site improvement may be the result of changed land management practices at this site.

Eroding bank data is shown in Figure 9.10. The Untreated site has remained fairly constant over the monitoring period.

Nitrate Nitrogen is shown in Figure 9.11. The nitrate nitrogen values measured in 1995 and 1998 significantly influenced the HQI score. Additional water chemistry data collected by the Division of Water Quality throughout the basin, provides a watershed perspective on water quality (DWQ, Water Quality Assessment: Otter Creek, Piute and Sevier Counties, Utah).

Water temperatures were recorded at the Otter Creek Above Narrows-Treated using a Hobo temperature data logger and will also be used for the Untreated site HQI temperature attribute. The Hobo data logger recorded temperatures from July 29, 1998 through October 6, 1998 (Table 9.4). According to the HQI protocol, the critical time period is August 1 to September 15, so data from this time frame was used (Binns, 1982). The maximum temperature of 68 F (20C) is the standard for a Class 3A, cold water game fishery, stream.

Fish food abundance (macroinvertebrate samples). Macroinvertebrates were collected for the HQI evaluation using a Surber sampler to measure the number of individuals per square foot. In addition to that analysis, Fred Mangum's Forest Service lab used several indices to assess water quality. Due to the rotenone treatment during the early 1990's, a field estimation was done in 1993 and data was not collected for the HQI in 1994. Supplemental data collected at the Narrows by the Division of Water Quality is included in Table 9.5.

Based on both DWQ and HQI samples, the Biotic Condition Index ranged from 51 to 57, which indicates the benthic communities were extremely stressed (Mangum, 1998). The Untreated site was dominated by sediment and organic enrichment tolerant simuliids; cleanwater taxa included only one mayfly. Low number of shredders indicate poor or unsuitable habitat conditions and spawning substrate in the riparian area. Conditions remained the stressed from 1995 to 1998.

Predicted Standing Crop of trout (lbs/acre) The Untreated sites shows improvement.

Conclusions

Electrofishing surveys have not been conducted at the monitoring sites due to rotenone treatments, and only recent reintroduction of brown trout and leatherside chubs. Brown trout were visibly observed at both the Treated and Untreated sites in 1998. Electrofishing surveys will be conducted during the next scheduled monitoring year to compare the predicted standing crop and the actual standing crop. An electrofishing survey was conducted two river miles downstream of the Treated site in 1998 by the Utah Division of Wildlife Resources. This survey indicated the presence and growth of brown trout and leatherside chubs.

In summary, certain attributes have shown improvement, while others have remained unchanged. It is thought that it will take nearly a decade of time before some attribute parameters can be expected to show change. Several attributes are affected by seasonal variation in precipitation, and the diversion of water for agricultural use in the area. The application of fertilizers or pesticides also has an influence. The streambed may dry up in some reaches, and drawn quite low in others, during drought years.

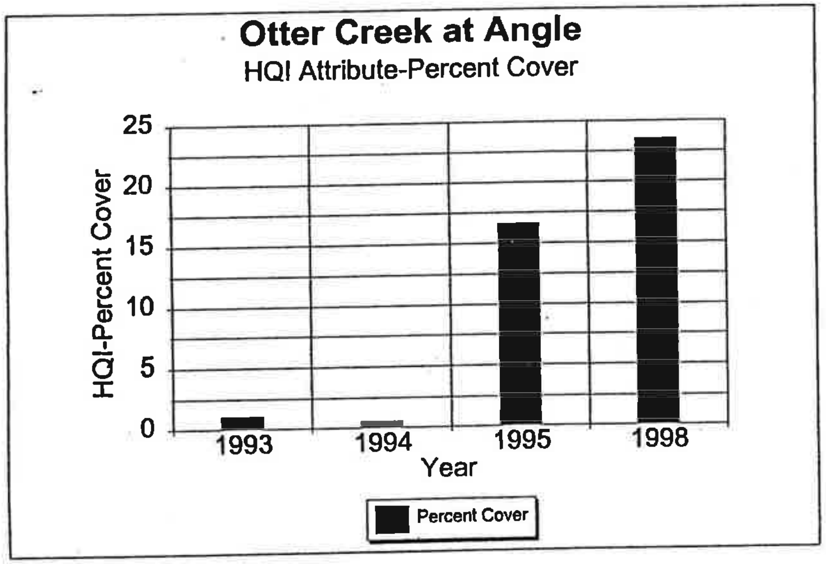


Figure 9.1 Cover Attribute at Angle

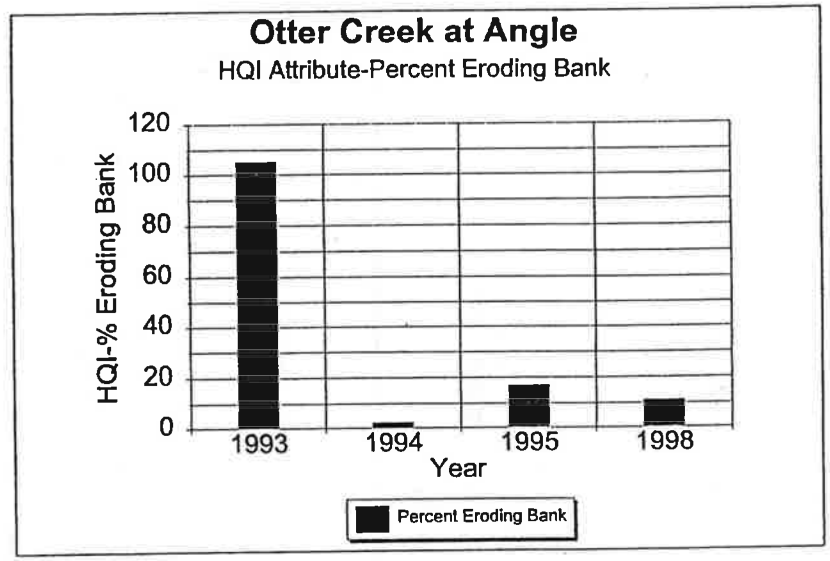


Figure 9.2 Eroding Bank Attribute at Angle

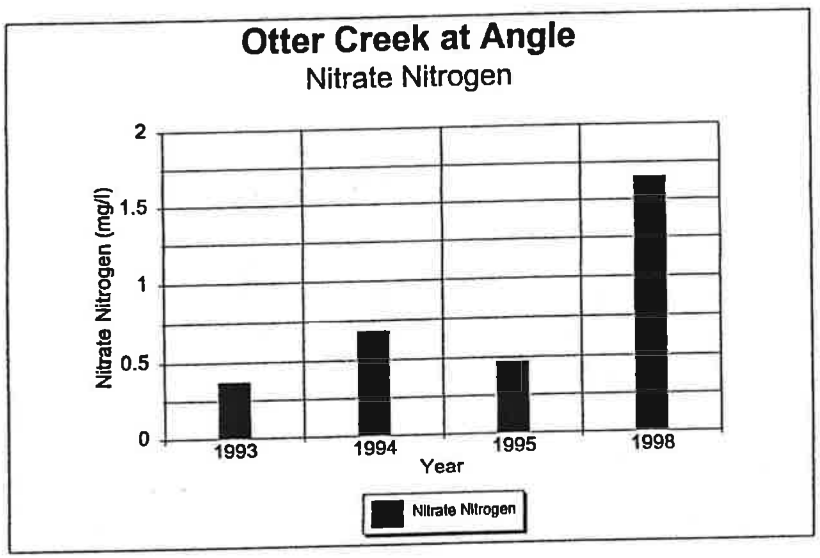


Figure ~~3~~ 9.3. Nitrate Nitrogen Attribute

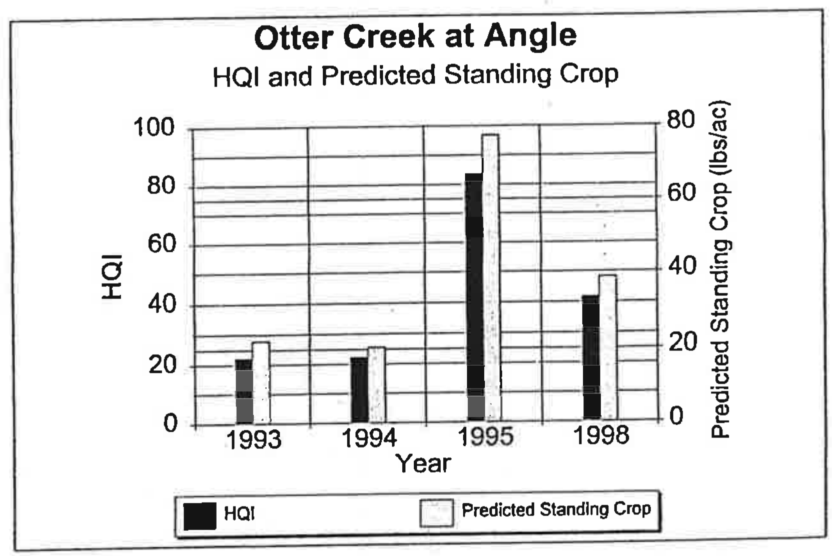


Figure 4 9.4. HQI and Predicted Standing Crop

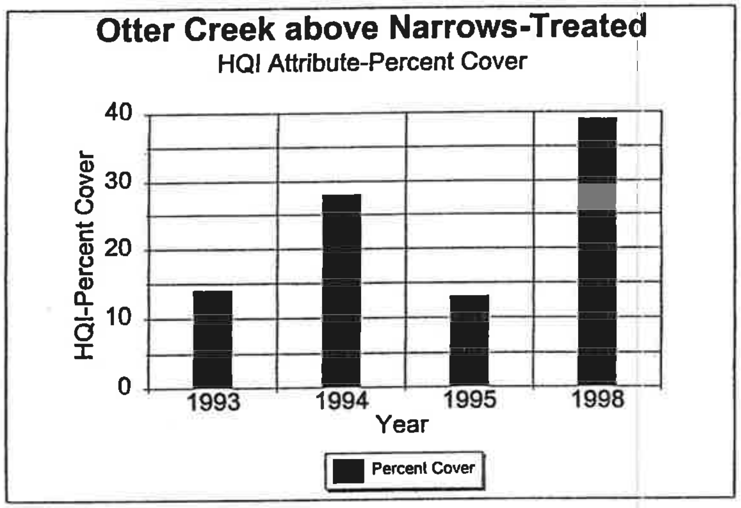


Figure 9.5 Cover Attribute

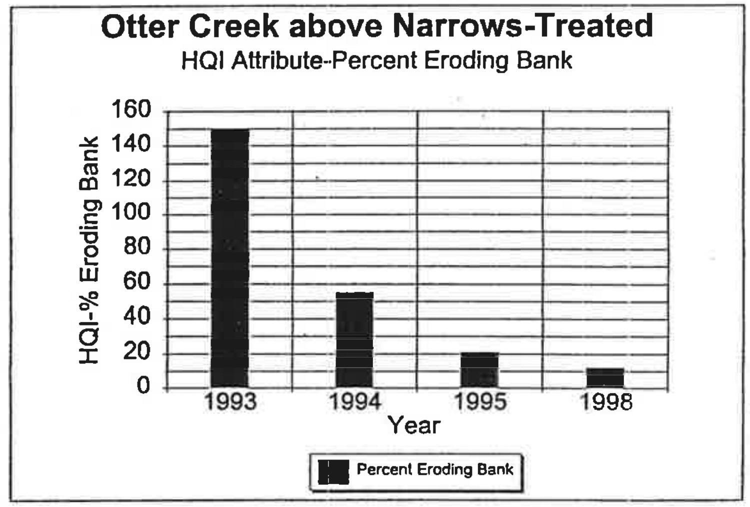


Figure 9.6 Eroding Bank Attribute

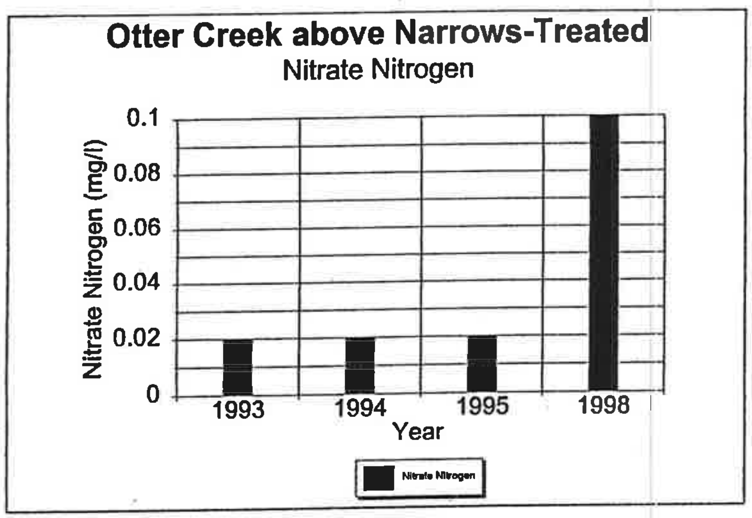


Figure 9.7 Nitrate Nitrogen Attribute

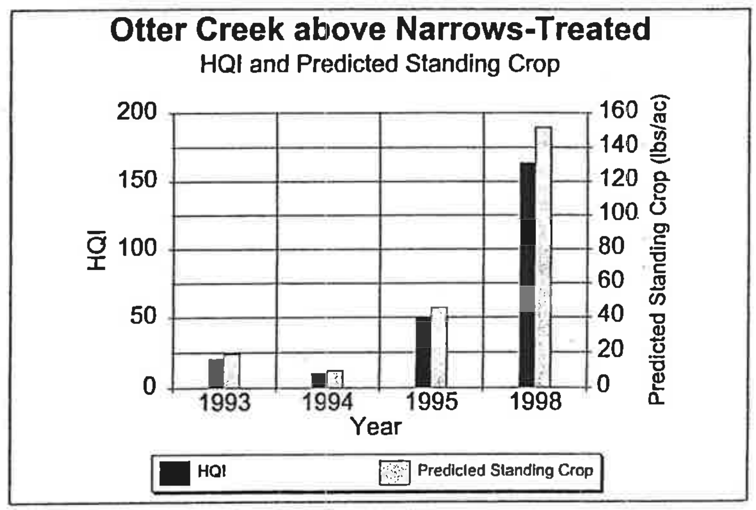


Figure 9.8 HQI and Predicted Standing Crop

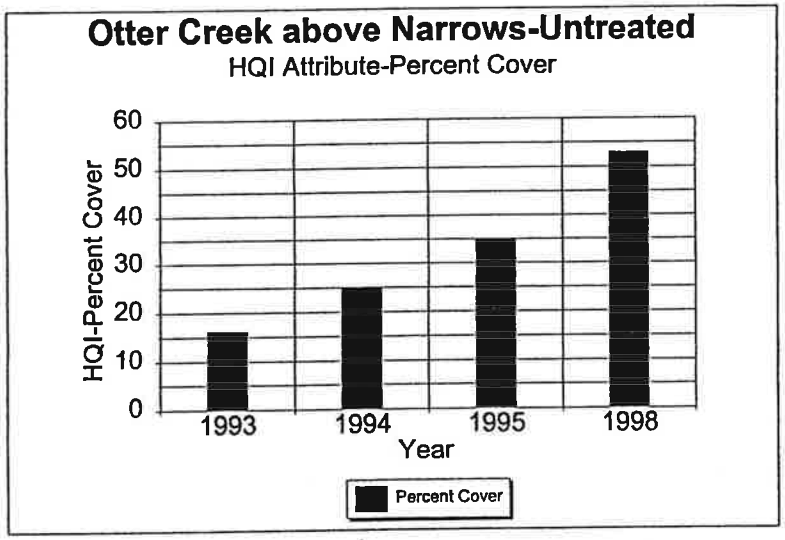


Figure 9.9 Cover Attribute

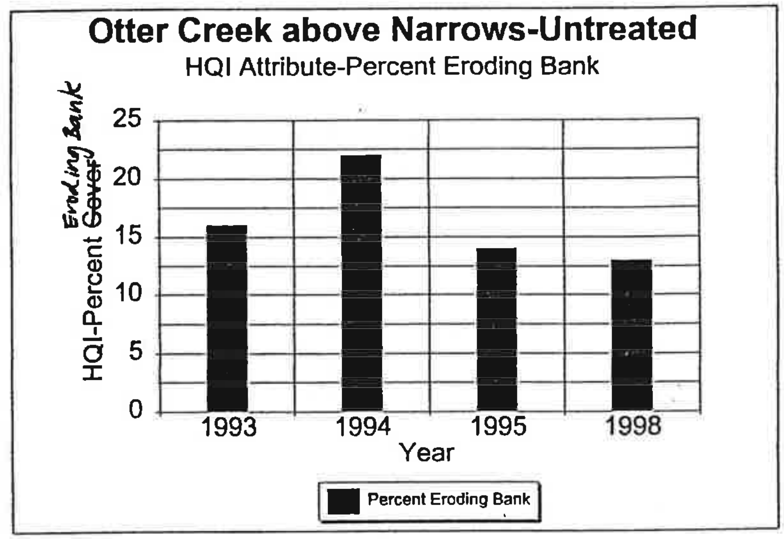


Figure 9.10 Eroding Bank Attribute

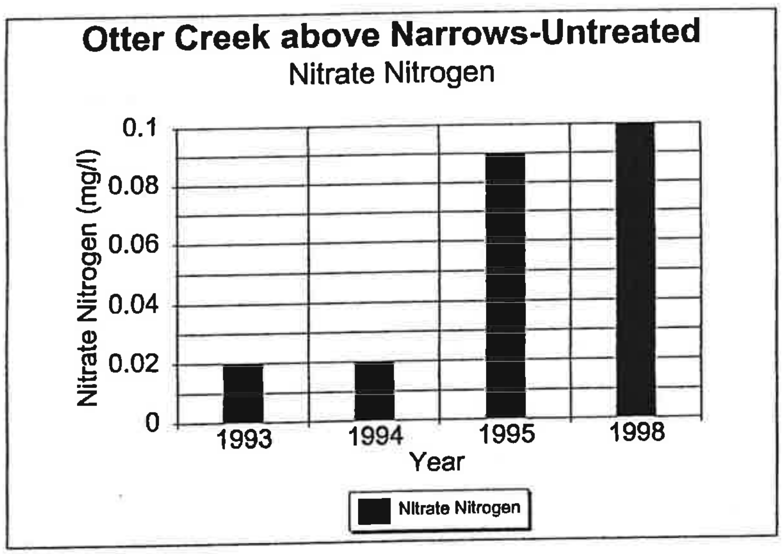


Figure 9.11 Nitrate Nitrogen Attribute

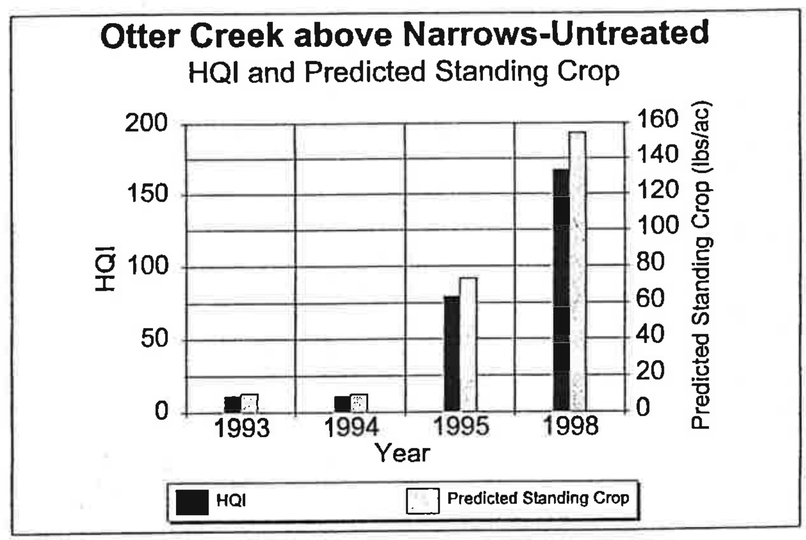


Figure 9.12 HQI and Predicted Standing Crop

Macroinvertebrate Analysis Summary
Otter Creek, Piute and Sevier Counties, Utah

Data Collected by Non Point Source Monitoring Work Group and Division of Water Quality.
Data analyzed by Fred Mangum, USDA-Forest Service, Provo Utah

Table 9.2 Otter Creek near Angle, Utah.

Station	Date	Diversity Index DAT (mean)	Standing Crop g/m^2 (mean)	Number of Organisms/ m^2	Number of Taxa	Biotic Condition Index BCI 50
494920	11/01/90	4.8	32	21,006	27	52
494920	04/18/91	4.6	17.8	18,988	14	53
494920	11/21/91	4.3	38.9	24,284	22	51
494920	04/09/92	4.3	23.2	22,785	21	49
494920	08/27/92	9.4	7.0	31,657	24	51
494920	10/14/92	7.8	31.3	55,198	23	51
494920	03/23/93	4.6	1.9	11,001	22	53
494920	08/17/93	5.2	5.3	36,738	17	53
494920	11/04/93	3.1	23	8,151	22	51
494920	04/06/94	4.9	11.5	15,769	19	53
494920	10/04/94	8.1	6.2	29,388	24	50
At Angle	08/3/95	10.7	11.3	103,205	24	57
At Angle	07/29/98	5.4	8.0	102,186	23	56

Scale	DAT	Standing Crop	BCI
Excellent	18-26	4.0-12.0	above 90
Good	11-17	1.6-4.0	80-90
Fair	6-10	0.6-1.5	72-79
Poor	0-5	0.0-0.5	below 72

9.4

Table 4. Data collected from Hobo Temperatrue Recorder at the Narrows-Treated Site.

DATE	MIN (F)	MAX (F)	AVG (F)	MIN (C)	MAX (C)	AVG (C)
7/29/98	64.22	68.33	66.22	17.90	20.18	19.01
7/30/98	60.80	70.39	65.26	16.00	21.33	18.48
7/31/98	60.80	70.39	65.04	16.00	21.33	18.35
8/1/98	55.97	71.08	63.40	13.32	21.71	17.45
8/2/98	57.35	73.15	64.98	14.08	22.86	18.32
8/3/98	58.73	73.84	65.94	14.85	23.24	18.85
8/4/98	59.42	75.22	66.97	15.23	24.01	19.43
8/5/98	61.48	76.62	68.35	16.38	24.79	20.19
8/6/98	60.80	75.92	68.06	16.00	24.40	20.03
8/7/98	61.48	73.15	67.14	16.38	22.86	19.52
8/8/98	60.8	66.96	64.49	16.00	19.42	18.05
8/9/98	57.35	71.77	64.35	14.08	22.09	17.97
8/10/98	61.48	69.02	64.56	16.38	20.57	18.09
8/11/98	59.42	72.46	65.70	15.23	22.48	18.72
8/12/98	58.73	71.08	64.98	14.85	21.71	18.32
8/13/98	58.73	73.15	65.50	14.85	22.86	18.61
8/14/98	59.42	70.39	65.35	15.23	21.33	18.53
8/15/98	58.04	71.77	64.54	14.47	22.09	18.08
8/16/98	58.04	69.02	63.90	14.47	20.57	17.72
8/17/98	58.73	69.71	64.06	14.85	20.95	17.81
8/18/98	58.04	67.65	62.83	14.47	19.81	17.13
8/19/98	55.28	68.33	61.72	12.93	20.18	16.51
8/20/98	55.97	71.08	62.86	13.32	21.71	17.14
8/21/98	57.35	70.39	63.95	14.08	21.33	17.75
8/22/98	59.42	73.84	66.02	15.23	23.24	18.90
8/23/98	59.42	73.15	66.02	15.23	22.86	18.90
8/24/98	58.73	66.28	63.35	14.85	19.04	17.42
8/25/98	57.35	66.28	61.75	14.08	19.04	16.53
8/26/98	57.35	69.71	63.38	14.08	20.95	17.43
8/27/98	56.66	72.46	64.32	13.70	22.48	17.96
8/28/98	57.35	73.84	64.78	14.08	23.24	18.21
8/29/98	57.35	73.15	64.89	14.08	22.86	18.27
8/30/98	56.66	68.33	62.89	13.70	20.18	17.16
8/31/98	58.73	62.17	59.97	14.85	16.76	15.54
9/1/98	55.97	62.85	59.90	13.32	17.14	15.50
9/2/98	56.66	69.02	62.16	13.70	20.57	16.76
9/3/98	56.66	68.33	62.38	13.70	20.18	16.88
9/4/98	59.42	67.65	63.18	15.23	19.81	17.32
9/5/98	59.42	70.39	63.74	15.23	21.33	17.63
9/6/98	60.11	64.91	62.30	15.62	18.28	16.83
9/7/98	57.35	63.54	60.42	14.08	17.52	15.79
9/8/98	55.97	64.22	60.27	13.32	17.90	15.71
9/9/98	55.28	66.96	60.94	12.93	19.42	16.08
9/10/98	58.73	67.65	62.34	14.85	19.81	16.85
9/11/98	55.97	61.48	57.87	13.32	16.38	14.37
9/12/98	53.89	63.54	58.03	12.16	17.52	14.46
9/13/98	53.19	64.91	59.29	11.77	18.28	15.16
9/14/98	53.89	68.33	60.77	12.16	20.18	15.98
9/15/98	55.28	68.33	61.77	12.93	20.18	16.54

Table 9.5 Otter Creek At Narrows.

Station	Date	Diversity Index DAT (mean)	Standing Crop g/m^2 (mean)	Number of Organisms/ m^2	Number of Taxa	Biotic Condition Index BCI 50
494894	11/02/90	11.0	10.6	21,742	21	56
494894	04/18/91	13.5	13.7	66,223	25	54
494894	08/14/91	10.0	2.2	14,671	26	52
494894	11/21/91	13.2	3.0	14,316	29	52
494894	04/10/92	9.4	8.2	41,248	23	51
494894	08/27/92	14.7	7.1	28,078	28	53
494894	10/14/92	9.5	3.7	14,316	26	54
494894	03/24/93	8.8	2.3	8,272	19	52
494894	08/17/93	12.1	1.1	8,603	25	54
494894	11/04/93	15.0	1.1	4,665	33	56
494894	10/18/95	13.2	7.9	80,472	27	53
494894	04/04/95	11.7	7.2	27,933	26	52
mwg-mid	08/01/95	12.2	9.6	41,517	21	57
mwg-upper	08/02/95	13.5	7.4	35,442	26	55
494894	10/18/95	13.2	7.9	80,472	27	53
494894	04/04/95	11.7	7.2	27,933	26	52
494894	10/30/96	12.3	4.7	23,239	23	54
484894	04/26/96	13.6	18.3	35,736	23	54
484894	03/19/97	12.1	2.8	5866	29	57
484894	10/9/97	10.8	3.6	25188	21	54
484894	04/16/98	9.1	3.5	15920	19	52
mwg-mid	07/29/98	13.7	3.6	19,070	25	57
mwg-upper	07/28/98	12.3	1.9	20,552	26	57

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CHAPTER TEN: CONCLUSIONS

Introduction

The NPS Monitoring Workgroup primary objective is to conduct effectiveness monitoring of resource management systems and BMP's of Section 319 funded watershed projects. Conclusions written in this report are reflective of the interdisiplinary efforts of the monitoring workgroup. The three Otter Creek projects discussed in this progress report have been monitored over a five year period. Considering this short time frame, this report is a *progress* evaluation of the sites.

The interdisiplinary method taken by the workgroup gives a detailed evaluation of the stream system. By integrating riparian vegetation surveys, fisheries habitat surveys, and physical channel characteristics, changes in the stream *system* can be measured. It is essential to state objectives, monitor the site before, during, and after project implementation, and establish permanent reference sites. This approach compliments the NPs water chemistry monitoring and gives another method to assess improvements in watershed management practices.

Otter Creek at Angle

The data collected at Angle shows an overall upward trend in this reach. Improvements were measured in several individual attributes. The geomorphology survey shows channel narrowing and point bar development from 1993 to 1998. The width to depth ratios have decreased over time and the channel has a more defined thalweg. The substrate distribution changed only slightly, with the median particle size being smaller in 1998. This result may be due to fine sediment deposition on the point bars that are developing. Over time, this attribute should be showing a decrease in fine sediment.

The riparian green line survey indicates an increase in wetland communities and in the hydrologic moisture regime which can indicate the channel is narrowing or the water table is rising. Although, the green line stability shows a steady moderate trend. Along the vegetation cross sections, there has been a significant increase in hydroriparian species and decrease in bare ground. Hydroriparian species have established on the developing depositional bar features. The ecological status shows the site is still in a early seral stage and woody species have not established on the site. There was no significant increase in shade over the stream.

The HQI fisheries evaluation shows an upward trend in cover and decrease in the eroding bank attribute, resulting in an overall increase in the rating for potential fish habitat units. This parameter will be more conclusive after a fish population survey has been conducted. A fish survey has not been recently conducted due to rotenone treatment to eliminate whirling disease. Following the fish survey, the potential and actual standing crop of trout can be compared. In addition, the macroinvertebrate analysis shows the site has remained extremely stressed. The macroinvertebrate samples should be considered a valuable indicator and analyzed in greater detail.

Photos 1-4 are taken from the same location in 1993 through 1998. At the beginning of the monitoring, the stream is wide and shallow with raw banks throughout the reach. By 1998 the channel has narrowed and deepened as shown in the channel cross section surveys. Photos 5-8 also illustrate point bar development, increasing bank vegetation, and bank stability.

Otter Creek above Narrows-Treated

The data collected at the Treated site shows an overall steady to upward trend over time. At this time, full implementation has not been completed. Upon completion, it the site is expected to show greater response in the monitoring attributes. There were no significant changes in the geomorphology cross section surveys. There was no increase in shade over the stream channel and there is still a significant amount of fine sediment in the channel. The vegetation evaluation and the fisheries habitat index did show some improvements.

The riparian green line survey indicates a trend in stability and in ecological status with an increase in wetland communities. There was also a change in the hydrologic moisture regime based on an increase in hydroriparian indicating the channel may be narrowing or the water table is rising. The green line stability index remains moderate. Along the vegetation cross sections, there was a significant increase in hydroriparian and a decrease in meso and xeroriparian indicating the site is becoming more moist.

The HQI fisheries evaluation shows an upward trend in cover and decrease in the eroding bank attribute, resulting in an overall increase in the rating for potential fish habitat units. This parameter will be more conclusive after a fish population survey has been conducted. A fish survey has not been recently conducted due to rotenone treatment to eliminate whirling disease. At this time, Otter Creek is stocked with trout. The existence of a self sustaining population is uncertain. Following the fish survey, the potential and actual standing crop of trout can be compared. In addition, the macroinvertebrate analysis shows the site has remained extremely stressed. The macroinvertebrate samples should be considered a valuable indicator and analyzed in greater detail.

Photos 9-10 show a planview perspective of the site. There are still some areas of eroding and sluffing bank. There are also areas of improvement shown in photos 11-12, which is also observed in the riparian evaluation.

Otter Creek above Narrows-Untreated

The data collected at the Untreated site shows an overall steady trend over time. There were no significant changes in the geomorphology cross section surveys. There was no increase in shade over the stream channel and there is still a significant amount of fine sediment in the channel. The riparian evaluation indicates a steady trend with little change over time. The fisheries habitat index did show slight improvements.

The riparian green line shows no significant change in wetland communities or in the hydrologic moisture regime. The green line stability index is moderate to good, indicating streambank and channel erosion has not changed since 1993. The vegetation cross sections indicate the site may becoming a bit more wet based on a slight increase in hydroriparian and slight decrease in mesoriparian.

The HQI fisheries evaluation shows an upward trend in cover and slight decrease in the eroding bank attribute. The high nitrate nitrogen and increase in cover resulted in the improvement in the HQI. This parameter will be more conclusive after a fish population survey has been conducted. A fish survey has not been recently conducted due to rotenone treatment to eliminate whirling disease. At this time, Otter Creek is stocked with trout. The existence of a self sustaining population is uncertain. Following the fish survey, the potential and actual standing crop of trout can be compared. In addition, the macroinvertebrate analysis shows the site has remained extremely stressed. The macroinvertebrate samples should be considered a valuable indicator and analyzed in greater detail.

Photos 13-14 are taken from the West monument of G-0 facing the East monument of G-0. There is no significant change observed. Photos 15-16 show transect G0b which shows sluffing banks in both 1993 and 1998. Thistles have increased over the time period, as observed in the same set of photos.

Conclusions

Improvements can be achieved and monitored using the surrogate indicators of water quality. There are some limitations to this study. For example, climate was not accounted for and stream flow was not evaluated in detail. The surveys were done in the same time period each year, and those attributes were assumed to have similar influence on each site.

At the Angle site, where mechanical and grazing alterations were implemented, results can be observed on a relatively fast time scale. In areas like the above Narrows sites, where grazing practices are altered and best management practices are still being implemented, it will take a much longer time period to document changes.

In cooperation with federal and state agencies, it is will take a community effort to improve watershed condition. It is essential that reports are written to document progress on these management practices. Reporting both successes and failures in order to make better decisions in land management is necessary, particularly on the local and regional levels. This interdisiplinary method represents a valuable tool and is worth both time and effort to continue for non point source monitoring evaluation.

Otter Creek at Angle- Photo Documentation

Photo 1. Pretreatment 1990, from culvert facing downstream.

Photo 2. Pretreatment 1991, from culvert facing downstream.

Otter Creek at Angle- Photo Documentation (continued)

Photo 3. Mid-implementation 1993, from culvert facing downstream.

Photo 4. Post treatment 1998, from culvert facing downstream. The sequence of photos 1-4 show an improvement in this site over time.

Otter Creek at Angle- Photo Documentation (continued)

Photo 5. Mid-implementation 1993, G0 facing upstream.

Photo 6. Post treatment 1998, G0 facing upstream (same location as photo 5). Notice the point bar development and increase in bank vegetation.

Otter Creek at Angle- Photo Documentation (continued)

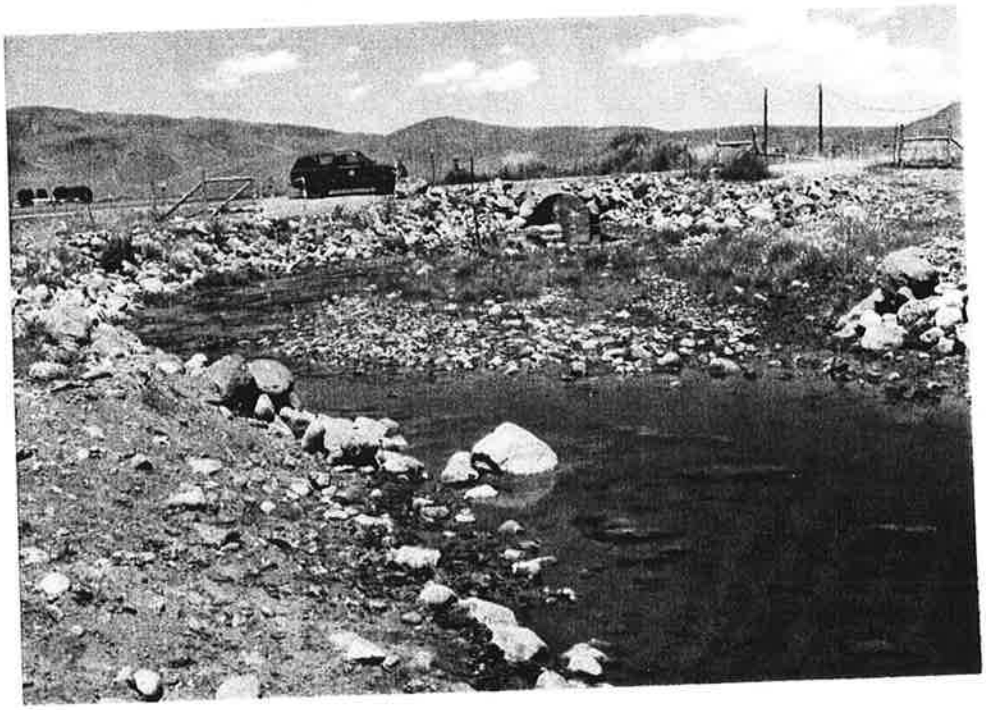

Photo 7. Mid-implementation 1993, G1 and G2 facing upstream.

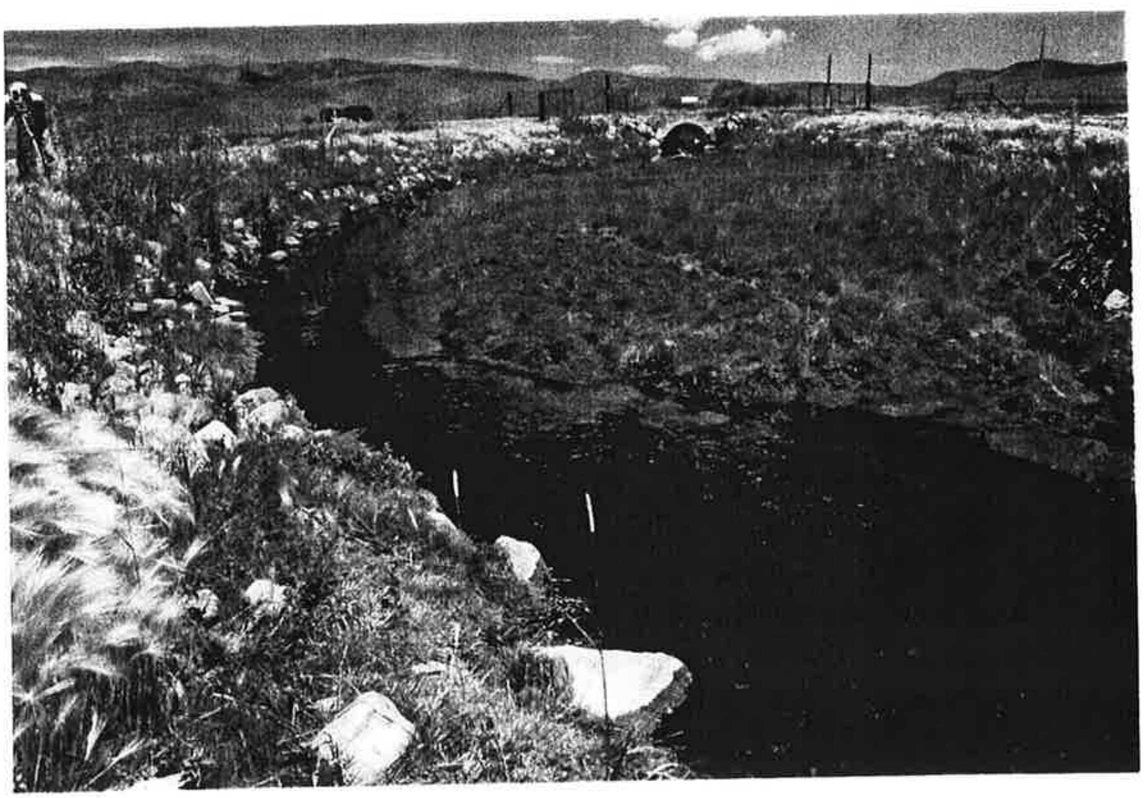

Photo 8. Post treatment 1998, G1 and G2 facing upstream (same location as photo 7). Notice the point bar development and increase in bank vegetation.

Otter Creek above Narrows-Treated - Photo Documentation

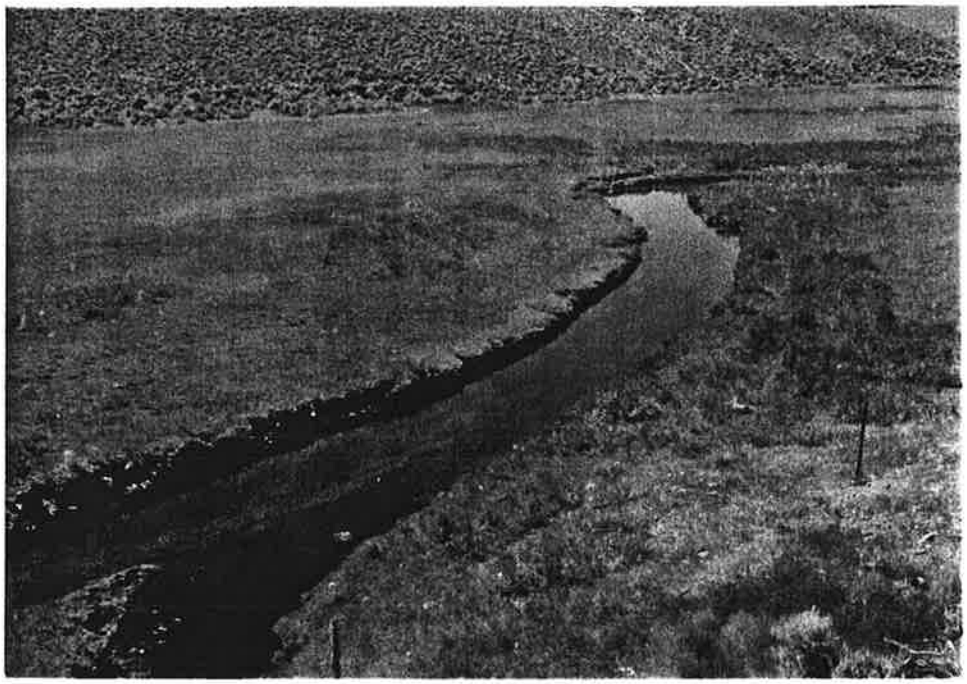

Photo 9. Planview 1993, downstream section of site. Arrow indicates a reference point between photo 9 and 10.

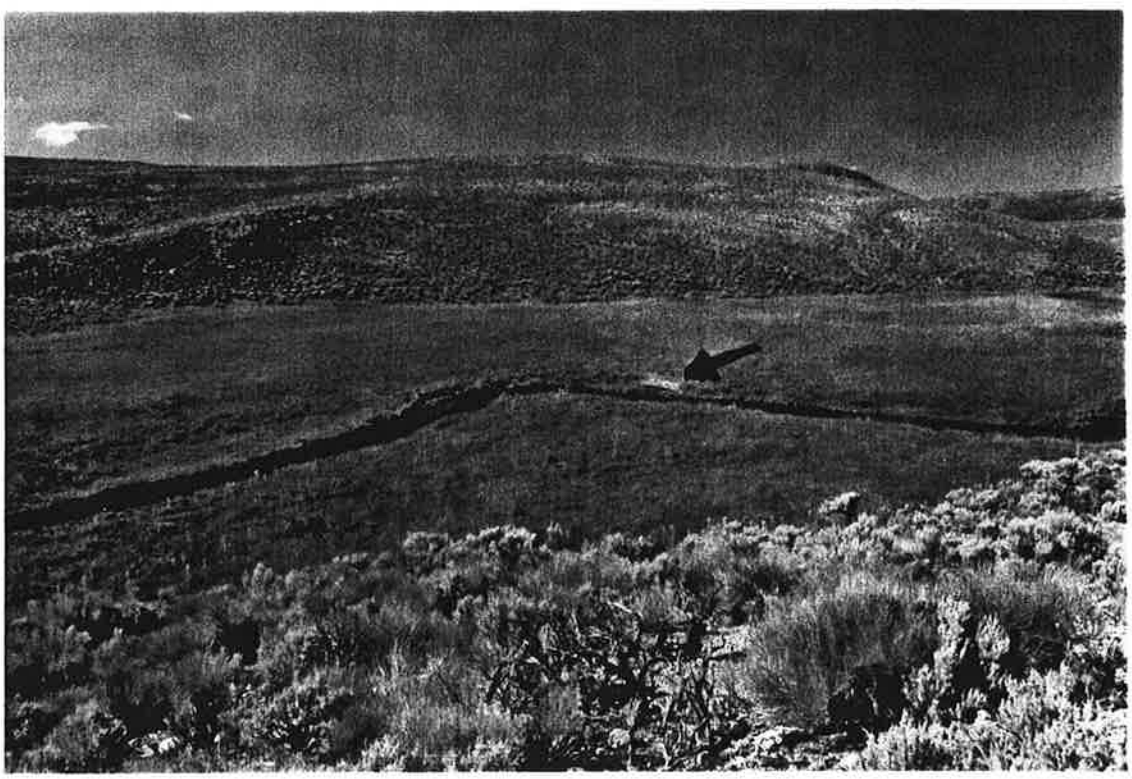

Photo 10. Planview 1998, downstream section of site. Trend at this site, based on the riparian evalution, shows improvement. But, some raw and eroding bank still occurs just above the arrow reference point.

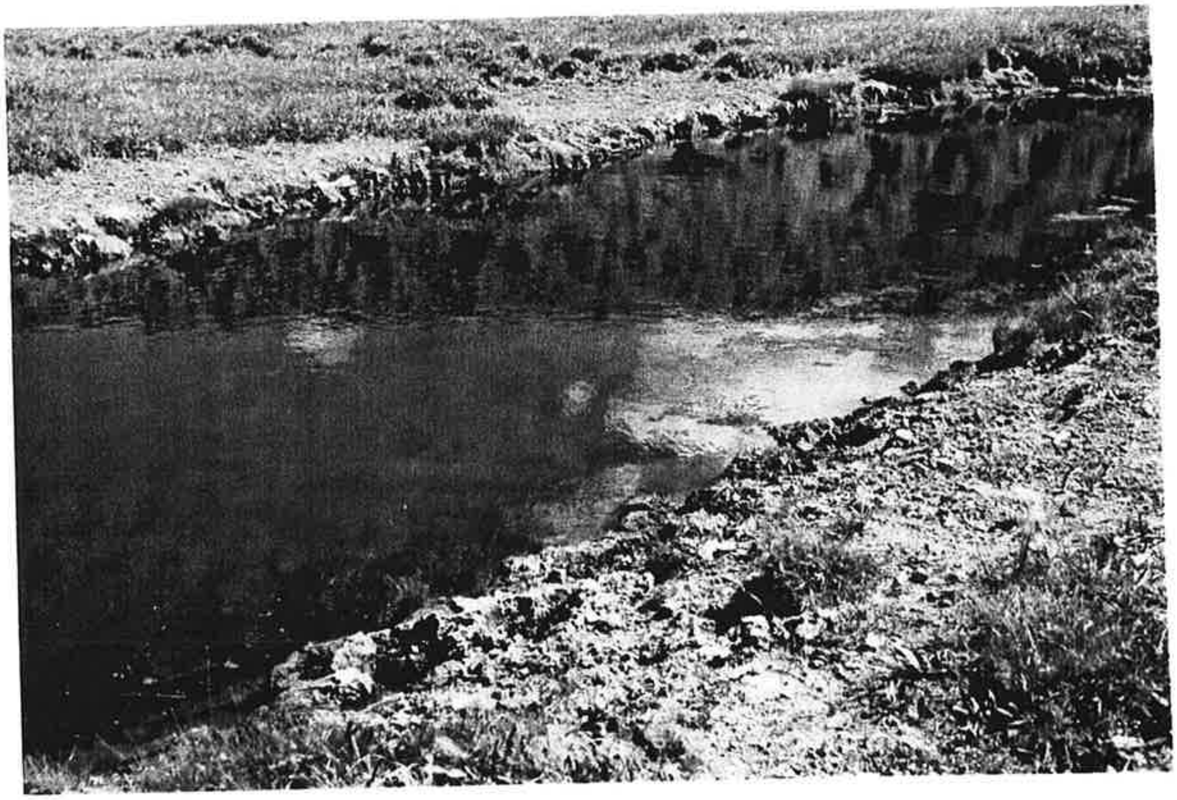

Photo 11. Greenline survey endpoint 1993.

Photo 12. Greenline survey endpoint 1998 (same location as photo 11) Comparing the far bank, there is improvement in streambank vegetation.

Otter Creek above Narrows-Untreated - Photo Documentation

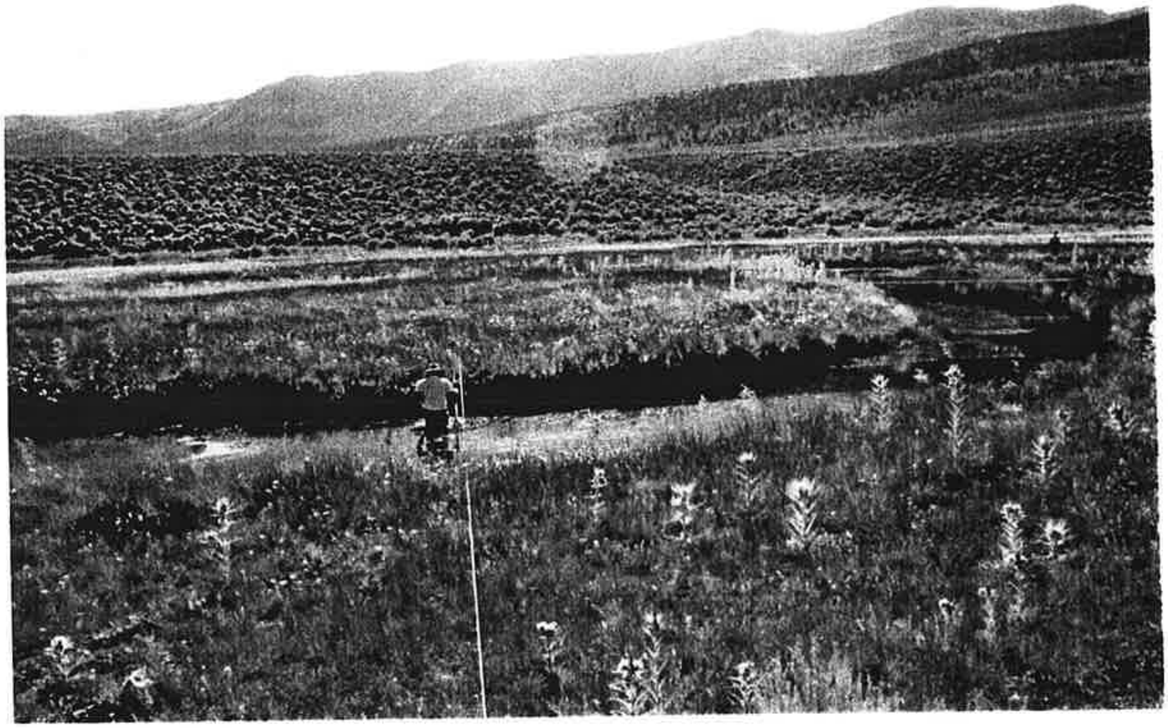

Photo 13. 1994, Transect G0a, b, c from West bank facing East bank.

Photo 14. 1998, Transect G0a, b, c (same location as photo 13). No significant changes observed.

Otter Creek above Narrows-Untreated - Photo Documentation (continued)

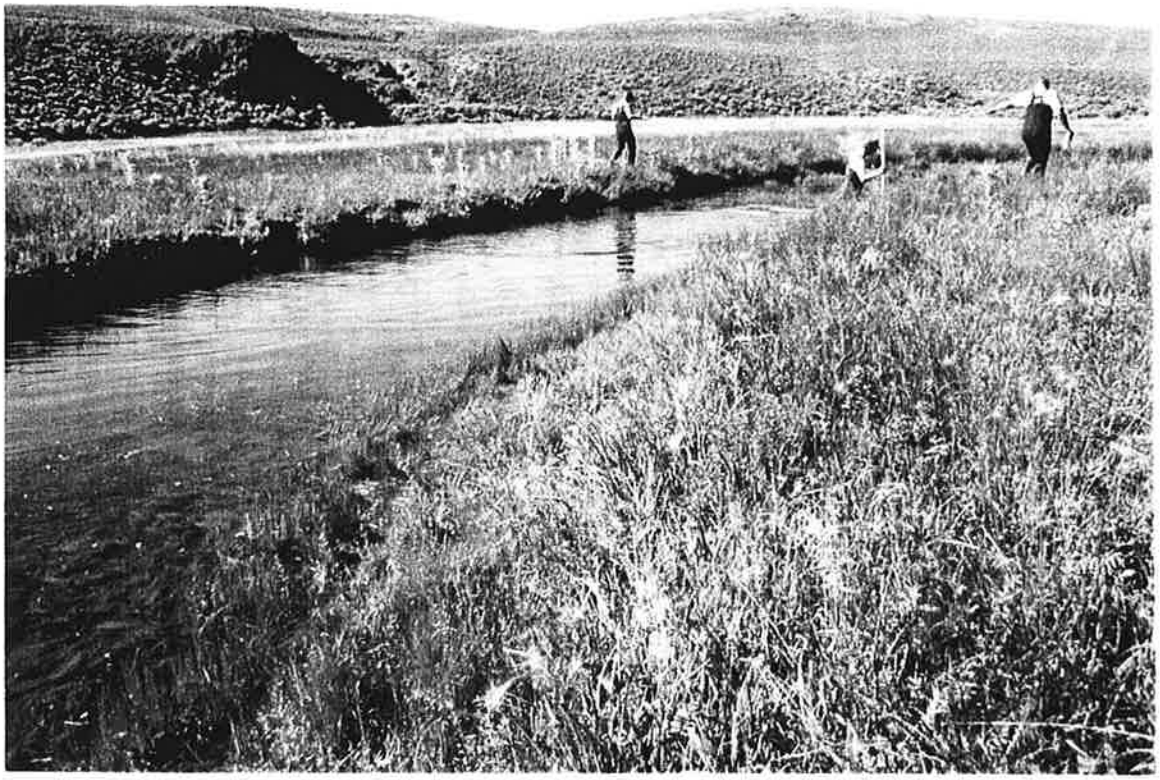

Photo 15. 1994, Transect G0b.

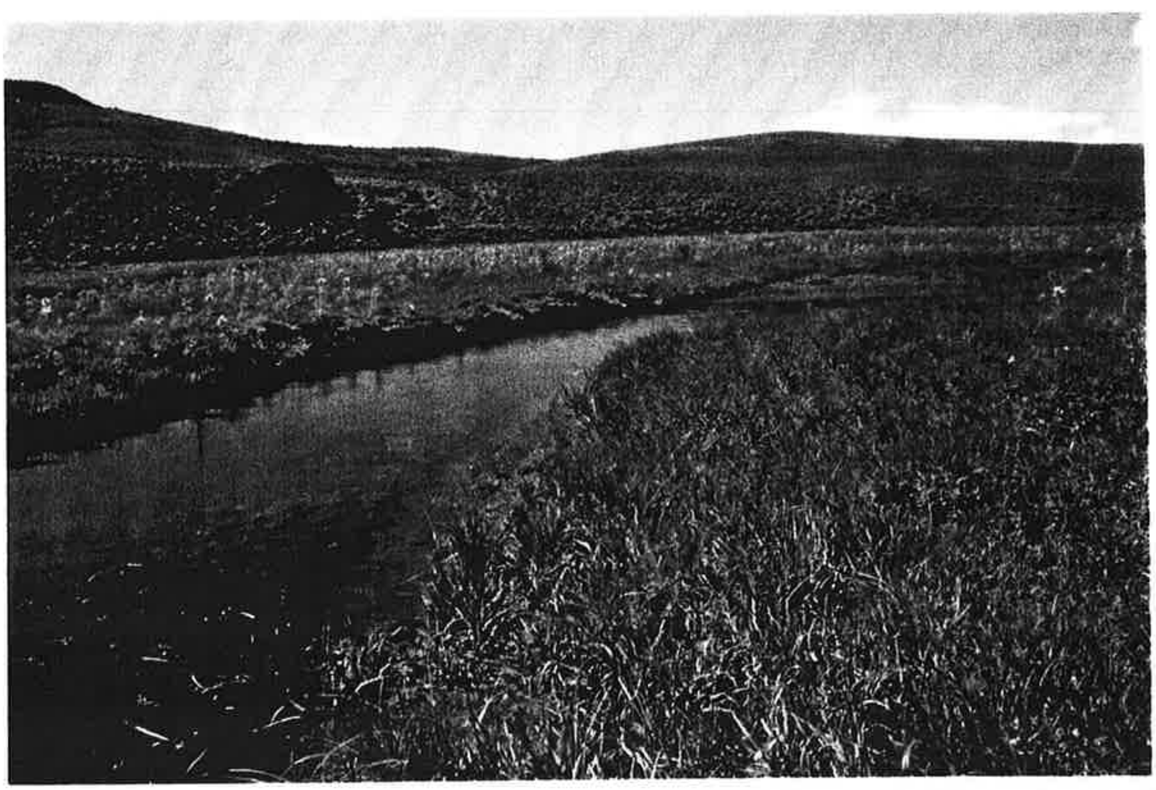

Photo 16. 1998, Transect G0b (same location as photo 15). No significant changes observed.