TILLAMOOK BAY DRAINAGE BASIN EROSION AND SEDIMENT STUDY OREGON

MAIN REPORT

A Cooperative Study by:

The Tillamook Bay Task Force and The Oregon State Water Resources Department
and
The United States Department of Agriculture Soil Conservation Service
Forest Service-Economics, Statistics, and Cooperatives Service

1978

The report for the Tillamook Bay Drainage Basin Erosion and
Sediment Study consists of three separate documents as follows:

SUMMARY REPORT

The Summary Report is brief and nontechnical. It is intended
for general information and should not be used as a source for
planning and management decisions. It describes the study area
and the erosion-sediment problems. It highlights the study and
discusses management techniques for dealing with problems.

MAIN REPORT

The Main Report contains a detailed description of the area, the
erosion-sediment problems, the study procedures, and managerial
strategies for sediment reduction with related costs and impacts.
It is written and organized for planners, land managers and
decision makers to utilize in doing their job.

APPENDICES

The appendices contain numerous detailed tables on erosion and
sediment input and output data. The tables are developed by
subareas within the five river subbasins. They are color coded
to the five river subbasins shown on the Study Area Map.

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CHAPTER I

SUMMARY

SUMMARY

NEED FOR STUDY

Sediment in Tillamook Bay is a major problem. The continual deposition of sediment in the bay has caused adverse effects on shipping and navigation, commercial and sports fishing, oyster production and clamming, and on environmental and aesthetic qualities of the basin. Sediment is the primary problem that prompted the Oregon State Water Resources Department and the Tillamook Bay Task Force to request the U.S. Department of Agriculture to conduct this study.

Erosion, the major cause of sediment, is also a severe problem in many places throughout the Tillamook Bay Drainage Basin. Channel banks, land slides, roads, old burned areas and clearcuts are some of the most noticeable major erosion source areas. Study of erosion problems was essential in order to find ways of reducing sediment.

SETTING AND RESOURCES

GEOGRAPHIC

The Tillamook Bay Drainage Basin is located in northwestern Oregon. It is bounded on the east by the crest of the Coast Mountain Range and on the west by the Pacific Ocean. The three resource areas considered in this study cover a total of 363,520 acres of which 323,050 acres are brush, cutover, and forested land on moderate to steep slopes and deeply incised canyons; 29,490 acres are non-forest and flat to gently sloping urban, agricultural and miscellaneous land; and 10,980 acres include the rivers and bay area.

Tillamook Bay is located 48 miles south of the mouth of the Columbia River and 60 miles west of Portland, Oregon. The bay is about six miles long in a southeast to northwest direction, two miles wide, less than six feet in average depth, and is barred with only a 1200 foot opening to the ocean. A sand spit, Bayocean Peninsula, extends from the south to near the north side of the bay where jetties have been constructed to facilitate entrance to the bay. Four large rivers, the Wilson, Trask, Kilchis and Tillamook enter the bay from the southeast while a fifth large river, the Miami, enters from the north and just opposite the entrance to the bay from the Pacific Ocean.

CLIMATIC

The strong marine influence of the Pacific Ocean dominates the climate in the Tillamook area. Wet winters and moderately dry summers

characterize the region, and temperature ranges are narrow. Frequent
storms from the southwest between November and March bring heavy
rainfalls over short periods. Average annual precipitation for the
drainage basin is 115 inches, with a 90-inch average at Tillamook
and up to 150 inches at higher elevations.

The average temperature is 42^0 F in January and 58^0 F in July.
Temperatures seldom drop below freezing near the shoreline of the bay.
The basin has a growing season of 190 days without a killing frost.
Fog is common throughout the year, particularly during night and
morning hours.

BIOLOGIC

Tillamook Bay and the streams and lands within the basin provide
habitats for diverse fish and wildlife species. All of the major
perennial streams are used by anadromous fish. The bay is rich with
vegetation and organic nutrients which contribute to high productivity
of oysters, clams, crabs and other shellfish.

ECONOMIC

Over 90 percent of the land in the Tillamook Bay Drainage Basin is
classified as forest. The wood products industry, including logging,
sawmills and plywood operations, timber holdings, and associated service
activities, accounts for about 43 percent of the total gross county
output.

The principal agricultural activity is dairy farming and related
food processing. These sectors, together with other minor farming, make
up about 17 percent of the total gross output.

The remaining gross output, about 40 percent, comes from construc-
tion, transportation, recreation, manufacturing, seafood, utilities,
and services.

OBJECTIVES

The major objective was to propose methods of reducing sediment
entering Tillamook Bay. A corollary objective was to insure sediment
reduction at least cost.

In order to analyze the problems and derive sediment reduction
alternatives, several study objectives were accomplished:

(1) To inventory the gross erosion rates by suitable categories
under present conditions;

(2) To estimate the sediment yield under existing use and management;

(3) To develop and evaluate alternative measures and land use management plans;

(4) To estimate future sediment yields for various alternative land management plans;

(5) To assess economic effects of soil erosion and sedimentation and evaluate economic consequences of proposed alternative solutions or plans;

(6) To recommend opportunities for implementation of erosion and sediment control measures.

PROCEDURES

The study objectives were accomplished by using both commonly accepted and, where necessary, innovative and new techniques and procedures. Erosion and sediment samples were taken from 160 sample plots and 14 stream gaging stations, respectively, over a two-year period. Aerial low-level photography, taken at different time periods, was analyzed and compared to assist in evaluating streambank erosion. Analysis and evaluation of the nature and extent of erosion problem areas was aided by the use of space-age earth satellite telemetry. Hundreds of hours were spent by the study staff and others conducting on-the-ground examinations and field investigations of erosion and sediment problems. The bay was sampled at 52 surface sites and at 14 core sites. All of the known published and unpublished materials related to Tillamook were studied, compared and evaluated. Technical information was obtained from specialists and experts in several different scientific disciplines, from universities, from agencies of state and federal government, and from consultants and individuals with expertise in specialized subject matters. An erosion and sediment computer model was programmed for the basin to determine least cost alternatives of sediment reduction.

Many meetings were held and individual contacts were made with concerned and knowledgeable citizens in Tillamook County during the course of the study. As a result of public involvement, many improvements were made in methodology and procedures as the study progressed.

FINDINGS AND CONCLUSIONS

Sediment enters Tillamook Bay at the rate of about 61,000 tons annually. Eighty-five percent, 51,600 tons, originates on the forested, upper watershed, which comprises about 90 percent of the total land area of the basin. Fifteen percent, 9,400 tons, comes from agricultural and urban lands adjacent to the bay.

Much is already being done to control erosion and sediment, but more can be accomplished. While the study does not propose an implementation plan, it does present and compare several alternative sediment reduction levels, at 10 percent increments. The maximum sediment reduction evaluated was 64 percent, about 38,800 tons. The 64 percent reduction could be achieved with present technology and commonly used control practices; however, the installation costs would be high, 189 million dollars (at 1975 prices).

A 30 percent sediment reduction, about 18,200 tons, would require installation expenditures of approximately 2.5 million dollars. Average annual costs would be about $171,000. Annual benefits came to about $273,000, leaving $102,000 net positive benefits. The 30 percent level could be achieved by stream stabilization measures; tree planting on landslides, clearcuts, and burns; and by closing and stabilizing some roads on forested lands.

DEVELOPMENT OF USDA PROGRAMS

Future implementation of a sediment reduction plan (not an intended objective of this study) offers opportunities for development of existing USDA programs as well as programs of many other agencies. The Emergency Watershed Protection Program (Sec. 216 of Public Law 81-516) is the most widely used program at the present time for stabilization of channel banks eroding as a result of major storms. The Agricultural Conservation Program has also been utilized to a limited degree in on-farm correction of sediment and erosion problems. The State Forest Practices Act may be applied in reforestation programs on forested lands in the basin.

Other implementation ideas and suggestions were discussed. A list of federal programs that may potentially offer assistance, or in some way relate to implementation, are presented in Chapter X of this report.

CHAPTER II

INTRODUCTION

INTRODUCTION

The U.S. Department of Agriculture (USDA) has completed a study of erosion problems and sediment deposition in the Tillamook Bay Drainage Basin. The study was made at the request of the Oregon State Water Resources Department. The agencies involved in the study by cooperative agreement are the Soil Conservation Service (SCS); Economics, Statistics, and Cooperatives Service (ESCS); and the Forest Service (FS). The SCS is responsible for overall leadership, with the ESCS and the FS participating. The results of the study may be used as a basis for the development of coordinated programs for controlling erosion in the upper watershed and reducing sediment deposition in Tillamook Bay Estuary.

The objectives of the study are to: (1) Inventory the gross erosion rates by suitable categories under present conditions. (2) Estimate the sediment yield under existing use and management. (3) Develop and evaluate alternative measures and land use management plans. (4) Estimate future sediment yields for various alternative land use management plans. (5) Assess economic effects of soil erosion and sedimentation, and evaluate economic consequences of proposed alternative solutions or plans. (6) Recommend opportunities for implementation of erosion and sedimentation control measures.

A public participation and involvement program was initiated early in the study. The Tillamook Bay Task Force served as the local steering committee and coordinated local public involvement. This provided an opportunity for interested groups, agencies, and individuals to review, comment, and participate in the study.

The Tillamook Bay Drainage Basin, located in the northwestern part of the state, is bounded on the east by the crest of the Coast Mountain Range and on the west by the Pacific Ocean. The three resource areas considered in this study cover a total of 363,520 acres of which 323,050 acres are forested land on moderate to steep slopes and deeply incised canyons; 29,490 acres are non-forest and flat to gently sloping urban, agricultural and miscellaneous land; and 10,980 acres contain water resources which include the rivers and Tillamook Bay Estuary.

Several agencies and organizations including the Tillamook Soil and Water Conservation District provided helpful assistance. The Tillamook field office of the Soil Conservation Service furnished much of the basic data related to soil types, past flooding conditions, past programs related to erosion control, and coordinated personnel for installing and measuring stream gages and obtaining water samples for laboratory quality analysis.

LOCATION MAP

R 10 W   9   8   7   6   5

T 2 N
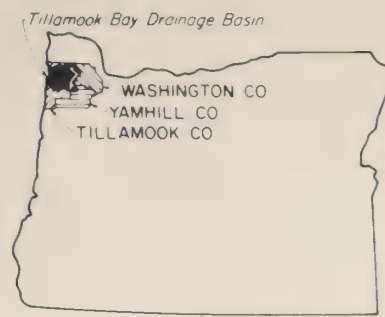
MAJOR SUBBASINS

	Miami River
	Kilchis River
	Wilson River
	Trask River
	Tillamook River

STUDY AREA MAP

TILLAMOOK BAY DRAINAGE BASIN

TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

NOVEMBER 1978

1   0   1   2   3   4   5 MILES

SCALE 1:187,500

M7-SN-23598-16
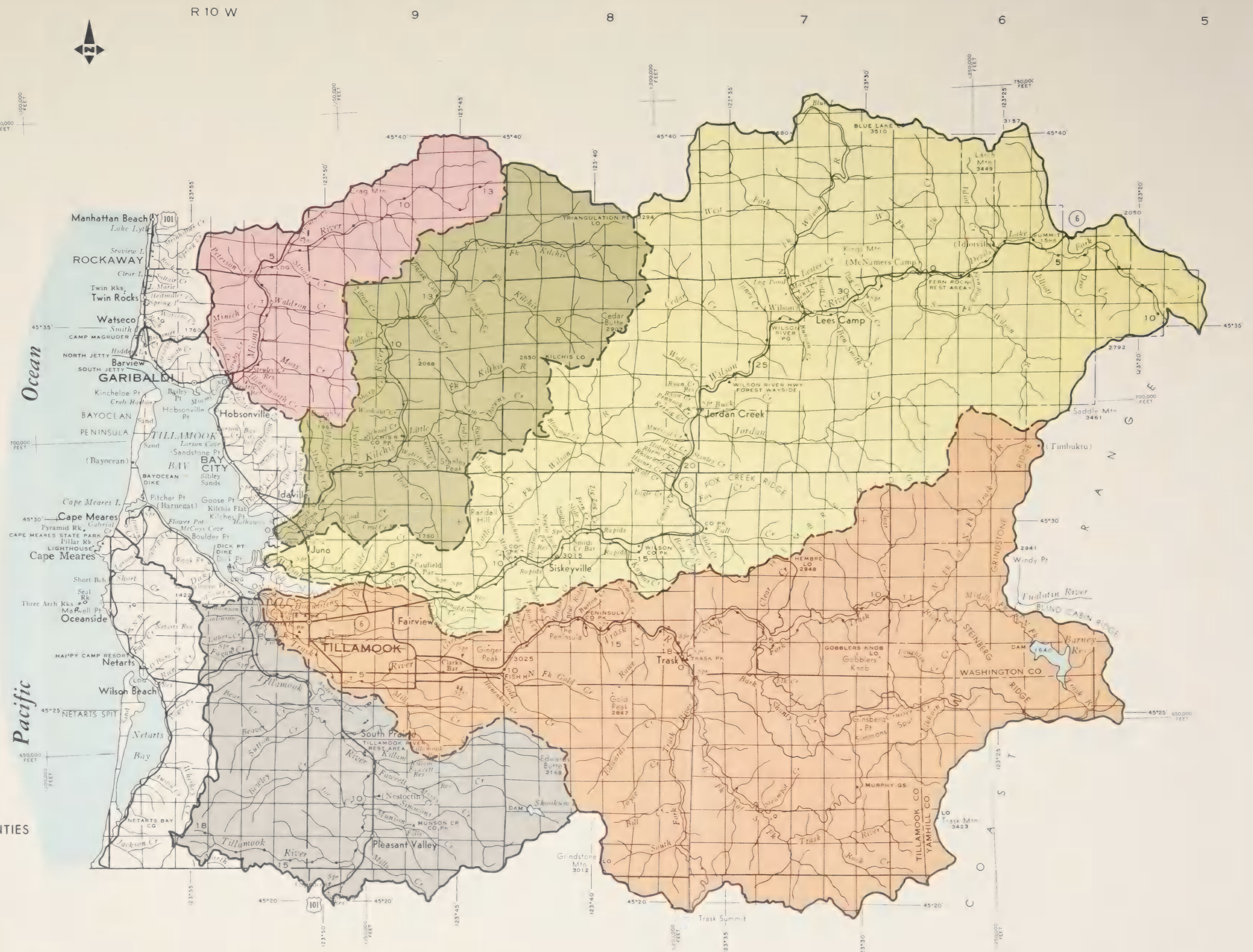
In 1976, under a cooperative agreement between the U.S. Geological Survey and the U.S.D.A. an extensive drilling and soil sampling program in Tillamook Bay Estuary was undertaken to provide a historical record of sedimentation. Samples were made available for comparative analysis and along with logs, test results and interpretations are included in this report. The Oregon Department of Environmental Quality conducted the analysis of the water quality samples.

Assistance on forest lands was provided by the local State Forester's office. Under a contract agreement between the U.S. Forest Service and the Earth Resources Remote Sensing Applications Laboratory (ERSAL) at Oregon State University, satellite imagery was utilized. The LANDSAT (PIXSYS) computer program was used to obtain data on land use and individual acreages based on cover conditions, both of which were used in the determination of erosion and sediment yields.

The study consisted of accumulating and evaluating previously recorded data, both published and unpublished. In addition, field observations and soil and water quality sampling programs were carried on by both the Soil Conservation Service and the Forest Service to gather additional basic data. This included physical characteristics of the watershed slopes, streambanks, streambottoms, agricultural lands, and the problems and needs of each tributary subwatershed. The ESCS constructed and operated a linear programming computer model which was used to determine least-cost land treatment measures that would result in specific levels of sediment reduction in Tillamook Bay.

The distribution of the three-part study report includes a public information program on the contents of the reports. Assistance will be provided for those using the report as a planning or land management guide.

USER'S GUIDE

The results of this study are presented in three reports, the Summary Report, the Main Report and the Appendices. The three reports are described briefly inside each cover.

Readers of these reports will have various general and specific areas of interest. The Summary Report's concise nontechnical discussion of the study and the problems may be adequate for many. The Main Report includes tables and maps concerning natural resources of the area. These can be easily located by using the Expanded Table of Contents. For those primarily interested in sediment reduction in Tillamook Bay and how this study can be used as a planning tool, time can be saved by following the User's Guide.

This report does not propose "a plan". Instead, the Main Report presents several control programs at different levels of sediment reduction. At each level the control program presented is the least-cost program. Selection of a sediment-reduction goal is the first step. Many factors may affect the selection of a goal. The amount and sources of funding may be one factor. Another factor could be the amount of sediment reduction desired, in relation to fish, habitat, channel maintenance, etc.

The User's Guide presents a narrated, step-by-step example of how the report can be used to guide planning and management decisions. The steps followed in the example are summarized as a flow chart following this guide; see Chart I, User's Guide.

Where Does One Start?

A level of sediment reduction is selected based on financial, biologic and other considerations. Various levels might be assumed for making comparisons and testing viability of proposals being considered.

Step 1. Sediment-Control Programs

Turn to page X-6, Table X-2, for a comparison of sediment-control programs. Suppose the goal is to reduce sediment by 20 percent. Under Levels of Reduction, 20% column, are shown beneficial and adverse effects.

Step 1A. Implementation

For some thoughts on implementation of sediment control, see pages X-7 through X-8, and Table X-3.

Step 2. Control Measures - Summaries

Summaries of sediment-control measures required for the least-cost 20 percent reduction are shown on Tables IX-12 and IX-13 (pages IX-29 and IX-30). The first table is for "agricultural" lower watershed lands. The second table shows acres of treatment measures required on "forested" upper watershed lands.

Step 3. Sediment Source Areas - Summaries

Go to Tables IX-16 and IX-17, pages IX-35 and IX-36, for a summary of acres of sediment-source areas on which treatments would be applied. At the 20 percent level, stream channel banks, clearcuts, and burns would be treated for a least-cost solution.

Step 4. Treatments and Source Areas

Steps 2 and 3 are shown in more detail on Table X-1. Here the acres of treatment measures are delineated by each sediment-source area. Also shown under the cost effectiveness column are the sediment reductions, 12,120 yards at 20 percent, and the per yard and total net benefits, $6.39 and $77,440, respectively. Another useful piece of information is found under the column, Institutional Constraints, where the total installation costs are shown, $893,000 for the 20 percent level.

Step 4A. Scenarios and Levels

In the same table, under the column, Achievement of Desired Results, are found gross sediment reductions as percentages of various results that could be obtained under differing assumptions. For example, at the 20 percent reduction, Scenario A, Level II, 38.2 percent of the objective would be met. To achieve 100 percent of the Scenario A, Level II objective or goal, river sediments would have to be reduced by 19,000 tons (see pages X-1 through X-2 which explain the different scenarios and goal levels).

Step 4B. Management Strategies and Study Limitations

Before going further in considering a particular plan, one should be aware of some of the limitations and alternative strategies that pertain to this study. A brief narrative can be found on pages X-9 through X-12.

Step 5. Acres Treated By Subbasin

Finally, it is determined which subbasins are to be treated. Turn to pages IX-32 and IX-33, Tables IX-14 and IX-15 for summaries of control measure acres by subbasin. For a 20 percent, least-cost reduction, 2,176 acres of forested lands would be treated and only about 6 acres of agricultural lands.

AT THIS POINT A PRELIMINARY PLAN CAN BE FORMULATED

Step 6. A Detailed Account

The next steps develop the specifics of the plan. A detailed account of acres of treatment measures, by source areas, by subbasin, for agricultural and forested lands can be found in the Appendices.

Portions of the Appendices are color coded. Each of the 5 principal subbasins is represented by a different color. Thus, tables pertaining to the Miami subbasin, for example, are all the same color. For those interested in a particular subbasin, pages of the same color can be quickly referenced.

Step 6A. Example of Detailed Account

An example of the appendix LP (linear programming) output tables is found on pages IX-23 through IX-27, Tables IX-7 through IX-11. This example, for the 20 percent reduction, consists of five tables. The first two tables, for the Kilchis, Lower Main Stem, illustrate the detailed information available throughout the Appendices. The next two tables are summaries of the first two. The fifth table is a summary of the 20 percent reduction over all subbasins.

NOTE: BASIC EXAMPLE IS NOW COMPLETED

The foregoing example shows where to find information relating to various alternative plans and treatment measures that can be used to control sediment. More information is contained in the study. For example, Step 8 mentions the map, Potential Surface Erosion Hazard, which could assist in selecting specific sites for certain treatment measures. Data collection methods may be of interest for consideration of specific values. The following steps are not all necessary in every case and they are not necessarily sequential. They are presented for the user's general guidance.

Step 7. Input Data Tables

In the Appendices section of this report are found the tables of input data used in the analysis of least-cost treatment alternatives.

Step 7A. Brief Example of Input Data

An example of the appendix input tables has been included in the Main Report (pages IX-16 through IX-17, Tables IX-4 and IX-5). These examples are again for a 20 percent reduction for the Kilchis, Lower Main Stem. The input tables show the per acre sediment rates for 1975, as well as rates for each control measure. The tables also show the acres of each source as well as the costs per acre, of sediment control measures.

Step 7B. More Data and Summary of Model

Additional narrative and tables pertaining to treatment measures and costs are found on pages IX-7 through IX-11. A brief explanation of the linear programming model and input data is found in the Main Report (pages IX-14 through IX-21).

Step 8. How Were the Data Obtained?

Chapter VI, Erosion and Sediment Yield Studies and Survey Procedures, should be read by those interested in the derivation of the data base. Survey procedures and results for both agricultural and forested lands, and for erosion and sediment, are set forth in this chapter. The following maps in the Main Report should be of special interest:

> Recording Gages and Sediment Sampling Stations
>
> Soil Samples and Erosion Plots
>
> Potential Surface Erosion Hazard
>
> Gross Erosion and Sediment, Forest Lands.
>
> The data shown on these maps are the basis for all the analysis of least-cost sediment control alternatives.

Step 9. Historical Development

For those unfamiliar with the Tillamook Drainage Basin, Chapter III is important. Local residents are familiar with historical development of the Tillamook Bay sediment problem. Others may not be aware of the many fires and floods and other factors affecting erosion and sediment in the area.

Step 10. Resource Inventories

For those interested in the natural resources of the area, see Chapter IV, Resource Inventory Summary. Resource management guidance is also included in this chapter.

NOTE: USER ASSISTANCE

For answers to specific questions concerning this report contact:

> USDA River Basin Planning Staff
> 1220 S.W. Third Ave.--16th Floor
> Portland, Oregon, 97204
> Telephone (503) 221-2797

Develop Preliminary Plan

Plan Details and Specifics

Begin
BEGIN-Select level of sediment Reduction

1
Sediment control programs-Table X-2 Page X-6

1a
Implementation considerations- Pages X-7 thru X-8 Table X-3

2
Control measures- Tables IX-12 & IX-13 Pages IX-29 & IX-30

3
Sediment source areas- Tables IX-16 & IX-17 Pages IX-35 & IX-36

4a
Scenarios & levels of reductions- Pages X-1 thru X-2

4
Treatment measures by source areas- Table X-1, Page X-3

4b
Managerial strategies & study limitations- Pages X-9 thru X-12

5
Control measures (acres treated by subbasin) Tables IX-14 & IX-15

Formulate a Preliminary Plan

Appendix LP-Model

6a
LP model output- Tables IX-7 thru IX-11 Pages IX-23 thru IX-27

6
LP model output

7
LP model input

7a
Example, data input- Tables IX-4 & IX-5 Pages IX-16 thru IX-17

7b
LP model data inputs- Pages IX-7 thru IX-11

Additional Data Available

8a
Recording gages & sediment sampling stations- Map following Page VI-6

8b
Soil Samples & erosion plots- Map following Page VI-1

9
Historical Problems Development- Chapter III Pages III-1 thru III-10

8
Erosion & sediment yield studies & survey procedures- Chapter VI Pages VI-1 thru VI-11

8c
Potential surface erosion hazard- Map following Page IV-34

8d
Forest land mean annual gross erosion & sediment rates- Map following Page VII-32

10
Description of the area & inventory of resources- Chapter IV Pages IV-1 thru IV-56

CHART I
USER'S GUIDE FLOW CHART

CHAPTER III

HISTORICAL DEVELOPMENT

HISTORICAL DEVELOPMENTS

EARLY HISTORY

The settlement of the Tillamook Bay Drainage Basin started in 1851 but had a slower growth pattern than surrounding areas of northwestern Oregon. The area was isolated from the Willamette Valley, Astoria and the middle coast area by rugged topography and nearly impenetrable forests. Families usually came by boat even though access by sea was difficult due to the dangerous bar at the mouth of Tillamook Bay. Many settlers managed to bring small herds of dairy cattle. By 1853, enough families had arrived to settle in Tillamook, Nestucca and Lower Nehalem and they petitioned the State to create Tillamook County. Their petition was considered, and on December 13, 1853, the State Legislature established the new county from portions of Yamhill and Clatsop Counties.

Access to the outside world (anywhere beyond Tillamook County) continued to be by water but the people could only plan on sporadic trips. Consequently, there were times when Tillamook was without staples and mail for extended periods of time. In addition, their butter would spoil waiting for shipment, giving them no income to purchase supplies. Regular ship service did not begin until 1886. The Trask Toll Road was opened for use in 1871, followed by the Tillamook, Nestucca via Beaver Toll Road in 1883 and the Wilson River Road in 1893. All of these early toll roads were single track, poorly maintained and impassable much of the time. The Wilson River Road was designated as a State highway in 1931 but was not constructed until 1941. The Coast Highway (present day US 101) was also completed about this time.

The railroad was completed to Tillamook in 1911, after which maintenance of the toll roads was discontinued. The people no longer had to depend upon ships for major movement of supplies and produce. The sea was still used by the lumber industry and also to support a sizeable commercial fishing fleet. Construction of the jetties by the U.S. Corps of Engineers began in 1918 and continued as funds became available. The Corps also dredged the channels for a period of time until sediment deposition became so serious as to negate dredging efforts within as little as three months. Fishing activities were curtailed some years ago; the Oregon Fish Commission closed Tillamook Bay to all commercial salmon fishing in 1962. Shipping activities began to decline until only a remnant charter fleet remains along with small pleasure craft. Much of the Tillamook fish catch is now landed at other ports. Canneries have closed, and shipping vessels no longer call at Tillamook ports. Logs, lumber, and cheese now leave the Tillamook area by truck or rail.

RESOURCE USES

Early settlers cleared the land of large spruce, hemlock, cedar and fir trees and used the lush vegetation of white clover to feed their dairy herds. The sale of butter and, to a lesser extent, milk was their livelihood. The original cows were a mixed breed including California longhorns. Now, the area has some of the most productive dairies with the finest herds of Holstein, Jersey, Guernsey and Ayrshire cows in the country.

Butter production was a risky business enterprise due to the difficulty of making shipments by sea or on poor roads. Finally, around the turn of the century, the art of cheese making was introduced. The rich milk from the cows in the basin resulted in a cheese which has become famous across the country. Individual farmers made and marketed their own cheeses until the Tillamook Creamery Association was formed in 1909. Uniform quality control was achieved by 1969. In 1971, the Association received from its members 156 million pounds of milk for processing. From that amount, 111 million pounds were used to process about 12 million pounds of Tillamook Cheese. There is a great demand today for the flavorful cheese from Tillamook.

Logging and lumber production started in the late 1860's. The work was done by hand using axes, crosscut saws, jack screws and peavies. It was necessary to work in close proximity to rivers and streams since the logs were rolled into the water by hand and floated to the mill. When oxen and skid trails were added to the logging process, it was possible to harvest logs farther away from the river bank. A crew of six men and 8 oxen moved 30-40 logs in a single day while now, a crew of four is expected to move 400-600 logs in a day. The donkey engine replaced the oxen about the turn of the century. Railroad spurs were extended inland and the industry began to pick up the pace. In 1923, twenty sawmills were operating in the county and an estimated 15 billion board feet of timber was produced in the Tillamook Bay drainage basin. This did not include weed species such as red alder.

Timber harvests were subject to considerable seasonal fluctuations but managed to maintain a steady growth from 1875 to 1922. Production increased to about 150 million board feet annually with 75 percent of the logs going to mills outside of Tillamook County.

After the devastating Tillamook forest fires, the salvage of fire-killed timber resulted in a rapid increase in the timber harvest starting in 1940 and peaking at about 610 million board feet in 1952. Harvest then began a decline until 1957 at which time it leveled out at about 255 million board feet. This level has continued into the 1970's but the average annual cut is projected to decrease to about 77 million board feet from 1980 to the year 2000.

Lumber production for the period 1875 to 1922 reached an annual level of about 35 million board feet and then remained fairly steady until 1945. Mill activity increased due to salvage of fire-killed timber. By the late 1960's, the average annual lumber production was about 140 million board feet. There were 19 mills in the county in 1948 but most of them were phased out following a decline in salvage operations. Production from the three presently existing saw mills now averages about 160 million board feet annually.

The fishing industry developed slowly in Tillamook because the bar at the mouth of the estuary was considered to be the most dangerous to cross of all the bars on the Oregon coast. Ship owners were unwilling to establish regular schedules and even more reluctant to locate there on a permanent basis. The fish which were harvested off the coast in the Tillamook area were often unloaded for processing at other ports such as Astoria.

Harbor improvement, jetty construction and dredging which took place after 1918 permitted development of a good fishery for a short period of time. The catch included salmon, crabs and other shellfish and bottom fish. However, the fishing industry was greatly affected and began to decline with the advent of the many forest fires in the upper basin area. Severe erosion problems developed and thousands of tons of soil washed into the stream systems. A substantial amount of soil ended up in the bay. Channels were blocked, eelgrass beds smothered and shellfish beds destroyed. By 1919, the channel between Tillamook and Bay City had been abandoned and, by 1925, the channel above Bay City was also lost to deep draft vessels. Since dredging operations were often negated by sediment deposition in less than three months after completion, (the normal effective period of time for a dredging operation is considered to be three years), the conclusion was reached that it was too costly to maintain a dredged channel the entire length of the bay. The U.S. Corps of Engineers then curtailed dredging operations, thus bringing to an end lumber ships calling at the port of Tillamook.

A reduced fishing industry continues to operate out of Tillamook Bay. The principal source of income is from oysters, crabs and a chum salmon hatchery-cannery development. Commercial oyster production has continued in the bay despite the problems created by sediment. More than 85 percent of Oregon's oyster production comes from Tillamook Bay. Approximately 80,000 pounds of meat was shucked from oyster beds in 1968. About 2,600 acres of tidelands in the bay are leased to oyster producers. These growers have curtailed operations to only 500 acres at the present time because of the difficulty of seeding the oysters and protecting them from siltation. The ocean fishery is composed mostly of small sports fishing craft which can negotiate the bar, a few commercial operators with shallow-draft boats, and boats from other ports.

When the railroad was completed in 1911, development accelerated. The recreation-oriented community of Bayocean had been started, and by 1915, fifteen hundred lots had been sold and construction of summer homes began. A natatorium was constructed on Bayocean Peninsula and deep sea fishing became a sport. The entire development has long since disappeared, having been washed away by erosion of the shores of the sand spit which forms the peninsula.

Sports fishing, unlike commercial fishing did survive and grow in spite of the sediment problems. Boat access is more difficult and the size of the boats is limited by bar conditions. The Oregon Fish Commission made a study of sports fishing in Tillamook Bay in 1971 and found that there were 66,500 person days devoted to recreational fishing annually. These people spent a total of 172,300 hours harvesting the different varieties of fish and shellfish. (See Table III-1).

The five river systems are also important fisheries. There were 102,600 angler days spent on the rivers in 1976 to catch 27,275 anadromous fish. The total sports fishery catch by river and angler days is summarized on Table III-2.

Hunting has also become popular in the basin. The Tillamook Burn has developed into an ideal habitat for deer and elk. Portland area hunters utilize the area in ever increasing numbers.

Another growing recreational activity in the basin is motorcycle riding on the many trails and roads particularly in the Tillamook Burn. Many cycle clubs from the Willamette Valley have competitive meets or cycle roundups there. It is not uncommon for several hundred cycle riders to be in the upper Wilson River area on a given weekend. This is especially true following a summer rainstorm.

Studies conducted by both Tillamook County and Oregon recreation planners indicate that recreation use in the Tillamook Bay Drainage Basin is growing faster than the population growth of the State. Demands for recreation may soon outstrip available resources. The sediment and erosion problems tend to aggravate the situation.

Table III-1--NUMBER OF ANGLER TRIPS, HOURS OF EFFORT, AND ANIMALS CAUGHT
TILLAMOOK BAY, BY MONTH
MARCH 1 THROUGH OCTOBER 31, 1971

Fishery	Month	No. Angler Trips	Angler Hours	Catch Finfish	Catch Crabs	Catch Clams	Catch Misc. Invert.	Catch Total
Boat	March	669	2,243	3	2,387	0	0	2,390
	April	1,162	3,973	2	3,043	0	2	3,047
	May	1,874	7,045	104	4,174	0	0	4,278
	June	1,411	4,795	247	3,095	0	0	3,342
	July	2,045	6,393	293	5,170	0	0	5,463
	August	3,383	11,740	226	5,479	0	0	5,705
	September	7,245	31,267	808	5,700	0	0	6,508
	October	6,693	31,020	945	3,274	0	0	4,219
	Total	24,482	98,476	2,628	32,322	0	2	34,952
Shore	March	673	1,333	511	26	0	0	537
	April	1,280	2,638	1,295	30	0	0	1,325
	May	3,122	6,477	5,363	126	0	0	5,489
	June	2,000	4,151	3,175	56	0	0	3,231
	July	3,724	7,555	3,452	147	0	0	3,599
	August	3,368	6,790	2,689	14	0	0	2,703
	September	1,858	3,766	773	0	0	0	773
	October	1,410	2,867	296	0	0	0	296
	Total	17,525	35,577	17,554	399	0	0	17,953
Tide Flat	March	3,745	5,202	26	18	93,900	5,600	99,544[1]
	April	3,025	4,653	21	15	75,900	4,500	80,436
	May	3,194	4,990	22	16	80,100	4,800	84,938
	June	4,194	6,453	29	21	105,200	6,200	111,450
	July	5,611	9,351	39	27	140,700	8,400	149,166
	August	3,643	6,071	25	18	91,400	5,400	96,843
	September	1,031	1,494	7	5	25,900	1,500	27,412
	October	28	41	0	0	700	40	740
	Total	24,471	38,255	169	120	613,800	36,440	650,529
Combined	March	5,087	8,778	540	2,431	93,900	5,600	102,471
	April	5,467	11,264	1,318	3,088	75,900	4,502	84,808
	May	8,190	18,512	5,489	4,316	80,100	4,800	94,705
	June	7,695	15,399	3,451	3,172	105,200	6,200	118,023
	July	11,380	23,299	3,784	5,344	140,700	8,400	158,228
	August	10,394	24,601	2,940	5,511	91,400	5,400	105,251
	September	10,134	36,527	1,588	5,705	25,900	1,500	34,693
	October	8,131	33,928	1,241	3,274	700	40	5,255
Grand Total		66,478	172,308	20,351	32,841	613,800	36,442	703,434

1/Catch data for the tideflat fishery determined by multiplying the average catch per year times the number of angler trips per month.

Source: Oregon Fish Commission, 1971

Table III-2, Tillamook Bay River System Fishery Data, 1970

Water	Angler Days	Sports Species	Harvest Number
Wilson R.	800	Spring (chs) Chinook	200
	4,400	Fall (chf) Chinook	1,100
	2,800	Coho (Co)	200
	44,800	Winter (stw) Steelhead	11,200
	2,000	Summer (sts) Steelhead	500
	2,500	Searun (cts) Cut Throat	1,250
Trask R.	1,400	Chs	350
	7,700	Chf	1,925
	4,900	Co	1,225
	14,800	Stw	3,700
	- -	Sts	- -
	2,500	Cts	1,250
Kilchis	240	Chs	60
	1,320	Chf	330
	840	Co	210
	4,000	Stw	1,000
	- -	Sts	- -
	1,500	Cts	750
Miami R.	40	Chs	10
	240	Chf	60
	120	Co	30
	900	Stw	225
	- -	Sts	- -
	1,000	Cts	500
Tillamook R.	240	Chs	60
	1,320	Chf	330
	840	Co	210
	400	Stw	100
	- -	Sts	- -
	1,000	Cts	500
Total	102,600		27,275

Source: Oregon Fish Commission 1970

MAJOR BURNS

Fires have always been a part of the ecological development of Tillamook Basin. The early burns did not have the devastating effect as did the fires in the twentieth century. One of the reasons recent fires have been so serious is the tendency for recurrence of severe burns over the same area within a short time interval. The first of the recent fires was in 1918, burning part of the upper Kilchis and North Fork Wilson River drainages (see Tillamook Burns Map). A larger fire occurred in 1933 which not only reburned most of the 1918 fire area, but also burned the remainder of the upper Kilchis, Wilson and Trask Rivers, covering a total area of 240,000 acres. Much of this same area burned again in 1939 covering 190,000 acres, and then again in 1945 when fire covered 180,000 acres. The concerned people of Tillamook and the State of Oregon launched a massive reforestation and fire control program in 1949 (completed in 1973). Sixty-one percent of the burned area has been reforested, 220 miles of fire breaks constructed, and 1½ million snags felled. So, when a fire occurred in 1951, it was stopped after burning only 20,000 acres. Altogether the fires, including the 1951 fire, covered a total of 355,000 acres with 228,600 acres occurring in the Tillamook Bay Drainage Basin. A loss of approximately 11 billion board feet occurred in the basin. Salvage operations recovered 4.5 billion board feet so that the net loss was about 6.5 billion board feet.

The effects of forest fires go beyond the loss of timber, forage and wildlife. Sediment deposition, streambank cutting and flooding are usually the aftermath of large burns.

The economy of Tillamook suffered both direct and indirect consequences from the fires. An estimated 10 million board feet of lumber was destroyed during one of these fires (1933). The County could not meet its State tax commitments, much less finance its own operations. Many companies and individuals were unable to keep their land so it was turned back to the County in lieu of taxes and eventually deeded to the State so that reforestation could be undertaken by the State Forester. Planting and seeding began on 22,000 acres through a County, State and Federal cooperative effort. Other groups, such as the Isaac Walton League, 4-H Clubs and schools also helped during the reforestation project.

The fires and salvage logging left thousands of acres bare to the coastal storms. Erosion processes were accelerated and thousands of tons of sediment were washed into the streams to eventually be deposited in the bay. Although the amount of sediment reaching the bay has been reduced since the reforestation program became effective, there is still a need for continued reduction in the amount of sediment entering the streams and estuarine systems.

To summarize, as a result of the fires, Tillamook Basin has lost an estimated $1,787 million in timber. The loss of fisheries, wildlife, and aesthetics is immeasurable. This estimation is over simplified, and the true losses are greater today than the $1,787 million because of economic multipliers and interest accrued on dollars earned. The fact remains that Tillamook suffered a tremendous financial loss.

SEDIMENT IN THE BAY

Modern deposition and erosion of river-borne sediments in Tillamook Bay Estuary began about 9000 years before present (B.P.) when worldwide rising ocean levels entered the river valleys which had been formed by earlier ocean fluctuations.

Extensive farming, logging operations, and numerous fires destroyed large areas of timber and protective ground cover in the upper watershed resulting in a drastic increase in erosion and sediment production. This source of sediment, in conjunction with the almost annual occurrence of overbank flooding and streambank cutting during periods of high water, produced conditions detrimental to the survival of aquatic life and industrial development in the bay area.

The bay is separated from the ocean by Bayocean Peninsula, a four-mile long sand spit varying in width from 1,000 feet to over 3,000 feet at the north end. Once a body of deep water with a fairly uniform depth, sediment deposition and delta expansion at the north and south end of the bay has caused it to become progressively more shallow. Deposition in the northwest section of the bay is likely due in part to the migration of beach sands through the 1200foot wide channel entrance as a result of tidal action. Construction of the rock jetties a number of years ago may have resulted in accelerated shoreline erosion and consequent deposition of sediment within the confines of the channel. This occurrence has resulted in the formation of shoals --a definite navigation hazard. Other contributing sources of sediment to the Bay area include the (1) wind transport of intertidal sands due to shore-line erosion, (2) spoil from landslides which is dumped along the highway on Tillamook Bay intertidal lands, and (3) sediment-laden streams draining into the bay.

In geologic terms, the youngest part of the modern fill is accumulating in the bay at the present time. The radiocarbon dating technique used on the detrital wood that forms the bulk of datable materials does not provide ages for the very youngest deposits. At a depth of 22.6 feet mean sea level (MSL), the age of the fill is 3,300 ± 200 years before present (B.P.). No datable younger materials from shallow depths were found anywhere in Tillamook Bay. Available stratigraphic data suggests deep or quiet water deposition for sediments in

R 10 W

9   8   7   6   5

T 2 N

1 N

1 S

2

3

Tillamook Bay Drainage Basin

WASHINGTON CO.

YAMHILL CO.
TILLAMOOK CO.
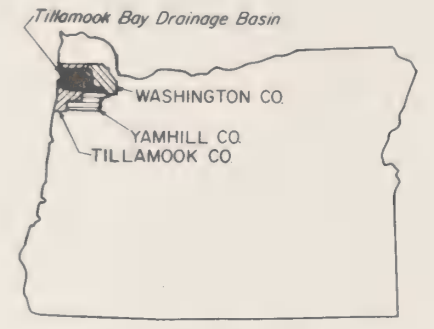
LOCATION MAP
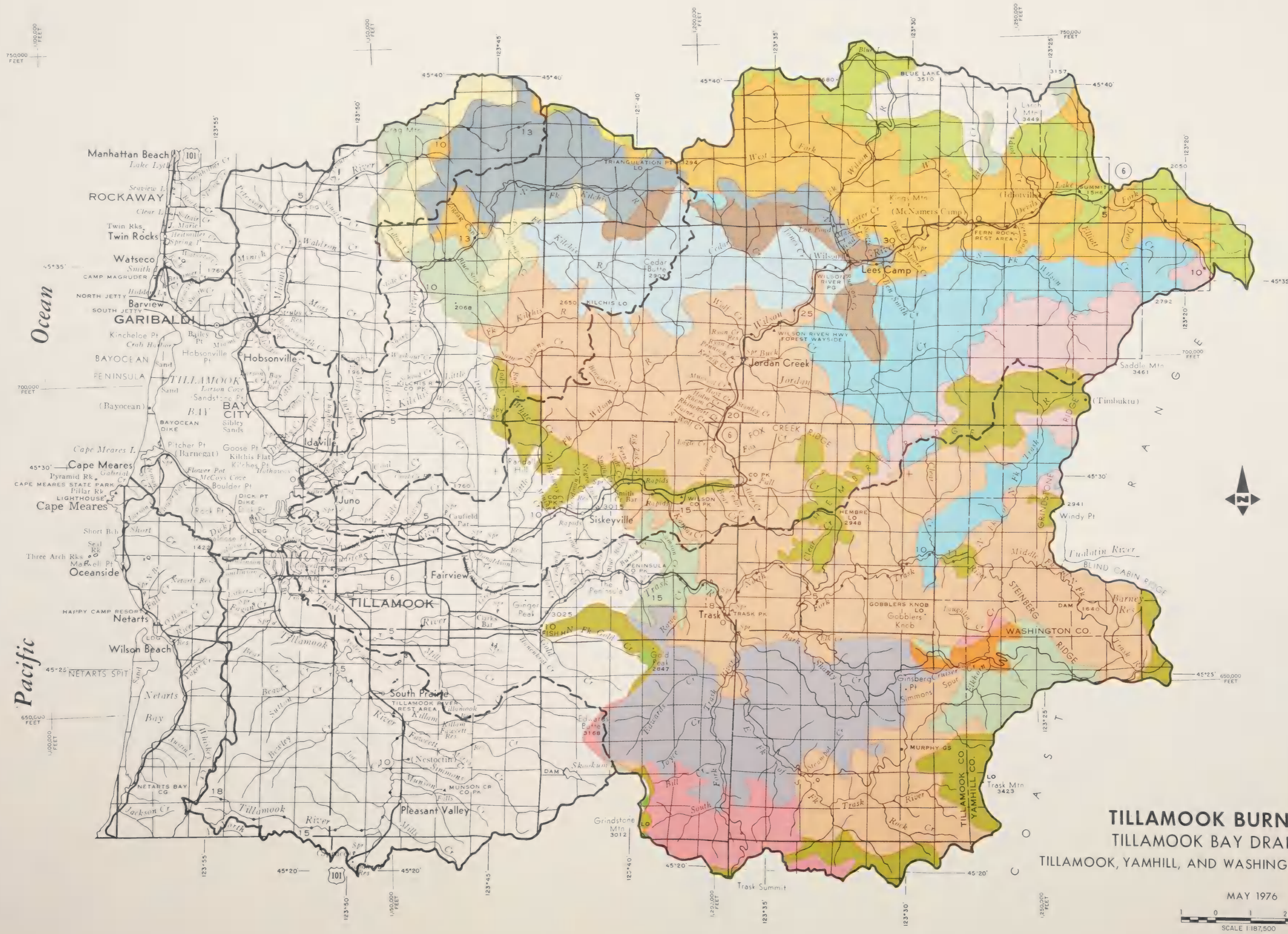
TILLAMOOK FIRES

Unburned

SINGLE BURN

1918
1933
1939
1945
1951

DOUBLE BURN

1918-1933
1918-1945
1933-1939
1933-1945
1933-1951
1939-1945
1939-1951

TRIPLE BURN

1918-1933-1939
1918-1933-1945
1933-1939-1945
1933-1939-1951

QUADRUPLE BURN

1918-1933-1939-1945

TILLAMOOK BURNS 1918-1951
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES, OREGON

MAY 1976

1 0 1 2 3 MILES
SCALE 1:187,500

Ocean

Pacific

Manhattan Beach
ROCKAWAY
Twin Rocks
Watseco
CAMP MAGRUDER
Barview
GARIBALDI
Hobsonville
BAYOCEAN PENINSULA
TILLAMOOK BAY
BAY CITY
(Bayocean)
Cape Meares
CAPE MEARES STATE PARK
Cape Meares
Oceanside
HAPPY CAMP RESORT
Netarts
Wilson Beach
NETARTS SPIT
Netarts Bay
Idaville
Juno
Fairview
TILLAMOOK
South Prairie
Pleasant Valley
Siskeyville
Jordan Creek
Lees Camp
Trask

FOX CREEK RIDGE

GRINDSTONE RIDGE

BLIND CABIN RIDGE

COAST RANGE

WASHINGTON CO.

TILLAMOOK CO.
YAMHILL CO.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE   USDA-SCS-PORTLAND,OR 1976

M7-SN-23598-3

the lower and middle part of the modern fill. Deep water implies that the sea level may have been considerably above the sediment deposition surface during the early and middle periods of bay filling.

PAST ECONOMIC EFFECTS

Economic development of Tillamook Bay Drainage Basin has historically centered around the timber and lumber industries. Dairying, tourism, and commercial fishing are also important sectors of the local economy. The wood products and related industries accounted for nearly 50 percent of the total value of county exports in 1973.

Lumber was first exported from the area by boat around the early 1880's. Sediment has long since choked the main shipping channel to the town of Tillamook, preventing water-borne export of logs and wood products. However, the economic effects are difficult to determine since exports of lumber and wood products continued via other means. In recent years, rail and truck shipments have replaced water-borne traffic. It could be argued that the major fires have likely had a greater effect on the timber industry than has sediment deposition in the bay. An estimated 13 billion board feet of timber was destroyed by those fires. [1]

The seafood industries and commercial fishing activities have suffered as a result of sediment accumulation in the bay. Commercial fishing used to be more important to the local economy than it is at the present time. From 1923-1947 the average annual catch of all species was about 1,543,000 pounds. The annual catch has decreased to 608,000 pounds from 1948-1956, and during the years 1957-1961, the average annual catch was only 101,000 pounds.(Oakley, Arthur L.) In 1962, the Oregon Fish Commission closed Tillamook Bay to all commercial Salmon fishing.

Severe economic reverses have been experienced by the commercial fishing industry. However, it is debatable as to how much of this hardship can be blamed on sediment since other coastal commercial fisheries on the Columbia River and as far north as British Columbia experienced downtrends during the same time periods.

Sediment has seriously affected recreational boating. With a high risk of getting stranded on sand bars in Tillamook Bay Estuary, recreational boaters have an incentive to look elsewhere for weekend boating activities.

_____
[1] See preceding section, Major Burns.

It is impossible to determine the historical economic effects of erosion and sediment on recreational activities. However, during the early 1900's, money was being invested at Bayocean City to develop a summer recreation resort. Erosion of the shores of the Bayocean Peninsula eventually resulted in the disappearance of the entire development, which thus had a direct damaging historical effect on the recreation industry.

While the economic impacts of sediment are often difficult to determine, such is not the case when it comes to dredging. The U.S. Corps of Engineers has been involved in the bay since 1888 and, since 1922, primarily with dredging.[1] In 1888, the Corps built dikes in Hoquarton Slough near the town of Tillamook. Ocean-going ships were able to navigate the length of the bay loaded with lumber. By 1919, the channel between Tillamook and Bay City had been abandoned, and by 1925 the channel above Bay City was also lost to deep draft vessels. Several studies were conducted by the Corps from 1897 to 1941, with the conclusion that it was too costly to maintain a dredged channel the length of the bay.

In recent years, the Corps has attempted to maintain the Garibaldi boat basin and a channel from the basin out past the bar to the ocean. However, even with the dredging program, navigational channels continue to fill with sediment. Often a dredging job will be effective for only three months. Historically, increased sediment in the bay has resulted in decreased use of the bay by boats, both commercial and non-commercial. With this decrease in use, the Corps finds less economic justification for dredging. Tillamook Bay is low on the dredging priority list, especially compared to the Columbia River and Coos Bay. Decreased dredging, in turn, results in decreased boating, completing the cycle.

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[1] From the U.S. Corps of Engineers open files.

CHAPTER IV

EXISTING LAND
& WATER RESOURCES

EXISTING LAND & WATER RESOURCES

RESOURCE INVENTORY SUMMARY BASE YEAR (1975)

The quantity and quality of the resources in Tillamook Basin in the base year (1975) were, in large part, the result of man's influence on the basin. Much of the flat land in the valley bottoms and around the bay was cleared of trees to permit development and to provide pasture and hay for the dairy herds. Timber harvest provided additional income, but this resource was frequently affected by fires. A massive reforestation program was undertaken but even with this effort, large quantities of sediment have moved into the streams and bay affecting the fishery resources. The construction of roads improved access and allowed the development of the area as a recreation resource. Table IV-1 refers to land use by acres for each of the five drainage basins within the Tillamook study area for the base year (1975).

LAND USE vs. DRAINAGE

Table IV-1

TILLAMOOK BAY DRAINAGE BASIN – 1975

Land Use	Tillamook Ac.	Miami Ac.	Kilchis Ac.	Wilson Ac.	Trask Ac.	Sub-Total Ac.	Total Ac.
Forest Lands 1/							
1. Clearcuts, low brush and seedlings	6,120	4,370	1,530	930	660	13,610	
2. Burns including low brush and seedlings	--	700	7,410	16,370	20,500	44,980	
3. Old-growth	1,290	1,490	2,630	15,010	10,140	30,560	
4. Mature second growth	4,530	3,130	4,830	15,580	8,180	34,250	
5. Pole timber	11,920	5,500	9,390	27,960	18,060	72,830	
6. Saplings	3,930	2,230	3,820	12,960	16,090	39,030	
7. Tall brush and seedlings	3,010	2,330	4,030	11,590	12,540	33,500	
8. Hardwoods	2,680	4,520	9,140	20,050	14,470	50,860	
9. Forested pasture	1,640	220	460	400	710	3,430	
Subtotal	35,120	24,490	43,240	118,850	101,350	323,050	323,050
Agricultural Lands 1/							
1. Irrigated pasture	120	200	460	1,120	1,820	3,720	
2. Other wet pasture	960	–	–	–	–	960	
3. Dry pasture unimproved	1,240	170	470	480	1,660	4,020	
4. Dry pasture improved	4,370	360	1,620	1,790	5,330	13,470	
5. Brush pasture	570	90	210	190	310	1,370	
Subtotal	7,260	820	2,760	3,580	9,120	23,540	23,540
Water 2/							
1. Rivers	280	70	280	600	600	1,830	
2. Bays	--	--	--	9,150	--	9,150	
Subtotal	280	70	280	600	600	10,980	10,980
Rock and Sand							
1. Other lands	40	--	500	2,380	1,110	4,030	
2. Bay	--	--	--	190	--	190	
Subtotal	40	--	500	2,380	1,110	4,220	4,220
Urban	440	170	140	130	850	1,730	1,730
TOTAL	43,140	25,550	46,920	125,540	113,030	- -	363,520

1/ Road and trail rights-of-way are also included in each acreage of this table. A more detailed analysis follows.

2/ Water listed above includes only streams wider than 10 feet and water bodies four acres or larger in size.

Source of Data: USDA staff using the PIXSYS Program at Oregon State University

TOPOGRAPHY AND GEOLOGY

The study area extends to the west from the sharp crestline of the Coast Range followed by gentle to steeply sloping rocky uplands, deeply incised canyons, and a flat to gently rolling floodplain. The western extremity of the area includes a coastline largely of sand dunes, beach sand and sedimentary rock alternating with an occasional rugged headland of volcanic rock. Most of the present upland topography is the result of downcutting and degradation by the tributary streams resulting in the formation of a dendritic and radial pattern.

Elevations along the summit vary from 600 feet to 3461 feet, averaging about 1500 feet. Well known peaks or ridges include Larch Mountain, 3449 feet; Hembre Ridge, 3409 feet; Kings Mountain, 3226 feet; Trask Mountain, 3423 feet; and Grindstone Mountain, 3012 feet. Major streams draining into Tillamook Bay include the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Notable tributary streams include the Elk, Drift, Jordan, and Fox Creeks on the Wilson River, the North, East and South Forks of the Trask River, and Edwards and Bark Shanks Creeks, all tributaries to the Trask River system.

The crust of the earth in northwestern Oregon appears to be very thin, probably not exceeding 10 miles in thickness in places. Resistivity studies indicate that it is primarily oceanic in character. Recent theories of plate tectonics suggest that it may represent Eocene sea floor that has been welded to the continent. There may be no older rocks than Eocene in the subsurface part of the area.

Structurally, the core of the Oregon Coast Mountain Range is interpreted to be a broad uplift which is generally described as a north-plunging geanticline. The oldest rocks in the basin, the Tillamook volcanics of lower Eocene age, cap the ridges with older sedimentary rocks being exposed in the canyon areas. Also, in the middle reaches of Wilson and Trask River drainages, a fault is indicated between exposures of lower Eocene volcanic rock on the west and exposures of undifferentiated Eocene sedimentary rocks to the east. Available attitudes and abrupt changes in lithology across the fault tend to rule out simple faulting or facies change. In addition, the north-south alignment of the middle reaches of the Wilson and Trask Rivers may indicate a north-south structural break in the Eocene terrain of this area (see Generalized Geology Map - following page IV-4).

Lithologically, indurated rock units ranging in age from Eocene
through Pliocene and unconsolidated deposits of Pleistocene to Recent
age, underlie the floodplain area and structurally from the steeper
slopes of the basin. The consolidated units total over 20,000 feet
in thickness and include submarine and subaerial dark gray to black
lava flows, flow breccia and some tuffaceous marine sedimentary rock;
marine siltstone, claystone and sandstone; intrusive igneous rock;
marine terrace deposits; and fluvial and tidal flat deposits. Rocks
units shown on the geology map included in this chapter are undiffer-
entiated Eocene sedimentary rocks, undifferentiated Eocene volcanic
rocks and middle to late Miocene basaltic intrusive rock. Unconsoli-
dated deposits of Pleistocene to Recent age characterize the flood-
plain area through which the five major drainages flow to reach Tilla-
mook Bay. These include marine terraces, terrace alluvium (silty clay
to silty sand over gravel), flood-plain alluvium (clay, silty clay,
silt, sandy silt and occasional gravel), and peat, active and stable
dune sand, beach sand, and tidal flat soils.
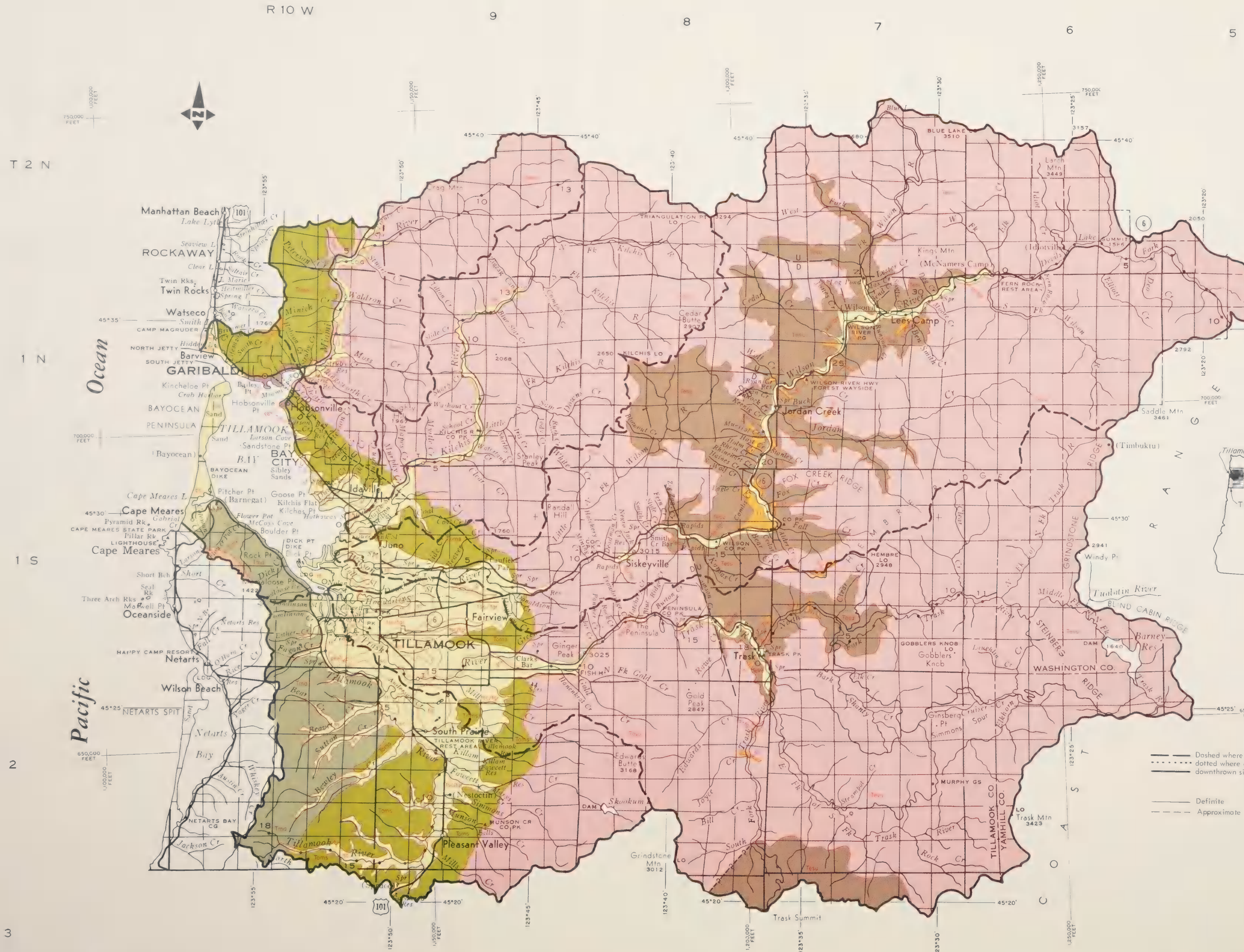
GENERALIZED GEOLOGY

UNCONSOLIDATED SURFICIAL UNITS

FLOOD PLAIN ALLUVIUM

tf — tidal flat
pt — peat
cl — clay
sc — silty clay
sl — silt
ss — sandy silt
gr — gravel

SANDS

bs — beach sand
ad — active dunes
sd — stable dunes

TERRACE ALLUVIUM

tsc — terrace silty clay
tgr — terrace gravel

STRATIGRAPHIC UNITS

MARINE TERRACES

MIOCENE VOLCANIC ROCKS

Localized accumulations of massive basaltic breccia (Onion Peak and Wickiup Mountain), basaltic flow rocks (Cape Meares), palagonitic breccias and pillow basalts. The basalts are petrochemically indistinguishable from the Yakima Basalt (Snavely, MacLeod and Rau 1969).

INTRUSIVE ROCKS

Primarily middle to late Miocene basaltic intrusive rock, which includes thick sills (Green Mountain and Tillamook Head), dikes, ring dikes, sills, podlike bodies (Neahkahnie Mountain (Ti)) and complex masses of small dikes and intruded sedimentary rocks (Tici); partly of late Eocene age in the Hebo quadrangle.

ASTORIA FORMATION

Approximately 2,000 feet of consolidated to semi-consolidated, thick-bedded to thin-bedded, medium grained, buff, micaceous, arkosic sandstone and interbedded siltstone.

OLIGOCENE TO MIOCENE SEDIMENTARY ROCKS

Over 5,000 feet of thin-bedded to massive, medium-gray to dark-gray, tuffaceous siltstone and claystone with subordinate amounts of sandstone and shale locally. Basaltic sandstone and conglomerate are present at the base of the section in places.

UNDIFFERENTIATED EOCENE VOLCANIC ROCKS

Several thousand feet of chloritized basalt flows and basalt breccias of submarine and subaerial origin. Zeolites are common locally. Equivalent primarily to the Nestucca Volcanics of Snavely and others (1949).

UNDIFFERENTIATED EOCENE SEDIMENTARY ROCK

Several thousand feet of undifferentiated, thin bedded to indistinctly bedded, tuffaceous, volcaniclastic siltstone, clay siltstone, and sandstone. The sedimentary rock occurs stratigraphically between the three Eocene volcanic units and grades laterally into them locally. Volcanic interbeds are present in places.
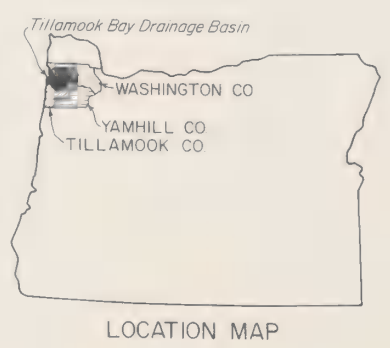
FAULT

—— Dashed where approximately located or indefinite, ········ dotted where concealed. U, upthrown side; D, downthrown side.

CONTACT

—— Definite
——— Approximate

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO
YAMHILL CO
TILLAMOOK CO

GENERALIZED GEOLOGY
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON

FEBRUARY 1976

SCALE 1:187,500
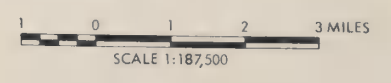
3 MILES

CLIMATE

GENERAL

Tillamook Bay Drainage Basin is bordered on the west by the Pacific Ocean. Close proximity to the ocean gives the area a marine climate. Most large air masses moving across the area originate many miles at sea, often taking many days to reach the coast. In time, the air masses become nearly saturated with moisture from the ocean and their temperature approaches that of the ocean. Year-round tempterature ranges are relatively small in the immediate coastal area.

There is considerable rain during the late fall, winter, and early spring and the usual amount of fog and low clouds associated with a marine climate. During the winter, ocean-spawned storms frequently move across the region. At this time the ground is much cooler than incoming air from the ocean. Immediately after crossing the coastline, this saturated air is subjected to two cooling processes -- by contact with the much colder land surface over which it is passing, and by lifting in its forced ascent while crossing the Coast Range. This latter process reduces the temperature at a rate of from three degrees to five degrees F. for each 1,000 foot increase in elevation. This cooling condenses a great deal of moisture causing precipitation on the west slopes of the Coast Range to add to the already very substantial storm totals. These combine to make this one of the heaviest rainfall areas in Oregon. Precipitation elevation relationships are displayed on Figure IV-1.

Nearly all the widespread winter precipitation in the area is produced either by a family of mature occlusions or by a quasistationary front with active minor waves. These storms may extend many hundreds of miles to the north or south and are generally three to five days in duration. Tropical cyclones are extremely rare and summer thunderstorms are of local rather than general occurrence. The infrequent hail or sleet storms over the area seldom reach destructive proportions. Mean annual precipitation by months is displayed on Figure IV-2.

Tillamook Basin has a marine-type climate with an average annual temperature of 50 degrees F. There is only about a 15-20 degree difference between the mean January and July temperature in any of the coastal areas, with a tendency for this difference to increase slightly with increase in distance from the ocean. Extremely high or low temperatures are rare. On the average, there are not more than one or two days a year with temperatures of 90 degrees F. or higher in the immediate coastal area and those of zero degrees F. or lower are practically unknown. Moving inland a few miles, the number of days

Figure IV-I

PRECIPITATION ELEVATION RELATION
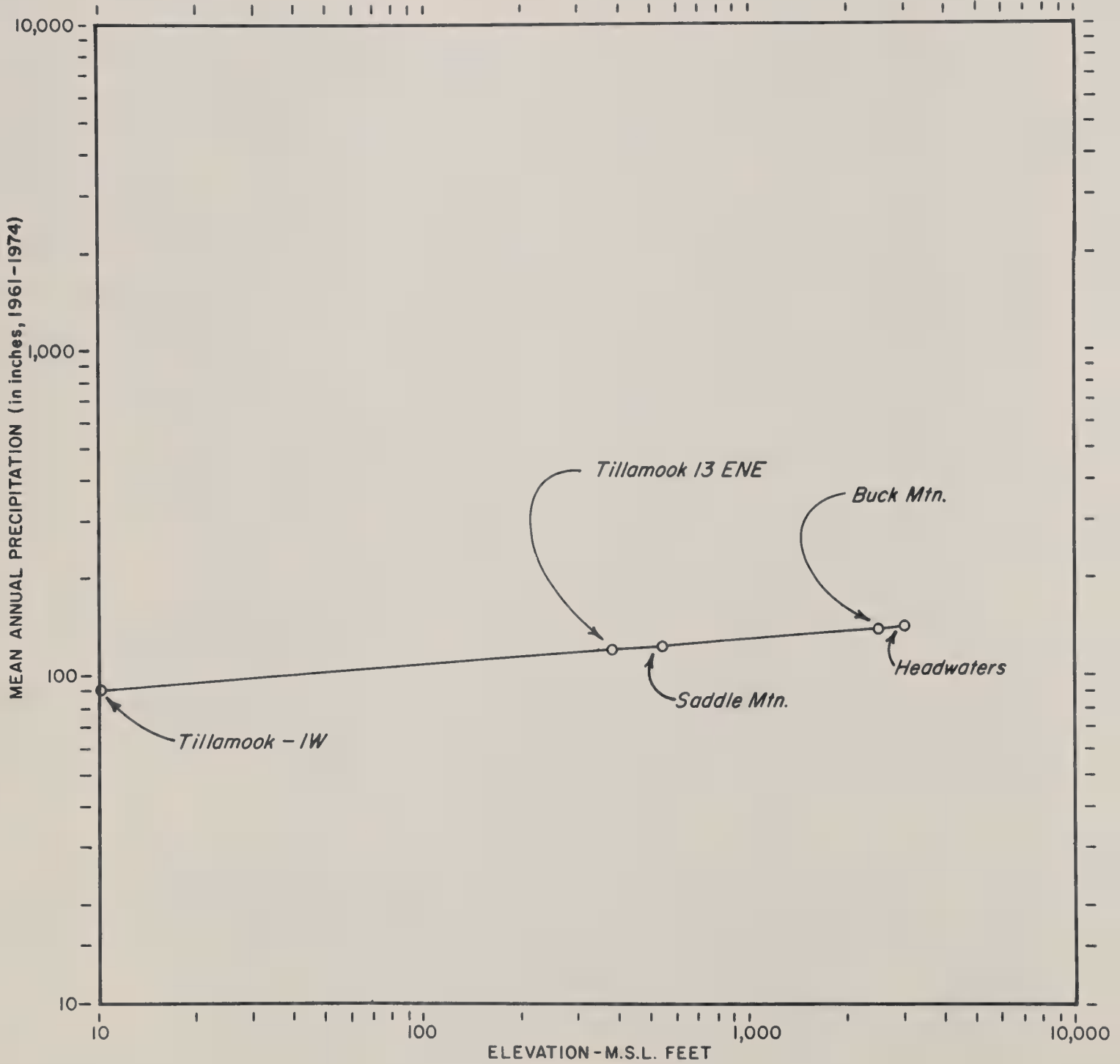
SOURCE: U.S.D.A. Study Team.

Figure IV-2

MEAN ANNUAL PRECIPITATION (1940-70) DISTRIBUTION BY MONTHS AT TILLAMOOK, OREGON
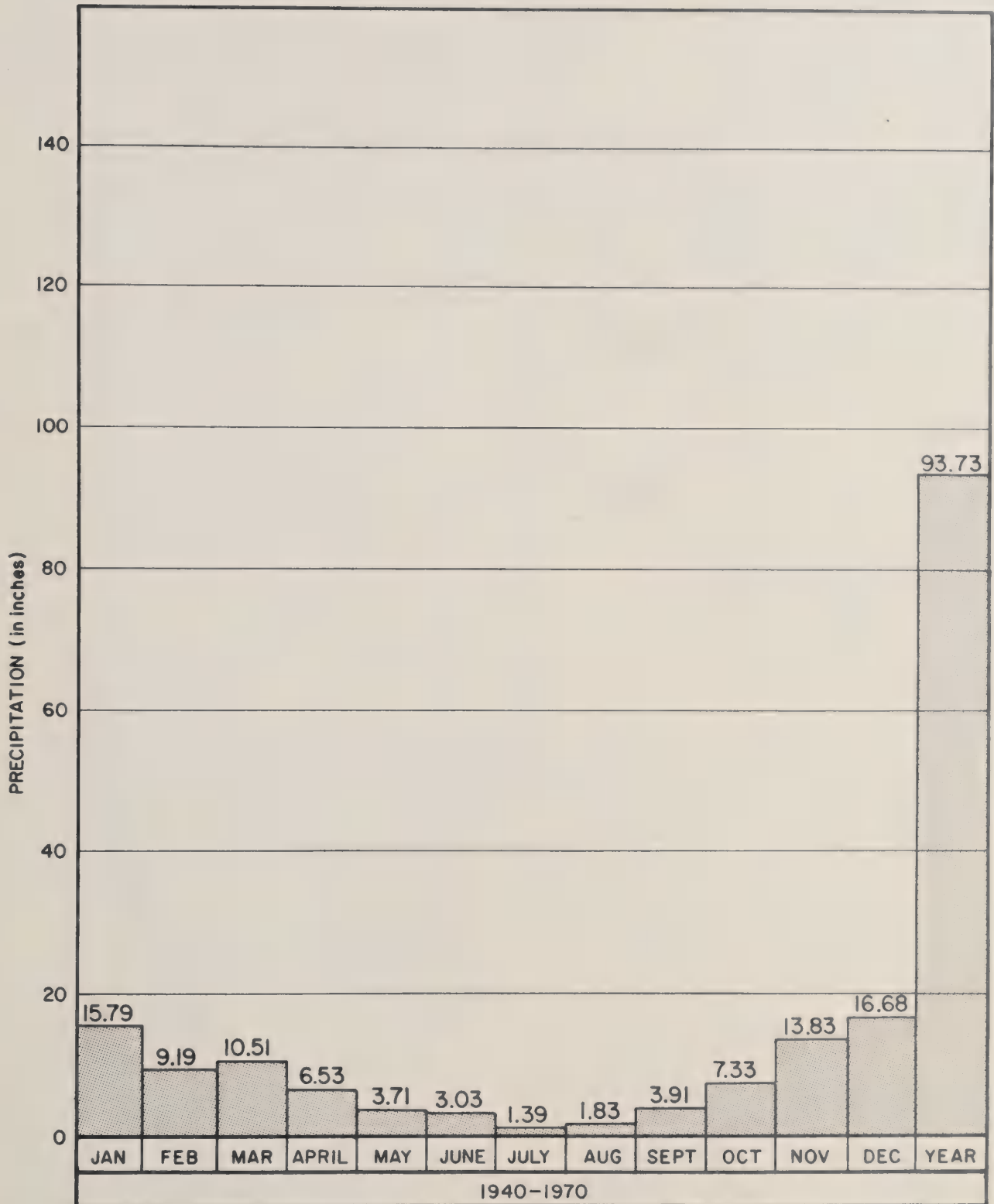
SOURCE : Climatography of the United States No. 81 (Oregon) NOAA

R 10 W   9   8   7   6   5

T 2 N

Manhattan Beach
Lake Lytle
Seaview L.
ROCKAWAY
Clear Lake
Twin Rks.
Twin Rocks
Spring L.
Watseco
Smith
CAMP MAGRUDER
NORTH JETTY
Barview
SOUTH JETTY
GARIBALDI
1 N
Kincheloe Pt.
Crab Harbor
Bailey
Hobsonville Pt.
Hobsonville
BAYOCEAN
PENINSULA
TILLAMOOK
Larson Cove
Sandstone Pt.
BAY CITY
(Bayocean)
BAYOCEAN
DIKE
Sibley
Sands
Idaville
Cape Meares L.
Fitcher Pt.
(Barnegat)
Goose Pt.
Kilchis Flat
Kilches Pt.
Cape Meares
Flower Pot
Pyramid Rk.
McCoys Cove
Boulder Pt.
CAPE MEARES STATE PARK
Pillar Rk.
LIGHTHOUSE
DICK PT.
DIKE
Cape Meares
Juno
Siskeyville
Short B'ch
Three Arch Rks.
Seal Rk.
Maxwell Pt.
Oceanside
Fairview
HAPPY CAMP RESORT
Netarts
TILLAMOOK
Trask
TRASK RD.
GOBBLERS KNOB
Cloverdale
Knob
WASHINGTON CO.
Clarks
Bar
FISH HN
Wilson Beach
NETARTS SPIT
South Prairie
TILLAMOOK RIVER
REST AREA
Netarts
Bay
MURPHY GS
NETARTS BAY
CG
Jackson Cr.
Tillamook River
Pleasant Valley
Grindstone
Mtn. LO
3012
Trask Summit

Lees Camp
Jordan Creek
WILSON RIVER HWY
FOREST WAYSIDE
BLUE LAKE
3510
3153

Ocean

Pacific

Tillamook Bay Drainage Basin

TILLAMOOK
COUNTY
WASHINGTON
COUNTY
YAMHILL
COUNTY

LOCATION MAP

LEGEND
Precipitation in Inches

MEAN ANNUAL PRECIPITATION
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES
OREGON

JUNE 1976

1 0 1 2 3 MILES
SCALE 1:187,500

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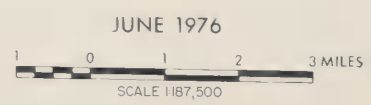
with 90 degrees F. and above may increase to as many as five a year, but those below zero degrees F. are rare. Days with minimums of 32 degrees F. or less, however, have a long period average of about 20 a year. The warmest average month is July, with 58.9 degrees F. and the coldest is January with 42.5 degrees.

Average annual precipitation ranges from 90 inches to 140 inches in the basin with 84 percent falling between October and May. Summer fog may contribute as much as 26 percent of the precipitation from July through September. Snow is of little significance immediately adjacent to the coast. The annual average is about one to two inches with many years having no measureable amount. Moving inland this gradually increases. The increase is sharply accentuated by increases in elevation. A few miles inland, annual total snowfalls may range from 5 to 20 inches. Density of the mountain snowpack increases from about 25 percent water equivalent in early winter to about 45 percent in April. The mean annual precipitation map in this report is an isohyetal map based on data from the U.S. Weather Service River Forecast Center, Portland, Oregon, using climatological data (1930-57) and information derived from correlations with physiographic factors.

The abundance of fresh marine air continually moving into the coastal area, together with the small daily temperature ranges, results in little seasonal or diurnal range in relative humidity. There is only about 20 percent difference between the long-period average of nearly 90 percent in the early morning, when it is the highest, and about 70 percent in the warmest part of the day, when the relative humidity tends to be lowest.

Despite relatively cool temperatures and fairly high humidity, there is an average April and October total evaporation of 20-25 inches as measured in Class A evaporation pans. The evapotranspiration averages as computed by the Palmer-Havens application to the Thornthwaite method is for a potential evapotranspiration of 25 inches annually. The computed actual value for soils with a two-inch water holding capacity is 18-20 inches and for those of a six-inch water holding capacity it is 20-24 inches.

This area, more than any other in the region, is exposed directly to the major winter storms that frequently move on to the Oregon-Washington coast, often with quite violent winds. Although only a limited amount of recorded wind information is available for the area, it seems reasonable to assume that winds with speeds of 60-70 mph occur almost every winter and those exceeding 100 mph have been recorded on at least four or five occasions in the last 65 years. The prevailing direction on an annual basis is generally westerly with the southerly or southwesterly component greatest in winter and the northwesterly component predominating in summer.

WATER YIELD

Forested land mean annual water yield as streamflow ranges from
7.5 to 8.6 feet per acre per year, with the greater amounts coming from
the steep, higher elevation lands in the Basin.

Figures IV-3 and IV-4 are synthesized hydrographs of the 11 major sub-
basins based on correlation with the long-term USGS gage on the Wilson
River. The runoff map of the basin is based on Figure IV-5.

The mean annual water yield as streamflow from the forested lands
in the Tillamook Estuary Basin amounts to 2,628,296 acre feet. This
yield is distributed by subbasins as shown in Table IV-2.

Table IV-2 - WATER YIELD BY SUBBASINS

River Subbasin	Water Yield Acre Feet	Percent
Tillamook	251,775	9.6
Miami	196,263	7.4
Upper Kilchis	178,262	6.8
Lower Kilchis	112,575	4.2
South Fork Kilchis	54,727	2.0
Lower Wilson	397,507	15.2
Upper Wilson	493,843	18.9
North Fork Wilson	131,440	5.0
Main Trask	541,380	5.0
East Fork Trask	156,854	5.9
South Fork Trask	113,170	4.0
TOTAL	2,628,296	100.0

Figures IV-6, IV-7, IV-8 and IV-9 are graphical presentations of the
hydrology of the Wilson River at the USGS stream flow gaging station.

Tables IV-3 and IV-4 relate to dependable yield and monthly mean discharge
rates, using the Wilson River as an example.

Table IV-5 is a summary by individual drainage of acreages classified
according to their hydrologic response.

Figure IV-3

MEAN ANNUAL HYDROGRAPHS

10 year 5 day average flows (1960-1970)

1. Miami Station #2
2. Miami Station #3
3. Wilson Station #4
4. Trask Station #3
5. Kilchis Station #2
6. Kilchis Station #3
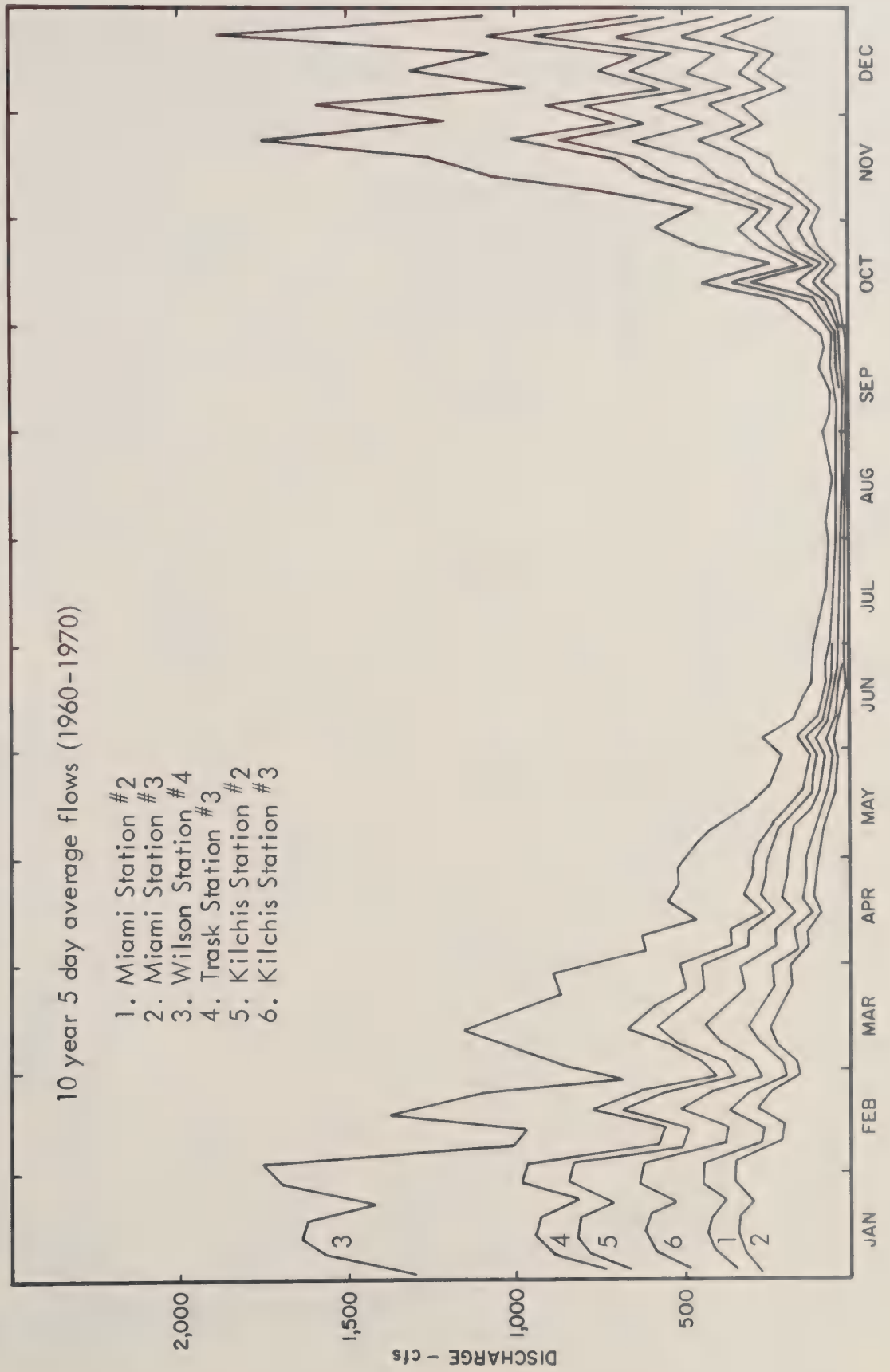
Figure IV-4

MEAN ANNUAL HYDROGRAPHS

10 year 5 day average flows (1960–1970)

1. Wilson Station #1
2. Wilson Station #2
3. Miami Station #1
4. Kilchis Station #1
5. Trask Station #1
6. Tillamook Station #1

Figure IV-5

STREAMFLOW VS. ELEVATION

DATA BASE: 1932-1974 U.S.G.S. Streamflow, Trask and Wilson Rivers

MEAN ANNUAL RUNOFF

TILLAMOOK BAY DRAINAGE BASIN

TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES
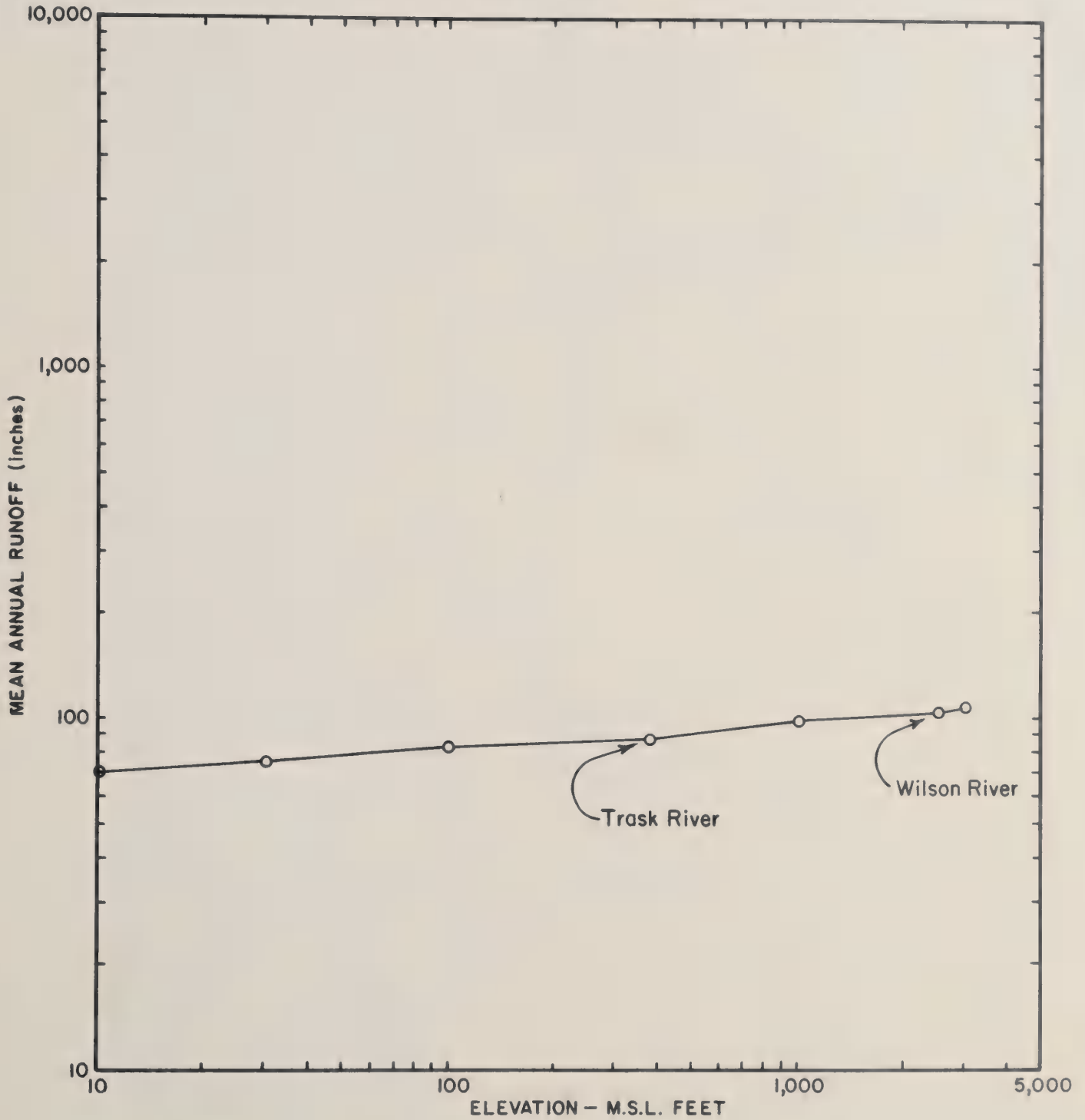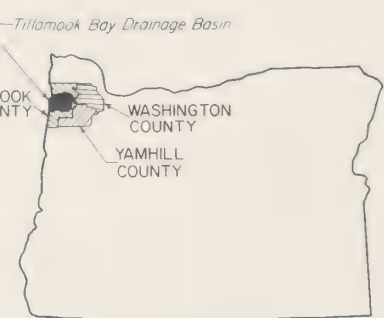
OREGON

JUNE 1976

LOCATION MAP

LEGEND

~~-100-~~ Runoff in Inches

SCALE 1:187,500

Source Data: Trask and Wilson River Stream Gage
(USFS Runoff-Precip. Curve)

Figure IV-6

MONTHLY DISCHARGE—WILSON RIVER NEAR TILLAMOOK, OR.

Annual Mean Discharge, cfs	
Maximum months	2,827
Maximum year	1,696
20 percent of time	1,681
Mean months	1,171
80 percent of time	704
Minimum year	734
Minimum months	319
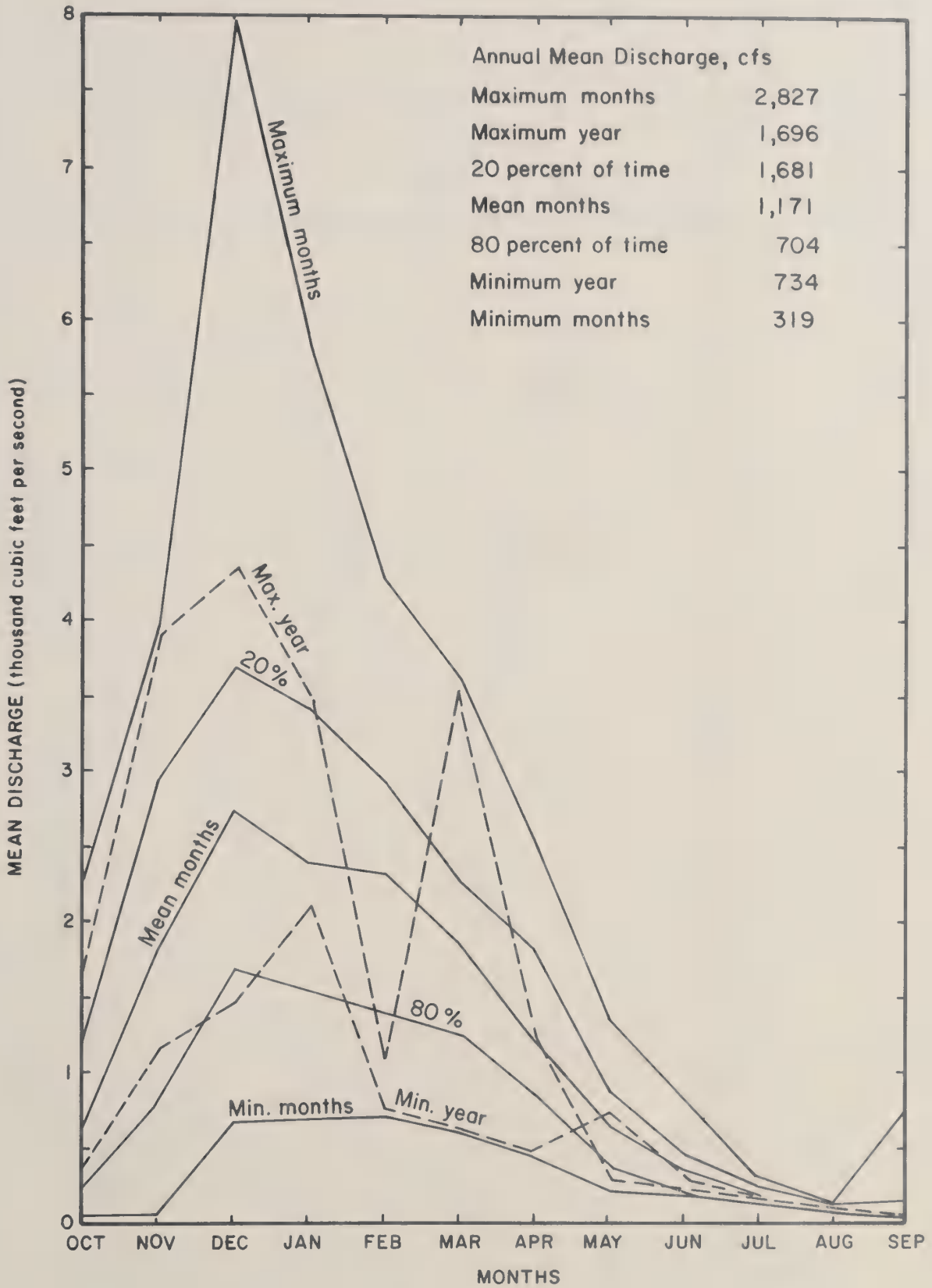
Period of record 1929–1958—1970 Conditions
Drainage area: 161 sq. mi.

Figure IV-7

FREQUENCY CURVES – WILSON RIVER NEAR TILLAMOOK, OR.
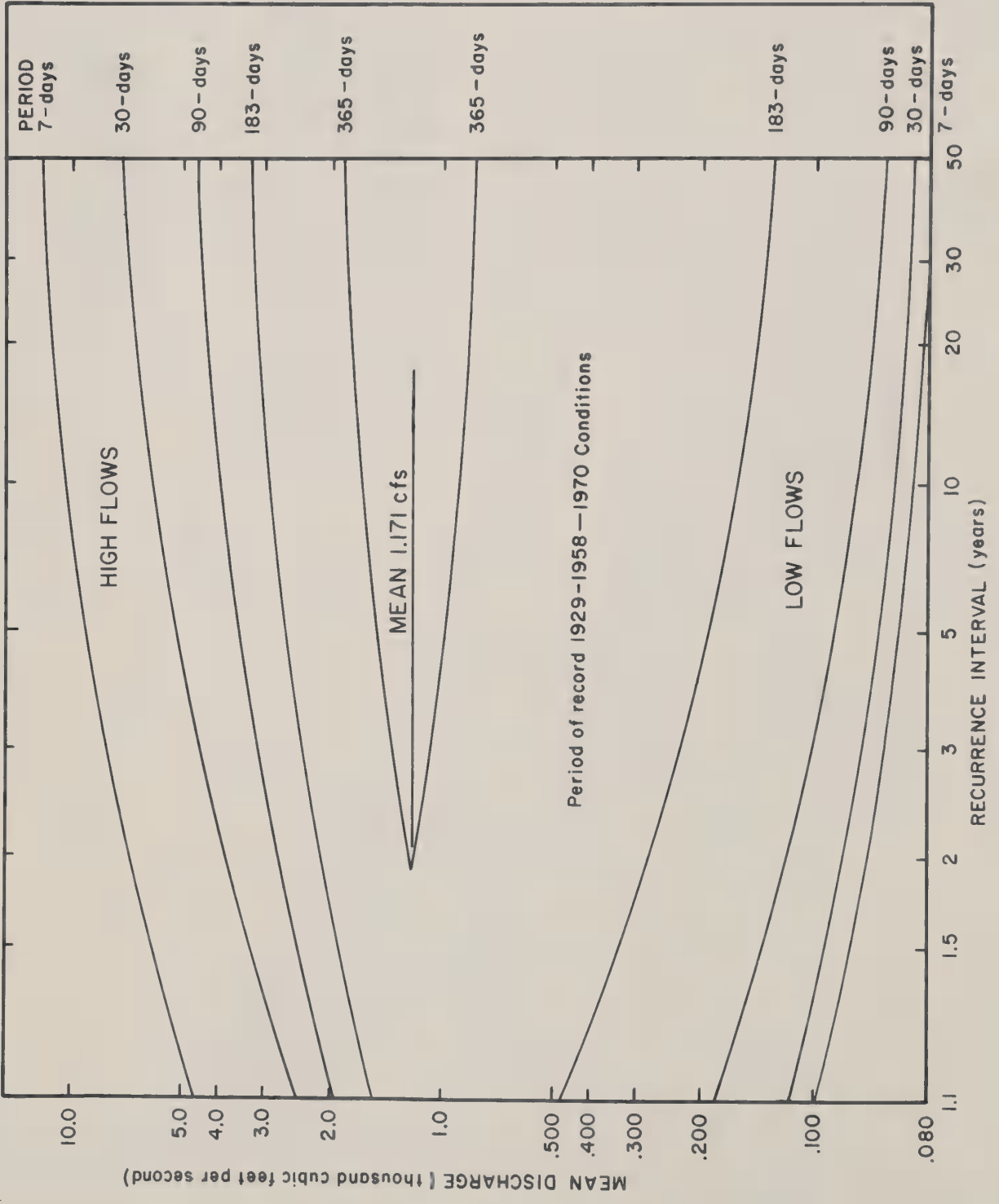
Figure IV-8

FREQUENCY CURVES OF ANNUAL PEAK FLOWS –
WILSON RIVER NEAR TILLAMOOK, OR.
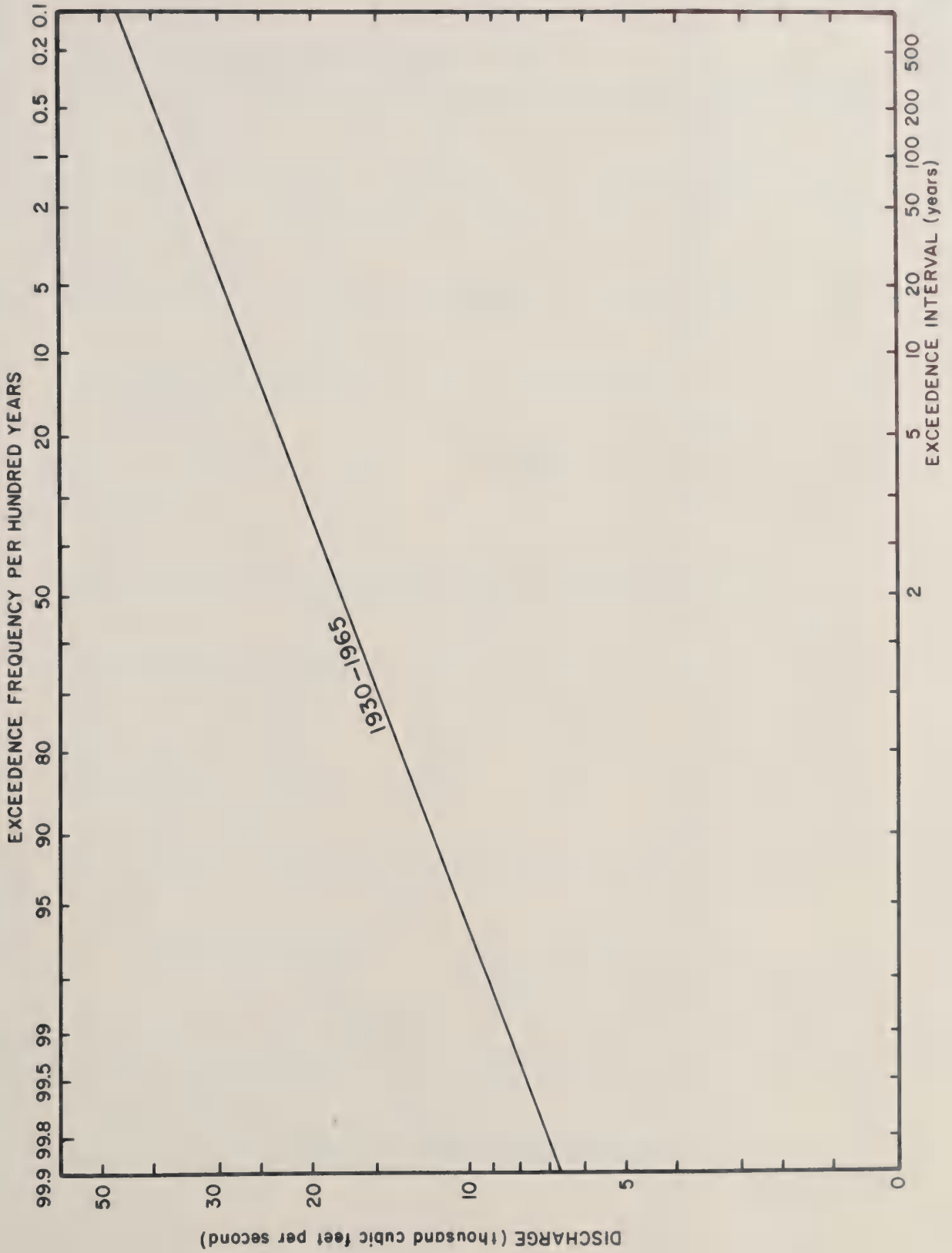
Figure IV-9

DURATION CURVES – WILSON RIVER NEAR
TILLAMOOK, OR.

Max. Discharge = 32,100 cfs

Max. Day = 27,500 cfs

Daily flows

Monthly flows

Annual flows

DISCHARGE (thousand cubic feet per second)

PERCENT OF TIME EQUALED OR EXCEEDED
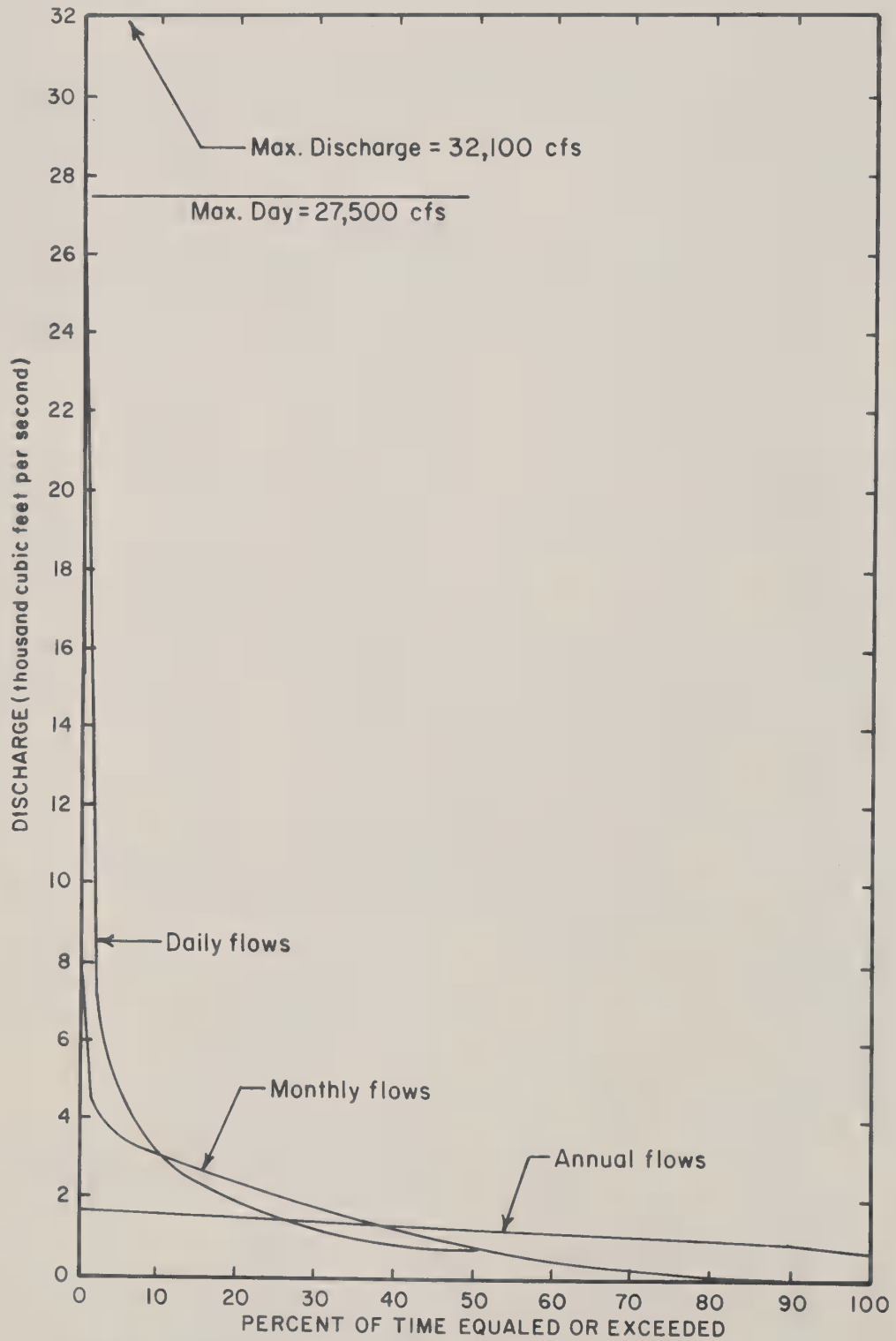
Period of record 1929 – 1958 — 1970 Condition

Table IV-3 - OBSERVED MONTHLY MEAN DISCHARGE, IN CFS, WILSON RIVER NEAR TILLAMOOK, OREGON

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1928										101	71	80	
1929	342	1602	1763	1824	1026	1392	2534	401	460	258	83	86	981
1930	134	60	1847	1094	4104	1552	1025	889	355	119	81	94	946
1931	112	704	661	1695	912	2240	2050	252	330	179	98	121	779
1932	804	2250	2240	2750	2210	3320	1320	428	187	122	99	76	1360
1933	197	2970	3410	2920	2020	2890	1260	1390	876	208	118	397	1550
1934	1192	1149	7988	3722	718	1764	914	744	191	131	98	124	1579
1935	2087	3975	3091	3068	1549	2039	1131	438	196	171	106	132	1500
1936	216	794	1446	4527	2044	1668	633	932	470	266	142	120	1106
1937	88	87	2133	940	2658	2101	2550	876	637	304	169	120	1044
1938	430	3621	4000	2145	1588	2269	1445	439	183	111	78	75	1364
1939	222	1453	1744	2041	2659	1541	426	202	252	156	89	74	894
1940	271	422	3056	1527	3301	1858	926	873	181	108	79	77	1051
1941	346	1104	1430	2064	751	595	489	704	285	146	120	765	734
1942	781	1443	3119	1015	1778	943	563	617	577	278	141	95	942
1943	213	3280	3178	1647	2921	1407	1758	476	389	183	121	89	1291
1944	487	784	1666	1541	1380	1072	1165	402	359	133	86	101	763
1945	167	1149	852	2246	2535	2497	1398	896	268	127	91	432	1045
1946	206	3086	3105	3006	2736	1990	1115	352	264	298	120	97	1356
1947	615	2750	3709	1933	2233	1211	938	273	457	222	123	230	1218
1948	2230	2278	1648	2437	2596	1603	1539	1386	312	153	109	169	1368
1949	581	2216	3487	694	4268	1718	715	920	186	124	91	91	1238
1950	455	2332	2497	3055	3506	3294	1790	660	238	126	107	93	1501
1951	1285	2610	3097	3498	2944	1664	852	445	200	104	69	111	1399
1952	1942	1808	2717	1699	2453	1515	939	446	213	127	83	67	1165
1953	58	146	1718	5776	2314	1495	872	916	405	191	155	141	1182
1954	599	1950	3686	3413	3540	1215	1489	269	469	266	139	159	1420
1955	613	1922	1909	1781	1834	1930	2069	821	287	202	117	122	1128
1956	1588	3935	4368	3476	1130	3637	1238	317	268	126	104	88	1696
1957	705	1033	2398	818	2394	2170	1059	429	317	177	133	81	968
1958	198	932	3740	3036	2884	909	1943	400	201	102	68	69	1198
Mean	369	1795	2723	2380	2333	1850	1223	620	334	174	107	150	1171

Table IV-4 DEPENDABLE YIELD, WILSON RIVER NEAR TILLAMOOK, OREGON

Consecutive Years of Lowest Mean Flow	Inclusive Years	Lowest Mean Flow	Percent of 1929-58 Mean
		(cfs)	
1	1941	734	62.7
2	1941-42	838	71.6
3	1939-41	892	76.1
4	1939-42	905	77.4
5	1939-43	982	83.9
6	1939-44	945	80.8
7	1939-45	960	82.1
8	1939-46	1,010	86.4
9	1937-45	1,014	86.7
10	1936-45	1,023	87.8
30	1929-58	1,171	100.0

RESPONSE RUNOFF POTENTIAL

Poor - Very High
Fair - High
Good - Moderate
Excellent - Low

Table IV-5--TILLAMOOK BAY DRAINAGE BASIN (Forested Area)

Acreages Classified According to Their Hydrologic Response

BASIN	Sub-Basin	RESPONSE				Acres of Basin	Percent of Area			
		Poor	Fair	Good	Excellent		Poor	Fair	Good	Excellent
Tillamook	Tillamook	2,334.93	11,596.85	25,204.35	1,094.27	40,230.40	6	29	63	3
Kilchis	1 (Lower)	542.15	8,815.94	9,434.13		18,792.22	3	47	50	
	2 (Little South Fork)		6,397.18	523.24		6,920.42		92	8	
	3 (Upper)		18,686.76	855.00		19,541.76	1	96	4	
	Subtotals	542.15	33,899.88	10,812.37		45,254.40	1	75	24	
Miami	Miami	67.79	12,424.72	12,281.89		24,774.40	0	50	50	
Wilson	1 (Little North Fork)	758.16	12,030.40	6,173.67		18,962.23	4	63	33	
	2 (Main)		34,451.63	12,643.09		47,094.72		73	27	
	4 & 5 (Upper)	1,813.82	29,170.81	22,609.57	28.85	53,623.05	3	54	43	T
	Subtotals	2,571.98	75,652.84	41,426.33	28.85	119,680.00	2	63	35	T
Trask	1 (Lower)	987.99	33,931.45	45,517.46		80,436.90	1	42	57	
	2A (East Fork)		8,015.17	10,699.52		18,714.69		43	57	
	3 (South Fork)		10,130.81	3,178.40		13,309.21		76	24	
	Subtotals	987.99	52,077.43	59,395.38		112,460.80	1	46	53	

T= Trace Percentage Amount

IV-19

HYDROLOGIC RESPONSE

Table IV-6 is a summary of hydrologic response to runoff by forested land subbasins. This response is related to soil infiltration rates, soil depth, land slope, and is the ability of that soil mantle to store and gradually release ambient precipitation. (See "Hydrology", USDA - SCS Engineering Handbook for a more complete interpretation).

Soil Group A - Excellent Hydrologic Response to Retard Runoff - These soils have high infiltration rates even when thoroughly wetted, and consist mainly of deep, well to excessively drained, sands and/or gravels. These soils have a high rate of water transmission and result in low runoff potential.

Soil Group B - Good Hydrologic Response to Retard Runoff - These soils have moderate infiltration rates when thoroughly wetted, consisting mainly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Soil Group C - Fair Hydrologic Response to Retard Runoff - These soils have slow infiltration rates when thoroughly wetted, consisting mainly of soils with a layer that impedes the downward movement of water or soils with moderately fine to fine textures. These soils have a slow rate of water transmission. In the Tillamook area relatively shallow soils were placed in this group.

Soil Group D - Poor Hydrologic Response to Retard Runoff - These soils have very slow infiltration rates when thoroughly wetted, consisting chiefly of soils with a high permanent water table or shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission which results in flashy runoff.

Based only on these characteristics of hydrologic response, the five subbasins in the Tillamook study area are rated as follows:

1. Tillamook - Best
2. Trask
3. Miami
4. Wilson
5. Kilchis - Poorest

There has been a tremendous improvement in hydrologic response on the forested lands since burned area rehabilitation began about 1945. The Hydrologic Response Trend Table IV-6 indicates that 283 square miles of watershed have been shifted from the poor to fair category due to this massive rehabilitation effort.

Table IV-6

HYDROLOGIC RESPONSE TREND - FOREST LANDS

Weighted Average Hydrologic Response	1975		1945*		1900*	
	Percent Area	Square Miles	Percent Area	Square Miles	Percent Area	Square Miles
Excellent	<1	5.1	2	10.1	51	258.3
Good	43	217.8	14	70.9	38	192.6
Fair	54	273.6	26	131.8	10	50.6
Poor	2	10.1	58	293.8	<1	5.1
TOTAL	100	506.6	100	506.6	100	506.6

* Estimated from burn area map.

IV-21

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO
YAMHILL CO
TILLAMOOK CO
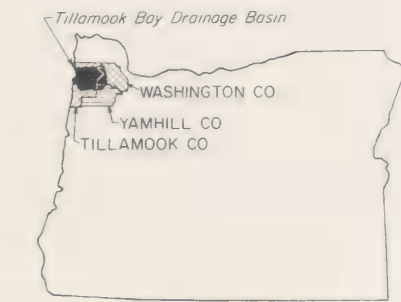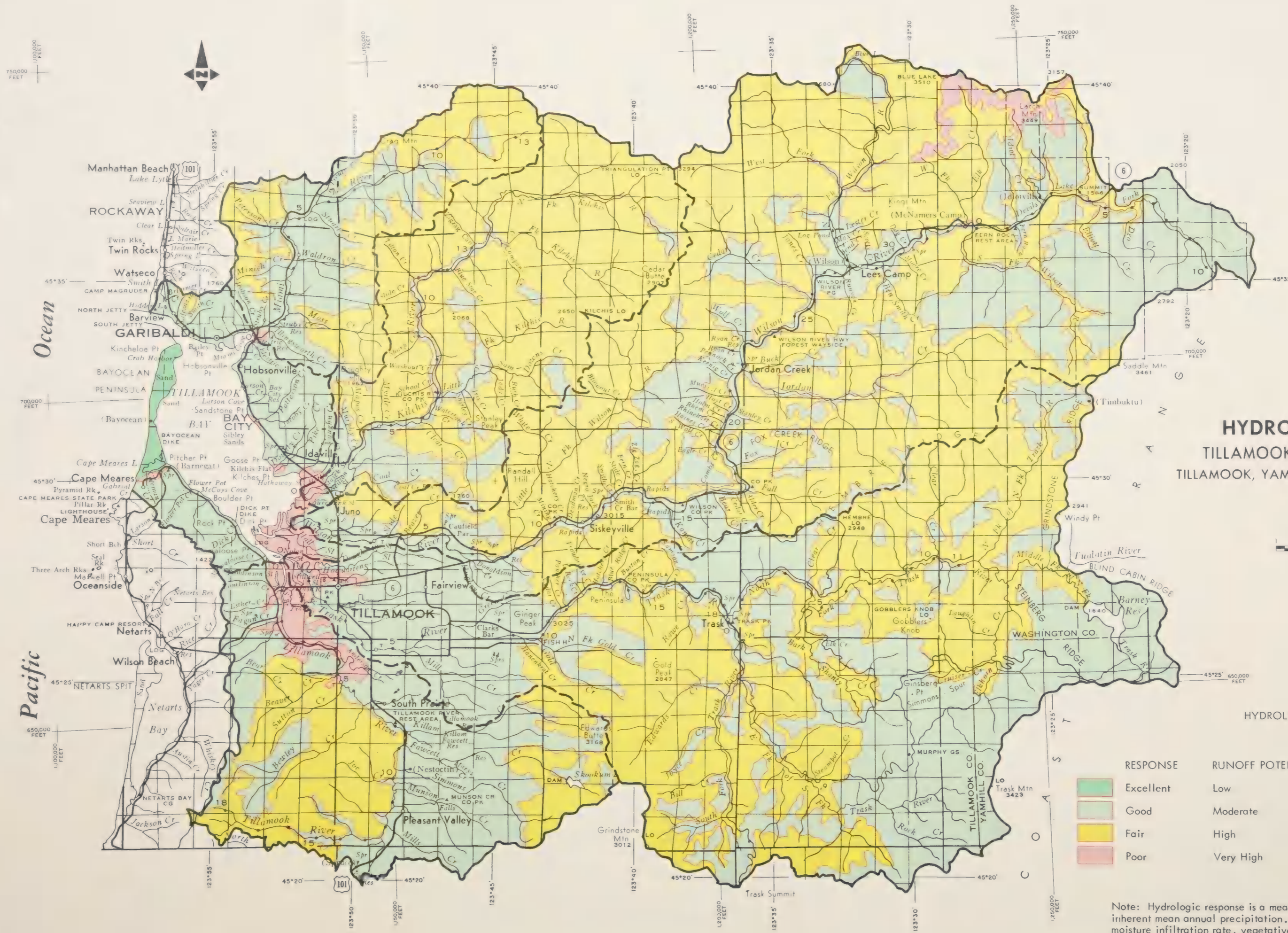
HYDROLOGIC RESPONSE
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON

JULY 1976

SCALE 1:187,500

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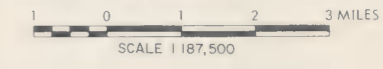
HYDROLOGIC RESPONSE

RESPONSE	RUNOFF POTENTIAL	ACRES	AREA PERCENT
Excellent	Low	1,040	0.0003
Good	Moderate	152,978	45
Fair	High	182,272	53
Poor	Very High	6,110	2
	Total	342,400 Ac.	100%

Note: Hydrologic response is a measure of the land type to orderly dispose of its inherent mean annual precipitation. Some controlling factors are land slope, soil moisture infiltration rate, vegetative cover, and aspect.

SOIL RESOURCES

GENERAL

Soil, the surface mantle of the earth is a basic resource. Soil characteristics are the basic building blocks for soil classification units, of which soil series are the lowest category of the system. Groups of soil series occurring together and making up a segment of the landscape in a characteristic pattern are known as soil associations.

The Soil Association Map for Tillamook Bay Drainage Basin, shows the location and relative extent of each soil association. These associations are named for the dominant soil series of which they are composed. Since the symbols used with each association appear on the map, they are not included with the following individual soil association descriptions and erosion hazards. The soils data has been developed from a recent reconnaissance-type soil survey of the eastern half of the basin by the Soil Conservation Service. A previously completed detailed soil survey of the western half was integrated into this survey on a soil association basis.

The hydrologic response is discussed in this chapter under - Climate-Hydrologic Response.

DESCRIPTION OF SOILS

Active Dunelands

This land type consists of wind drifted sand without vegetation. It consists of a grayish brown, single grained, porous sand. It is used for recreation. Wind erosion hazard of this unit is very high.

Astoria - Ecola Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Ecola series is a moderately deep, well drained soil. The surface layer is a very dark grayish brown silty clay loam. The subsoil is a dark yellowish brown silty clay loam, underlain by siltstone bedrock. Astoria soils comprise about 50 percent of this association and Ecola soils about 35 percent. Trask and Winema soils with other less extensive soils comprise about 15 percent. Soils of this association

LOCATION MAP

Tillamook Bay Drainage Basin
WASHINGTON CO
YAMHILL CO
TILLAMOOK CO
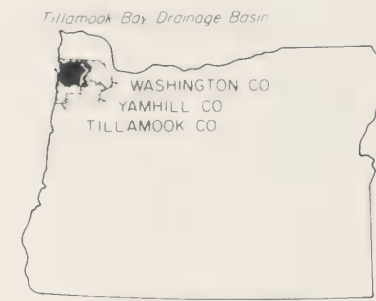
LEGEND

DUNELANDS

AD   Active Dunelands

BOTTOMLANDS & TERRACES

CA   Coquille-Brailler Association, 0 to 3% slopes
CB   Chitwood-Brenner Association, 0 to 12% slopes
NB   Nehalem-Brenner Association, 0 to 3% slopes
KW   Knappa-Gauldy Association, 0 to 12% slopes
KX   Knappa-Hebo Association, 0 to 12% slopes
KY   Knappa-Nehalem Association, 0 to 12% slopes
QG   Quillayute-Ginger Association, 0 to 12% slopes

3 TO 30% SLOPES

AE   Astoria-Ecola Association, 3 to 30% slopes
AF   Astoria-Fendall Association, 3 to 30% slopes
AH   Astoria-Hembre Association, 3 to 30% slopes
AW   Astoria-Winema Association, 3 to 30% slopes
BK   Blachly-Klickitat Association, 3 to 30% slopes
HA   Hembre-Astoria Association, 3 to 30% slopes
HK   Hembre-Klickitat Association, 3 to 30% slopes
KG   Klickitat-Hembre Association, 3 to 30% slopes

30 TO 60% SLOPES

AG   Astoria-Fendall Association, 30 to 60% slopes
AJ   Astoria-Hembre Association, 30 to 60% slopes
AT   Astoria-Trask Association, 30 to 60% slopes
BL   Blachly-Klickitat Association, 30 to 60% slopes
HB   Hembre-Astoria Association, 30 to 60% slopes
HL   Hembre-Klickitat Association, 30 to 60% slopes
KH   Klickitat-Hembre Association, 30 to 60% slopes
KK   Klickitat-Kilchis Association, 30 to 60% slopes
KT   Klickitat-Trask Association, 30 to 60% slopes
VY   Valsetz-Yellowstone Association, 3 to 60% slopes

60 TO 90% SLOPES

KC   Kilchis-Klickitat Association, 60 to 90% slopes
KJ   Klickitat-Hembre Association, 60 to 90% slopes
KL   Klickitat-Kilchis Association, 60 to 90% slopes
KU   Klickitat-Trask Association, 60 to 90% slopes
VZ   Valsetz-Yellowstone Association, 60 to 90% slopes
RK   Rock outcrop-Kilchis Association, 60 to 90% slopes
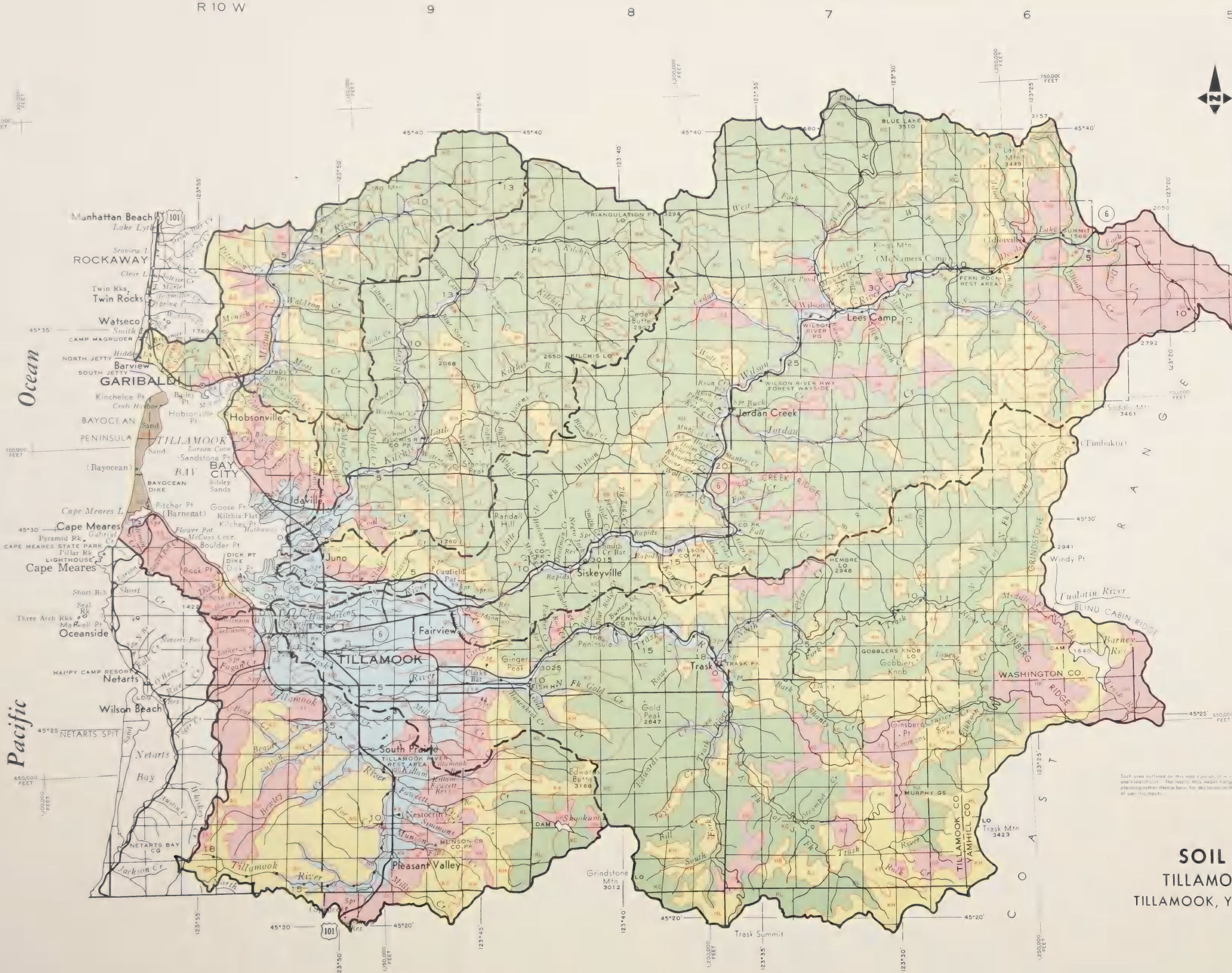
SOIL ASSOCIATION MAP
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,
OREGON

SEPTEMBER 1978
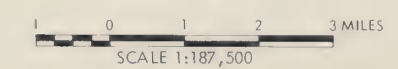
1   0   1   2   3 MILES
SCALE 1:187,500

are used mostly for timber production. Erosion hazard on either soil ranges from moderate to high.

Astoria - Fendall Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. Fendall series is a moderately deep, well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a yellowish brown clay underlain by siltstone. Astoria soils comprise about 75 percent of this association and Fendall soils about 20 percent. Various minor soils make up the remaining 5 percent. Soils of this association are used mostly for timber production. Erosion hazard ranges from low to moderate on both soils.

Astoria - Fendall Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltstone bedrock. The Fendall series is a moderately deep, well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a yellowish brown clay underlain siltstone bedrock. Astoria soils comprise about 55 percent of this association and Fendall soils about 30 percent. Minor soils including those of the Trask and Ecola series comprise about 15 percent. Soils of this association are used mostly for timber production. Erosion hazard on both soils is very high.

Astoria - Hembre Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltstone bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam, underlain by basalt bedrock. Astoria soils comprise about 60 percent of this association and Hembre soils about 30 percent. Klickitat and Ecola soils with other less extensive soils comprise about 10 percent. Soils of this association are used mostly for timber production. Erosion hazard of this unit is moderate.

Astoria - Hembre Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Hembre series

is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam under lain by basalt bedrock. Astoria soils comprise about 40 percent of this association, Hembre soils about 25 percent, and Fendall soils about 15 percent. Trask, Winema, and other less extensive soils comprise the remaining 20 percent. These soils are used mostly for timber production. Erosion hazard for any or all of this association ranges from high to very high.

Astoria - Trask Association, 30 to 60 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. The Trask series is a moderately deep, well drained soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam underlain by siltstone bedrock. Astoria soils comprise about 55 percent of this association and Trask soils about 30 percent. Winema, Ecola, and other minor soils comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard on these soils ranges from high to very high.

Astoria - Winema Association, 3 to 30 percent slopes

The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay, underlain by siltsone bedrock. The Winema series is a very deep, well drained soil. The surface layer is a black silt loam. The subsoil is a dark yellowish brown silty clay or clay underlain by siltstone bedrock. Astoria soils comprise about 60 percent of this association and Winema soils about 30 percent. Minor soils including those of the Trask and Winema comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this soil association is high.

Blachly - Klickitat Association, 3 to 30 percent slopes

The Blachly series is a very deep, well drained soil. The surface layer is a dark reddish brown silty clay loam. The subsoil is a yellowish red silty clay. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Blachly soils comprise about 40 percent of this association and Klickitat soils about 25 percent. The remaining 35 percent is made up of soils of the Hembre, Olyic, and other less extensive series. The soils of this association are used mostly for timber production. Erosion hazard of this unit is moderate.

Blachly - Klickitat Association, 30 to 60 percent slopes

The Blachly series is a very deep, well drained soil. The surface layer is a dark reddish brown silty clay loam. The subsoil is a yellowish red silty clay. The Klickitat series is a deep, well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. Blachly soils comprise about 40 percent of this association and Klickitat soils about 30 percent. Soils of the Hembre, Olyic, Kilchis and other less extensive series comprise the remaining 30 percent. Erosion hazard of this unit is very high.

Coquille - Brailler Association 0-3 percent slopes

The Coquille series is a very deep, very poorly drained soil subject to tidal overwash. The surface layer is a very dark brown mottled silt loam. The subsoil is a dark grayish brown silty clay loam. The Brailler series is a very deep, very poorly drained peat soil subject to tidal or stream flooding. The surface is a dark brown peat. The sub-soil is a dark brown peat underlain by layers of peat and muck. The Coquille soils comprise 75 percent of this association and Brailler soils 15 percent. Unnamed minor soils comprise the remaining 10 percent. Soils of this association are used mostly for pasture and hay production. Erosion hazard of this unit is slight.

Chitwood - Brenner Association, 0 to 12 percent slopes

The Chitwood series is a very deep, somewhat poorly to moderately well drained soil. The surface layer is a dark grayish brown silt loam over a mottled yellowish brown silty clay. The Brenner series is a very deep, poorly drained soil subject to flooding. The surface layer is a dark grayish brown silt loam. The subsoil is a dark grayish brown mottled silty clay. Chitwood soils comprise about 45 percent of this association and Brenner soils about 25 percent. Hebo, Nestucca, and other less extensive soils make up the remaining 30 percent. These soils are used mostly for hay and pasture. No erosion hazard is present on these soils.

Hembre - Astoria Association, 3 to 30 percent slopes

The Hembre series is a deep well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. The Astoria series is a very deep well drained soil. The surface layer is a very dark grayish brown silt loam. The subsoil is a yellowish brown silty clay underlain by siltstone bedrock. Hembre soils comprise about 65 percent of this association and Astoria soils 30 percent. Minor soils, including those of the Klickitat series comprise the remaining 5 percent. Erosion

hazard of this unit is moderate.

Hembre - Astoria Association, 30 to 60 percent slopes

The Hembre series is a deep, well drained soil. The surface layer
is a dark reddish brown silt loam. The subsoil is a reddish brown silty
clay loam underlain by basalt bedrock. The Astoria series is a very
deep well drained soil. The surface layer is a very dark grayish brown
silt loam. The subsoil is a yellowish brown silty clay underlain by
siltstone bedrock. Hembre soils comprise about 50 percent of this
association and Astoria soils 35 percent. Klickitat and Fendall soils
and other less extensive soils comprise the remaining 15 percent. The
soils of this association are used mostly for timber production.
Erosion hazard of this unit is high.

Hembre - Klickitat Association, 3 to 30 percent slopes

The Hembre series is a deep well drained soil. The surface layer
is a dark reddish brown silt loam. The subsoil is a reddish brown silty
clay loam underlain by basalt bedrock. The Klickitat series is a deep,
well drained soil. The surface layer is a dark reddish brown gravelly
clay loam. The subsoil is a very gravelly clay loam underlain by basalt
bedrock. Hembre soils comprise about 65 percent of this association and
Klickitat soils about 25 percent. Minor soils including those of the
Kilchis and Marty series comprise the remaining 10 percent. These soils
are used mostly for timber production. Erosion hazard of this unit is
moderate.

Hembre - Klickitat Association, 30 to 60 percent slopes

The Hembre series is a deep, well drained soil. The surface layer
is a dark reddish brown silt. The subsoil is a reddish brown silty
clay loam underlain by basalt bedrock. The Klickitat series is a deep,
well drained soil. The surface layer is a dark reddish brown gravelly
clay loam. The subsoil is a very gravelly clay loam underlain by basalt
bedrock. Hembre soils comprise about 50 percent of this association
and Klickitat soils about 35 percent. Minor soils including those of
the Kilchis series comprise the remaining 15 percent. These soils are
used mostly for timber production. Erosion hazard of this unit is high.

Kilchis - Klickitat Association, 60 to 90 percent slopes

The Kilchis series is a shallow, well drained soil. The surface
layer is a dark reddish brown gravelly loam. The subsoil is a very
gravelly loam over basalt bedrock. The Klickitat series is a deep, well
drained soil. The surface layer is a dark reddish brown gravelly clay
loam. The subsoil is a very gravelly clay loam underlain by basalt
bedrock. Kilchis soils comprise about 50 percent of this association
and Klickitat soils about 35 percent. The remaining 15 percent is rock

outcrop, Hembre soils and unnamed soils less than 12 inches deep to bedrock. These soils are used mostly for timber production. Erosion hazard of this unit is very high.

Klickitat - Hembre Association, 3 to 30 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 45 percent of this association and Hembre soils about 35 percent. Minor soils including those of the Kilchis series comprise the remaining 20 percent. The soils of this association are used mostly for timber production. Erosion hazard of this soil association ranges from low to moderate.

Klickitat - Hembre Association, 30 to 60 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 60 percent of this association and Hembre soils about 30 percent. Rock outcrop and minor soils including those of the Kilchis series comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this soil unit is high.

Klickitat - Hembre Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Hembre series is a deep, well drained soil. The surface layer is a dark reddish brown silt loam. The subsoil is a reddish brown silty clay loam underlain by basalt bedrock. Klickitat soils comprise about 70 percent of this association and Hembre soils about 25 percent. Rock outcrop and Kilchis soils comprise most of the remaining 5 percent. The soils in this association are used mostly for timber production. Erosion hazard of this soil association is very high.

Klickitat - Kilchis Association, 30 to 60 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Kilchis

series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. Klickitat soils comprise about 40 percent of this association and Kilchis soils about 30 percent. Hembre soils, rock outcrop and unnamed soils less than 12 inches deep to bedrock comprise the remaining 30 percent. These soils are used mostly for timber production. Erosion hazard of this soil association is high.

Klickitat - Kilchis Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Kilchis series is a shallow, well drained soil. The surface layer is a dark reddish brown gravelly loam. The subsoil is a very gravelly loam over basalt bedrock. Klickitat soils comprise about 40 percent of this association and Kilchis soils about 25 percent. Hembre soils, rock outcrop and unnamed soils less than 12 inches deep to bedrock comprise the remaining 35 percent. The soils in this association are used mostly for timber production. Erosion hazard of this unit is very high.

Klickitat - Trask Association, 30 to 50 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Trask series is a moderately deep, well drained soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam. Klickitat soils comprise about 55 percent of this association and Trask soils about 30 percent. Minor soils including those of the Kilchis, Astoria and Hembre series comprise the remaining 15 percent. These soils are used mostly for timber production. Erosion hazard of this soil association ranges from moderate to high.

Klickitat - Trask Association, 60 to 90 percent slopes

The Klickitat series is a deep well drained soil. The surface layer is a dark reddish brown gravelly clay loam. The subsoil is a very gravelly clay loam underlain by basalt bedrock. The Trask series is a moderately deep, well drianed soil. The surface layer is a dark brown shaly loam. The subsoil is a strong brown very shaly silt loam. Klickitat soils comprise about 60 percent of this association and Trask soils about 30 percent. Minor soils including those of the Hembre and Astoria series comprise the remaining 10 percent. These soils are used mostly for timber production. Erosion hazard of this unit is moderate to high.

Knappa - Gauldy Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Gauldy series is a deep, excessively drained soil subject to flooding. The surface layer is a dark brown loam. The subsoil is a dark yellowish brown loam. The substratum is a very gravelly sand. Knappa soils comprise about 55 percent of this association and Gauldy soils about 25 percent. Less extensive soils including those of the Meda, Gardiner and Nestucca series comprise the remaining 20 percent. These soils are used mostly for hay, pasture and timber production. Erosion hazard of this unit is slight to moderate.

Knappa - Hebo Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Hebo series is a very deep, poorly drained soil. The surface layer is a very dark gray silty clay loam. The subsoil is a mottled dark gray clay. Knappa soils comprise about 50 percent of this association and Hebo soils about 30 percent. The remaining 20 percent is Chitwood, Quillayute and other less extensive soils. The soils in this association are used mostly for hay and pasture. The erosion hazard of this soil association ranges from slight to moderate.

Knappa - Nehalem Association, 0 to 12 percent slopes

The Knappa series is a very deep well drained soil. The surface layer is a very dark brown silt loam. The subsoil is a dark yellowish brown silty clay loam. The Nehalem series is a very deep, well to moderately well drained soil subject to flooding. The surface layer is a very dark brown silt loam. The subsoil is a dark brown silty clay loam. Knappa soils comprise about 40 percent of this association and Nehalem soils about 30 percent. Gauldy and Nestucca soils and other less extensive soils comprise the remaining 30 percent. These soils are used mostly for hay and pasture. Erosion hazard of this unit ranges from slight to moderate.

Nehalem - Brenner Association, 0 to 3 percent slopes

The Nehalem series is a very deep well to moderately well drained soil subject to flooding. The surface layer is a very dark brown silt loam. The subsoil is a dark brown silty clay loam. The Brenner series is a very deep, poorly drained soil subject to flooding. The surface layer is a very dark grayish brown silt loam. The subsoil is a dark grayish brown mottled silty clay. Nehalem soils comprise about 65 percent of this association and Brenner soils about 20 percent. Less

extensive soils including those of the Nestucca, Gauldy and Gardiner
series comprise the remaining 15 percent. These soils are used mostly
for hay and pasture. Erosion hazard of this unit is very slight.

Quillayute - Ginger Association, 0 to 12 percent slopes

The Quillayute series is a very deep, well drained soil. The sur-
face layer is a black silt loam. The subsoil is a yellowish brown
silty clay loam. The Ginger series is a deep, somewhat poorly drained
soil. The surface layer is a black silt loam. The subsoil is a mot-
tled grayish brown silty clay. Quillayute soils comprise about 60
percent of this association and Ginger soils about 20 percent. Less
extensive soils including those of the Hebo and Chitwood series com-
prise the remaining 20 percent. The soils of this association are used
mostly for hay and pasture. Erosion hazard of this soil association
ranges from very slight to moderate.

Rock outcrop Kilchis Association, 60 to 90 percent slopes

This land type consists of barren rocky slopes, ridges and rock
escarpments. The Kilchis series is a shallow, well drained soil. The
surface layer is a dark reddish brown gravelly loam. The subsoil is
a very gravelly loam over basalt bedrock. Rock outcrops comprise about
65 percent of this association and Kilchis soils about 25 percent. Un-
named soils less than 12 inches deep to bedrock comprise the remaining
10 percent. The soils in this association are watershed and wildlife
areas with some used for timber production. Erosion on rock outcrops
would be very slight but may vary depending on the type of rock.
Erosion hazard of this soil association is high.

Valsetz - Yellowstone Association, 3 to 60 percent slopes

The Valsetz series is a moderately deep, well drained soil. The
surface layer is a dark reddish brown gravelly loam. The subsoil is a
very gravelly loam underlain by intrusive igneous rock. The Yellow-
stone series is a shallow, somewhat excessively drained soil. The
surface layer is a dark brown gravelly loam. The subsoil is a very
stony loam over igneous rock. Valsetz soils comprise about 55 percent
of this association and Yellowstone soils about 30 percent. Less ex-
tensive soils including those of the Mulkey series comprise the remain-
ing 15 percent. These soils are used mostly for timber production.
Erosion hazard of this soil association ranges from slight to high.

Valsetz - Yellowstone Association, 60 to 90 percent slopes

The Valsetz series is a moderately deep, well drained soil. The
surface layer is a dark reddish brown gravelly loam. The subsoil is
a very gravelly loam underlain by intrusive igneous rock. The Yellow-
stone series is a shallow somewhat excessively drained soil. The sur-
face layer is a dark brown gravelly loam. The subsoil is a very stony

loam over igneous rock. Valsetz soils comprise about 45 percent of this association and Yellowstone soils about 35 percent. Rock outcrop and less extensive soils including those of the Mulkey series comprise the remaining 20 percent. The soils in this association are used mostly for timber production. Erosion hazard of this unit is very high.

POTENTIAL SURFACE EROSION HAZARD

This interpretation compares the relative rapidity and amount of erosion by water after removal of protective vegetation and organic layer. The ratings were made after considering the effects of soil structure, texture, depth, permeability, slope, bedrock type and degree of fracturing, rate of geologic erosion, and visual observations. Since these ratings are based on the soil's inherent capacity to erode, climatic factors such as storm intensity or frozen soil conditions are not considered.

Slight indicates surface soil loss and problems of erosion control are generally minimal, assuming that moving water is not permitted to concentrate on exposed mineral soil. Soils placed in this rating usually have most of the following characteristics: Gentle slopes, strong structure, good permeability, and deep sola. Minimum practices may include careful construction of water bars on disturbed areas where running water may accumulate, such as tractor roads, trails, and fire lines. Potential soil loss is less than 5 tons per acre per year.

Moderate indicates that normal forest land management practices should be accompanied by careful erosion control measures that are necessary to hold erosion at a minimum and maintain soil productivity. Soils with this rating will generally have most of the following characteristics: Moderate to long slopes, weak to moderate structure, moderately thin sola, and moderate permeability. The soil damage may be sheet and gully erosion or a reduction in fertility caused by the removal of soil fines. Minimum land management practices should include intensive water barring of skid roads, trails, fire lines, and other disturbed areas. Yarding practices which cause a minimum disturbance, such as uphill cable or skyline, are desirable. Potential soil loss varies from 5 to 10 tons per acre per year.

Severe indicates that surface erosion will be high when the organic cover is removed by land management practices. Soils with this rating will have most of the following characteristics: Long, steep slopes, massive to weak structure, shallow sola, and poor permeability. They may be situated in topographic positions subject to rapid geologic erosion. Many soils with this rating are at or near the angle of repose. Soil damage from erosion may be sheet erosion, gullying, and the loss of soil fines. Some areas have completely lost soil materials down to bedrock. Great caution should be exercised when

logging in these areas. It is vital to maintain the soil organic cover as nearly to its original condition as possible. For this reason burning should be done with the utmost care and timed when the soil and litter are moist. From the soil erosion viewpoint there will be situations where burning is not recommended.

Road grades should be kept low with frequent water diversion structures. All fire lines and skid roads should be intensively water barred, with the water bars placed so that they drain onto vegetated ground, thus preventing further erosion. Where roads parallel stream channels, adequate distance should be maintained to prevent stream pollution. Waste materials should be dumped in areas where they will not reach streams and should be protected from surface erosion by covering with litter and/or establishing grass cover. Tractor logging is not recommended on these areas. The skyline method does much less soil damage. If jammer logging is done, great care should be exercised to hold soil disturbance at a minimum. Logs should be yarded uphill whenever possible.

In general, when planning a logging operation on these soils, each area should be critically analyzed. Some areas will be more critical than others due to topographical considerations and proximity of major streams. In some areas it may be permissible to skyline log only, while in other areas it may be desirable to completely refrain from logging. Potential soil loss varies from 10-30 tons per acre per year.

Very severe indicates that surface soil loss will be far greater than normal when the land cover is removed by natural or management practice means. Soils with this rating are typically on long, very steep, deeply dissected slopes at the higher elevations. These areas generally have shallow soils and can least afford erosion. Many of these areas were severely disturbed by wildfire and have greatly reduced capability to produce commercial timber, particularly when located at higher precipitation-runoff zones. The surface erosion potential in these areas is greater than 30 tons per acre per year.

Data from Table IV-7 indicates that when all the forested lands in the basin are considered, the potential erosion hazard areas are distributed as follows:

POTENTIAL SURFACE EROSION Tons/Acre/Year	BASIN Percent	AREA Square Miles
Slight (0-5)	22.3	115.5
Moderate (5-10)	24.8	125.6
Severe (10-30)	18.7	94.8
Very Severe (30+)	33.7	170.7
TOTAL	100.0	506.6

Table IV-7--SUBBASIN ACREAGES CLASSIFIED ACCORDING TO THEIR POTENTIAL SURFACE EROSION HAZARD

BASIN	Sub-Basin	HAZARD				Total Acres of Basin	Percent of Area			
		Slight	Moderate	High	Very High		Slight	Moderate	High	Very High
Tillamook	Tillamook	19,576.99	15,972.70	3,700.51	980.20	40,230.40	49	40	9	2
Kilchis	1 (Lower)	5,160.51	3,572.06	5,195.28	4,715.81	18,643.66	28	19	28	25
	2 (Little South Fork)	342.59	1,089.62	1,318.40	4,341.12	7,091.73	5	15	19	61
	3 (Upper)	3,844.93	591.98	43.44	15,038.66	19,519.01	20	3	0	77
	Subtotals	9,348.03	5,253.66	6,557.12	24,095.59	45,254.40	21	12	14	53
Miami	Miami	2,787.71	5,139.28	13,106.55	3,740.86	24,774.40	11	21	53	15
Wilson	1 (Little North Fork)	3,244.35	3,469.84	2,374.18	9,474.66	18,563.03	17	19	13	51
	2 (Main)	4,830.24	8,940.19	15,122.05	17,183.68	46,076.16	10	19	33	38
	4 & 5 (Upper)	16,823.04	9,562.63	11,660.93	16,994.21	55,040.81	31	17	21	31
	Subtotals	24,897.63	21,972.66	29,157.16	43,652.55	119,680.00	21	18	24	37
Trask	1 (Lower)	18,982.18	26,034.08	8,556.16	26,533.92	80,106.34	24	32	11	33
	2A (East Fork)	2,331.75	7,828.32	2,951.26	5,915.39	19,026.72	12	41	16	31
	3 (South Fork)	279.20	2,912.22	166.56	9,969.76	13,327.74	2	22	1	75
	Subtotals	21,593.13	36,774.62	11,673.98	42,419.07	112,460.80	19	33	10	38
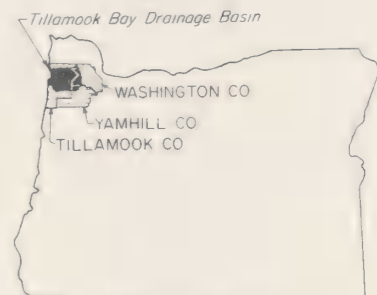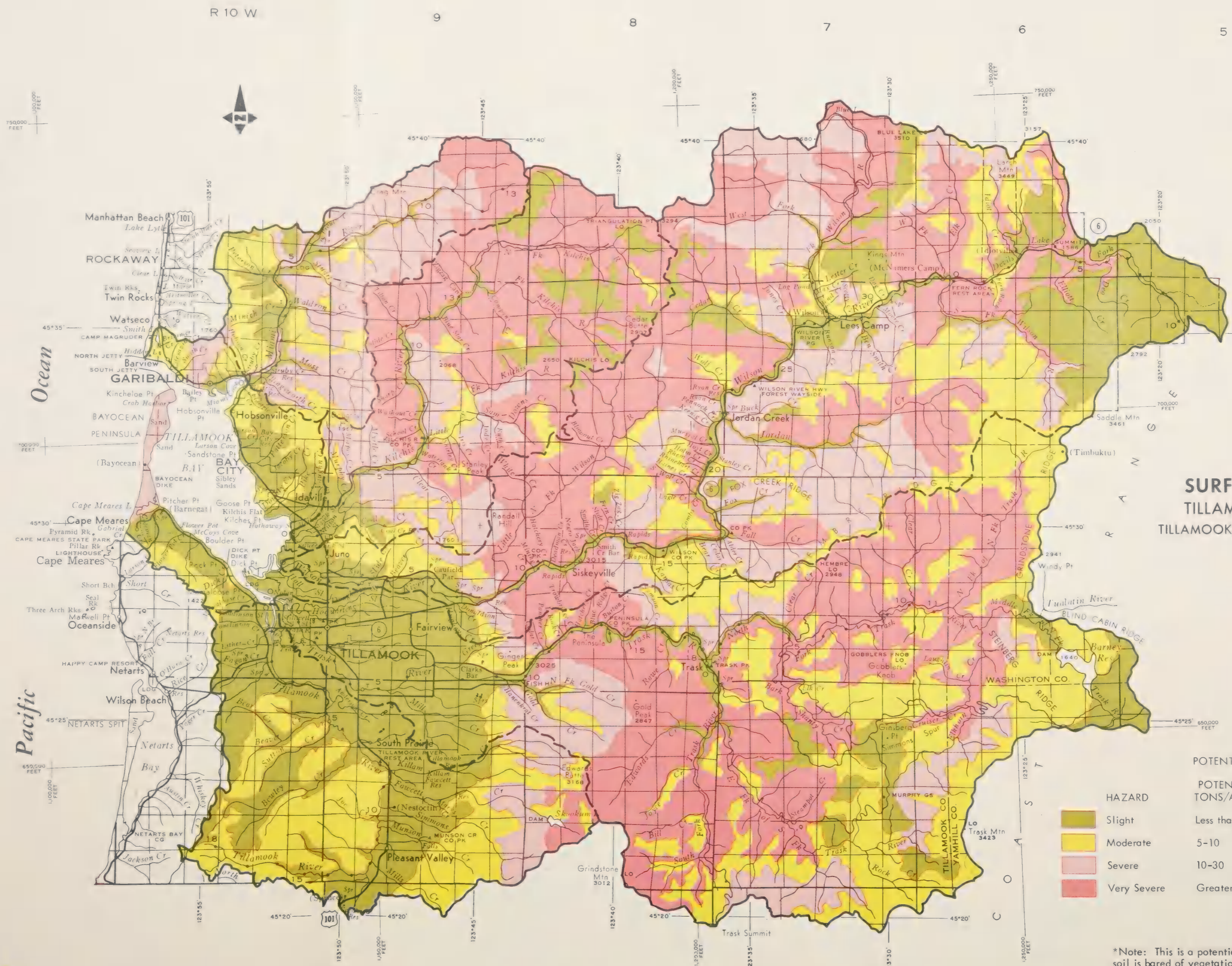
POTENTIAL
SURFACE EROSION HAZARD
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,
OREGON

JULY 1976

SCALE 1:187,500

0 1 2 3 MILES

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO
YAMHILL CO
TILLAMOOK CO

POTENTIAL SURFACE EROSION HAZARD

HAZARD	POTENTIAL RATE* TONS/ACRE/YEAR	ACRES	AREA PERCENT
Slight	Less than 5	85,920	25
Moderate	5-10	81,350	24
Severe	10-30	71,900	21
Very Severe	Greater than 30	103,230	30
	Total	342,400 Ac.	100%

*Note: This is a potential rating and rate which could be achieved when the soil is bared of vegetation.

M7-SN-23598-8

VEGETATIVE RESOURCES

GENERAL COVER AND LAND USE

Vegetative resource data was derived from satellite imagery using the LANDSAT Program (PIXSYS) at the Earth Resources Remote Sensing Laboratory (ERSAL) at Oregon State University. Digital tapes of the satellite data for July 25, 1975 were used in the program.

The primary purpose of the Tillamook Bay Study is directed towards erosion and sediment programs. Vegetative resources were inventoried in categories which relate to these problems and are summarized in Table IV-8. The following discussion is in terms of these categories, which are designated by symbols on the Vegetative Cover and Land Use Maps for the five subbasins included in this study.

Most of the Tillamook Bay Drainage (363,520 acres) is classed as forest lands. Exceptions are the coastal valley, beaches, small meadows along the narrow stream bottoms, and the bay itself. There are 323,050 acres or 89 percent of the basin within the forest resource area. The agriculture, non-forest, urban and miscellaneous resource area includes 29,490 acres (8 percent) and the Bay area and the rivers include 10,980 acres (3 percent). Both are defined in Table IV-8, Generalized Land Cover.

Land uses in Tillamook Bay Drainage Basin would be considered by most planners to be very intensive. The intensity with which the resources are used could be related to the changes in elevation or in relationship to the proximity to the Estuary. The estuarine area receives heavy demands from nearly all of the economic community, including fisheries, lumbering, dairying, and recreation services,

There is little opportunity left for additional development on the Tillamook Bay shoreline because of the current demands and the land ownership pattern. Bayocean Peninsula is in county and federal ownership, tidal mudflats are in state and county ownership, and the surrounding uplands are in large timber industry ownerships. The floodplain is owned mostly by the many dairymen in the area.

Table IV-8, GENERALIZED LAND COVER

TILLAMOOK BAY DRAINAGE BASIN, OREGON

Subbasin	Unit	Forest	Nonforest	Water[1]	Total
Tillamook	Acres	35,120	7,740	280	43,140
Trask	Acres	101,350	11,080	600	113,030
Wilson	Acres	118,850	6,090	600	125,540
Kilchis	Acres	43,240	3,400	280	46,920
Miami	Acres	24,490	990	70	25,550
Bay Area	Acres		190	9,150	9,340
Total	Acres	323,050	29,490	10,980	363,520
Percent		89	8	3	100

[1] Includes only streams 10 feet or more in width and water bodies of 4 acres or more.

LAND USE PLANNING

Tillamook County and its municipalities have been active in land use planning since 1945 when the third of the big fires led to the planning for reforestation and protection of the Tillamook Burn. Various county, state and federal regulations have intensified these planning efforts, especially in the 1970's.

The Tillamook County Planning Commission prepared a report on land use in the Tillamook Bay Area in 1967. The State Land Board inventoried fill areas of the Estuary in 1972. The Tillamook Bay Task Force did an overview of Tillamook Basin, taking a general look at its resources, uses, and problems in 1973 and that led to this USDA Study. An Advisory Committee to the Governor made a statewide study of current and future environmental quality problems in Oregon in 1971. The Oregon Legislative Assembly acted in 1971 to pass several acts with far reaching environmental quality implications.

Oregon's coastal goals and guidelines effective January 1, 1977 have been adopted for planning resource uses of estuaries, coastal shorelines, beaches, dunes, and the ocean 200 mile zone. The report,

<u>Land and Water Use Guidelines for the Development of Tillamook Bay Estuary</u>
identifies 15 shoreline planning units. To facilitate comprehensive
planning in compliance with the Estuarine Resources Goal, the Oregon
Land Conservation and Development Commission (LCDC) has released estu-
arine classification guidelines indicating that Tillamook Bay should be
classed as a shallow-draft barge estuary. That designation provides
for commercial and recreational development requiring an access channel
not greater than 22 feet deep upstream of the jetties.

Tillamook County has adopted a comprehensive land use plan as well
as zoning and subdivision ordinances. These serve as the basic controls
on development outside incorporated areas. In addition, the county has
prepared a comprehensive water and sewerage study, transportation plan,
and parks and recreation study.

On the local level, the communities of Tillamook and Bay City both
have planning commissions, comprehensive plans, and zoning ordinances.
Bay City has prepared a subdivision ordinance. Garibaldi, after having
prepared a comprehensive plan in 1964, has formed a citizens advisory
committee to prepare a new plan assisted by the Clatsop Tillamook In-
tergovernmental Council.

The ports of Bay City and Tillamook Bay had a development program
and plan prepared for the bay. The plan's recommended program and pro-
posed development areas were not widely accepted by the community.
Both port districts also have single element development plans that
have not been widely circulated.

Following a series of public meetings and revisions, Statewide
Planning Goals and Guidelines for Coastal Resources were adopted by
the Land Conservation and Development Commission and took effect on
January 1, 1977. The adopted goals include No. 16 (Estuarine Resources),
No. 17 (Coastal Shorelands Goal), No. 18 (Beaches and Dunes Goal), and
No. 19 (Ocean Resources Goal). The proposed navigation improvements at
Tillamook would comply with the Estuarine Resources Goal, since con-
struction would be subtidal areas seaward of the estuary. The absence
of sand-bypass provisions as a part of project construction could make
the proposal inconsistent with the Beaches and Dunes Guidelines. Main-
tenance of the navigability of Tillamook entrance would be consistent
with other statewide planning goals related to transportation. The
U.S. Geological Survey, Estuarine Research Section, is conducting a
five-year study of the Tillamook Estuary.

Urban use in the basin is somewhat limited by surrounding land own-
ership. The area's most intensive urban concentration occurs in the
City of Tillamook. Other urban areas include Garibaldi and Bay City.

Outside the urban areas, the valley floor is largely occupied by
the dairies which maintain pastures or hay forage production. The up-
lands are mostly covered by forests. The land ownership largely follows
this management scheme as does land use planning in the basin.

The plans for present and future uses of the resources appear to be well formulated. These uses may not always be in the best interest of the environment. Some changes may surface as the result of the on-going planning efforts. Also, a change in the approach and timing of the uses may be advisable if goals in sediment reduction are to be reached. This will be elaborated upon under managerial strategies in Chapter X.

CROPLAND RESOURCES

Almost all of the cropland is devoted to production of forage crops. The forage is used as feed for dairy cattle.

The cool, moist climate helps to produce good yields from the various mixtures of grasses and legumes. However, it is difficult to produce good quality hay so the forages are harvested by pasturing, green chopping, or made into silage. Most of the hay used in this area is alfalfa hay trucked in from eastern Oregon.

There are 23,540 acres of croplands within the basin. These lands are used for production of hay, silage, and pasture. There are an additional 3,430 acres of forest lands that are also grazed. The above acreage figures are gross acreages and include the roads serving these areas. Acreage figures in Table IV-9 are net acreages.

There are 4,680 acres of irrigated and sub-irrigated croplands that are used for production of silage, green-chop, and pasture.

There are 13,470 acres of improved dryland pasture. These fields are sometimes harvested as green chop or silage in the early summer when plant growth is vigorous and livestock grazing cannot keep up with the plant development.

There are 4,020 acres of unimproved dryland pasture. Vegetation is predominantly grasses and legumes native to the area. These fields are generally too rough for harvesting by machinery and are usually grazed.

There are 1,370 acres of poorly drained brush-pasturelands that are in low lying tidal effected areas. The vegetation contains sedges, rushes and saltwater-tolerant grasses. They are used for livestock grazing.

FOREST RESOURCES

There are 323,050 acres of forest lands in the basin. This acreage includes 319,620 acres within the forest resource area and 3,430 acres in the agricultural resource area. Forest land managers have classified 318,520 acres of forest lands as commercial forest and 4,530 acres as noncommercial forest.

Table IV-9--LAND COVER VS. LAND-USE, TILLAMOOK BAY DRAINAGE BASIN, OREGON 1975

Land Cover Designation [1]	Total Acres	Pasture	Recreation	Timber	Land Uses Cropland	Gravel Operations	Urban	Permanent R/W	Water-shed
Sand & Rock	4,220		230					460	3,530
Water	10,980		10,980						
Tall Brush Dominating	34,870	1,330		30,460				3,080	(2,100)[2]
Grass	22,170	20,460			710	20		980	
Low Brush, Logging, Slash, Seedlings, Clearcuts & Burns	53,910			48,990				4,920	
Bare Soil (Clearcuts & Burns)	6,410			4,350			1,730	330	
Forested (Sapling size & larger)									
a. Conifers	179,700		3,000	161,340				15,360	(19,530)[2]
b. Hardwoods	51,260		850	46,140				4,270	(20)[2]
Total	363,520	21,790	15,060	291,280	710	20	1,730	29,400	3,530

[1] This is the cover condition of the soil on the 23rd of July 1975

[2] The primary land use is timber production. The lands also serve as watersheds for municipal storage reservoirs.

Noncommercial forest lands in the basin include areas of 70 percent slopes and steeper with very shallow, erosive soils. Rock outcrops often are associated with noncommercial forest areas.

A total of 3,850 acres of the commercial forest land is reserved from normal timber harvest practices. This acreage includes 15 recreation sites and areas on which recreation values take priority over timber harvest.

There are also 188 miles of stream and highway corridors. Timber harvest practices on the state-owned portion of these corridors have been modified to recognize open space values.

The commercially available portion of the forest lands is primarily managed for timber production. Other uses are allowed, but only to the extent that these uses do not interfere with timber growing and harvesting programs.

Natural forest eco-zones found in the Tillamook Drainage Basin include the Sitka spruce eco-zone and the western hemlock eco-zone. The Sitka spruce zone is generally limited to areas under 800 feet in elevation. The balance of the basin lies in the western hemlock zone. Fire has historically been a part of the ecologic development of the basin forest resources. The climax forest communities of the two eco-zones were limited to a fraction of their normal environment by periodic fires (fires of 100 to 300-year intervals in Tillamook Basin) which prevented development of climax communities.

Douglas fir tends to dominate these eco-zones when periodic fires occur. This was the situation at the turn of the century. Massive Douglas fir dominated the forests of the area later known as "Tillamook Burn". Periodic fires occurred over the basin for 33 years, beginning with the 1918 fire. Each succeeding fire ran unchecked even with all out efforts by man. The extent of each fire was determined more by changes in weather than by human effort. The fires were not limited to the Tillamook Bay Drainage, crossing the crest of the Coast Range and burning a portion of the Willamette River Basin. The Salmonberry Fork of the Nehalem River was also burned. The 1951 fire was the last of the big fires. The five fires, along with timber harvest, have removed most of the oldgrowth stands so that in 1975 only 30,650 acres remained in the basin.

Much of the forest resource area was so badly damaged by repeated burning that the soils lay bare with little chance of natural regeneration. Erosion problems were extensive and downstream sedimentation of the estuarine system increased drastically. A reforestation effort that was to become one of the largest undertaken in this country was launched by the State Board of Forestry in 1949. Culmination of this program came in 1973 with the successful reforestation of 217,800 acres, including portions of the Willamette and Nehalem Drainages.

The new forests will not necessarily fit the description of tree species normally found in these eco-zones. The micro-climate of the soils has been temporarily changed. Spruce plantations have been successfully established well above 800 foot elevations and ponderosa pine, normally an eastside species, now grows in Tillamook. Mixed stands of hemlock, spruce and Douglas fir in different combinations have been introduced to take advantage of potential productivity capabilities of the different soils, slopes and aspects.

The forest resources were inventoried in categories which relate to erosion rather than productivity. This inventory is summarized on Table IV-10 and the categories are defined as follows:

Clearcuts

Areas included in this category are those which were clearcut within the last 10-15 years and the vegetated portion of the soil is dominated by brush and slash. The conifers, if present, are not large enough to fill in and dominate the area. There were 13,610 acres of these stands in 1975.

Burns

Areas included in this category are those which are within the boundary of the Tillamook fires and have not been successfully reforested, or the trees are not large enough to fill in and dominate the area. Brush species now dominate the vegetated portion of the soils. Many of the sites in this category have a satisfactory number of coniferous trees which will eventually attain dominance over the brush. There were 44,980 acres in this category in 1975.

Old Growth

These are timber stands which are relatively undisturbed. The old-growth (120 plus years old) conifers dominate the tree canopy. There were 30,560 acres of these stands in 1975.

Mature Second Growth

These are timber stands which have been established following early timber harvest. These stands are generally 50-90 years old and are well stocked with near crown closure. There were 34,250 acres of these stands in 1975.

Pole-sized Stands

These are satisfactorily stocked conifer timber stands which have attained pole-size, generally 20-40 years old. About 44,200 acres of these stands are the result of the reforestation effort of the State Forester on the Tillamook Burn. There was a total of 72,830 acres of these stands in 1975.

Table IV-10--FOREST RESOURCE INVENTORY, TILLAMOOK BAY DRAINAGE BASIN, OREGON 1975

Resource Area/Vegetative Condition	Unit	Total	Tillamook	Trask	Wilson	Kilchis	Miami
Forest Resource Area							
1. Clearcuts							
a. > 75% bare soil	Acres	1,570	950	40	40	180	360
b. 50-75% bare soil	Acres	2,150	940	140	180	210	680
c. 25-50% bare soil	Acres	5,820	2,350	370	400	660	2,040
d. < 25% bare soil	Acres	4,070	1,880	110	310	480	1,290
		(13,610)	(6,120)	(660)	(930)	(1,530)	(4,370)
2. Burns							
a. > 75% bare soil	Acres	740	--	190	490	40	20
b. 50-75% bare soil	Acres	220	--	130	60	20	10
c. 25-50% bare soil	Acres	24,680	--	11,060	9,500	3,960	160
d. < 25% bare soil	Acres	19,340	--	9,120	6,320	3,390	510
		(44,980)	( )	(20,500)	(16,370)	(7,410)	(700)
3. Old-growth stands	Acres	30,560	1,290	10,140	15,010	2,630	1,490
4. Mature second growth stands	Acres	34,250	4,530	8,180	13,580	4,830	3,130
5. Pole-sized stands	Acres	72,830	11,920	18,060	27,960	9,390	5,500
6. Sapling-sized stands	Acres	39,030	3,930	16,090	12,960	3,820	2,230
7. Tall brush and seedlings	Acres	33,500	3,010	12,540	11,590	4,030	2,330
8. Hardwood stands	Acres	50,860	2,680	14,470	20,050	9,140	4,520
Subtotal		319,620	33,480	100,640	118,450	42,780	24,270
Agricultural Resource Area							
1. Mature second-growth stands	Acres	180	80	30	10	50	10
2. Pole-sized stands	Acres	430	130	140	110	30	20
3. Sapling-sized stands	Acres	2,420	1,280	460	250	260	170
4. Hardwood stands	Acres	400	150	80	30	120	20
Subtotal		3,430	1,640	710	400	460	220
Total	Acres	323,050	35,120	101,350	118,850	43,240	24,490

Sapling-sized Stands

These are satisfactorily stocked stands which have attained size and crown density sufficient to dominate the sites. These stands may be as young as 5 years. However, it usually takes 10 years to attain crown dominance over brush and hardwoods. Trees are generally two to four inches in diameter by then. There were 39,030 acres of these stands in 1975. There were 27,980 acres of these stands as a result of the State Forester's reforestation efforts.

Tall Brush and Seedlings

Tall brush with both hardwood and conifer seedlings occupy the stand. Without specie conversion, hardwoods will dominate the stand. There were 33,500 acres in this category in 1975.

Hardwood Stands

These stands, consisting mostly of red alder, are generally 15-40 years of age. The stands are well stocked with near crown closure. There was a total of 50,860 acres of these stands in 1975.

PRODUCTIVITY

Productivity of forest soils is often expressed in terms of site class.[1] Site Class (I) is the most productive and Site Class (V) the least productive. The average volume of a fully stocked 90-year-old stand on Site I soils in the Basin would be about 18,000 cubic feet per acre. The same stand on Sites II, III, IV, and V would be about 15,000 cubic feet, 12,400 cubic feet, 8,500 cubic feet, and 5,500 cubic feet per acre, respectively.

Erosion problems affecting productivity on Sites I, II, and III have a very significant effect on the timber economy of the Basin. Nearly 95 percent of the forest soils fall within these three site classes, as shown on the Timber Site Class Map (Figure IV-10). Most of the erosion also occurs on these soils. It follows that erosion problems on forest lands in the Tillamook area will be of great concern both environmentally and economically.

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[1] The soil series associated with the Astoria series are classified as site class II for productivity. However, Astoria soils are generally rated as site class I.

R 10 W   9   8   7   6   5

LEGEND

TIMBER SITE CLASS II

- AE Astoria–Ecola Association, 3 to 30% slopes
- AF Astoria–Fendall Association, 3 to 30% slopes
- AG Astoria–Fendall Association, 30 to 60% slopes
- AH Astoria–Hembre Association, 3 to 30% slopes
- AJ Astoria–Hembre Association, 30 to 60% slopes
- AW Astoria–Winema Association, 3 to 30% slopes
- HA Hembre–Astoria Association, 3 to 30% slopes
- HB Hembre–Astoria Association, 30 to 60% slopes
- HK Hembre–Klickitat Association, 3 to 30% slopes
- HL Hembre–Klickitat Association, 30 to 60% slopes
- KX Knappa–Hebo Association, 0 to 12% slopes
- KY Knappa–Nehalem Association, 0 to 12% slopes
- NB Nehalem–Brenner Association, 0 to 3% slopes
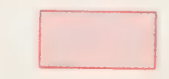
TIMBER SITE CLASS III

- AT Astoria–Trask Association, 30 to 60% slopes
- BK Blachly–Klickitat Association, 3 to 30% slopes
- BL Blachly–Klickitat Association, 30 to 60% slopes
- KG Klickitat–Hembre Association, 3 to 30% slopes
- KH Klickitat–Hembre Association, 30 to 60% slopes
- KJ Klickitat–Hembre Association, 60 to 90% slopes
- KK Klickitat–Kilchis Association, 30 to 60% slopes
- KL Klickitat–Kilchis Association, 60 to 90% slopes
- KT Klickitat–Trask Association, 30 to 60% slopes
- KW Knappa–Gauldy Association, 0 to 12% slopes

TIMBER SITE CLASS IV

- KC Kilchis–Klickitat Association, 60 to 90% slopes
- KU Klickitat–Trask Association, 60 to 90% slopes
- RK Rock outcrop–Kilchis Association, 60 to 90% slopes
- VY Valsetz–Yellowstone Association, 3 to 60% slopes

TIMBER SITE CLASS V

- VZ Valsetz–Yellowstone Association, 60 to 90% slopes

LOCATION MAP

WASHINGTON CO
Tillamook Bay Drainage Basin
YAMHILL CO
TILLAMOOK CO

TIMBER SITE CLASS MAP
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES
OREGON
OCTOBER 1978

1   0   1   2   3   4   5 MILES
SCALE 1:187,500

Vegetative Cover and Land Use Maps

LOCATION MAP

Tillamook River Subbasin

TILLAMOOK BAY DRAINAGE BASIN

VEGETATIVE COVER AND LAND USE MAP
TILLAMOOK RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

AUGUST 1977

½   0   ½   1   1½ MILES

SCALE 1:62,500

VEGETATIVE COVER AND LAND USE

c   Clearcuts   75% bare
c   Clearcuts   50-75% bare
c   Clearcuts   25-50% bare
c   Clearcuts   25% bare
•   Brush and seedlings
o   Saplings
G   Pole timber
•   Mature second growth
▪   Old growth
r   Hardwoods
•   Irrigated and other wet pasture
•   Dry pasture, unimproved
•   Dry pasture, improved
•   Urban
U ▪ Water
H   Old-growth conifer-hardwoods mix
–   Hardwoods-brush mix
%   Urban and bare soil
@

R 10W

R 9W

R 8W

T 1 S

T 2 S

T 3 S

LOCATION MAP

VEGETATIVE COVER AND LAND USE MAP
TRASK RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

AUGUST 1977

SCALE 1:62,500

7 - E - 23983

LOCATION MAP

VEGETATIVE COVER AND LAND USE MAP

WILSON RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN

TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

AUGUST 1977

7 - E - 23984

LOCATION MAP

Kilchis River Subbasin

TILLAMOOK BAY
DRAINAGE BASIN

VEGETATIVE COVER AND LAND USE

- Clearcut or burn > 75% bare soil
- Clearcut or burn 50-75% bare soil
- Clearcut or burn 25-50% bare soil
- Clearcut or burn < 25% bare soil
- Brush (may have seedling conifer)
- Conifer, sapling size
- Conifer, pole size
- Mature second growth conifer
- Old-growth conifer
- Old-growth conifer-hardwoods mix
- Hardwoods
- Hardwoods-brush mix
- Rock (in the forested areas only)
- Mud flats (in the agriculture areas only)
- Urban and bare soil
- Wet pasture (irrigated and subirrigated)
- Dry pasture, improved   improved
- Dry pasture, unimproved
- Water
- Fire boundary
- Agriculture lands boundary
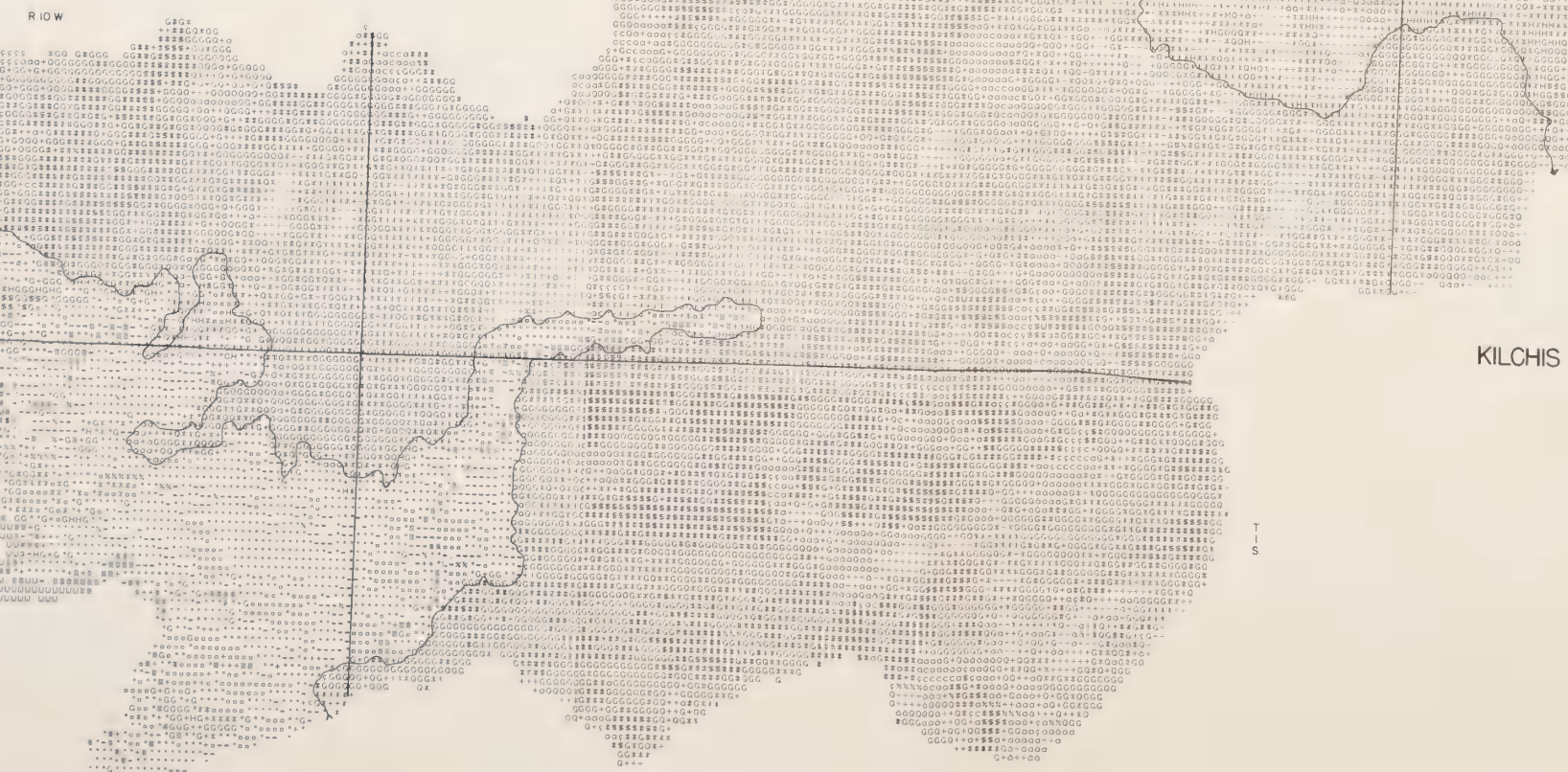
VEGETATIVE COVER AND LAND USE MAP
KILCHIS RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

MARCH 1977

SCALE 1:62,500

7-0-23985

Miami River Subbasin

TILLAMOOK BAY
DRAINAGE BASIN

LOCATION MAP

R.9.W.

R.10.W.

VEGETATIVE COVER AND LAND USE

- Clearcut or burn v 75% bare soil
- Clearcut or burn 50-75% bare soil
- Clearcut or burn 25-50% bare soil
- Clearcut or burn v 25% bare soil
- Brush (may have seedling conifers)
- Conifer saplings
- Conifer pole-size
- Mature second growth conifer
- Old-growth conifer
- Old-growth conifer-hardwood mix
- Hardwoods (sapling through mature)
- Hardwoods-brush mix
- Bare soil and urban
- Wet pasture (irrigated and subirrigated)
- Dry pasture, improved
- Dry pasture, unimproved
- Water
- Mud flats (in the agriculture areas only)
- Fire boundary
- Agriculture boundary

VEGETATIVE COVER AND LAND USE MAP

MIAMI RIVER SUBBASIN OF TILLAMOOK BAY DRAINAGE BASIN

TILLAMOOK, YAMHILL AND WASHINGTON COUNTIES

OREGON

MARCH 1977

2 MILES

SCALE 1:62,500

7-N-23986

RECREATION RESOURCES

GENERAL

Recreation is becoming an increasingly important industry in the Pacific Northwest. There seems to be no limit to the demand for recreational facilities and tourist accomodations -- and that is a potential problem. The Oregon coast, because of its richly endowed beauty and wealth of recreation opportunities, is attracting more and more people.

Average daily traffic from October to May increases drastically between June and September. When the salmon are running or there is a good minus tide for clamming, traffic counters and tempers are sent soaring to new highs. Delays of two hours and more are encountered at popular Tillamook Bay boat launching sites and the highways home are crowded with a seemingly unending stream of slow moving traffic.

Linked to heavy day usage by Willamette Valley residents is the demand by both Oregonians and out-of-state visitors for public overnight campgrounds. Nationwide studies indicate a tripling in outdoor recreation participation by the year 2000, but rank camping low on the list of user preferences (Table IV-11).

Table IV-11, USER PREFERENCE

State Park Users in Area - 1964	Siuslaw National Forest Users - 1966	United States 1960
1. Sightseeing	1. Camping	1. Swimming
2. Camping	2. Picnicking	2. Sightseeing
3. Swimming	3. Fishing	3. Picnicking
4. Picnicking	4. Hunting	4. Fishing
5. Fishing	5. Boating	5. Boating
6. Hiking	6. Swimming	6. Camping
7. Boating	7. Hiking	7. Hiking

Source: Recreation-Tourism - Central Oregon Coast, Bureau of Governmental Research and Service, 1969, P. 16

The rankings in Table IV-11 indicate that the Oregon coast is a mecca for campers due to the ocean influence and the excellent job the state and county have done in campground development, thereby resulting in a much higher ranking locally for overnight facilities. The Tillamook area has emphasized this aspect of its recreation resources by developing campgrounds, picnic areas, boat launch sites, and beach access throughout the coastal area.

The rate of growth for the western states is greater than for the nation as a whole. Also, the Willamette Basin population, which contributes heavily to Tillamook County recreational demands, is expected to grow at a faster rate than the state.

Projected population within Tillamook County is another measure of future recreational demands as shown on Table IV-12. The components of local population were analyzed in a recent publication concerning utility planning. This separated local permanent population from seasonal and tourist population, and will aid in determining the needs for recreational facilities.

Table IV-12, TILLAMOOK COUNTY POPULATION

	Estimated - 1967	Projected - 1990
Permanent Population	18,000	20,600
Seasonal Population	5,500	8,200
Tourist Population	5,700	15,200
	29,200	44,000

Source: Comprehensive Water and Sewerage Planning Study-Tillamook County, Oregon: Volume 1, Planning Background, CH2M, revised 7-31-69, P. 20.

Sports fishing and the taking of shellfish account for much of the recreational activity in the basin. Anadromous fish, including chinook, silver, chum, salmon, and steelhead are taken from the bay, the five major rivers, and off-shore fishing grounds. In addition, resident stocks of trout occur in small lakes and streams throughout the basin. For salmon fishing in the ocean there is the exciting prospect of joining dorymen at Barview and launching directly through the surf. Fishing boats cross the bar at Tillamook headed for offshore fishing grounds.

All of the foregoing serve as general indications of what the basin might expect future recreational demands to be. Satisfying those demands might require additional conversion of the coastal area, with expanded and new campgrounds, more angler access and beach access points, an accelerated road and highway improvement program, and a more rapid development of shore and hillside lands for summer homesites. Public facilities and services would need to be expanded and increased to minimize the adverse effects of increased human occupation of the land. Care must be taken in developing recreation-oriented uses or the very assets that the area boasts of could be severely damaged -or lost.

Developed recreation resources exist primarily to serve the public. Campgrounds and boat launching sites are emphasized in development programs of most agencies with recreation resource management responsibilities. There are 16 boat launching sites, 11 campgrounds, and 7 picnic sites in the area. The activities and facilities available at the campgrounds and picnic sites are summarized on Table IV-13.

Sometimes overlooked is the extent to which private enterprise provides recreation facilities. For example, about half of the marinas, docks, launch sites, etc. available to the public in Tillamook area are privately owned and operated. Major timber companies also help by providing campgrounds for public use as well as opening selected portions of their land to permit hunting and fishing. Based upon the multiple use concept, these facilities and policies allow recreation enjoyment of areas where tree farming and sustained yield are practiced.

BAYOCEAN PENINSULA

The Bayocean Peninsula on Tillamook Bay is of particular interest to the county in that much of the property on this sandspit is county-owned due to tax foreclosures. Any future development should avoid the mistakes made on the Bayocean Peninsula that caused the community of Bayocean to be cut off from the mainland due to a breaching of the spit, with subsequent abandonment of property and the resultant tax delinquency. There still are some scattered private ownerships that will need to be taken into account when detailed plans are made for the spit.

Figure IV-11 is a sketch of a typical dune cross-section similar to some areas of Bayocean Peninsula. It will serve as a model for a brief discussion of planning considerations related to various parts of a dune system. For a more detailed discussion see Beaches and Dunes of the Oregon Coast, USDA-SCS-March, 1975.

The first zone of a typical dune is the ocean beach, an area highly tolerant of human use for walking, fishing, sunbathing, swimming, and surfing, but essentially unsuited for uses other than public recreation. This is the so-called "dry sand" area lying seaward of the vegetation line in which Oregon statutes prohibit (below 16 feet elevation) any construction without a permit.

The next zone is the primary dune which is absolutely intolerant to trampling, and a zone in which no development should be allowed. This is the first line of defense against storms and floods and must not be breached.

Table IV-13--RECREATION SITES AND AREAS, TILLAMOOK BAY DRAINAGE BASIN, OREGON, 1975

Site/Area Name	Ownership	Acres	Camping Units	Picnicking Units[2]	Boating Ramps	Activities[1]
Wilson River Wayside	State	789				P, F, S
Wilson River Picnic Area	Private	15		24		F, S, P
Jones Creek State Park	State	56	75			F, C, S, H
Keenig Creek State Park	State	22	38			F, C, S, H
Fern Rock Wayside	State	2/		3		F, P, S
Kilchis River Recreation Area	County	2,500	30		X	F, S, SW, H, C, B
Trask River State Park	State	39	100			F, S, H, C
Barview Jetty Park	Tillamook Co.	300	164			F, OB, D, V, SW, C, P
Tillamook River Wayside	State	8		6		P, F, S
Goodspeed Park	Municipal	2	2/			
Marine Park	Municipal	1/2	2/			
Liberty Park	Municipal	4	2/			
Bay City Park	Municipal	2/	2/			
Wilson River Co. Park	County	40	2/			
Munson Falls Park	County	25	2/			
Peninsula	State	20	6			F, C, H, S
Diamond Mill	State	10	15			F, C, H, S
Elk Creek	State	9	15			F, C, H, S
Camp Brown	State	20	15			F, C, H, S

1/

History	H	Swimming	SW
Lake - Stream	L-S	Hiking	HK
Nature Study	N	Picnicking	P
Ocean Beach	OB	Camping	C
Rockhound	R	Hunting	HU
Sand Dunes	D	Boating	B
Scenic Views	V	Geology	G
		Fishing	F

2/ Data Unknown
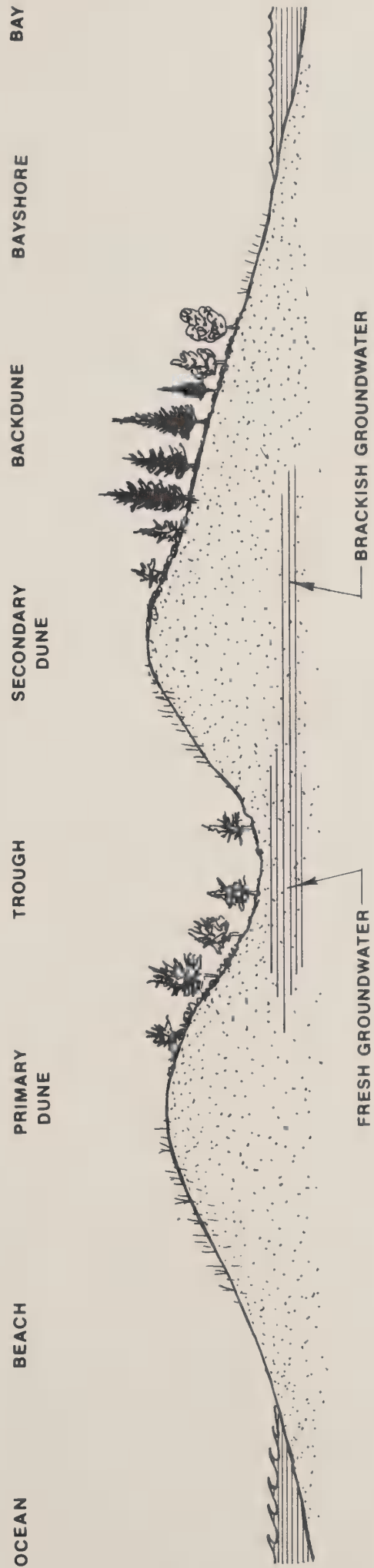
Typical Dune Cross Section

Fig. IV-11

OCEAN   BEACH   PRIMARY   TROUGH   SECONDARY   BACKDUNE   BAYSHORE   BAY
                  DUNE   DUNE

FRESH GROUNDWATER   BRACKISH GROUNDWATER

The next zone is the trough which is more tolerant of development. However, any drawdown of ground water supply through the use of shallow wells or the diversion of rain water from roofs and paved parking areas into drains and piped waste-water systems, could upset vegetation due to the altered water table and set the stage for reduced stability in the primary dune.

The secondary dune is the second line of defense and is as vulnerable as the primary dune. The backdune, however, is a more permissive location and may be the most suitable area for some development. Though development should not occur at the narrowest portion of the dune, the wider, flatter, and better protected portions could offer recreational opportunities for water-oriented uses as well as some shore developments.

Human occupation should be regulated so that ground water sources not be lowered to a critical level and that sewage not be allowed to seep into the bay. This may mean that a peninsula community water supply from other sources will be required and that a sewerage system complete with proper treatment should be made a part of any plan for development.

Closing the breach on the Bayocean Peninsula by a diking project conducted by the Corps of Engineers points out another way in which dune stabilization can be accomplished. Road access, if located on the bay side and constructed on top of an artificial dune, can prevent further breaching. Road fill material should generally be dredged from the ocean side, not the bay side where the shellfish beds may be disturbed.

The jetties at the mouth of Tillamook Bay probably influence the stability of the sandspit. See Inventory, Oregon Coastal Shoreline Erosion, State Soil and Water Conservation Commission, September 1978 for a more detailed discussion.

HISTORICAL RESOURCES

Tillamook Drainage Basin has many operating examples related to its historical development. Many old dairy barns from the last century are still used today much as they were when first built. The famous Tillamook Cheese Factory is visited by nearly all tourists who come to the basin.

The Pioneer Museum in Tillamook contains a wide variety of natural and historical displays pertaining to the northwest as well as the local Tillamook County area. Its natural history exhibits are especially noteworthy and are considered to be among the most outstanding in the Pacific Northwest. Financial support for the museum has come largely from local sources.

ARCHEOLOGICAL RESOURCES

Little is known of the prehistory in the Tillamook region. In the late 1950's the first archeologic excavations were begun and these provide much of the knowledge of the region.

Archeological evidence indicates firmly established cultures on the shores of Columbia River 9,000 years ago. Archeologists believe the Coast Salish influenced development in the Tillamook area during the 1400's; by 1670, the Northwest Coast culture was complex and fully developed. Villages were composed mainly of long, rectangular cedar plank dwellings, often sheltering two or three families. The Indians depended upon the bay area for food, particularly salmon. Ten village sites have been identified. The main village, Kil-har-hurst, is almost completely covered by the present town of Garibaldi. In historic times, remnants of the Tillamook Nation lived in Squaw Town, a settlement a mile south of the Miami River.

The approximate locations of remaining archeological sites are shown in Figure IV-12. Most of these sites have been destroyed; however, Netarts Landing, an important canoe landing area for north-south travelers, and the village, Tow-er-gust-tons have been subjected only to natural forces. A known site on the Bayocean Peninsula was destroyed in 1952 when a storm reached the spit.
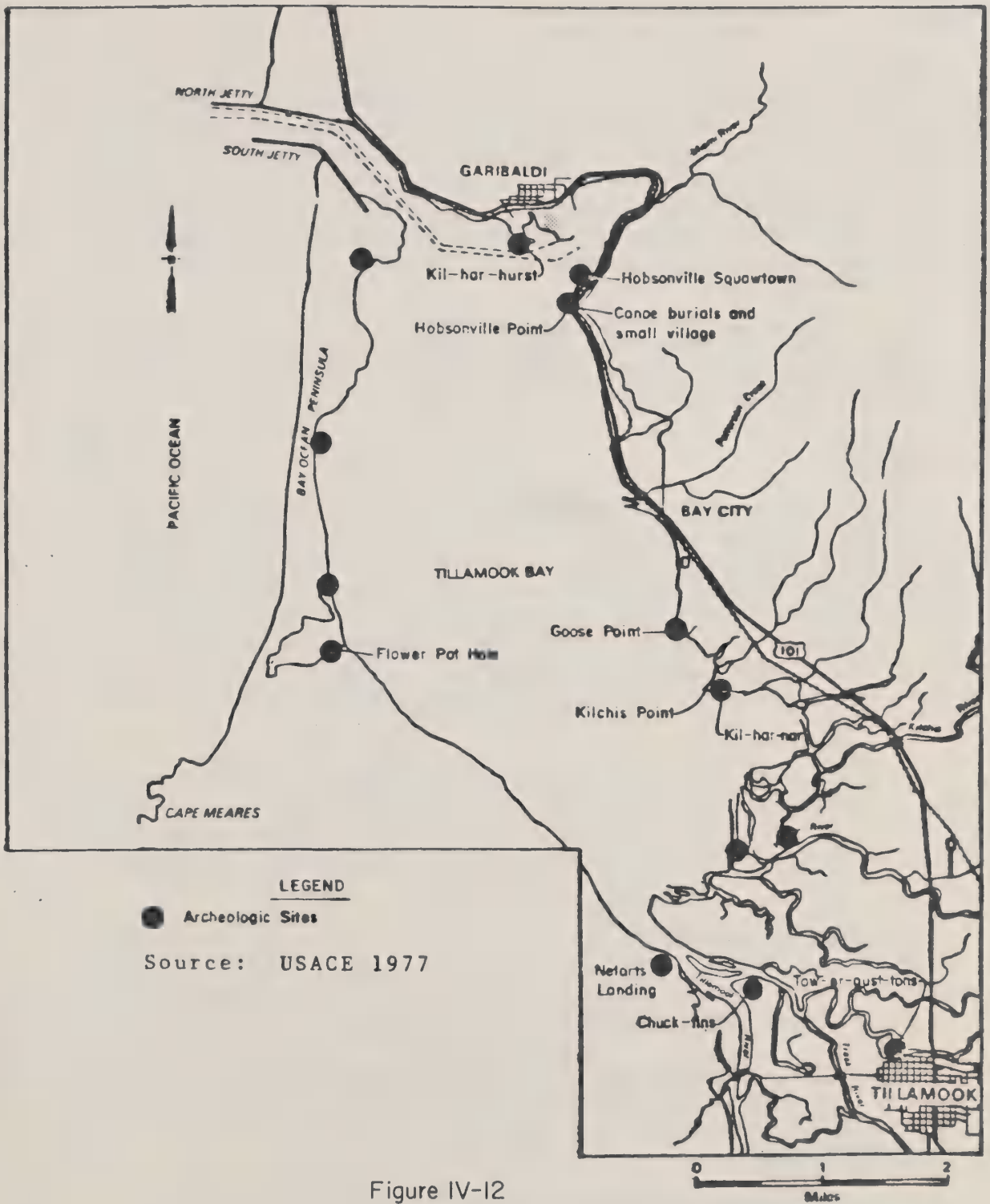
Figure IV-12

ARCHEOLOGIC AND HISTORIC SITES

IV-52

FISH AND WILDLIFE RESOURCES

GENERAL

The primary concern of this Study is sedimentation in Tillamook Bay. The fisheries and shellfisheries are directly affected by sedimentation. Human activities in the estuary have increased in recent years and will probably continue to expand in the future. Many of these activities will occur along shorelines or in shallow waters. Such shallow areas are often necessary to many important fish and shellfish species and the food organisms on which they depend. Misuse of other estuaries in the past has reduced their productivity for fish and wildlife and diversity for human use.

The Oregon Fish Commission conducted an inventory of freshwater and marine resources in Tillamook Bay in 1971. The following fish resources data is from that study.

FISH RESOURCES

Estuaries are among the most productive ecosystems in the world, and Tillamook Bay has been one of the most important producers of fish and shellfish in Oregon. Sediment deposition has had both beneficial and detrimental effects on these resources. The nutrients so vital to a highly productive ecosystem are replenished yearly by soils eroded from the uplands. Excessive erosion and sedimentation results in covering up nutrients so that they are not available. Sediment also smothers eel grass beds, shellfish beds, and the larvae of fish and shellfish.

Eel grass beds are found scattered throughout Tillamook Bay (See Fisheries Resources Map Sheet 2 of 2). These beds are usually found in areas of shallow water and high salinities. Clams and other important marine fauna are usually an integral part of the eel grass beds.

More than 80 percent of the oysters grown in Oregon come from Tillamook Bay. The Fisheries Resources Map (Sheet 1 of 2) shows the commercial oyster leases, totaling 2,285 acres. An estimated 3,300 acres of Tillamook Bay are considered suitable for oyster culture.

The food production areas, fish feeding areas, and fish migration routes in Tillamook Bay are shown on the Fisheries Resources Map (Sheet 2 of 2). Also outlined on the Map (Sheet 1 of 2) are the known herring spawning areas.

The productivity of estuarial areas is related to length of shoreline, depth of water, and geographical location. Within each estuary, tidelands are generally more productive than deep water

FISHERIES RESOURCES TILLAMOOK BAY

TILLAMOOK BAY DRAINAGE BASIN
OREGON

JULY 1977

1/2   0   1/2   1 MILE

SCALE 1:66,000

MIAMI RIVER

45°35'

45°33'

PACIFIC OCEAN

123°52'

TILLAMOOK BAY

KILCHIS RIVER

123°56'

45°29'

WILSON RIVER

45°29'

TRASK RIVER

123°52'

TILLAMOOK RIVER

LEGEND

Clam Beds

LEGEND

Commercial Oyster Leases, 1971

Known Herring Spawning Areas, 1971

MIAMI RIVER

45°35'

45°33'

PACIFIC OCEAN

123°52'

TILLAMOOK BAY

KILCHIS RIVER

123°56'

45°29'

WILSON RIVER

45°29'

TRASK RIVER

123°52'

TILLAMOOK RIVER

N

Tillamook Bay
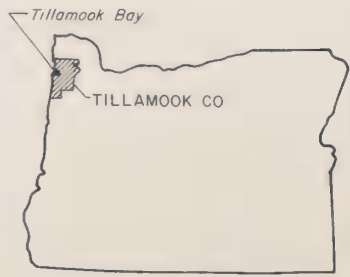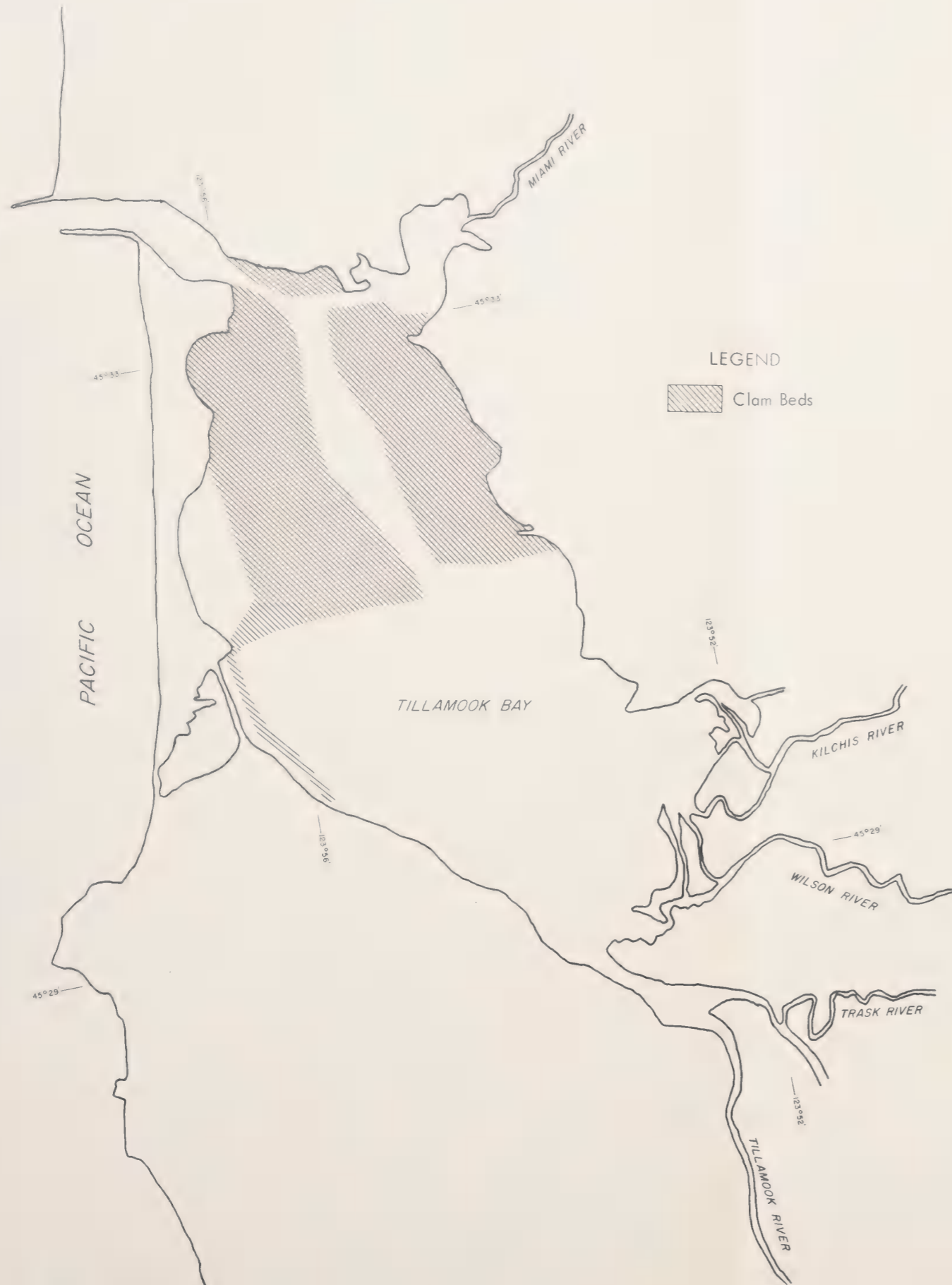
TILLAMOOK CO

LOCATION MAP

FISHERIES RESOURCES TILLAMOOK BAY

TILLAMOOK BAY DRAINAGE BASIN

OREGON

JULY 1977

1/2 0 1/2 1 MILE

SCALE 1:66,000

Left map labels:

MIAMI RIVER

PACIFIC OCEAN

TILLAMOOK BAY

KILCHIS RIVER

WILSON RIVER

TRASK RIVER

TILLAMOOK RIVER

45°33

45°33

123°52

45°29

123°56

45°29

123°52

LEGEND

Eelgrass Beds, 1971

Right map labels:

ROCKFISH

MIAMI RIVER

SALMON

PERCH

CRAB

PACIFIC OCEAN

TILLAMOOK BAY

FLOUNDER

SALMON

KILCHIS RIVER

SEARUN CUTTHROAT TROUT

WILSON RIVER

TRASK RIVER

TILLAMOOK RIVER

45°33

123°52

45°33

123°56

45°29

123°52

45°29

LEGEND

Principal Boat Fishing Areas, 1971

Crab (Jan.-Dec.)
Salmon (May-Nov.)
Perch (May-July)
Rockfish (May-Aug.)
Flounder (May-June)
Searun Cutthroat Trout (July-Oct.)

N

Tillamook Bay

TILLAMOOK CO.

LOCATION MAP

M7-EN-23598-12
Sheet 2 of 2
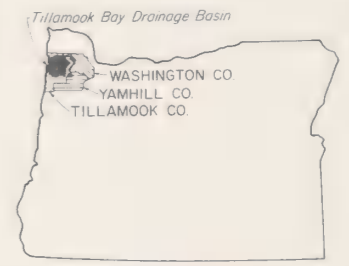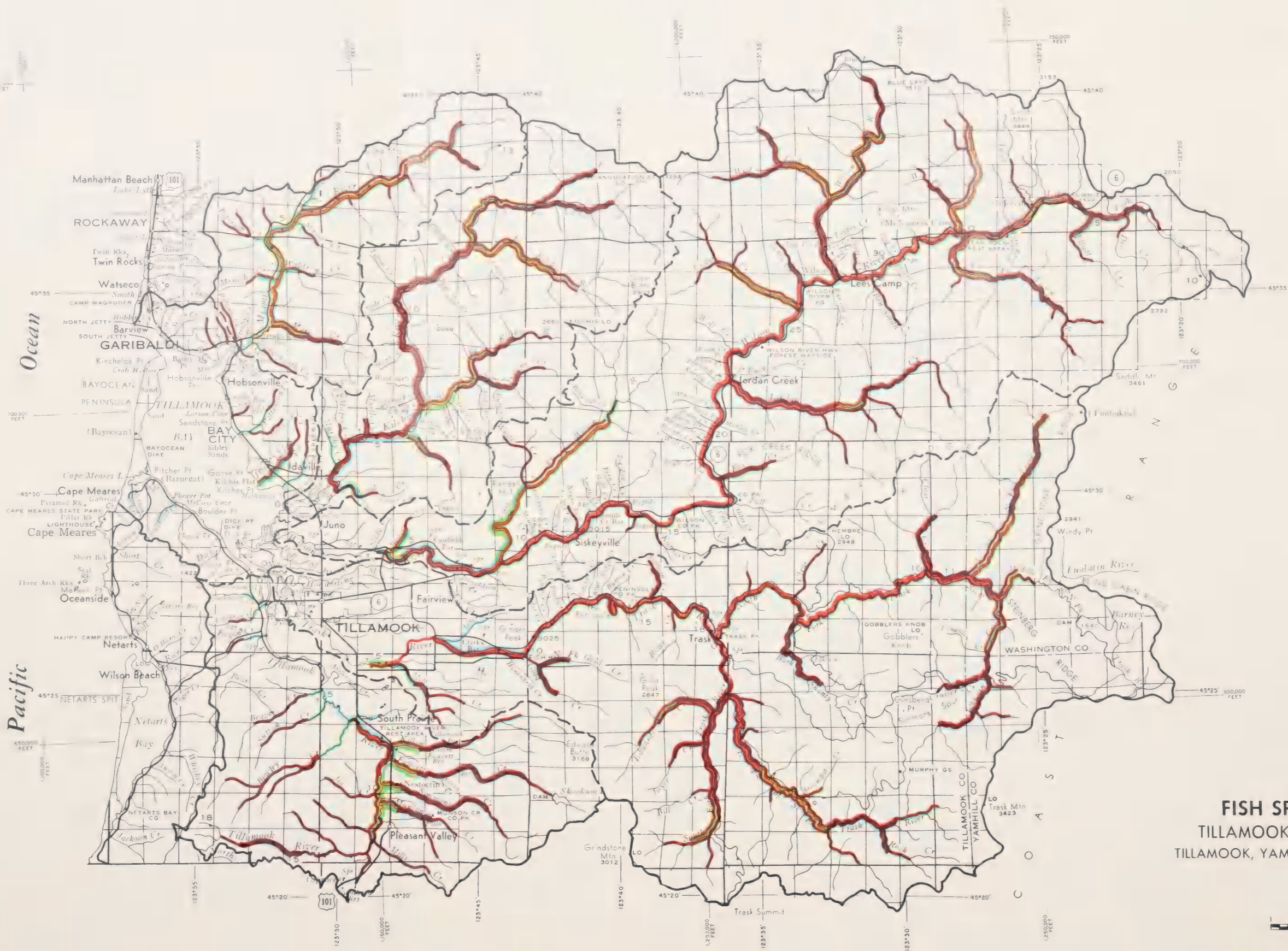
FISH SPAWNING AREAS

▬	Steelhead
▬	Fall Chinook Salmon
▬	Spring & Fall Chinook Salmon
▬	Chum Salmon
▬	Coho Salmon
▬	Chum & Coho Salmon

FISH SPAWNING AREAS
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES,
OREGON

MARCH 1977

SCALE 1:187,500

LOCATION MAP

WASHINGTON CO.
YAMHILL CO.
TILLAMOOK CO.

M7-SN-23598-9

channel areas. Tidelands are also the primary sediment deposition areas. The production of food organisms in Tillamook Bay occurs throughout the entire estuary. These food organisms include the bacteria, microscopic phyloplankton and other algae, zooplankton, small crustaceans, mollusks, annelids, and fish which are all important in the estuarine food chain.

The fish feeding areas of Tillamook Bay (for finfish and shellfish) include all areas of the estuary under tidal influence. Tideflats as well as deep-water channels and rocky areas provide a variety of rearing habitat. Species of fish, numbers, and distribution within each area are generally related to type of food organisms, bottom type, water depth, and water quality. Forty-five species of fish have been identified in Tillamook Bay.

Fish and shellfish typically found associated with tideflats include flounder, sole, perch, rockfish, salmon, crabs, shrimp and soft shell clams. In addition to those species found on tideflats, herring, anchovy, and smelt reside in the estuary channels; period of residency is dependent on species, season, and location.

Rocky areas in Tillamook Bay are the preferred feeding and rearing areas of perch, rockfish, greenling, and cabezon. These fish reside near the jetties and rock groins of the lower bay.

Fish migration routes are those areas traveled by fish to and from spawning, feeding, or rearing areas. Fish migration routes through Tillamook Bay are as varied as the species that use them. Species and age class of fish, season, water depth, and water quality all play an important role in fish migration patterns.

The use of channel areas throughout the estuary by salmon, trout, perch, flounder, and baitfish is well known. In addition, during high tides, these same fish frequently swim across tideflats to reach their destination.

From January through March, herring eggs can be found adhered to pilings, rocks, or eel grass in those areas outlined on the Fisheries Resource Map (Sheet 1 of 2). More complete observations in the future will no doubt reveal other areas used by these fish.

Nearly every stream segment in the basin provides spawning and rearing habitat for some species of anadromous fish. Spawning areas are displayed on the Fish Spawning Map.

WILDLIFE RESOURCES

There have been many adverse as well as beneficial impacts of the fires and subsequent logging activity on wildlife populations. The dense forest dwellers such as the spotted owl suffered drastic reductions in its habitat.

Wildlife species which benefitted most from the fires are those which require forest-edge-type habitat such as Roosevelt elk, and black-tailed deer. Much of the burn was invaded by forbs, grasses, and brush species. This provided ideal forage and when coupled with the unburned islands and new forest cover which developed, provided ideal habitat allowing rapid deer population growth. The population of these species have since peaked out. Black-tailed deer populations are now much reduced while elk numbers have stabilized.

The habitat can be divided into feeding areas and resting areas.

There are 230,960 acres in the basin which provide good cover for escape, resting, and breeding of larger wildlife species with 41,450 acres also providing limited forage. Primary forage is available on 88,780 acres. The primary forage areas also provide limited cover.

The current habitat situation will remain somewhat stable. Timber harvest will provide a constant forage-cover ratio much as it is today. This will favor wildlife which readily adapt to rotation of feeding and resting areas. Species such as the spotted owl will probably continue to be limited.

Small populations of game birds includes mountain quail, blue and ruffed grouse, and band-tailed pigeon. These receive light hunting pressure during the fall. Waterfowl seasonally inhabit the estuary and sloughs.

Non-game animals include beavers, muskrats, otters, minks, marten, racoons, skunks, coyotes, bobcats, nutrias, rabbits, squirrels, mountain beavers and many types of rodents including moles. Non-game birds include hawks, owls, crows, ravens, herons, and a variety of song birds. Populations of ocean and shore birds are outstanding and contribute greatly to natural and scenic areas.

WATER RESOURCES

TILLAMOOK BAY

The major body of water within the study area is Tillamook Bay Estuary. The bay is about 6 miles long in a southeast to northwest direction, 2 miles wide, and less than 6.5 feet in average depth. The elliptical-shaped area is separated from the Pacific Ocean by a long, narrow sandspit, Bayocean Peninsula, that extends northward from Cape Meares. Access to the ocean is through a 1200-foot-wide channel at the north end of the bay. The entrance is protected from winter storms by two rock jetties. The south jetty was constructed primarily for this purpose and the hope that it might also alleviate shoaling at the entrance. However, because of littoral drift patterns, jetty shoaling in the entrance results in navigation hazards. Periodic but limited dredging operations by the U.S. Corps of Engineers have been necessary to maintain an 18-foot-wide channel into Tillamook Bay from the bar to permit access by fishing boats and commercial barges to the City of Garibaldi. At one time, access to the south end of the Bay was comparatively easy for tug boats, barges, etc. However, continued deposition of sediment has reduced this area to a series of sand bars and several very shallow and narrow channels.

RIVERS AND STREAMS

Tillamook Bay is the termination point for a radial-shaped network of five major rivers which originate in the upper reaches of the basin (see Study Area Map). These are, from north to south, the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Several small streams also flow from the rolling hills adjacent to the margins of Tillamook Bay.

The smallest of the tributaries, the Miami River, flows south, draining an area of 39.9 square miles, and enters the north end of the bay. Five miles to the south, the Kilchis River with a drainage area of 73.3 square miles enters the bay from a north-easterly direction. The largest of the five drainages, the Wilson River with its many upland tributaries covers 34.5 percent of the total basin. It flows directly west to the bay from a drainage area of 196.1 square miles. The Trask River with a coverage of 31.2 percent of the basin, flows west to northwest and divides the basin area between the Wilson and Tillamook Rivers. Like the Wilson River, it has many upland tributaries flowing from a watershed area of 176.7 square miles. The fifth major drainage, the Tillamook River, has a low gradient. It has numerous tributaries and flows northward to the bay from a 67.4 square mile drainage area.

URBAN AND OTHER RESOURCES

Land classified in this category includes areas other than crop-
land, permanent pasture, brush and cutover land and forest lands. It
amounts to 12,867 acres or 3.5 percent of the total basin area. Urban
and industrial areas account for 1,730 acres. Roads and railroads
comprise 29,400 acres or 8.0 percent of the land classified as "other
resources". Approximately 10,980 acres, or 3.0 percent of this classi-
fication, includes all bodies of water--namely Tillamook Bay and its
five major tributaries.

LAND OWNERSHIP

The catastrophic fires of 1918 through 1951 have also affected the
land ownership of Tillamook Drainage Basin. Repeated burns destroyed
valuable stands of timber, leaving many landowners in financial despair,
while others lacked resources to reforest the lands. Many thousands
of acres were turned back to the county in lieu of paying the taxes.
The county, in turn, signed the lands over to the State of Oregon.

The state is now the principal landowner in the Study area with
235,190[1]/ acres. The balance includes 10,130 acres in county and muni-
cipal; 16,720 acres in federal; 74,950 acres in timber industry; and
26,530 acres in small private and other ownerships. (See Land Owner-
ship Map.)

Federal lands include 15,800 acres of public domain and Oregon
and California Railroad (O&C) lands administered by the Bureau of Land
Management (BLM). Lands of the defunct O&C have reverted to federal
ownership. The remaining 920 acres in federal ownership are national
forest lands administered by the Forest Service (FS), through the Hebo
Ranger District of the Siuslaw National Forest. These ownerships are
summarized in Table IV-14.

1/ The State of Oregon claims all navigable waters in the state.
    These are included with the exception of where these waters
    cross federal lands.

Table IV-14--LAND OWNERSHIP, USE, AND COVER

Land Cover and Use (Acres)

Landowner	Forest Land[1]	Cropland[1]	Urban[1]	Water	Rock & Sand	Total
Federal						
Dept. of Agriculture National Forest	920	--	--	--	--	920
Subtotal Dept. of Agr.	920	--	--	--	--	920
Dept. of Interior Public domain	15,480	--	--	40	280	15,800
Subtotal Dept. of Int.	15,480	--	--	40	280	15,800
Total Federal	16,400	--	--	40	280	16,720
State of Oregon	220,840	--	--	10,770	3,580	235,190
County and municipal	5,860	2,010	1,730	170	360	10,130
Timber industry	74,450	500	--	--	--	74,950
Other	5,500	21,030	--	--	--	26,530
Total	323,050	23,540	1,730	10,980	4,220	363,520

1/ These areas include rights-of-way through the resource use area.

LAND OWNERSHIP
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON

MAY 1976

SCALE 1:187,500

1   0   1   2   3 MILES

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO.
YAMHILL CO.
TILLAMOOK CO.
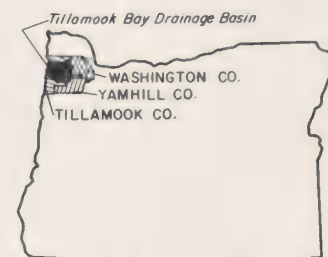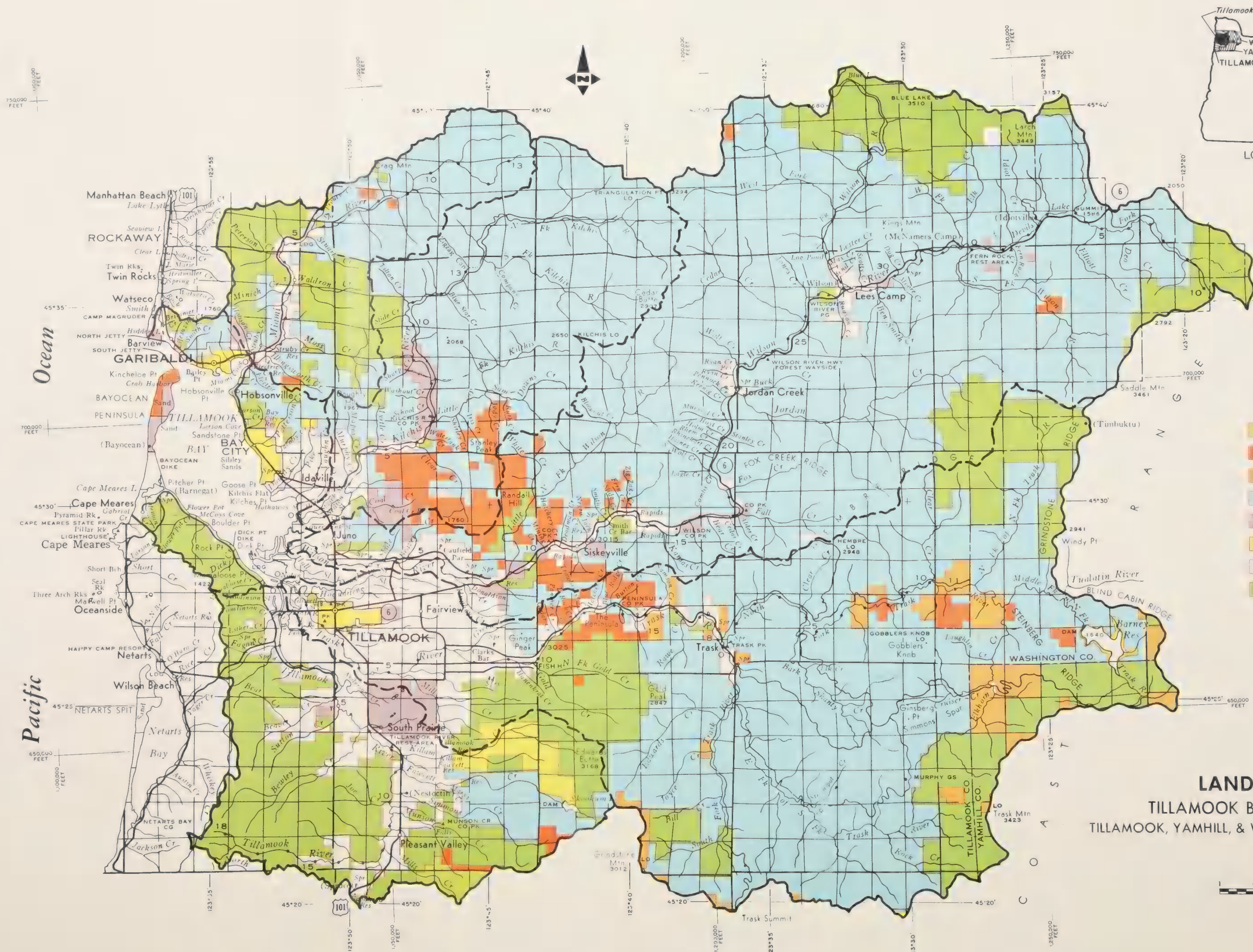
LEGEND

- National Forest
- Public Domain (BLM)
- O & C (BLM)
- State
- County
- Municipal
- Other
- Timber Industry
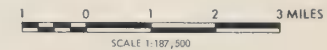
CHAPTER V

ECONOMIC DEVELOPMENT

ECONOMIC DEVELOPMENT

GENERAL

The economy of the Tillamook Bay Drainage Basin area is based primarily on forestry, agriculture, and recreation or tourism.

Population is essentially rural in character with only 22 percent classified as urban. Annual unemployment has averaged about 7.5 percent of the labor force in recent years. Average family income was $9,401 in 1970 for county residents, below the average for both the U.S. and Oregon.

POPULATION

Population trends are shown in Figure V-1 for Tillamook County and Tillamook City. County population peaked in 1960, declined during the mid-sixties, and has gradually increased during the early seventies.

Population of the Tillamook Bay Drainage Basin study area is about 70 percent of that of the county or 12,715 persons in 1970. The heaviest population densities are concentrated in towns and rural areas adjacent to Tillamook Bay. The towns of Tillamook, 3,968; Garibaldi, 1,083; Bay City, 898; and Rockaway, 665, accounted for 52 percent of the total study area population in 1970.

While overall county population decreased by about six percent during the last census decade, the number of people 65 years and over increased by 26 percent from 1,894 in 1960 to 2,395 in 1970. For various socio-economic reasons, younger age groups have tended to migrate out of the county.

In addition to resident population, several thousand non-resident tourists visit the area during the summer tourist season. Peak seasonal non-resident population was estimated at 9,860 persons for Tillamook County in 1973.[1] Tourists bring in recreation dollars. But they also require camping sites, roads, picnic areas and they directly increase the requirements for water systems, sewerage treatment, law enforcement, and other public services.

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[1] Estimated nonresident population (tourists) was developed by the Oregon Projections Sub-Work Group for use by the Oregon State Water Resources Board (now the Oregon State Water Resources Department.)

Figure V-I

POPULATION-TILLAMOOK COUNTY, OREGON
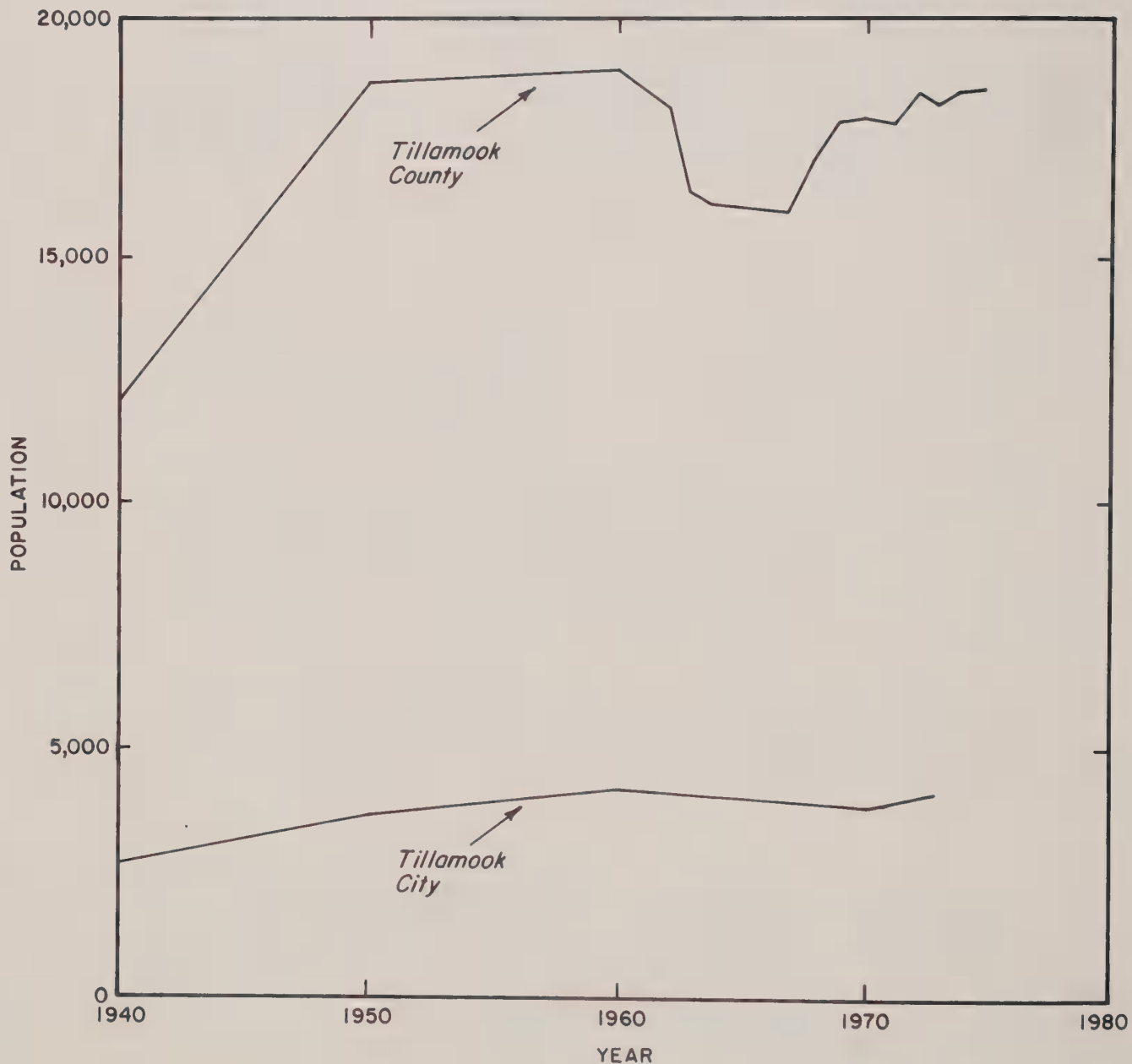
Center for Population Research and Census – Portland State University

EMPLOYMENT

Total Tillamook County employment for 1970 was 6,230 persons (Table V-1). The lumber and wood products industry is the major employer, with about 1400 people in 1970. Employment increased 65 percent from 1940 to 1950 and has since decreased. The largest employment decreases occurred in agriculture, forestry, fisheries, and the lumber and wood products sectors, all of which are basic industries to Tillamook's economy. Some retail trades, the medical and professional services, and public administration sectors experienced increases in employment from 1950 to 1970, partially offsetting the losses in basic industries. Despite offsetting employment gains, total county employment decreased by 10 percent over the 20-year period.

Average annual unemployment in Tillamook County ranged between 5.9 and 10.8 percent from 1970 to 1974. Average monthly unemployment over the same time period ranged between 4.2 percent for September 1972 and 18.6 percent for December 1974. The wide range in monthly unemployment is indicative of the highly seasonal nature of the major industries: Forestry, fishing, recreation, and agriculture.

Table V-1 Employment, Tillamook County, 1940, 1950, 1960, 1970

Industry	Year			
	1940	1950	1960	1970
Agriculture, forestry & fisheries............	1,126	1,303	1,002	762
Contract construction........................	241	412	243	366
Manufacturing:				
Food....................................	139	202	253	143
Lumber & wood...........................	979	2,159	1,792	1,404
Printing & publishing...................	29	48	34	33
Other manufacturing.....................	30	54	48	169
Transportation...............................	101	139	159	108
Communications...............................	22	75	75	46
Utilities....................................	42	110	110	127
Wholesale trades.............................	76	164	68	116
Retail food stores...........................	144	212	181	132
Eating places, bars, taverns.................	94	211	226	311
Other retail trades..........................	241	455	535	557
Finance, insurance, real estate.............	55	128	160	147
Hotels, personal services...................	227	272	235	259
Private households...........................	130	104	120	75
Businesses & repair services................	92	141	154	139
Entertainment, recreation....................	33	69	24	46
Medical, professional services..............	279	497	750	985
Public administration........................	114	194	236	289
Other employment.............................	10	5	8	16
TOTAL.................................	4,204	6,954	6,413	6,230

U.S. Department of Commerce, Census of Population.

INCOME

Average per capita income of county residents in 1969 was $2,843 (Table V-2). This was lower than the per capita income for the adjacent counties of Clatsop and Lincoln, and well below Oregon and the United States.

According to the federal definiticn of poverty, 11.1 percent of all families in Tillamook County in 1970 earned incomes below the poverty level. Tillamook was ranked with the ninth highest poverty level of all counties in the state. Approximately 1,795 persons were living at or below poverty levels.

Table V-2--Personal Income Comparisons, Tillamook County, 1969

Area	Per Capita Income	Oregon Relative Per Capita Income	Family Mean Income
Tillamook County.............	2,843	.90	9,401
Clatsop County...............	3,150	.996	10,335
Lincoln County...............	2,897	.92	9,031
Oregon.......................	3,163	1.00	10,695
United States................	3,139		9,590

Source: Oregon Coastal Area, etc.

MAJOR ECONOMIC ACTIVITIES

The predominant economic activity in Tillamook County is the timber and wood products industry. In 1972, 35 firms were directly involved in the logging or processing of timber and lumber products. Other principal economic activities include dairying, commercial fishing and seafood processing, and recreation-related enterprises.

The value of Tillamook County gross outputs, by economic sector, was estimated for this study. The wood products industry which includes logging, sawmill and plywood operations, timber holdings, and associated service activities account for about 43 percent of total gross county output. The agriculture and food processing sectors are composed primarily of the dairy industry, and together make up about 17 percent of total county output. Remaining gross county output, 40 percent, stems from the construction, transportation and utilities, manufacturing, trades, services, and seafood sectors.

Table V-3, Total Estimated Gross Output by Major Economic Sector
Tillamook County, Oregon, 1972

Major Economic Sector	Gross Output
	Thousand dollars
Agriculture...	13,100
Wood products......................................	71,700
Commercial seafoods................................	300
Construction.......................................	4,700
Food processing....................................	15,400
Transportation & utilities........................	10,900
Manufacturing......................................	5,700
Wholesale & retail trades..........................	11,100
Finance, insurance & real estate..................	16,800
Services...	15,300
TOTAL..............	165,000

The value of gross outputs shown in Table V-3 were the result of an input-output (I-O) model constructed of the Tillamook County economy for this study. This model can be used to estimate dollar impacts of economic changes on all of the interrelated sectors of Tillamook's economy.

The Tillamook model was tested in a trial run to analyze the economic effects of three types of public service funding. For this example, the levels of funding were:

Hospital remodeling	$773,000
Public service (CETA)	327,500
Flood disaster relief	1,800,000
TOTAL	$2,900,500

Analysis of these funds through the use of the Tillamook model showed the largest impacts to be on the construction industry (Table V-4). This is to be expected since a large share of the funds were used in the construction industry.

Table V-4 Total Estimated Gross Output by Sector After
Incorporating Public Service Funds
Tillamook County, Oregon

Major Economic Sector	Gross Output
	Thousand dollars
Agriculture............................	13,100
Wood products.........................	71,800
Commercial seafoods...................	300
Construction..........................	7,200
Food processing.......................	15,400
Transportation & utilities...........	10,900
Manufacturing.........................	5,700
Wholesale & retail trades.............	11,300
Finance, insurance & real estate......	16,900
Services..............................	15,600
TOTAL.............	$168,200

The difference between total gross outputs in Tables V-3 and V-4 is 3.2 million dollars. This is $300,000 more than the amount originally incorporated into the model. The additional $300,000 represents interdependence of the directly-impacted sectors with other sectors of the economy.

It should be pointed out that the model has some limitations. Three limitations have to do with data availability, aggregation problems, and the static (single year) nature of the model. But I-O analysis also has many advantages. It requires that attention be given to all sectors of the economy of an area. It is uniquely adaptable to computers and it is consistent in the sense that solutions of demands and expenditures will add up to a total gross product.

CHAPTER VI

EROSION & SEDIMENT YIELD STUDIES & SURVEY PROCEDURES

EROSION & SEDIMENT YIELD STUDIES
& SURVEY PROCEDURES

SURVEY PROCEDURES

GENERAL

No previous detailed erosion and sediment yield studies have
been made on agricultural land in the basin. However, water quality
sampling to provide sediment load data has been in progress on four
of the five tributary drainages for the past two years. Laboratory
analysis was completed by the Department of Environmental Quality
but no detailed interpretation of the results was available prior to
implementation of this study.

AGRICULTURAL LANDS

Inventory and analysis of erosion and sediment on agricultural
lands involved two facets--sheet and rill erosion and streambank
erosion. Evaluation of sheet and rill erosion initially involved the
determination of the total acres of each soil type within the boundaries
of each of the five tributary drainages. This was completed by planimet-
ering each soil component as mapped by the Soil Conservation Service
on 1953 aerial photographs. This data was correlated with visually
selected field sites based on degree of slope and current land use.
The Universal Soil Loss Equation (USLE) was then applied to this data
to determine the degree of sheet and rill erosion which could be
expected to occur annually within each selected site area. It was
then expanded to similar areas in other parts of each drainage.
Consideration was also given to overbank flooding which, due to
variable velocities, contributes to sheet and rill erosion as well as
sediment deposition on farmlands, roads, etc. Based on the results
obtained from using the USLE and a field judgment of sediment delivery,
an estimate was made of the total amount of sediment which could be
expected to reach each tributary drainage and Tillamook Bay.

Sediment deposition on farmland was quite evident, particu-
larly in areas adjacent to the stream channel in four of the five
drainages included in this study. Samples were taken of both the
depositional sediment and the original underlying topsoil at the same
location (See Soil Sample and Erosion Plots Map). A complete analysis
was made on each sample with regard to nutrient deficiencies, labor-
atory work for which was done by Oregon State University Soil Testing
facility at Corvallis, Oregon (See Table VI-1). The tests on these
random soil samples indicate that the sediment deposits have a pro-
nounced effect on various element deficiencies within the underlying
soil profile, particularly nitrogen and organic matter content.

TABLE VI-1

TILLAMOOK BAY DRAINAGE BASIN
EROSION AND SEDIMENT STUDY

NUTRIENT ANALYSIS
TOPSOIL AND SEDIMENT DEPOSITION SAMPLES

Sample	Sample depth	Lab.	pH	P (ppm)	K (ppm)	Extractable cations			B (ppm)	Salts (mmhos/cm)	Org. Matter %	Total Nitrogen %	CEC (meq/100g)
						Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)					
M-Sed-1 (Miami R.)	Sediment Flood Dec. 75'	2292	6.3	15	146	25	7.4	.30		.14	.11	.05	32.3
M-Sed-2	Topsoil Below Sample 1	2293	5.9	14	128	24	6.4	.35		.15	5.3	.16	38.4
K-Sed-1 (Kilchis R)	Sediment Flood Dec. 75'	2294	6.3	19	170	34	6.3	.33		.12	1.1	.04	36.8
K-Sed-2	Topsoil Below Sample 1	2295	6.0	12	164	25	5.9	.35		.17	6.8	.26	46.2
W-Sed-1 (Wilson R)	Sediment Flood Dec. 75'	2296	6.4	16	112	32	6.9	.26		.26	1.2	.05	30.2
W-Sed-2	Topsoil Below Sample 1	2297	6.1	9	156	30	6.3	.37		.19	7.1	.19	42.6
T-Sed-1 (Trask R.)	Sediment Flood Dec. 75'	2298	6.6	9	106	38	7.3	.26		.13	.44	.01	31.5
T-Sed-2	Topsoil Below Sample 1	2299	6.3	16	156	30	6.4	.28		.30	2.0	.06	30.1

R 10 W   9   8   7   6   5

Tillamook Bay Drainage Basin

WASHINGTON CO.
YAMHILL CO.
TILLAMOOK CO.
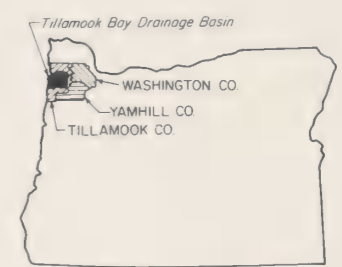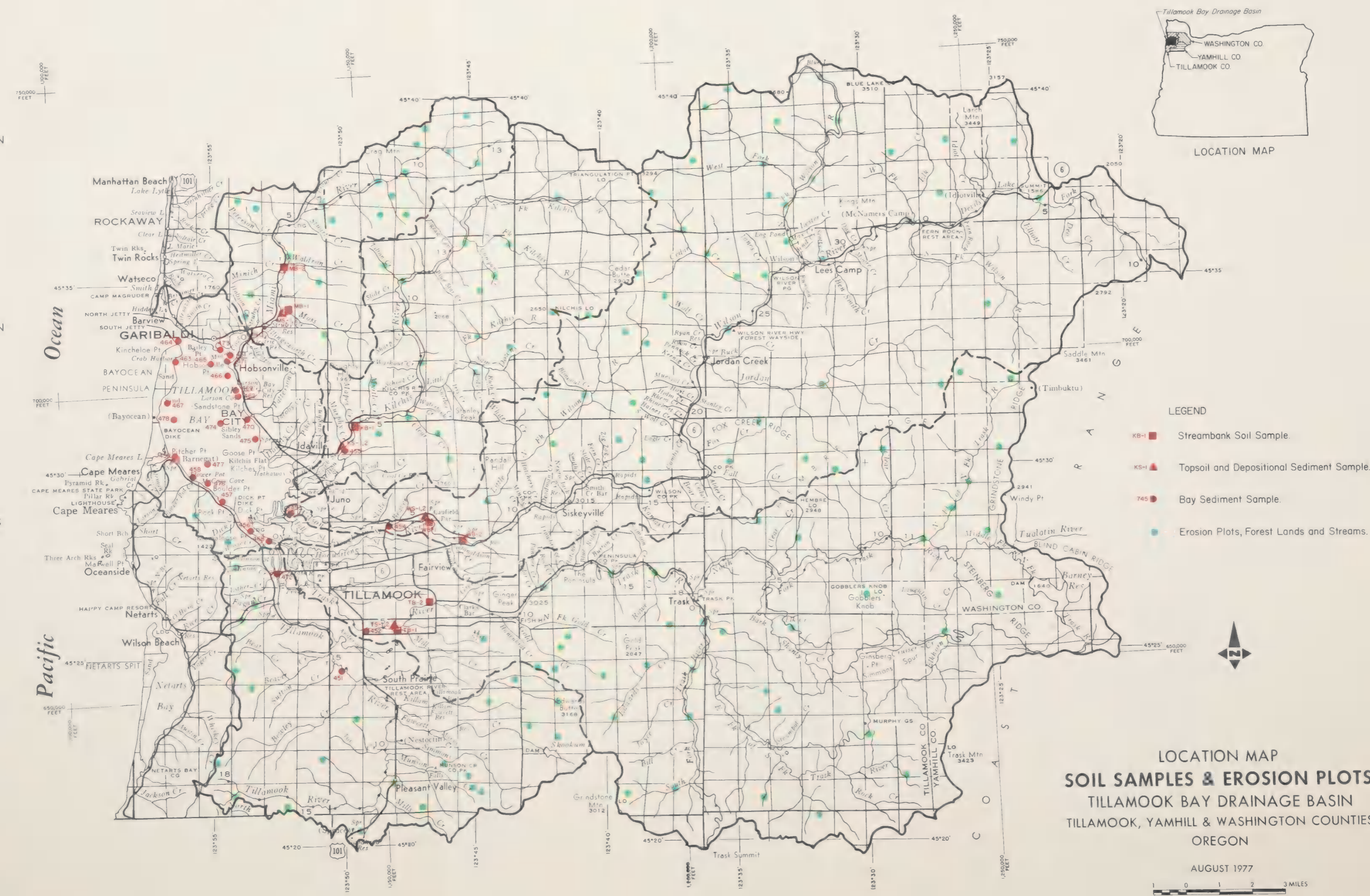
LOCATION MAP

LEGEND

KB-1 ■ Streambank Soil Sample.

KS-1 ▲ Topsoil and Depositional Sediment Sample.

745 ● Bay Sediment Sample.

● Erosion Plots, Forest Lands and Streams.

LOCATION MAP
SOIL SAMPLES & EROSION PLOTS
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL & WASHINGTON COUNTIES,
OREGON

AUGUST 1977

1   0   1   2   3 MILES
SCALE 1:187,500

T 2 N

Manhattan Beach
Lake Lytle
ROCKAWAY
Clear L.
Twin Rks.
Twin Rocks
Watseco
Smith L.
CAMP MAGRUDER
1 N
NORTH JETTY
Barview
SOUTH JETTY
GARIBALDI
Kincheloe Pt.
Crab Harbor
Hobsonville
BAYOCEAN
PENINSULA
TILLAMOOK
BAY
CITY
Sandstone Pt.
(Bayocean)
BAYOCEAN
DIKE
Sibley Pt.
Idaville
Pitcher Pt.
Barnegat
Kilchis Flat
Cape Meares L.
Cape Meares
45°30'
Pyramid Rk.
CAPE MEARES STATE PARK
Pillar Rk
LIGHTHOUSE
Cape Meares
Boulder Pt.
Rock Pt.
DICK PT.
DIKE
Juno
Siskeyville
1 S
Short Bch.
Seal Rk.
Three Arch Rks.
Maxwell Pt.
Oceanside
Fairview
HAPPY CAMP RESORT
Netarts
TILLAMOOK
Trask
Wilson Beach
South Prairie
TILLAMOOK RIVER
REST AREA
2
NETARTS SPIT
Netarts
Bay
Pleasant Valley

Ocean
Pacific

LOCATION MAP

BLUE LAKE
3510
Larch Mtn
3449
Idlorville
SUMMIT
Lees Camp
FERN ROCK
REST AREA
McNamers Camp
Jordan Creek
(Timbuktu)
FOX CREEK RIDGE
Windy Pt
GRINDSTONE RIDGE
Tualatin River
BLIND CABIN RIDGE
Burney Res.
GOBBLERS KNOB
Gobblers Knob
WASHINGTON CO.
STENBERG RIDGE
DAM
Trask Mtn
3423
MURPHY GS
Grindstone Mtn
3012
Trask Summit

Source:
Base map furnished by Oregon State Staff.
Thematic detail compiled by State Staff.

M7-SN-23598-11

Determination of channel reaches was based on bank heights as observed and measured in the field. Each reach of channel, as traced on drafting film from each of two aerial photo flights taken at different times, was cut out and the area determined by weight. Simultaneously, the area of streambank erosion and the average bank height were then used to obtain the volume of soil loss in acre feet and coverted to tons for each reach of channel due to bank erosion which occurred during the period between the two flights.

To further substantiate the foregoing data, all of the channel within the agricultural lands in each of the five tributary drainages were checked in the field to verify conditions as established on the aerial photos. At that time, all necessary changes were made so as to update any erosion problems to the current year (1977).

Critically eroding sections of unprotected channel bank were located, studied and measured to determine a reasonable erosion rate and the number of surface acres lost by bank recession which had been and still appears to be occurring. (See Stream Stability Map) The remaining banks were placed in a non-critical category and an erosion rate under present conditions was estimated based on visual examination.

FOREST LANDS

Erosion sources on forest lands were inventoried using false color infrared aerial photographs taken from U-2 aircraft in 1975. A scale of 2 inches per mile was used. Ground truth data was obtained from a field survey to assure correct photo interpretation. The erosion sources were grouped into 29 categories as follows:

Group	Subgroup
Roads	Paved
	Gravel 2-lane
	Secondary 1½ lane
	Spurs 1-lane
	Skid roads ½-lane
Trails	Fire trails
	Rail grades used
	Rail grades abandoned
	Transmission lines
	Motorbike trails
Landslides	Upper 1/3 slope
	Middle 1/3 slope
	Lower 1/3 slope

```
Streams------------------------- Channel bank
                                 Channel bottoms
                                 Flood plain scour

Clearcuts---------------------->75 percent bare ground
                                50-75 percent bare ground
                                25-50 percent bare ground
                                 <25 percent bare ground

Forested Areas------------------ Brush and seedlings
                                 Saplings and poles
                                 Mature second growth
                                 Hardwoods
                                 Old growth

Burns--------------------------- >75 percent bare ground
                                 50-75 percent bare ground
                                 25-50 percent bare ground
                                  <25 percent bare ground
```

The actual length for each corridor erosion source in miles and the mean erosion width were determined by field measurement.

Landslides were inventoried by slope position using false color infrared low elevation aerial photography flown in 1975. Erosion plots were used to determine the erosion rates. The erosion rates were so high on many plots as to completely erode the plot pins and troughs.

Stream stability was determined using the USFS Stream Reach Inventory and Channel Stability Evaluation System, USFS R-1, 1975. Correlations between stream stability and channel erosion were established using index transects along selected streams to arrive at coefficients for lateral migration, aggradation, and degradation. (See Stream Stability map following page VI-4)

The clearcut, forested and burn areas and the percent of bare ground were determined using satellite infrared imagery and the computer program called LANDSAT (PIXSYS) developed by the Earth Resources Remote Sensing Applications Laboratory (ERSAL) at Oregon State University, Corvallis, Oregon. The ground field survey, pixel signatures, and interpretations were done by the USFS.

The bedload component of gross sediment was determined by field measurement using a Helli Smith bedload sampler and correlation of the resulting data with actual bedload removal data from two channel gravel mining operations located in the Miami and Trask Rivers.

LOCATION MAP

WASHINGTON CO
YAMHILL CO
TILLAMOOK CO
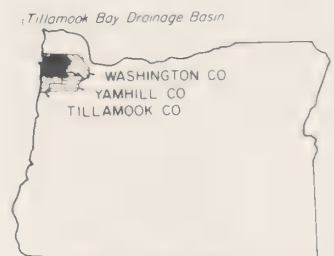
Tillamook Bay Drainage Basin

CRITICAL STREAMBANK ZONES

——— Streambank Zones

STREAM STABILITY RATINGS

——— Excellent

——— Good

——— Fair

——— Poor

CRITICAL STREAMBANK ZONES
AND
STREAM STABILITY MAP
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL & WASHINGTON COUNTIES,
OREGON

NOVEMBER 1978

| 1 | 0 | 1 | 2 | 3 MILES |

SCALE 1 : 187,500

3

N

TILLAMOOK BAY
DRAINAGE BASIN

UPPER WILSON

LOWER WILSON

MAIN TRASK

EAST FORK TRASK

SOUTH
FORK
TRASK

TILLAMOOK

NORTH
FORK
WILSON

UPPER KILCHIS

SOUTH
FORK
KILCHIS

MIAMI

LOWER KILCHIS

MIAMI

TILLAMOOK

Figure VI-I

FOREST LAND
by SUBBASIN

The sediment samples were field collected at 14 primary sediment-discharge sampling stations in the basin. (See Recording Gages and Sediment Sampling Stations Map following Page VI-6). Several secondary sampling stations were also established to get estimates of sediment delivery ratios within the subwatersheds. The computer program titled Polynominal Regression (RPOLY) is filed at the USDA Fort Collins, Colorado Computer Center. This is a USFS Region 6 program developed by the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Figures VI-2, VI-3, VI-4, and VI-5 are the sediment-discharge regression for the 14 primary fluvial sediment data collection stations. The (r^2) coefficients of determination for these stations range from .66 to .99 and average .91. In most cases the quadratic or cubic expression resulted in the best data fit. One analytical value of these regression lines is that as restoration needs are implemented and erosion and resulting fluvial sediment is reduced, the slope of the new regression lines will become more vertical and the resulting water quality improvement can be measured.

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO
YAMHILL CO
TILLAMOOK CO
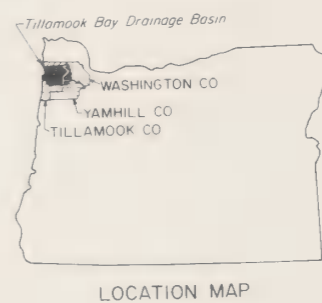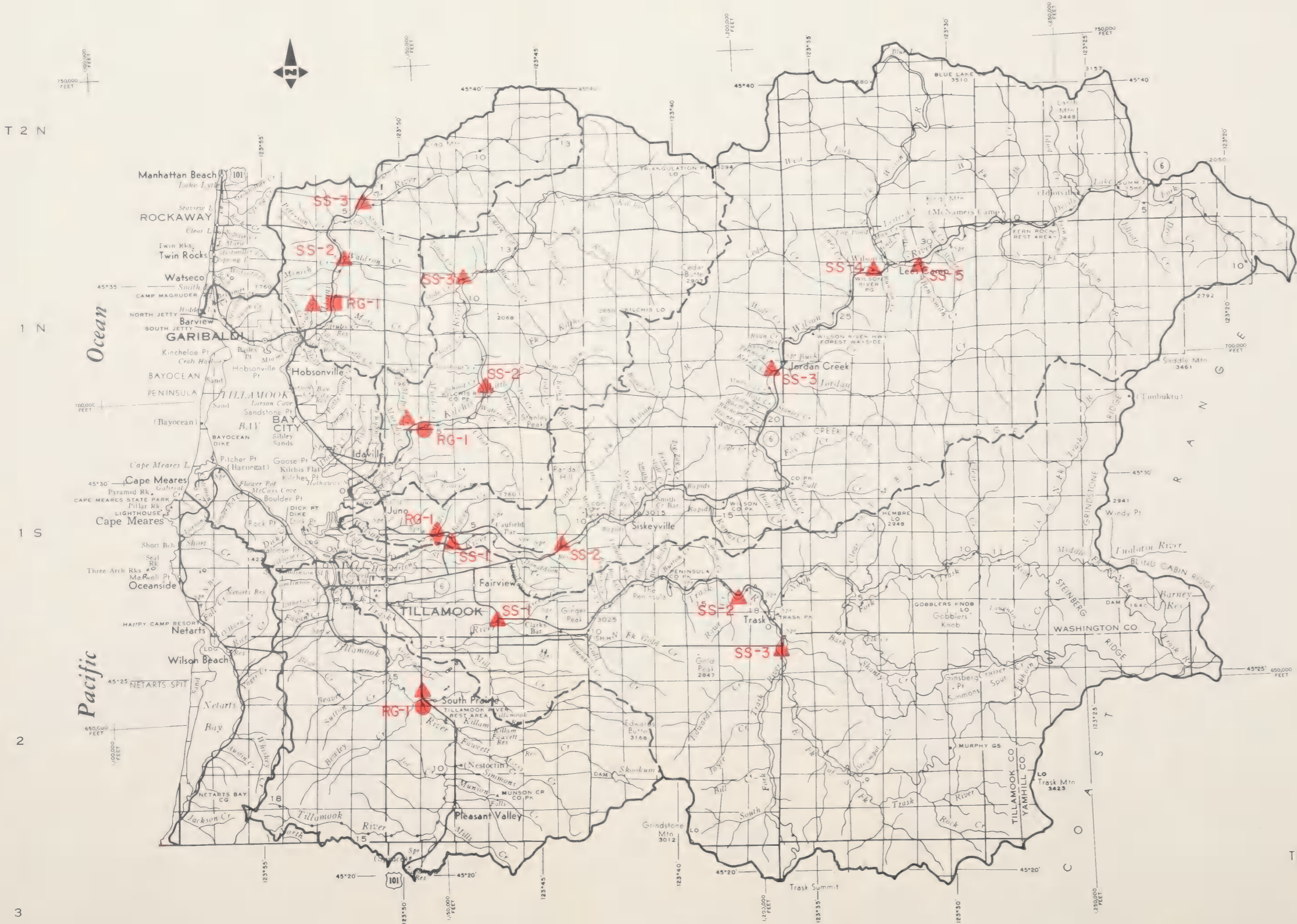
LEGEND

● SCS Recording Gage

■ Oregon State Recording Gage

◆ USGS Recording Gage

▲ Suspended Sediment Load Sampling Stations

RECORDING GAGES AND
SEDIMENT SAMPLING STATIONS
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, & WASHINGTON COUNTIES, OREGON

APRIL 1977
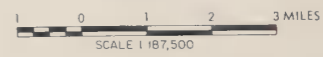
SCALE 1:187,500

SCALE 1 187,500

M7-N-23598-10

Figure VI-2 Comparative Analysis of Sediment/Discharge–Miami River.

SAMPLE STATIONS

1 Lower Miami ($r^2 = 0.97$)
   T 1 N, R 10 W, NE 1/4 Sec. 14
   $y = 160.02 + (-0.61)x + 0.00038 x^2$

2 Upper Miami ($r^2 = 0.96$)
   T 1 N, R 10 W, SE 1/4 Sec. 2
   $y = 19.18 + (-0.17) x + 0.00035 x^2$

3 Upper Miami ($r^2 = 0.99$)
   T 2N, R 10 W, SW 1/4 Sec. 36
   $y = 92.79 + (-0.61) x + 0.00063 x^2$

Discharge–cfs

Sediment–tons/day

VI-7
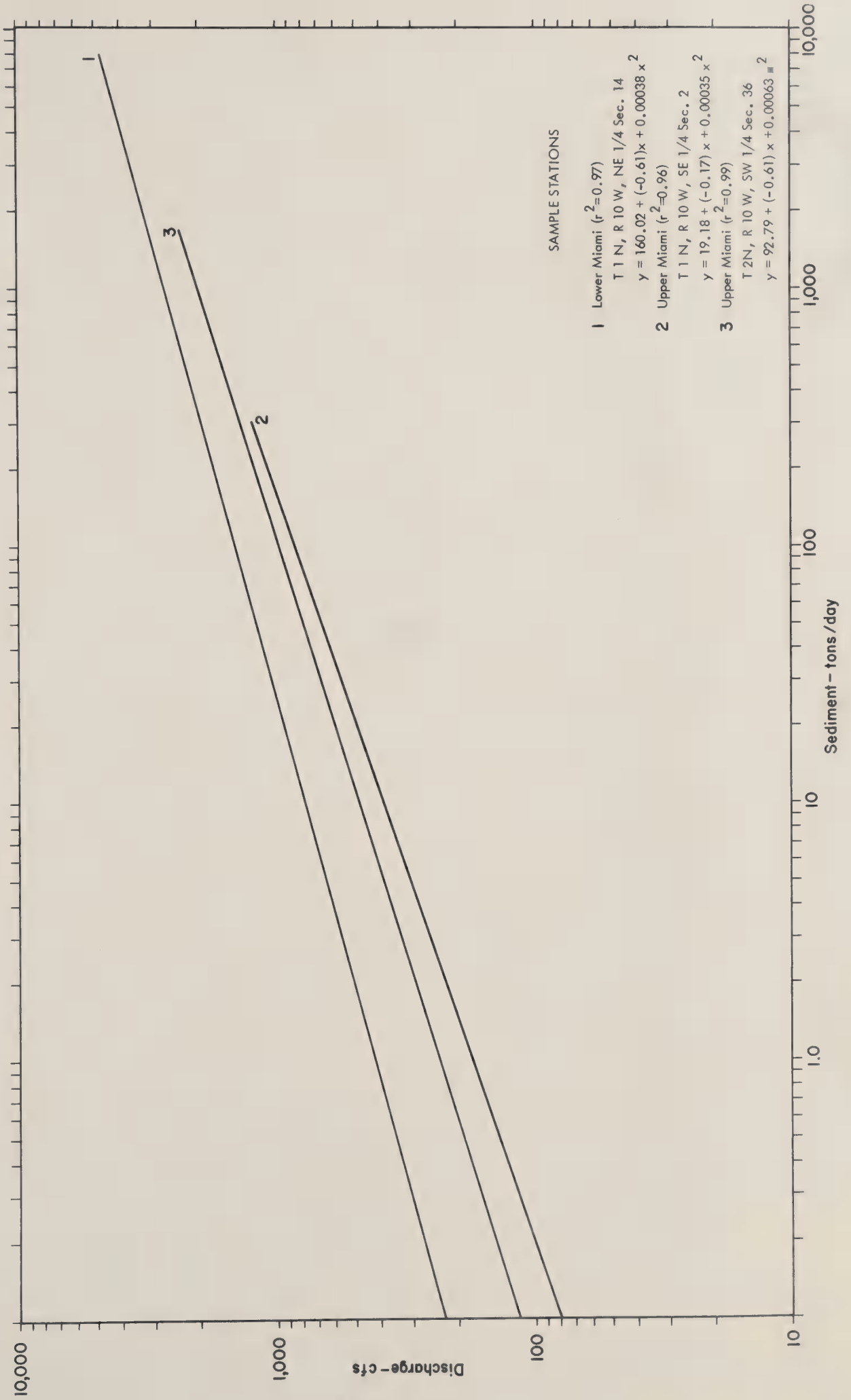
Figure VI-3 Comparative Analysis of Sediment / Discharge – Kilchis River.

SAMPLE STATIONS

1 Lower Kilchis (r^2=0.99)
   T 1 S, R 9 W, SE 1/4 Sec. 6
   $y = (-419.39) + 0.73x + (-0.00027)x^2 + 0.0000003x^3$

2 Upper Kilchis (r^2=0.91)
   T 1 N, R 9 W, SE 1/4 Sec. 28
   $y = 68.67 + (-0.68)x + 0.00094x^2$

3 Upper Kilchis (r^2=0.85)
   T 1 N, R 9 W, NW 1/4 Sec. 9
   $y = 3.93 + (-0.04)x + 0.0001x^2 + (-0.00000048)x^3$

VI-8
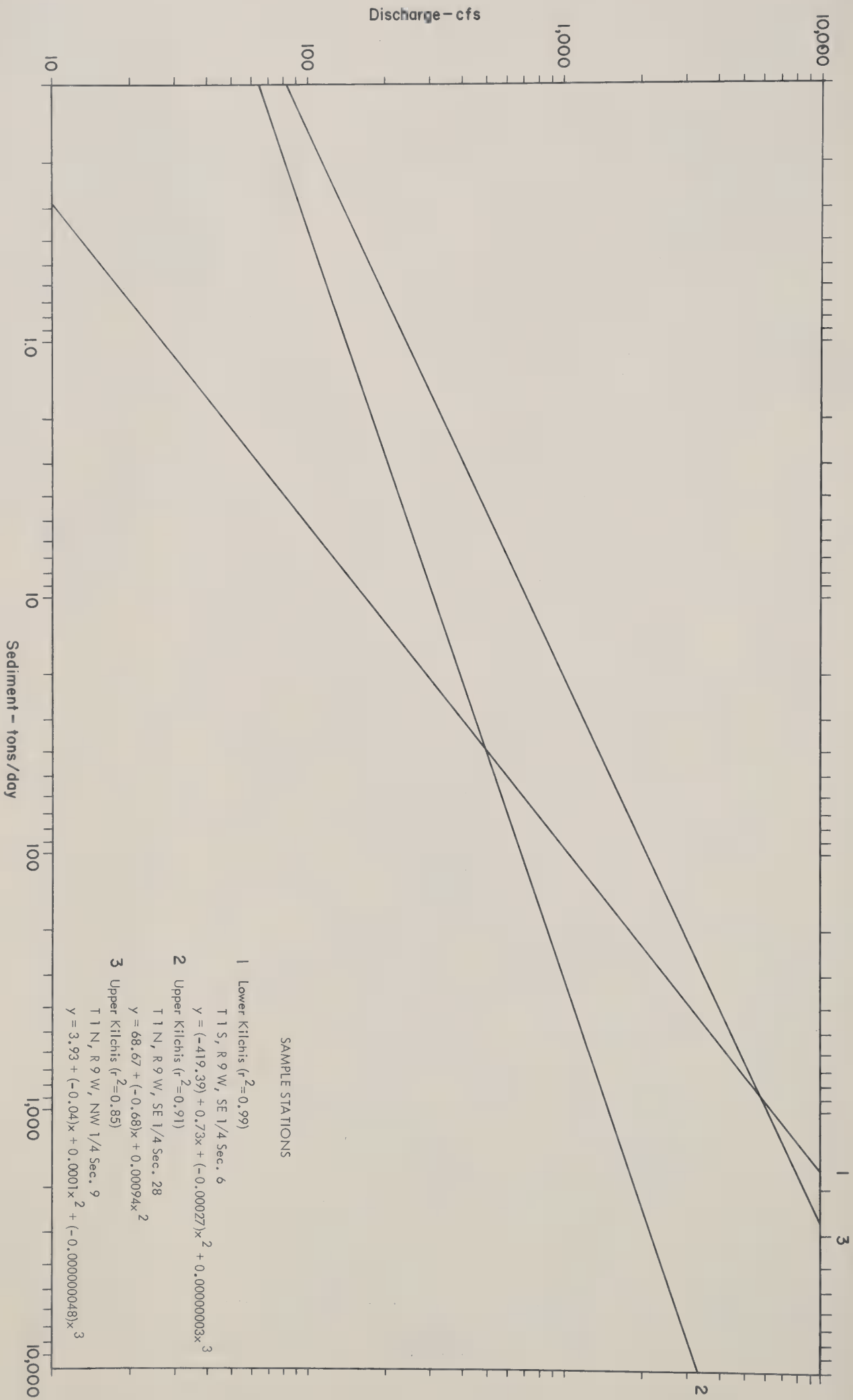
Figure VI-4 Comparative Analysis of Sediment/Discharge-Wilson River.

SAMPLE STATIONS

1 Lower Wilson (r^2=0.95)
   T 1 S, R 9 W, NE 1/4 Sec. 20
   $y = (-41.22) + (-0.06)x + 0.000047x^2$

2 Lower Wilson (r^2=0.66)
   T 1 S, R 9 W, NW 1/4 Sec. 24
   $y = (-666.34) + 0.51x + (-0.000015)x^2$

3 Upper Wilson (r^2=0.67)
   T 1 N, R 7 W, NW 1/4 Sec. 9
   $y = 11.14 + (-0.03)x + 0.000026 x^2$

4 Upper Wilson (r^2=0.91)
   T 1 N, R 7 W, NW 1/4 Sec. 10
   $y = (-0.79) + (-0.01)x + 0.000034x^2$

VI-9
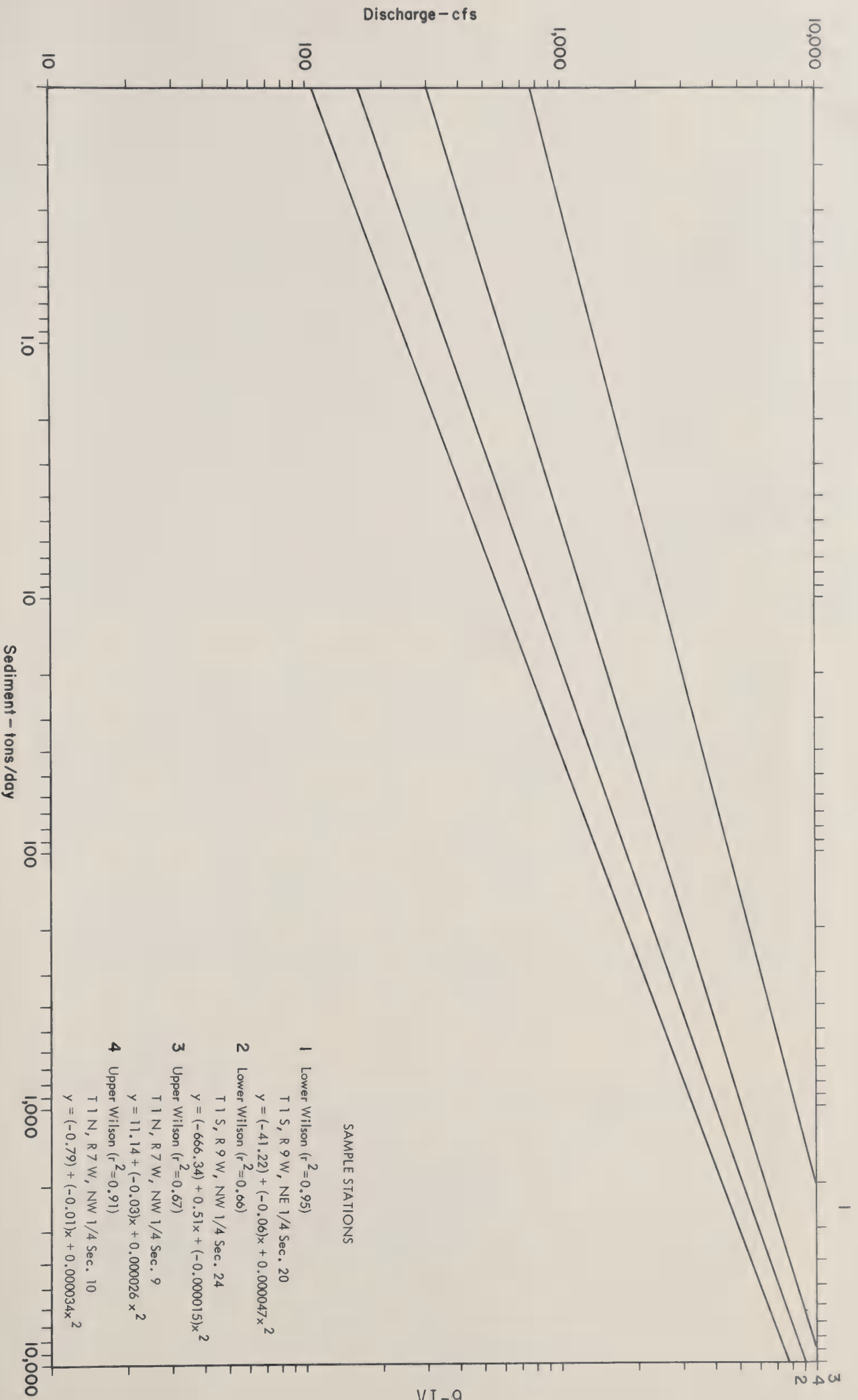
Figure VI-5 Comparative Analysis of Sediment/Discharge-Tillamook and Trask Rivers.

SAMPLE STATIONS

1 Tillamook River ($r^2 = 0.99$)

T 2 S, R 9 W, SW 1/4 Sec. 8

$y = 21.96 + (-0.10)x + 0.00014x^2$

2 Lower Trask ($r^2 = 0.99$)

T 1 S, R 9 W, SW 1/4 Sec. 34

$y = (-74.47) + 0.14x + (-0.00004)x^2 + (0.00000001)x^3$

3 Upper Trask ($r^2 = 0.91$)

T 1 S, R 8 W, SE 1/4 Sec. 26

$y = 17.61 + (-0.08)x + 0.000089x^2$

4 Upper Trask ($r^2 = 0.99$)

T 2 S, R 7 W, NW 1/4 Sec. 7

$y = 34.64 + (-0.26)x + 0.00041x^2$
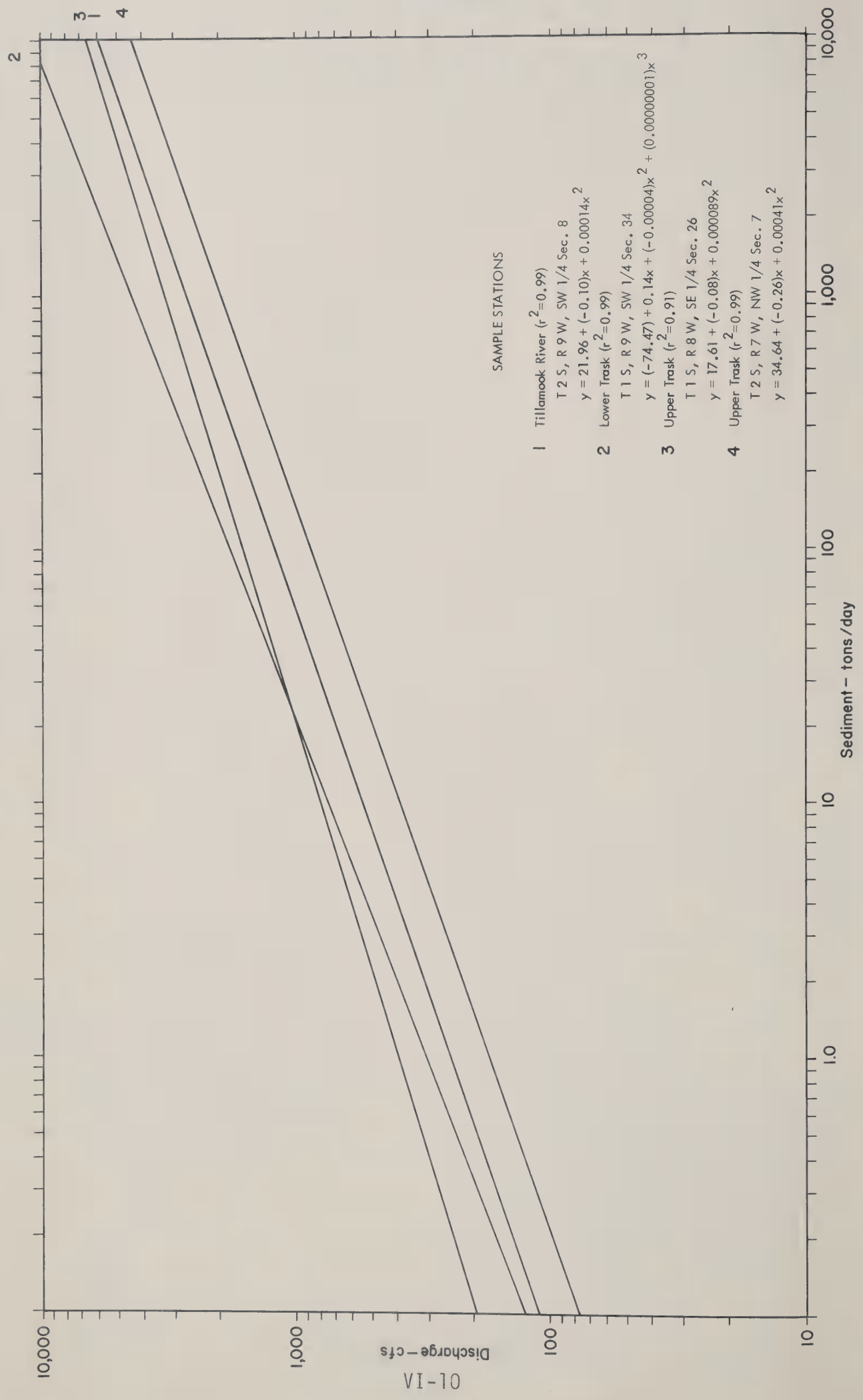
TILLAMOOK BAY

Sediment samples were obtained at 52 surface sites and 17 core sites in and around Tillamook Bay (See map Figure 1, Sample Locations and Data). Surface sediment samples were collected by either a standard U.S. BM54 sampler or by hand dipping a 454 gram (g) sample container to a maximum depth of 2 inches below the sediment surface. Ten surface sediment samples were collected near or above the head of tides in the five major rivers entering Tillamook Bay Estuary and an additional 11 samples were obtained from the tidally effected portions of the major rivers. The remaining 31 samples are from intertidal to shallow subtidal environments within Tillamook Bay Estuary proper. For purposes of analyzing the data, the bay samples are assigned to one of four geographic parts for the bay. These parts are called: (1) Southwestern Margin, (2) Western Margin, (3) Central Bay, and (4) Eastern Margin. The western and central parts are divided into "bay" and "ocean" and "southern" and "northern" portions, respectively. In general, the margin parts probably extend bayward from the shoreline to about the nearest deep tidal channel, and the central part includes all of the bay isolated from the shoreline by a deep channel or channels.

Core samples were obtained by augering to the sample depth, removing the center plug from the hollow stem of the auger, inserting a split tube sampler about 18.4 inches long and 2.4 inches in diameter, and driving the tube into the sediments below the bottom of the auger. Core site locations include two on land adjacent to the estuary and 15 within Tillamook Bay proper. For purposes of comparing and analyzing core data, core sample sites also are assigned to the appropriate marginal or central geographic parts of the bay.

With the exception of two core sites, the bay locations are all in intertidal environments very close to mean lower low water (MLLW). The sediment surface, which is used as a datum for sample depths at all core sites, ranges from 1.9 feet in the upper part of the bay to 2.9 feet in the lower bay below the standard geodetic mean sea level (MSL) datum.

Sample Analyses

To determine modern and Holocene sources of sediments in the Tillamook Bay Estuary, surface and core sediment samples were analyzed for quantitative and qualitative aspects of the components in the nonopaque heavy (specific gravity greater than 2.96) fraction of the very fine sand (between 62 and 125 micrometers) materials. Between 200 and 300 nonopaque grains were identified and counted by standard optical petrographic techniques in each surface sample and in 55 samples from the core sites.

To evaluate Holocene sediment deposition rates and depositional history, heavy mineral compositional data were combined with field and laboratory observations of stratigraphic variations in sediment colors, texture, organic content, and drilling characteristics. In addition, 13 core samples from various depths at five core sites were analyzed for their age by the radiocarbon technique.

Sample Locations and Data

Prepared in cooperation with

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SAMPLE LOCATIONS AND DATA
TILLAMOOK BAY SEDIMENT INVESTIGATION
TILLAMOOK BAY, OREGON

OCTOBER 1978

SCALE 1:40,000

SOUNDING DATUM–Mean lower low water

—— Mean high water line

(7)   Soundings in feet at mean lower low water
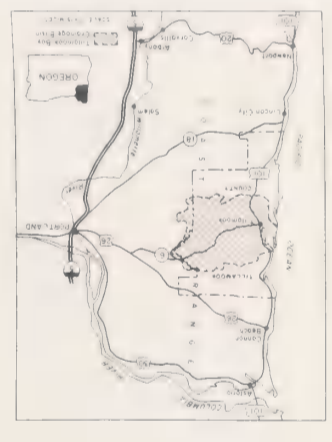
EXPLANATION

Surface Sediment Sample Sites

○ River
▲ Tidal River

Core Sediment Sample Sites
▸ Southwestern Margin
◂ Western Margin
● Central Bay
▸ Eastern Margin

Core Sediment Sample Sources
□ Land
▪ Southwestern Margin
▫ Western Margin
■ Central Bay
▪ Eastern Margin

R River
RS River and Shoreline
RM River and Marine
M Marine
MR Marine and River
S Shoreline
Depth to the Base of the Modern Fill
29M Meters

TILLAMOOK

BAY CITY

TILLAMOOK   BAY

PACIFIC   OCEAN

BAYOCEAN   SPIT

GARIBALDI

CAPE MEARES
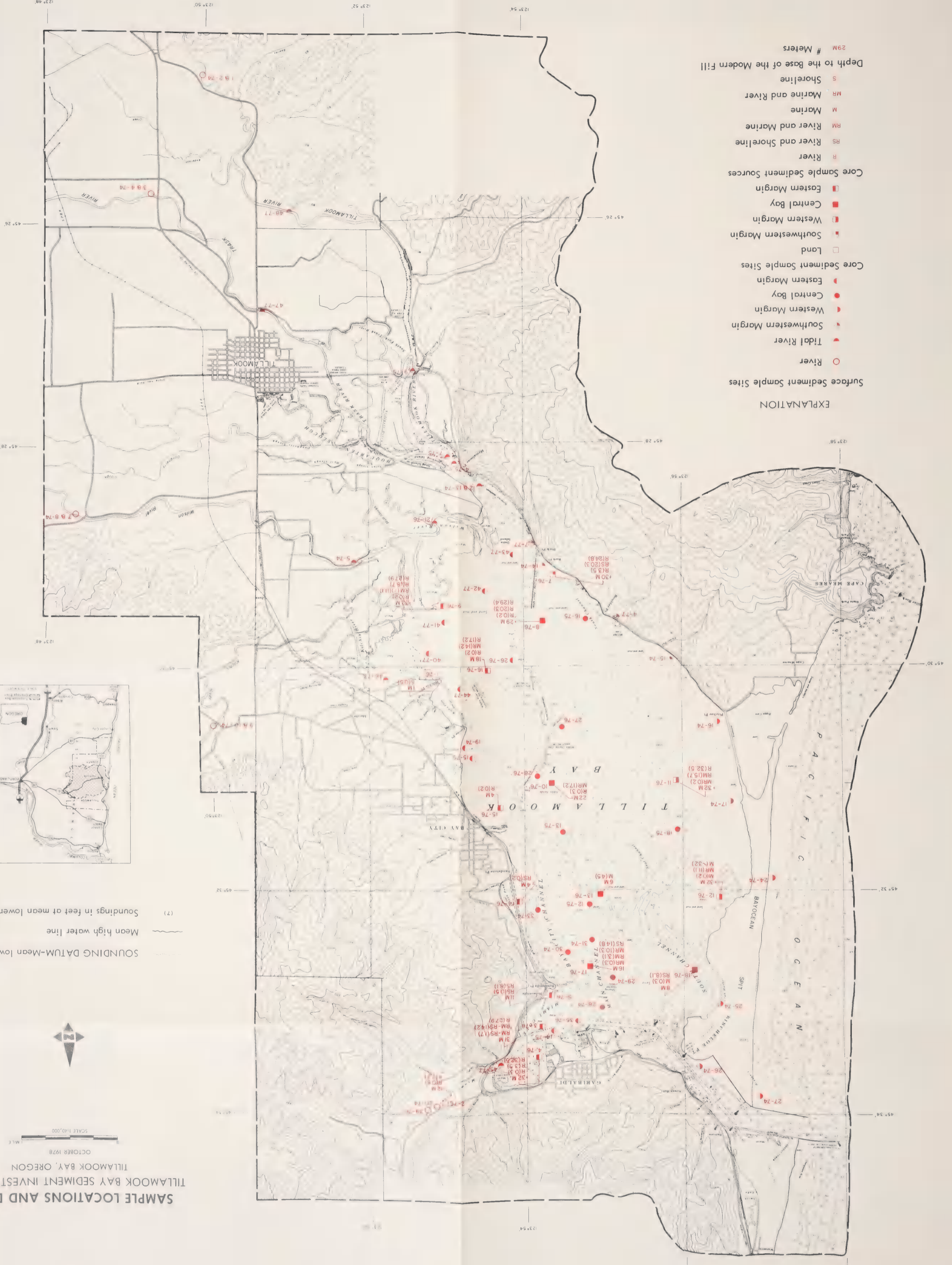
CHAPTER VII

EROSION & SEDIMENT PROBLEMS

EROSION AND SEDIMENT PROBLEMS

SEDIMENT AND DEBRIS DEPOSITION

AGRICULTURAL LANDS

Sediment deposition on agricultural lands in the Tillamook basin occurs periodically from prolonged overbank flooding concurrent with sheet and rill erosion. It is estimated that there are 5,700 tons of sediment per year which occur as a result of sheet and rill erosion. Due to the suspended nature of the sediment, only 1,300 tons/year or approximately 25 percent is projected as reaching any one of the five major drainage channels. The remaining sediment is trapped in isolated areas due to obstructions, such as roads, railroads, farmsteads, and general areas of brush and timber.

Overbank flooding and crosscountry flow of varying velocities have resulted in deposition of coarse debris, logs, etc., over large areas of farmland. Complete removal is necessary to return the land to a normal level of productivity.

FOREST LANDS

Forest lands and croplands have been separated in the study for inventory and analysis. The two areas are not independent, however; upstream problems can either amplify or reduce downstream problems. The total sediment in the system is the crucial problem. This is summarized in Table VII-1.

An estimate of the historic sediment trend from forest lands was made using recent data. This was accomplished by using current sediment data from stable subwatersheds composed primarily of old-growth timber to represent forest land watershed conditions in 1875. The fire occurrence map which shows fires by area, size, and year of occurrence was a basis for determining past land disturbance along with road intensity, timber harvest, salvage logging, and other land disturbance activities over time. Old existing cedar stumps were indicators for depth of soil loss. Stream flow data from the Wilson River USGS gage (1914-1975) and early precipitation data were also used. The following sediment graph from 1875 to 1975 is only an estimate (Figure VII-1). If the conditions portrayed on the graph are approximately representative, we can assume there has been a 20-fold increase in sediment from the forest lands today as compared with average conditions which existed in 1875. The gross sediment from forest lands today is only 12.5 percent of the extremely high rate which probably occurred between 1939 and 1945 as a result of wildfire and salvage logging.

Table VII-1, TOTAL EROSION AND SEDIMENT
BY RESOURCE AREA (MEAN ANNUAL)

Resource Area	Acres	Gross Erosion (tons)	Gross Sediment (tons)
Forest Resource Area	323,050	286,245	51,603.0
Agricultural Resource Area	29,490	13,381	9,010.0
Bay Area	10,980	1/	1/
Total	363,520	299,626	60,613.0

1/ Erosion and sediment not determined in this study.

SOIL EROSION

AGRICULTURAL LANDS

Erosion on agricultural lands in the basin is confined to two types--sheet and rill erosion and streambank cutting. Although the vegetative cover is generally permanent pasture and in good condition, overbank flow during periods of high water has resulted in sporadic sheet and rill erosion. Erosion occurs in the form of very narrow rivulets which traverse the very gentle slopes prevailing in the flood plain area. Occasional small gullies occur in isolated areas but are considered to be an insignificant source to the overall erosion picture.

Streambank erosion along the five drainages in the basin is the more prevalent of the two types. Overbank flooding in periods of high water results in saturation of exposed bank areas and collapse of the soil profile as the water recedes. During moderately high flows, increased velocities result in undercutting and collapse of both exposed and vegetated streambanks, with the major problems generally occurring in the outer bank of the channel curves. Isolated sections of streambank along each drainage are affected by the movement of cattle from agricultural land into the channel bottom during periods of low water. This causes deterioration of the bank, resulting in additional contribution of sediment to the channel and the bay.

No serious degradation or agradation is apparent in the channel bottoms. However, stream bottom scour causes constant shifting of the

Channel bank erosion--Agricultural land.

Riprap installation--Agricultural land.

Overbank flooding on agricultural lands.

Sediment deposition on agricultural land.

Figure VII-1   Estimated Sediment Rates 1875–1975
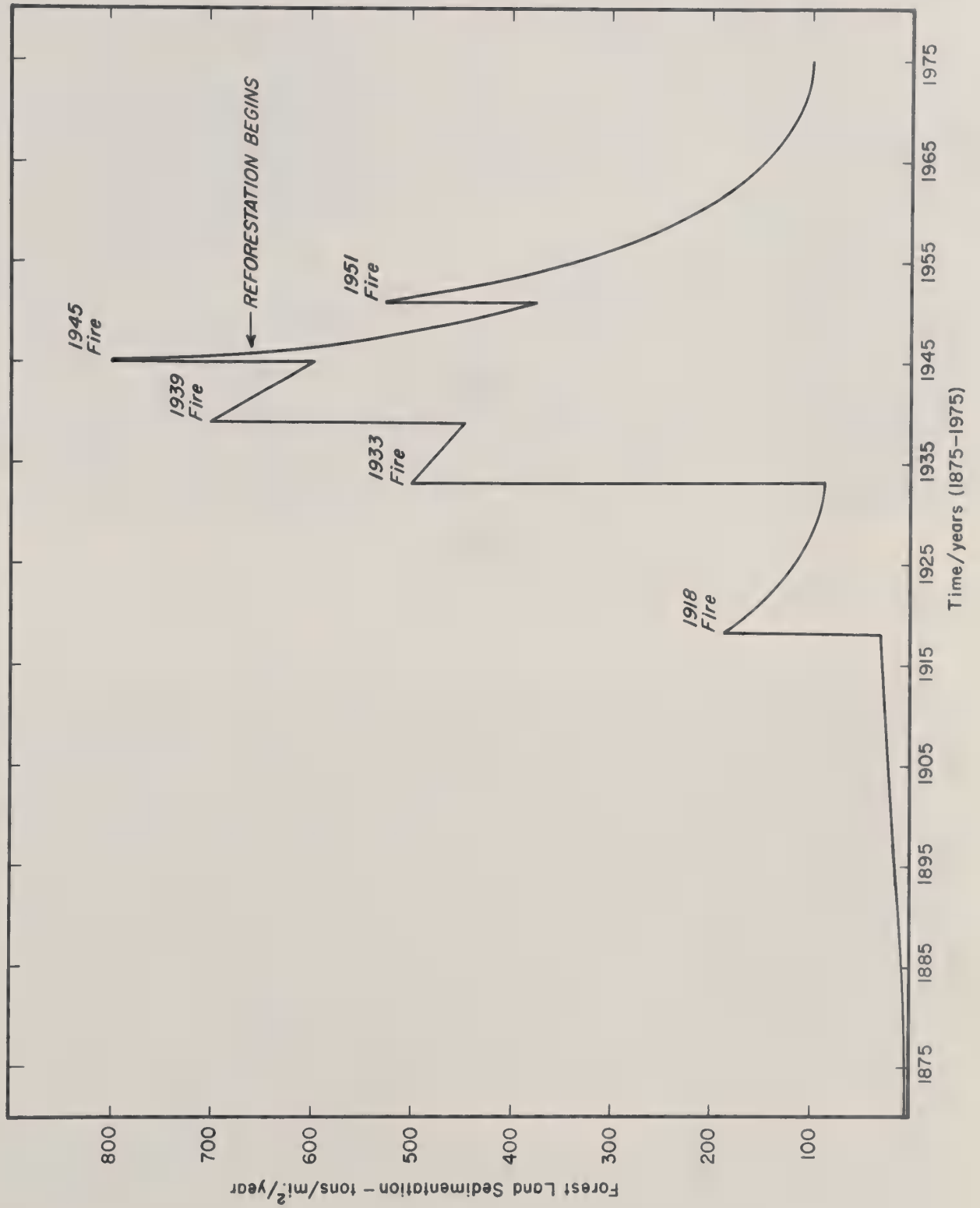
channel gravel deposits resulting in erosive changes and moderately high soil losses, depending on the volume and velocity of streamflow. Commercial gravel operations within four of the rivers also cause periodic changes in channel flow and result in reduction in the amount of sediment available for transport.

Erosion data is displayed and summarized for agricultural lands by the five subbasins. A summary of this data is presented in Tables VII-2 thru VII-7.

FOREST LANDS

Erosion of forest lands is physically important to the development of the flood plain and estuarine resources. Due to numerous fires and increasing activity by man on the upper basin slopes, erosion has occurred to such a degree that both corrective and protective measures had to be taken to reduce soil losses.

The five subbasins of the Tillamook basin forest resource area, each a complete river drainage, were further divided into 11 subbasins to facilitate studies on forest lands (see Figure VI-1).

Erosion rates and sediment sources were inventoried and measured in the field and by false-color infrared aerial photography. The basis for erosion estimates was erosion plots utilizing troughs and pins. The fluvial sediment estimates are based on a total of 404 sets of streamflow-gross fluvial sediment measurements. The regressions between streamflow and sediment have coefficients of determination (r^2) ranging from .66 to .99. These regressions were applied to 10-year mean annual hydrographs based on the U.S. Geologic Survey long-term stream gaging station on the Wilson River and the runoff elevation regression.

Erosion and sediment data is displayed and summarized for forest lands by 11 subbasins. A summary of this data is presented in Table VII-8 thru VII-18. Mean annual gross erosion and fluvial sediment rates are depicted for the forest lands of the basin on the Mean Annual Gross Erosion and Sediment Rate map.

EROSION AND SEDIMENT SUBBASIN SUMMARIES

AGRICULTURAL LANDS - FIVE SUBBASINS

Miami Subbasin

The Miami Subbasin contains 1,260 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 220.2 tons from 1205.6 acres. Of this total, approximately 27 percent or 59.0 tons of sediment per year reaches the Miami River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.

Two tributaries to the Wilson River which received large amounts of deposition.

Deposition of fine sediments on the Lower Wilson. Note debris on upper
banks and in branches of the brush.

The fine sediments on this Lower Wilson terrace were left by the November
1977 high flows. This is part of a long-term natural process which creates
valley agricultural lands.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 10.9 acres is 1211.2 tons. Of this total, approximately 92 percent or 1114.3 tons per year is transported to the bay area. A total of 774 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-3). The mean annual gross erosion on these critical unprotected banks is 134 tons, of which 92 percent or 123 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.75 to 1.2 feet per year. In the non-critical area, a total bank length of 39,362 lineal feet was examined and estimated to have an annual loss of 372 tons under existing conditions.

Kilchis Subbasin

The Kilchis subbasin contains 3,600 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 534 tons from 3350.1 acres. Of this total, approximately 25 percent or 126.8 tons of sediment per year reaches the Kilchis River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by manmade obstacles and deposited on farmland.

The mean annual gross erosion caused by streambottom scour and channel bank cutting on 18.6 acres is 1413.6 tons. Of this total, approximately 92 percent or 1300.5 tons per year is transported to the bay area. A total of 1,133 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-4). The mean annual gross erosion on these critical unprotected banks is 262 tons of which 92 percent or 241 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.50 to 1.1 feet. In the non-critical area, a total bank length of 40,330 lineal feet was examined and estimated to have an annual loss of 416 tons under existing conditions.

Wilson Subbasin

The Wilson subbasin contains 4,430 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 634 tons from 4090.3 acres. Of this total, approximately 23 percent or 144 tons of sediment per year reaches the Wilson River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 33.5 acres is 1,973 tons. Of this total, approximately 95 percent or 1,874.3 tons per year is transported to the bay area. A total of 1,136 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-5). The mean annual gross erosion on these critical unprotected banks is 229 tons, of which 95 percent or 217.5 tons is assumed to reach the bay area. The average annual bank recession rate ranged from 0.58 to 1.0 feet. In the non-critical area, a total bank length of 70,041 lineal feet was examined and estimated to have an annual loss of 520 tons under existing conditions.

Trask Subbasin

The Trask subbasin contains 11,090 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 1896.4 tons from 10,651.7 acres. Of this total, approximately 21 percent or 397 tons of sediment per year reaches the Trask River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by man-made obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 44.8 acres is 2,479 tons. Of this total, approximately 95 percent or 2355 tons per year is transported to the bay area. A total of 1,666 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-6). The mean annual gross erosion on these critically unprotected banks is 435 tons, of which 95 percent or 413.2 tons is assumed to reach the bay area. The average annual bank recession rate ranged from 0.50 to 0.80 feet. In the non-critical area, a total bank length of 88,304 lineal feet was examined and estimated to have an annual loss of 591 tons under existing conditions.

Tillamook Subbasin

The Tillamook subbasin contains 9,570 acres of agricultural lands. The mean annual gross erosion due to sheet and rill erosion amounts to 1,868 tons from 9,340 acres. Of this total, approximately 20 percent or 370 tons of sediment per year reaches the Tillamook River channel and is transported to Tillamook Bay. The remainder of the sediment is trapped by manmade obstacles and deposited on farmland.

The mean annual gross erosion due to streambottom scour and channel bank cutting on 34.7 acres is 1,151.7 tons. Of this total, approximately 93 percent or 1,071 tons per year is transported to the bay area. A total of 766 lineal feet of critically eroding bank exist intermittently along the drainage (Table VII-7). The mean annual gross erosion on these critical unprotected banks is 162 tons, of which 93 percent or 150.6 tons is assumed to reach the bay area. The average annual bank recession rate ranges from 0.30 to 0.75 feet. In the non-critical area, a total bank length of 162,533 lineal feet was examined and estimated to have an annual loss of 105 tons per year under existing conditions.

Table VII-2, EROSION AND SEDIMENT INTENSITY BY SUBBASINS [1]
(Agricultural Lands - Based on Unit Production)

Subbasin	Erosion Load Rank	Sediment Load Rank
Miami	1	1
Kilchis	2	3
Wilson	3	4
Trask	5	5
Tillamook	4	2

[1] Lowest Contributor (1)
Highest Contributor (5)

TABLE VII-3

MIAMI RIVER

PRESENT EROSION ON STREAMBANKS

AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS 1/ 3/						NON-CRITICAL EROSION AREAS 1/ 3/				
		SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	EROSION (T/Yr.)	AF/Yr.
1	-	-	-	-	-	-	-	3,590	0.1 2/	359	14	.008
2	-	-	-	-	-	-	-	4,165	0.2	833	33	.019
3	-	-	-	-	-	-	-	2,103	0.35	736	29	.01
4	-	-	-	-	-	-	-	2,500	0.2	500	20	.01
5	7' vertical	.037	233	7	49	1,324	0.75	2,478	0.3	743	30	.01
6	-	-	-	-	-	-	-	3,850	0.35	1,347	54	.03
7	4' vertical	.024	262	4	31	1,292	0.75	14,905	0.2	2,891	116	.066
8	-	-	-	-	-	-	-	2,475	0.3	743	30	.017
9	4' vertical	.026	279	4	54	2,077	1.2	3,296	0.35	1,154	46	.026
		0.087	774		134	4,693		39,362		9,306	372	0.19

1/ Erosion on banks not riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 13,697 lin. ft. or 2.0 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII-4

KILCHES RIVER
PRESENT EROSION ON STREAMBANKS
AGRICULTURAL LAND

		CRITICAL EROSION AREAS 1/ 3/						NON-CRITICAL EROSION AREAS 1/ 3/				
REACH	CHANNEL BANK (CRITICAL EROSION)	SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION 4/ RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	EROSION (T/Yr.)	AF/Yr.
1	-	-	-	-	-	-	-	3,700	0.2 2/	740	30	.016
2	-	-	-	-	-	-	-	3,328	0.24	799	32	.018
3	7' angular	.033	206	7	43	1,303	0.75	894	0.1	894	4	.002
4	-	-	-	-	-	-	-	1,925	0.1	193	8	.004
5a	8' vertical	.034	187	8	45	1,324	0.75	) 6,137	0.3	1,841	74	.042
5b	7' vertical	.044	276	7	77	1,750	1.0	)				
6	-	-	-	-	-	-	-	2,810	0.2	562	22	.012
7	8' vertical	.044	243	8	39	886	0.50	2,507	0.3	752	30	.017
8	6' vertical	.030	221	6	58	1,933	1.1	6,654	0.25	1,664	67	.038
9	-	-	-	-	-	-	-	12,375	0.3	3,713	149	.085
		0.185	1,133		262	7,196		40,330		10,353	416	0.234

1/ Erosion on banks not riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 40,330 lin. ft. or 3.2 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII-5

WILSON RIVER
PRESENT EROSION ON STREAMBANKS
AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS 1/ 3/ SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	NON-CRITICAL EROSION AREAS 1/ 3/ EST. EROSION 4/ RATE (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	EROSION (T/Yr.)	AF/Yr.
1	-	-	-	-	-	-	-	8,777	0.2 2/	1,755	70	.04
2	15' vertical	.078	229	15	80	1,026	0.582	30,571	0.1	3,057	122	.07
3	-	-	-	-	-	-	-	6,050	0.24	1,452	58	.03
4	-	-	-	-	-	-	-	1,650	0.1	165	6.6	.004
5	8' vertical	.034	185	8	30	882	0.50	8,065	0.26	2,097	84	.048
6a	5' vertical	.057	500	5	75	1,316	0.75	) 14,928	0.3	4,478	179	.10
6b	5' angular	.025	222	5	44	1,760	1.0	)				
		0.194	1,136		229	4,984		70,041		13,004	520	0.29

1/ Erosion on banks not now riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 23,863 lin. ft. or 8.8 acres of banks protected by riprap not included in above figures. These areas are classes as non-critical and do not require any additional treatment measures.

TABLE VII-6

TRASK RIVER
PRESENT EROSION ON STREAMBANKS
AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS 1/ 3/						(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	NON-CRITICAL EROSION AREAS 1/ 3/			
		SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)		EST. EROSION RATE 4/ (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	EROSION (T/Yr.)	AF/Yr.
1	-	-	-	-	-	-	-	17,487	0.2 2/	3,497	140	.080
2a	10' vertical	.055	243	10	49	891	0.50	)				
2b	10' angular	.045	199	10	48	1,067	0.60	) 21,030	0.1	2,103	84	.048
2c	10' angular	.058	253	10	51	879	0.50	)				
3	15' angular	.106	308	15	96	906	0.52	16,342	0.2	3,268	131	.075
4	10' vertical	.090	396	10	127	1,411	0.80	11,154	0.1	1,115	45	.025
5	12' vertical	.073	267	12	64	877	0.50	8,183	0.3	2,455	98	.056
6	-	-	-	-	-	-	-	4,623	0.2	925	37	.021
7	-	-	-	-	-	-	-	3,575	0.1	358	14	.008
8	-	-	-	-	-	-	-	4,675	0.2	935	37	.021
9	-	-	-	-	-	-	-	1,235	0.1	124	5	.002
		4.27	1,666		435	6,031		88,304		14,780	591	0.336

1/ Erosion on banks not riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 21,318 lin. ft. or 8.68 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

TABLE VII- 7

TILLAMOOK RIVER
PRESENT EROSION ON STREAMBANKS
AGRICULTURAL LAND

REACH	CHANNEL BANK (CRITICAL EROSION)	CRITICAL EROSION AREAS 1/ 3/						NON-CRITICAL EROSION AREAS 1/ 3/				
		SURFACE ACRES	LENGTH OF BANK (Ft.)	HEIGHT OF BANK (Ft.)	BANK EROSION (T/Yr.)	BANK EROSION (T/A/Yr.)	AVG. BANK RECESSION RATE (Ft./Yr.)	(NOT CRITICAL OR NOT RIPRAPPED) REMAINING BANKS (Ft.)	EST. EROSION RATE 4/ (Cu.Ft./Lin.Ft.Yr.)	EROSION (Cu.Ft./Yr.)	EROSION (T/Yr.)	AF/Yr.
1	-	-	-	-	-	-	-	18,700	0.02 2/	374	15	.008
2	-	-	-	-	-	-	-	29,700	0.02	594	24	.013
3	-	-	-	-	-	-	-	8,800	0.01	88	4	.002
4a	7' angular	.030	187	7	21	700	0.40	} 26,400	0.01	264	10	.006
4b	7' angular	.029	183	7	15	577	0.30	}				
5	12' vertical	.059	215	12	77	1,305	0.75	21,385	0.02	428	17	.009
6	7' vertical	.029	181	7	25	862	0.50	29,229	0.02	585	23	.013
7	-	-	-	-	-	-	-	28,600	0.01	286	12	.006
		0.147	766		162	3,444		162,533		2,619	105	0.057

1/ Erosion on banks not riprapped.

2/ Channel bank recession affected by tidal action.

3/ Figures used for 17 yr. period (1953-1970) and updated to 1978 based on field observations.

4/ These are field estimates based on judgment and experience of the geologist.

NOTE: 2,839 lin. ft. or 0.50 acres of banks protected by riprap not included in above figures. These areas are classed as non-critical and do not require any additional treatment measures.

FOREST LANDS

Miami Subbasin

The Miami subbasin contains 24,290 acres of forested lands. A total of 96 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 20,492.0 tons or 540.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 2,041.4 tons or 53.7 tons per square mile. Of this gross sediment, approximately 47 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 10 percent; i.e., 10 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment. (See Mean Annual Gross Erosion and Sediment Rates

There are approximately 336 miles of road in the subbasin which amounts to 8.9 miles of road corridor per square mile. The area contains 610 visible landslides or 16.1 slides per square mile.

There are 1.2 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 196,263 acre feet or 8 feet in depth per acre.

Upper Kilchis Subbasin

The Upper Kilchis subbasin contains 21,400 acres of forested lands. A total of 27 sets of flow/sediment data were collected in the subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.85. The mean annual gross erosion from this area amounts to 12,040.0. tons or 360.05 tons per square mile. The mean annual gross fluvial sediment from the forest lands amounts to 1,070.0 tons or 32.0 tons per square mile. Of this gross sediment, approximately 47 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 8.8 percent; i.e., 8.8 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 363 miles of road in this subbasin which amounts to 10.8 miles of road corridor per square mile. The area contains 515 visible landslides or 15.4 slides per square mile.

There are 1.3 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 178,262 acre feet.

Lower Kilchis Subbasin

The lower Kilchis subbasin contains 15,010 acres of forested lands. A total of 38 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.95. The mean annual gross erosion from this area amounts to 11,704.7 tons or 578.5 tons per square mile. The mean annual gross fluvial sediment, from the forested lands amounts to 2,310.7 tons per year or 98.5 tons per square mile. Of this gross sediment, approximately 64 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 19.7 percent; i.e., 19.7 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 245 miles of road in this subbasin which amounts to 10.5 miles of road corridor per square mile. The area contains 210 visible landslides or 8.9 slides per square mile.

There are 1.1 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 112,575 acre feet or 7.5 feet in depth per acre.

South Fork Kilchis Subbasin

The South Fork Kilchis subbasin contains 6,910 acres of forested lands. A total of 31 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 10,466.1 tons or 967.2 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 1,000.1 tons or 92.6 tons per square mile. Of this gross sediment, approximately 17 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 9.5 percent; i.e., 9.5 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 84 miles of road in this subbasin which amounts to 7.8 miles of road corridor per square mile. The area contains 131 visible landslides or 12.1 slides per square mile.

There are 1.9 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 54,727 acre feet or 7.9 feet in depth per acre.

Lower Wilson Subbasin

The Lower Wilson subbasin contains 47,720 acres of forested lands. A total of 26 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.95. The mean annual gross erosion from this area amounts to 41,535.4 tons or 557.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts

to 8,514.8 tons or 114.2 tons per square mile. Of this gross sediment, approximately 66 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 20.5 percent; i.e., 20.5 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 800 miles of road in this subbasin which amounts to 10.7 miles or road corridor per square mile. The area contains 689 visible landslides or 9.2 slides per square mile.

There are 0.8 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 397,507 acre feet or 8.3 feet in depth per acre.

Upper Wilson Subbasin

The Upper Wilson subbasin contains 56,960 acres of forested lands. A total of 51 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.81. The mean annual gross erosion from this area amounts to 28,833.3 tons or 324.0 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 4,325.4 tons or 46.8 tons per square mile. Of this gross sediment, approximately 41 percent comes in the form of bedload. The gross sediemnt delivery ratio for the subbasin amounts to 15 percent; i.e., 15 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 1,323 miles of road in this subbasin which amounts to 14.9 miles of road corridor per square mile. The area contains 1,176 visible landslides or 13.2 slides per square mile.

There are 0.46 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 493,843 acre feet or 8.67 feet in depth per acre.

North Fork Wilson Subbasin

The North Fork Wilson subbasin contains 16,430 acres of forested lands. A total of 30 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.74. The mean annual gross erosion from this area amounts to 7,103.44 tons or 276.72 tons per square mile. The mean annual gross fluvial sediemnt from the forested lands amounts to 416.1 tons or 16.2 tons per square mile. Of this gross sediment, approximately 23 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 5.8 percent; i.e., 5.8 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 139 miles of road in this subbasin which amounts to 5.4 miles of road corridor per square mile. The area contains 91 visible landslides or 3.5 slides per square mile.

There are 0.66 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 131,440 acre feet or 8.0 feet in depth per acre.

Main Trask Subbasin

The main Trask subbasin contains 69,920 acres of forested lands. A total of 32 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.98. The mean annual gross erosion from this area amounts to 78,504 tons or 718.6 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 16,485.8 tons or 150.9 tons per square mile. Of this gross sediment, approximately 19 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 21 percent; i.e., 21 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 1,599 miles of road in this subbasin which amounts to 14.6 miles of road corridor per square mile. The area contains 453 visible landslides or 4.2 slides per square mile.

There are 0.69 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 541,880 acre feet or 7.75 feet in depth per acre.

East Fork Trask Subbasin

The East Fork Trask subbasin contains 18,830 acres of forested lands. A total of 26 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.91. The mean annual gross erosion from this area amounts to 29,002 tons or 985.8 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 7,250.5 tons or 246.5 tons per square mile. Of this gross sediment, approximately 11 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 25 percent; i.e., 25 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 370 miles of road in this subbasin which amounts to 12.6 miles of road corridor per square mile. The area contains 196 visible landslides or 6.6 slides per square mile.

There are 1.0 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 156,854 acre-feet or 8.3 feet in depth per acre.

South Fork Trask Subbasin

The South Fork Trask subbasin contains 13,190 acres or 20.61 square miles of forested land. A total of 16 sets of flow/sediment data were collected in this subbasin. The regression coefficient of correlation between streamflow and fluvial sediment was .99. The mean annual gross erosion from this area amounts to 4,955.7 tons or 240.45 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 1,090.27 tons or 52.9 tons per square mile. Of this gross sediment, approximately 48 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 22 percent; i.e., 22 percent of all erosion from the forest lands in the subbasin ends up as fluvial sediment.

There are approximately 199 miles of road in this subbasin which amounts to 9.6 miles of road corridor per square mile. The area contains 473 visible landslides or 23.0 slides per square mile.

There are 1.21 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin is 113,170 acre feet or 8.6 feet in depth per acre.

Tillamook Subbasin

The Tillamook subbasin contains 33,570 acres of forested lands. A total of 31 sets of flow/sediment data were collected in this sub-basin. The regression coefficient of correlation between streamflow and fluvial sediment was 0.99. The mean annual gross erosion from this area amounts to 41,628.7 tons or 793.7 tons per square mile. The mean annual gross fluvial sediment from the forested lands amounts to 7,097.6 tons or 135.3 tons per square mile. Of this gross sediment, approximately 7.6 percent comes in the form of bedload. The gross sediment delivery ratio for the subbasin amounts to 17 percent; i.e., 17 percent of all erosion in the basin ends up as fluvial sediment.

There are approximately 630 miles of road in this subbasin which amounts to almost 12 miles of road corridor per square mile. The area contains 136 visible landslides or 2.6 slides per square mile.

There are 1.33 miles of perennial streams per square mile. The mean annual runoff as streamflow in this subbasin in 251,775 acre feet or 7.5 feet in depth per acre.

TABLE VII-8

MIAMI RIVER
EROSION AND SEDIMENT
FOREST LANDS

	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS							
Paved Roads	6	30	22.0	1.15	25.30	.12	3.0
Gravel 2 Track	190	55	1,266.0	.45	569.70	.10	57.0
Secondary 1½ Track	80	60	582.0	1.38	803.16	.09	72.3
Spurs 1 Track	25	40	121.0	2.84	343.64	.08	27.5
Skid Rds. ½ Track	35	15	64.0	3.90	249.60	.09	22.5
			2,055.0		1,991.40		182.3
TRAILS							
Fire Trails	11	5	7.0	1.10	7.70	.05	.4
Rail Grades Used							
Rail Grades Abandoned							
Transmission Lines							
Motorbike Trails	3	3	1.0	3.18	3.18	.07	.2
			8.0		10.88		.6
LANDSLIDES							
Upper 1/3 Slope			371.0	2.86	1,061.06	.06	63.6
Middle 1/3 Slope			247.0	3.59	886.73	.12	106.4
Lower 1/3 Slope			123.0	4.35	535.05	.25	133.7
			741.0		2,482.84		303.7
STREAMS							
Channel Bank	9	5	5.5	250.80	1,379.40	.28	386.1
Channel Bottoms	5	15	9.0	170.60	1,535.40	.20	307.0
Flood Plain Scour	2	20	5.0	22.40	112.00	.60	67.2
			19.5		3,026.80		760.3
CLEARCUTS							
>75% Bare Ground			324.5	14.14	4,588.80	.08	367.1
50-75% Bare Ground			620.0	3.80	2,356.00	.07	164.9
25-50% Bare Ground			1,790.0	1.90	3,401.00	.06	204.0
<25% Bare Ground			1,120.0	.08	89.60	.05	4.5
			3,854.5		10,435.40		740.5
FORESTED AREAS							
Brush & Seedlings			1,990.0	.20	398.00	.04	15.9
Saplings & Poles			6,660.0	.05	333.00	.02	6.6
Mature 2nd-Growth			3,040.0	.03	91.20	.026	2.7
Hardwoods			3,970.0	.02	79.40	.0009	.7
Old-Growth			1,300.0	.01	13.00	.005	.07
			16,960.0		914.60		25.97
BURNS							
>75% Bare Ground			20.0	10.00	200.00	.04	8.00
50-75% Bare Ground			10.0	6.00	60.00	.03	1.80
25-50% Bare Ground			150.0	3.00	450.00	.02	9.00
<25% Bare Ground			460.0	2.00	920.00	.01	9.20
			640.0		1,630.00		28.00
Water (Streams)10'Wide			12.0		.00	.00	
			24,297.0		20,499.60		2,041.77

Gross Acres = 24,297
Gross Sq. Mi. = 37.95
Total Miles Stream = 45
Watershed: Road Ratio:
  8.84 Mi/mi^2
Total Miles of Road = 336

Gross Sediment = 2,041.77 Tons/yr.
Gross Erosion = 20,499 Tons/yr.
Gross Erosion = 539.97 Tons/mi^2

Gross Sediment = 53.7 Ton/mi^{2}yr.
Suspended Sediment = 28.7 T/mi^{2}yr.
Bedload = 25 Tons/mi^{2}yr.
Sediment Delivery Rate = 10%

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		2	35	8	1.20	9.6	.06	.58
Gravel 2 Track		110	40	533	.83	442.4	.10	44.24
Secondary 1½ Track		77	50	466	2.27	1,057.8	.09	95.20
Spurs 1 Track		28	25	84	4.15	348.6	.07	26.40
Skid Rds. ½ Track		28	12	40	5.85	234.0	.02	4.68
				1,131		2,092.4		171.10
TRAILS								
Fire Trails		4	15	7	.75	5.3	.05	.27
Rail Grades Abandoned		5	10	6	.20	1.2	.02	.02
Power Lines		5	40	24	.35	8.4	.08	.67
Motorbike Trails		2	4	1	6.25	6.2	.02	.12
				38		21.1		1.08
LANDSLIDES								
Upper 1/3 Slope				198	2.15	425.7	.20	85.14
Middle 1/3 Slope				66	2.80	184.8	.43	79.46
Lower 1/3 Slope				51	3.95	201.4	.65	130.91
				315		811.9		295.51
STREAMS								
Channel Bank				5	120.00	600.0	.85	510.00
Channel Bottoms				8	63.00	504.0	.95	479.00
Flood Plain Scour				3	10.50	31.5	.55	17.00
				16		1,135.5		1,006.00
CLEARCUTS								
>75% Bare Ground				150	10.90	1,625.0	.12	196.20
50-75% Bare Ground				180	8.40	1,512.0	.15	220.00
25-50% Bare Ground				450	4.60	2,070.0	.10	207.00
<25% Bare Ground				420	3.30	1,386.0	.05	69.30
				1,200		6,593.0		692.50
FORESTED AREAS								
Rock				10				
Brush & Seedlings				740	.19	140.6	.12	16.87
Saplings & Poles				4,870	.06	292.2	.08	23.38
2nd-Growth				3,690	.03	110.7	.09	9.96
Hardwoods				2,800	.02	56.0	.11	6.16
Old-Growth				130	.01	1.3	.10	.13
Water (Streams >10' Wide)				20				
				12,260		600.8		56.50
BURNS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				50	8.80	440.0	.20	88.00
<25% Bare Ground								
Total Forest Land Acres				15,010		11,694.7		2,310.60

Gross Acre Forest Land = 15,010.0
Gross Sq. mi. = 23.45
Total Miles Perennial Stream =
  22= 1.07/mi./mi^2
Total Miles Road = 245.0 - 10.45
  mi/mi^2

Mean Annual Erosion = 11,694.7 Tn/Yr.
Gross Erosion = 578.45 T/mi^2
Sediment Delivery Ratio - .197

Mean Annual Sediment = 2,310.6y Tn/Yr.
Gross Sediment = 98.54 Tons/mi^2/Yr.
Suspended Sediment = 35.65 Tns/mi^2/Yr.
Bedload = 62.89 Tons/mi^2/Yr.

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac./Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads								
Gravel 2 Track		20	30	73.00	1.50	109.5	.10	10.95
Secondary 1½ Track		30	30	109.00	2.40	261.6	.05	13.08
Spurs 1 Track		19	25	57.00	4.60	262.2	.10	25.74
Skid Rds. ½ Track		15	20	36.00	6.00	216.0	.10	21.60
				275.00		849.3		71.37
TRAILS								
Fire Trails								
Rail Grade Abandoned								
Power Lines								
Motorbike Trails		3	5	2.00	7.00	14.0	.12	1.68
LANDSLIDES								
Upper 1/3 Slope				91.00	3.00	273.0	.08	21.84
Middle 1/3 Slope				54.00	4.00	216.0	.09	19.44
Lower 1/3 Slope				51.00	7.00	357.0	.45	160.69
				196.00		846.0		201.97
STREAMS								
Channel Bank		2	3	.73	155.00	113.1	.97	109.17
Channel Bottoms		1	10	1.27	80.00	101.6	.50	50.80
Flood Plain Scour								
				2.00		214.7		159.97
CLEARCUTS								
>75% Bare Ground				10.00	12.00	120.0	.18	21.60
50-75% Bare Ground				10.00	10.00	100.0	.14	14.00
25-50% Bare Ground				110.00	6.00	660.0	.09	59.40
<25% Bare Ground								
				130.00		880.0		85.00
FORESTED AREAS								
Rock				20.00				
Brush & Seedlings				490.00	.25	122.5	.12	14.70
Saplings & Poles				2,200.00	.05	110.0	.09	9.90
2nd-Growth				840.00	.03	25.2	.07	1.76
Hardwoods				1,840.00	.02	36.8	.08	2.94
Old-Growth				260.00	.01	2.6	.05	.13
Water				5.00				
				5,655.00		297.1		29.43
BURNS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				650.00	11.30	2,345.0	.06	440.70
Total Forest Land Acres				6,910.00		5,445.8		990.12

Gross Acres Forest Land = 6,910
Gross Sq. Miles = 10.8
Total Miles Perennial Stream = 1.85/mi^2
Total Miles Road = 84 = 7.8/mi^2

Mean Annual Erosion = 5,445.8 Tons/Yr.
Gross Erosion = 967.23 Tons/mi^2/Yr.
Sediment Delivery Ratio = .95

Mean Annual Sediment = 990.12 Tons/Yr.
Gross Sediment = 92.60 Ton/mi^2/Y
Bedload = 15.43 Tons/mi^2/Yr.

TABLE VII-11
KILCHIS RIVER - UPPER MAIN STEM
EROSION AND SEDIMENT
FOREST LANDS

Erosion Source	QUANTITY Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS							
Paved Roads	1	20	2	1.20	2.4	.06	.14
Gravel 2 Track	150	35	611	.80	488.8	.10	48.88
Secondary 1½ Track	110	45	576	2.00	1,152.0	.05	57.60
Spurs 1 Track	40	25	116	3.90	452.4	.07	31.10
Skid Rds. ½ Track	45	15	78	4.50	351.0	.10	35.10
			1,383		2,446.6		162.82
TRAILS							
Fire Trails	5	15	8	.70	5.6	.05	.28
Rail Grades Abandoned	6	10	7	.25	1.7	.02	.03
Power Lines	3	30	10	.40	4.0	.08	.32
Motorbike Trails	3	3	1	6.00	6.0	.12	.72
			26		17.3		1.35
LANDSLIDES							
Upper 1/3 Slope			399	6.00	2,394.0	.08	205.00
Middle 1/3 Slope			241	4.00	964.0	.09	86.76
Lower 1/3 Slope			132	5.00	660.0	.17	112.20
			772		4,018.0		403.90
STREAMS							
Channel Bank	7	5	4	40.00	160.0	.70	112.00
Channel Bottoms	3	15	5	30.00	150.0	.50	75.00
Flood Plain Scour	2	10	2	50.00	100.0	.25	25.00
			11		410.0		212.00
CLEARCUTS							
>75% Bare Ground							
50-75% Bare Ground							
25-50% Bare Ground							
<25% Bare Ground							
FORESTED AREAS							
Rock			470				
Brush & Seedlings			2,290	.20	458.0	.12	54.96
Saplings & Poles			5,028	.05	251.4	.09	22.63
2nd-Growth			1,320	.04	52.8	.07	3.70
Hardwoods			3,610	.03	108.3	.08	8.66
Old Growth			760	.01	7.6	.05	.38
Water			10				
			13,488		878.1		90.33
BURNS							
>75% Bare Ground			30	2.00	60.0	.12	7.20
50-75% Bare Ground			20	1.50	30.0	.10	3.00
25-50% Bare Ground			2,690	1.00	2,690.0	.05	134.50
<25% Bare Ground			2,980	.50	1,490.0	.03	44.70
			5,720		4,270.0		190.40
Total Forest Land Acres			21,400		12,040.0		1,060.80

Gross Acres Forest Land = 21,400
Gross Sq. Miles = 53.44
Total Miles Perennial Stream = 44 = 1.32/mi²
Total Miles Road = 363 = 10.86/mi²

Mean Annual Erosion = 12,040 Tons/Yr.
Gross Erosion = 360.05 Tons/Mi²/Yr.
Sediment Delivery Ratio = .088%

Mean Annual Sediment = 1,060.8 Tns/Yr.
Gross Sediment = 32.0 Tons/mi²/Yr.
Suspended Sediment = 17.0 Tons/Mi²/Yr.
Bedload = 15.0 Tons/mi²/Yr.

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		2	--	8.00	1.00	8.0	.010	0.08
Gravel 2 Track		32	--	172.00	0.55	94.6	.020	1.89
Secondary 1½ Track		51	--	342.00	1.64	560.4	.060	35.47
Spurs 1 Track		34	--	116.00	2.53	293.6	.060	17.62
Skid Roads ½ Track		20	--	32.00	3.50	112.0	.050	5.60
				670.00		1,068.6		60.66
TRAILS								
Fire Trails		2	--	18.00	1.80	32.4	.020	0.65
Rail Grade Used		5	--	--	0.40	3.6	.010	0.04
Rail Grades Abandoned		10	--	1.00	0.30	0.3	.020	0.01
Transmission Lines		1	--	8.00	1.30	10.4	.020	0.21
Motorbike Trails		12	--	14.00	2.40	33.6	.040	1.34
				41.00		80.3		2.25
LANDSLIDES								
Upper 1/3 Slope		--	--	44.00	3.70	162.8	.200	32.56
Middle 1/3 Slope		--	--	11.00	4.30	47.3	.400	18.92
Lower 1/3 Slope		--	--	13.00	4.90	63.7	.650	41.41
				69.00		273.8		92.89
STREAMS								
Channel Bank		--	--	3.00	41.60	125.0	.800	100.00
Channel Bottoms		--	--	5.00	15.00	75.0	.950	71.25
Flood Plain Scour		--	--	1.00	6.00	6.0	.600	3.6
				9.00		206.0		174.85
CLEARCUTS								
>75% Bare Ground		--	--	20.00	9.00	180.0	.040	7.20
50-75% Bare Ground		--	--	110.00	4.10	452.0	.030	13.56
25-50% Bare Ground		--	--	190.00	2.33	442.0	.020	8.84
<Bare Ground		--	--	180.00	0.66	118.0	.010	1.18
				500.00		1,192.0		30.78
FORESTED AREAS								
Brush and Seedlings		--	--	1,450.00	0.22	316.0	.020	6.32
Saplings and Poles		--	--	4,230.00	0.07	296.1	.015	4.44
Mature 2nd Growth		--	--	2,110.00	0.06	126.6	.010	1.27
Hardwoods		--	--	3,420.00	0.04	136.8	.002	0.27
Old Growth		--	--	2,670.00	0.01	26.7	.001	0.03
				13,880.00		902.2		12.30
BURNS								
>75		--	--	--	--	--	--	--
50-75		--	--	--	--	--	--	--
25-50		--	--	190.00	4.50	855.5	.020	17.11
<25		--	--	1,010.00	2.50	2,525.0	.010	25.25
Rock		--	--	35.00	0.00	--	--	--
Water (Streams 10'+ Wide)		--	--	18.00	0.00	--	--	--
				1,253.00		3,380.5		42.36
Total Acres Forest Lands				16,422.00		7,103.4		416.09

Gross Acres Forest Land = 16,422
Gross Sq. Miles - 25.67
Total Miles Perennial Streams = 17 =
.66mi/mi^2
Total Miles Road = 139
Watershed Road Ratio = 5.41 mi/mi^2

Gross Sediment = 416.09
Gross Erosion = 7,103.40
Gross Erosion = 276.72T/Mi^2

Gross Sediment = 16.21T/mi^2
Suspended Sediment = 12.47 T/Mi^2
Bedload = 3.8T/mi^2
Sediment Delivery Rate = .058

TABLE VII-13
WILSON RIVER-LOWER MAIN STEM
EROSION AND SEDIMENT
FORESTED LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		18	--	86.00	1.8	154.3	.06	9.29
Gravel 2 Track		140	--	764.00	.7	534.8	.10	53.48
Secondary 1½ Track		372	--	2,480.00	1.4	3,472.0	.06	212.48
Spurs 1 Track		95	--	319.00	2.0	638.0	.07	44.66
Skid Roads ½ Track		175	--	276.00	3.2	883.2	.08	70.66
				3,925.00		5,682.0		390.57
TRAILS								
Fire Trails		18	--	83.00	1.5	124.5	.05	6.23
Rail Grades Used		--	--	--	--	--	--	--
Rail Grades Abandoned		--	--	--	--	--	--	--
Transmission Lines		40	--	218.00	0.9	196.2	.08	13.70
Motorbike Trails		90	--	109.00	2.1	228.9	.15	34.34
				410.00		549.6		56.27
LANDSLIDES								
Upper 1/3 Slope		--	--	381.00	5.82	2,219.8	.11	243.96
Middle 1/3 Slope		--	--	140.00	10.94	1,532.0	.30	458.76
Lower 1/3 Slope		--	--	166.00	5.94	985.6	.45	440.64
				687.00		4,737.4		1,143.36
STREAMS								
Channel Bank		--	--	12.00	360.00	4,320.0	.53	2,272.00
Channel Bottoms		--	--	30.00	228.00	6,840.0	.47	3,230.65
Flood Plain Scour		--	--	6.00	42.00	252.0	.60	151.20
CLEARCUTS								
>75% Bare Ground		--	--	20.00	8.80	176.0	.12	21.12
50-75% Bare Ground		--	--	60.00	4.50	270.0	.15	40.50
25-50% Bare Ground		--	--	180.00	2.60	468.0	.10	46.80
<25% Bare Ground		--	--	110.00	0.50	55.0	.05	2.75
				370.00		969.0		111.07
FORESTED AREAS								
Brush and Seedlings		--	--	4,270.00	0.20	854.0	.12	102.48
Saplings and Poles		--	--	13,140.00	0.10	1,314.0	.08	105.12
Mature 2nd-Growth		--	--	3,810.00	0.07	266.7	.09	24.00
Hardwoods		--	--	9,980.00	0.03	299.4	.11	32.93
Old Growth		--	--	5,100.00	0.02	102.0	.10	10.20
				36,300.00		2,836.0		274.73
BURNS								
>75		--	--	220.00	6.50	1,430.0	.10	143.00
50-75		--	--	10.00	4.10	41.0	.08	3.28
25-50		--	--	2,620.00	3.50	9,170.0	.06	550.20
<25		--	--	2,140.00	2.20	4,700.0	.04	188.32
Rock		--	--	870.00	0.00	0.0	--	--
Water (Streams 10' + Wide)		--	--	120.00	0.00	0.0	--	--
				5,980.00		15,341.0		8,514.80
Total Acres Forest Land				47,720.00		41,527.0		16,144.65

Gross Acres Forest Land = 47,720
Gross Sq. Miles = 74.56
Total Miles Perennial Streams = 60 = .80mi/mi^2
Total Miles Road = 800
Watershed Road Ratio = 10.73 mi/mi^2

Gross Sediment = 8,514.75
Gross Erosion = 41,527
Gross Erosion = 557.07T/mi^2

Gross Sediment = 114.2T/mi^2
Suspended Sediment = 38.4T/mi^2
Bedload = 75.8T/mi^2
Sediment Delivery Rate = .20530

TABLE VII-14
UPPER WILSON RIVER
EROSION AND SEDIMENT
FORESTED LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/AC/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads	7	--		37.00	1.60	59.2	.09	5.3
Gravel 2 Track	328	--		1,791.00	0.60	1,074.6	.10	107.5
Secondary 1½ Track	647	--		4,311.00	1.40	6,035.4	.05	288.6
Spurs 1 Track	121	--		413.00	2.10	867.3	.08	69.4
Skid Roads ½ Track	220	—		346.00	2.90	1,003.4	.06	60.2
				6,898.00		9,039.9		531.0
TRAILS								
Fire Trails	23	--		232.00	1.70	394.4	.05	19.7
Rail Grades Used	--	--		--	--	--	--	--
Rail Grades Abandoned	--	--		--	--	--	--	--
Transmission Lines	14	--		74.00	2.80	207.2	.06	12.4
Motorbike Trails	178	--		216.00	1.80	388.8	.09	35.0
				522.00		990.4		67.1
LANDSLIDES								
Upper 1/3 Slope	--	--		643.00	5.40	3,472.2	.10	347.2
Middle 1/3 Slope	--	—		166.00	9.80	1,626.8	.20	325.4
Lower 1/3 Slope	—	--		367.00	5.90	2,172.3	.30	651.7
				1,176.00		7,271.3		1,324.3
STREAMS								
Channel Bank	--	--		8.00	225.00	1,800.0	.52	940.0
Channel Bottoms	--	--		20.00	85.00	1,700.0	.54	915.0
Flood Plain Scour	--	--		4.00	20.00	80.0	.50	40.0
				32.00		3,580.0		1,895.0
CLEARCUTS								
>75% Bare Ground	--	—		--	--	--	--	--
50-75% Bare Ground	--	--		--	--	--	--	--
25-50% Bare Ground	—	--		--	--	--	--	--
<25% Bare Ground	--	--		--	--	--	--	--
FORESTED AREAS								
Brush and Seedlings	—	--		4,480.00	0.18	806.40	.12	96.8
Saplings and Poles	--	--		18,470.00	0.11	2,068.40	.08	165.5
Mature 2nd Growth	--	--		6,020.00	0.08	481.60	.07	33.7
Hardwoods	--	--		4,490.00	0.02	89.80	.06	5.4
Old Growth	--	--		5,520.00	0.01	55.20	.05	2.7
				38,980.00		3,501.40		304.1
BURNS								
>75	--	--		200.00	4.20	840.00	.08	67.2
50-75	--	—		40.00	2.50	100.00	.06	6.0
25-50	--	--		5,410.00	0.60	3,024.30	.04	121.0
<25	--	—		2,430.00	0.20	486.00	.02	9.7
Rock	--	--		1,160.00	0.00	--	--	--
Water (Streams 10'+ Wide	—	--		112.00	0.00	--	--	--
				9,352.00		4,450.00		203.9
Total Acres - Forest Lands				56,960.00		28,833.00		4,325.4

Gross Acres Forest Land = 56,960
Gross Sq. Miles = 89.0
Total Miles Perennial Streams = 41 =46mi/mi^2
Watershed Road Ratio = 14.87mi/mi^2

Gross Sediment = 4,325.4
Gross Erosion = 28,833.3
Gross Erosion = 323.97T/mi^2

Gross Sediment = 48.6T/mi^2
Suspended Sediment = 27.4T/mi^2
Bedload = 19.4T/mi^2
Sediment Delivery Rate = .150

TABLE VII-15
MAIN STEM TRASK RIVER
EROSION AND SEDIMENT ALLOCATION
FOREST LANDS

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads		8.0		29	1.50	43.5	.10	4.35
Gravel 2 Track		580.0		3,915	1.90	6,678.5	.14	963.98
Secondary 1½ Track		621.0		4,140	2.20	9,108.0	.15	1,321.60
Spurs 1 Track		170.0		824	2.80	2,307.2	.15	346.08
Skid Rds. ½ Track		220.0		400	3.00	1,200.0	.11	132.00
				9,308		19,337.2		2,768.01
TRAILS								
Fire Trails		20.0		78	2.10	163.8	.05	8.19
Rail Grades Used								
Rail Grades Abandoned		72.5		97	0.30	29.1	.02	0.58
Transmission Lines		12.0		61	0.80	48.8	.06	2.93
Motorbike Trails		80.0		68	3.70	251.6	.18	45.29
				304		493.3		56.90
LANDSLIDES								
Upper 1/3 Slope				97	5.00	435.0	.40	174.00
Middle 1/3 Slope				65	10.00	650.0	.70	455.00
Lower 1/3 Slope				30	7.00	560.0	.90	504.00
				192		1,645.0		1,133.00
STREAMS								
Channel Bank				15	424.70	6,371.2	.87	5,532.64
Channel Bottoms				10	240.00	7,200.0	.40	2,880.00
Flood Plain Scour				46	52.00	3,432.0	.25	858.00
				71		17,363.2		9,290.64
CLEARCUTS								
>75% Bare Ground				10	6.10	183.0	.15	27.45
50-75% Bare Ground				120	4.30	516.0	.12	61.92
25-50% Bare Ground				340	2.00	650.0	.10	64.00
<25% Bare Ground				40	0.50	45.0	.05	2.25
				510		1,394.0		155.62
FORESTED AREAS								
Brush and Seedlings				6,340	0.28	3,789.2	.10	178.92
Saplings and Poles				19,400	0.19	3,686.0	.11	405.46
Mature 2nd-Growth				6,420	0.09	577.0	.12	69.36
Hardwoods				9,220	0.03	278.1	.10	27.81
Old Growth				6,920	0.01	69.2	.08	5.54
				48,350		6,399.3		687.09
BURNS								
>75% Bare Ground				100	6.70	1,072.0	.12	128.64
50-75% Bare Ground				90	4.50	405.0	.10	40.50
25-50% Bare Ground				3,930	3.20	18,976.0	.08	1,519.08
<25% Bare Ground				4,210	2.80	11,788.0	.06	707.28
				9,130		32,241.0		2,395.50
Total Acres - Forest Lands				67,865		78,873.0		16,486.76

Gross Acres = 69,865   Gross Sediment = 16,485.76 T/Yr.   Gross Sediment = 130.9 T/mi^2
Gross Sq. Mi. = 109.25   Gross Erosion = 78, 873.0T/Yr.   Suspended Sediment = 121.75 T/mi^2
Total Miles Perennial Streams = 75   Gross Erosion = 718.57 T/mi^2/yr.   Bedload = 29.15 T/mi^2
Watershed: Road Ratio = 14.64 mi/mi^2 Gross Erosion = 718.57 T/mi^2/yr.   Sediment Delivery Ratio = .21
Total Miles Road = 1.599
Watershed: Stream Ratio = 69 mi/mi^2

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads								
Gravel 2 Track	68.0			413	2.00	824.0	.15	123.60
Secondary 1½ Track	124.0			826	3.40	2,972.2	.20	594.44
Spurs 1 Track	18.0			87	4.60	401.1	.17	68.19
Skid Roads ½ Track	160.0			291	3.20	931.2	.10	93.12
				1,617		5,128.3		879.35
TRAILS								
Fire Trails	5.0			12	2.00	24.0	.09	2.14
Rail Grades Used								
Rail Grades Abandoned	7.5			9	1.60	14.4	.05	0.72
Transmission Lines	4.5			11	2.90	43.5	.08	3.48
Motorbike Trails	18.0			44	5.50	242.6	.10	24.20
				67		324.5		30.50
LANDSLIDES								
Upper 1/3 Slope				64	7.00	476.0	.50	238.00
Middle 1/3 Slope				3	11.00	55.0	.80	44.00
Lower 1/3 Slope				25	12.00	300.0	.90	270.00
				92		831.0		552.00
STREAMS								
Channel Bank				4	531.33	3,188.0	.93	2,967.39
Channel Bottoms				15	223.67	2,355.0	.24	815.00
Flood Plain Scour				2	110.00	220.0	.20	44.00
				21		6,763.0		3,826.39
CLEARCUTS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground								
<Bare Ground								
FORESTED AREAS								
Brush and Seedlings				2,708	1.36	3,790.0	.10	378.00
Saplings and Poles				6,670	0.30	2,001.0	.08	160.08
Mature 2nd-Growth				469	0.09	41.4	.09	3.73
Hardwoods				1,489	0.06	88.8	.07	6.22
Old-Growth				1,299	0.02	25.8	.05	1.29
				12,635		5,947.0		549.22
BURNS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground				2,620	2.68	7,026.0	.15	1,033.90
<25% Bare Ground				1,660	1.80	2,992.0	.12	359.04
Rock				42				
Water (Streams 10'+ wide)				10				
				4,332		10,018.0		1,392.94
Total Acres- Forest Lands				18,674		29,011.8		7,230.20

Gross Acres = 18,674
Gross Sq. Mi. = 29.42
Total Miles Perennial Streams = 29
Watershed: Road Ratio = 12.58 mi/mi^2
Total Miles Road = 370
Watershed: Stream Ratio = 1 mi/mi^2

Gross Sediment = 7,230.2 T/yr.
Gross Erosion = 29,011.8 T/Yr.
Gross Erosion = 985.79 T/Ac./yr.

Gross Sediment = 246.45 Ton/mi^2/yr.
Suspended Sediment = 218.75 T/mi^2/yr.
Bedload = 27.7 T/mi^2/yr.
Sediment Delivery Rate = .25

Erosion Source	QUANTITY	Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS								
Paved Roads								
Gravel 2 Track		42.0		255	0.30	76.50	.15	11.48
Secondary 1½ Track		105.0		700	0.50	350.00	.10	35.00
Spurs 1 Track		12.0		58	1.10	63.80	.12	7.66
Skid Roads ½ Track		40.0		73	1.20	87.60	.09	7.88
				1,086		577.9		65.02
TRAILS								
Fire Trails		7.0		17	0.90	15.30	.05	0.77
Rail Grades Used								
Rail Grades Abandoned								
Transportation Lines		3.5		28	1.10	30.80	.09	2.77
Motorbide Trails		14.0		32	2.80	89.60	.15	13.44
				77		135.70		16.98
LANDSLIDES								
Upper 1/3 Slope				143	2.20	314.60	.20	62.92
Middle 1/3 Slope				34	5.10	173.40	.15	26.01
Lower 1/3 Slope				59	4.30	253.70	.30	76.11
				236		741.70		165.04
STREAMS								
Channel Bank				5	103.80	319.00	.40	208.44
Channel Bottoms				12	79.10	950.00	.54	510.00
Flood Plain Scour				2	30.00	60.00	.20	12.00
				19		1,529.00		730.44
CLEARCUTS								
>75% Bare Ground								
50-75% Bare Ground								
25-50% Bare Ground								
<25% Bare Ground								
FORESTED AREAS								
Brush and Seedlings				1,890	0.07	128.80	.80	12.88
Saplings and Poles				3,840	0.05	192.00	.09	17.23
Mature 2nd-Growth				210	0.03	6.30	.08	0.50
Hardwoods				1,860	0.02	37.20	.07	2.60
Old-Growth				620	0.01	6.20	.05	0.31
				8,370		370.50		33.52
BURNS								
>75% Bare Ground								
50-75% Bare Ground				30	1.50	45.00	.10	4.50
25-50% Bare Ground				1,150	0.67	765.97	.06	45.96
<25% Bare Ground				2,150	0.37	790.00	.04	31.60
Rock				62				
Water (Streams 10+ wide)				10				
				3,402		1,600.9		82.06
Total Acres - Forest Lands				13,190		4,955.7		1,092.80

Gross Acres = 13,190
Gross Sq. Mi. = 20.61
Total Miles Perennial Streams= 29
Waterbed: Road Ratio = 9.66 mi/mi^2
Total Miles Road = 199
Watershed: Stream Ratio = 1.21 mi/mi^2

Gross Sediment = 1,092.8 T/Yr.
Gross Erosion = 4,955.77 T/yr.
Gross Erosion = 240.45 T/mi^2/yr.

Gross Sediment = 52.9 T/mi^2/yr.
Suspended Sediment = 27.7 T/yr.
Bedload = 25.2 T/mi^2/ Yr.
Sediment Delivery Rate = 22

TABLE VII-18
TILLAMOOK RIVER
EROSION AND SEDIMENT ALLOCATION
FOREST LANDS

Erosion Source	QUANTITY Length Miles	Erosion Width-Feet	Area Acres	Erosion Rate T/Ac/Yr.	Gross Erosion Ton/Yr.	Sediment Delivery Ratio	Gross Sediment Ton/Yr.
ROADS							
Paved Roads	9.0	40.0	43.6	1.15	50.4	.09	4.5
Gravel 2 Track	351.0	50.0	2,127.2	.45	957.2	.22	209.0
Secondary 1½ Track	120.0	60.0	872.7	1.38	1,204.3	.20	240.0
Spurs 1 Track	30.0	30.0	109.0	2.84	309.6	.15	46.5
Skid Rds. ½ Track	120.0	15.0	218.2	3.90	850.9	.30	255.0
			3,370.7		3,372.4		755.0
TRAILS							
Fire Trails							
Rail Grades Used							
Rail Grades Abandoned	45.0	10.0	54.5	.83	45.2	.08	3.60
Transmission Lines	10.0	40.0	48.0	1.23	59.0	.15	8.60
Motorbike Trails	5.0	5.0	3.1	5.16	15.9	.24	3.80
			105.6		120.1		16.00
LANDSLIDES							
Upper 1/3 Slope			92.0	4.35	400.2	.39	150.00
Middle 1/3 Slope			315.0	2.86	900.9	.56	504.00
Lower 1/3 Slope			184.0	3.59	660.5	.20	528.00
			591.0		1,961.6		1,182.00
STREAMS							
Channel Bank	13.6	4.0	6.6	393.94	2,600.0	.90	2,340.00
Channel Bottom	2.8	7.5	2.5	160.00	400.0	.95	380.00
Flood Plain Scour	7.0	12.5	10.6	47.17	500.0	.42	209.00
			19.7		3,500.0		2,929.00
CLEARCUTS							
>75% Bare Ground			860.0	12.08	11,008.0	.10	1,100.80
50-75% Bare Ground			890	7.06	6,764.0	.08	540.70
25=50% Bare Ground			2,070.0	4.04	9,108.0	.03	273.24
<25% Bare Ground			1,690.0	1.07	2,873.0	.02	56.89
			5,510.0		29,753.0		1,971.63
FORESTED AREAS							
Brush & Seedlings			2,640.0	.21	534.4	.12	69.97
Saplings & Poles			13,795.5	.14	1,931.3	.08	154.50
Mature 2nd-Growth			3,970.0	.06	238.3	.05	11.92
Hardwoods			2,330.0	.07	163.1	.04	6.52
Old-Growth			1,150.0	.03	34.5	.03	1.04
			23,885.5		2,921.6		243.95
Sand Beach			40.0	.00	.0		.00
Water			47.5	.00	.0		.00
		Total	33,570.0		41,628.7		7,097.58

Forest Land Total = 33,970 Acres
Forest Land Total = 52.45 Miles
Perennial Stream = 70 miles = 1.33/mi^2
Miles of Road = 630 = 12.0/mi.^{2}

Close examination of the foregoing data indicates that there are terrestrial and instream erosion and sediment problems. It is difficult to determine the difference when the sediment reaches the bay. Both sources are important contributors. However, the instream contribution becomes quite significant due to higher delivery ratios.

There are two effects on the stream system of terrestrial source sediment which reaches stream systems. First, the sediment carried by a stream from a land area source tends to dissipate the energy of the water, especially during flood periods, thus reducing the capacity of the flowing water to dislodge streambank and streambed particles. This sediment also serves as an abrasive to increase the effectiveness of the flowing water as an erosive agent. It becomes difficult to ascertain where one effect leaves off and the other begins, since the two are inter-related. The actual dynamics of this process is much more complex and beyond the scope of this study. However, to summarize the situation, a stream will continue to erode soil particles and transport them some distance as long as it retains the energy to do so. The stream systems in Tillamook Bay drainage basin have large energy capacities because of gradient, volume of runoff, and short duration of accumulation for runoff. These conditions, when coupled with the soils and geology of the basin, result in fairly high geologic erosion and sediment delivery rates. The contribution of stream systems in the forest resource area are emphasized on Table VII-19.

Table VII-19   STREAM SYSTEM EROSION AND SEDIMENT PRODUCTION.
FOREST LANDS

Subbasin	Stream System Mean Erosion Tons Per Year	Stream System Mean Sediment Tons Per Year
Tillamook	3,500	2,929
Miami	3,026	760
Upper Kilchis	410	212
Lower Kilchis	1,135	1,006
Little S. Fk. Kilchis	215	160
Little N. Fk. Wilson	206	171
Upper Wilson	3,580	1,895
Lower Wilson	11,412	5,654
Main Stem Trask	17,003	9,290
E. Fork Trask	6,763	3,826
S. Fork Trask	1,529	730
TOTAL	48,799 t/yr	26,633 t/yr

Note: The stream system contributes 17.3 percent of the mean annual
gross erosion and 51.5 percent of the mean annual gross fluvial
sediment.

      Erosion and Sediment Intensity by Subbasin (Table VII-20) and
A Summary of Landslides and Roads (Table VII-21) are shown next.
These tables summarize the major erosion and sediment problems on
forest lands by subbasin.

Landslide erosion on upper forest land slopes.

Roadside erosion--Forest lands.

Mile 7 on the Wilson Highway--Debris-choked tributary
stream.

Closeup of above debris-choked stream.

Table VII-20 - EROSION AND SEDIMENT INTENSITY BY SUBBASIN[1]/
FOREST LANDS

Subbasin	Area Miles^2	Stream Miles/ Mile^2	Roads/ Mile^2	Landslides/ Mile^2	Gross Erosion T./Mi.^{2}/yr.	Erosion Load Rank	Gross Sediment T./Mi.^{2}/yr.	Sediment Load Rank
Tillamook	52.45	1.33	12.00	2.59	793.68	9	135.30	9
Miami	37.95	1.19	8.85	16.07	539.97	5	53.70	5
Upper Kilchis	33.44	1.32	10.86	15.40	360.05	4	32.00	2
Lower Kilchis	23.45	1.07	10.45	8.96	578.45	7	98.54	7
South Fork Kilchis	10.80	1.85	7.80	12.13	967.23	10	92.60	6
Lower Wilson	74.56	.80	10.73	9.24	557.07	6	114.20	8
Upper Wilson	89.00	.46	14.87	13.21	323.97	3	46.80	3
North Fork Wilson	25.67	.66	5.41	3.54	276.72	2	16.21	1
Main Trask	109.25	.69	14.64	4.15	718.57	8	150.90	10
East Fork Trask	29.42	1.00	12.58	6.66	985.79	11	246.45	11
South Fork Trask	20.61	1.21	9.66	22.95	240.45	1	52.90	4
Total	506.60							

1/ Erosion and sediment load expressed as mean tons per square mile per year ranked by subwatershed are rated
Lowest contributor·(1) to highest (11).

Table VII-21 - SUMMARY OF LANDSLIDES AND ROADS*(FOREST LANDS)

RIVER	BRANCH	MAN-CAUSED LANDSLIDES				NATURAL-CAUSED LANDSLIDES				Total for Man-Caused and Natural	Road Miles
		Upper 1/3 Slope	Middle 1/3 Slope	Lower 1/3 Slope	TOTAL	Upper 1/3 Slope	Middle 1/3 Slope	Lower 1/3 Slope	TOTAL		
Trask	Main	163	127	146	436	11	3	3	17	453	1,599
	S. Fork	282	66	118	466	5	2	0	7	473	199
	E. Fork	133	10	47	190	4	0	2	6	196	370
	Total	578	203	311	1,092	20	5	5	30	1,122	2,168
Wilson	Lower	363	133	163	659	18	8	4	30	689	800
	Upper Forks	625	161	362	1,148	18	5	5	28	1,176	1,323
	Little N. Fork	43	10	13	63	15	3	10	28	91	139
	Total	1,031	304	538	1,870	51	16	19	86	1,956	2,262
Kilchis	Lower	131	40	31	202	1	4	3	8	210	245
	Upper	255	158	84	497	11	3	4	18	515	363
	Little S. Fork	61	34	34	129	0	2	0	2	131	84
	Total	447	232	149	828	12	9	7	28	856	692
Miami	Entire Basin	307	123	96	526	33	27	24	84	610	336
Tilla-mook	Entire Basin	77	27	20	124	12	0	0	12	136	630
					4,440				240	4,680	6,088

*Includes those landslides and roads visible on 2" = 1 mile, U-2 aircraft, false color, infrared photography dated 1975

By: Clif Benoit, USFS, R-6, S&PF 8-5-77

LOCATION MAP

Tillamook Bay Drainage Basin

WASHINGTON CO.
YAMHILL CO.
TILLAMOOK CO.
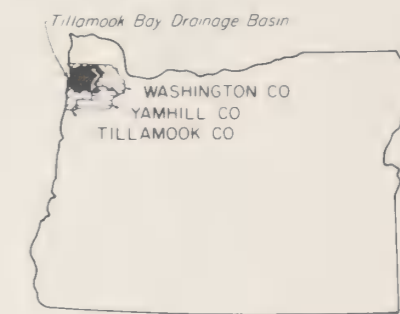
MEAN ANNUAL GROSS EROSION & SEDIMENT RATES

SUB BASIN	AREA SQ. MI.	GROSS EROSION RATE-TON/MI^2/YR.	GROSS SEDIMENT RATE-TONS/MI^2/YR.
Tillamook	52.45	793.68	135.30
Miami	37.95	539.97	53.70
Upper Kilchis	33.44	360.05	32.00
Lower Kilchis	23.45	578.45	98.54
S. Fk. Kilchis	10.80	967.23	92.60
Lower Wilson	74.56	557.07	114.20
Upper Wilson	89.00	323.97	46.80
N. FK. Wilson	25.67	276.72	16.21
Main Trask	109.25	718.57	150.90
E. FK. Trask	29.42	985.79	246.45
S. FK. Trask	20.61	240.45	52.90
Total (Mean Annual)	506.60	286,245 Tons/year	51,603 Tons/year
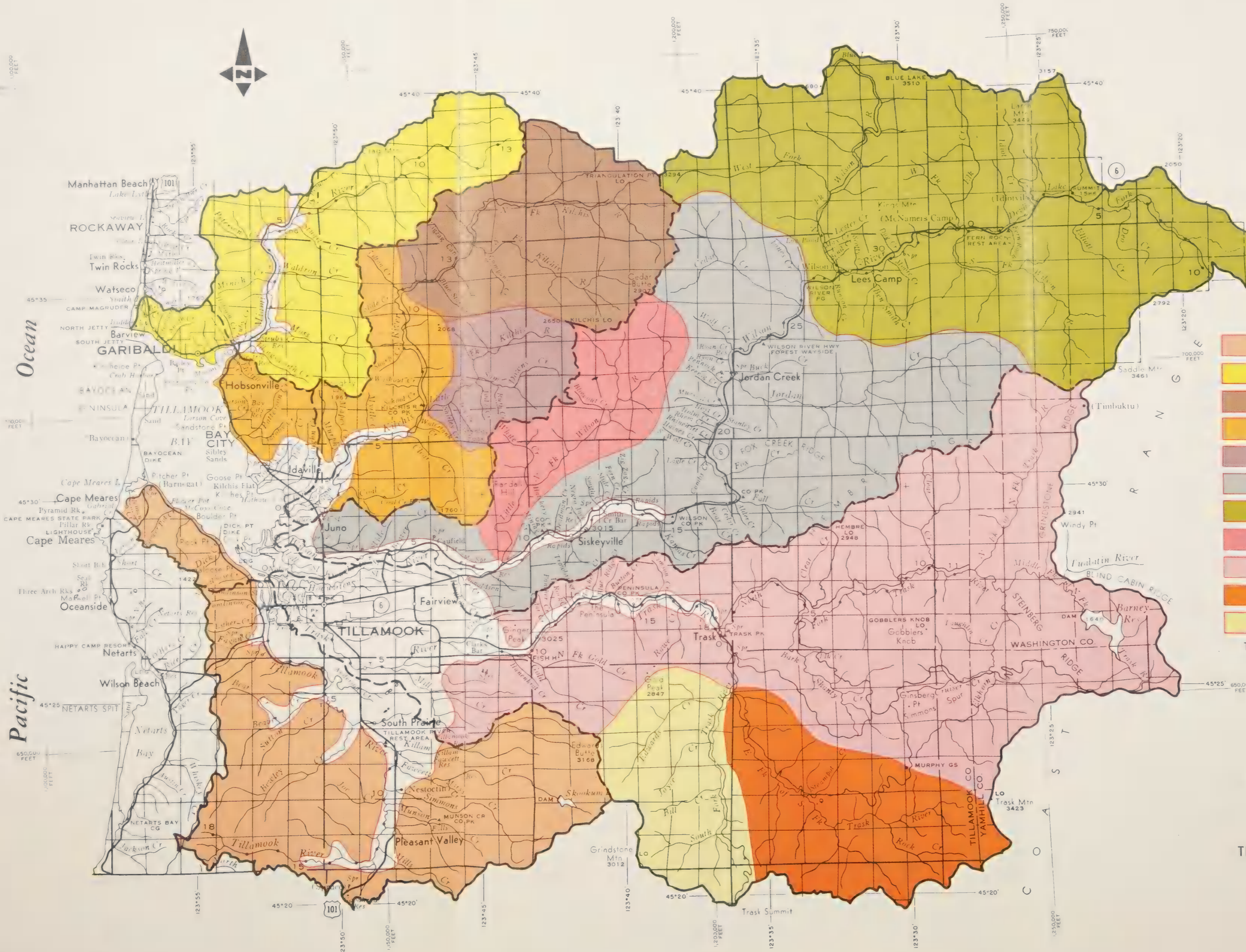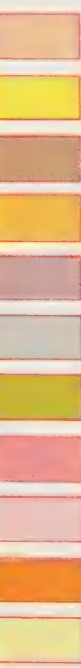
FOREST LAND
MEAN ANNUAL GROSS EROSION
AND SEDIMENT RATES
TILLAMOOK BAY DRAINAGE BASIN
TILLAMOOK, YAMHILL, AND WASHINGTON COUNTIES
OREGON

JANUARY 1978

SCALE 1:190,000

1 0 1 2 3 MILES

M7-EN-23598-14

TILLAMOOK BAY

SURFACE SAMPLES

The major nonopaque heavy components in river bottom sediment samples 1/ are pyroxene group minerals and rock fragments. Kulm, et al. (1968, p. 168-169) also noted the dominance of pyroxene group minerals in Tillamook Bay rivers, although they did not report the abundance of rock fragments. The clinopyroxenes, augite plus diopside, comprise the bulk of the pyroxene group. Only trace amounts of orthopyroxenes, chiefly hypersthene, were noted. The rock fragments are grains with at least two constituents, usually a feldspar and/or a pyroxene, and a fine-grained or opaque "groundmass". The feldspar twinning, where observed, suggests a basic to intermediate composition, and most multiple constituent grains are classified as volcanic rock fragments. Small amounts of amphibole group minerals and of olivine also occur in most river sediment samples.

Sample sites and referenced locations are shown on Sample location and Data Map   Figure VI-1.

MINERALOGY OF THE BAY

The rivers entering Tillamook Bay do not show highly significant compositional differences. However, the Tillamook River may differ slightly from the other four rivers. Avolio (1973, p. 51-52), from X-ray diffraction patterns for heavy mineral separates from Tillamook Bay rivers, identified somewhat distinctive patterns for each river, with the Miami River seeming to differ significantly from the Trask, Wilson, and Kilchis Rivers.

Tidal river samples, on the average, show less rock fragments and pyroxenes and more amphibole and accessory minerals than river samples show. However, on an individual river basis, only the Tillamook and some of the combined Tillamook-Trask tidal river samples differ greatly from river samples. Tillamook-Trask tidal river samples from downstream of the entrance of the main Trask River show only a "river" composition; those upstream of this entrance show the increased percentages of amphiboles and accessory minerals that are reflected in tidal river averages. In general, from the Trask to the Miami tidal river samples, there is a continuation of the trends (decreasing pyroxenes, increasing rock fragments) suggested by river samples.

Compositional data for surface sediment samples from the Southwestern Margin of Tillamook Bay are characterized by rather extreme

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1/ Tables of sample data are on file at the Soil Conservation Service, Federal Bldg., 16th Floor, 1220 S.W. 3rd Ave., Portland, Oregon

local variability. Although two samples were collected in 1974 and two in 1977, the variability seems to be spatial rather than temporal. On the average, samples along the Southwestern Margin show substantial increases in amphiboles, accessory minerals, and "others" over samples from river or tidal river areas. These increases are chiefly at the expense of pyroxene group minerals, which on the average, are 20 to 25 percent less abundant than in river or tidal river areas. Even in those samples (14-74 and 4-77) where pyroxenes are as abundant as in many river samples, amphiboles and accessory minerals tend to be present in amounts greater than in river samples.

Major compositional differences occur between samples from the Western Margin of Tillamook Bay and those from Tillamook Bay rivers. These differences are: (1) a 20 percent decrease in rock fragments, (2) a 200 to 600 percent increase in accessory minerals, and (3) a change in pyroxene group composition from almost 100 percent clinopyroxenes to about a 30:70 percent orthopyroxene (hypersthene): clinopyroxene ratio. In addition to these quantitative changes, significant qualatative changes occur. These changes are most apparent in the degree of grain rounding. In river and in most tidal river and Southwestern Margin samples, most grains are angular to subangular (Pettijohn, 1957, pp. 58-59), whereas in the Western Margin samples most grains are subrounded to well rounded. In addition, optically isotropic fringes, which are common on grains in river samples, are very rare on grains from Western Margin samples.

No highly significant quantitative or qualitative differences are apparent when Western Margin samples are divided into those from the "Bay" and those from the "Ocean" sides of Bayocean Peninsula.   In addition, the data do not establish the significance of possible compositional trends along Bayocean Peninsula.

The composition of Central Bay samples may be discussed by dividing the Central Bay into "southern" and "northern" portions. For this presentation, the boundary has been established arbitrarily in about the vicinity of Sandstone Point. Based on composition alone, a case could be made for establishing the boundary between sample sites 33-74 and 31-74, but no significant difference in conclusions results from doing so.

The southern Central Bay has a composition that is generally similar to that in river samples, with the exception of slightly higher average clinopyroxene percentages and lower rock fragment percentages. These changes are accompanied by some improvement in grain rounding, although most grains are still subangular to subrounded at best.

In the northern part of the Central Bay, the composition changes include decreases in average pyroxene group abundance (and the appearance in most samples of measurable amounts of hypersthene) and increases in accessory minerals. These changes, in general, are accompanied by continued improvement in grain rounding, particularly in those samples north and west of sample site 33-74.

The possibility of east-west compositional changes within the Central Bay cannot be established unequivocally with the data presented here. In the southern part, however, such changes seem unlikely because of the similarity between samples on the eastern (28-76 and 13-75) and western (18-75) sides (see also data for core site 11-76). In the northern part, Avolio (1973, p. 51) noted a progressive change from east to west with the X-ray pattern for an easternmost sample resembling a pattern for Miami River sediments and the pattern for the westernmost sample similar to that for beach and dune samples from Bayocean Peninsula.

The composition of Eastern Margin samples is basically the same as that of adjacent river and tidal river samples. In the central part of the Eastern Margin from Kilchis Point to just north of Sandstone Point, some samples (44-77, 19-74, see also data for core samples 15-76-1a and 14-76-1a) located close to the shoreline have somewhat anomalous and highly variable compositions. Likewise, sample 35-76, at the lower end of Miami Cove differs from typical Miami River samples.

Discussion- Surface Sample Composition

Compositional data for surface sediment samples establish three possible sources of modern surface sediments in Tillamook Bay. The five major rivers draining the Coast Range east of Tillamook Bay may be combined as one source, hereafter referred to as the "river" or "riverine" source. This source is almost exclusively a provider of angular clinopyroxenes and volcanic rock fragments to Tillamook Bay. A second major source provides substantial amounts of rounded orthopyroxenes and probably accessory minerals to surface sediments along the Western Margin and in the northern part of the Central Bay. This source will be referred to as the "marine" or "oceanic" sediment source. Kulm, et al. (1968, p. 176-177), from heavy mineral analyses of beach sands along the Oregon coast, concluded that either the Columbia River drainage or drainage basins south of Tillamook Bay (or both) were the ultimate source of "marine" sediments in the Tillamook area.

Sediments from the river source, when exposed to depositional conditions where marine source sediments are found, would "lose" their volcanic rock fragments and become better rounded due to abrasion. These changes probably could not increase the orthopyroxene and accessory mineral contents in typical river source sediments to the levels observed in marine source sediments.

The third source is shoreline erosion and small streams draining sedimentary bedrock along the Southwestern and Eastern Margins of Tillamook Bay. This source, referred to as the "shoreline" source, has no absolutely unique quantitative or qualitative compositional attributes. If this source were of greater extent, or if the contributions from this source were large relative to those from rivers, it is possible that no marine source would be necessary. It does not seem, however, that the shoreline source is capable of providing all of the orthopyroxenes that are found in marine source sediment. The compositional variability in samples from the Southwestern Margin and from the Eastern Margin north of Kilchis Point is a reflection of a mixed shoreline and river source for the sediment.

Core Samples

Core sample data include "heavy" component compositional analyses, stratigraphic descriptions, and radiocarbon ages. Unlike the surface sample data, which are most useful for showing area variations at the present time, core sample data establish the nature of changes with time (depth) at each core site. The selection of samples for detailed analyses for this purpose was based on the presence or absence of suitable materials (organic matter for radio-carbon analyses, etc.) and on field and laboratory descriptions of the stratigraphy at each core site. Although not every core sample could be analyzed, the major changes with time at each site are believed to have been determined.

Core Sample Composition

The percentages of nonopaque "heavy" components in core samples from Tillamook Bay are described with emphasis on emphasizing areal variations in composition among the core sites and on stratigraphic variations at a core site. In presenting areal variations, it should be noted that comparisons among core sites may be based on samples from different depths.

Areal and stratigraphic compositional variations at and among core sites are summarized in Map Figure VI-1 Sample Locations and Data. The probable source(s) of sediment for each sample analyzed is designated by "R" for river, "M" for marine and "S" for shoreline, followed by the depth, in meters, of the sample below the sediment surface. The source of sediment is interpreted only for those samples from the upper or Holocene part of the sediment fill in Tillamook Bay.

Stratigraphic differences in the source of sediments are indicated by compositional data at some core sites. The apparent exceptions are core sites 2, 4, and 8-76, where only river source sediments were identified, and core sites 1, 13, 14, and 15, where the upper sediment fill was relatively thin and only a single sample may have been analyzed. Core sites with uniform river sediment sources are generally well toward the upper end of Tillamook Bay, and they usually are remote from possible shoreline sources. Cores from near the shoreline (5 and 7-76) in the upper bay show a mixed river plus shoreline (RS) source, or sediments whose source varies from river to river plus shoreline at different depths.

Compositional differences with depth at core sites in Tillamook Bay south of Sandstone Point are shown by data from core sites 9, 16, 10, and 11-76. The general picture that emerges from these data includes: (1) a river source for deep samples, (2) a river plus marine (RM) or marine plus river (MR) source for intermediate depth samples, (3) a river source for shallow surface samples from the upper or eastern side of the bay, and (4) a marine plus river source for the shallow surface sample from the western side of the bay.

North of Sandstone Point, strictly river source sediments occur at depth only in cores from Miami Cove, where intermediate and shallow surface samples show mixed river, river plus shoreline, or river plus marine sources. Core sediments from the main part of Tillamook Bay north of Sandstone Point typically start with a mixed river plus shoreline composition, and seem to become more marine toward the surface.

Discussion-Core Sample Composition

Core sample compositional analyses generally reveal the same sediment sources for different parts of Tillamook Bay as were established by surface sample analyses. They also indicate, however, that the sources of sediments at core sites downbay from the modern river deltas have changed with time. The general nature of this change has been (1) strictly local river and shoreline sources for older, basal sediments, (2) a mixed marine and river source for sediments of intermediate age in the middle of section, and (3) a return to a river source for younger near-surface sediments in the uppper part of the bay. These changes suggest a transgressive-regressive sedimentation sequence in Tillamook Bay. During the transgressive phase, marine source sediments moved into Tillamook Bay, only to be overlain by river source sediments as the rate of transgression slowed, or the regressive phase began, and the rivers started to build deltas out into the bay.

Core Sample Stratigraphy

Stratigraphic data and interpretations for Tillamook Bay cores indicate that the deposits beneath the bay can be divided into an upper and lower unit. The upper unit is the Holocene or "modern"

fill in the bay, and its source and depositional history are the primary concerns of this effort. The lower unit in Tillamook Bay proper is divisible into (1) an upper intensely weathered gravel with relatively unweathered gravels, sands, and silts at depth, and (2) a lower moderately weathered but very hard, sand and silt with rare gravels. One or both of these possible divisions were penetrated at core sites 1, 3, 5, 10, 13, 14, 15, 16, 17, and 18-76. The best examples of the upper division are the 45.9 feet of weathered gravels at core site 18-76 and the 78.7+ of relatively unweathered gravels, sands, and peaty silts and clays at core site 13-76. Core sites 5 and 14-76 contain the best examples of lower division materials beneath Tillamook Bay. In the Miami River valley, basalts and interbedded clays underlie upper unit deposits, and are lower division materials.

The depth to the boundary between upper and lower units is shown on Figure VI-1, Sample Locations and Data. This boundary is very sharply defined in 11 of 17 cores by a change in drilling characteristics and or stratigraphy (Tables 11-27); the deposits below the boundary are frequently badly weathered (oxidized) at the surface, but still are usually more difficult to penetrate than are sediments of the upper unit.

The thickness of the upper unit varies from about 3.2 feet to greater than 104.9 feet (Map Figure VI-1). The unit is thin along the Eastern Margin of the bay north of the modern Tillamook-Trask-Wilson - Kilchis River delta where only 3.28 to 13.1 feet (1, 15, and 14-76) are present. The Central Bay west and north of Sandstone Point is underlain by a ridge of the lower unit, so that only 13.1 to 26.2 feet of the upper unit are present. Upper unit thicknesses in excess of 104.9 feet are observed in the modern major river deltas (4-76 in the Miami delta; 7,8, and 9-76 in the Tillamook-Trask-Wilson-Kilchis delta) and toward the Western Margin (11 and 12-76) of the bay. In contrast, only 39.3 feet are present at core site 2-76 along the margin of the Miami River valley above the modern delta.

The stratigraphy of the upper unit is strongly depth dependent. The texture generally is "fine-grained", relative to that of the lower unit, with all samples analyzed averaging about 60 percent sand and 40 percent silt plus clay. Where the unit is thick in the modern river deltas, basal samples may show brown, gravel-size materials, and drilling data may indicate the presence of cobble and/or boulder size materials. Similar size materials are not present, however, in deep samples from core sites along the Western Margin of the bay.

Basal, coarse sediments are overlain by a 13.1 to 47.6 foot thick sequence of chiefly well stratified, silt and clay with only minor amounts of sand. These sediments may form the basal part of the upper unit where the unit is thin or, more commonly they overlie a thin unit that includes a mixture of silt and clay, some sand, and even fine gravels. Toward the Western Margin of the bay, the middle finer unit is not as well developed as in the delta regions, although the sediments there do become slightly finer at depth. In general, the top part of the upper unit is more sandy and less well stratified than the middle part almost regardless of the core site location.

The upper unit is characterized by abundant organic materials. These materials are chiefly isolated wood clasts or woody to fibrous and very fine organic layers. Their occurrence indicates that they are all detrital in origin. There also are occasional shell layers or zones that are mostly toward the lower part of the unit at core sites where the unit is thin. In general, organic materials, particularly woody materials, are more abundant in the delta regions than in core sites toward the Western Margin of the bay.

Core Sample Age

The results of age determinations by the radiocarbon technique are shown in Table VII-22 and are plotted in Figure VII-2. All samples analyzed for age were wood fragments or fibrous to fine woody organic materials that are detrital in origin. The data show that the sedimentary fill beneath Tillamook Bay consists of materials older than about 38,000 years before present (B.P.) and younger than about 8,400±400 years B.P. Stratigraphic data indicate that the older samples came from the lower unit, whereas the younger dates came from samples of the upper or "modern" fill in Tillamook Bay.

The modern fill in Tillamook Bay in the deep parts of the modern river deltas began to accumulate shortly before about 8,000 years B.P. In the Miami River delta (core site 3-76), a linear extrapolation of age-depth data to the base of the fill suggests that deposition there began between about 8,600 and 9,200 years B.P. At core site 5-76, also in the Miami River delta, the base of the modern fill is only about 36.3 feet below the sediment surface (about 39.6 feet below MSL), and the age of the basal materials is probably only about 6,500 to 7,000 years B.P. The base of the modern fill in the combined Tillamook-Trask-Wilson-Kilchis delta (9-76) was not defined by drilling data (Table 18), but is probably not far from the termination of drilling at about 105.9 feet (MSL); thus, the age of the basal part of the modern fill at this delta core site also should not be more than about 9,000 years B.P.

Table VII-22 RADIOCARBON AGE DETERMINATION OF SELECTED SEGMENTS FROM
TILLAMOOK BAY ESTUARY SEDIMENT CORES

Field Sample Number	USGS Laboratory Number	^{14}C Age* (Years B.P.)	Approximate Depth Below Sediment Surface (Feet)
3-76-7MB	W-3796	7,850 ± 300	60.6
3-76-9M	W-3795	8,310 ± 300	91.5
5-76-4B	W-3651	6,360 ± 300	26.5
5-76-6M	W-3660	>40,000	66.6
7-76-8M	W-3810	6,970 ± 250	66.6
9-76-2M	W-3658	3,300 ± 200	21.6
9-76-3MB	W-3729	5,190 ± 300	36.4
9-76-6M	W-3668	7,230 ± 350	61.3
9-76-7C	W-3654	7,450 ± 400	76.4
9-76-8M	W-3669	8,400 ± 400	91.5
13-76-3M	W-3645	>40,000	20.0
13-76-5C	W-3643	>38,000	36.7
13-76-7C	W-3642	>40,000	55.1

* Analyses were done in the Radiocarbon Laboratory of the U.S.
Geological Survey, Reston, Virginia. The ^{14}C dates are based on
the Libby half-life (5570 years) and are referenced to the year
A.D. 1950. The error stated, always larger than the standard
one-sigma statistical counting error commonly used, takes into
account variable larobatory factors but does not include external
variations or fractionation (field or atmospheric). The data
have not been corrected for fractionation by a ^{13}C measurement
nor have they been converted to a calendar date by use of a tree
ring curve.

Figure VII-2   Generalized world-wide sea level rise curve (from Kraft, 1971) and Tillamook Bay sediment disposition curve.
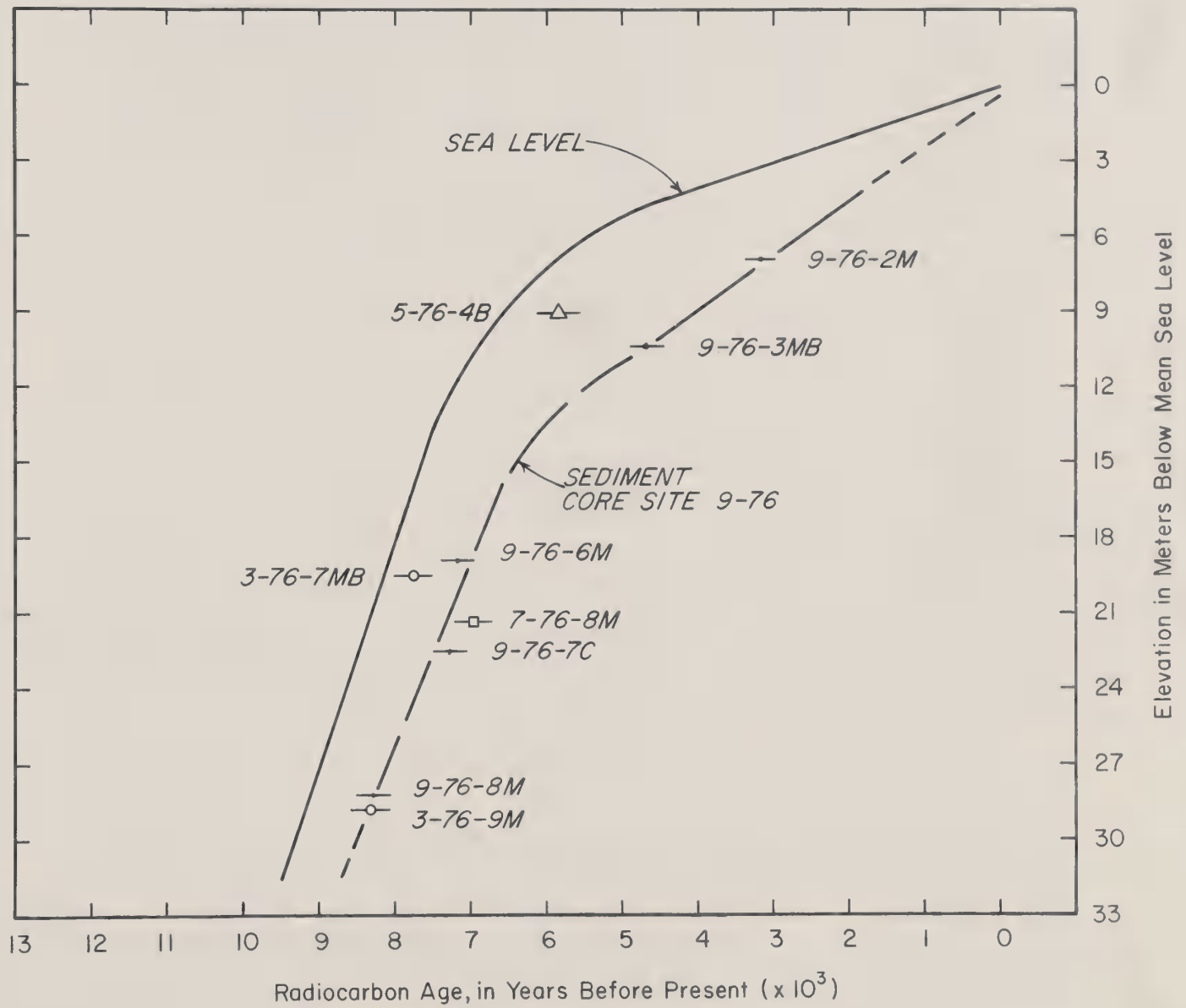
The minimum and maximum deposition rates were computed assuming the maximum and minimum age differences, respectively, between horizons; the "average" computation assumes that the age difference is equal to the measured value(s) without considering the possible stated error. The computed "deposition rates" do not take into account possible compaction or geometry changes, which are believed to be minimal but which are not readily determinable with the available data. In general, the apparent "deposition rates" indicate rapid disposition up to 6,000 to 7,000 years B.P., and slower rates since that time. The data suggest the possibility of different rates in the northern bay (Miami delta) than in the southern bay (Tillamook-Trask-Wilson-Kilchis delta). There is little evidence to establish a change in deposition rate in either delta in historical time; the rate at core site 9-76 between about 3300 and 5200 years B.P. is basically the same as the rate between the present and about 3300 years B.P.

Core Sample Stratigraphy and Age

Stratigraphic and radiocarbon data indicate that Tillamook Bay, prior to the deposition of the modern fill, consisted of southern and northern deep river valleys separated by a ridge extending northwestward from about Sandstone Point. The deposits beneath the ridge and flanking the river valleys included materials that are interpreted as being Oligocene to Miocene sedimentary bedrock similar to that cropping out along the nearby bay margins. In some places, the bedrock is overlain by an older fill of weathered and unweathered fluvial gravels and interbedded lucastrine, peaty deposits that are Pleistocene (greater than 38,000 years B.P.) in age. Similar deposits have been described by Frye (1976, pp. 57-72) and have been found underlying terraces between Tillamook and Idaville, Oregon.

The modern fill in Tillamook Bay began to accumulate sometime prior to about 9,000 years ago when the gravels and sands of the river valley deposits rather abruptly changed to the silts, clays, and sands that characterize the modern of Holocene fill. In general, the deposition and characteristics of the Holocene fill apparently are related to the world-wide Holocene rise in ocean level. During the early rapid rise period, from about 7,000 to greater than 9,000 years B.P., the deposition was rapid and the deposits in much of the present estuary are well-stratified silts and clays. These characteristics suggest possible deep water deposition at rates sufficiently rapid to prevent much winnowing or disturbance by burrowing organisms. The relatively rapid deposition rate during this period might be a reflection of the geometry of the depositional embayment, the rate of sediment supply, the source(s) of sediments, or an increase (over the present) in the sediment "trap efficiency" of the early Tillamook estuary. Relative to sediment sources, compositional data begin to indicate initial contributions from the marine source during this period of relatively rapid ocean level rise. When the rate of ocean level rise began to decrease about 6,000 years

B.P., the rate of sediment deposition also decreased and the sediments generally are coarser and not as well stratified. Presumably these sediment characteristics reflect more winnowing and more time for organisms to "homogenize" the sediments. Sometime between about 3,000 and 5,000 years B.P., the ridge between southern and northern parts of Tillamook Bay should have begun to develop its present configuration. At the present time, sediments from the river source are accumulating in the river deltas and are prograding into the bay over sediments from the marine source. The vertical rate of accumulation of these sediments seems to be about the same from the present to 3,300 years B.P. as it was from 3,300 to 5,200 years B.P.

Mineralogy of the River System

The major rivers emptying into the bay include the Miami, Kilchis, Wilson, Trask, Killam, and the Tillamook. The rivers for the most part originate in tuffaceous marine sedimentary rocks, intrusive rocks, and the Tillamook and Nestucca Formations.

The Miami River sediments range in volcanic glass content from 15 to 81 percent. The sediments from Illingsworth Creek are lowest with 15 percent, those from the Minich Creek are next with 29 percent, and those near the main channel of the Miami River are highest with 81 percent. These data fit the geologic formations which serve as source areas for the sediments. Illingsworth and Minich Creeks are mostly confined to the weathered sediments of the terraces and uplands in the lower part of the Miami River Valley. These sediments were derived from weathered basalt or sediments derived from basalt. They contain important amounts of pyroxene and iron oxides, but very little quartz. The sediments in the Miami River bank are mostly volcanic glass with minor amounts of feldspar and pyroxene. Neither the fine sand nor the very fine sands contain any quartz.

The sediments near the mouth of the Miami River near Hobsonville appear to have been derived from weathered basaltic area also. In the bay near the main channel to the north of the bay bar the sediments are relatively high in quartz, but may have been derived in part from sediments transported by off-shore ocean currents.

The Kilchis River sediments range in glass content from 38 to 88 percent. None of these sediments contain significant amounts of quartz either. Sediments in the Mapes Creek bank are only 38 percent glass, vut the sands contain no quartz suggesting they came from weathered basalt. Again, the main channel of the river is very high in volcanic glass. The upper part of the Kilchis River is entirely in the Tillamook volcanic series. Bay sediments at the mouth of the Kilchis River are high in volcanic glass as one would expect considering the source area for the Kilchis River.

The Wilson River sediments range in volcanic glass content from 42-55 percent. Iron oxides such as hematite and magnetite are also important components. Only a percent or two of quartz was found. The source area includes the Tillamook volcanic series (mostly basalt), the Nestucca volcanic series (dark-grey tuffaceous shale and siltstone and thin-bedded sandstone with interbedded basalt and andesite), and smaller areas of mafic intrusive rocks (gabbro, diorite, and diabase).

The Trask River is another large potential sediment contributor. Its sediment seems a little lower in glass than does the Wilson River. Pyroxene is a major component of these sediments. The sediment source seems to be the same as that of the Wilson River.

The Tillamook River has one tributary, Killam Creek, which flows through the Tillamook volcanic series (basalt), but for the most part its sediments are derived from sedimentary rocks (massive, micaceous sandstones, tuffaceous and micaceous sandstone, tuffaceous siltstone, and mudstone). Its glass content is also high and quartz content low.

CHAPTER VIII

OTHER ENVIRONMENTAL PROBLEMS

OTHER ENVIRONMENTAL PROBLEMS

IMPACTS OF SEDIMENT ON FISHERIES

There have been many studies elsewhere on the Oregon coast of the impacts of sediment on fisheries and the production of sediment by road building, logging, and slash burning activities. Much of that data has been used in the Tillamook basin.

There are three recognized kinds of direct effects which sediment may have on fish. Sediment may suffocate the eggs, thus preventing hatching. Sediment may seal the surface gravels and prevent the fry from emerging. Sediment may also cause physical damage to the surviving fish, interrupting normal development, maturing, and spawning processes.

Examination and observation of salmonids subjected to various sediment concentrations have led researchers to believe that the behavior of the fish can also be disrupted. Fish have been observed to become erratic in their movements after being subjected to heavy sediment loads but apparently suffered no physical damage.

Aquatic insects and small crustaceans which form important segments in the food chain can be used to measure the health of a watershed. The eggs and various larval stages prior to achieving maturity are subject to damage by sediment. A significant reduction of eggs decreases the carrying capacity of a stream as a rearing or growing area. Streams of a deteriorating watershed will have fewer of the desirable insects and crustaceans such as the odonates (damsalfly) and amphipods, while the less desirable insects and crustaceans, such as the dipteras and annelids, will increase.

No literature was found to support the foregoing in the Tillamook basin. However, sampling and measurement of sediment in Tillamook stream systems and the bay sediments indicate very high sediment loads.

Historical records of fish caught in the streams and estuary indicate a definite decline in numbers available. While there may be other factors contributing to this reduction, the most significant one noted has been that of the heavy sediment loads. A strong correlation is evident between the increase in sediment yield from Tillamook Bay tributaries and the decline of chum salmon. Catch and escapement records show the average 10-year catch took a 63 percent drop from the 1937-46 catch to the 1947-56 catch and a 78 percent drop from there to the 1957 to 1962 period. Commercial fishing was discontinued on chum salmon in 1962.

IMPACT OF SEDIMENT ON RECREATION

Tillamook Bay is Oregon's second largest estuary, yet the bay is not as busy nor as popular as others such as Winchester Bay. Sediment has filled the bay over the years until today 75 percent of the area is less than five feet deep during high tides. The shallow areas can be a hazard to the inexperienced visitor. Many unsuspecting boat operators are trapped on the mud flats when the waters recede with the change in tide. There is very little time from the start of the water recession until the mud flats are exposed.

The tideflats of Tillamook Bay are quite extensive with much debris, rotting vegetation, and other organic matter exposed at low tide. The odor emitted can be very unpleasant.

ANIMAL WASTE

Tillamook drainage basin pastures are among the most productive in the County. Nearly all of the cattle are dairy stock. The very style of operation tends to concentrate the cows even when they are on pastures. The normal practice is to set up the lands of the dairy in 40 or 80-acre pasture units and to keep the cows, often as many as 200, together on the same pasture and rotate the pasture use as needed. The cows are even more concentrated twice a day when they are milked.

The effluent resulting from these periods of concentration and from cleaning the barns causes a serious problem. Rainfall intensities are such that storage and disposal is costly and complicated. Disposal has been partially resolved. The effluent from several dairies is now being collected and stored in liquid form in concrete tanks during the rain periods. The liquid slurry is then sprayed on the pastures during the dry months, thus irrigating and fertilizing them at the same time.

The effluent from farms without tanks tends to wash and drain into the stream systems, contributing to the total pollution problem of the bay. The high nutrient and bacteria content of the effluent encourages undesirable vegetative and animal propagation and contributes to the odor problem of the bay.

AIR POLLUTION

Slash burning of clearcuts is not nearly the problem today that it was prior to passage of the Federal Environmental Quality Act. All clearcuts had been burned as part of the accepted timber harvesting program.

Substantial volumes of residue from logging operations and from natural processes in the forest environment are still burned each year as a forest management practice. The burning aids in reforestation of the site, reduces the chances of wildfires, and helps to control pests without use of chemicals.

Most slash burning takes place in the fall after the first rains. The impact of slash fires on air quality is of concern in the basin because of the restricted ventilation conditions and the type of forest areas located there. The older timber stands are highly defective, and much of the cull and rotten material cannot be economically utilized. Thus, residue volumes averaging 120 tons per acre often remain following harvesting operations.

Several forces are involved in reducing the amount of slash burning and in rendering the practice less harmful. A regulatory program now provides for restricted areas and the issuance of burning permits. Another smoke management plan on a voluntary basis calls for timing the burning operations with most favorable meterological conditions. The Department of Environmental Quality, along with public and private timber owners, is involved in this cooperative effort. Other factors that have contributed toward a reduction in slash burning have been (1) an improved technology that leads to increased utilization of certain materials which formerly were left in the forest as debris after harvesting operation, (2) clean logging or complete yarding of residue that either makes burning unnecessary or permits off-season burning, (3) a gradual replacement of old-growth timber by second-growth stands and substitution of partial cutting for clear cutting, (4) pressure brought about by passage of the Federal Environmental Quality Act and an executive order from the Office of the President which permits federal agencies to engage in polluting practices only as a last resort.

Old-growth or other timber stands will have substantial debris that will not be salvageable. At the present rate of cutting, old-growth stands in the basin will be completely harvested by year 2020.

CHAPTER IX

LAND TREATMENT ALTERNATIVES

LAND TREATMENT ALTERNATIVES

EXISTING MEASURES AND PROGRAMS

Tillamook Bay drainage basin has a long history of flooding, erosion, and sediment problems. The problems are triggered by major storm events such as occurred in 1964, 1972, and 1977. The impacts of these events can be greatly reduced by a well-planned program of resource improvement, protection and use.

The on-going programs have accomplished much in protection and correction. These may not always have been the most economical or efficient methods available. This section will explore the current programs and relate them to the needs for accelerating the efforts to further reduce sediment delivery into the estuary.

AGRICULTURAL LANDS

Present land treatment measures related to control of sheet and rill erosion, streambank erosion, and sediment deposition on agricultural lands are relatively limited in the agricultural area. Installation of rock riprap on the channel banks has been the principal treatment measure, with some being placed under the Emergency Watershed Protection Program (Section 216 of Public Law 81-516) and the remainder placed at the expense of the local landowner. As of 1977, a total of 69,434 lineal feet of riprap has been installed. Observations indicate that it is probably the most effective means for treating streambank erosion.

Restoration of dikes in the lower flat areas of some drainages has been accomplished by rebuilding the dikes and protecting them with riprap materials. Since these areas are affected by both streamflow and tidal action, such treatment has materially reduced the erosion hazard. Repair work has been done by individual landowners or under the Emergency Watershed Protection Program. Approximately 2,397 lineal feet of this type of protection has currently been completed on the lower reaches of the Miami, Kilchis, and Trask Rivers.

Reseeding of streambanks and other small areas of eroded farmland has been done on an intermittent basis--usually following periods of high water and/or overbank flooding conditions. Much of this type of treatment has been voluntary but some has been financed under the previously mentioned emergency program. Tree removal from the channel banks has been minimal, as well as removal of debris from the channels. Those temporary remedial measures are usually financed by the local landowner.

FOREST LANDS

Twelve million dollars were expended on forest lands in the basin over a 24-year period to reforest the Tillamook Burn. It proved to be one of the most ambitious reforestation and fire protection efforts ever undertaken in this country. Reduction of soil loss was an objective of this effort, but not the primary one. If erosion control and sediment reduction had been the primary objective, another twelve million would have been needed and the restoration period reduced to maybe 2 to 5 years.

The fires had left a total of about 355,000 acres devoid of vegetation and destroyed most of the natural regeneration and early reforestation efforts. The five basins were contributing massive loads of sediment to the stream systems. The reforestation program, under the direction of the State Forester, was started in 1949 and culminated in 1973 with the successful planting and seeding of 217,800 acres and intensified fire protection of the entire watershed. Tillamook drainage basin portion of the "Burn" was estimated to be 228,600 acres with about 194,700 acres reforested.

A resource management plan is being developed to provide for the best management of this forest for the future. The State Forest Practices Act applies to all forested lands in the basin and will provide much of the direction taken in administration of these resources. This Act was passed by the State of Oregon in 1972 to maintain forest tree species, soil, air and water resources, and fish and wildlife habitat of the forests of Oregon. The various sections of the Act provide minimum practices and set limitations upon forest land managers to attain these ends.

Forest landowners of the basin have included in their timber harvest plans various erosion control programs to coincide with timber harvest. These include stabilization of soils on 163 miles of temporary roads, grass seeding of 3,138 acres to prevent sheet erosion, stabilizing 374 earth slumps and slides, and surfacing of 918 miles of permanent roads to control surface erosion. These are displayed by planning periods on Table IX-1. These measures are planned as part of future harvesting programs for each of those periods. The backlog of needs to control erosion and sediment resulting from the fires and past resource uses will still remain. An accelerated program is necessary if the impact of old problems is to be reduced.

Table IX-1 Erosion Control Work Planned--Forest Lands

Type of Work	1975-1980	1981-1990	1991-2000
Temp. Roads & Spurs To be put to bed (miles)	21	62.5	79.5
Grass & Legume Seedings (acres)	786	1,599	753
Stumps & Slides to be Stabilized (ea.)	78	141	155
Roads Surfaced to Control Soil losses (miles)	146	404	368

TILLAMOOK BAY

The U.S. Corps of Engineers has given the Tillamook Bay considerable attention since 1912 when authorization was received to construct the north jetty. Construction was started in 1914 and finished in 1918 to a length of 5,400 feet. The jetty was repaired and extended to 6,000 feet in 1931-33 and has been rehabilitated twice; once in 1953 and again in 1965. The south jetty was authorized in 1965 and construction was underway in 1969, resulting in a 6,000-foot jetty. Consideration has been given to extending the south jetty to 8,500 feet.

A breach of Bayocean Peninsula occurred in 1952. The breach was repaired by constructing a concrete dike and filling in behind it with dredged material from the bay. Construction of the south jetty has led to increased marine source deposition of sand and an increase in width of the spit. It also has, to some extent, countered the affect of the north jetty. Erosion has been reduced behind both jetties and deposition increased between the jetties.

The bar continues to present a problem. Sand is trapped between the jetties and there has been an apparent increase of inner channel sediment deposition in recent years. Shoaling of the bar has all but closed access to the bay during low tide.

Dredging in the basin began in 1922 with the initial effort directed to maintaining the port at Bayocean. This effort proved futile and was abandoned about 1930 in favor of the Miami Cove port and boat basin. Dredging from that time on was carried out on the bar, in the channel to Garibaldi, and in the Miami Cove boat basin.

In 1927 a great deal of effort and dollars was expended to create the boat basin at Miami Cove. Since that time, there has been a decrease in effort. The dollars spent per year for the period 1922 through 1929 averaged about $28,100. Expenditures dropped to about $11,500 during 1930-39 and held near this level until 1970-76 at which time it climbed back to $25,800. This was due to an all out effort in 1976 when $180,300 was spent. (See Figure IX-1 and Figure IX-2).

Accomplishments have had a steady decline, as noted on Figure IX-1 and IX-2 since the beginning of operations. In effect, dredging operations have been loosing ground due to increased costs, increase in bay and bar sediments, and the lack of new dollars to do an adequate job.

OTHER LANDS

Land treatment measures on urban acreage is limited to seedings and tree plantings around industrial plants. Tillamook County has done some critical area seeding in areas such as the county dump. The erosion and sediment control measures applied to private farm home and building areas include planting lawns and/or various types of landscaping on areas subject to erosion.

Figure IX-1 : U.S. Corps of Engineers Dredging of Tillamook Bay 1922-1976
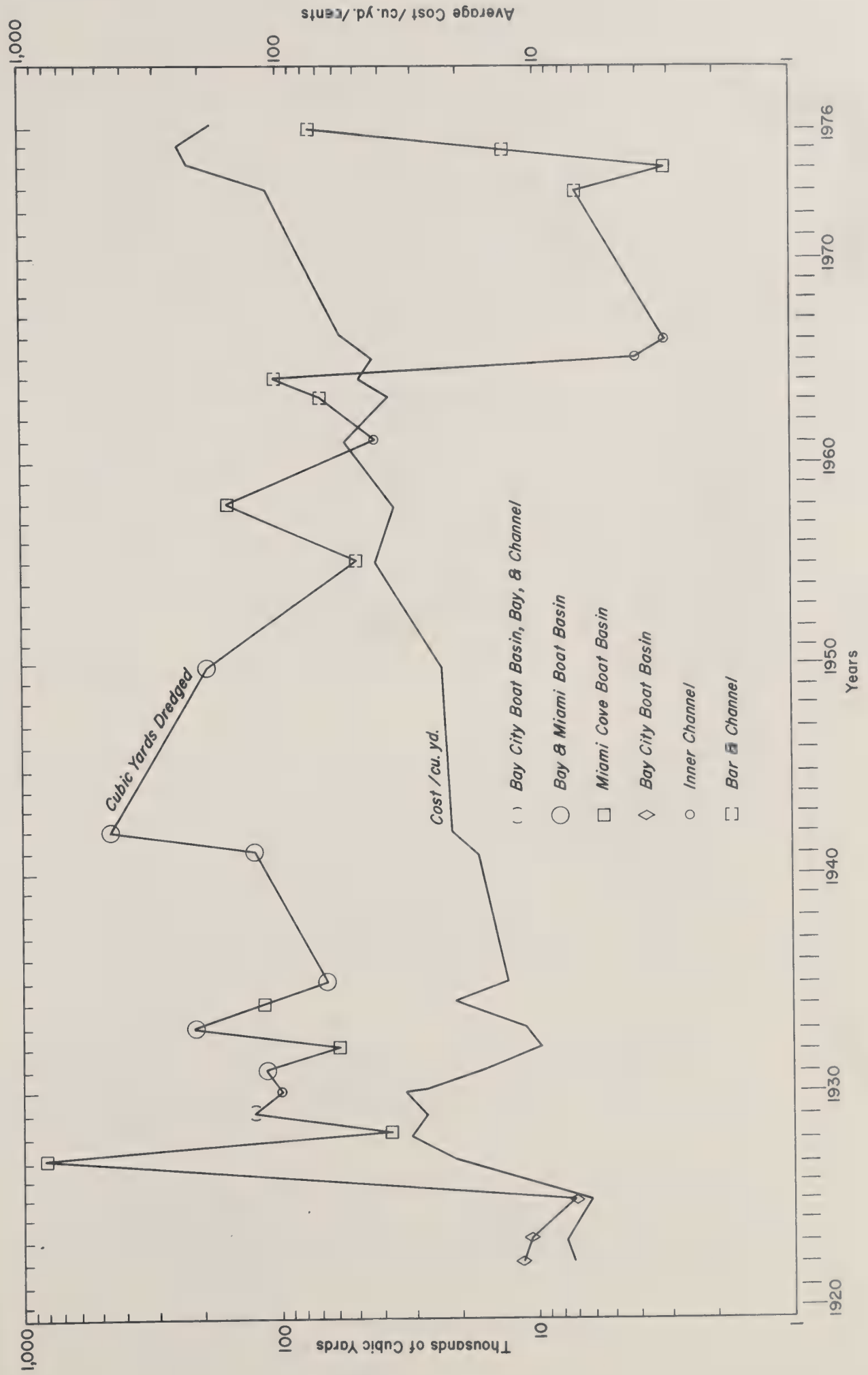
Figure IX-2   Periodic Means of U.S. Corps of Engineers Dredging.
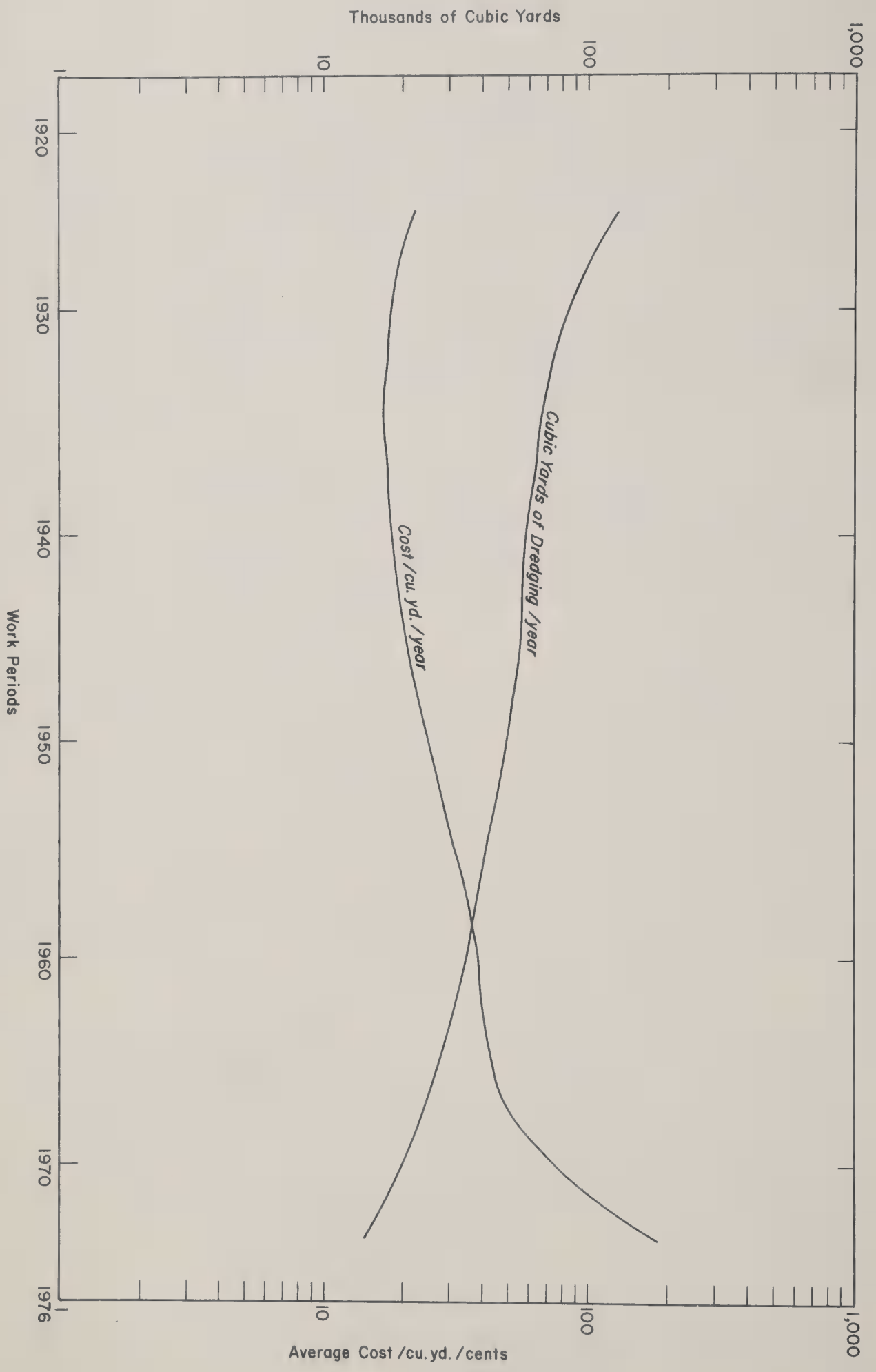
ALTERNATIVES TO ACCELERATE LAND TREATMENT

AGRICULTURAL LANDS

With an over-all cropping pattern of largely irrigated and dryland pasture, any reduction in sediment yield is limited to re-establishment of older or eroded areas of pastureland. This would also apply to areas of brush-pasture although there would be variable benefits through protection by access trails, deferred grazing, and electric fence installations.[1] In small isolated areas of pasture-timber, fencing and/or deferred grazing should also permit a small reduction in sediment yield.

Although the estimated acres subjected to flood scour are small, there are a number of possible alternatives which will result in erosion and sediment yield reductions. On cropland, the primary treatment is plowing, seeding, fertilizing and irrigating of affected areas, with added benefits from electric fencing and deferred grazing. Scouring on gently sloping streambank areas can be minimized through application of pit run gravel on cattle access areas. Similar improvement and reduction in sediment yield can be made on the steeper bank areas which are subject to surface runoff by placement of riprap, back sloping and revegetation, or removal of any debris from the area.

Alternatives to reduction of roadside erosion are seeding, mulching and fertilizing the area affected.

The placement of riprap on critically eroding streambank areas was considered to be a possible solution to reduce erosion and sediment yield caused by bankcutting. Backsloping and revegetation measures on both critical and non-critical banks would provide limited protection although it probably would require annual maintenance and would take more land out of production. An alternative measure to reduce erosion on cattle trails into the river bottom would be the application of pit run gravel on the area affected to firm up the trail and also to provide better drainage. Another logical alternative would be to install an electric fence around the areas, thus excluding it from all use.

Removal of streambottom debris is one practical sediment treatment measure to control streambottom scour. In some cases commercial operations for removal of gravels (except Tillamook River) can be expected to have a limited effect on the quantity of sediment available for transport to Tillamook Bay.

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[1] Electric fencing, a temporary measure to keep cattle away from erosion problem areas, is actually just another category of deferred grazing. Electric fencing is considered temporary, or "stop-gap", since it could be moved and quickly reinstalled where needed.

A total of 13 viable land treatment measures to reduce erosion and sediment yield in the agricultural area were selected for analysis from a list of known treatment measures. These varied in initial cost from $6.00 per acre for portable electric fencing to $39,200.90 per acre for installing rock riprap. The thirteen selected measures and costs are shown on table IX-2.

These alternatives, their costs, and effects on erosion and sediment rates have been analyzed using a least-cost erosion and sediment model, discussed later in this chapter.

Several levels of sediment reduction have been proposed in this study along with the resulting alternatives to reach these levels. Alternative measures not included in this analysis were considered as not being cost-effective at this time.

FOREST LANDS

Erosion and sediment delivery rates on forest lands in the basin are among the highest for any forest lands in the State. The average annual sediment yield today is about 20 times that which probably occurred prior to 1875. However, the average sediment rate today is only about 12.5 percent of the extremely high rate that very likely occurred between 1939 and 1945 as a result of wildfires and salvage logging.

The reduction in the sediment delivery rate from forest lands since 1945 could not have occurred naturally in this time period. The repetitive fires, expansive areas covered by the fires, and the severity of the burns left the soils totally bare over most of the 228,600 acres burned in the basin. Concerned citizens and the land management skills of the staff of the State Forester led to one of the largest reforestation and resource protection efforts ever launched in this country. A total of about 194,700 acres of the basin portion of the "Burn" were successfully reforested by 1973. The resulting reduction of erosion and sediment rates was an objective of this effort, in addition to putting the lands back into production.

Erosion and sediment rates on forest lands still make significant contributions to the problems of the basin. The mean annual gross erosion amounts to 286,245 tons. The mean annual fluvial sediment load is 51,602.6 tons from forest lands. These are 95.6 percent and 85.1 percent, respectively, of the basin totals.

Any further reduction of the sediment load caused by the existing problems will require an accelerated program. Eighteen feasible alternative land treatment measures were selected for analysis from a list of known treatment measures. These varied in initial cost from $70.00

Table IX-2 - Amortization of costs of sediment control measures, agricultural lands, Tillamook Bay Drainage Basin, 1975

Control Measure	Initial cost	Expected duration	Average annual cost 1/	Annual Maintenance cost	Total average annual cost
	Dollars per acre	Years	----------Dollars per acre per year----------		
Seed grass..................	100.00	5	24.15	0	24.15
Seed & mulch grass..........	150.00	5	36.22	0	36.22
Seed, mulch, & fert. grass......	250.00	5	60.36	0	60.36
Plow, seed, & fert. grass......	300.00	8	49.51	0	49.51
Plow, seed, fert. & irr. grass..	400.00	8	66.02	0	66.02
Backslope & revegetate........	6,530.00	15	700.07	57.35	757.42
Remove stream debris..........	150.00	1	159.94	0	159.94
Rock pit run.................	3,200.00	10	447.74	96.00	543.74
Rock riprap..................	39,200.00	30	3,040.83	392.00	3,432.83
Portable electric fence........	6.00	1	6.40	0	6.40
Deferred grazing.............	50.00	1	53.31	0	53.31
Access trails................	11,912.00	10	1,666.72	96.00	1,762.72
Gravel removal...............	0				0

1/ The average annual cost was calculated using the current interest rate in Federal Water Resource projects set by the Water Resources Council (6 5/8%).

SOURCE: Based on information provided by the Soil Conservation Service, Portland, Oregon.

per acre to seed trees (1975 cost basis) to $20,000 per acre for seed, mulch, fertilize and rock buttress. The eighteen selected measures and costs are shown on Table IX-3.

These alternatives, their costs, and effects on reduction of erosion and sediment rates have been analyzed using a least-cost erosion and sediment model, discussed later in this chapter.

The data accumulated for each of the eleven sub-watersheds was examined individually and as a whole. Several levels of sediment reduction have been proposed in the model along with the resulting alternatives to reach these levels. Alternative measures not included in this analysis were considered as not being costeffective at this time.

Table IX-3 Amortization of costs of sediment control measures, forest
lands, Tillamook Bay Drainage Basin, 1975

Control Measures	Initial cost	Total average annual cost 1/
	Dollars per acre	Dollars per acre per year
Seed grass...........................	150	9.95
Seed & fertilize grass...............	300	19.91
Seed, fert., mulch, & net grass.....	600	39.82
Seed, mulch, terrace & fert. grass..	2,100	139.35
Plant brush on streamsides..........	520	34.51
Plant brush on landslides...........	800	53.09
Plant trees..........................	300	19.91
Seed trees...........................	70	4.65
Plant trees, grass, & fert..........	600	39.82
Water bar & vegetate................	1,750	116.13
Gravel road surface.................	5,500	364.97
Stabilize & close roads.............	2,200	145.99
Gravel road surface & hydromulch....	5,800	384.88
Seed, mulch, fert., & rock buttress.	20,000	1,327.17
Rock riprap..........................	15,000	995.38
Backslope & plant brush.............	1,500	99.54
Check dams...........................	8,000	530.87
Debris & log jam removal............	10,000	663.59

1/ The average annual cost was calculated using the current interest
rate in Federal Water Resource projects set by the Water Resources Coun-
cil (6 5/8 percent at 100 years).

SOURCE: Based on information provided by the Forest Service,
Portland, Oregon.

TILLAMOOK BAY

Some resource uses of Tillamook Bay have been greatly reduced by the erosion and sediment problems of the basin. Funds available for dredging have not been sufficient to maintain a clear bar and an open channel to the various boat basins and docks. Economic losses have occurred to fisheries and shell fisheries. Portions of the bay have been filled by sediments to the point that these areas are now above high water line. These areas now provide a mesic type pasture or have been further filled and developed for industrial uses. A total of 102.63 acres of tidelands had been filled in by 1972, and put to other uses. This particular treatment of the tidelands has been largely curtailed. Land ownership patterns restrict further fill and development as do county plans and coastal zone management planning for Tillamook Bay.

Reduction of the erosion and sediment rates occurring from land and stream sources is not the total solution to sediment problems in the bay. Following are several examples of alternatives which could be considered to possibly alleviate the present sediment load already in the bay system. These alternatives would require additional study to determine technical and environmental feasibility and economic justification.

1. Construction of a floodgate and channel to the ocean at the upper end of the bay. The floodgate could then be opened and closed alternately with the tides and flood events to change the flow pattern of the bay and to provide a surge-flush action on the upper bay sediments.

2. Increase funds for a one to five year period and dredge the bay and channels to a desirable depth. This would be successful only after the watershed is well stabilized.

3. Do nothing and allow the estuary to continue to fill with sediment and convert to new uses such as additional pasture.

4. Accelerate sedimentation in selected portions of the bay by a series of dikes and dredge-fill operations. This would result in a smaller, deeper bay.

All of the alternatives will be disruptive to the estuarine ecosystem. This system has already had much disruption and will continue to deteriorate even if nothing (alternative 3) is done. The primary objective of this study was to suggest alternative measures to reduce the sediment loads coming into the estuary. Once sediment is reduced to acceptable levels, consideration can be given to the complex question of what must be done with in-bay sediments.

Some questions that must be answered are:

1. If the sediment load from the watershed is reduced to an acceptable level, what minimum depth tide is desirable throughout the bay?

2. Is the public willing to accept short term (3-5 year) interruption of the existing ecosystems to allow overall dredging?

3. How much channel is needed to what ports or boat basins, and when should these be accessible--high tide or low tide? There will no doubt be many other questions requiring answers.

Above all, both economic and environmental justification will be necessary for all decisions made as a result of this study.

OTHER LANDS

Any further reduction in erosion and sediment production should include increased application of erosion control measures on industrial, city and county areas. Additional treatment measures could also be projected to cover privately owned areas containing homes and farm buildings.

ANALYSIS OF ALTERNATIVE TREATMENT MEASURES

ANALYTICAL PROCEDURES

The major objective of this study was to propose methods of reducing sediment entering Tillamook Bay. A corollary objective was to insure sediment reduction at least cost.

Erosion and sediment control measures, costs, tons per acre, and acres were presented in preceding sections.[1] Now it will be explained how the control measures and the associated sediment rates and costs were analyzed to determine least cost solution combinations.

Several alternative sediment reduction levels were examined.[2] Analyses were conducted at 10 percent reduction intervals to the maximum possible reduction.[3] Least cost combinations of control measures were obtained for sediment at each reduction level.

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[1] Erosion and sediment control measures and costs are presented in this chapter, LAND TREATMENT ALTERNATIVES, ALTERNATIVES TO ACCELERATE LAND TREATMENT MEASURES. Existing (1975) erosion and sediment rates were also discussed in this chapter under EXISTING MEASURES AND PROGRAMS.

[2] At the time this analysis was conducted, no clear picture was evident as to how much sediment should be reduced. Data were not available to indicate how much of the sediment entering the bay is washed on out past the jetties into the ocean. In hopes that later in this study, or in subsequent studies, more information would be forthcoming on sediment depositions in the bay, it was decided to continue the analyses over the entire range of possible reductions.

[3] Analyses can be conducted for any desired feasible erosion or sediment reduction.

THE MODEL

The technique used to conduct the analysis was linear programming. Linear programming basically involves finding an optimal solution to several equations, simultaneously, subject to specified constraints.[1] For Tillamook, the equations represent relationships between erosion and sediment rates, costs, and acres for each of 11 forested and 5 agricultural sub-basins. Optimal solutions provide minimum or least-cost combinations of control measures. Constraints consist of acreages of erosion and sediment sources, and limits of total permissible erosion or sediment in tons per acre.

Several solutions were obtained at different constraint levels. The 1975 solution was used as a base or present situation. Erosion and sediemnt rates were then constrained to succeedingly lower levels and least-cost solutions obtained at each constraint level. Finally, the maximum possible erosion or sediment reduction was determined with an associated control cost.

DATA

Data for the sediment analyses were provided by the Soil Conservation Service and Forest Service. Data and data-gathering techniques have been explained earlier in this report. Tables IX-4 and IX-5 are examples of sediment data used in the model. Information shown on these tables - sources, rates, acres, and costs are explained next. Data tables for all 16 sub-basins are included in the Appendices.

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[1] Linear programming is a standard research tool and has been around for some time, at least since World War II when it was used for planning military operations. For additional information see: Scheurman, Lynn, REX Linear Programming System, Version 1, Oregon State University Computer Center, Revised May, 1972; and Dantzig, George B., Linear Programming and Extension, Princeton University Press, Princeton, New Jersey, 1963, 632 pages. Many other good references on linear programming are also available.

Due to the large number of mathematical calculations necessary to solve for optimal LP solutions, the modern, highspeed computer is a uniquely suited tool for this type of analysis.

Table IX-4 —Sediment rates of alternative control measures, agricultural lands, Wilson River, Tillamook Bay Drainage Basin, 1975

| | | Control Measures | | | | | | | | | | | | | |
Sediment Source	1975 Sediment Rates	Seed Grass	Seed & Mulch Grass	Seed, Mulch, & Fertilize Grass	Plow, Seed, & Fertilize Grass	Plow, Seed, Fertilize, & Irrigate Grass	Backslope & Revegetate	Remove Stream Debris	Rock Pit Run	Rock, Rip Rap	Portable Electric Fence	Deferred Grazing	Access Trails	Gravel Removal	Area Acres
		———————————————————————————Tons per acre per year———————————————————————————														
Irrigated pasture	.0005	—	—	—	.0005	.0005	—	—	—	—	.0005	.0005	.0005	—	762.80
Dryland pasture	.0463	—	—	—	.0442	.0260	—	—	—	—	.0442	.0416	.0442	—	2134.20
Brush pasture	.0525	—	—	—	.0378	.0231	—	—	—	—	.0462	.0420	.0504	—	190.00
Brush-hardwood	.0633	—	—	—	—	—	—	—	—	—	.0593	.0570	.0613	—	30.00
Brush-Douglas Fir	.0246	—	—	—	—	—	—	—	—	—	.0246	.0246	.0246	—	110.00
Pasture-Douglas Fir	.0552	—	—	—	—	—	—	—	—	—	.0528	.0480	.0552	—	250.00
Douglas Fir	.0060	—	—	—	—	—	—	—	—	—	.0060	—	—	—	10.00
First season tillage	.0240	—	—	—	.0216	.0072	—	—	—	—	.0072	—	—	—	357.20
Urban lands	.0003	—	—	—	—	—	—	—	—	—	—	—	—	—	130.00
Paved roads	.0020	.0015	.0014	.0011	—	—	—	—	—	—	.0017	—	—	—	71.20
Gravel roads	.0730	.0498	.0397	.0381	—	—	—	—	—	—	.0663	—	—	—	31.50
Channel erosion	28.9489	—	—	—	—	—	25.1321	26.2478	—	—	—	—	—	24.8385	17.03
Channel erosion, critical	1123.7113	—	—	—	—	—	932.9897	979.3854	—	.0000	—	—	—	969.0722	.19
Channel bank cattle access	166.2500	—	—	—	—	—	118.7500	—	.0438	—	85.0000	—	—	—	.16
Streambottom scour	156.7500	—	—	—	—	—	—	145.5000	—	—	—	—	—	97.0000	.40
Streambottom debris	156.8571	—	—	—	—	—	—	145.5000	—	—	—	—	—	97.0000	7.00
Flood plain scour	.1057	—	—	—	.0543	.0500	.0700	.0500	—	.0500	.0943	.0500	—	—	7.00
Water	.0000	—	—	—	—	—	—	—	—	—	—	—	—	—	306.10
Gravel operations	.5296	—	—	—	—	—	.3380	.3380	—	.0966	—	—	—	.2910	6.42
Rip Rap	.0000	—	—	—	—	—	—	—	—	—	—	—	—	—	8.80
TOTAL ACRES															4430.00
		——————————————————————————————Dollars per acre——————————————————————————————														
Control cost per acre, 1975		100	150	250	300	400	6,530	150	3,200	39,200	■	50	11,912	0	

SOURCE: U.S. Department of Agriculture, Soil Conservation Service; Forest Service; Economics, Statistics, and Cooperatives Service; in cooperation with the Oregon Water Resources Department and the Tillamook Bay Task Force.

Table IX-5.—. Sediment rates of alternative control measures, forested lands, Trask River-Main Stem, Tillamook Bay Drainage Basin, 1975.

Values in columns 1975 sediment rates through Debris & log jam removal are in tons per acre per year; Area is in acres; Control cost per acre is in dollars per acre.

Sediment sources	1975 sediment rates	Seed grass	Seed & fertilize grass	Seed, fert., mulch, & net grass'	Seed, mulch, terrace, & fert. grass	Plant brush on streamsides	Plant brush on landslides	Plant trees	Sand trees	Plant trees, grass, & fertilize	Waterbar & vegetate	Gravel road surface	Stabilize & close roads	Gravel surface and hydromulch	Seed, mulch, fertilize, and rock buttress	Rock riprap	Backslope & plant brush	Check dams	Debris & log jam removal	Area
Brush & seedlings......	.0280	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6,390
Saplings & poles.......	.0209	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	19,400
Mature second growth...	.0108	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6,420
Hardwoods..............	.0030	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	9,270
Old growth.............	.0008	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	6,920
Paved roads...........	.1500	.0636	.0311	.0130																29
Gravel two track......	.2742	.1402	.0731	.0305							.0591	.1041		.0416						3,515
Secondary 1 1/2 track.	.3192	.1573	.0972	.0694							.0592	.1331		.0444						4,140
Spur one track........	.4200	.2129	.1183	.0710								.3216	.0177	.0338						824
Skid road 1/2 track...	.3300	.1608	.1100	.0677							.0095		.0203							400
Fire trails...........	.1050																			78
Rail grade - in use...	---																			---
Rail grade - abandoned	.0060		.0009								.0030									97
Power line corridors..	.0480		.0281								.0109									61
Motor bike trails.....	.6660										.4857		.1844							68
Landslides, upper 1/3.	2.0000			1.3793	.3678		1.0115	1.7931		.8276										87
Landslides, middle 1/3	7.0000			3.9161	1.2238		3.4266	5.3846		2.2028										65
Landslides, lower 1/3.	6.3000			4.7386	2.1060		2.9836	4.7386		2.6326					.3510					80
Channel banks.........	370.1760					187.9355										37.5871	93.9678			15
Channel bottoms.......	96.0000																	60.0000	42.0000	30
Flood plains..........	13.0000					4.1340		5.5120											8.2680	66
Clearcuts, >75% bare..	.9150	.3660						.7306	.8206	.1830										33
Clearcuts, 50-75% bare.	.5160	.2064						.4128	.4888	.1018										120
Clearcuts, 25-50% bare.	.2000							.1600												320
Clearcuts, 0-25% bare..	.0250							.0200												90
Burns, >75% bare......	.8040		.5628					.6593		.2814										160
Burns, 50-75% bare....	.4500		.3150					.3750		.1125										40
Burns, 25-50% bare....	.2560		.1536					.1707		.0683										3,930
Burns, 0-25% bare.....	.1680		.1596					.1260		.0420										4,210
Streams, >10' wide....	---																			155
Sand beach............	---																			---
Rock..................	---																			860
TOTAL ACRES..........																				69,920
Control cost per acre, 1975...........		150	300	600	2100	520	800	300	70	600	1750	5500	2200	5800	20,000	15,000	1500	8000	10,000	

SEDIMENT SOURCES

Criteria for selection of sediment sources was explained earlier. Basically, sediment source areas imply a recognition of readily distinguishable categories of known sediment problems. Sources were delineated in such a way so as to be adaptable to specific data-gathering techniques. Various categories of source acres always sum to the sub-basin total acreage. Thus, total acreage for any given sub-basin is always accounted for, even acreages with no problems; i.e., water, rock, etc.

CONTROL MEASURES

Thirty-one control measures, or combinations of control measures, were picked as being applicable to the Tillamook Basin. These 31 were gleaned from a much larger list. Most of the measures not chosen were judged to be ineffective or unreasonably costly. Sediment rates were estimated for control measures, based primarily on expert knowledge of the effectiveness of these measures in the Tillamook Bay Drainage and in other areas.

EROSION RATES

Techniques used to obtain erosion rates per acre are explained earlier in this report. In summary, the Universal Soil Loss Equation System (USLE) was used for crop and pasture lands in the agricultural areas. Channel bank erosion on agricultural lands was estimated from comparative aerial photo analyses where differences in bank cutting were calculated on an average annual basis. Forested erosion rates were based primarily on 160 randomly chosen, carefully monitored, sample plots.

SEDIMENT RATES

Stream sediment sampling was conducted on 14 stream gauging stations and total suspended and bedload sediment estimated on an average annual basis. This information was translated into sediment rates per acre by the use of previously determined erosion rates and erosion/sediment delivery ratios.

COSTS

Costs of various treatment measures were provided on a per acre basis by the Soil Conservation Service and the Forest Service. All costs were based on 1975 prices and amortized.

ACRES

Acres of each sediment source were determined for broad erosion source categories primarily by satellite telemetry[1] and checked by comparative aerial photography and by extensive ground proofing. (Herzog, et. al)

SUB-BASINS

For purposes of identifying as closely as possible the specific area where treatment measures apply, 11 forested sub-basins and 5 sub-basins adjacent to the bay were delineated by the Forest Service and the Soil Conservation Service. The sub-basins adjacent to the bay were termed "agricultural" lands, although included within this category are acreages of urban and other lands.[2]

CONSTRAINTS

Constraints were set for several control measures and sediment sources. Constraints affect the number of acres that may enter the solution at a given percent sediment reduction.

The model was constrained to force tree planting on clearcuts and burns with greater than 50 percent bare ground. For the 10 percent sediment reduction, at least one-fourth of the total clearcut and burned areas with 50 percent or more bare ground were required to be planted to trees. The 20 percent sediment reduction brought in at least one-half of the available areas, and the remaining sediment reduction levels forced tree planting on all the available clearcuts and burned areas with 50 percent or more bare ground. If tree planting had originally been given a negative cost to account for positive average annual benefits from the future sale of timber, then tree planting would have undoubtedly entered the solutions more frequently as a sediment control measure. Thus tree planting was forced into the model as an attempt to recognize future benefits of timber harvests.

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[1] The Pixal System (PIXSYS), earlier referred to as COVEDS (Coordinated Vegetation Digital Study), at Oregon State University (OSU) was used to obtain digitized base maps which provided acres of basic erosion source areas.

[2] At the beginning of the study, five sub-basins covering the entire Tillamook Drainage were considered sufficient. However, as th study progressed it was found that significant differences in erosion rates existed between areas. In order to more specifically account for differences in erosion rates and to allow for more precise allocations of any future funds to be designated for erosion and sediment control, it was decided to expand the number of sub-basins from 5 to a total of 16.

The only other set of constraints pertaining to forested lands relate to spur roads, skid roads, and motor bike trails. These particular roads and trails were observed to be a potential causal factor of severe sediment problems on other source areas; e.g., gulleys starting from roads and trails that cut into areas with no previous erosion problems.

To take this factor into account, the control measure "stabilize and close roads" was required for spur roads, skid roads, and motor bike trails as follows. At the 10 and 20 percent levels no constraints were imposed. At the 30 percent reduction 3 percent of the area in these 3 source categories was marked for stabilization and closure; at the 40 percent level, 16 percent of the area was set; at the 50 percent level, 67 percent; and for the 60 percent and maximum levels of reduction, all of these 3 categories of roads and trails were required to be stabilized and closed.

For agricultural lands, constraints were placed on certain sediment source combinations of pasture and brush. These constraints account for the fact that of the total acreage of pasture and brush combinations, not all acreages have a problem severe enough to warrant treatment. Constraints on these sources recognize an upper limit of acreages on which treatment measures would be effective. Measures constrained were access trails, deferred grazing, and fencing.

Also, for agricultural lands, small acreages of rock riprap were constrained into the solutions. Rock riprap is an on-going standard solution for critical channel bank erosion, and by requiring at least a minimum number of acres of this treatment, it is recognized that rock riprapping will continue to be an accepted practice for treating critical channel erosion. Areas selected for rock riprapping are seldom amenable to effective erosion control by any other treatment measure. (Actually, the rock riprap constraint has little effect since this measure had been entering the solutions on earlier, unconstrained runs of the model. Rock riprap is a highly effective means of controlling sediment compared to other control measures, and while costly, is still economically efficient when looked at in terms of the cost per ton of sediment reduction.)

Another constraint limited the number of dryland pasture acres that could be irrigated under the control measure - plow, seed, fertilize, and irrigate grass. Water available for irrigation was the limiting factor for this control measure.

Also, on agricultural lands, two corrections were handled via constraints, 1) access trails were not allowed on channel bank cattle access, and 2) new irrigation of brush pasture was eliminated.

An example of the above constraints is shown on Table IX-6 for the Tillamook sub-basin.

ANALYSES

A basic objective of this study was to determine various means of reducing sediment entering Tillamook Bay. An objective of the economic analysis was to achieve sediment reduction at least cost.

To accomplish the economic objective, least cost solutions were found for seven levels of sediment reduction. These seven levels represent reductions in average annual sediment entering the Bay. The levels of reduction are spaced at 10 percent intervals, from a 10 percent reduction, to the maximum reduction (64 percent). Reduction levels were figured using the 1975 base year rate, 60,606 tons, as a starting point. For example, to achieve a 50 percent reduction, average annual sediment would need to be reduced by 30,303 tons.

To obtain the seven least cost solutions, per acre sediment rates and costs of control measures for all 16 sub-basins were analyzed simultaneously. By analyzing all components of the Tillamook drainage simultaneously, least cost solutions are assured at each level of sediment reduction.[1]

The detailed linear programming outputs are presented in the Appendix. Detailed outputs include control measure solutions, by sediment source for each of the 16 sub-basins and for all 7 reduction levels. Summaries of the detailed appendix material are presented throughout the remainder of this report. An example of a detailed output follows.

SELECTED EXAMPLE

The computer linear programming outputs are presented in the Appendix. For illustrative purposes, five detailed appendix tables are shown here (Tables IX-7 through IX-11). This example shows control measures needed in the Lower Kilchis sub-basin for a 20 percent Tillamook Drainage overall reduction level. Tables IX-7 and IX-8 show the control measures required by sediment source. Agricultural and forested lands components are shown separately. Tables IX-9 and IX-10 summarize data presented in the previous two tables. The overall 20 percent solution is summarized for all 16 sub-basins in the Tillamook Drainage Basin on Table IX-11.

Four of the twenty-eight control measures entered the 20 percent least-cost solution for the Kilchis, Lower Main Stem.

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[1] If analyses had been conducted separately by component parts; i.e., by sub-basins, the summed total of the individual solutions would not be an overall least cost solution.

Sediment Source	Plow, seed, ferti-lize & irrigate grass	Rock riprap	Portable electric fence	Deferred grazing	Access trails	Plant trees	Stabilize and close roads	Constraint applies to sediment reduction levels
			-----------	Acres	-----------			
Tillamook Subbasins:								
Sediment reduced 10 percent:								
Agricultural lands:								
Dryland pasture..............	≤ 300		≤ 300	≤ 450	≤ 200			10 thru Max
Brush pasture................	= 0		≤ 100	≤ 200	≤ 100			10 thru Max
Brush-hardwood...............			≤ 30	≤ 30	≤ 60			10 thru Max
Brush-Douglas Fir............			≤ 20	≤ 25				10 thru Max
Pasture-Douglas Fir..........			≤ 150	≤ 150				10 thru Max
Channel erosion critical.....		≥0.04						10 only
Channel bank cattle access...					= 0			10 thru Max
Forested lands:								
Clearcuts, > 75% bare........						≥ 215		10 only
Clearcuts, 50-75% bare.......						≥ 222.5		10 only
Sediment reduced 20 percent:								
Channel erosion critical.....		≥ 0.15						20 thru Max
Clearcuts, > 75% bare........						≥ 430		20 only
Clearcuts, 50-75% bare.......						≥ 445		20 only
Sediment reduced 30 percent:								
Spur one-track roads.........							≥ 3.27	30 only
Skid roads 1/2 track.........							≥ 6.55	30 only
Motor bike trails............							≥ 0.09	30 only
Clearcuts, > 75% bare........						≥ 860		30 thru Max
Clearcuts, 50-75% bare.......						≥ 890		30 thru Max
Sediment reduced 40 percent:								
Spur one-track roads.........							≥ 17.44	40 only
Skid roads 1/2 track.........							≥ 34.91	40 only
Motor bike trails............							≥ 0.50	40 only
Sediment reduced 50 percent:								
Spur one track roads.........							≥ 73.03	50 only
Skid roads 1/2 track.........							≥146.19	50 only
Motor bike trails............							≥ 2.08	50 only
Sediment reduced 60 percent:								
Spur one track roads.........							≥109.0	60 and Max
Skid roads 1/2 track.........							≥218.2	60 and Max
Motor bike trails............							≥ 3.1	60 and Max

TABLE IX-77.--SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE
  --EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM
  --AGRICULTURAL LANDS COMPONENT
  --LEAST COST SOLUTION, 1975

MAJOR SEDIMENT SOURCE	TOTAL AREAS BY SOURCE	NO NEW CONTROL MEASURES	SEDIMENT CONTROL MEASURES		
			ROCK RIP RAP	PORTABLE ELECTRIC FENCE	TOTAL AREA TREATED
	ACRES				
FARMLANDS:					
IRRIGATED PASTURE	460.00	460.00	-	-	-
DRYLAND PASTURE	1947.10	1947.10	-	-	-
BRUSH PASTURE	210.00	210.00	-	-	-
BRUSH - HARDWOOD	120.00	120.00	-	-	-
BRUSH - DOUGLAS FIR	30.00	30.00	-	-	-
PASTURE - DOUGLAS FIR	260.00	260.00	-	-	-
DOUGLAS FIR	50.00	50.00	-	-	-
FIRST SEASON TILLAGE	-	-	-	-	-
URBAN LANDS	140.00	140.00	-	-	-
ROADS:					
PAVED	90.00	90.00	-	-	-
GRAVEL	34.00	34.00	-	-	-
STREAMS:					
CHANNEL EROSION	10.68	10.68	-	-	-
CHANNEL BANK CRITICAL	.19	-	.19	-	.19
CHANNEL BANK, CATTLE ACCESS	.13	-	-	.13	.13
STREAM BOTTOM SCOUR	.40	.40	-	-	-
STREAM BOTTOM DEBRIS	4.00	4.00	-	-	-
FLOOD PLAIN SCOUR	5.00	5.00	-	-	-
MISCELLANEOUS:					
WATER	231.29	231.29	-	-	-
GRAVEL OPERATIONS	4.00	4.00	-	-	-
RIPRAPPED AREA	3.21	3.21	-	-	-
TOTAL ACREAGE	3600.00	3599.68	.19	.13	.32
	TONS PER YEAR				
SEDIMENT, BASE YEAR 1975	1483.49	1212.89	249.00	21.60	270.60
SEDIMENT REDUCTION	-261.34	-	-249.00	-12.34	-261.34
SEDIMENT REMAINING	1222.15	1212.89	-	9.26	9.26
	DOLLARS				
COST OF CONTROL MEASURES, 1975	-	-	652.24	.83	653.07

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE; FOREST SERVICE;
ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE -- IN COOPERATION WITH THE
OREGON WATER RESOURCES DEPARTMENT AND THE TILLAMOOK BAY TASK FORCE.

TABLE IX-8.--SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE
            --EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM
            --FORESTED LANDS COMPONENT
            --LEAST COST SOLUTION, 1975

MAJOR SEDIMENT SOURCE	TOTAL AREAS BY SOURCE	NO NEW CONTROL MEASURES	SEDIMENT CONTROL MEASURES		
			PLANT BRUSH ON STREAMSIDE	PLANT TREES	TOTAL AREA TREATED
			ACRES		
FOREST COVER:					
BRUSH AND SEEDLINGS - - - -	740.00	740.00	-	-	-
SAPLING AND POLES - - - -	4870.00	4870.00	-	-	-
MATURE SECOND GROWTH - - - -	3690.00	3690.00	-	-	-
HARDWOODS - - - - - - - -	2800.00	2800.00	-	-	-
OLD GROWTH - - - - - - - -	130.00	130.00	-	-	-
ROADS AND TRAILS:					
PAVED - - - - - - - - -	8.00	8.00	-	-	-
GRAVEL TWO TRACK - - - - - -	533.00	533.00	-	-	-
SECONDARY ONE + A HALF TRACK	466.00	466.00	-	-	-
SPUR ONE TRACK - - - - - -	84.00	84.00	-	-	-
SKID ROAD, HALF TRACK - -	40.00	40.00	-	-	-
FIRE TRAILS - - - - - - -	7.00	7.00	-	-	-
RAIL GRADE - IN USE - - - -	-	-	-	-	-
RAIL GRADE - ABANDONED - - -	6.00	5.00	-	-	-
POWER LINE CORRIDORS - - - -	24.00	24.00	-	-	-
MOTOR BIKE TRAILS - - - -	1.00	1.00	-	-	-
LANDSLIDES:					
UPPER THIRD SLOPE - - - - -	198.00	198.00	-	-	-
MIDDLE THIRD SLOPE - - - -	66.00	66.00	-	-	-
LOWER THIRD SLOPE - - - -	51.00	51.00	-	-	-
STREAMS:					
CHANNEL BANK - - - - - - -	5.00	-	5.00	-	5.00
CHANNEL BOTTOM - - - - - -	8.00	8.00	-	-	-
FLOOD PLAIN - - - - - - -	3.00	3.00	-	-	-
CLEARCUTS:					
> 75 % BARE GROUND - - - -	150.00	75.00	-	75.00	75.00
50 - 75 % BARE GROUND - - -	180.00	90.00	-	90.00	90.00
25 - 50 % BARE GROUND - - -	450.00	450.00	-	-	-
0 - 25 % BARE GROUND - - -	420.00	420.00	-	-	-
BURNS:					
> 75 % BARE GROUND - - - -	-	-	-	-	-
50 - 75 % BARE GROUND - - -	-	-	-	-	-
25 - 50 % BARE GROUND - - -	50.00	50.00	-	-	-
0 - 25 % BARE GROUND - - -	-	-	-	-	-
MISCELLANEOUS:					
WATER - - - - - - - - - -	20.00	20.00	-	-	-
SAND BEACH - - - - - - - -	-	-	-	-	-
ROCK - - - - - - - - - -	10.00	10.00	-	-	-
TOTAL ACREAGE	15010.00	14840.00	5.00	165.00	170.00

			TONS PER YEAR		
SEDIMENT, BASE YEAR 1975 - - -	2308.69	1590.59	510.00	208.10	718.10
SEDIMENT REDUCTION - - - - -	-292.84	-	-251.03	-41.77	-292.34
SEDIMENT REMAINING - - - - -	2015.85	1590.59	258.97	166.33	425.76

			DOLLARS		
COST OF CONTROL MEASURES, 1975	-	-	172.55	3285.15	3457.70

TABLE IX-99.--SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE
　　　　--EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM
　　　　--AGRICULTURAL LANDS COMPONENT
　　　　--LEAST COST SOLUTION, 1975

KILCHIS RIVER, LOWER MAIN STEM SUB-BASIN SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA
	- - - - - - - - - - ACRES - - - - - - - - - -		
AREA - - - - - - - - - - - - - -	.32	3599.68	3600.00
	- - - - - - - - - - TONS - - - - - - - - - -		
GROSS SEDIMENT:			
BASE YEAR, 1975 - - - - - - -	270.60	1212.89	1483.49
SEDIMENT REDUCTION - - - - - -	-261.34	-	-261.34
SEDIMENT REMAINING - - - - - -	9.26	1212.89	1222.15
	- - - - - - - - - TONS PER ACRE - - - - - - - - -		
AVERAGE SEDIMENT PER ACRE:			
BASE YEAR, 1975 - - - - - - -	845.63	.34	.41
SEDIMENT REDUCTION - - - - - -	-816.69	-	-0.07
SEDIMENT REMAINING - - - - - -	28.94	.34	.34
	DOLLARS		
CONTROL MEASURE COSTS, TOTAL - -	653.07		
	DOLLARS PER ACRE		
AVERAGE COST PER ACRE - - - - -	2040.84		
	DOLLARS PER TON		
AVERAGE COST PER TON REDUCTION -	2.50		

TABLE IX-10.--SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOCK BAY DRAINAGE
        --EFFECTS ON THE KILCHIS RIVER, LOWER MAIN STEM
        --FORESTED LANDS COMPONENT
        --LEAST COST SOLUTION, 1975

KILCHIS RIVER, LOWER MAIN STEM SUB-BASIN SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA
	ACRES		
AREA - - - - - - - - - - - -	170.00	14840.00	15010.00
	TONS		
GROSS SEDIMENT:			
BASE YEAR, 1975 - - - - - - -	718.10	1590.59	2308.69
SEDIMENT REDUCTION - - - - - -	-292.84	-	-292.84
SEDIMENT REMAINING - - - - - -	425.26	1590.59	2015.35
	TONS PER ACRE		
AVERAGE SEDIMENT PER ACRE:			
BASE YEAR, 1975 - - - - - - -	4.22	.11	.15
SEDIMENT REDUCTION - - - - - -	-1.72	-	-0.02
SEDIMENT REMAINING - - - - - -	2.50	.11	.13
	DOLLARS		
CONTROL MEASURE COSTS, TOTAL - -	3457.70		
	DOLLARS PER ACRE		
AVERAGE COST PER ACRE - - - - -	20.34		
	DOLLARS PER TON		
AVERAGE COST PER TON REDUCTION -	11.81		

TABLE IX-11 .--SEDIMENT REDUCED 20 % OVER ALL LANDS IN THE TILLAMOOK BAY DRAINAGE
         --EFFECTS ON THE TILLAMOOK BAY DRAINAGE
         --ALL LANDS
         --LEAST COST SOLUTION, 1975

TILLAMOOK BAY DRAINAGE OVERALL SUMMARY	CONTROL MEASURE AREAS	NON-CONTROL MEASURE AREAS	TOTAL AREA	
	ACRES			
AREA - - - - - - - - - - - - -	2181.87	351998.13	354180.00	
	TONS			
GROSS SEDIMENT:				
BASE YEAR, 1975 - - - - - - -	17941.57	42654.24	60595.59	
SEDIMENT REDUCTION - - - - - -	-12111.33	-	-12121.11	
SEDIMENT REMAINING - - - - - -	5830.24	42654.24	48484.48	
	TONS PER ACRE			
AVERAGE SEDIMENT PER ACRE:				
BASE YEAR, 1975 - - - - - - -	8.22	.12	.17	
SEDIMENT REDUCTION - - - - - -	-5.55	-	-0.03	
SEDIMENT REMAINING - - - - - -	2.67	.12	.14	
	DOLLARS			
CONTROL MEASURE COSTS, TOTAL - -	63348.35			
	DOLLARS PER ACRE			
AVERAGE COST PER ACRE - - - - -	29.03			
	DOLLARS PER TON			
AVERAGE COST PER TON REDUCTION -	5.23			

Sediment is reduced by 260 tons per year on agricultural lands, and by 290 tons per year on forested lands. The total reduction is 550 tons, or 15 percent. To achieve the overall Tillamook Drainage reduction of 20 percent, sediment reduction in other sub-basins was greater than 20 percent. A total of 2,182 acres would be treated to achieve the 20 percent reduction; 351,998 acres would require no new control measures (Table IX-11). [1]

The annual amortized least-cost solution of a 20 percent reduction is $63,348, or $5.23 per ton per year of sediment reduction (Table IX-11).[2]   The Kilchis, Lower Main Stem share of this cost is $653 for the agricultural component and $3,458 for the forested component (Tables IX-7 and IX-8).

All costs shown in the detailed linear programming output tables are annual amortized (Tables IX-7 through IX-11, and Appendix). Annual amortization was necessary for valid analyses and comparisons of sediment control measures in the model.

Amortized costs should not be confused with initial capital requirements necessary for installation of control measures. Initial capital requirements, or installation costs, are summarized in tables IX-18 and X-1, and presented in detail by sediment source area and treatment measure in Table IX-19.

SUMMARIES OF RESULTS

Treatments

Acreages of treatment required for specified least-cost reductions of sediment varied greatly (Tables IX-12 and IX-13). For example, as one might expect, the areas of rock riprap are relatively small since not many areas would be amenable to this method of channel bank stabilization. On the other hand, large tracts of forest lands are amenable to the planting and fertilization of trees as shown for the maximum sediment reduction where 38,500 acres entered the least-cost solution.

Some interesting results are shown on Tables IX-12 and IX-13 that had not been expected. Several treatment measures did not enter any of the solutions; i.e., planting brush on landslides, seeding trees, gravelling surfaces of roads, and building check

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[1] It was assumed that control measures in effect previous to this study would be continued.
[2] Costs were amortized at 6 5/8 percent, the current rate of interest used for federal water resource projects set by the Water Resources Council.

Table IX-12--Least cost sediment control measures, forested lands, Tillamook Bay Drainage Basin, 1975

Sediment Control Measures	Percentage Sediment Reduction							
	0	10%	20%	30%	40%	50%	60%	Max (64%)
	———————————————————————————Acres———————————————————————————							
Seed grass...................	0	0	0	0	1,083.37	10,204.63	9,087.68	0
Seed & fertilize grass........	0	0	0	0	0	3,394.81	13,557.32	183.50
Seed, fertilize, mulch, & net grass...	0	0	0	0	0	0	4,775.12	11,754.80
Seed, mulch, terrace, & fert. grass....	0	0	0	0	0	163.00	1,604.00	3,861.00
Plant brush on stream sides........	0	29.69	22.41	89.60	100.60	101.60	101.60	101.60
Plant brush on land sides.........	0	0	0	0	0	0	0	0
Plant trees.................	0	1,058.63	2,117.25	4,244.50	4,235.50	4,234.50	5,714.50	12,954.50
Seed trees.................	0	0	0	0	0	0	0	0
Trees, grass, & fertilize.........	0	0	0	175.00	848.00	3,262.00	23,363.00	38,500.00
Water bar & vegetate...........	0	0	0	0	0	0	0	948.00
Gravel surface..............	0	0	0	0	0	0	0	0
Stabilize & close roads.........	0	0	0	139.48	743.89	3,115.03	4,628.18	4,649.30
Gravel surface & hydromulch.......	0	0	0	0	0	0	0	15,405.70
Seed mulch, fert., & rock buttress....	0	0	0	0	0	0	25.00	1,251.00
Rock riprap................	0	0	0	6.00	27.60	58.83	70.83	70.83
Back slope & plant brush.........	0	0	36.42	66.83	43.23	12.00	0	0
Check dams.................	0	0	0	0	0	0	0	0
Debris & log jam removal.........	0	0	0	38.67	107.70	137.77	137.77	137.77
TOTAL ACRES TREATED...........	0	1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	63,065.00	89,818.00
TOTAL ACRES NOT TREATED........	324,230.00	323,141.58	322,053.92	319,469.92	317,040.11	299,545.83	261,165.00	234,412.00
TOTAL ACRES...............	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

Table IX-13--Least cost sediment control measures, agricultural lands, Tillamook Bay Drainage Basin, 1975

Sediment Control Measures	0 1/	10%	20%	Percent Sediment Reduction 30%	40%	50%	60%	Max (64%)2/
				—Acres—				
Seed grass...................	0	0	0	0	0	0	0	0
Seed, mulch, fert., grass.......	0	0	0	0	0	0	0	1,135.70
Seed & mulch grass..............	0	0	0	0	0	0	0	34.00
Plow, seed, & fert. grass.......	0	0	0	0	0	0	0	12,079.28
Plow, seed, fert., irr. grass..	0	0	0	0	0	0	0	1,170.00
Backslope & revegetate..........	0	0	0	0	0	0	40.07	44.07
Remove stream debris............	0	0	0	3.82	44.70	84.77	73.05	78.05
Rock pit run....................	0	0	0	.84	.84	.84	.84	.90
Rock riprap.....................	0	1.23	4.89	4.89	4.89	4.89	4.89	30.61
Portable electric fence.........	0	.90	.84	0	0	0	401.00	1,245.00
Deferred grazing................	0	0	.06	.06	.06	.06	.06	1,957.00
Access trails...................	0	0	0	0	0	0	0	1,015.00
TOTAL ACRES TREATED.............	0	2.13	5.79	9.61	50.49	90.56	519.91	18,789.61
TOTAL ACRES NOT TREATED.........	29,920	29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	29,430.09	11,160.39
TOTAL ACRES.....................	29,950	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00

1/ This column represents the 1975 base year situation. Many control measures were in effect in 1975 and more have been installed since then. This study begins from the base year situation and looks at measures in addition to those already being applied at that time.

2/ This is the maximum sediment reduction possible, given the input data rates per acre.

dams on forested lands and seeding grass on agricultural lands. Other
measures that had relatively high costs and little effect on sediment
reduction were forced into the solution only at the maximum reduction;
i.e., water bar and vegetate, and gravel hydromulch road surfaces on
forested lands, and seed mulch and fertilize grass, seed and mulch
grass, plow seed and fertilize grass, plow and fertilize and irrigate
grass, and construction of cattle access trails on agricultural lands.
Other measures entered a solution set, increased, and phased back out
at higher reduction levels; i.e., seeding grass, and backsloping and
planting brush on forested lands.

An important finding from Tables IX-12 and IX-13 is that de-
cision makers and planners should use caution in setting sediment
reduction planning goals. Each level of sediment reduction rep-
resents a least-cost solution only for that level. If, for example
the 60 percent level of reduction were to be chosen as a planning
goal, planners might be tempted to reach that goal by first ac-
complishing lower levels of reduction such as the 50 percent level.
Using the 50 percent level as a "stepping stone" to the 60 percent
level may be all right as long as the acres of treatment measures
for the 50 percent level were also called for at the 60 percent
level. Backsloping and planting the 12 acres of brush called for at
the 50 percent level would be a waste of money at the 60 percent
level, where this measure is not part of the solution. Thus, while
admitting that decision makers will have a difficult task in de-
termining a sediment-reduction goal, such a determination could be
more efficient in the long run.

Sub-Basins

The next summary is a presentation of the acres of reduction
levels that enter the solutions for each sub-basin (Tables IX-14
and IX-15). All sub-basins are affected at every reduction level.
However, for some sub-basins, substantially fewer acres would
need to be treated compared to other sub-basins. For example, at
the 30 percent level the least-cost solution calls for only .32
acres to be treated on agricultural lands in the Kilchis, Lower
Sub-basin, compared to 1,779.61 acres on forested lands in the
Tillamook Sub-basin.

A few more interesting facts can be learned from Tables
IX-14 and IX-15. At the 60 percent reduction level only 519.91
acres (Table IX-14) would be treated on agricultural lands, or
about 2 percent of the total agricultural acres. But to achieve
the maximum reduction of 64 percent, nearly two-thirds of all the
agricultural acres would have to be treated. An additional 18,269.7
acres would be treated (from 519.91 to 18,789.61 acres) to gain
only an additional 4 percent sediment reduction (from 60-64 per-
cent). A similar analogy holds for forested lands. Yet when look-
ing at the Tillamook Bay Drainage Basin, less than one-third of the

Table IX-14 --Least cost control measure acreages by sub-basin for specified percentage reductions in sediment, agricultural lands, Tillamook Bay Drainage Basin, 1975

Sub-basin	Total Acres	Percent Sediment Reduction						
		10	20	30	40	50	60	Max (64)
		Acres						
Tillamook..............	9,570.00	.29	.40	.40	5.90	5.90	284.25	6,909.25
Miami.................	1,260.00	.08	.15	3.97	8.27	8.27	113.27	1,008.95
Kilches lower..........	3,600.00	.18	.32	.32	15.40	15.40	54.40	688.40
Wilson lower...........	4,430.00	.21	.35	.35	7.75	24.78	31.78	2,565.10
Trask main............	11,090.00	1.37	4.57	4.57	13.17	36.21	36.21	7,617.91
TOTAL ACRES TREATED.....		2.13	5.79	9.61	50.49	90.56	519.91	18,789.61
TOTAL ACRES NOT TREATED.		29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	29,430.09	11,160.39
TOTAL ACRES............	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00

Table IX-15—Least cost control measure acreages, by sub-basin, for specified percentage reductions in sediment, forested lands, Tillamook Bay Drainage Basin, 1975

Sub-basin	Total Area	Percentage Sediment Reduction							
		10	20	30	40	50	60	Max (64)
				—Acres—					
Tillamook............	33,570	444.10	881.60	1,779.61	2,189.84	3,562.68	5,837.00	9,597.00
Miami................	24,290	243.63	492.75	990.58	1,014.76	1,302.67	3,791.00	7,318.00
Kilches Lower........	15,010	82.50	170.00	341.75	417.00	1,090.47	2,713.00	2,750.00
Kilches Upper........	21,400	12.50	25.00	61.85	87.20	387.67	2,217.00	7,912.00
Kilches South........	6,910	5.00	10.73	23.58	86.93	817.34	1,255.00	1,255.00
Wilson Lower.........	47,720	79.59	167.00	379.12	776.64	1,607.76	10,019.00	10,430.00
Wilson Upper.........	56,960	60.00	128.00	281.25	428.00	1,745.72	8,636.00	16,708.00
Wilson North.........	16,430	32.50	65.00	138.86	172.92	326.10	901.00	2,497.00
Trask Main...........	69,920	115.00	215.00	670.93	862.72	9,696.56	20,179.00	20,505.00
Trask East...........	18,830	6.00	6.00	50.66	1,088.60	3,895.99	6,086.00	6,098.00
Trask South..........	13,190	7.50	15.00	41.89	65.28	251.21	1,431.00	4,748.00
TOTAL ACRES TREATED.......		1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	63,065.00	89,818.00
TOTAL ACRES NOT TREATED......	324,230	323,141.68	322,053.92	319,469.92	317,040.11	299,545.83	261,165.00	234,412.00
TOTAL ACRES..........	324,230	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

total area, 31 percent, would need to be treated for the maximum
sediment reduction. Also surprising, is that at the lower reduction
levels, not a very large portion of the total area would need to be
treated; e.g., only 1,090.45 acres (.3 percent) for a 10 percent
sediment reduction.

Source Areas

The next two tables (Tables IX-16 and IX-17) show acres treated
by sediment source areas.

Table IX-16, for agricultural lands, shows that channel ero-
sion and cattle accesses need to be treated at the lower sediment
reduction levels to attain the least-cost solutions. Stream-
bottoms enter the solution at the 40 percent level. The other
sediment sources do not enter until the 60 percent and the maximum
reductions are required.

On forested lands (Table IX-17) channel banks, clearcuts, and
burns would be treated at the 10 and 20 percent reduction levels.
At the 30 percent reduction level some roads and trails, landslides,
channel bottoms and flood plains begin to enter the solution. Some
source areas would not be treated until the 60 percent and maximum
sediment reduction levels; i.e., fire trails, railroad grades,
power line corridors, clearcuts with less than 50 percent bare
ground, and burns with less than 25 percent bare ground.

It is interesting to note that there is more area in roads
and trails (32,941.3 acres) than there is in streams and floodplains
(310.2 acres) on forested lands (in fact, roads and trails are over
100 times the area of streams and floodplains). Roads and trails
account for more than 10 percent of the total forested land area
of the basin.

While acreages of control measures by source (Tables IX-16
and IX-17), and by sub-basin (Tables IX-14 and IX-15), always in-
crease from the lower to the higher levels of sediment reduction,
the acreages by control measure (Tables IX-12 and IX-13) jump
around some; e.g., backsloping and planting brush on forested
lands. This phenomenon is to be expected since some control mea-
sures are relatively less expensive in terms of dollars per ton
of reduction, but do not decrease sediment as much as other more
expensive measures. Thus, as gross sediment is "tightened down,"
the more cost-efficient measures enter at the lower reduction
levels, but yield to less cost-efficient measures at higher re-
duction levels.

Table IX-16—Least cost sediment control measures by sediment source, at specified levels of reduction, Tillamook Bay Drainage Basin, 1975

Sediment Source	Total Acres	Percentage Sediment Reduction						
		10	20	30	40	50	60	Max (64)
		Acres						
Farmlands:								
Irrigated pasture	3,887.50	0	0	0	0	0	0	200.00
Dryland pasture	16,476.38	0	0	0	0	0	100.00	14,669.28
Brush pasture	1,330.00	0	0	0	0	0	100.00	1,330.00
Brush-hardwood	390.00	0	0	0	0	0	0	300.00
Brush-Douglas Fir	420.00	0	0	0	0	0	0	45.00
Pasture-Douglas Fir	2,300.00	0	0	0	0	0	150.00	905.00
Douglas Fir	170.00	0	0	0	0	0	0	0
First season tillage	712.50	0	0	0	0	0	0	0
Subtotal	(25,686.38)						(350.00)	(17,449.28)
Urban lands	1,730.00	0	0	0	0	0	0	0
Roads:								
Paved	901.20	0	0	0	0	0	0	901.20
Gravel	268.50	0	0	0	0	0	34.00	268.50
Subtotal	(1,169.70)						(34.00)	(1,169.70)
Streams:								
Channel erosion	82.92	0	0	3.82	14.50	54.57	82.92	82.92
Channel bank, critical	4.89	1.23	4.89	4.89	4.89	4.89	4.89	4.89
Channel bank, cattle access	.90	.90	.84	.84	.84	.84	.84	.90
Stream bottom scour	2.20	0	0	0	2.20	2.20	2.20	2.20
Stream bottom debris	28.00	0	0	0	28.00	28.00	28.00	28.00
Floodplain scour	32.00	0	.06	.06	.06	.06	17.06	32.00
Subtotal	(150.91)	(2.13)	(5.79)	(9.61)	(50.49)	(90.56)	(135.91)	(150.91)
Miscellaneous:								
Water	1,169.43	0	0	0	0	0	0	0
Gravel operations	19.72	0	0	0	0	0	0	19.72
Riprap area	23.86	0	0	0	0	0	0	0
Subtotal	(1,213.01)							(19.72)
Total acres treated		2.13	5.79	9.61	50.49	90.56	519.91	18,789.61
Total acres not treated		29,947.87	29,944.21	29,940.39	29,899.51	29,859.44	29,430.09	11,160.39
TOTAL ACRES	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00	29,950.00

Table IX-17--Least cost sediment control measures by sediment source, at specified levels of reduction, Tillamook Bay Drainage Basin, 1975

Sediment Sources	Total Acres	Percentage Reduction						
		10%	20%	30%	40%	50%	60%	Max (64%)
		Acres						
Forest Cover:								
Brush & seedlings......	29,360.00	0	0	0	0	0	0	0
Saplings & poles......	98,303.50	0	0	0	0	0	0	0
Mature second growth....	31,890.00	0	0	0	0	0	0	0
Hardwoods........	45,050.00	0	0	0	0	0	0	0
Old growth........	25,720.00	0	0	0	0	0	0	0
Subtotal......	(230,323.50)	0	0	0	0	0	0	0
Roads & Trails:								
Paved...........	235.60	0	0	0	0	66.00	227.60	235.60
Gravel two-track......	11,519.20	0	0	0	0	3,927.00	11,347.20	11,519.20
Secondary 1½ track.....	15,405.70	0	0	0	827.00	6,305.70	15,405.70	15,405.70
Spur one-track......	2,304.00	0	0	69.12	441.72	2,141.31	2,304.00	2,304.00
Skidroad ½ track......	1,854.20	0	0	55.63	479.96	1,816.91	1,854.20	1,854.20
Fire trails........	462.00	0	0	0	0	0	0	462.00
Rail grade-in use......	9.0	0	0	0	0	0	0	9.00
Rail grade-abandoned.....	174.50	0	0	0	0	0	63.50	174.50
Power line corridors.....	486.00	0	0	0	0	0	165.00	486.00
Motor bike trails......	491.10	0	0	14.73	78.58	329.04	491.10	491.10
Subtotal......	(32,941.30)	0	0	(139.48)	(1,827.26)	(14,585.96)	(31,858.30)	(32,941.30)
Landslides:								
Upper third slope......	2,517.00	0	0	0	68.00	672.00	2,517.00	2,517.00
Middle third slope......	1,344.00	0	0	70.00	210.00	802.00	1,344.00	1,344.00
Lower third slope......	1,251.00	0	0	105.00	570.00	1,251.00	1,251.00	1,251.00
Subtotal......	(5,112.00)	0	0	(175.00)	(848.00)	(2,725.00)	(5,112.00)	(5,112.00)
Streams:								
Channel bank........	70.83	29.69	58.83	70.83	70.83	70.83	70.83	70.83
Channel bottom.......	137.77	0	0	38.67	107.70	137.77	137.77	137.77
Flood plain........	101.60	0	0	101.60	101.60	101.60	101.60	101.60
Subtotal......	(310.20)	(29.69)	(58.83)	(211.10)	(280.13)	(310.20)	(310.20)	(310.20)
Clearcuts:								
>75% bareground.......	1,414.50	353.63	707.25	1,414.50	1,414.50	1,414.50	1,414.50	1,414.50
50-75% bareground......	1,990.00	497.50	995.00	1,990.00	1,990.00	1,990.00	1,990.00	1,990.00
25-50% bareground......	5,110.00	0	0	0	0	0	1,060.00	5,110.00
0-25% bareground......	3,610.00	0	0	0	0	0	420.00	3,610.00
Subtotal......	(12,124.50)	(851.13)	(1,702.25)	(3,404.50)	(3,404.50)	(3,404.50)	(4,884.50)	(12,124.50)

Continued.

Table IX-17--Least cost sediment control measures by sediment source, at specified levels of reduction, Tillamook Bay Drainage Basin, 1975, Continued.

Sediment Sources	Total Acres	Percentage Reduction						
		10%	20%	30%	40%	50%	60%	Max (64%)
		----Acres----						
Burns:								
>75% bareground.........	630.00	157.50	315.00	630.00	630.00	630.00	630.00	630.00
50-25% bareground.......	200.00	50.00	100.00	200.00	200.00	200.00	200.00	200.00
25-50% bareground.......	21,460.00	0	0	0	0	2,828.51	12,060.00	21,460.00
0-25% bareground........	17,040.00	0	0	0	0	0	8,010.00	17,040.00
Subtotal............	(39,330.00)	(207.50)	(415.00)	(830.00)	(830.00)	(3,658.51)	(20,900.00)	(39,330.00)
Miscellaneous:								
Water...............	519.50	0	0	0	0	0	0	0
Sandbeach...........	40.00	0	0	0	0	0	0	0
Rock................	3,529.00	0	0	0	0	0	0	0
Subtotal............	(4,088.50)	0	0	0	0	0	0	0
ACRES TREATED...........	0	1,088.32	2,176.08	4,760.08	7,189.89	24,684.17	63,065.00	89,818.00
ACRES NOT TREATED.......	324,230.00	324,141.68	322,053.92	319,469.92	317,040.11	299,545.83	261,165.00	234,412.00
TOTAL ACREAGE...........	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00	324,230.00

Costs

What does all this mean in terms of costs? Shown on Table
IX-18 are the amortized costs and the capital costs or installation
costs at each percentage level reduction for the Tillamook Bay
Drainage Basin. Also shown are the tons of sediment reduction
and the tons of sediment remaining at each level.

Readily apparent from Table IX-18 is the fact that costs in-
crease rapidly as sediment is reduced. Installation costs of 189
million dollars for the maximum reduction are substantially high-
er than the .38 million dollars required for the 10 percent re-
duction.

Installation capital costs are further broken down in Table
IX-19 by reduction levels and treatment measures. Initial in-
stallation costs are significantly higher than amortized costs for
the same treatment (except for those items where the project life
is one year).

It should be pointed out that some control measures may be de-
sirable or beneficial for reasons other than just sediment con-
trol. The particular sets of treatment measures at the various
levels of reduction are the result of fulfilling a particular
objective; namely, the least-cost reduction of sediment to Tilla-
mook Bay. Many of the control measures considered in this study
could be used to satisfy other objectives; i.e., erosion control,
increased timberland productivity, better roads for hunters and
recreationists, etc.

Table IX-18 -- Minimum costs of sediment reduction, Tillamook Bay Drainage Basin, 1975

Percentage reduction	Total sediment reduction	Amortized cost of control measures [1]	Installation costs of control measures	Total sediment remaining
Percent	Thous. tons per year	------Thousand dollars------		Thous. tons per year
0	0	0	0	60 [2]
10	6	26	381	54
20	12	63	893	48
30	18	171	2,504	42
40	24	369	5,338	36
50	30	1,046	15,510	30
60	36	2,754	41,040	24
Max (64) [3]	39	14,143	189,035	21

[1] With sediment constrained to the indicated percentage levels, these are the minimum amortized costs of achieving each level of reduction. The amortization interest rate was 6 5/8 percent, which is the rate used for federal water resource projects set by the Water Resources Council.

[2] This row represents the 1975 base year situation. Many control measures were already in use in 1975, and more have been installed since. This study "takes off" from the base year and looks at measures in addition to those already being applied at that time.

[3] Maximum sediment reduction possible, given the input data control measure rates, costs, and constraints for the 1975 base year.

Table IX-19--Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975

Sediment reduction levels and treatment measures	Area	Installation, capital costs	Amortized annual costs[1]
	Acres	------------Dollars------------	
10% Plant brush on streamsides............	29.69	15,439	1,025
Plant trees...........................	1,058.63	317,589	21,077
Rock Riprap...........................	1.23	48,216	4,222
Portable electric fence...............	.90	5	6
TOTAL.............................	1,090.45	381,249	26,330
20% Plant brush on streamsides............	22.41	11,653	773
Plant trees...........................	2,117.25	635,175	42,154
Backslope & plant brush...............	36.42	54,630	3,626
Rock Riprap...........................	4.89	191,688	16,787
Portable electric fence...............	.84	5	5
Deferred grazing......................	.06	3	3
TOTAL.............................	2,181.87	893,154	63,348
30% Plant brush on streamsides............	89.60	46,592	3,161
Plant trees...........................	4,244.50	1,273,350	84,508
Trees, grass & fertilize..............	175.00	105,000	6,969
Stabilize & close roads...............	139.48	306,856	20,363
Backslope & plant brush...............	66.83	100,245	6,453
Debris & log jam removal..............	38.67	386,700	25,664
Rock riprap, forest...................	6.00	90,000	5,972
Rock riprap, agric....................	4.89	191,688	16,787
Rock pit run..........................	.84	2,688	457
Deferred grazing......................	.06	3	3
Remove stream debris..................	3.82	573	611
TOTAL.............................	4,769.69	2,503,695	170,948
40% Plant brush on streamsides............	100.60	52,312	3,472
Plant trees...........................	4,235.50	1,270,650	84,329
Trees, grass, & fertilize.............	848.00	508,800	33,767
Stabilize & close roads...............	743.89	1,636,558	108,600
Seed grass............................	1,083.37	162,506	10,780
Backslope & plant brush...............	43.23	64,845	4,303
Debris & log jam removal..............	107.70	1,077,000	71,471
Rock riprap, forest...................	27.60	414,000	27,472
Rock riprap, agric....................	4.89	191,688	16,787
Rock pit run..........................	.84	2,688	457
Deferred grazing......................	.06	3	3
Remove stream debris..................	44.70	6,705	7,149
TOTAL.............................	7,240.38	5,387,754	386,587

Continued

Table IX-19--Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975, Continued.

Sediment reduction levels and treatment measures	Area	Installation, capital costs	Amortized annual costs[1]
	Acres	------------Dollars----------------	
50% Plant brush on streamsides.............	101.60	52,832	3,506
Plant trees............................	4,234.50	1,270,350	84,309
Trees, grass, & fertilize.............	3,262.00	1,957,200	129,893
Stabilize & close roads...............	3,115.03	6,853,066	454,763
Seed grass............................	10,204.63	1,530,695	101,536
Seed & fertilize grass................	3,394.81	1,018,443	67,591
Seed, mulch, terrace, & fert. grass....	163.00	342,300	22,714
Backslope & plant brush...............	12.00	18,000	1,194
Debris & log jam removal..............	137.77	1,377,700	91,423
Rock riprap, forest..................	58.83	882,450	58,558
Rock riprap, agric...................	4.89	191,688	16,787
Rock pit run..........................	.84	2,688	457
Deferred grazing......................	.06	3	3
Remove stream debris..................	84.77	12,716	13,558
TOTAL.............................	24,774.73	15,510,130	1,046,292
60% Plant brush on streamsides.............	101.60	52,832	3,506
Plant trees............................	5,714.50	1,714,350	113,776
Trees, grass, & fertilize.............	23,363.00	14,017.800	930,315
Stabilize & close roads...............	4,628.18	10,181,996	675,668
Seed grass............................	9,087.68	1,363,152	90,422
Seed & fertilize grass................	13,557.32	4,067,196	269,926
Seed, fert., mulch, & net grass........	4,775.12	2,865,072	190,145
Seed, mulch, terrace, & fert. grass....	1,604.00	3,368,400	223,517
Seed, mulch, fert. grass & rock buttress............................	25.00	500,000	33,179
Debris & log jam removal..............	137.77	1,377,700	91,423
Rock riprap, forest..................	70.83	1,062,450	70,503
Rock riprap, agric...................	4.89	191,688	16,787
Rock pit run..........................	.84	2,688	457
Deferred grazing......................	.06	3	3
Backslope & revegetate................	40.07	261,657	30,350
Remove stream debris..................	73.05	10,958	11,684
Portable electric fence...............	401.00	2,406	2,566
TOTAL.............................	63,584.91	41,040,348	2,754,227

Table IX-19 —Costs of sediment control measures, Tillamook Bay Drainage Basin, 1975, Continued

Sediment reduction levels and treatment measures	Area	Installation, capital costs	Amortized annual costs[1]
	Acres	--------------Dollars--------------	
MAX			
64% Plant brush on streamsides............	101.60	52,832	3,506
Plant trees...........................	12,954.50	3,886,350	257,924
Trees, grass, & fertilize.............	38,500.00	23,100,000	1,533,070
Stabilize & close roads..............	4,649.30	10,228,460	678,751
Water bar & vegetate.................	948.00	1,659,000	110,091
Gravel surface & hydromulch...........	15,405.70	89,353,060	5,929,346
Seed & fertilize grass...............	183.50	55,050	3,653
Seed, fert., mulch & net grass........	11,754.80	7,052,880	468,076
Seed, mulch, ter., & fert. grass......	3,861.00	8,108,100	538,030
Seed, mulch, fert. & rock buttress....	1,251.00	25,020,000	1,660,290
Debris & log jam removal..............	137.77	1,377,700	91,443
Rock riprap, forest..................	70.83	1,062,450	70,503
Seed & mulch grass....................	34.00	5,100	1,231
Seed, mulch, & fert. grass............	1,135.70	283,925	68,551
Plow, seed, & fert. grass.............	12,079.28	3,623,784	598,045
Plow, seed, fert. & irr. grass........	1,170.00	468,000	77,243
Rock riprap, agric...................	30.61	1,199,912	105,079
Rock pit run..........................	.90	2,880	489
Deferred grazing......................	1,957.00	97,850	104,328
Backslope & revegetate................	44.07	287,777	33,380
Remove stream debris..................	78.05	11,708	12,483
Portable electric fence...............	1,245.00	7,470	7,968
Access trails........................	1,015.00	12,090,680	1,789,161
TOTAL.............................	108,607.61	189,034,968	14,142,641

1/ Annual costs were amortized at 6 5/8 percent, the rate set by the Water Resources Council to be used for federal water resource projects.

IX-42

CHAPTER X

ALTERNATIVE PLANS
(Formulation)

ALTERNATIVE PLANS (Formulation)

CONSIDERATION OF DIFFERENT CONTROL PROGRAMS

ANALYSIS OF CONTROL PROGRAMS

Table X-1 summarizes the measure of fitness of alternative goals expressed in percentages of sediment reduction. There are several undetermined aspects of the study which leave the study team in an "if" and "assume" situation. Some of these aspects are as follows.

1. A sediment reduction goal has never been ascertained.

2. The inflow of marine sediments through the mouth of the estuary is not known.

3. The outflow of river-source sediments through the mouth of the estuary is not known.

4. The "in-bay" shifting of sediments is unknown.

The study team, through necessity, has set some "if" situations and made some "assumptions" which may be questioned, and hopefully will be closely examined. This has been done with the hope of activating thought processes which may result in answers to Items 1-4 and provide an integration of the data contained in this report with local land-use planning efforts.

Column 7, Achievement of desirable results, in the measure-of-fitness table (Table X-1) is based upon the following "ifs" and "assumptions" (Scenario A).

Scenario A

1. All river-source sediemnts remain in the estuarine system.

2. No new marine sediments enter the estuary.

3. There is no shifting of sediments in the bay.

4. The in-bay sediments are, or will be, reduced to a desirable depth through bay sediment-removal programs.

Two levels of sediment reduction are considered under the scenario. The first level considered was to approach, as nearly as possible, the natural historic level. There is no accurate measurement of this condition; however, analysis presented earlier in this report indicates it was probably close to 3,000 tons per year. Total sediment reduction needed to reach this goal would be 58,000 tons, annually.

The second level considered was a reduction to that which would permit the U.S. Corps of Engineers to maintain an open bar and channel to Kilchis Point with two boat basins. This would mean that the Corps must expand their dredging program to maintain the additional area from Garibaldi to Kilchis Point, and that the sediment level would be reduced to that same equivalent. In this case, we assume a maintenance level of about 42,000 yards[1]/ per year. Total sediment reduction necessary to meet this goal is about 19,000 tons, annually.

Other scenarios and levels could be assumed. The scenario and levels mentioned here, and shown on Table X-1, are for illustrative purposes to show how sediment reduction might affect hypothesized planning goals.

The basis for the measure of fitness, as summarized on Table X-1 utilizes a comparison of the cost of dredging and disposal of sediment from the bay as opposed to retaining the soils on site. The Corps of Engineers' dredging program in Tillamook Estuary has averaged 14,100 yards per year since 1970, at an average cost of $1.70 per yard.

The Corps will soon (1979) be without a land-based spoil site to deposit in-bay dredging materials. Ocean disposal will add about $1.50 per yard after 1979. Acquisition of lands to use for spoil at today's prices is nearly prohibitive, and in many cases, environmentally constrained.

Table X-1 provides a comparison of control programs on scenario levels. Also on Table X-1 are statements on cost effectiveness, public acceptance, and institutional constraints.

1/ A cubic yard of sediment weighs between .98 and 1.08 tons;
    1 ton per yard was used as the standard for this report.

Table X-1.—Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975

Planning Goals	Treatment measures[1]	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints[2]
10%	Plant brush on streamsides Plant trees Plant trees Plant trees Plant trees Rock, rip rap Portable electric fence	Channel banks Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Channel erosion, critical Channel bank cattle access	29.69 353.63 497.50 157.50 50.00 1.23 .90	The 10% level of accomplishment would reduce annual sediment entering the stream systems by 6,060 cubic yards. [3] The cost of dredging with marine disposal, $3.20 per cubic yard, would be saved by not having to remove this material from the Bay. Other benefits such as increased timber production [4], reduced land losses, and increased employment are included in the annual net benefits of $7.23 per cubic yard. The total average annual net benefit is $43,830 from the 10% level.	Treatment measures selected at this level on agricultural lands are to stabilize eroding streambanks and livestock access trails by placement of rock rip rap on streambanks and placement of electric fence on the access trails. Both measures are being used effectively by the ongoing program. The problem sources selected for treatment are considered as critical, requiring extreme measures to hold the soil in place against very swift currents created by flood waters to which these areas are periodically exposed. Treatment measures selected at this level on forested lands have long been accepted as not only desirable, but necessary, because of the effective control of erosion, also the environmental improvement, visual desirability, increased wildlife habitat which results, and increased production of wood fiber.	Objective, Scenario A. Level I – 10.4% of objective met. Level II – 31.9% of objective met.	The 10% level of accomplishment of sediment reduction will require a total (unamortized) expenditure of $381,000 (at 1975 prices). Possibly, the 10% level could be obtained through a change in priorities by land managers in order to perform these jobs as opposed to other jobs.
20%	Plant brush on streamsides Plant trees Plant trees Plant trees Plant trees Backslope & plant brush Rock, rip rap Portable electric fence Deferred grazing	Channel banks Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour	22.41 707.25 995.00 315.00 100.00 36.42 4.89 .84 .06	12,120 yards sediment reduction[5] $6.39 per yard net benefit $77,440 total net benefit	The only new treatment measure brought in at this accomplishment level on forest lands is to backslope some streambanks prior to planting shrubs. These are well-established practices which are often necessary in certain situations if streambanks are to be successfully stabilized.	Objective, Scenario A, Level – 20.9% of objective met. Level II – 63.8% of objective met.	The 20% level of sediment reduction will require an expenditure of $893,000. Such an amount would require changes in priorities and/or a source of cost-sharing funds for installation of control measures. There may be some objection because of temporary disruption of the shoreline habitat by backsloping.
30%	Plant brush on streamsides Plant trees Plant trees Plant trees Plant trees Plant trees Trees, grass & fertilize Trees, grass & fertilize Stabilize & close roads Stabilize & close roads Stabilize & close roads Backslope & plant brush Debris & log jam removal Rock, rip rap Rock, rip rap Rock pit run Deferred grazing Remove stream debris	Flood plains Clearcuts, > 75% bare ground Clearcuts, 50-75% bare ground Burns, > 75% bare ground Burns, 50-75% bare ground Flood plains Landslides, middle 1/3 slope Landslides, lower 1/3 slope Spur roads, one track Skid roads, half track Motorbike trails Channel banks Channel bottoms Channel banks Channel erosion, critical Channel bank cattle access Flood plain scour Channel erosion	89.60 1,394.50 1,880.00 650.00 310.00 10.00 70.00 105.00 69.12 55.63 14.73 66.83 38.67 6.00 4.89 .84 .06 3.82	18,180 yards sediment reduction[5] $5.63 per yard net benefit $102,380 total net benefit	New treatment measures which come in at this accomplishment level include seeding grass and fertilizing; removing debris and log jams from stream channels; stabilizing and closing roads; and the placing of pit run rock on cattle access trails. Debris and log jam removal have often been questioned. The method of removal and the material to be removed must be carefully planned to avoid adverse impacts on environmental relationships such as a log-pool environment.	Objective, Scenario A, Level I – 31.3% of objective met. Level II – 95.7% of objective met.	At 30%, treatment measures will cost $2,504,000. The increase in costs over the 20% level will require a reordering of priorities by land managers and a source of funding, possibly cost sharing, for installation of the control measures. Debris and log jam removal may constitute a significant impact on the environment, which would require the EIS (Environmental Impact Statement) procedures. Coordination with fish and wildlife agencies would be necessary to plan and conduct the program. Stabilization and closure of some roads may constitute an institutional constraint.

Planning Goals	Treatment measures[1]	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints[2]
40%	Plant brush on streamsides	Flood plains	100.60	24,240 yards sediment reduction[5]	New treatment measures brought in at this accomplishment level include seeding on forest road ditches. Grass seeding is a well-established and accepted practice for soil stabilization on bare soils.	Objective, Scenario A, Level I – 41.8% of objective met. Level II – 127.6% of objective met.	Total cost of a 40% reduction is $5,388,000. At 40%, net economic benefits are negative. Justification would have to be based on net beneficial environmental and/or social well-being effects. Comments for the 30% level apply here also.
	Plant trees	Clearcuts, > 75% bare ground	1,414.50	– $1.19 per yard net benefit			
	Plant trees	Clearcuts, 50-75% bare ground	1,990.00	– $28,800 total net benefit			
	Plant trees	Burns, > 75% bare ground	630.00				
	Plant trees	Burns, 50-75% bare ground	200.00				
	Plant trees	Flood plains	1.00				
	Trees, grass & fertilize	Landslides, upper 1/3 slope	68.00				
	Trees, grass & fertilize	Landslides, middle 1/3 slope	223.00				
	Trees, grass & fertilize	Landslides, lower 1/3 slope	557.00				
	Stabilize & close roads	Spur roads, one track	368.64				
	Stabilize & close roads	Skid roads, half track	296.67				
	Stabilize & close roads	Motorbike trails	78.58				
	Seed grass	Secondary roads, 1½ track	827.00				
	Seed grass	Spur roads, one track	73.08				
	Seed grass	Skid roads, half track	183.29				
	Backslope & plant brush	Channel banks	43.23				
	Debris & log jam removal	Channel bottoms	107.70				
	Rock, rip rap	Channel banks	27.60				
	Rock, rip rap	Channel erosion, critical	4.89				
	Rock, pit run	Channel bank cattle access	.84				
	Deferred grazing	Flood plain scour	.06				
	Remove stream debris	Channel erosion	14.50				
	Remove stream debris	Stream bottom scour	2.20				
	Remove stream debris	Stream bottom debris	28.00				
50%	Plant brush on streamsides	Flood plains	101.60	30,300 yards sediment reduction[5]	New treatment measures brought in under this accomplishment level are seeding grass, mulching, and terracing. These practices are recognized as effective measures to hold soils in place on extreme slopes and on soils which are difficult to hold in place after being mechanically disturbed. Comments under the 30% level of accomplishment are still applicable.	Objective, Scenario A, Level I – 52.2% of objective met. Level II – 159.5% of objective met.	Control measures would cost $15,510,000 for a 50% sediment reduction. Statements for the 30 and 40 percent levels still apply.
	Plant trees	Clearcuts, >75% bare ground	1,414.50	–$17.20 per cubic yard net benefit			
	Plant trees	Clearcuts, 50-75% bare ground	1,990.00	–$521,020 total net benefit			
	Plant trees	Burns, > 75% bare ground	630.00				
	Plant trees	Burns 50-75% bare ground	200.00				
	Trees, grass & fertilize	Landslides, upper 1/3 slope	604.00				
	Trees, grass & fertilize	Landslides, middle 1/3 slope	732.00				
	Trees, grass & fertilize	Landslides, lower 1/3 slope	1,226.00				
	Trees, grass & fertilize	Burns, 25-50% bare ground	700.00				
	Stabilize & close roads	Spur roads, one track	1,543.68				
	Stabilize & close roads	Skid roads, half track	1,242.31				
	Stabilize & close roads	Motorbike trails	329.04				
	Seed grass	Paved roads	66.00				
	Seed grass	Gravel roads, two track	3,927.00				
	Seed grass	Secondary roads, 1½ track	5,478.70				
	Seed grass	Spur roads, one track	242.22				
	Seed grass	Skid roads, half track	490.71				
	Seed & fertilize grass	Secondary roads, 1½ track	827.00				
	Seed & fertilize grass	Spur roads, one track	355.41				
	Seed & fertilize grass	Skid roads, half track	83.89				
	Seed & fertilize grass	Burns, 25-50% bare ground	2,128.51				
	Seed, mulch, ter & fert grass	Landslides, upper 1/3 slope	68.00				
	Seed, mulch, ter & fert grass	Landslides, middle 1/3 slope	70.00				
	Seed, mulch, ter & fert grass	Landslides, lower 1/3 slope	25.00				
	Backslope & plant brush	Channel banks	12.00				
	Debris & log jam removal	Channel bottoms	137.77				
	Rock, rip rap	Channel banks	58.83				
	Rock, rip rap	Channel erosion, critical	4.89				
	Rock, pit run	Channel bank cattle access	.84				
	Deferred grazing	Flood plain scour	.06				
	Remove stream debris	Channel erosion	54.57				
	Remove stream debris	Stream bottom scour	2.20				
	Remove stream debris	Stream bottom debris	28.00				

Planning Goals	Treatment measures[1]	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints[2]
60%	Plant brush on streamsides	Flood plains	101.60	36,360 yards sediment reduction[5]	New treatment measures brought in under this	Objective, Scenario A, Level I - 62.7% of objective	This set of treatment measures would
	Plant trees	Clearcuts, > 75% bare ground	1,414.50	-$34.61 per cubic yard net benefit	accomplishment level on agricultural areas	met. Level II - 191.4% of objective met.	cost $41,040,000. Adverse net econo-
	Plant trees	Clearcuts, 50-75% bare ground	1,990.00	-$1,258,360 total net benefit	are the use of electric fences to control		mic effects and the controversial
	Plant trees	Clearcuts 25-50% bare ground	1,060.00		livestock movement and backsloping and		nature of several control measures
	Plant trees	Clearcuts 0-25% bare ground	420.00		revegetation of streambanks adjacent to		lessen the possibility that the 60%
	Plant trees	Burns, > 75% bare ground	630.00		farmlands. Fencing is in current use on		level of reduction could be justified.
	Plant trees	Burns 50-75% bare ground	200.00		many of the dairies as a means to obtain		Comments for the 30 and 40 percent
	Trees, grass & fertilize	Landslides, upper 1/3 slope	2,226.00		optimum use of forage. Electric fences		levels are still applicable.
	Trees, grass & fertilize	Landslides, middle 1/3 slope	576.00		would effectively constrain livestock from		
	Trees, grass & fertilize	Landslides, lower 1/3 slope	681.00		areas with erosion potential. Rock but-		
	Trees, grass & fertilize	Burns, 50-75% bare ground	5,980.00		tressing is not included on forest areas.		
	Trees, grass & fertilize	Burns, 25-50% bare ground	10,100.00		This is an extreme measure used when it is		
	Trees, grass & fertilize	Burns, 0-25% bare ground	3,800.00		necessary to physically constrain a land-		
	Stabilize & close roads	Spur roads, one track	2,304.00		slide on site.		
	Stabilize & close roads	Skid roads, half track	1,833.08				
	Stabilize & close roads	Motorbike trails	491.10				
	Seed grass	Paved roads	10.00				
	Seed grass	Gravel roads, two track	1,521.00				
	Seed grass	Secondary roads, 1½ track	3,245.68				
	Seed grass	Burns, 25-50% bare ground	4,311.00				
	Seed & fertilize grass	Paced roads	217.60				
	Seed & fertilize grass	Gravel roads, two track	4,108.20				
	Seed & fertilize grass	Secondary roads, 1½ track	8,813.02				
	Seed & fertilize grass	Rail grades, abandoned	63.50				
	Seed & fertilize grass	Power line corridors	165.00				
	Seed & fertilize grass	Burns, 25-50% bare ground	190.00				
	Seed, fert, mulch & net grass	Gravel roads, two track	3,927.00				
	Seed, fert, mulch & net grass	Secondary roads, 1½ track	827.00				
	Seed, fert, mulch & net grass	Skid roads, half track	21.12				
	Seed, mulch, ter & fert grass	Landslides, upper 1/3 slope	291.00				
	Seed, mulch, ter & fert grass	Landslides, middle 1/3 slope	602.00				
	Seed, mulch, ter & fert grass	Landslides, lower 1/3 slope	711.00				
	Seed, mulch, fert grass & rock buttress	Landslides, lower 1/3 slope	25.00				
	Debris & log jam removal	Channel bottoms	137.77				
	Rock, rip rap	Channel banks	70.83				
	Rock, rip rap	Channel erosion, critical	4.89				
	Rock, pit run	Channel bank cattle access	.84				
	Deferred grazing	Flood plain scour	.06				
	Backslope & revegetate	Channel erosion	40.07				
	Remove stream debris	Channel erosion	42.85				
	Remove stream debris	Stream bottom scour	2.20				
	Remove stream debris	Stream bottom debris	28.00				
	Portable electric fence	Dryland pasture	100.00				
	Portable electric fence	Brush pasture	100.00				
	Portable electric fence	Pasture, Douglas Fir	150.00				
	Portable electric fence	Gravel roads	34.00				
	Portable electric fence	Flood plain scour	17.00				

Table X-1.—Measure of fitness for alternative levels of accomplishment, Tillamook Bay Drainage Basin, 1975   (Continued)

Planning Goals	Treatment measures[1]	Source areas	Acres	Cost effectiveness	Public acceptance	Achievement of desirable results	Institutional constraints[2]
Maximum	Plant brush on streamsides	Flood plains	101.60	38,800 yards sediment reduction[5]	New practices brought in on agricultural lands include plowing, irrigation, mulching, and construction of access trails. These are all well-established practices utilized by prudent land managers.	Objective, Scenario A, Level I – 66.9% of objective met. Level II – 204.2% of objective met.	For the maximum possible reduction of sediment, 64%, the cost is $189,035,000.
	Plant trees	Clearcuts > 75% bare ground	1,414.50	-$264.43 per cubic yard net benefit			
	Plant trees	Clearcuts 50-75% bare ground	1,990.00	-$10,259,830 total net benefit			
	Plant trees	Clearcuts 25-50% bare ground	5,110.00				
	Plant trees	Clearcuts 0-25% bare ground	3,610.00				
	Plant trees	Burns > 75 % bare ground	630.00		New practices brought in on forest lands include netting slopes, gravel surfacing, hydromulching, and water-barring. These practices are all commonly used by foresters in preventing soil movement on forest soils. Closing roads may be controversial in areas where off-road vehicle use has become established. Current damage to the soil and water resources should justify such action on specific roads and trails.		
	Plant trees	Burns 50-75% bare ground	200.00				
	Plant trees	Burns 25-50% bare ground	21,410.00				
	Trees, grass & fertilize	Burns 0-25% bare ground	17,090.00				
	Trees, grass & fertilize	Spur roads, one track	2,304.00				
	Stabilize & close roads	Skid roads, half track	1,854.20				
	Stabilize & close roads	Motorbike trails	491.10				
	Stabilize & close roads	Fire trails	462.00				
	Water bar & vegetate	Powerline corridors	486.00				
	Water bar & vegetate	Secondary roads, 1½ track	15,405.70				
	Gravel surface & hydromulch	Rail grades, in use	9.00				
	Seed & fertilize grass	Rail grades, abandoned	174.50				
	Seed & fertilize grass	Pavel roads	235.60				
	Seed, fert, mulch & net grass	Gravel roads, two track	11,519.20				
	Seed, fert, mulch & net grass	Landslides, upper 1/3 slope	2,517.00				
	Seed, mulch, ter & fert grass	Landslides, middle 1/3 slope	1,344.00				
	Seed, mulch, ter & fert grass	Landslides, lower 1/3 slope	1,251.00				
	Seed, mulch, fert grass & rock buttress	Channel bottoms	137.77				
	Debris & log jam removal	Channel banks	70.83				
	Rock, rip rap	Gravel roads	34.00				
	Seed & mulch grass	Paved roads	901.20				
	Seed, mulch & fertilize grass	Gravel roads	234.50				
	Seed, mulch & fertilize grass	Irrigated pasture	200.00				
	Plow, seed & fertilize grass	Dryland pasture	10,974.28				
	Plow, seed & fertilize grass	Brush pasture	905.00				
	Plow, seed & fertilize grass	Dryland pasture	1,170.00				
	Plow, seed, fert & irr grass	Channel erosion	4.89				
	Rock, rip rap	Flood plain scour	10.00				
	Rock, rip rap	Gravel operations	15.72				
	Rock, rip rap	Channel bank cattle access	.90				
	Rock, pit run	Dryland pasture	1,250.00				
	Deferred grazing	Brush pasture	210.00				
	Deferred grazing	Brush, hardwood	90.00				
	Deferred grazing	Brush, Douglas Fir	30.00				
	Deferred grazing	Pasture, Douglas Fir	360.00				
	Deferred grazing	Flood plain scour	17.00				
	Deferred grazing	Channel erosion	40.07				
	Backslope and revegetate	Gravel operations	4.00				
	Backslope and revegetate	Channel erosion	42.85				
	Remove stream debris	Stream bottom scour	2.20				
	Remove stream debris	Stream bottom debris	28.00				
	Remove stream debris	Flood plain scour	5.00				
	Remove stream debris	Dryland pasture	700.00				
	Portable electric fence	Brush pasture	100.00				
	Portable electric fence	Brush, hardwood	80.00				
	Portable electric fence	Brush, Douglas Fir	20.00				
	Portable electric fence	Pasture, Douglas Fir	345.00				
	Portable electric fence	Dryland pasture	575.00				
	Access trails	Brush pasture	115.00				
	Access trails	Brush, hardwood	60.00				
	Access trails	Brush, Douglas Fir	5.00				
	Access trails	Pasture, Douglas Fir	260.00				

1/ The model was constrained to reflect potential net profits from tree planting and to account for on-going programs on agricultural lands of placing rock rip rap. Also, road closure and stabilization was required on certain forested roads and trails to prevent potential erosion from occurring on other source areas. Constraints are discussed in detail in the previous chapter.

2/ Costs are total, unamortized, using 1975 prices.

3/ A cubic yard of sediment weighs between .90 and 1.08 tons; one ton per yard was used as the standard for this report.

4/ Benefits of timber harvest, 70 years hence, were depreciated and amortized for an average annual present value of $44.90 per acre per year.

5/ For narrative, see the 10% level.

COMPARISONS OF CONTROL PROGRAMS

Preceding sections of the report have shown how the study developed to this point. Sediment problems were defined, data were collected and analyzed, control measures were formulated, and least-cost combinations of control measures were established. Now these combinations of control measures will be examined to determine economic, environmental, and other effects. An analysis and comparison of these effects is required of all federally sponsored national resource studies.(16 and 43)

This evaluation of effects included beneficial and adverse impacts that the Study Team was able to ascertain at the time this report was written. Other beneficial and adverse effects may exist. Beneficial effects to the economic development account were especially difficult to determine. Several unknowns complicate the evaluation of the beneficial effects of sediment reduction. Some of these unknowns have been described earlier.

The most frustrating unknown relates to the problem of determining physical and economic effects of sediment impacts in the bay. While earlier sections of this report have pointed out in detail how sediment entering the bay can be reduced, considerable confusion still exists as to the effects of sediment in the bay. And a basic question remains unanswered: How much of the sediment entering the bay stays in the bay? Until additional insight is obtained as to retention of river sediments, inflows and outflows of marine sediments, and intra-bay mixing of sediments, the physical and economic evaluation of impacts of bay sediments will continue to be frustrating.

Many possible or potential beneficial and adverse economic effects remain unevaluated. Some items unevaluated in this study, but which would likely be affected by sediment reduction include:

- The commercial seafoods industry

- Sports fishing and hunting

- Flood damages

- The recreation and tourist industry

- Transportation modes, water versus land

- Agriculture, crop and pasture yields

- Municipal and industrial water quality

- Commercial and industrial port development.

This list is not meant to be all inclusive. Also, some of these, and others, have been evaluated from the standpoint of beneficial and adverse environmental and social well-being effects.

In the absence of precise, definitive data relating to sediment effects, different assumptions were constructed and evaluated. These assumptions were presented in the preceding section. The comparison of alternative sediment control programs or plans (Table X-2) is based on the assumed hypothesis that all sediment entering the bay stays in the bay.

For reasons already explained, this study does not present a preferred plan. Several alternative plans are shown on Table X-2 where the beneficial and adverse economic, environmental, and social well-being effects are evaluated. Again, it must be pointed out that not all of the effects of sediment reduction were evaluated.

In Table X-2, under Economic Development, are comparisons of amortized annual[1] beneficial effects and costs of the different alternatives. At the 30 percent level of reduction, a $102,380 net annual benefit is shown. At the 40 percent level, net annual benefits are negative -$28,800, which suggest that selection of the 40 percent reduction plan would have to be based on criteria other than economics; i.e., net beneficial environmental or social well-being factors. Somewhere between the 30 and 40 percent reduction levels, net economic benefits become zero (the precise point was not determined). One might be tempted to conclude that the 30 percent level of reduction should be the sediment-reduction goal. Such a conclusion would be risky since economic beneficial and adverse effects do not give a complete picture. Environmental and social well-being factors should also have a bearing on the selection of a reduction goal and may be justification for a greater (or smaller) sediment reduction level.

Looking at the maximum reduction level, 64 percent, annual net benefits are a negative $10 million. The reason for such a large negative benefit is that several costly control measures are required to achieve the maximum least-cost reduction. Comparing costs, it can be seen that a substantial increase is required for the 4 percent sediment reduction obtained going from the 60 percent reduction to the 64 percent reduction, from $2,754,230 to $14,142,620. The larger sediment-reduction levels would likely be prohibitive from an economic standpoint.

1/ Annual costs were amortized using the current interest rate (6 5/8 percent) in federal resource projects set by the Water Resources Council.

Table X-2.--Comparison of alternative control programs, all lands, Tillamook Bay Drainage Basin, 1975

Alternative Plans	Levels of Reduction						
	10%	20%	30%	40%	50%	60%	Maximum 64%
	$	$	$	$	$	$	$
Economic Development:							
Average annual beneficial effects							
Reduced land loss	1,080	1,900	2,590	3,450	4,010	4,600	4,910
Reduction in sediment	19,390	38,780	58,180	77,570	96,970	116,360	124,180
Increased agricultural production	--	--	--	--	--	--	374,200
Increased forest production	47,540	95,060	197,580	228,200	336,590	1,149,190	2,310,760
Employment							
Installation	1,010	2,370	7,030	14,350	41,170	105,960	501,700
O&M	1,140	2,680	7,950	16,220	46,530	119,760	567,040
TOTAL	70,160	140,790	273,330	339,790	525,270	1,495,870	3,882,790
Adverse effects							
Average annual cost of measures	26,330	63,350	170,950	368,590	1,046,290	2,754,230	14,142,620
Net beneficial effects	43,830	77,440	102,380	-28,800	-521,020	-1,258,360	-10,259,830

Environmental Quality:
Beneficial and adverse

10%: There would be 1,088 acres of improved wildlife habitat available as forage and cover. 1,058 acres would become usable as cover only in about 20 years.

There would be improved shading of about 50 miles of stream.

A slight improvement in water quality.

Less fine sediment to clog spawning gravels.

Improved visual quality of the stream environment.

Improved visual quality of another 207.5 acres of Tillamook Burn.

Improved visual quality of about 851 acres of old clearcuts.

Would reduce average annual sediment yield to Bay.

Loss of vegetative conditions necessary for wildlife habitat on 1.23 acres.

20%: There would be 2,176 acres of improved wildlife habitat available as forage and cover. 2,117 acres would become usable as cover only in about 20 years.

Improved shading to about 130 miles of stream.

Some improvement of stream water quality.

A much-improved fish spawning environment.

Improved visual quality of the stream environment.

Temporary loss of wildlife habitat due to backsloping on 36.42 acres.

Rip rap would impair or destroy potential wildlife habitats due to lack of vegetation on 4.89 acres.

Improve visual quality of 415 acres of the Burn.

Improve visual quality of 1,702.25 acres on old clearcuts.

Would reduce average annual sediment yield to Bay.

Backsloping & revegetation would be subject to damage unless fencing is utilized.

30%: There would be 4,390.93 acres of improved wildlife habitat available as forage and cover. 4,234.5 acres would become usable as cover only in about 20 years.

There would be a loss of 11.73 acres of shoreline habitat due to rock rip rap and pit run rock.

Improved shading to about 180 miles of stream.

Improved visual quality of the stream environment.

A temporary (1-3 years) disruption of instream environment on 3.82 acres of streambed.

A temporary loss of 66.83 acres of shoreline habitat due to backsloping.

A significant improvement in water quality.

Improve visual quality of 960 acres of the Burn.

Improve visual quality of 3,274.5 acres of old clearcuts.

Treatment measures will reduce sediment yield to Bay.

Backsloping & revegetation would be subject to damage unless fencing is utilized.

40%: There would be 5,903.22 acres of improved wildlife habitat for forage and cover. 5,015.5 acres would become usable as cover only in about 20 years.

Improved shading on about 274 miles of stream.

A loss of 33.33 acres of shoreline habitat to rock rip rap and pit run rock.

A temporary loss of 43.23 acres of shoreline habitat due to backsloping.

Temporary disturbance of instream environment on 44.7 acres.

Water quality would be greatly improved.

Improved visual quality of streamside and roadside environment.

Backsloping & revegetation would be subject to damage unless fencing is utilized.

Improve visual quality of the Burn and of old clearcuts.

Treatment will reduce sediment to the Bay.

50%: There would be 14,120.87 acres of improved wildlife habitat for forage and cover. 7,486.5 acres would become usable only in about 20 years.

Improved shading of about 270 miles of stream.

Improved visual environment of streams and roadsides.

A loss of 64.56 acres of shoreline habitat.

Temporary disruption of 222.9 acres of stream bottom environment.

Temporary loss of 113.6 acres of shoreline habitat.

Water quality would become very good.

Backsloping & revegetation would be subject to damage unless fencing is utilized.

Improve visual quality of the Burn and of old clearcuts.

Treatment will reduce sediment yield to the Bay.

60%: There would be 35,451.35 acres of improved wildlife habitat for forage and cover. 29,077.5 acres would become usable as cover only in about 20 years.

Improved shading of about 258 miles of stream.

Improved visual environment of stream and roadsides.

A loss of 76.56 acres of shoreline habitat to rock rip rap and pit run rock.

A temporary loss of 40.07 acres of shoreline habitat due to backsloping.

A temporary disruption of the instream eco-system.

Water quality would be excellent.

Spawning gravels would be relatively free of sediments.

Improve visual quality of the Burn and of old clearcuts.

Treatment will reduce sediment yield to the Bay.

Maximum 64%: There would be 68,007 acres of improved wildlife habitat for forage and cover. 51,454.5 acres would become usable as cover only in about 20 years.

Improved shading of about 262 miles of stream.

The basin would have less of the Tillamook Burn aspect, and would have an excellent visual environment throughout.

Loss of 102.3 acres of shoreline habitat due to rock rip rap and pit run rock.

Temporary disruption of 215.8 acres of instream eco-system.

Water quality would be as near to the natural system as is possible today.

Salmon and steelhead runs would have maximum habitat available for propagation.

Social Well Being:
Beneficial and adverse

10%: The impact of floods on loss of life and property due to sediment would be slightly reduced.

Some stream banks treated would be safer for bank fishermen.

Cattle access trails would provide established entry into channel bottom and would also serve as natural drainageways for rapid removal of floodwater from farm operation areas.

Rip rap would provide improved protection for farm operations and urban development and would prevent loss of additional pastureland.

Rip rap could result in serious injuries with regard to access of personnel to channel.

20%: The impacts of flooding on loss of life and property due to sediment would be noticeably reduced.

Volume of sediment deposited on crop lands would be partially reduced.

Some stream banks treated would be safer for bank fishermen.

Would provide improved access to channel area for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel

30%: The impacts of flooding on loss of life and property due to sediment would be significantly reduced.

Volume of sediment deposited on crop lands would be reduced noticeably.

Some stream banks treated would be safer for bank fishermen.

Would provide improved access to channel area for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel.

40%: The impacts of flooding on loss of life and property due to sediment would be greatly reduced.

Volume of sediment deposited on croplands would be significantly reduced.

Some stream banks treated would be safer for fishermen.

Roads would be safer to drive.

Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.

Deferred grazing would improve existing pasture land.

Will provide better access to channel bottom for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel.

50%: The impacts of flooding on loss of life and property due to sediment would be greatly reduced.

Sediment deposition on cropland would be greatly reduced.

Some stream banks treated would be safer for fishermen.

Roads would be safer to drive.

Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.

Deferred grazing would improve existing pasture land.

Will provide better access to channel bottom for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel.

60%: The impacts of flooding on loss of life and property due to sediment would be greatly reduced.

Sediment deposition on cropland would be minor.

Some stream banks treated would be safer for fishermen.

Roads would be safer to drive. Some roads which are not usable during wet seasons could be used without damage to vehicles or resources.

Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.

Deferred grazing would improve existing pasture land.

Will provide better access to channel bottom for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel.

Maximum 64%: The impacts of flooding on loss of life and property due to sediment from forest lands is reduced to insignificance.

Sediment deposition on cropland would be minor.

Some banks would be safe for fishermen.

Roads would be safer to drive. The basin would be accessible by all-weather roads.

Reduction of sediment would permit better crop development, thus avoiding out-of-area purchase of feed for cattle.

Deferred grazing would improve existing pasture land.

Will provide better access to channel bottom for recreational purposes.

Rip rap could result in serious injuries with regard to access of personnel to channel.

1/ Average annual costs were amortized using the current interest rate in federal water resource projects set by the Water Resources Council (6 5/8 percent).

IMPLEMENTATION CONSIDERATIONS

The study team has not developed a preferred or recommended alternative for this report. There are too many questions which remain unanswered at this time, the most critical of which is the establishment of sediment-reduction goal. These questions must be answered before a preferred alternative can be recommended.

The levels of sediment reduction as presented in this report are based upon a least-cost analysis of all alternative measures. The levels themselves were selected at 10 percent reduction levels except for the maximum which was dictated by the upper limit of feasible program accomplishment. This analysis was presented with specific constraints as noted in previous sections.

The local people anticipate utilizing data presented in this report as basic data inputs into a land-use plan for Tillamook County. The land-use plan is being developed under contract at this time. Decisions will be made by local people, hopefully including the aforementioned establishment of a sediment-reduction goal. Implementation of individual treatment measures selected through the county land-use planning process may be assisted by several federal programs. Potential sources of financial and technical assistance are quite varied and often require some prior knowledge of their existence. A publication is available entitled Catalog of Federal Domestic Assistance, which catalogs over 1,000 grant, loan, or technical advice and information programs administered by 55 Federal agencies.

The United States Department of Agriculture recognized the frustration which an individual or organization may experience in using this document. To help with this problem, the Department has computerized a portion of the catalog for programs which pertain to problems facing local governments. This program will search the records with a minimum of time and effort to identify programs in a particular category for which the applicant is eligible. The computer will print a list of the program titles and catalog numbers which can then be used to refer back to the 900-page catalog for more complete information. The Oregon State University Extension Service makes this resource available to communities of the State. Trained staff can assist interested community representatives in obtaining information. The service is available to both public and private individuals and groups.

The study team staff has searched the catalog and selected those programs which appear to have some potential application to the Tillamook study area. These are listed on Table X-3. Detailed descriptions of the programs and applications for assistance are available through the responsible agencies.

Some of the programs listed on Table X-3 may not have a direct relationship to erosion and sediment reduction. They may provide benefits to resources affected by erosion and sediment problems; monitor the erosion, sediment, and flood situation; provide means of enhancement of recreation, environmental, and economic values of natural resources upon which erosion and sediment problems may have an impact; and provide potential means of funding and employment to accomplish erosion and sediment reduction.

Various other means (other than federal-assistance programs) of promoting sediment reduction might also be considered in the planning of an implementation program. Some of these means could include:

- Educational programs and workshops

- Tax benefits

- New laws and regulations

- Stricter enforcement of existing laws

- Zoning

- Monetary incentives.

Formulation of a sediment-reduction plan will necessarily require the input of many individuals, groups, and agencies - local, state, and federal. An implementation plan requires that a sediment-reduction goal be established, and that funding sources be identified. The data and model presented in this report could be an important aid in the formulation of a sediment reduction implementation plan.

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction,
Tillamook Bay Drainage Basin, 1978.

Department, Agency, and Program	Short Title	Index [1]	Relationship to Study	Type of Assistance [2]
U.S. DEPARTMENT OF AGRICULTURE:				
ASCS-Agricultural Stabilization and Conservation Service				
Emergency Conservation Measures	ECM	10.054		B
Water Bank Program		10.062		B, K
Agricultural Conservation Program	ACP	10.063		B
Forestry Incentives Program	FIP	10.064		B
FHA-Farmers Home Administration				
Irrigation, Drainage, and other Soil and Water Conservation Loans		10.409		F
Recreation Facility Loans		10.413		F
Resource Conservation and Development Loans		10.414		F
Soil and Water Loans	SW	10.416		F
Watershed Protection and Flood Prevention Loans		10.419		F
FS-Forest Service				
Assistance to States for Tree Improvement	TITLE IV	10.655		B
Cooperative Forest Fire Control		10.656		A
Cooperation in Forest Management and Processing	CFM	10.657		A
Cooperative Forest Insect and Disease Management	FIDM	10.658		B
Cooperative Production and Distribution of Forest Tree Planting Stock		10.659		B
General Forestry Assistance	GFA	10.660		B
Youth Conservation Corps-Grants to States		10.661		B
Rural Community Fire Protection	RCFP	10.662		B
SCS-Soil Conservation Service				
Resource Conservation and Development		10.901		B, K
Soil and Water Conservation		10.902		K
Watershed Protection and Flood Prevention	PL-566	10.904		B, K
Plant Materials for Conservation		10.905		H
River Basin Surveys and Investigations	CRBS .	10.906		J, K
U.S. DEPARTMENT OF COMMERCE:				
EDA-Economic Development Administration				
Economic Development-Grants & Loans for Public Works & Development Facilities		11.300	Flood Control	B, E
Economic Development-Support for Planning Organizations		11.302		B
Economic Development-Public Works Impacts Projects		11.304	Jobs for Unemployed	▪
Economic Development-State & Local Economic Development Planning		11.305		B
Economic Development-District Operational Assistance		11.306		B
Economic Development-Special Economic Development and Adjustment Assistance Program		11.307		B
Grants to States for Supplemental & Basic Funding of Titles I, II, III, IV, and IX Activities		11.308		
Redevelopment Area Loan Program	204	11.310		E

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Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction, Tillamook Bay Drainage Basin, 1978. (continued)

Program	Code	No.	Item	Notes
NOAA—National Oceanic and Atmospheric Administration				
Nautical Charts and Related Data		11.401	Channel Measurements	J, K, L
Commercial Fisheries Disaster Assistance		11.406	Fisheries Restoration	B
Commercial Fisheries Research and Development		11.407		A
Coastal Zone Management Program Development		11.418		B
Coastal Zone Management Program Administration		11.419		B
Coastal Zone Management Estuarine Sanctuaries		11.420	Estuarine Monitoring	B
Maritime Administration				
Development and Promotion of Ports and Intermodal Transportation		11.501		K, L
Development and Promotion of Domestic Water-borne Transport Systems		11.509		K, L
National Technical Information Service				
National Technical Information Service	NTIS	11.650	Computerized Research Information	
U.S. DEPARTMENT OF DEFENSE - ARMY:				
Army Corps of Engineers				
Aquatic Plant Control		12.100	Obnoxious Plant Control	J, L
Beach Erosion Control Projects		12.101		J
Flood Control Works and Federally Authorized Coastal Protection Works, Rehabilitation	PL-99	12.102		J
Flood Fighting and Rescue Operations, and Emergency Protection of Coastal Protective Works Federally Authorized	PL-99	12.103		J
Flood Plain Management Services	FPMS	12.104		K, L
Protection of Essential Highways, Highway Bridge Approaches and Public Works		12.105	Emergency Bank Protection	
Flood Control Projects		12.106		
Navigation Projects		12.107		
Snagging and Clearing for Flood Control		12.108		
Snagging and Clearing for Navigation		12.109		
Planning Assistance to States	SEC-22	12.110		
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE:				
Office of Education				
Environmental Education		13.522	Resource Allocation, Conservation	
University Community Service-Special Projects		13.557	Environmental Pollution	
Social and Rehabilitation Service				
Public Assistance-State and Local Training		13.724	Assistance Plan Training	
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT:				
Federal Insurance Administration				
Flood Insurance		14.001		
Community Planning and Development				
Comprehensive Planning Assistance	"701"	14.203	Funds for Local Planning	
Community Development Block Grants/Discretionary Grants		14.219		
Federal Disaster Assistance Administration				
Disaster Assistance		14.701	Disaster Plans and Programs	
State Disaster Preparedness Grants		14.702		

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Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction, Tillamook Bay Drainage Basin, 1978. (continued)

U.S. DEPARTMENT OF THE INTERIOR:

Program		Code	Description	
Bureau of Land Management				
Public Land for Recreation, Public Purposes, and Historic Monuments		15.202	Recreation Planning Development	B
Public Land for Right-of-Way		15.203		
Bureau of Outdoor Recreation				
Outdoor Recreation-Aquisition, Development, and Planning		15.400	Land & Water Conservation Fund Grants	A
Outdoor Recreation-Technical Assistance		15.402		J
Fish and Wildlife Service				
Fish Restoration		15.605	Restore Sports Fishing	
Sport Fish Technical Assistance		15.608	Sediment Effects on Fish Runs	
Geological Survey				
Water Resources Investigations		15.804	Stream Flow & Sediment Monitoring	J, L
Office of Water Research and Technology	TITLE II			
Additional Water Resources Research		15.950	Research	B, P
Water Resources Research-Assistance to State Institutes		15.951	Research	A
Water Resources Research-Matching Grants to State Institutes		15.952	Research	B
Water Resources Scientific Information Center	WRSIC	15.953	Technical Information	L

U.S. DEPARTMENT OF LABOR:

Program		Code	Description	
Employment and Training Administration				
Job Corps		17.211	Sediment Control Project Training	B
Employment & Training Institutional Grants		17.219	Training for Planners	B
Comprehensive Employment & Training Programs	CETA	17.232	Job Training & Employment	A, B
Employment & Training Research and Development Projects		17.233		

U.S. DEPARTMENT OF TRANSPORTATION:

Program	Code	Description	
Federal Highway Administration			
Highway Research, Planning, & Construction	20.205	Disaster & Other Road Repair	A, B
Federal Railroad Administration			
Railroad Rehabilitation & Improvement – Guarantee of Obligations	20.309		F
Railroad Rehabilitation & Improvement – Redeemable Reference Shares	20.310		C

U.S. CIVIL SERVICE COMMISSION:

Program	Code	Description	
Federal Employment for Disadvantaged Youth – Summer	27.004	Summer Aids Program	O
Federal Summer Employment	27.006	Summer Jobs	O
Training Assistance to State & Local Governments	27.009		K, L, M

U.S. NATIONAL SCIENCE FOUNDATION:

Program	Code	Description	
Intergovernmental Program	47.036	Local Government Technology Integration	B

U.S. COMMUNITY SERVICES ADMINISTRATION:

Program	Code	Description	
Community Action	49.002	Unemployment Relief	B
Community Economic Development	49.011	Unemployment Relief	B

Table X-3.--Federal assistance programs having a potential relationship to soil erosion and sediment reduction, Tillamook Bay Drainage Basin, 1978. (continued)

U.S. SMALL BUSINESS ADMINISTRATION:

Program	Number	Code	Note	Type
Economic Injury Disaster Loans	59.002	EIDL		E, F
Physical Disaster Loans	59.008	DL		E, F

U.S. WATER RESOURCE COUNCIL:

Program	Number	Code	Note	Type
Water Resource Planning	65.001	TITLE III		A

U.S. ENVIRONMENTAL PROTECTION AGENCY:

Office of Water and Hazardous Materials

Program	Number	Code	Note	Type
Water Pollution Control – State and Interstate Program Grants	66.419	106	Water Pollution Control	A
Water Pollution Control – State and Local Manpower Program Development	66.420		Manpower Training	B
Water Quality Control Information System– Orientation/Training Seminars, Data and Monitoring Publications	66.423	STORET		M
Water Pollution Control – State and Area-wide Water Quality Management Planning Agency	66.426			B
Water Pollution Control Loans	66.431		Partly Relates to Dredging	E

Office of Research and Development

Program	Number	Code	Note	Type
Environmental Protection – Consolidated Research Grants	66.500			B
Water Pollution Control – Research, Development, and Demonstration Grants	66.505			B

Office of Planning and Management

Program	Number	Code	Note	Type
Environmental Protection Consolidated Grants– Program Support	66.600			B
Environmental Protection Consolidated Grants– Special Purpose	66.602			B

PACIFIC NORTHWEST REGIONAL COMMISSION:

Program	Number	Code	Note	Type
Pacific Northwest Regional Economic Development	76.001	TITLE V		B
Pacific Northwest Technical and Planning Assistance	76.002		Demonstration Projects	B
Pacific Northwest Regional Transportation	76.004		Transportation Modes (Barging Logs?)	B

1/ For more information, see Catalog of Federal Domestic Assistance, OMB, Washington, D.C.
2/ A–Formula Grants, B–Project Grants, C–Direct payments for specified use, E–Direct loans, F–Guaranteed/insured loans, G–Insurance, H–Sale, exchange, or donation of property and goods, J–Provision of specialized services, K–Advisory services and counseling, L–Dissemination of technical information, M–Training, O–Federal employment, P–Research contracts.

MANAGERIAL STRATEGIES

Several alternative plans to reduce sediment were developed during the course of this study. For reasons that are stated elsewhere in this report, an implementation plan was not developed. There will be a need to continue to provide assistance after conclusion of this study, during implementation phases. This continued cooperative effort should include detailed problem analysis based upon problem-specific data, and an analysis of the future situation based upon proposed future land resource management objectives.

Some problem relationships must be explained to obtain a clearer picture of the least-cost combination of selected alternatives. Some alternative measures do not appear until the 60 percent solution, and others do not enter until the maximum solution. Yet, there may be instances when a preferred solution at, say, the 30 percent level should include one or more measures that are not a part of the least-cost combination at the 30 percent level. Some of these situations will be discussed next.

1. <u>Roads and trails related to gullies and landslides</u>.

Many miles of roads and trails in the study area are currently contributing an insignificant amount of sediment when the total existing problem is analyzed. The potential exists for some of these trails to become serious gullies and landslides. This potential cannot be ignored in the selection of treatment measure alternatives.

Motorcycle trails, for example, which are nearly parallel (plus or minus 30°) to the slope on steep (50% plus) terrain in those areas noted as having a severe or very severe potential erosion hazard, must be considered if future, more serious problems are to be prevented. Many trials already exceed 2 feet in depth and could be accelerated into a landslide or massive gully by a major storm event.

Landslides begin to enter the solution at the 30 percent level. There is a causal relationship between some of the existing slides and some roads. All slides selected for treatment must be examined for this potential situation. When a causal relationship between a road and a slide exists, the road problem must also be treated at the same time if slide stabilization efforts are to be effective.

2. <u>The problem with averages</u>.

Sediment rates used in the least-cost model are estimated averages
for each kind of sediment source for each of the sub-watersheds. The
costs and effects of alternative treatment measures are also estimated
averages. Solutions selected by the least-cost model are based upon
these averages. Selection of individual problem sources to receive
indicated treatment measures must be based upon field examination of
all applicable source areas. Examination of source areas would be
appropriate until all sources of a specific problem entered at the maximum
possible sediment reduction. An example follows.

Channel bank stabilization is called for on forested lands
for 29.7 acres at the 10 percent level. The balance of 70.8
acres enters at the 30 percent level. All 70.8 acres would
have to be examined on the ground to select the 29.7 acres
to be treated at the 10 percent level.

3. <u>Multiple goal considerations</u>.

The least-cost selection of alternative treatment measures
is based on the goal of sediment reduction to the bay. In some
instances, other goals may take precedence. For example, the
least-cost sediment control solutions for several reduction
levels include rock riprap. However, decision makers may de-
cide that rock riprap is not a desirable solution because of
environmental or other considerations. Thus, these other con-
siderations, or goals, may take precedence over the goal of
achieving sediment reduction at least cost. When these other
considerations become known, they can be translated into con-
straints for the least-cost solutions; e.g., no more than so
many acres of rock riprap.

4. <u>Treatment measures to solve nonsediment problems</u>.

Decision makers and planners must not lose sight of alter-
native treatment measures at levels above the selected goal.
Again, referring to Number 2 preceding, the rates, costs, and
effects used in the model are averages. If the goal is to re-
duce sediment by 40 percent, management must not lose sight
of those problem sources and treatment measures which come in
at the 50 and 60 percent solution levels. There may be source
areas and treatment measures at these higher levels which, when
viewed on an individual basis, would be preferred over a selected
least-cost sediment reduction source or treatment. Resource
management goals, environmental goals, or other economic factors
not related to sediment reduction may influence this decision.
Examples of this situation follow.

All feasible channel bank critical erosion is selected by
the model for treatment at the 30 percent level. Some
slides are also selected at that level. Additional slides
come in at the 40-50 percent levels. There may be a slide
at the 40 percent level which, when viewed on an individual
basis, should be corrected for reasons other than sediment
control; e.g., a slide blocking a key access road or an
anadromous fish stream. Resource management and environ-
mental goals may dictate selection of that particular slide
over a source selected by the model at the lower reduction
level.

5.   The importance of goal selection prior to implementation.

Selection of a sediment-reduction planning goal is important
prior to implementation of treatment measures selected by the model.
This point is demonstrated by the following example.

Channel bank stabilization on forested lands enters the
30 percent solution on 66.8 acres. The treatment mea-
sure is to backslope and plant brush. At the 40 percent
level only 6 acres of channel banks would be treated by
backsloping and planting brush. For the model to achieve
a 40 percent reduction, it was necessary to go to rock rip-
rap which reduces sediment by a larger amount. If a plan
were implemented at the 30 percent level and later changed
to the 40 percent level, then the backsloping and brush
planting, already installed, would not be a part of the
40 percent solution, It would have been more efficient to
have implemented the 40 percent plan directly rather than
using measures from the 30 percent plan as a "stepping stone."
Proposed changes to a sediment reduction goal should be examined
carefully to avoid inefficient allocations of treatment re-
sources.

6.   A note on restoration versus prevention

Many of the major forested land-erosion problems stem from
several destructive fires that have occurred over the last 60 years.
A number of these old erosion problems still exist today. To a
large extent, this study concentrated on these chronic erosion
problems. Many treatment measures shown in this study are restor-
ative in nature; aimed at correcting old erosion problems.

Resource managers now distinguish between resource capability
and resource suitability. Resource capability is defined with ref-
erence to the productive capacity or the potential of fixed re-
sources to produce valuable (in an economic sense) renewable re-
sources. Resource suitability is defined in terms of the appropriate-
ness of harvesting, or otherwise making use of the resource. For

example , a steep, forested slope may have the capability of producing commercial timber, but because of a severe erosion potential or other adverse environmental consequences, resource managers may decide that the timber is unsuitable for intensive management due to environmental constraints and the limitations of present technology.

The distinction between capability and suitability is important. In terms of erosion and sediment control programs, suitability relates to preventive control measures rather than restorative measures. Several on-going programs in the basin are preventive; that is, aimed at preventing erosion problems from occurring in the future even though no present erosion problem exists. Advanced logging systems, and establishment of cover crops on agricultural lands prior to the fall and winter rainy seasons, are examples of preventive control practices.

Preventive techniques are better understood today because of improved resource inventories relating capability and suitability. Better decisions are being made today because of improved technology and management's willingness to understand and mitigate the environmental risks.

The study team concentrated on major erosion problems as they existed during the course of study. Future or potential sources of erosion, and corresponding preventive treatment measures were not a specific study objective. Preventive, on-going treatment measure programs should be continued and strengthened.

FUTURE CONSIDERATIONS - THE MODEL

In the previous section on managerial strategies, several suggestions were made relative to implementation planning. The computer model that was used to help develop least-cost combinations of control measures is on file and available. It could be put to beneficial use during the implementation- planning process. Ways in which the model could be of further use are explained next.

- Any number of constraints can be placed on treatment measures and sediment sources. Suppose, for example, rock riprap was determined not to be an acceptable solution in some sub-basins. The model could be re-run for a least-cost solution with rock riprap constrained to less than a specified number of acres.

- The model can be used to determine how much sediment reduction is possible, subject to a limit of funds available for sediment-control measures. Suppose, for

example, $100,000 were made avaialble for sediment con-
trol. The model could be used to determine the treat-
ment measures that would bring about the largest sedi-
ment reduction with that amount of money.

- This study dealt with sediment. Since erosion rates
  are already in the model, it could be rerun with erosion
  reduction as the objective. Least-cost solutions for
  specified levels of erosion reduction would then be the
  model output.

- Erosion and sediment could be combined into joint ob-
  jective functions.

- The model could be run to solve for the least-cost sedi-
  ment (or erosion) control measures for any combination
  of the 16 sub-basins. Forested lands could be run sep-
  arately from agricultural lands, for example.

- As the time goes by, changes will occur in the acreages
  of erosion sources. Also, changes will occur in ero-
  sion and sediment rates by source. Significant changes,
  mostly increases, will occur for control costs. To
  some extent, particularly on forested, publicly owned
  lands and on large timber holdings, programs have been
  planned far into the future. These planned changes
  could be run through the model to develop future strat-
  egies for erosion and sediment control.

Another model, input-output, is available and could be of
use during implementation planning. The input-output model was
developed specifically for the Tillamook economy. It could be
used to evaluate the secondary economic effects of an imple-
mentation program on major economic sectors in the Tillamook
County economy.

GLOSSARY

GLOSSARY

Aggradation   To build up grade or slope of a channel by
               deposition of sediment.

Amphibole   A mineral composed largely of silica, calcium,
               and magnesium. (ex. - hornblende, asbestos).

Anadromous   Fishes which spend part of their lives in the
               ocean but move into fresh water to spawn.

Andesite   Fine-grained, dark gray rock of volcanic origin
               containing phenocrysts of feldspar and darker
               minerals.

Annelid   Worm with a body made of joined segments or rings.

Augite   A black, complex silicate mineral occuring in
               basic igneous rocks.

B.P.   Before present - 1950.

Basalt   A hard, heavy, dark colored rock of volcanic origin.

Breccia   A rock consisting of sharp cornered fragments of
               glacial or volcanic origin which are cemented to-
               gether with sand or clay.

Coefficient   Coefficient of Correlation is a statistical term for
               the measure of dependence of one variable or another
               variable.

               Coefficient of Determination is a statistical term
               which is the ratio of the explained variation to the
               total variation. Mathematically, it is the square of
               the coefficient of correlation.

Crustacean   A class of invertebrates that live in water and
               breathe through gills (shrimp, crab, etc.)

Dendrite   Tree-like; branching in form.

Detrital   Fragments of rock, etc.; produced by disintegration
               or wearing away.

Diabase	A dark colored igneous rock made up largely of augite and feldspar.
Diopside	A kind of pyroxene, usually transparent.
Diorite	A dark gray or greenish igneous rock, consisting chiefly of feldspar and hornblende.
Dipteras	A large group of insects having one pair of membranous wings (housefly, mosquito, etc.)
Diurnal	Daily; happening each day.
Ecology	Branch of biology that deals with the relations between living organisms and their environment.
Eocene	Period of geologic time. Earliest epoch of Tertiary Period during which mammals became the dominant animals.
Estuarine	Formed or deposited in an estuary.
Estuary	A semi-enclosed coastal water body having free connection with the open sea with which sea water is measurable mixed with fresh water drained from the land.
Eutrophication	A means of aging of a body of water whereby aquatic plants and marine life are abundant and waters are deficient in oxygen.
Feldspar	Crystalline minerals made up of aluminum silicates and found in igneous rocks.
Fluvial	To flow; found in or produced by a river or rivers.
Gabbro	Dark, heavy igneous rock composed chiefly of pyroxene and feldspar.
Geanticline	A great upward folding of the earth's crust.
Holocene	Recent epoch of geologic time.
Hypersthene	A greenish-black mineral of the pyroxene group, a silicate of iron and magnesium.
Kilometer	A unit of length or distance, equal to 1000 meters.

Lacustrine	Sediment deposits in or on lakes.
M.S.L.	Mean sea level.
Micaceous	Characteristic of mica (thin, transparent, easily separated layers).
Miocene	Period of geologic time. Third era of tertiary Period characterized by development of large mountain ranges.
Nonopaque	Letting light pass through substances.
Oligocene	Period of geologic time. Second epoch of Tertiary Period characterized by the development of the higher mammals.
Olivine	A silicate of magnesium and iron, existing usually as green crystals and used as a semiprecious stone.
Orthopyroxene	Regular silicate mineral containing iron, magnesium, and calcium found in igneous rocks.
Pileated	Having a crest extending from the bill to the nape (ex. woodpecker).
Pixel	Decision model for establishing erosion control strategies.
Pleistocene	Period of geologic time. First epoch of Quaternary Period characterized by rise and recession of contnental ice sheets and by the appearance of man.
Pliocene	Period of geologic time. Last epoch of the Tertiary Period during which modern plants and animals were developed.
Pyroxene	A complex silicate mineral containing iron, magnesium, and calcium and found in igneous rocks.
Quasistationary	In a sense stationary or not moving.

Rill	A groove, furrow or long, narrow, shallow trench.
Riverine	Of, like, or produced by a river or rivers.
Sheet	A layer of soil that is broad in extent and comparatively thin.
Shoaling	When a ridge of sand or silt is deposited across the mouth of a river resulting in shallow water.
Spatial	Happening or existing in space.
Temporal	Lasting only for a time; temporary.
Terrestrial	Consisting of land as distinguished from water.
Tertiary	First period of Cenozoic Era or its system of rocks.
Transgressive	Tending to overstep or go beyond.
Tuffaceous	Of or like tuff, a porous rock formed by consolidation of volcanic ash and dust.
Winnowing	To analyze or examine carefully in order to separate the various elements.

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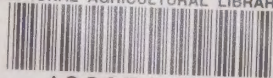
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