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Report to Congressional Requesters

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OREGON WATERSHEDS

Many Activities Contribute to Increased Turbidity During Large Storms

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The Honorable Dale Bumpers
Ranking Minority Member, Committee
on Energy and Natural Resources
United States Senate

The Honorable Ron Wyden
United States Senate

In response to your requests and as agreed with your offices, this report describes (1) the human activities that may have contributed to the high turbidity levels in western Oregon's municipal watersheds in February 1996 and (2) the efforts under way by federal, state, local, and private land managers and owners, as well as the affected cities, to ensure safe drinking water during future storms. We limited our review to five municipal watersheds—those serving the cities of Cottage Grove, Eugene, Portland, Salem, and Sandy. The report contains recommendations to the Secretaries of Agriculture and of the Interior designed to increase the efficiency and effectiveness of efforts to improve water quality and ensure safe drinking water for cities in western Oregon.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Agriculture, the Secretary of the Interior, the Chief of the Forest Service, and the Director of the Bureau of Land Management. We will also make copies available to others upon request.

Please call me at (202) 512-8021 if you or your staff have any questions about this report. Major contributors to this report are listed in appendix III.

Barry T. Hill
Associate Director, Energy, Resources,
and Science Issues

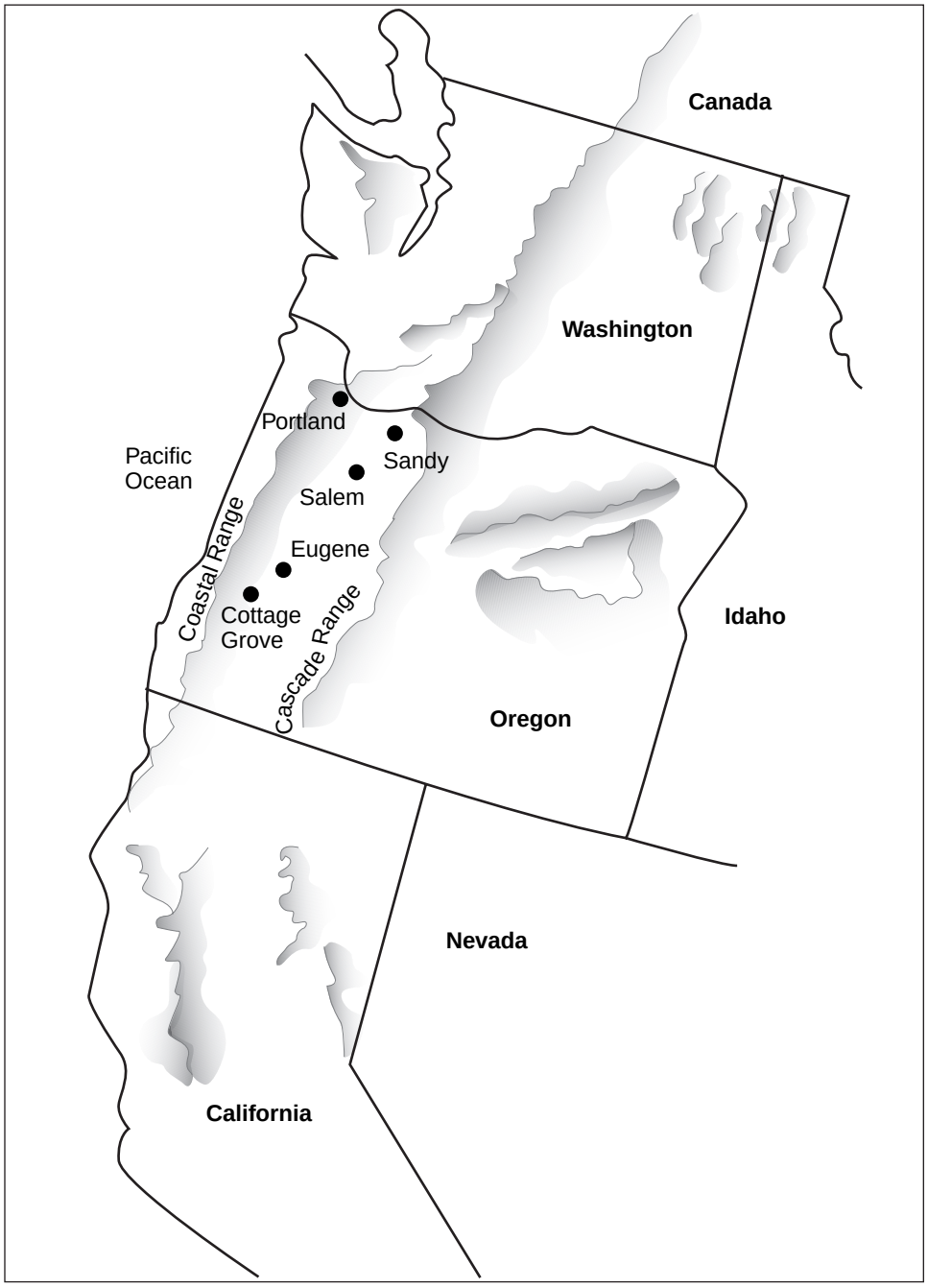
Executive Summary

Purpose

Cities in western Oregon have a history of providing safe drinking water to their residents. However, in February 1996, during the region's worst storm since December 1964, the water quality in rivers and streams was severely degraded as the amount of fine sediment suspended in the water—or turbidity—increased dramatically. Because of the increased turbidity caused by the storm, the municipal water treatment system serving Salem, Oregon, was shut down for over a week, threatening the city's ability to provide its residents with safe drinking water. Other cities in western Oregon's Willamette and Lower Columbia river basins also reported high turbidity levels in the water flowing into their municipal water treatment systems. After the storm, Salem and certain environmental groups raised concerns about the extent to which the timber harvests and forest roads on lands managed by the U.S. Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Land Management (BLM) contributed to the increased turbidity.

In response to congressional requests, this report describes (1) the human activities that may have contributed to the high turbidity levels during and following the February 1996 storm and (2) the efforts under way by federal, state, local, and private land managers and owners, as well as the affected cities, to ensure safe drinking water during future storms. As agreed with the requesters' offices, GAO limited its review to five municipal watersheds in western Oregon—those serving the cities of Cottage Grove, Eugene, Portland, Salem, and Sandy. (See fig. 1.)

Figure 1: Location of the Five Cities Included in GAO's Review



Results in Brief

GAO's review of scientific studies and other documents showed that human activities—timber harvests and related roads as well as agricultural, industrial, urban, and residential development—can contribute to elevated sediment levels during large storms. These activities result in soil that is compacted, paved, covered, or cleared of most vegetation. Rain falling on compacted or cleared soil can run off into streams, carrying with it eroded topsoil. In addition, rain falling on roofs, paved roads and parking lots, and other covered surfaces does not penetrate into the ground, thereby increasing the runoff that moves across barren or disturbed soil and eroding topsoil. This sediment can then be transported into streams. The sediment from human activities in a municipal watershed, combined with the accelerated erosion that naturally occurs during storms, can shut down a municipality's water treatment system, as occurred in Salem in February 1996.

Ongoing federal and nonfederal efforts have made significant progress in (1) mitigating the impact of human activities on water quality and ensuring safe drinking water to cities in the Willamette and Lower Columbia river basins and (2) involving more key landowners and other stakeholders in discussing, understanding, and addressing watershed issues and concerns and in implementing restoration plans. Nevertheless, some key landowners have not been included in coordination efforts, and many efforts could benefit from a better understanding of, and data on, the condition of the watersheds.

Principal Findings

Human Activities Contribute to Increased Turbidity During Large Storms

All five of the cities included in GAO's review have experienced timber harvesting and related road construction in their municipal watersheds. GAO's review of scientific studies and other documents showed that these activities can contribute to elevated sediment levels in rivers and streams during large storms. Past timber-harvesting practices, including removing all of the trees from a streamside timber-harvesting site at one time and using heavy equipment such as tractors to haul logs along trails, were often not designed to protect water quality. These practices resulted in cleared and compacted areas that exposed soil to the erosive impact of rain and contributed sediment to streams, especially during large storms. In addition, forest roads constructed prior to the early 1970s along streams and on hillsides used designs that were subject to erosion and failure.

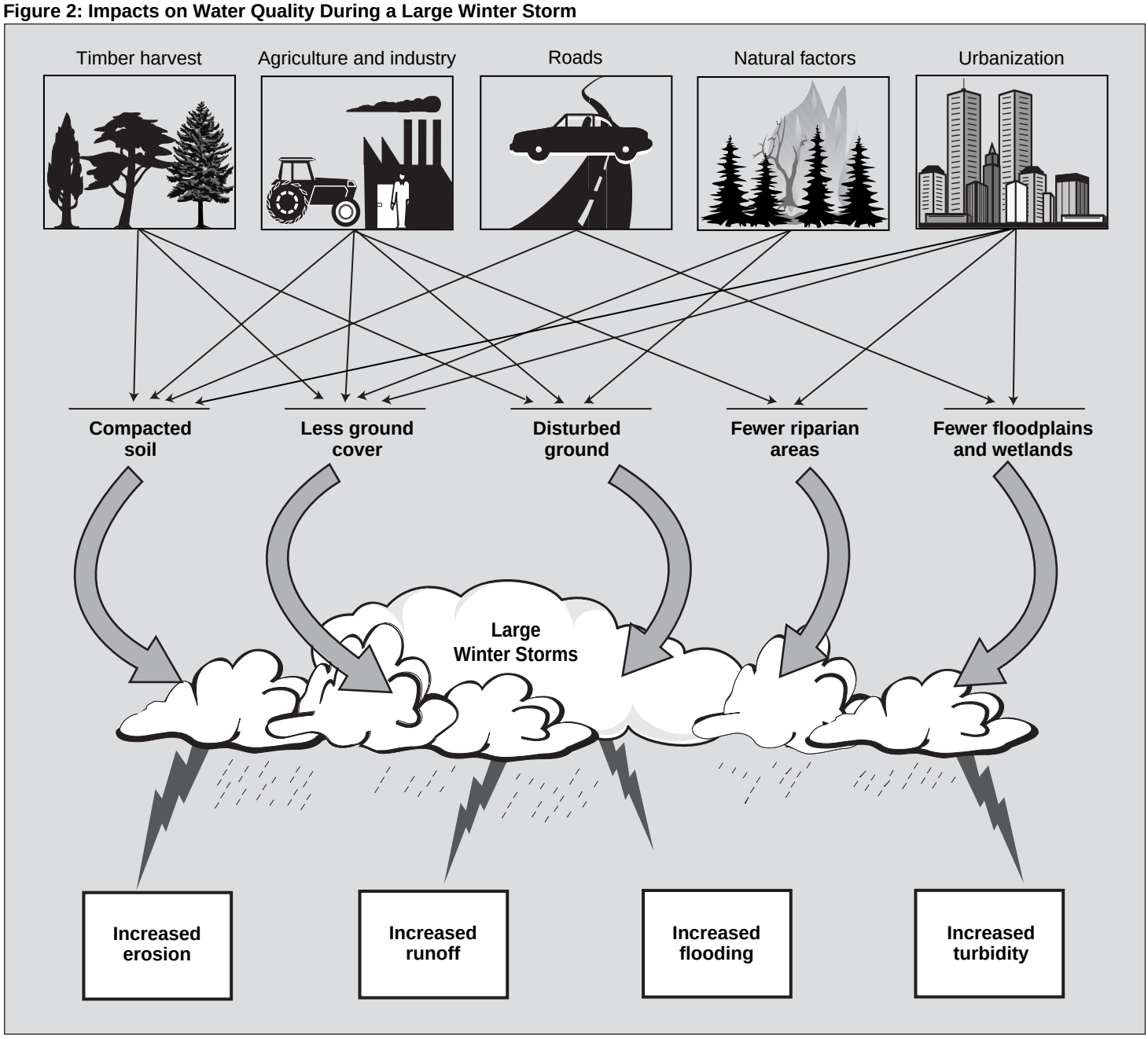
These roads have been found to be a major contributor of sediment to streams.

Two of the municipal watersheds—those serving Eugene and Salem—also have agricultural, industrial, urban, and residential development that can contribute sediment to streams during large storms. Agricultural operations can compact soil and frequently clear the land of most vegetation. A 1997 study commissioned by the governor of Oregon found that agriculture in the Willamette River basin contributes more sediment to the river than any other activity.

The 1997 study also found that urban sites in the Willamette River basin contribute the greatest amount of suspended sediment to the river on a per acre basis. Residential and industrial development have increased the percentage of the basin covered by roofs, paved roads and parking lots, and other surfaces that prevent rain from penetrating into the soil and can increase runoff and erosion during storms. In addition, streambank stabilization projects, which were constructed to protect property from flooding (1) prevent floodplains, wetlands, and riparian areas from filtering suspended sediment from surface runoff before it reaches streams and (2) increase a river's velocity and erosive power.

The accelerated erosion that naturally occurs during large storms, combined with the sediment from human activities in a municipal watershed, can shut down a city's water treatment system, as occurred in Salem in February 1996. (See fig. 2.)

Figure 2: Impacts on Water Quality During a Large Winter Storm



Salem's watershed has experienced timber harvesting and related road construction as well as agricultural, industrial, urban, and residential development, including a highway that parallels the city's sole source of drinking water—the North Santiam River. All these activities can contribute to increased turbidity during storms. The watershed also includes the Detroit Dam, and soils containing high levels of microscopic clay particles that remain suspended in the water behind the dam and may be released downstream to the city's water treatment system for days or weeks following a large storm. Because the city's water treatment system could not remove the sediment and the city lacks an adequate secondary source of water, the elevated sediment levels during and following the February 1996 storm resulted in Salem's having to (1) shut down its water treatment system for 8 days and (2) obtain an exemption from the state in order to deliver to its customers drinking water that had turbidity levels exceeding drinking water standards through July 16, 1996.

Other western Oregon cities, including the other four GAO reviewed, also experienced elevated sediment levels during and following the storm but were better prepared than Salem to continue to deliver safe drinking water to their customers. For example, although Eugene experienced sediment levels more than 20 times higher than those reported by Salem, Eugene shut down its water treatment system for about 12 hours and relied on reserve water supplies until its water treatment system could be adjusted to handle the rapidly changing turbid water.

Moreover, although Salem and certain environmental groups expressed concerns about the extent to which the timber harvests and forest roads on federal lands contributed to increased turbidity, a study by the Forest Service and others showed that (1) naturally occurring erosion and erosion from human activities on primarily nonfederal lands in the lower portions of the watershed below the Detroit Dam shut down the city's water treatment system and (2) most of the microscopic clay particles that caused the persistent turbidity in the water behind the Detroit Dam and caused the city's need to obtain an exemption to safe drinking water standards probably did not result from past timber-harvesting practices or the failure of timber-related roads on federal lands above the dam but rather from naturally occurring erosion.

Progress Has Been Made to Ensure Safe Drinking Water During Future Storms

Federal land management agencies, the state of Oregon, the municipalities, and private landowners have made significant progress in mitigating the impact of human activities on water quality and in ensuring safe drinking water to cities in the Willamette and Lower Columbia river basins. Both the Forest Service and BLM have acted within their multiple-use mandates—which include providing timber as well as protecting watersheds—to mitigate the impact of past and planned timber harvests and roads on their lands. They have also shown a willingness to involve cities and other stakeholders more in their decision-making and to come together with these parties to discuss, understand, and address watershed problems and issues and to implement restoration plans.

Similarly, Oregon regulates timber harvesting on nonfederal lands to help protect water quality. Its requirements for harvesting timber on state and private lands, although found by the Environmental Protection Agency (EPA) to be less stringent than those for federal lands, have also been recognized by EPA as best management practices. The state is also working with private landowners and farmers on a voluntary basis to reduce agriculture's contribution to water quality problems and has enacted legislation and appropriated funds to promote voluntary local watershed councils to implement plans for watershed restoration.

As part of an effort initiated by the governor to protect both water quality and salmon, the landowners of industrial forests have not only agreed to implement a voluntary program to identify and address risks to water quality caused by forest roads but have also promised about $130 million over the next 10 years to manage and upgrade older forest roads on these lands.

Finally, the Congress has acted to ensure safe drinking water for Portland by (1) enacting legislation to protect the city's watershed from settlement, development, and timber harvesting that could adversely affect water quality and (2) appropriating most of the funds to protect and restore the watershed.

Although the Forest Service, BLM, the state of Oregon, the municipalities, and private landowners have made significant progress in working together to mitigate the impact of human activities on water quality and to ensure safe drinking water to cities in the Willamette and Lower Columbia river basins, opportunities exist to improve the efficiency and effectiveness of these efforts. GAO found that as more landowners within a watershed collaborate, more activities are likely to be coordinated and

managed across the watershed, thereby better ensuring the quality of the water. However, memorandums of understanding between federal land management agencies and the cities to address watershed issues and concerns in the Willamette and Lower Columbia river basins have not included key landowners, who are critical to understanding and addressing the condition of the watershed.

For instance, the formal memorandum of understanding among the Forest Service, BLM, and Sandy on activities within the city's municipal watershed does not include a large industrial forest landowner whose holdings include a significant portion of the watershed directly above the location where water flows into the city's treatment system. Likewise, the memorandum of understanding between Salem and the Forest Service excludes both BLM and nonfederal landowners in the city's watershed.

Moreover, human activities vary by watershed, and the condition of a watershed can change over time as a result of these activities as well as of storms and other natural disturbances. Therefore, an analysis of the overall condition of a municipal watershed is essential to (1) guide project planning and decision-making and identify the restoration activities with the greatest likelihood of success; (2) make sound management decisions concerning the type, location, and sequence of appropriate management activities within the watershed; and (3) dissociate public concern about water quality from dissatisfaction over other land management issues, such as timber harvesting and road construction. However, (1) few of the watershed analyses GAO reviewed corresponded directly to the boundaries of a municipal watershed and (2) the data gathered by different federal agencies and nonfederal parties within a municipal watershed may not be comparable.

Recommendations

To increase the efficiency and effectiveness of efforts to improve water quality and ensure safe drinking water to cities in western Oregon, GAO recommends that the Secretary of Agriculture direct the Chief of the Forest Service and that the Secretary of the Interior direct the Director of BLM to include key landowners—who are critical to understanding and addressing the condition of a watershed—in memorandums of understanding with cities and in other agreements to address watershed issues and concerns. GAO also recommends that the Secretary of Agriculture direct the Chief of the Forest Service and that the Secretary of the Interior direct the Director of BLM to take the following actions when conducting watershed analyses: (1) at a minimum, gather data on

municipal water quality that are comparable with the data gathered by other federally funded analyses; (2) when feasible, include water quality as a primary focus and/or conduct the analyses along the boundaries of the municipal watersheds; (3) to the extent possible, collaborate with nonfederal land managers and owners to gather data that are comparable and useful to municipal watershed decisionmakers; and (4) when practical, develop data on the impact of new timber-harvesting methods and road construction practices on water quality.

Agency Comments

GAO provided copies of a draft of this report to the Forest Service and BLM for their review and comment. The agencies (1) stated that the report provides a comprehensive and objective view of the complexities and factors involved in watershed management in the Pacific Northwest; (2) agreed with, and promised to pursue implementation of, the report's recommendations; and (3) noted that they have made progress in developing data on the impact of new timber-harvesting methods and road construction practices on water quality. The agencies' comments appear in appendixes I and II.

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Abbreviations

BLM	Bureau of Land Management
EPA	Environmental Protection Agency
GAO	General Accounting Office

Introduction

The quality of water is described by a number of different measurements, such as its temperature, the amount of dissolved oxygen it contains, and its mineral content. One measurement for drinking water quality is its turbidity, which is the amount of suspended sediment in the water. Suspended sediment levels fluctuate with time and can change dramatically during a single day and within a short distance.

In February 1996, western Oregon experienced its worst storm since December 1964. Prior to the storm, large amounts of precipitation during the fall and early winter months of 1995 and 1996 had saturated the soil in the Cascade and Coast mountain ranges and in the valley areas. During January 1996, heavy snow had accumulated in the mountains, followed by freezing temperatures. The storm arrived with warmer temperatures and heavy rainfall—8 to nearly 15 inches in 4 days in many locations. The warm rain on top of the snow (rain-on-snow), saturated soil, and frozen ground produced rapid snowmelt and runoff, resulting in severe flooding and erosion. Water quality during the storm was severely degraded as the turbidity increased dramatically.

Because of the increased turbidity, the municipal water treatment system serving Salem, Oregon, was shut down for 8 days, threatening the city's ability to provide its residents with safe drinking water. Other cities in western Oregon's Willamette and Lower Columbia river basins—including Cottage Grove, Eugene, Portland, and Sandy—also reported high turbidity levels at the locations (intakes) where water flows into their water treatment systems. After the storm, Salem and certain environmental groups raised concerns about the extent to which the timber harvests and related roads on the lands managed by the U.S. Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Land Management (BLM) contributed to the increased turbidity.

The Federal Government Is a Major Landowner in Western Oregon

The federal government owns nearly 40 percent of the more than 15 million acres of land in western Oregon, most of which are managed by the Forest Service and BLM. Less than 100,000 acres are managed by other federal agencies, including Interior's National Park Service. The remaining lands are under various ownerships, including state and local governments and industrial and private landowners.

In the Cascade mountain range, Forest Service lands are located primarily in the higher elevations, while BLM lands are located primarily in the lower

elevations. Both agencies manage lands interspersed throughout the Coast mountain range.

Several cities—both large and small—in western Oregon's Willamette and Lower Columbia river basins obtain their drinking water from the streams that drain watersheds in the nearby Cascade and Coast mountain ranges.[1] The Forest Service and BLM manage lands within many of these municipal watersheds, and the condition of their lands affects the quality of the water that flows from them.

Both the Forest Service and BLM Manage Their Lands Under the Principles of Multiple Use and Sustained Yield

The Forest Service manages about 4.3 million acres of land in western Oregon. The laws guiding the management of the National Forest System require the agency to manage its lands under the principles of multiple use and sustained yield to meet the diverse needs of the American people. Under the Organic Administration Act of 1897, the national forests are to be established to improve and protect the forests within their boundaries or to secure favorable water flow conditions and provide a continuous supply of timber to citizens. The Multiple-Use Sustained-Yield Act of 1960 added the uses of outdoor recreation, range, watershed, and fish and wildlife. This act also requires the agency to manage its lands to provide high levels of all of these uses to current users while sustaining undiminished the lands' ability to produce these uses for future generations (the sustained-yield principle). Under the National Forest Management Act of 1976 and its implementing regulations, the Forest Service is to (1) recognize wilderness as a use of the forests and (2) maintain the diversity of plant and animal communities (biological diversity).

Similarly, the Federal Land Policy Management Act of 1976 requires BLM to manage its lands for multiple uses and sustained yield. The act defines multiple uses to include recreation; range; timber; minerals; watershed; fish and wildlife; and natural scenic, scientific, and historic values.

About 2.6 million acres of Oregon and California Railroad and Coos Bay Wagon Road grant lands in western Oregon are managed primarily by BLM under the Oregon and California Grant Lands Act of 1937. Under the act, timber on these lands managed by BLM is to be sold, cut, and removed in conformity with the principle of sustained yield for the purpose of

[1]A watershed is an area of land in which all surface water drains to a common point. A watershed can range from less than 100 acres that drain to a stream to many thousands of acres that drain through hundreds of smaller streams to a large, single stream or river. A watershed from which a city obtains its drinking water is called a "municipal watershed."

providing a permanent source of timber supply, protecting watersheds, regulating stream flow, contributing to the economic stability of local communities and industries, and providing recreational facilities. The Oregon and California Railroad grant lands managed by the Forest Service are subject to the same statutory and regulatory requirements as other lands within the National Forest System.

Erosion Is a Natural Process That Increases During Large Storms

Erosion is a natural process that has shaped the valleys and mountains of the Pacific Northwest (western Oregon, western Washington State, and northern California) for millions of years. Rare large rain-on-snow storms that occur at intervals of several decades or centuries are responsible in part for creating the many streams in this region, and the accompanying flooding and increased turbidity are recognized as natural aspects of healthy river and stream systems.

The geologic origins and conditions of the Cascade and Coast mountain ranges have a significant impact on natural erosion and sedimentation, which affect water quality. Because of wet weather conditions and other factors, many of the rocks and soils within these mountain ranges have undergone physical changes that leave them unstable and subject to erosion. In addition, prior natural disturbances, such as windstorms and fires, leave the soil in the forests subject to erosion by destroying the trees and vegetation that holds soil on hillsides.[2]

Although the baseline rates at which erosion should naturally occur in large watersheds have not been identified for periods of accelerated sediment production during large storms, studies have shown that erosion increases in the presence of large, infrequent storms, and, from evidence in the forests, it appears that this process has occurred for centuries. In normal years, the first one or two large storms of the winter season transport much of the sediment that flows from a watershed during the entire year. However, when the rainy season is punctuated by a rare, large-scale storm, such as the ones in December 1964 and February 1996, a large amount of precipitation is delivered in a short period of time. The precipitation can cause considerable erosion and flooding and transport several decades of accumulated sediment through the region's river systems.

[2]Historically, fire has been a natural ecological component in the Pacific Northwest that has disturbed large and small areas of the Cascade and Coast mountains, thereby contributing to increased turbidity during storms. However, according to Forest Service officials, fire probably did not contribute significantly to increased turbidity during the February 1996 storm because a long-standing policy of suppressing fires on federal lands has limited the number of acres disturbed by fire.

Objectives, Scope, and Methodology

Senators Dale Bumpers and Ron Wyden asked us to examine the extent to which human activities may have contributed to the high turbidity levels in western Oregon's municipal watersheds during a large storm in February 1996. As agreed with their offices, this report describes (1) the human activities that may have contributed to the high turbidity levels in five western Oregon municipal watersheds during and following the storm and (2) the efforts under way by federal, state, local, and private land managers and owners, as well as the affected cities, to ensure safe drinking water during future storms. The five watersheds serve the cities of Cottage Grove, Eugene, Portland, Salem, and Sandy. (See table 1.1.)

Table 1.1: Watersheds Serving Five Cities in Western Oregon

City	Watershed	Approximate area in acres[a]
Cottage Grove	Layng Creek	42,000
Eugene	McKenzie River	740,000
Portland	Bull Run	65,000[b]
Salem	North Santiam River	432,000
Sandy	Alder Creek	4,600

[a]Represents the area of the watershed upstream from the location where water flows into each city's water treatment system.

[b]Public Law 95-200, enacted on November 23, 1977, created the 95,382-acre Bull Run Watershed Management Unit, which includes the physical drainage area as well as a buffer area.

We also obtained information on the Cedar River watershed, which serves Seattle, Washington, and compared and contrasted its management to the management of Portland's Bull Run watershed. Seattle, like Portland, is one of the few large cities in the United States that relies primarily on unfiltered water.[3] (Portland treats the water from the Bull Run watershed with chlorine.) In addition, both watersheds have long histories of timber harvesting, road construction, and water quality protection.

We met with, and reviewed documents provided by, managers and staff in the Forest Service's Pacific Northwest (Region 6) office and in the offices for three national forests—Willamette, Umpqua, and Mt. Hood. We also met with, and reviewed documents provided by, managers and staff in BLM's Oregon State Office and in two districts—Salem and Eugene. In addition, we spoke with officials from the (1) U.S. Army Corps of Engineers concerning issues pertaining to dams in the Willamette River valley and (2) Environmental Protection Agency (EPA) concerning issues

[3]Other large cities that rely on unfiltered water are Tacoma, Washington; New York, New York; Boston, Massachusetts; and San Francisco, California.

pertaining to protecting water quality. We also spoke with and obtained information from officials and individuals from (1) the six cities included in our review, (2) the McKenzie Watershed Council,[4] (3) environmental groups, (4) scientific and academic communities, (5) private industry and its representative organizations, and (6) the state of Oregon.

We also collected and reviewed published scientific studies of forestry practices and reports on water quality issues in Oregon and Washington as well as other documents provided by federal, state, and local officials; environmental and industry groups; and concerned individuals. (See the bibliography for the scientific studies that we reviewed.) We attended several conferences that addressed issues relating to the February 1996 storm and visited several of the municipal watersheds.

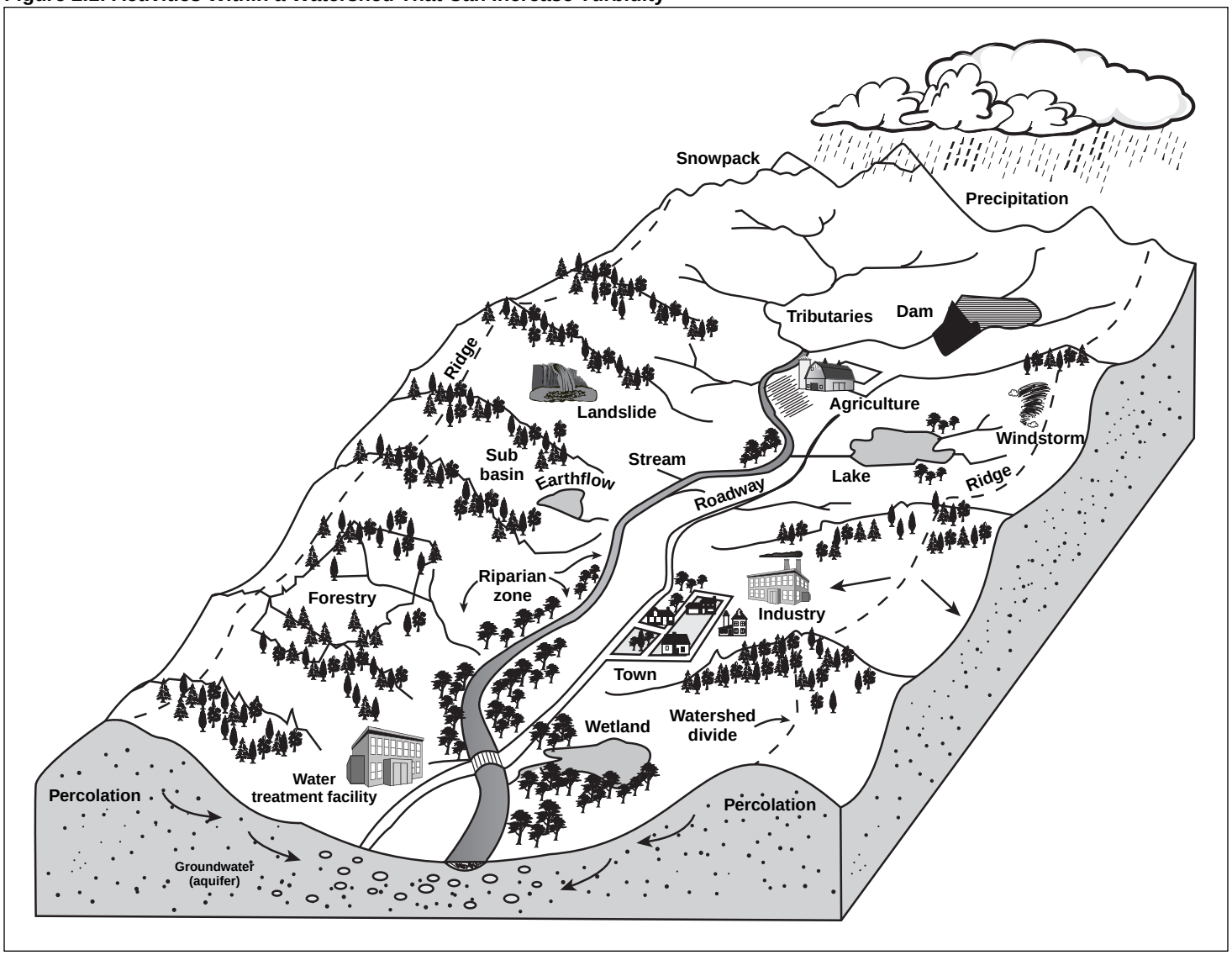
We performed our work from July 1997 through June 1998 in accordance with generally accepted government auditing standards. We provided pertinent information from a draft of this report to officials in each of the cities included in our review and made changes in response to their comments. We also obtained comments on a draft of the report from the Forest Service and BLM. These agencies' comments are presented in appendixes I and II, respectively.

[4]The 20-member McKenzie Watershed Council was formed in 1993 to address water quality and other issues within the McKenzie River watershed. Council members include representatives from the Forest Service, BLM, the U.S. Army Corps of Engineers, large private industrial landowners, state and local officials, and environmental and other concerned citizen groups.

Human Activities Contribute to Increased Turbidity During Large Storms

Our review of scientific studies and other documents showed that human activities—timber harvests and related roads as well as agricultural, industrial, urban, and residential development—can contribute to elevated sediment levels during large storms. These activities result in soil that is compacted, paved, covered, or cleared of most vegetation. Rain falling on such soil and surfaces can run off into streams, carrying with it eroded topsoil. This sediment from human activities in a municipal watershed, combined with the accelerated erosion that naturally occurs during storms, can shut down a municipality's water treatment system, as occurred in Salem in February 1996. (See fig. 2.1.)

Figure 2.1: Activities Within a Watershed That Can Increase Turbidity



Source: Lane Council of Governments, McKenzie Watershed Council.

Past Timber Harvests and Related Roads Can Increase Sediment

All five of the cities included in our review have experienced timber harvesting and related road construction in their municipal watersheds. These activities can contribute to erosion. Our review of scientific studies and other documents showed that past timber-harvesting practices were often not designed to protect water quality and resulted in cleared and

compacted areas that exposed soil to the erosive impact of rain and contributed sediment to streams, especially during large storms. In addition, older forest roads along streams and on hillsides were designed in ways that made them subject to erosion and failure. These roads have been found to be a major contributor of sediment to streams.

Timber Harvesting

The municipal watersheds for Cottage Grove, Eugene, Portland, Salem, and Sandy have all experienced varying levels of timber harvesting. For example, since 1960, approximately 28 percent of the national forest lands in Cottage Grove's Layng Creek watershed have been harvested. Approximately 21 percent of the Forest Service lands in Salem's North Santiam River watershed upstream from the Detroit Dam have been cut, and about 20 percent of Portland's Bull Run Watershed Management Unit have been harvested.

The fertile soil of the Cascade and Coast mountain ranges provides some of the best conditions in the United States for growing wood fiber, and federal Oregon and California grant lands are recognized as one of the nation's most productive and valuable commercial forest properties. Timber has been an important component of the region's economy, and timber harvesting on federal and nonfederal lands has generated considerable sums of money for counties in western Oregon. However, past timber-harvesting practices did not always protect water quality.

Timber Harvesting Has Been Viewed as a Desirable Activity

Local governments and industries have often viewed timber harvesting as a desirable activity. By federal law, counties are entitled to up to 50 percent of the receipts from timber sales on federal lands located within their boundaries. In addition, Oregon, together with Washington and California, receives a specially legislated payment to compensate them for federal timber receipts lost as a result of the listing of the northern spotted owl as a threatened species under the Endangered Species Act. The funds can be used to benefit roads and schools in the counties where the receipts were earned.[1]

In addition, Oregon's legislation emphasizes timber production on the about 875,000 acres of timberland[2] administered by the Oregon

[1]Forest Service: Distribution of Timber Sales Receipts, Fiscal Years 1992-94 (GAO/RCED-95-237FS, Sept. 8, 1995).

[2]Timberlands are lands that are producing, or are capable of producing, crops of industrial wood (i.e., more than 20 cubic feet per acre per year); are not withdrawn from timber utilization by law or regulation; and represent the lands potentially available for harvesting timber resources.

Department of Forestry to maximize revenue over the long term for schools and counties.[3] Another 8.6 million acres of timberland are owned by the private sector.

The timber industry has historically provided many jobs in western Oregon that have contributed to the counties through taxes and discretionary spending. Furthermore, removing trees may increase the quantity of water delivered to streams, and ultimately to municipal and industrial users, by increasing runoff.

Past Timber-Harvesting Practices Did Not Always Protect Water Quality

Although removing trees along streams can increase the quantity of water available for municipal and industrial uses, it can also increase erosion and sedimentation, thus degrading water quality. For instance, until 1992, clear-cutting was commonly used to harvest timber from the national forests. Scientific studies have shown that this harvesting method, which removes all of the trees from a timber-harvesting site at one time, can contribute sediment to streams, especially during large storms. (See the bibliography for the scientific studies we reviewed on the impact of past timber-harvesting practices on water quality.)

These studies have also shown that other past timber-harvesting practices can contribute to sedimentation during large storms. For example, ground-based logging practices, including the use of heavy equipment such as tractors to haul logs along trails to landings where they are loaded onto trucks, compact the soil and create ruts. Rain falling on these areas tends to run off the surface, following the ruts, allowing sediment to flow more easily into streams. Similarly, using fire to clear harvested areas of all vegetation before reforestation (broadcast burning) can destroy protective layers of organic debris and expose soil to the erosive impact of rain. Finally, vegetation along streams and large, woody debris in streams—both of which can trap and filter sediment—were often removed during timber harvesting. Without the vegetation and debris, water velocity increases, allowing streams to (1) carry more sediment and (2) cut more into stream banks, eroding them and transporting the sediment downstream.

Timber-Related Road Construction

Harvesting timber has often required the construction of numerous miles of roads to move heavy equipment into the harvest areas and up and down hillsides. When sections of these roads fail, which occurs most often

[3]Public Timber: Federal and State Programs Differ Significantly in Pacific Northwest (GAO/RCED-96-108, May 23, 1996).

during large winter storms, erosion can result. Erosion from roads has been found to be a major contributor of sediment to riparian areas and streams.

Initially, the easiest timber to reach was along streams, so streamside roads were constructed in these areas, primarily on private industrial lands. However, the increased demand for timber from federal lands to meet post-World War II housing construction needs and to replace the supply of timber from depleted industrial lands, resulted in roads being constructed on steep slopes on federal lands.

Road construction on federal lands continued rapidly between 1950 and 1970. These roads were constructed using a "sidecast construction" design in which excavated soil was used to build much of the roadbed along a hillside. Roadside ditches were constructed to move water quickly from roadbeds into nearby streams, thereby reducing the damaging effects of the water to the roadbeds. Stream crossings consisted of culverts to pass water beneath the road.

By the time of the December 1964 storm, which was similar in magnitude to the one that occurred in February 1996, road location, sidecast road construction, and culverts had been recognized as major contributors to sediment delivery to streams during large storms for a number of reasons. First, sidecast construction on hillsides had resulted in unstable roadbeds that were unconsolidated, not part of the natural slope of the hill, and subject to erosion and failure. Second, roadside ditches transported eroded topsoil from the roadbeds and hillsides and delivered it quickly into streams and rivers. And, finally, culverts became blocked, resulting in water flowing across the roadbeds and contributing to their erosion and failure.

A Forest Service report prepared after the December 1964 storm concluded,[4] among other things, that (1) road damage could have been avoided entirely or greatly reduced by better road location or design to cope with site conditions; (2) in some cases, the primary criterion for road location was apparently the "shortest distance from clearcut to clearcut;" (3) some of the most impressive storm damage was caused by sidecast road construction on steep slopes; and (4) the failure or impairment of drainage structures (i.e., ditches and culverts) was involved in almost all road-related storm damage.

[4]A Report of the Region 6 Storm Damage Evaluation Committee. Part II: Storms of December 1964 and January 1965, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region (Dec. 1966).

More recently, BLM has identified roads as a contributor to increased streamflows and sedimentation in some watersheds. For instance, in an analysis of the lower McKenzie River watershed[5]—an area of mostly nonfederal ownership and mixed uses—BLM found that (1) some of the primary causes of increased peak and total water flows were an increase in compacted areas from roads, forest and agricultural activities, man-made structures, and other human development and an extension of the stream network resulting from the direct routing of water from roads to streams and (2) elevated sediment levels in a portion of the watershed were in part explained by the large number of hillside roads, many of which lacked proper drainage and roadside vegetation. BLM estimated that streamside roads contribute more than twice as much sediment per mile than other forest roads. (See the bibliography for the scientific studies we reviewed on the impact of forest roads on water quality.)

During the 1970s and 1980s, the Forest Service and BLM made concerted efforts to reduce road failures through improved location, design, and maintenance. However, by then, the main road networks had been nearly completed, and only small secondary roads were required to obtain access to new timber harvest areas. Thus, the national forests and BLM lands contain a mixture of roads—of different ages and construction designs—that vary in their potential to deliver eroded soil to streams during large storms.

Agricultural, Industrial, Urban, and Residential Development Can Increase Turbidity

Two of the watersheds—those serving Eugene and Salem—have agricultural, industrial, urban, and residential development. All of these activities have been shown to contribute to increased turbidity during large storms.

Agriculture Can Contribute Sediment

In addition to being ideal for growing wood fiber, the fertile soil of the Willamette River basin provide some of the best conditions in the United States for growing agricultural products, including fruits and berries, vegetables, and ornamental plants. As a result, agriculture is a major economic activity in the basin. However, agricultural development in the Pacific Northwest has altered or removed natural plant communities and replaced them with pastures and industrial farming operations. Soil is compacted and land frequently may be cleared of most vegetation. Rain

[5]Vida/McKenzie Watershed Analysis, BLM (Apr. 1996).

falling on this land can run off into streams, carrying with it eroded topsoil.

A June 1993 report for Oregon's Department of Environmental Quality[6] stated that nonpoint source pollution was a major contributor to water quality degradation in the Willamette River and its tributaries.[7] Statewide, agriculture accounted for 39 percent—or more than double forestry's 17 percent—of all nonpoint water pollution. Boating contributed another 14 percent, while urban runoff contributed an additional 12 percent. (See table 2.1.)

Table 2.1: Percentage of Statewide Nonpoint Source Pollution by Category of Land Use

Land use	Percentage of statewide nonpoint pollution
Agriculture	39
Forestry	17
Boating	14
Urban	12
Natural	10
Mining	5
Construction	3
Total	**100**

Source: Nonpoint Source Pollution Control Guidebook for Local Government, Oregon Department of Environmental Quality and Oregon Department of Land Conservation and Development (June 1994).

A 1997 study commissioned by the governor of Oregon found that agriculture in the Willamette River basin contributes the greatest amount of suspended sediment to the river.[8] The study also reported that an estimated 1.8 million tons of soil is lost each year from erosion on agricultural lands in the basin.

[6]Willamette River Basin Water Quality Study: Summary Report, Oregon Department of Environmental Quality (June 30, 1993).

[7]Nonpoint source pollution is water pollution that does not result from a discharge at a specific, single location or point source (such as a single pipe) but generally results from runoff, precipitation, atmospheric deposition, or percolation and normally is associated with land management, construction, and urban runoff.

[8]J.D. Miller et al., Willamette River Basin Task Force: Recommendations to Governor John Kitzhaber (Dec. 1997).

Industrial, Urban, and Residential Development Can Contribute to Increased Sediment

The 1997 study also found that urban sites in the Willamette River basin contribute the greatest amount of suspended sediment to the river on a per acre basis. The basin's population had increased from approximately 1.5 million in 1970 to about 2.2 million in 1995, or by 47 percent, and growth projections for the basin anticipate that this number will nearly double over the next 25 to 30 years. This growth in population has resulted in soil that is compacted, paved, covered, or cleared of most vegetation.

For example, since the 1940s, residential development and related roads have nearly doubled in some watersheds. Development has increased the percentage of the basin covered by roofs, roads, parking lots, compacted areas, and other surfaces that prevent rain from penetrating into the soil. During storms, this increased runoff moves across barren or disturbed soil, eroding the soil, which can then be transported into streams. In addition, construction activities can contribute sediment to streams. For instance, without proper controls at construction sites, sediment loads can reach 35 to 45 tons per acre per year.

Interstate highways, state and county roads, and other types of roads also contribute sediment to streams during large storms. According to information provided by two groups sponsored by the state of Oregon—the Willamette River Basin Task Force and the Willamette Valley Livability Forum—the basin's roads (paved and unpaved, urban and rural) total over 46,500 miles—about enough to circle the earth twice. Both the North Santiam River watershed serving Salem and the McKenzie River watershed serving Eugene have highways that parallel the rivers upstream from the locations where water flows into the cities' water treatment systems. Like those constructed to harvest timber, these streamside roads increase the likelihood that sediment will be delivered directly into streams during large storms.

Increased populations in the Willamette and Lower Columbia river basins have also resulted in the construction of a large number of streambank stabilization projects to protect property from flooding. Nearly half of the original primary and secondary river channels in the Willamette River basin have been eliminated by channel straightening and other activities, and one-quarter of the remaining channel banks have been stripped of riparian vegetation and stabilized with rocks. As a result, floodplains, wetlands, and riparian areas are no longer able to function as intended—that is, to absorb excess water and dissipate its energy during storms and to provide buffers to filter suspended sediment from surface runoff before it reaches streams. Streambank stabilization projects also

increase water velocity and the erosive power of the river on downstream reaches.

For example, the settlement and development of the floodplain, as well as the lands around the mouths of many of the tributaries, within Eugene's McKenzie River watershed have accelerated since World War II. As a result, essentially the entire lower portion of the river's corridor has experienced landscaping, road construction, channel simplification, agricultural cropping and pasture, and residential development.

According to a 1997 report by the Oregon Department of Environmental Quality on water quality in Eugene's McKenzie River watershed,[9] sites in the upper subbasin—primarily federally owned lands—were relatively free of point and nonpoint source pollution. Conversely, in the lower subbasin—on predominantly nonfederal lands—agricultural and urban runoff was loading the river with soil, organic materials, and other wastes and pollutants.

Preliminary results from a pilot project to monitor storms, recently completed by the McKenzie Watershed Council, reached a similar conclusion.[10] Although the Council cautions that information derived from repeated monitoring over a number of storms will be required before general conclusions can be reached on the patterns of water quality in the watershed, data from one storm indicated that the highest recorded turbidity levels came from a growing residential area east of Eugene and that turbidity levels measured from this area during the storm were about double those from agricultural lands and considerably higher than those from federal forest lands. In addition, a recent study for the Eugene Water & Electric Board identified runoff from road surfaces and agricultural and urbanized areas, along with fuel and chemical spills, roadside vegetation management, recreation, and forest practices, as the greatest risks to the city's water supply.[11]

[9]The McKenzie Basin Water Quality Report, Oregon Department of Environmental Quality, Laboratory Division (Portland, Ore.: Feb. 1997).

[10]Monitoring Program: Storm Event Monitoring Pilot, McKenzie Watershed Council (Feb. 21, 1998).

[11]Final Report For the Eugene Water & Electric Board: Environmental Risk Assessment of EWEB's Drinking Water Supply, GEM Consulting, Inc. (Eugene, Ore.: Feb. 1995).

Increased Turbidity During and Following Large Storms Can Render a Water Treatment System Inoperable

Despite the timber harvests and forest roads and agricultural, industrial, urban, and residential development in the Willamette and Lower Columbia river basins, the cities included in our review as well as others in western Oregon have a history of providing safe drinking water to their residents. However, during and following large storms, such as those that occurred in December 1964 and February 1996, cities in the Pacific Northwest, including those we reviewed, experienced elevated sediment levels at the locations where water flows into their water treatment systems.

The accelerated erosion that naturally occurs during large storms, combined with the sediment from human activities in a municipal watershed, can shut down a city's water treatment system. For instance, the increase in naturally occurring erosion and erosion resulting from human activities during the February 1996 storm resulted in Salem's shutting down its water treatment system for 8 days.

Salem uses a process known as "slow sand filtration," which is unique to the Pacific Northwest, to filter its drinking water. Unlike the "rapid sand filtration" process used by Cottage Grove, Eugene, and Sandy—which pretreats the water with chemicals to cause sediment to settle out of the water prior to filtering it through sand beds—Salem's process removes impurities and sediment as the water filters through large beds composed of sand and the biological mat that forms on the beds' surface. This system, though inexpensive and not uncommon for small communities, is not used by any other city in the Pacific Northwest with a population of more than 100,000 people, according to a report prepared for Salem.[12]

According to documents that we reviewed, as it did during the 1964 storm, the Detroit Dam and Reservoir, located at the boundary of Forest Service lands and about 30 miles upstream from the location where water flows into Salem's water treatment system, provided flood control during the 1996 storm by retaining the turbid water from the Willamette National Forest as well as from lands owned by the state of Oregon and private landowners.[13] The dam, like other dams and flood retention structures, also acted like a giant sediment-settling pond. When flowing water entered the reservoir behind the dam, much of the sediment in the water fell out of suspension and settled to the bottom.

[12]City of Salem: The Water System Master Plan, CH2M Hill (Corvallis, Ore.: June 7, 1994).

[13]The state of Oregon and private landowners own more than 9 percent of the North Santiam River watershed upstream of the Detroit Dam.

However, according to a 1998 study of the 1996 storm in the North Santiam watershed—conducted by Salem, the Willamette National Forest, the Forest Service's Pacific Northwest Research Station, and the Willamette Geological Services—sediment from natural erosion and human activities on primarily nonfederal lands in the lower portions of the watershed below the dam was transported down the city's sole source of drinking water—the North Santiam River.[14] This sediment shut down the city's treatment system and rendered it inoperable on February 6, 1996.

In addition, not all of the sediment in the water behind the Detroit Dam settled to the bottom of the reservoir. The North Santiam River watershed contains soils with high levels of microscopic clay particles. Although the larger clay particles carried by the storm water settled to the bottom of the Detroit Reservoir behind the Detroit Dam, the finer sediment remained suspended in the water retained by the dam. This material was delivered downstream when the U.S. Army Corps of Engineers began releasing flood waters from the reservoir on February 9, 1996.

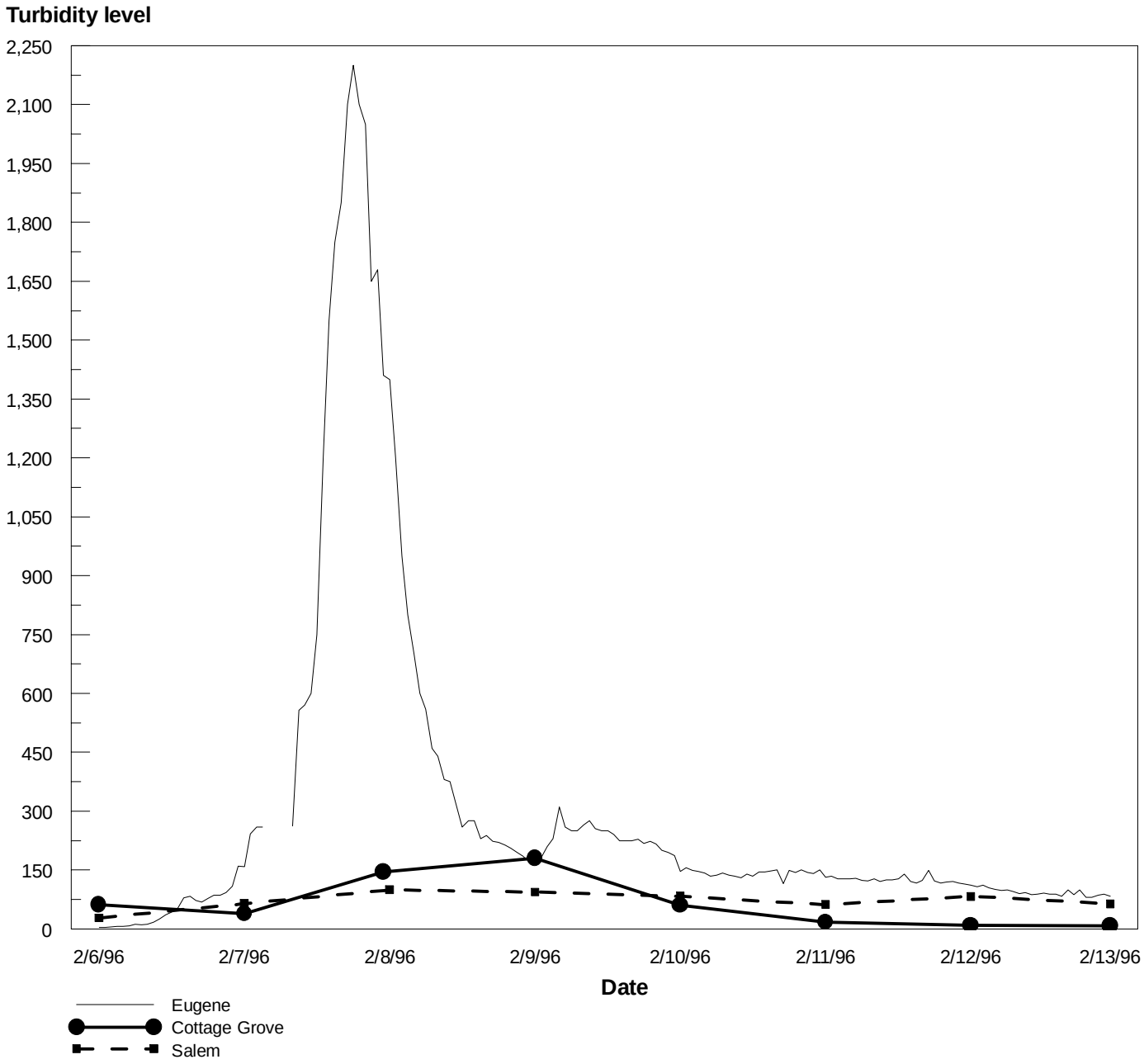
Without a secondary source of water, Salem nearly exhausted its reserve water supplies and had to take emergency measures, according to city officials. These measures included (1) drilling emergency wells, (2) purchasing water from neighboring communities, (3) constructing an emergency system to pretreat the water, (4) asking customers to curtail their use of water, and (5) banning all nonessential outdoor uses.

Salem restarted its water treatment system on February 14, 1996. However, according to city officials, water use had to be curtailed for more than a month after the storm to reduce the demand on Salem's crippled water treatment system. The system was also not able to adequately filter the turbid water being released from the Detroit Reservoir. Since the microscopic clay particles were able to pass through the water treatment system's filter beds, the city had to obtain an exemption from the state in order to deliver to its customers drinking water that had a turbidity level exceeding drinking water standards through July 16, 1996. In addition, one of the system's filters was damaged by the microscopic clay particles and has continued to create operational problems, according to city officials.

[14]D. Bates et al., "North Santiam River Turbidity Study, 1996-1997," Willamette National Forest (Eugene, Ore.: Feb. 1998).

Other western Oregon cities experienced elevated sediment levels during and following the February 1996 storm (see fig. 2.2) but were better prepared to continue to deliver safe drinking water to their customers.

Figure 2.2: Turbidity Levels at Cottage Grove, Eugene, and Salem During and Following the February 1996 Storm



(Figure notes on next page)

Notes: Turbidity level is in nephelometric turbidity units, which indicate the amount of suspended sediment in the water. The standard for safe drinking water is no more than one nephelometric turbidity unit.

The cities of Portland and Sandy are not included on this figure, because (1) Portland's maximum turbidity level of less than 11 was too small to display on this graph and (2) Sandy was unable to provide us with data on turbidity levels during and following the February 1996 storm.

The break in Eugene's turbidity data represents a short period of time when this information was not collected.

Source: GAO's presentation of data provided by each of the cities.

Specifically, Cottage Grove did not experience severe flooding, and although turbidity levels were slightly higher than those reported by Salem, the city was able to filter and deliver safe drinking water to its residents. In Eugene, turbidity levels were more than 20 times greater than those reported by Salem. Eugene shut down its water treatment system for about 12 hours and relied on its reserve water supplies until its water treatment system could be adjusted to handle the rapidly changing turbid water. Portland experienced considerably lower turbidity levels than Cottage Grove, Eugene, and Salem and relied on its backup water system—a well field along the Columbia River—for 5 days to provide safe drinking water during and following the storm, when water from its watershed was too turbid to meet safe drinking water standards.

According to Sandy's public works director, the city is usually prepared to continue to deliver safe drinking water to its customers during large storms. Sandy never shuts down its water treatment system but relies on a secondary source of water and reserve water supplies, rather than Alder Creek, to meet demand. However, the city's secondary source of water had been severely damaged during a windstorm in late 1995 when large trees adjacent to a timber harvest clearcut on private land fell onto the source's pipes and storage tanks. In addition, a malfunctioning sensing device in the city's main storage reservoir led the city to believe that this reservoir was full, when in fact it was nearly empty. As a result, the city had to stop the delivery of water to its customers and rely instead on emergency water supplies, including bottled water and tank trucks, until its treatment system could again filter water from Alder Creek.

After the storm, Salem and certain environmental groups expressed concerns about the extent to which the timber harvests and forest roads on federal lands contributed to increased turbidity. However, the 1998

study of the 1996 storm in the North Santiam watershed builds on the findings in previous studies on persistent turbidity.[15] The 1998 study reaffirms earlier findings that the persistent turbidity in the Detroit Reservoir came from the microscopic clay particles that remained suspended in the water retained by the Detroit Dam. The main sources of these particles are (1) natural, large, deep-seated, slow-moving masses of earth (called earthflows) and (2) naturally occurring erosion from streambanks, which brings to the surface deep-seated clay deposits. The study notes that other types of erosion—including erosion from the failure of forest roads on federal lands and from past timber harvests—are minor sources of these clays.

This persistent turbidity had also been observed in some Oregon reservoirs following the December 1964 storm.[16] According to Salem's water source supervisor at the time of the 1964 storm, turbidity persisted in the Detroit Reservoir for several months following the storm; however, drinking water standards did not exist at that time and Salem was able to deliver the turbid water to its customers. A 1994 report on a water system master plan for Salem recognized that the city's reliance on the North Santiam River as its sole source of water left it vulnerable to emergency situations that could result in multiple-day closures of its treatment system and in a total loss of its water supply capability.[17] At the time of the February 1996 storm, however, the city had done little to develop additional reserve water supplies or to expand its water treatment system, as recommended in the report.

Since the February 1996 storm, the city has (1) constructed a permanent pretreatment basin to remove sediment from turbid storm water before delivering the water to the slow-sand filter beds and (2) continued to develop additional reserve water supplies. However, according to Salem officials, the type of fine sediments after the February 1996 flood would still result in a "treatment challenge" and "may result in finished water exceeding drinking water standards for turbidity."

[15]D. Bates et al., "North Santiam River Turbidity Study, 1996-1997," Willamette National Forest (Eugene, Ore.: Feb. 1998).

[16]Hills Creek Reservoir Turbidity Study, Water Resources Research Institute, Oregon State University (Corvallis, Ore.: Dec. 1971).

[17]City of Salem: The Water System Master Plan, CH2M Hill (Corvallis, Ore.: June 7, 1994).

Progress Has Been Made to Ensure Safe Drinking Water During Future Storms

Ongoing federal and nonfederal efforts have made significant progress in (1) mitigating the impact of human activities on water quality and in ensuring safe drinking water for cities in the Willamette and Lower Columbia river basins and (2) involving more key landowners and other stakeholders in discussing, understanding, and addressing watershed issues and concerns and in implementing restoration plans. Nevertheless, some key landowners have not been included in coordination efforts, and many efforts could benefit from a better understanding of, and data on, the condition of the watersheds.

Progress Has Been Made in Mitigating the Impact of Human Activities on Water Quality

Federal land management agencies, the state of Oregon, the municipalities, and private landowners have made significant progress in mitigating the impact of human activities on water quality. Efforts to date have tended to focus primarily on timber and related roads; however, other efforts are now under way at the federal, state, and local levels in western Oregon to address other human activities that can contribute to increased turbidity during large storms.

Federal Efforts to Mitigate the Impact of Timber Harvests and Roads

Federal efforts—including a new plan, requirements, and legislation—are intended to mitigate the impact of timber harvests and roads on water quality. An April 1994 plan—known as the Northwest Forest Plan—provides management direction for the 22.1 million acres of land managed by the Forest Service and BLM in the Pacific Northwest, including those in the Willamette and Lower Columbia river basins.[1] The plan also begins to address the legacy of water quality degradation associated with past timber-harvesting and road construction practices. In addition, as discussed below, the Congress has enacted legislation to protect Portland's watershed and its unfiltered water supply.

The Northwest Forest Plan Is Intended to Protect Water Quality

In the late 1980s and early 1990s, timber sales on the lands managed by the Forest Service and BLM in the Pacific Northwest were brought to a virtual halt by federal injunctions. In various rulings, the federal courts enjoined the agencies from selling timber until they addressed issues related to the northern spotted owl and its habitat.[2] The President directed his administration to develop a plan that would (1) satisfy the courts so they

[1]Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl and Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl, Forest Service and BLM (Apr. 1994).

[2]See, for example, Seattle Audubon Society v. Evans, 771 F. Supp. 1081 (W.D. Wash.), aff'd, 952 F.2d 297 (9th Cir. 1991) and Seattle Audubon Society v. Moseley, 798 F. Supp. 1484 (W.D. Wash. 1992), aff'd sub nom., Seattle Audubon Society v. Espy, 998 F.2d 699 (9th Cir. 1993).

would lift the injunctions, (2) protect the environment, and (3) stabilize the regional economy. The result was the Northwest Forest Plan.

In order to resurrect their timber programs under the Northwest Forest Plan, the Forest Service and BLM have (1) significantly reduced the volume of timber harvested; (2) deemphasized the use of clearcutting as the preferred method to harvest timber; (3) created requirements (standards and guidelines) to mitigate the impact of timber harvests and forest roads on water quality; (4) continued to implement practices or combinations of practices determined to be the most effective, practicable means of preventing or reducing sedimentation (best management practices); and (5) started to address the conditions created by past timber-harvesting and road construction practices. EPA has stated that the full implementation of the Northwest Forest Plan is a cornerstone of the recovery of water quality on federal lands within western Oregon's watersheds.

The volume of timber harvested from federal lands in the Pacific Northwest declined from 5.2 billion board feet in fiscal year 1989 to slightly more than .6 billion board feet in fiscal year 1997, a decrease of about 88 percent. In addition, between fiscal year 1992—when the Forest Service announced plans to reduce the volume of timber harvested by clearcutting—and fiscal year 1997, the percentage of all timber harvested by this method fell from 22 to 10 percent.

The Northwest Forest Plan also refines requirements and best management practices for harvesting timber and constructing roads. These practices have evolved over the past several decades in response to new federal requirements and growing public concern about the impacts of these activities on the environment. (See the bibliography for the scientific studies we reviewed on the impact of newer timber-harvesting and road construction practices on water quality.) For example, riparian areas vital to protecting and enhancing aquatic and terrestrial resources are now preserved. In its 1996 report,[3] the Oregon Natural Resources Council notes that maintaining riparian buffers protects streams from the effects of logging.

Current timber-harvesting and road construction practices on federal lands are designed to mitigate these activities' adverse effects on water quality. Specifically, timber harvesters have developed methods to remove timber from hillsides that are less damaging to the soil than older

[3]"Economic Considerations of Municipal Watershed Use: To Grow Timber or Water," Oregon Natural Resources Council (Apr. 1996).

practices. These newer practices leave trees and large, woody debris in riparian buffers to trap and filter sediment before it reaches streams. Additionally, new forest roads are designed to be more stable and to reduce the potential for failure. Finally, road drainage systems have been improved to reduce the amount of water and sediment delivered to streams.

The Northwest Forest Plan Addresses Legacy Conditions on Federal Lands

Older forest roads constructed and timber-harvest areas cleared using past practices that were not designed to protect water quality can continue to contribute to increased turbidity during storms and affect other watershed values. EPA has noted that it will likely take watersheds decades to recover from the impacts of these practices. Under the Northwest Forest Plan, both the Forest Service and BLM are addressing these conditions, together with other issues, through watershed restoration efforts.

Restoration efforts include controlling and preventing road-related runoff and sediment production by closing and stabilizing (decommissioning) some roads and upgrading others by removing soil from locations where there is a high potential for erosion, modifying road drainage systems to reduce the extent to which the road functions as an extension of the stream network, and reconstructing stream crossings. These efforts also include restoring riparian vegetation and, to prevent instream erosion, adding back large, woody debris into the streams from which it was removed.

The Congress Has Enacted Legislation to Protect Portland's Watershed

Over the past 100 years, the Congress has acted to protect Portland's unfiltered drinking water. Almost all of Portland's nearly 65,000-acre Bull Run watershed is owned by the federal government and managed by the Forest Service. Legislative and administrative decisions in the late 1890s and early 1900s protected the watershed from settlement and development.[4] Public Law 95-200, enacted in 1977, established the Bull Run Watershed Management Unit as a special resources management unit to be administered as a watershed by the Secretary of Agriculture. In addition, title VI of the Oregon Resource Conservation Act of 1996,[5] which amended Public Law 95-200, protects the watershed from timber harvesting that could adversely affect water quality but permits timber to be harvested to protect or enhance water quality or quantity.

[4]A proclamation signed by the President on June 17, 1892, declared the Bull Run area a national forest reserve. The law of April 28, 1904, ch. 1774, 33 Stat. 526, protects "the Bull Run Forest Reserve and the sources of the water supply of the City of Portland, State of Oregon."

[5]Pub. L. 104-208, Division B, tit. VI, 110 Stat. 3009-541.

Forest Service officials estimate that they spend nearly $1 million a year managing federal lands in Portland's watershed. Conversely, Seattle, Washington—which, like Portland, relies primarily on unfiltered water—has purchased or otherwise acquired all of the lands within its more than 90,000-acre Cedar River watershed from private timber companies (after the timber was harvested) and from the Forest Service. According to a city official, Seattle has harvested second-growth timber from its watershed since about 1940 and uses the revenue generated each year from timber sales to acquire habitat. Thus, while Seattle has incurred the costs to acquire, and generates revenue from, its watershed, the costs to protect and restore Portland's watershed are paid primarily by federal taxpayers.

State Efforts to Mitigate the Impact of Timber Harvests and Roads

The state of Oregon has implemented rules and regulations for timber harvesting on state and private lands. Although found by EPA to be less stringent than the requirements on federal lands, the state's requirements also protect water quality.

According to the Oregon Department of Forestry,[6] Oregon was the first state in the nation to regulate timber harvesting on nonfederal lands to protect water quality. Oregon began legislating timber-harvesting activities with the passage of the Oregon Forest Conservation Act of 1941, which addressed reforestation and fire protection. According to a state official, this act was repealed in 1971 when the Oregon Forest Practices Act[7] was enacted. Rules were first promulgated under the 1971 act in 1972. In 1979, the rules were certified by EPA as best management practices for controlling nonpoint source pollution from forestry in the state. Major amendments to the rules in 1987, 1991, and 1996 further increased protection for stream and water quality.

The rules specify practices required to protect water quality, including (1) stabilizing soil and keeping it out of streams, (2) retaining ground cover to filter surface water flows, (3) protecting vegetation around stream channels, (4) limiting soil disturbance, and (5) maintaining stable roadbeds. The majority of the forest industry in the state has supported compliance with the act and its rules and has led efforts to update and

[6]The Oregon Forest Practices Act Water Protection Rules: Scientific and Policy Considerations, Oregon Department of Forestry (Dec. 1994).

[7]Oregon Revised Statutes (ORS) 527.610 to 527.770, 527.990(1), and 527.992 are known as the Oregon Forest Practices Act.

refine them. The state monitors compliance with the rules during commercial timber harvesting on all nonfederal lands.

In addition, motivated by concerns over the possibility that additional coastal salmon species would be listed as endangered or threatened under the Endangered Species Act, the governor of Oregon initiated an effort—the Coastal Salmon Restoration Initiative—in 1997 not only to prevent such a listing and improve fish habitat but also to protect water quality to support people, industry, fish, and wildlife. As part of this effort, landowners of industrial forests have agreed to implement a voluntary program to identify and address risks to water quality caused by forest roads. They have also promised about $130 million over the next 10 years to manage and upgrade older forest roads on these lands. The Oregon Department of Forestry and other state and private agencies will monitor the implementation of the initiative.

Although they have been certified as best management practices by EPA, Oregon's requirements to help protect water quality have been found by EPA to be less stringent than the requirements on federal lands. For example, according to EPA, the state's Forest Practices Act, as amended, still affords substantially less protection to riparian areas, across all stream categories, than federal requirements.

State and Local Efforts Are Under Way to Address Other Activities Contributing to Increased Turbidity

Although lagging behind the efforts to mitigate the effects of timber harvests and roads, efforts are under way at the state and local levels in Oregon to address other human activities that are known to contribute to increased turbidity during large storms. For example, a gubernatorial task force that assessed the current status of waters in the Willamette River basin reported in December 1997 that significant resources had been expended over the prior 8 years to study the impact of agricultural practices on groundwater and to develop techniques to reduce this impact.[8] The report also noted that Oregon's Department of Agriculture had recently stepped up efforts to develop water quality management area plans for agriculture in Willamette River subbasins that do not meet water quality standards under the Clean Water Act.[9]

[8]J.D. Miller et al., Willamette River Basin Task Force: Recommendations to Governor John Kitzhaber (Dec. 1997).

[9]The purpose of the Federal Water Pollution Control Act of 1972, as amended, (commonly called the Clean Water Act) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

Unlike its regulatory approach to timber harvesting and road construction under the Forest Practices Act, the state's approach to agriculture depends on the voluntary cooperation and initiative of private landowners and farmers to reduce their contribution to water quality problems. Key building blocks of the state's plan include water quality assessments, monitoring programs, education and outreach strategies, and technical assistance. However, the plan's success depends on (1) the ability of the state to deliver technical and educational assistance to private landowners and (2) the willingness of the landowners to use this information to protect water quality. State agencies have started working with landowners to develop management plans to control erosion and reduce the contaminants entering streams. However, since compliance is voluntary, there is no assurance that landowners will participate.

The gubernatorial task force also found that some cities in the Willamette River basin had significantly reduced the discharge of pollutants, including sediment, into the Willamette River and its tributaries. Approaches taken included (1) removing suspended sediment from stormwater, (2) educating the public on water quality, and (3) managing wetlands.

Cooperation and Collaboration Among Stakeholders Has Improved

In a June 1995 report on selected watershed projects,[10] we noted that the major lesson to be learned from our review of two projects in western Oregon was that involving local stakeholders in planning and implementing a project can help overcome a community's suspicion of government-sponsored initiatives and result in a cooperative partnership of community interests and government agencies. Our review indicated that collaboration between federal and nonfederal parties in the Willamette and Lower Columbia river basins is improving. In addition, local, voluntary watershed councils have been established to bring stakeholders together to discuss, understand, and address watershed problems and issues and to implement watershed restoration plans.

Public Participation in Federal Agencies' Decision-Making Has Increased

The public has expressed its desire to become more involved in the decision-making processes of federal land management agencies and has demonstrated its preference for presenting its concerns, positions, and supporting documentation during, rather than after, an agency's development of proposed plans and projects. The public has also signaled

[10]Agriculture and the Environment: Information on and Characteristics of Selected Watershed Projects (GAO/RCED-95-218, June 29, 1995).

its intention to challenge decisions that it has not been involved in reaching.[11]

In western Oregon's municipal watersheds, the Forest Service and BLM have involved the public in their decision-making by (1) working more closely with some municipal officials, local citizen groups, and other stakeholders in developing proposed plans and in designing projects, such as timber sales, and (2) entering into some formal agreements—called memorandums of understanding—with municipalities and the state of Oregon to address watershed issues.

Specifically, the Forest Service and Portland have collaborated in the management of the city's Bull Run watershed for decades. Cottage Grove has worked closely with the Forest Service since the 1970s to improve and protect water quality. Both the Forest Service and the city have worked to monitor water quality, and the agency has identified and mitigated sources of turbidity. The Forest Service has also acted to improve water quality by (1) reducing the volume of timber harvested in the city's Layng Creek watershed, (2) maintaining roads and seeding roadside areas to prevent erosion, and (3) directing Layng Creek away from an earthflow and building a rock wall to stop the earthflow's movement. According to monitoring data gathered by the Forest Service and Cottage Grove, these efforts have reduced turbidity and improved water quality.

In 1997, Sandy entered into a formal memorandum of understanding with the Forest Service and BLM on activities within the Alder Creek watershed and on ways to gain a better understanding of how the watershed functions. That same year, Salem entered into a similar agreement with the Forest Service for the North Santiam River watershed.

While the benefits of working together cooperatively often outweigh the costs of early and continuous public involvement, our prior work has shown that decision-making on managing federal lands is inherently contentious and that public involvement in the process should not be viewed as a panacea to legal challenges.[12] Dissatisfaction with an agency's process for public involvement often cannot be dissociated from dissatisfaction with the outcome of the process, and parties opposed to a particular activity, such as timber harvesting, can cause a federal agency

[11]Forest Service Decision-Making: A Framework for Improving Performance (GAO/RCED-97-71, Apr. 29, 1997).

[12]Forest Service Decision-Making: A Framework for Improving Performance (GAO/RCED-97-71, Apr. 29, 1997) and Restoring the Everglades: Public Participation in Federal Efforts (GAO/RCED-96-5, Oct. 24, 1995).

to delay, alter, or withdraw projects by availing themselves of the opportunities for administrative appeal and judicial review that are provided by statute or regulation.

Watershed Councils Have Been Established to Address Water Quality Issues and Concerns

The state of Oregon has recognized the important role of collaboration among watershed stakeholders and enacted legislation in 1995 to promote local, voluntary watershed councils to implement plans for watershed restoration. The state provides both funding for the councils and guidelines for their membership.[13] In 1997, the state placed $20 million in a watershed enhancement fund and directed that the funds be used to support watershed councils as well as soil and water conservation districts, monitoring, and watershed improvements.

One of the earliest and more advanced watershed councils in the Willamette River basin is the McKenzie Watershed Council. The Council has developed plans and objectives for improving water quality within the watershed and has begun to monitor ongoing efforts to better understand the impact of different activities on water quality. It has also provided public education and developed informational brochures and literature addressing different water quality issues.

Efforts Could Benefit From More Participation and Better Information

Although ongoing efforts within the Willamette and Lower Columbia river basins have made significant progress in addressing many of the activities that can contribute to turbidity and in increasing collaboration between federal and nonfederal parties, there are opportunities to improve the efficiency and effectiveness of these efforts. Specifically, some of the efforts could benefit from involving more key landowners in their decision-making, and many could benefit from a better understanding of, and data on, the condition of the watersheds.

Coordination Efforts Sometimes Exclude Key Landowners

Our prior work has shown that, to be more effective, a watershed approach to protecting water quality and ensuring safe drinking water should include all the key landowners and other stakeholders. As more landowners and others within a watershed collaborate, more activities are likely to be coordinated and managed across the watershed.[14] In our

[13] 1995 Or. Laws Ch. 187 (providing, in part, for amendment to ORS 541.350 to 541.395).

[14] Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach (GAO/RCED-94-111, Aug. 16, 1994).

June 1995 report on selected watershed projects,[15] we noted that participants in two projects in western Oregon emphasized that the projects—which addressed drinking water quality and other watershed issues—could not progress until the stakeholders had moved beyond blaming each other and begun concentrating on solutions. These participants also said that the stakeholders needed to be involved to ensure that all economic interests were represented and considered when defining the problem and developing a solution.

However, memorandums of understanding between federal land management agencies and cities to address watershed issues and concerns in the Willamette and Lower Columbia river basins did not include key landowners, who are critical to understanding and addressing the condition of the watershed. For instance, the formal memorandum of understanding among the Forest Service, BLM, and Sandy on activities within the city's municipal watershed does not include a large industrial forest landowner whose holdings include a significant portion of the watershed directly above the location where water flows into the city's treatment system.

Likewise, many human activities on lands owned by the state of Oregon, landowners of industrial forests, local communities, and private individuals both above and below the Detroit Dam probably contributed to the elevated sediment levels that initially shut down Salem's water treatment system during the February 1996 storm. However, the memorandum of understanding between Salem and the Forest Service excludes both BLM and nonfederal landowners in the city's watershed.

The Current Condition of Many Municipal Watersheds Is Not Known

Our review has shown that the extent to which human activities increased turbidity in the Willamette and Lower Columbia river basins during the February 1996 storm varied by watershed. Moreover, the condition of a municipal watershed can change over time as a result of storms and other natural disturbances and human activities. Therefore, in planning to protect water quality, a one-size-fits-all approach will not work. Rather, efforts to ensure safe drinking water must be tailored to address the activities occurring in a particular municipal watershed and should be based on an analysis of the overall condition of the watershed, including its land-use history and the impact of previous storms and human activities. However, (1) few of the watershed analyses we reviewed

[15]Agriculture and the Environment: Information on and Characteristics of Selected Watershed Projects (GAO/RCED-95-218, June 29, 1995).

corresponded directly to the boundaries of a municipal watershed and (2) the data gathered by different federal agencies and nonfederal parties within a municipal watershed may not be comparable. As a result, the information obtained from the analyses may be of limited value in describing the condition of some municipal watersheds in the Willamette and Lower Columbia river basins and may not be useful to those responsible for municipal watersheds.

As discussed in chapter 2, human activities vary by watershed. For example, all five of the cities included in our review have experienced timber harvesting and related road construction in their watersheds, but only two watersheds—those serving Eugene and Salem—also have agricultural, industrial, urban, and residential development.

In addition, while some past and ongoing human activities may be contributing to increased sediment, others may not. For instance, a number of comprehensive, long-term scientific studies have shown that the effects on water quality of timber harvesting along streams decrease several years after the activity occurred. Similarly, studies of timber roads constructed between 1950 and the early 1970s have shown that (1) the highest levels of sediment delivered to streams occurred during storms shortly after the roads were built and (2) these levels generally declined as roadside vegetation increased and other natural stabilization occurred. Moreover, although few long-term studies have been conducted to support the water quality benefits of improved road location, design, and maintenance, timber-related roads constructed during the late 1970s and 1980s are likely to be less prone to failure than those built between 1950 and the early 1970s. Furthermore, several studies have noted that, since only a small portion of a large watershed may be logged at one time, timber harvests probably do not have a noticeable impact on downstream users in these watersheds. As a result, several studies have found that, despite decades of timber harvesting, water quality in Portland's 65,000-acre Bull Run watershed remains excellent, with no detectable decline.[16]

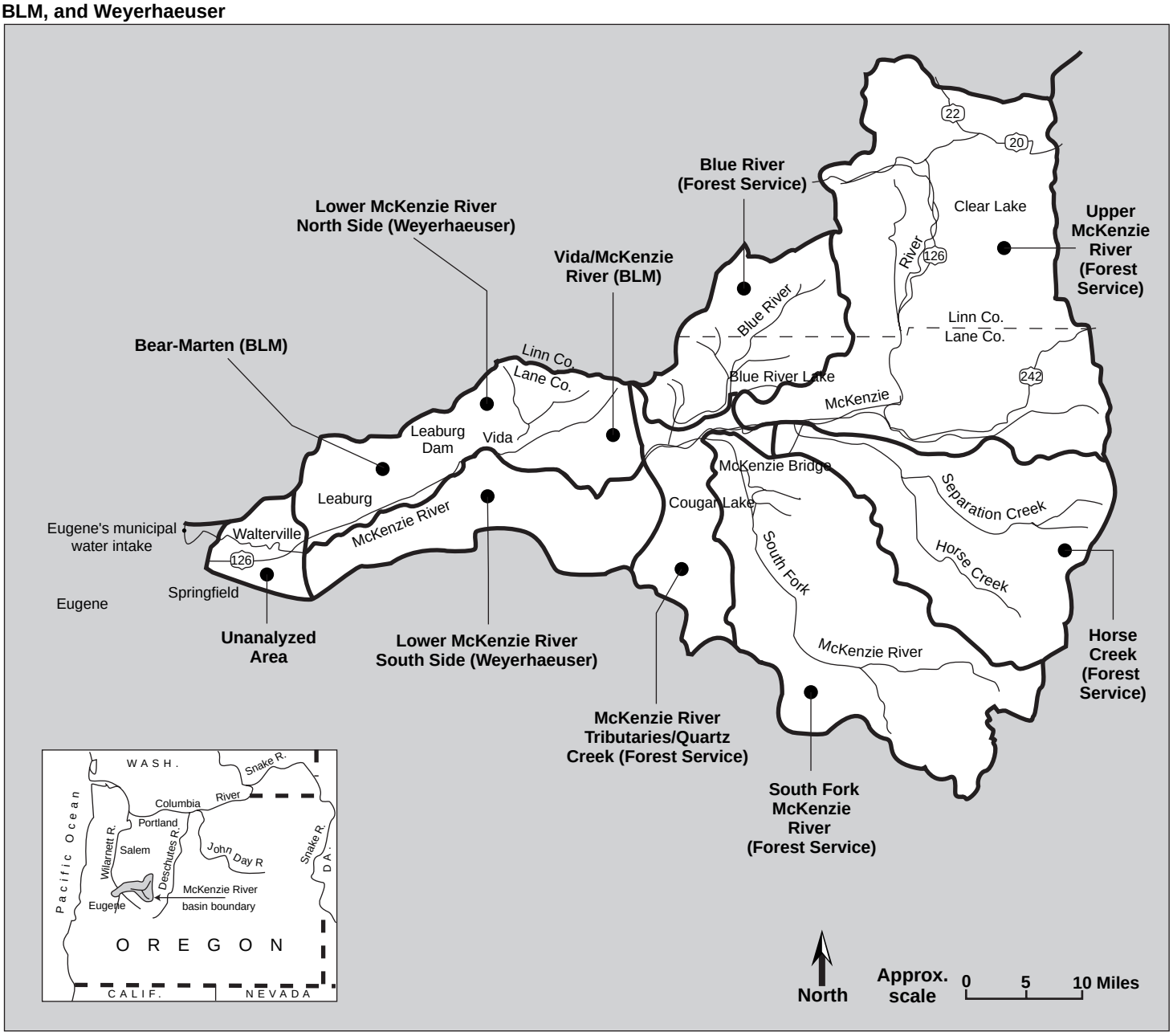
Because human activities vary by watershed and the condition of a watershed changes over time, an analysis of the overall condition of a

[16]N.G. Aumen, T.J. Grizzard, and R.H. Hawkins, Water Quality Monitoring in the Bull Run Watershed, Oregon, available from the City of Portland, Oregon, Bureau of Water Works (1989); City of Portland, Bureau of Water Works, Water Quality and Environmental Policy Division, Water Quality in the Bull Run Watershed: A Comparison of Past and Present Conditions (1988); N.G. Aumen, J.R. Boydston, T.J. Grizzard, and R.H. Hawkins, Progress Toward Implementation of Wyden Task Force Recommendations, prepared for the Bureau of Water Works, City of Portland, Oregon, and Columbia Gorge Ranger District, U.S. Forest Service (1990).

municipal watershed is considered essential to guide project planning and decision-making and identify the restoration activities with the greatest likelihood of success. A watershed analysis characterizes the human, aquatic, riparian, and terrestrial features, conditions, processes, and interactions within a watershed by collecting and compiling the analytical information essential for making sound management decisions concerning the type, location, and sequence of appropriate management activities within the watershed. However, few of the watershed analyses we reviewed corresponded directly to the boundaries of a municipal watershed, and the data gathered by different federal agencies and nonfederal parties within a municipal watershed may not be comparable.

For example, Eugene's McKenzie River watershed encompasses approximately 740,000 acres. Within its boundaries, the Forest Service has completed five analyses, and BLM and a large industrial forest landowner—Weyerhaeuser—have each completed two analyses. However, other areas of the watershed have not yet been analyzed, and the overall condition of Eugene's municipal watershed is not known. Figure 3.2 shows the areas of the McKenzie River municipal watershed included in the nine different watershed analyses.

Figure 3.2: The Mckenzie River Municipal Watershed With Watershed Analysis Areas Completed by the Forest Service, BLM, and Weyerhaeuser



Source: Adapted from a map by the McKenzie Watershed Council.

The McKenzie Watershed Council has recently applied for a grant to fund an effort to synthesize the data from the various watershed analyses into a useful description of basinwide issues. However, our prior work and federal guidelines for watershed analyses have shown that the data gathered in the different analyses may not be comparable and may not be easily combined to assess the direct, indirect, and cumulative effects of human activities throughout the watershed.[17]

Sandy's municipal watershed is much smaller than Eugene's watershed. The Alder Creek watershed encompasses only about 4,600 acres, or less than 1 percent of the acreage in Eugene's McKenzie River watershed. The Alder Creek watershed was included in a watershed analysis conducted by the Forest Service that covered almost 68,000 acres owned by over 900 different landowners. The analysis addressed the condition of Sandy's municipal watershed as well as other issues and concerns. However, as the size of a watershed analysis increases, it becomes more difficult to provide meaningful information for planning and decision-making at the local level.

Conclusions

Federal land management agencies, the state of Oregon, the municipalities, and private landowners have made significant progress in working together to mitigate the impact of human activities on water quality and to ensure safe drinking water to cities in the Willamette and Lower Columbia river basins. Nonetheless, there are opportunities to improve the efficiency and effectiveness of these efforts by involving more key landowners in the decision-making process and by developing a better understanding of, and data on, the condition of the watersheds.

As more landowners within a watershed collaborate, more activities are likely to be coordinated and managed across the watershed. However, memorandums of understanding between federal land management agencies and cities to address watershed issues and concerns in the Willamette and Lower Columbia river basins have not included the key landowners who are critical to understanding and addressing the condition of the watershed.

[17]Forest Service Decision-Making: A Framework for Improving Performance (GAO/RCED-97-71, Apr. 29, 1997); Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach (GAO/RCED-94-111, Aug. 16, 1994); and Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis, the Regional Interagency Executive Committee and the Intergovernmental Advisory Committee, Portland, Ore. (Aug. 1995).

Moreover, because human activities vary by watershed and the condition of a watershed can change over time, an analysis of the overall condition of a municipal watershed is essential to (1) guide project planning and decision-making and identify the restoration activities with the greatest likelihood of success; (2) make sound management decisions concerning the type, location, and sequence of appropriate management activities within the watershed; and (3) dissociate concern about water quality from dissatisfaction over other land management issues, such as timber harvesting and road construction. However, many of the watershed analyses we reviewed may not be useful for municipal watershed planning because the analyses did not corresponded directly to the boundaries of a municipal watershed and/or the data gathered may not be comparable with data gathered by other federal agencies and nonfederal parties within a municipal watershed.

Recommendations

To increase the efficiency and effectiveness of efforts to improve water quality and ensure safe drinking water to cities in western Oregon, we recommend that the Secretary of Agriculture direct the Chief of the Forest Service and that the Secretary of the Interior direct the Director of BLM to include key landowners—who are critical to understanding and addressing the condition of a watershed—in memorandums of understanding with cities and in other agreements to address watershed issues and concerns. We also recommend that the Secretary of Agriculture direct the Chief of the Forest Service and that the Secretary of the Interior direct the Director of BLM to take the following actions when conducting watershed analyses: (1) at a minimum, gather data on municipal water quality that are comparable with the data gathered by other federally funded analyses; (2) when feasible, include water quality as a primary focus and/or conduct the analyses along the boundaries of the municipal watersheds; (3) to the extent possible, collaborate with nonfederal land managers and owners to gather data that are comparable and useful to municipal watershed decisionmakers; and (4) when practical, develop data on the impact of new timber-harvesting methods and road construction practices on water quality.

Agency Comments

We provided copies of a draft of this report to the Forest Service and BLM for their review and comment. The agencies' comments appear in appendixes I and II, respectively. The agencies (1) stated that the report provides a comprehensive and objective view of the complexities and factors involved in watershed management in the Pacific Northwest;

(2) agreed with, and promised to pursue the implementation of, the report's recommendations; and (3) noted that they have made progress in developing data on the impact of new timber-harvesting methods and road construction practices on water quality. The agencies also provided comments on the factual content of the report, and changes were made as appropriate.

Comments From the U.S. Department of Agriculture

United States Department of Agriculture | Forest Service | Washington Office | 14th & Independence SW
P. O. Box 96090
Washington, DC 20090-6090

File Code: 2540-2

Date: JUL 9 1998

Mr. Barry T. Hill
Associate Director, Energy, Resources
and Science Issues
U.S. Government Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Hill:

On July 6, 1998, the Pacific Northwest Region of the USDA Forest Service mailed you a preliminary response to your draft report titled Oregon Watersheds: Many Activities Contribute to Increased Turbidity Following Large Storms (GAO/RCED-98-220). Stephen Glasser, of my staff, spoke with your Assistant Director, Mr. Charles Cotton, about our response to the report and promised Mr. Cotton a final response by July 9.

The Forest Service's Washington Office concurs with the Government Accounting Office's recommendations in the report and requests that the suggested changes in the July 6 letter, signed by Deputy Regional Forester Nancy Graybeal, be incorporated into the final version of this audit report. A copy of that letter is enclosed for your convenience.

Thank you for helping Senators Ron Wyden and Dale Bumpers, the USDA Forest Service, the five cities visited by your staff, and all affected parties achieve a better understanding of the 1996 floods and the recommendations for minimizing flood damage in the future.

Sincerely,

ROBERT C. JOSLIN
Deputy Chief for
National Forest System

Enclosure

United States Department of Agriculture | Forest Service | Pacific Northwest Region | P.O. Box 3623 Portland, OR 97208-3623 333 S.W. First Avenue Portland, OR 97204

File Code: 2500

Date: July 6, 1998

Barry T. Hill
Associate Director, Energy, Resources
and Science Issues
U.S. Government Accounting Office
441 G Street NW
Washington, DC 20548

Dear Mr. Hill:

Thank you for the opportunity to review and comment on the draft Government Accounting Office (GAO) report, Oregon Watersheds: Numerous Factors and Activities Impact Water Turbidity During Large Storms. Regional Office Staff, Pacific Northwest Research Station scientists and representatives from each of the involved National Forests have compiled the enclosed comments and suggestions.

Management of watersheds to provide high quality water is one of the primary uses of National Forest land in the Pacific Northwest. The Forest Service places great emphasis on protection of water quality and aquatic resources on all National Forest lands and has the responsibility to manage public lands within its jurisdiction to provide levels of water quality that are within the range of natural variability for an area, and that protect all the beneficial uses. Continued implementation of the Northwest Forest Plan has strengthened our on-the-ground application of policies for protection of water quality and quantity in support of all beneficial uses--including municipal supply. We strive to involve communities and citizens in every step of our planning process. Implementation of the Environmental Protection Agency's Source Water Assessment and Protection Program will enhance existing relationships and create new ones between the states, the Forest Service, and communities that depend on National Forest lands for drinking water.

The GAO report validates our long held belief in the need for, and benefits of frequent and meaningful communication between all landowners within areas that provide water supplies. The Pacific Northwest Region of the Forest Service will pursue implementation of the GAO's recommendations recognizing that this will help us meet our goal to provide high quality water for public use.

I want to thank the GAO, and especially Alan Dominicci, for providing a comprehensive and objective view of the complexities and factors involved in watershed management in the Pacific Northwest. The report and recommendations will benefit the Forest Service and the communities that use water originating on National Forest lands. Please feel free to contact me or my staff in the future if we can be of further assistance.

Sincerely,

ROBERT W. WILLIAMS
Regional Forester

Enclosure

Comments on GAO Draft Report

Oregon Watersheds: Numerous Factors and Activities Impact Water Turbidity During Large Storms

USDA Forest Service
July 6, 1998

Policy Comments:

With the completion, approval, and implementation of the Northwest Forest Plan (NWFP) and its Aquatic Conservation Strategy (ACS), the Forest Service in the Pacific Northwest began applying a set of Standards and Guidelines that represent an unrivaled level of protection of water quality. These Standards and Guidelines implement an ecosystem management strategy that will protect water quality in the short term. Additionally, they recognize that ecological disturbance, in the form of flooding and subsequent sedimentation, is a needed, natural and essential part of long-term water quality and quantity protection.

Forest Service participation in the Environmental Protection Agency's Source Area Assessment and Protection Program will strengthen existing relationships and establish new ones with communities and the public in general. As managers of the headwaters of many municipal watersheds our participation in developing, implementing, and improving source water protection actions is part of our role as stewards of the National Forests.

The GAO report notes that timber management practices of the past were often not designed to protect water quality. Forest Service land management practices, particularly those associated with timber harvest and road construction, have evolved over time. When viewed through the lens of today's management sensitivities, some past practices may appear overly harsh. However, it has always been the policy of the agency, working in concert with our research division, to apply land management practices that are considered to be 'best science' at the time. This learning process and subsequent adjustment is ongoing. While evolutionary in nature there are some milestones worth noting for their impact on the way land management practices were changed or altered. The following list represents only some of the many events, legislative and administrative, that ultimately culminated in the development of the Standards and Guidelines in the 1994 Northwest Forest Plan.

Year	Event	Impact
1948	H.J. Andrews Experimental Forest Established	Originally tested logging systems, evolved into a center for watershed, landscape, and ecosystem research.
1950's	Increased timber harvest in response to post World War II demand for housing.	Expansion of roading network, Area under harvest expanded. Hi-lead logging used to protect soil. Practices of the time included sidecast of excess material during road construction.
1960	Multiple Use Sustained Yield Act	Recognized that National Forests need to provide a full range of resources including water, timber, recreation, range, and wildlife.
1964	Major flood in Western Oregon	Post flood studies indicated that roads caused most of the watershed damage.

		Changes included: increasing use of full bench with end haul road construction, avoidance of unstable ground, more focus on partial or full suspension logging techniques; removal of large organic debris from streams represented 'science of the day.'
1969	National Environment Policy Act	Upgraded interdisciplinary planning process. More hydrologists and soil scientists and other specialists hired to conduct analysis and field reviews of projects.
1972	Clean Water Act Amendments PL 92-500	Non-point source assessments under Section 208, recognition of non-point pollution, water quality monitoring initiated within the Forest Service on silviculture and roading activities.
1973	Establishment of Forest Engineering Institute at Oregon State University	Agency students presented with techniques to better protect resource values. Graduates employed and improved upon techniques learned.
1973	Endangered Species Act	Eventual listing of fish species--stronger stream protection measures.
1976	National Forest Management Act	Established the need to do Forest Planning. Initially conducted as Unit Plans, evolved into Forest Planning efforts of the 1980's.
1978	Forest Service Designated as Clean Water Protection Agency by Oregon DEQ and Washington DOE	Forest Service watershed protection measures designated as Best Management Practices by States of Washington and Oregon--MOU signed.
1980s	Continued evolution of watershed management practices including the recognition of the role of large organic debris in providing aquatic habitat and water quality. Active program to reintroduce large organic debris into streams. Role of watershed specialists on interdisciplinary teams strengthened. Standards and Guidelines developed during Forest Planning incorporated Best Management Practices for the protection of water quality. Water quality monitoring, baseline and project, conducted on all Forests. Willamette NF Forest Plan Standards & Guidelines recommended no programmed harvest along perennial streams. Riparian Management Guide developed by Willamette NF and Oregon State University. Assessment of watershed cumulative effects from land management activities conducted on all Forests.	
1990	Revision of MOU with Oregon DEQ	Developed Non-point Source Management to incorporate Section 319 of Clean Water Act Programs

1993	President's Forest Conference, Portland Oregon	Establishment of Forest Ecosystem Management Assessment team. Resulted in development of NWFP/ACS concepts of: 1. Key Watersheds 2. Riparian Reserves 3. Watershed Analysis 4. Watershed Restoration
1994	Record of Decision for Northwest Forest Forest Plan (NWFP) signed.	Implementation of NWFP Aquatic Conservation Strategy. Watershed analysis process developed and conducted. Area under harvest greatly reduced. Timber harvest prescriptions change to a current mixture of commercial thinning, shelterwood, multistory uneven age management, regeneration with reserves.
1996	Major flood in Western Oregon/Washington	Focused attention on watershed management issues and water quality.

Comments on Factual Content:

Many of the following comments on the factual content of the report were conveyed to Alan Dominicci during exit interviews, and while not exhaustive, are mentioned here for completeness:

In general we would suggest that use of the term "Past timber harvesting" be given some temporal context. As it is used in the document it could refer to practices from the 1950s through the 1980s even though significant institutional and operational changes had been implemented by the 1980s.

Page 5, Para #3 - "--also have agricultural, industrial, urban, and residential development that can contribute sediment to streams"
Response: Would suggest changing the word "can" to "do" as recent monitoring and research studies indicate that such areas are sometimes the most significant contributors to sediment and turbidity during storms.

Page 13, Para #2 - " heavy rainfall--8 to nearly 15 inches in 4 days in many locations'
Response: Data from the Oregon Climate Service show that in some higher elevations within the Willamette River watershed as much as 20 to 27 inches of precipitation fell during the period February 5-9, 1996.

Page 19, Table 1.1 - Approximate area for North Santiam River watershed is listed as 490,000 acres.
Response: Tributary acres, North Santiam River to City of Salem intake on Geren Island, ~432,000 acres.

Page 40, Para #1 - "A July 1, 1993 plan -- known as the Northwest Forest Plan"
Response: The Record of Decision for the Northwest Forest Plan was signed on April 13, 1994 and is the implementing document.

Page 43, Para #2 - "the costs to protect and restore Portland's watershed are shared by the city and the federal government"

Response: Suggest that the above sentence be worded, "the costs to protect and restore Portland's watershed are mainly paid for by federal taxes."

Page 48, Para #1 - " and (3) managing wetlands"
Response: Suggest adding the following " and plans to (4) not dump Portland's raw sewage into the Willamette River during large rain storms."

Implementation of Recommendations:

1. "to include key landowners--who are critical to understanding and addressing the condition of a watershed--in memorandums of understanding with cities to address watershed issues and concerns."

The Forest Service agrees with this recommendation and fully supports participation in memoranda of understanding (MOU) with all parties involved in the management of a watershed. The Agency views participation in these MOU's as an effective tool to establish and enhance our working relationships. However, participation in a particular memorandum of understanding is not solely within our ability to execute. Participation in MOU's is voluntary. Invitations to participate, extended by various municipalities to land owners within their municipal watershed may be more appropriate.

The Willamette National Forest has recently entered into new negotiations with the City of Salem, the Salem Bureau of Land Management, the US Army Corps of Engineers and the Oregon Department of Forestry to establish a more comprehensive MOU for the North Santiam River. The Willamette NF has encouraged the City of Salem to include in the MOU smaller cities and private landowners located in the watershed.

The Mt. Hood National Forest has completed MOUs for both the Clackamas and the Mollala River watersheds. These two MOU's are between the Federal Agencies and the water suppliers in the respective watersheds.

Additionally, as a member of various Watershed Councils the Forest Service helps to establish goals and action plans which can comprise the basis for an MOU. In these cases the language of agreement would just need to be formalized into an MOU. However, such a formal document may not be necessary to enhance working relationships.

2. (a) "at a minimum, gather data on municipal water quality that are comparable with data gathered by other federally funded analyses;"

The Forest Service agrees with this recommendation and recognizes that past efforts to collect, organize, and interpret data on municipal water quality may have been disjointed. Federally funded analyses of watersheds in the Pacific Northwest have been conducted by a variety of agencies and the resulting information, while often useful, may not have been comparable or extendable to other watersheds. The Province Advisory Committees, established as part of the Northwest Forest Plan, of which each Forest is a member, gives us the opportunity to coordinate analysis efforts and will serve as a neutral forum for the presentation of the results of such studies.

(b) "when feasible, include water quality as a primary focus and/or conduct the analyses along the boundaries of the municipal watersheds;"

The Forest Service supports this recommendation and will work to ensure that water quality becomes a Key Issue in watershed analyses that examine municipal watersheds. Our watershed analysis process is guided by direction contained in Ecosystem Analysis at the Watershed Scale, ver. 2.2, August 1995. The recommended scale for watershed analysis given in the above document is 50 to 200 square miles. In

some cases, this may include the boundaries of a municipal watershed and in others it will not. In the particular case of large municipal watersheds, such as Eugene and Salem, with multiple land ownerships, the Forest Service is prepared to participate in conducting an analysis at a larger scale. Such an analysis could integrate previously completed watershed analyses from a variety of agencies or landowners.

Our current Watershed Analyses are always bounded by the physical margins of a watershed. However, this may or may not include the total area of a particular municipal watershed.

(c) "to the extent possible, collaborate with nonfederal land managers and owners to gather data that are comparable and useful to municipal watershed decision-makers, including data on the impact of new timber harvesting methods and road construction practices on water quality"

The Forest Service supports this recommendation. Collaboration with nonfederal land managers to gather and share comparable and useful data is critical to our participation with all landowners in a given watershed. We view participation in Watershed Councils to be a particularly efficient avenue to share such data and to ensure comparability. Joint monitoring efforts between the Forest Service and the City of Salem, a joint monitoring plan for the McKenzie River under the guidance of the McKenzie Watershed Council, and long term, joint monitoring of Layng Creek by the City of Cottage Grove and the Umpqua National Forest are examples of our current efforts to ensure data compatibility and usefulness.

The gathering and interpretation of data on new timber harvesting methods and road construction techniques as to their potential to impact water quality is an ongoing effort conducted in concert with the Pacific Northwest Research Station in Corvallis, Oregon (PNW) and the Pacific Southwest Research Station, Redwood Sciences Laboratory in Arcata, California (PSW). Ongoing studies include investigations of sediment quantity and sources in the North Santiam River, South Santiam River, and Layng Creek conducted by scientists from PNW, the University of Oregon and Oregon State University. Additionally, studies of the performance of roads built under new and old methods during the recent flooding are reaching a point of publication. These studies are being conducted jointly at the H.J. Andrews Experimental Forest by PNW and Oregon State University scientists. Studies conducted over the past 37 years in the Caspar Creek watershed in Northern California by PSW scientists have recently been summarized in a conference and publication. Included in the report are papers assessing the effectiveness of new roading techniques in relation to water quality. Additionally, a Synthesis of Scientific Information about roads is currently in preparation, by PNW scientists, as part of the Forest Service National Roads Initiative.

Full implementation of this recommendation will require a higher level of interaction among watershed councils, land managers, and the scientific community than is currently the norm.

List of Forest Service Personnel Involved in Preparation of These Comments:

Bruce McCammon	Pacific NW Regional Office	Regional Hydrologist
Ron Escano	Pacific NW Regional Office	Group Leader: Water, Fish & Wildlife
Thomas Ortman	Mt. Hood National Forest	Natural Resources Staff Officer
Herbert Wick	Willamette National Forest	Natural Resources Staff Officer
Terry Brumley	Umpqua National Forest	Natural Resources Staff Officer
Mikeal Jones	Umpqua National Forest	Hydrologist
Gordon Grant, Ph.D.	Pacific NW Research Station	Research Hydrologist
Fred Swanson, Ph.D.	Pacific NW Research Station	Research Geologist
Deigh Bates	Willamette National Forest	Hydrologist

In consultation with:

Bill Brookes	BLM - Oregon/Washington State Office	Hydrologist
Dick Prather	BLM - Salem District	Cascades Area Manager

Comments From the Department of the Interior

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

JUL 10 1998

Mr. Barry T. Hill
Associate Director, Energy, Resources
and Science Issues
General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Hill:

Thank you for the opportunity to review and comment on the draft General Accounting Office (GAO) report Oregon Watersheds: Numerous Factors and Activities Impact Water Turbidity During Large Storms. The Bureau of Land Management (BLM) Oregon State Office staff and a representative from the BLM Salem District have compiled the enclosed comments and suggestions.

Management of watersheds to provide high quality water is one of the primary uses of public lands in the Pacific Northwest. The BLM places great emphasis on protection of water quality and aquatic resources on all public lands. Continued implementation of the North West Forest Plan has strengthened our on-the-ground application of policies for protection of water quality and quantity in support of all beneficial uses, including municipal supply. We strive to involve communities and citizens in every step of our planning process. Implementation of the Environmental Protection Agency's Source Area Assessment and Protection Program will enhance existing relationships and create new ones between the BLM and the communities that depend on public lands for drinking water.

The GAO report validates our long held belief in the need for, and benefits of, frequent and meaningful communication between all landowners within areas that provide water supplies. The BLM will pursue implementation of the GAO's recommendations recognizing that this will help us meet our goal to provide high quality water for public use.

I want to thank the GAO, and especially Mr. Alan Dominicci, for providing a comprehensive and objective view of the complexities and factors involved in watershed management in the Pacific Northwest. The report and recommendations will serve well the BLM and the communities that use water originating on public lands. Please feel free to contact Mr. Lee Delaney, BLM Group Manager for Rangelands, Soils, Water and Wild Horses and Burros at 202-452-7796, if we can be of further assistance.

Sincerely,

FOR Piet deWitt

Bob Armstrong
Assistant Secretary - Land and
Minerals Management

Enclosure

Comments on General Accounting Office Draft Report
Oregon Watersheds: Numerous Factors and Activities
Impact Water Turbidity During Large Storms

United States Department of the Interior
Bureau of Land Management
July 6, 1998

Policy Comments:

With the completion, approval, and implementation of the North West Forest Plan (NWFP) and its Aquatic Conservation Strategy, the Bureau of Land Management (BLM) in the Pacific Northwest began applying a set of Standards and Guidelines that represents an unprecedented level of protection of water quality. These Standards and Guidelines implement an ecosystem management strategy that will protect water quality in the short term. Ecological disturbance, in the form of flooding and subsequent sedimentation, is an essential and natural part of long-term water quality protection and water yield. The BLM's municipal watershed policy is to provide water that, with adequate treatment by the purveyor, can achieve standards for drinking water. Additionally, the BLM has the responsibility to manage public lands within its jurisdiction to provide levels of water quality that are within the range of natural variability for an area and that protect all the beneficial uses.

The BLM's participation in the Environmental Protection Agency's Source Area Assessment and Protection Program will strengthen existing relationships and establish new ones with communities and the public in general. As manager of the headwaters of many municipal watersheds, our participation in developing, implementing, and improving source water protection actions is part of our role as stewards of the public lands.

The General Accounting Office report notes that timber management practices of the past were often not designed to protect water quality. The BLM land management practices, particularly those associated with timber harvest and road construction, have evolved over time. When viewed through the lens of today's management sensitivities, some past practices may appear overly harsh. However, it has always been the policy of the agency, working in concert with the scientific community, to apply land management practices that are considered to be "best science" at the time. This learning process and subsequent adjustment are ongoing. While evolutionary in nature, there are some milestones worth noting for their impact on the way land management practices were changed or altered. The following list represents only some of the many events, legislative and administrative, that culminated in the development of the Standards and Guidelines in the NWFP.

Year	Event	Impact
1948	H. J. Andrews Experimental Forest Established	Originally tested logging systems, evolved into a center for watershed, landscape, and ecosystem research.

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1950's	Increased timber harvest in response to post World War II demand for housing.	Roading network and timber harvest expanded. High-lead logging used to protect soil. Practices of the time included sidecast of excess material during road construction.
1964	Major flood in western Oregon	Post flood studies indicated that roads caused most of the watershed damage. Changes included increasing use of full bench with end haul road construction, avoidance of unstable ground, and more focus on partial or full suspension logging techniques. The removal of large organic debris from streams represented "science of the day."
1969	National Environmental Policy Act	Upgraded interdisciplinary planning process. More hydrologists and soil scientists and other specialists hired to conduct analysis and field reviews of projects.
1972	Federal Water Pollution Control Act Amendments Public Law 92-500	Nonpoint source assessments under section 208, recognition of nonpoint source pollution, and water quality monitoring initiated within the BLM on silviculture and roading activities.
1973	Establishment of Forest Engineering Institute at Oregon State University	Agency students presented with techniques to better protect resource values. Graduates employed and improved upon techniques learned.
1973	Endangered Species Act	Eventual listing of fish species--stronger stream protection measures.
1976	Federal Land Policy and Management Act Public Law 94-579	Established the need to do planning. Initially conducted as Unit Plans, evolved into Forest Planning efforts of the 1980's

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1978	BLM designated as Clean Water Protection Agency by Oregon Department of Environmental Quality (DEQ) and Washington State Department of Ecology.	BLM watershed protection measures designated as Best Management Practices by States of Washington and Oregon - Memorandum of Understanding signed.
1980's	Continued evolution of watershed management practices, including the recognition of the role of large organic debris in providing aquatic habitat and water quality. Active program to reintroduce large organic debris into streams. Role of watershed specialists on interdisciplinary teams strengthened. During resource planning, Best Management Practices are incorporated into the plan for protection of water quality. Water quality monitoring, baseline and project, conducted on all Districts. BLM developed and began implementation of riparian management policy.	
1990	Revision of Memorandum of Agreement with Oregon DEQ	Developed nonpoint source management program requirements consistent with Section 319 of the Water Quality Act.
1993	President's Forest Conference, Portland, Oregon	Establishment of Forest Ecosystem Management Assessment Team. Resulted in development of NWFP and concepts of: 1. Key Watersheds; 2. Riparian Reserves; 3. Watershed Analysis; and 4. Watershed Restoration.

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1994	Record of Decision for NWFP signed.	Implementation of NWFP Aquatic Conservation Strategy. Watershed analysis process developed and implemented. Timber harvest prescriptions changed from predominately clearcut (minimal reserves) to a current mixture of commercial thinning, shelterwood, multistory uneven age management, and regeneration with reserves.
1996	Major flood in western Oregon/Washington	Focused attention on watershed management issues and water quality.

Factual Content:

Many of the following comments on the factual content of the report were conveyed to Mr. Alan Dominicci during exit interviews:

In general, we would suggest that use of the term "past timber harvesting" be given some temporal context. As used in the document, it could refer to practices from the 1950's through the 1980's, even though significant institutional and operational changes had been implemented by the 1980's.

Page 5, paragraph 3 - ". . . also have agricultural, industrial, urban, and residential development that can contribute sediment to streams . . . ."
Response: Would suggest changing the word "can" to "do" as recent monitoring and research studies indicate that such areas are sometimes the most significant contributors to sediment and turbidity during storms.

Page 13, paragraph 2 - "Heavy rainfall--8 to nearly 15 inches in 4 days in many locations."
Response: Data from the Oregon Climate Service show that in some higher elevations within the Willamette Valley as much as 20-27 inches of precipitation fell during February 5-9, 1996.

Page 19, Table 1.1 - Approximate area for North Santiam River watershed is listed as 490,000 acres.
Response: Tributary acres, North Santiam River to City of Salem intake on Geren Island, approximately 432,000 acres.

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Page 40, paragraph 1 - "A July 1, 1993 plan -- known as the Northwest Forest Plan . . . ."
Response: The Record of Decision for the NWFP was signed on April 13, 1994, and is the implementing document.

Page 43, paragraph 2 - "The costs to protect and restore Portland's watershed are shared by the city and the federal government . . . ."
Response: Suggest that the above sentence be worded, "The costs to protect and restore Portland's watershed are mainly paid for by Federal taxpayers . . . ."

Page 48, paragraph 1 - ". . . and (3) managing wetlands . . . ."
Response: Suggest adding the following, ". . . and plans to (4) not dump Portland's raw sewage into the Willamette River during large rain storms . . . ."

Implementation of Recommendations:

1. ". . . to include key landowners--who are critical to understanding and addressing the condition of a watershed--in Memoranda of Understanding with cities to address watershed issues and concerns . . . ."

The BLM agrees with this recommendation and fully supports its participation in MOUs with all parties involved in the management of a watershed. The BLM views participation in these MOUs as an effective tool to establish and enhance working relationships. However, participation in a particular MOU is not solely within our ability to execute. Participation in MOUs is voluntary. Invitations to participate, extended by various municipalities to landowners within their municipal watershed, may be more appropriate.

Additionally, as a member of various watershed councils, the BLM helps to establish goals and action plans which can comprise the basis for an MOU. In these cases, the language of agreement would need to be formalized into an MOU, but such a formal document may not be necessary to enhance working relationships.

2. (a) ". . . at a minimum, gather data on municipal water quality that are comparable with data gathered by other federally funded analyses; . . ."

The BLM agrees with this recommendation and recognizes that past efforts to collect, organize, and interpret data on municipal water quality may have been disjointed. Federally funded analyses of watersheds in the Pacific Northwest have been conducted by a variety of agencies and the resulting information, while often useful, may not have been able to be extrapolated to other watersheds. The Province Advisory Committees, established as part of the NWFP, of which each BLM District is a member, give us the opportunity to coordinate analysis efforts and will serve as a neutral forum for the presentation of the results of such studies.

(b) ". . . when feasible, include water quality as a primary focus and/or conduct the analyses along the boundaries of the municipal watersheds; . . ."

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The BLM supports this recommendation and will work to ensure that water quality becomes a key issue in watershed analysis documents that examine municipal watersheds.

Our watershed analysis process is guided by direction contained in Ecosystem Analysis at the Watershed Scale, ver. 2.2, August 1995. The recommended scale for watershed analysis given in the above document is 50-200 square miles. In some cases, this may include the boundaries of a municipal watershed and in others it will not. In the particular case of large municipal watersheds, such as Eugene and Salem, with multiple land ownerships, the BLM is prepared to participate in conducting an analysis on a larger scale. Such an analysis could integrate previously completed watershed analyses from a variety of agencies and landowners.

Our current watershed analyses are always bounded by the physical margins of a watershed. However, this may or may not include the total area of a particular municipal watershed.

(c) ". . . to the extent possible, collaborate with nonfederal land managers and owners to gather data that are comparable and useful to municipal watershed decision-makers, including data on the impact of new timber harvesting methods and road construction practices on water quality."

The BLM supports this recommendation. Collaboration with non-Federal land managers to gather and share comparable and useful data is critical to our participation with all landowners in a given watershed. We view participation in watershed councils to be a particularly efficient avenue to share such data and ensure comparability. Joint monitoring efforts between the BLM and the city of Salem, and a joint monitoring plan for the McKenzie River under the guidance of the McKenzie Watershed Council, are examples of our current efforts to ensure data compatibility and usefulness.

The gathering and interpretation of data on new timber harvesting methods and road construction techniques as to their potential to impact water quality are an ongoing effort conducted in concert with the Pacific North West Forest Experiment Station in Corvallis, Oregon (PNWFES), and the Pacific Southwest Research Station, Redwood Sciences Laboratory, in Arcata, California. Ongoing studies include investigations of sediment quantity and sources in the North Santiam River, South Santiam River, and Layng Creek conducted by scientists from PNWFES, the University of Oregon, and Oregon State University. Additionally, studies of the performance of roads built under new and old methods during the recent flooding are reaching a point of publication. These studies are being conducted jointly at the H. J. Andrews Experimental Forest by PNWFES and Oregon State University scientists. Studies conducted over the past 37 years in the Caspar Creek watershed in northern California by Forest Service scientists have recently been summarized in a conference and publication. Included in the report are papers assessing the effectiveness of new roading techniques in relation to water quality. Additionally, a "Synthesis of Scientific Information" about roads is currently in preparation, by PNWFES scientists, as part of the Forest Service's National Roads Initiative.
Full implementation of this recommendation will require a higher level of interaction among watershed councils, land managers, and the scientific community than currently exists.

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Bibliography of the Scientific Studies Reviewed by GAO

This bibliography lists the scientific studies we reviewed on the impacts of past and newer timber-harvesting and road construction practices on water quality.

Scientific Studies on the Impacts of Past Timber-Harvesting Practices on Water Quality

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