Marys River Watershed

Preliminary Assessment

Prepared by

Ecosystems Northwest
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for

The Marys River Watershed Council
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INTRODUCTION AND PURPOSE OF THIS DOCUMENT

This document is the product of a preliminary watershed assessment for the Marys River Watershed. The purpose of the document is to describe what is known about the condition of the Marys River Watershed, and to present a list of prioritized issues for the Marys River Watershed Council for their use in the development of strategies for further assessment and subsequent watershed protection and restoration. The assessment examined land use history, water quality, aquatic and terrestrial habitats, soil conditions, and social and economic conditions. The assessment followed the guidance provided by the Oregon Watershed Assessment Manual (NonPoint Solutions 1998) where practical. In some instances, diversions were made from the Assessment Manual based on discussions and direction from the technical steering committee of the Council. Examples of divergence includes the addition of a chapter on social or economic conditions, inclusion of upslope conditions such as soil erosion processes, and the initiation of an annotated bibliography. This assessment, in general, did not collect new data, did not perform channel typing, and did not perform aerial photographic assessments of riparian zones. The main focus of the assessment was a synthesis of existing data sets and studies pertaining to the Marys River Watershed to provide a better picture of the watershed at this point in time.

An eight-person team performed the assessment with assistance and guidance by the technical steering committee. The assessment consisted of three phases. During the first phase, a set of issues was identified for the assessment. Presentations were made to the Marys River Watershed Council, discussions were held with the steering committee, and a facilitated public meeting was held at the Greenberry Grange during December 1998. Input from these activities, together with guidance from the Assessment Manual, was used to produce and prioritize a set of issues. The second phase consisted of seeking out and gathering existing data pertaining to the Marys River Watershed. Data was gathered from government files, aerial photos, GIS maps, unpublished reports and data sets, published literature, theses and dissertations, and from consultations with experts from government agencies, research organizations, and residents and others with background knowledge of the basin. The gathered data is largely represented in the annotated bibliography at the end of this document. The third phase consisted of constructing a synthesis of the current picture of watershed health and assembling the data into a series of figures, GIS maps, photographs, and tables that comprise this document.

In the remainder of this document, the Marys River Watershed is described in terms of chapters on: 1) watershed characterization, 2) history of human use, 3) water quality and quantity, 4) aquatic and terrestrial habitats, 5) soils, and 6) social and economic considerations. A final chapter presents a prioritized list of issues derived from the previous six chapters on watershed condition. This list is used to present a set of recommended strategies for the Watershed Council in the final chapter.

CHAPTER 1: WATERSHED CHARACTERIZATION

Location

The Marys River Watershed encompasses 310 square miles of forested, agricultural, and urban lands along the east side of the Coast Range in western Oregon. The watershed reaches to the highest point in the Coast Range, Marys Peak, at 4,200 feet elevation. Several headwater streams from the Coast Range merge into the Marys River, which flows into the Willamette River at the town of Corvallis at 250 feet elevation.

The West Slope of the Willamette Basin

The watershed is one of five major river systems that drains the west side of the Willamette River basin. These "westslope" rivers are quite different from the "eastslope" rivers of the Willamette Basin with respect to a number of characteristics. The westslope drainages are underlain by older geological formations of a sedimentary origin, whereas eastslope drainages are commonly of a volcanic origin. Accordingly, westslope stream valleys tend to be mature, with more downcutting and larger amounts of fine sediment than eastslope valleys. A lack of snow pack in the westslope headwaters results in different flow patterns; these streams have sustained high winter flows and periods of low flows during summer months. The elevational extremes are less pronounced on the western slope of the Willamette Basin, and valleys tend to be wide and flat. Also, much of the area of westslope watersheds is on the floor of the Willamette Valley, resulting in differences in fish assemblages. Salmon are thought not to have been native to these streams. Even human settlement patterns were probably influenced by the more accessible, flatter ground of the western slopes, which were preferred travel routes by early settlers in the valley. As a result, the westslope rivers form a unique functional group within the Willamette Basin.

Three Characteristic Areas

From a hydrological, biological, and land-use perspective, the Marys River Watershed may be considered as having three distinct areas: an upland forest area, a valley agriculture area, and a downstream urban area (Map 1; all maps are located in Appendix 7). These distinctions may be useful to the reader as they consider the services and functions that the streams and landscapes perform in each area. Also each area has its own set of management issues and demands that are being made on them by the landowners and the public.

The upland forest area is located in the western and northwestern portions of the watershed, where small, relatively fast-flowing streams on forested slopes coalesce into the headwaters of either the Marys River or Muddy Creek. These streams are generally cool and clear and flow over gravels and cobbles. The streams support cutthroat trout, sculpins, and a variety of amphibians. The landscape is a mix of second growth forests with scattered residences and small farms as shown in Photo 1.

Photo 1: Forest uplands area is composed of a mix of land uses including residences, small farms, and forests. Map 1 (Appendix 7) shows location of this photo in the Tum Tum sub-watershed.

Streams then enter the valley agriculture area, which is located on the floor of the Willamette Valley, of the Marys River Watershed. As these streams leave the foothills of the Coast Range, gradient decreases and stream velocity slows. This area includes the Marys River near the town of Philomath and most of lower Muddy Creek basin. The valley area was originally a mix of forests, open prairies, and seasonal wetlands. The flat landscape was formed by a series of catastrophic Pleistocene floods that occurred in the Columbia River and back-washed fine sediment up into the Willamette Basin. Streams in the valley area are normally warm, tend flow over sand and silt sediments, and are characterized by wetland areas and wide, often hardwood-dominated riparian zones. These streams support a greater variety of warm-water fishes such as peamouth, sand rollers, Oregon chub, dace, and redside shiners, along with many introduced species of fish. These streams are in close proximity to human development and often are affected by transportation crossings, drainage projects, and reduced riparian cover. This landscape is now mostly in agriculture, pastures, and scattered residences, with remnant forests as shown in Photo 2.

The downstream urban area of the Marys River begins as it enters Philomath and continues east, flowing through a developed landscape. This area includes a variety of riverside parks and developed landscapes, channelization or bank stabilization, and point source discharges of stormwater runoff and wastewater effluent. The Marys

River flows through downtown Corvallis before it joins the mainstem of the Willamette River.

Photo 2: Valley floor area. This winter scene shows grass-seed agriculture, a few remnant oak trees; the standing water in the field are drainage ditches. The hills to the west are the forest uplands. Map 1 (Appendix 7) shows location of this photo in the Muddy Creek sub-watershed.

Land Use, Ownership, and Population

Land use in the watershed also is a reflection of the three separate areas. Forestry is the main land use in the upland zone, mixed agricultural and rural residential are the main land use type in the valley zone. The urban growth boundaries of Philomath and Corvallis represent the urban zone (Map 2).

Land ownership in the watershed falls into different patterns in each area (Map 3). Major land owners in the upland forest area consists of industrial forestry firms, Siuslaw National Forest, Bureau of Land Management, the State of Oregon, the City of Corvallis, and a mix of other private groups and individuals. The unincorporated communities of Wren, Blodgett, Summit, and Burnt Woods are located in this area. Ownership in the valley area is diverse of types and largely private. Land holdings include large-acreage grass seed farms, large-acreage Christmas tree farms, small-acreage farm enterprises that produce a variety of food and agricultural products, and rural residential homesteads. The Corvallis airport and some light industries are also located in the valley area, as are Finley National Wildlife Refuge and the communities of Alpine and Bellfountain. The urban zone is a typical mix of businesses, residences, and light industries, and includes the Oregon State University campus and the cities of Philomath and Corvallis (Map 4).

The population density of the watershed shows development has occurred in several areas outside the urban growth boundaries of Philomath and Corvallis. The distribution of households in the watershed is shifting from rural and farm- associated holdings to non-farm residences and developments as more people seek rural settings for homesites (Map 5). This shift likely has been slowed by state land-use laws that are effective at controlling growth into lands zoned as agriculture and forestry. Yet a basic issue of concern for the Marys River Watershed is pronounced landscape modification over a relatively short period of time. Most of the modifications are the indirect results of an increasing human population and its associated homes, roads, cities, and activities. People bring with them increased demands and uses of the watershed.

Sub-basins within the Watershed

The Marys River Watershed is itself a sub-basin of the larger, 11,500 square mile watershed of the Willamette River. Ninety-five percent of the Marys River Watershed is within Benton County, and Small edges of the watershed fall into Lincoln, Polk and Lane counties (Map 7).

The Marys River Watershed may be divided into a series of 24 smaller “sub-basins.” These sub-basins generally follow hydrologic boundaries (Map 6 and Table 1), but some units include a series of small watersheds that do not drain into a common stream (e.g., Wren, Blakesley Creek) or include stream segments that are parts of a larger watershed (e.g., North Muddy Creek, Middle Muddy Creek, and South Muddy Creek). Nevertheless, the 24 units are referred to here as sub-basins and provide a convenient way to refer to areas within the larger watershed.

Sub-basins are grouped by those in the Marys River proper and those in the Muddy Creek drainage basin. About five miles upstream of the mouth, or halfway between Corvallis and Philomath, is the confluence of Muddy Creek and the Marys River. Muddy Creek drains 42% of the entire Marys River Watershed. During the high-flow periods of winter, discharge from Muddy Creek can add an additional two-thirds to the volume of the Marys River. The separate areas upstream of this junction are quite distinct. The watershed area drained by the Marys River upstream of its confluence with Muddy Creek is mostly upland forest area, while the lower reaches of Muddy Creek drain the valley agriculture area. These two major sub-watersheds provide a convenient way to discuss some of the variation within the watershed.

The difference in stream gradient between the Marys River and Muddy Creek likely results in hydrologic and water quality differences between the two sub-basins. As described earlier, the Marys River drains the upland forest areas and has a steep gradient throughout most of its 20-mile pathway to the valley floor near Philomath. Muddy Creek and its tributaries flow steeply from their Coast Range headwaters for only a few miles before flattening out on the floor of the Willamette Valley. The longitudinal profiles of the Marys River and Muddy Creek are contrasted in Figure 1.

Table 1: Marys River Watershed sub-basin areas and channel lengths.

Sub-basins shown on Map 6	**Area** (square miles)	**Channel length** (miles)
Marys River sub-basins		
Upper Marys	25.8	8.16
Norton Creek	8.7	3.18
Tum Tum River	12.5	12.09
Blakesley Creek	9.2	5.85
Oak Creek/Squaw Creek	16.8	3.48
Wren Creek (Gellatly, LaBare, Read Creeks)	6.4	2.07
Shotpouch Creek	9.9	4.83
Bark Creek	7.6	7.64
Middle Marys River	15.0	3.30
Lasky Creek	3.1	7.74
Mulkey Creek	4.4	6.03
Newton Creek	5.7	5.00
Woods Creek	9.9	4.30
Lower Marys River	8.9	10.45
Greasy Creek	37.2	13.84
Muddy Creek sub-basins		
North Muddy Creek	18.8	4.70
Evergreen Creek	7.4	4.47
Bull Run Creek	6.5	6.10
Beaver Creek	24.6	4.77
Middle Muddy Creek	15.1	22.99
Reese Creek/Oliver Creek	27.5	4.81
Gray Creek	5.9	2.60
Hammer Creek	15.3	1.87
South Muddy Creek	7.9	7.47
TOTAL Marys River sub-basins and Marys River channel	181.0	41.04
TOTAL Muddy Creek sub-basins and Muddy Creek channel	129.0	32.33
GRAND TOTAL Marys River Watershed	310.0	

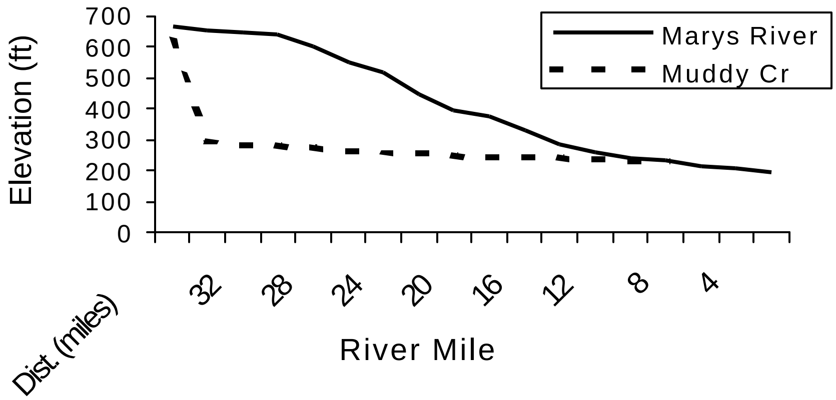


Figure 1: Longitudinal gradient profiles for Marys River and Muddy Creek

Geology and Landforms

The watershed is bounded on the north, west and southwest by sloping to very steep uplands formed by volcanic, sedimentary and intrusive rocks of the northern Coast Range (Map 20). The rocks of the northern Coast Range are made up of thick volcanic flows and tuffaceous sedimentary rock of the Eocene Siletz River Volcanics, overlain by the Flournoy sandstone (Appendix 5, Section 1). Several prominent peaks of the Coast Range, including Marys Peak, are igneous rocks that intruded these older rocks. During the Plio-Pleistocene, streams of the Coast Range excavated their valleys as the Coast Range slowly rose (Baldwin 1976).

The drainage divide in the eastern part of the watershed occurs on the nearly level alluvial and lacustrine terraces of the southern Willamette Valley. The lacustrine and alluvial deposits of the Willamette Valley terraces and floodplains are Quaternary aged, and include old alluvium, sediments from repeated Missoula Flood events during the late Pleistocene, and recent floodplain deposits. Floodplains and terraces rise stepwise from the Willamette River and its tributaries towards the foothills. These stepwise deposits correlate with distinctive geomorphic formations and soils (Appendix 5, Section 1).

Hydrology

All streamflow in the Marys River Watershed originate from atmospheric inputs. Mean annual precipitation ranges from 40 inches per year at lower elevations to greater than

100 inches per year at the highest elevations in the watershed. Long-term precipitation records exist for Corvallis at the Marys River mouth and for Summit near the headwaters of the Marys River. Monthly averages of precipitation for these stations show consistently higher precipitation at Summit's higher elevation (Figure 2). Precipitation peaks in November through January and falls to very low amounts in July and August. Precipitation data for the Corvallis station from 1986-1998 show high levels of inter-seasonal and inter-annual variability (data not shown). These data are available from Oregon State University via the internet (http://www.ocs.orst.edu/).

Stream discharge records are available for three stations in the Marys River Watershed: Marys River between Muddy Creek and Philomath (1941-1986), Muddy Creek at the first road crossing (1964-1968), and Rock Creek (1946-1952, 1975-1980). Stream stage (water level height) is still being recorded for the Marys River station, but since 1986 no measurements have been taken to relate stage to discharge. These data are available via the Internet from the USGS web page (http://waterdata.usgs.gov/nwis-w/OR/) or the US Army Corps of Engineers (http://nwp71.nwp.usace.army.mil/graphics/willamette/willtrib/willtrib.html).

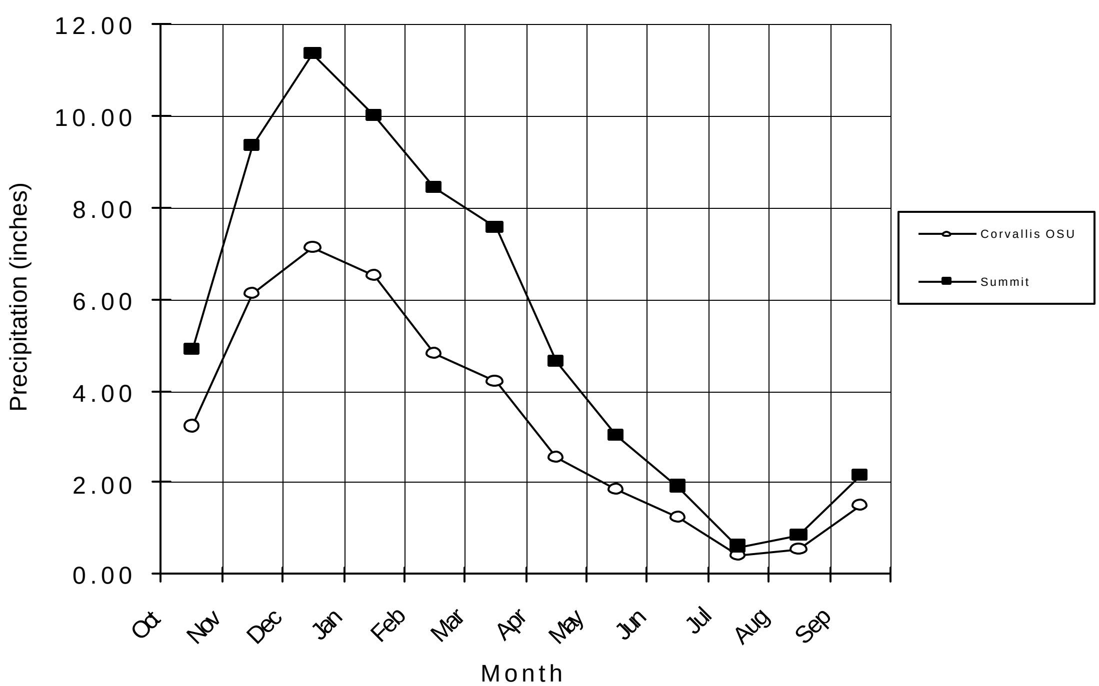


Figure 2: Long-term average monthly precipitation records collected near the headwaters and mouth of the Marys River.

Data from these three stations provide a description of the stream flow from three distinct watersheds. The Marys River discharge suggests a drainage area that is relatively large and steep, with high peak flows in the winter and an extended period of baseflow into the spring. Analysis of the discharge averaged by month over the period of record shows discharge peaking in January (Figure 3), while precipitation peaks in December. This lag between precipitation and discharge peaks results from a combination of saturated soils during the winter season and late-season snowmelt. These factors delay the runoff peak and extend high flows into February. The period of low flow, primarily during from July through October, is important for its effects on water quality and the stress on fish populations.

Much of the Muddy Creek channel flows through low-gradient, agricultural lands and the hydrographs are less flashy (not peaking as dramatically in a short time) than the mainstem of the Marys River. Only a five-year record exists for Muddy Creek, but general trends can be seen in monthly average discharge values (Figure 3). Little variability among peak, mean and low flows is evident during the 5-year period of record. Peak flow occurs in January and low flows begin as early as May. The extended low-flow period extends from June through October. These low flows impact agricultural withdrawals for irrigation as well as aquatic habitat.

Rock Creek is a small sub-basin of Greasy Creek on mostly steep, forested lands. Average monthly values for 11 years of record show runoff peaks in February (Figure 3), which correspond with the onset of snow melt. The importance of snow melt in the Rock Creek sub-basin also may explain the increased discharge for the Marys River in February and March, which reflects drainage of high-elevation areas of the watershed. Low flow in Rock Creek may occur as early as May and extend well into the fall.

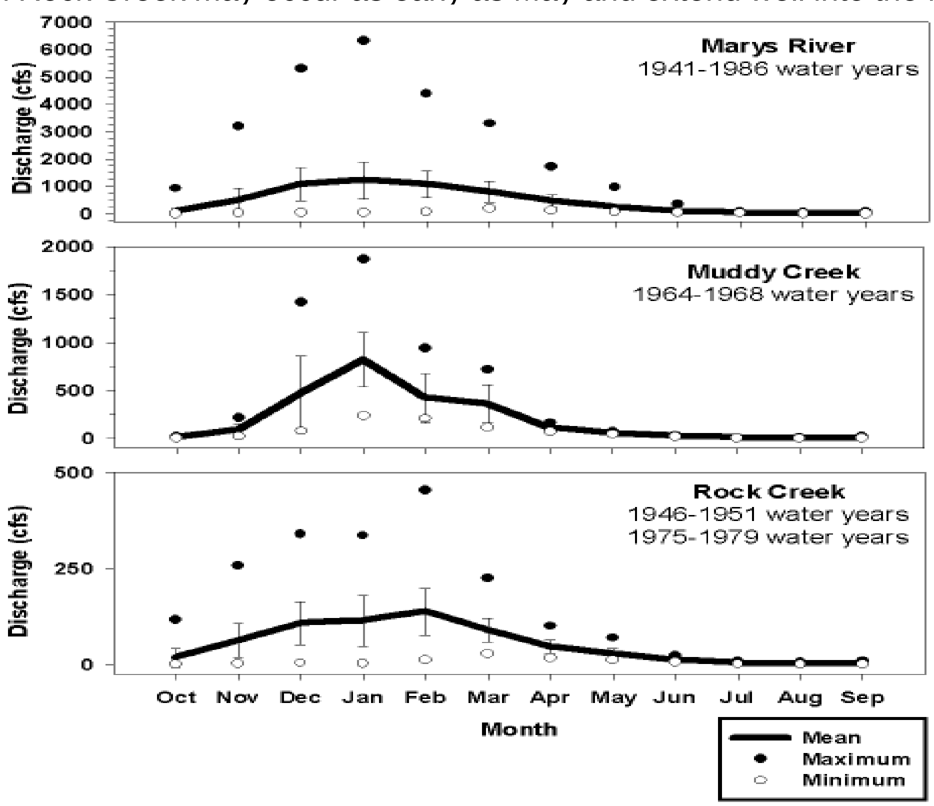


Figure 3: Stream discharge averaged by month for Marys River, Muddy Creek, and Rock Creek showing mean, standard deviation, maximum and minimum.

Flooding in the Marys River Watershed is a primary concern in the lower watershed. A map of the extent of flood waters during the 1996 flood event shows flooding along Marys River and Greasy Creek upstream of Philomath (Map 8). Most flooding, however, occurred downstream of Philomath and below the confluence with Muddy Creek. In addition to receiving drainage waters from the larger watershed, these downstream areas may experience localized flooding from runoff generated by impervious areas within Corvallis and Philomath. At the Marys River gauging station, major flood events occur at flows exceeding 5485 cfs (Appendix 4, Section 1). Bankfull flow, when water leaves the channel and flows into the floodplain, occurs at 2745 cfs. Marys River discharge exceeded flood stage in 22 of the 45 years of record (Figure 4). In all but four years over the same period, Marys River discharge exceeded bankfull discharge. With no dams for flood control on the Marys River, floodplain management will be an important watershed issue as urban development continues to expand into historical floodplain areas.

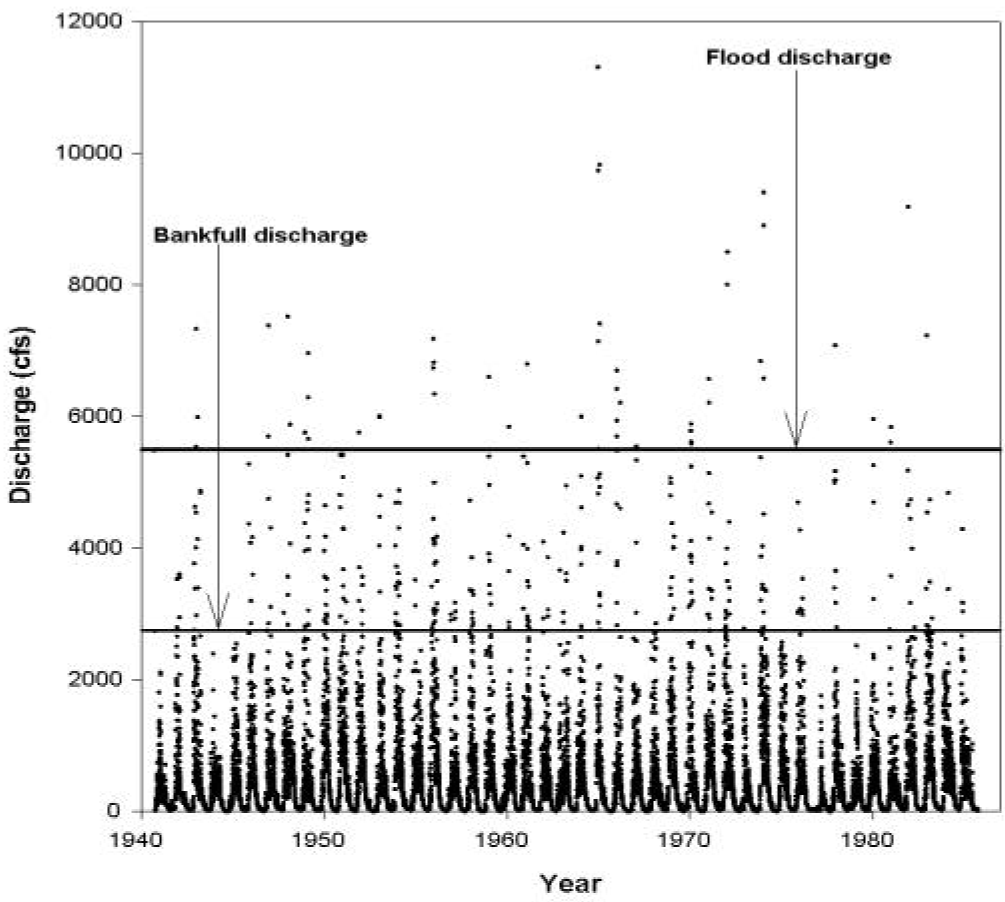


Figure 4: Marys River Discharge 1941-1986.

CHAPTER 2: HISTORICAL CONDITIONS

This chapter provides an overview of historical conditions for the Marys River Watershed. The historical record is summarized here to provide insights into what the area looked like at the time of Euro-American exploration and settlement and to gain an understanding of how human uses have modified the watershed through time.

For the purpose of this analysis, the history of the Marys River Watershed is divided into three periods: the Kalapuyan landscape, the American pioneers, and the transition to modern times (Table 2). Watershed conditions during each of these historical periods are described based on evidence from written and verbal first-hand accounts of explorers and watershed residents, resource inventories, maps, drawings, and photographs.

Table 2: Periods of social and institutional changes in the Marys River watershed.

pre-Columbian–1845	Kalapuyan landscape
1846–1879	American pioneers
1880–1940	Transition to modern times

These historical periods set the context for the current conditions in the Marys River watershed. By World War II, many of the land use activities and other trends were established.

The Kalapuyan Landscape: pre-Columbian–1845

The indigenous people in the Marys River Watershed and surrounding area at the time of Euro-American contact called themselves the Kalapuya. It is not known how long the Kalapuya lived in the Willamette Valley prior to Euro-American contact. Technologies such as roasting of filberts and camas used by these people are thought to be at least 9000 years old (Minor and Toepel 1991, Reckendorf and Parsons 1966). At the time of the Lewis and Clark expedition in 1805-1806, at least six nations of Native Americans, estimated at 10,000-12,000 individuals total, lived in the valley (Boyd 1986). By 1841, only 400 or so Kalapuya survived in the Willamette Valley, with much of the population before this period decimated by disease (Wilkes 1845).

Evidence shows that the Kalapuya practiced active resource management in the Marys River Watershed and that these activities were responsible for the landscape and vegetation encountered by the early explorers. The first recorded history of the Kalapuya was on October 4, 1826. In the approximate area of Berry Creek, in southern Polk County, the McLeod expedition noted a group of Kalapuya digging roots (Davies 1961). At the time of Euro-American settlement, grizzly bears, white-tailed deer, California condors, lamprey eels, Willamette chub, wolverines, cougar, wolves, and elk inhabited the Marys River Watershed (Storm 1941). In 1834, Hudson Bay Company chief trader John Work, following the route of the McLeod expedition, noted extensive broadcast burning in the Willamette Valley (Scott 1923). One of the few known sketches of the landscape at the time of Euro-American arrival is shown in Figure 5.

The use of fire for vegetation management has been termed "pyroculture" (Gilsen 1989). This process involved periodic broadcast burning over large areas of the landscape to control unwanted plants, including Douglas-fir and possibly poison oak, to the advantage of desired plants, including oak, camas and huckleberries (Boyd 1986; Minore 1972; Gilsen 1989). The widespread use of this practice is evidenced by patterns of plants that exist today and by thousands of prehistoric artifacts used to process food, medicine, and dyes that occur in the Marys River Watershed and adjacent areas (Aikens 1975, Collins 1951). Vaughn (1890 p. 64) stated: “At that time there was not a brush or tree to be seen on all those hills, for the Indians kept it burned over every spring, but when the whites came, they stopped the fires for it destroyed the grass and then the young spruces sprang up and grew as we now see them.”

Figure 5: Sketch of a Kalapuya man near a Marys River tributary, 1841 (Wilkes 1845). Drawn by A. A. Agate. The drawing shows a somewhat more open landscape in the 1840’s.

The following accounts from early explorers provide a picture of the Marys River landscape comprised of open oak savannas, rich grassland prairies, wetlands, and trees in the streamside areas.

Monday June 1, 1834: The road now lay along an extensive plain, some parts of it swampy, to Laurie [Marys] river where we are camped not far from its discharge into a Channel of the Willamett. Here is an extensive plain on both sides of the river, and the mountains to the W. are nearly without wood. Clover was observed today on both the high and on the low ground. The soil & herbage has the same appearance as usual. Where we are camped at the usual traverse of the river is too high to be forded, but we learn from the Indians it is fordable a little higher up. (Wilkes, 1845).

Thursday July 2, 1834: Fine. Continued our course 6 1/2 hours across the plain to River Lauries [Marys] river where we camped. The Indians set fire to the dry grass on the neighboring hill, but none of them came near us. The plain is also on fire on the opposite side of the Willamet. [Marys River]. (Wilkes, 1845).

Monday June 9, 1845: Morning Clear the sun arose in splendid majesty over the snowy peaks of Mount Jefferson The vally covered in dew like a rain passed through some beautifull country for farming and Likewise some very wet land early in the Day we came to a small river supposed to be the Tom Beoff [Long Tom River]. (Palmer 1845).

Mouse [Marys] River joins the Willamette about thirty-five miles above the Lucky-mate [Luckiamute]. It had its origin in the Coast Range, has two principal branches, which unite near the mountains, passes ten miles over a pebbly bottom, and then becomes more sluggish to its mouth. This, like the other streams described, has timber upon its boarders, but less than some; good country, fine prospects, and but a few claims made. (Palmer 1845).

1841 (Late Summer): The country in the southern part of the Willamette Valley, stretches out into wild prairie-ground, gradually rising in the distance into low undulating hills, which are destitute of trees, except scattered oaks; these look more like orchards of fruit trees, planted by the hand of man, than groves of natural growth, and serve to relieve the eye from the yellow and scorched hue of the plains. The meandering of the streams may be readily followed by the growth of trees on their banks as far as the eye can see. (Wilkes, 1845).

Between the Lucky-mate and Mouse River there is a range of hills, as between other streams; but at one place a spur of the Coast Range approaches within ten miles of the Willamette; from this issue many small streams which run down it, and through the fine plains to the Lucky-mate upon the one side, and into Mouse River on the other. This is a beautiful region; from the bottom can be seen, at different points, seven snow-covered peaks of the Cascade Range. The Cascade is within view for a great distance, to the north and south; which, together with the beautiful scenery in the valley, renders it a picturesque place. Thrifty groves of fir and oak are to be seen in *every direction; the earth is carpeted with a covering of luxuriant grass, and fertilized by streams of clear running rivulets, some of which sink down and others pursue their course above ground to the river. Between the forks of Mouse River approaches a part of the Cascade [Coast range], but it leaves a valley up each branch about one mile in width, the soil of which is rich and good prairie for several miles above the junction. The mountain sides are covered heavily with timber. Thus these beautiful valleys offer great inducements to those who wish to have claims of good land, with fine grounds for pasturage and timber close at hand. There are no claims made as yet above the forks, These streams furnish good mill sites for each of the first six miles, and are well filled with trout.* (Palmer 1845).

American Pioneers: 1846–1879

The southern Willamette Valley, with its open prairies, good soil and abundant water, was an attractive area for settlement. Settlement appears to have occurred rapidly after 1850. In 1849, Benton County population was 870; the county at this time extended to the coast and stretched to the California border (Fagan 1885). By 1858, Corvallis was described as a “substantial community of warehouses, stores and residences” (Phinney, 1942, p. 21). By 1860, the population of Benton county had grown to 3,047 (Bureau of Municipal Research and Service, 1959).

During the 1850’s the General Land Office (GLO) surveyed the landbase of much of the western United States. These surveys are on record with the Benton County Tax Assessor’s Office and provide an excellent historical record of the Marys River landscape at the time of these early surveys. The surveyors’ notes contain information about a number of historical features, which can be used to reconstruct roads and homesteads, vegetation patterns, stream channels and other features. A copy of the 1853 GLO survey for a portion of the lower Marys River Watershed (Appendix 3, Figure 2, and Map 9a in Appendix 7) shows the growing town of Marysville (which later became Corvallis), the road network, homesteads, and vegetation patterns. The historic vegetation thought to exist in 1850 is portrayed in Map 9, which was created by the Oregon Natural Heritage Council.

The following entry from “Oregon Geographic Names” provides details on the widespread use of the name “Mary” in the basin.

In the early days of the fur traders Marys River, which heads north of Marys Peak, was known as Mouse River. In his journal for October 17, 1833, John Work refers to this stream as River de Souris, or Mouse River, and the context seems to show that the name Souris was already established. Duflot de Mofras used the name Rivere de Souris, Mice River, in 1841, and Joel Palmer called the stream Mouse River in 1845-46. Cal Thrasher, a Benton County pioneer, is authority for the statement that Marys Peak in early days was called Mouse Mountain, a translation of an Indian name. See editorial page of the Corvallis Gazette-Times, September 20, 1935. The name Marys River appears in an act passed by the Oregon legislature December 12, 1846, and it was apparently in public use at that time. There are at least two stories about the *origin of the name Marys River. One is to the effect that it was applied by Adam E. Wimple, and early settler from Oneida County, New York, for his sister, who had never been in Oregon. Wimple murdered his girl wife, Mary, August 1, 1852, whom he had married the year before, and he was hanged at Dallas October 8, 1852. She had attacked him with a pistol. For narrative of the murder, see the Oregonian, August 8, September 11, 25, 1852. The other story is that the stream was named by Wayman St. Clair for Mary Lloyd, daughter of John Lloyd, who came to Oregon from Clay County, Missouri, in 1845, and in 1846 settled near the present town of Monroe in Benton County. She was said to be the first white woman to cross Marys River, in 1846 (George H. Himes). She married John Foster in Benton County, June 20, 1846; died in August, 1854. Lloyd was born in Buncombe County, North Carolina; died in Benton County, Oregon, January 6, 1880. His house is said to have been the farthest south in the Willamette Valley at one time. Wayman St. Clair was a member of the territorial legislature in 1850-51, representing Benton County in the lower house; also in 1854. He was an immigrant of 1845. He and John Lloyd were alternate captains of the last party that followed the Meek Cutoff. In the winter of 1847 Joseph C. Avery began to lay out a town at the mouth of Marys River, and the place was called Marysville. In 1853 the name was changed to Corvallis. Marysville was probably named for the stream, although there may have been additional reasons. Mrs. John (Mary) Stewart, one of the first settlers, said that Avery told her he would apply the name Marysville in her honor. See Corvallis Gazette-Times, June 7, 1935. It has been suggested that French-Canadian employees of the Hudsons Bay Company may have named the stream Saint Marys River, but there seems to be no contemporary record of the event.*

The vegetation in the 1850's consisted of mostly grass prairies and oak savannas, with scattered conifer forests along the valley floor (Hulse et al. 1998). Some descriptions noted riparian area vegetation. In 1852, Reverend Ezra Fisher noted "on the Willamette bottoms [the vegetation consisted of] the balm of Gilead [cottonwoods], white fir [Douglas fir] and soft maple (Storm 1941, p.13). Vegetation common to riparian areas was black cottonwood, Oregon ash, alder, big-leaf maple, willow, Douglas-fir, western redcedar, and some ponderosa pine. Map 9a, which depicts historical vegetation types along the Marys River reconstructed from the GLO surveys, shows a mix of vegetation communities, with deciduous forests along the floodplains and a mix of open prairies, conifers, and oaks in the uplands.

The open prairies of the Marys River Watershed offered an attractive landscape for agriculture. In 1846 Lieutenant Niel M. Howison observed: "Continuous ranges of prairie land free from the encumbrances of trees or other heavy obstacles to the plow, stretch along, ready for the hand of the cultivator" (Storm 1941, p. 10). Records in 1880 of livestock list 5,993 cattle, 28,818 sheep; 5,460 hogs; 3,226 horses; and 83 mules (The Willamette Valley Project 1936, p. 31). The main field crop was wheat; by 1873, wheat yields were estimated at 300,000 bushels.

Ferries were used for a short time during this period to cross the Marys River (Farnell 1979). J. C. Avery operated a ferry about a quarter mile above the confluence with the Willamette River (near the present site of Avery Park) and another individual operated a ferry about one-half mile further upstream. In 1856, a bridge was built near the Avery ferry site, putting the ferry out of business until the bridge was washed out in the 1861 flood.

The Marys River was used as a transportation highway during the early years of settlement. Records show that one settler, Ben Bratton, hauled his wheat to a gristmill on Beaver Creek in a canoe drawn by a yoke of oxen (Farnell 1979). The major transportation use of the river, however, was for log drives. In 1856 the Benton County Court declared the Marys River "navigable for the floating of lumber and sawlogs from about two miles above William Woods [in Blodgett Valley], thence down to Marzger and Co.'s Mill." This stretch extends from River Mile 35 to River Mile 14 (Farnell 1979). Large numbers of logs were moved from the headwaters to as far downstream as Corvallis. Records from a 1879 foreclosure lawsuit (*Friendly v. McCullogh*) indicate that at one point a company had 600,000 board feet of sawlogs in the channel upstream of the Corvallis mill (Farnell, 1979). Log drives down the Marys River and its tributaries continued until the 1940's.

Logging was an important activity to the settlers of the Marys River Watershed. Lumber was used to build homes and businesses. Mills were located near timber sources because horse or ox teams were used for transport. Most of these lumber mills required waterpower to run the operation so they were also located on the Marys River or other streams. Seven mills are known to have existed in Benton County in 1855, including operations on the mainstem of the Marys River, as well as Beaver and Rock creeks (from the Benton County Historical Society Display, Philomath, OR). One of the first sawmills in the watershed was the mill near Harris on the Marys River. This mill, probably built by Danniel H. Byrd in 1853, was used to supply lumber to the first houses in the area (Stark et al. 1998). Mills in the watershed would come and go over time as timber was harvested, demand changed, and transportation methods improved. The Harris area, for example, had a series of mills at various times: 1853, 1880–1880's, 1917–1929, and again in 1944 (Stark et al. 1998). T.J. Starker's map (Appendix 3, Figure 4) provides an overview of the locations of sawmills.

Transition to Modern Times: 1880–1940

By the 1880's, agriculture was an important part of the economy and the primary land use in the Marys River Watershed. Fagen (1885, p. 227) stated that the watershed was characterized by "excellent prairie, grass and grain lands…and contains some of the finest agricultural land in Oregon, and is well watered and timbered; the hills adjacent to the valleys are not only favorable for grazing purposes but also produce abundantly, especially of the cereals." In 1880 Benton County produced 256,832 bushels of oats and 497,068 bushels of wheat (Fagan 1885). By the 1890's farmers diversified their business interests to include poultry and egg production, extensive prune orchards, pears, apples, cherries, walnuts and filberts (The Willamette Valley Project 1936).

The population of the area also grew rapidly during this period. By 1880 the county had a population of 6,403, which was nearly double the 1860 population of 3,074; Corvallis had a population of 1800 (Fagan 1885). In 1930, the county's population had grown to 6,555 (Willamette Valley Project 1936). More people were living in Corvallis, although the largest proportion (54%) still lived in the rural areas (Willamette Valley Project 1936).

Timber harvest continued to be an important economic activity in the watershed. In 1885 Fagan (p. 445) stated: "To the west of the foothills is the Coast Range, whose commanding heights and deep canyons are clad with timber awaiting the penetrating axe of the woodsman. There are several sawmills in the [area]. That known as Newhouse Mill is located at the head of Beaver Creek in a grove of remarkable fine timber..." The Kalapuya practice of using fire to control vegetation was limited during the period of Euro-American settlement. Grasslands and open, oak-woodlands in the valley bottoms were being replaced by conifer forests.

Improved technology made it possible to transport logs longer distances and harvest larger volumes of timber. Improvements in transportation reduced the need for mills to be located near timber supplies. By 1880, railroads were used for transporting logs. Many of these railroads followed stream courses in the watershed. The steam donkey was developed in the 1880's and had replaced the horse and ox by the turn of the century (from the Benton County Historical Society Display, Philomath, OR). The steam donkey was a stream-powered winch used to skid logs from the slopes to loading areas where they could be transported by water or railroad.

The following are the dates and locations of log drives in the Marys River Watershed (Farnell 1979):

- 1889–1891: Greasy Creek from the confluence of Rock Creek. The logs were destined for the J.A. Hawkins Sawmill west of Philomath.
- 1902–1944: In 1902 the Corvallis Lumber Company was preparing to drive 600,000 board feet of logs down the Marys River to Corvallis. The last log drive destined for the mill in Corvallis was in 1944.
- 1915–?: The west fork of the Marys River (beginning above River Mile 40). These drives were probably assisted by a wall of water created when a splash dam at River Mile 37 was breached.

Logging trucks and other machines allowed the harvest of large volumes of timber with less effort and the transport of logs over long distances to mills. By the late 1930s crawler tractors were replacing steam donkeys. Power chainsaws were introduced a few years later. In 1936 the Marys River Watershed had 32 sawmills with production capacities ranging from 20,000 to 200,000 board feet of timber per day (Willamette Valley Project 1936).

The Marys River Watershed has been a source of water to Corvallis and Philomath since 1904. By the early 1900's, it was apparent that the Willamette River was too polluted to use as a drinking water source, so Corvallis began to explore alternative water sources (Sue Ross, City of Corvallis Public Works, pers. comm.). Several wells were drilled in Corvallis, but when they either failed or produced inadequate volumes of water, the city began to search for sources in the Marys River Watershed. Eventually, the Rock Creek Watershed on the east side of Marys Peak, known for its pure water, was selected as the drinking water source. Corvallis began buying homestead acres in the watershed, but soon ran out of funds. The city then convinced the U.S. Forest Service to purchase additional acres in the watershed and share ownership of the area, which eventually resulted in a 10,000-acre municipal watershed, with 2,500 acres of city property and an additional 7,500 acres in USFS ownership.

Sources and treatment locations of drinking water for the City of Corvallis have changed over time. The water from the Rock Creek Watershed was originally transported in 8-inch diameter redwood pipes to a pressure treatment facility near Philomath, where it was filtered and disinfected before being sent on to Philomath and Corvallis. The Rock Creek Treatment Facility was the sole treatment location for water until 1949, when the Taylor Treatment Plant was built. The Taylor Treatment Plant was built to treat water pulled from the Willamette River, augmenting the Rock Creek Watershed supply in the summer months. During these months, water supply from Rock Creek is low, due to reduced snowmelt runoff from Mary's Peak, and unable to meet increased consumer demand. In 1956 the Rock Creek treatment facility near Philomath was replaced with a treatment plant on Marys Peak. Today, the Taylor Plant is Corvallis' primary supply, treating 3–16 million gallons of water per day, while the Rock Creek Facility is secondary, providing 3–4 million gallons of water per day (Sue Ross, City of Corvallis Public Works, pers. comm.).

The 1930's were marked by the beginning of the era of intensive natural resource management in the Willamette Basin for "greater economic and social advancement" (Willamette Valley Project 1936). This State of Oregon initiated a program termed "the Willamette Valley Project," which had three key elements related to natural resources:

1) Hydraulic control of the entire basin through the building of dams and storage reservoirs;
2) Agricultural land use designed to encourage more effective farming practices; and
3) Forest strategy to encourage the sustained yield of forest resources.

This program was part of a larger works program by the federal government designed to modify the environment of the basin. Most of the actions were focused on the consequences of floods, including the construction of dams to regulate flow and projects to control river meandering and erosion. In 1936, 54,000 lineal feet of rip-rap was installed along the Willamette between Eugene and Harrisburg to stabilize and protect stream banks. Another key part of this program was "clearing flood channels to prevent the loss of land by erosion and reduce flood heights" (Willamette Valley Project 1936, p. 20). A number of waterways in the Willamette Basin were targeted for removal of logs and other debris from the channel. Under the Flood Control Act of 1936, $2,430,000 was authorized for bank protection and channel clearing, including $70,000 for debris removal in the Marys River (Willamette Valley Project 1936).

By the late 1930's the pattern of land uses in the Marys River Watershed was becoming similar to the present situation. Corvallis was a growing urban and educational center, with a number of sawmills and other industries. Large and small farms occupied most of Benton County, primarily valley bottoms along the Marys River, Muddy Creek, and the Willamette River. Over 55 percent of the county was occupied by farmlands, the second highest in the Willamette Valley (Willamette Valley Project 1936). Aerial photographs provide an excellent way to view vegetation patterns and land use activities. A series of aerial photographs beginning in 1937 (Appendix 2, Photo 3a-3c) shows a Muddy Creek Watershed with farms occupying areas that were once grasslands, wetlands, and riparian areas. A substantial loss of these natural features and reduced riparian corridors along the river is obvious.

Water pollution was recognized as an issue in the Willamette Basin by the 1930's, with most of the sources listed as domestic sewage and discharge of domestic wastes (Willamette Valley Project 1936). Public opinion and policy, however, were not focused on water quality issues: "Because the rivers of the Valley are not largely used for municipal water supply and because evidence of befoulment are not widely forced upon the senses, the public is tolerant toward stream pollution." (Willamette Valley Project 1936, p. 109).

Summary

By the 1930's, the landscape features of the Marys River Watershed had changed dramatically. Lands that were historically grass prairies, oak savannas, wetlands, and riparian forests had been converted to farmlands, and, to a lesser extent, other land uses. The end of the Kalapuyan practice of using fire to control vegetation resulted in conversion of areas that were once grasslands and open oak woodlands to conifer forests. Human population within the watershed had increased, with people concentrated in Corvallis and Philomath. Stream habitat, especially along the mainstem of the Marys River, had been modified through log drives, woody debris removal, and bank stabilization projects. Water quality problems from domestic sewage were recognized as an issue, although there was little public action.

Detailed historical investigations of individual streams and sub-basins would provide a additional understanding ecological change across the landscape. These historical assessments could focus on collecting and transcribing oral histories from long-time watershed residents, agency personnel, and other individuals who have observed landscape changes through time. Zybach and Wisner (1994) provide an approach for oral history interviews and documentation. Further use of the primary historical sources, such as GLO surveys, would reconstruct historical conditions for individual watersheds or specific areas, and may be useful in planning habitat enhancement projects.

CHAPTER 3: WATER QUALITY AND QUANTITY

Water Quality Background

The Clean Water Act of 1972 established the regulatory framework that guides much of the Federal, State, and local action targeted at monitoring and controlling water quality of surface water and groundwater (Clean Water Act 1972). As mandated by the Clean Water Act, beneficial uses are designated for each water body to represent the human or ecological services the water provides. States use different systems to designate beneficial uses by stream reach or by watershed. In Oregon, beneficial uses are broadly designated for large watershed areas (Oregon Administrative Rules 340.41). Designated beneficial uses that apply to the Marys River watershed are listed below (Table 3).

Table 3: Oregon designated beneficial uses for the Marys River Watershed (Oregon Administrative Rules 340.41).
Aesthetic Quality
Anadromous Fish Passage
Boating
Fishing
Hydroelectric Power
Industrial Water Supply
Irrigation
Livestock Watering
Private Domestic Water Supply
Public Domestic Water Supply
Resident Fish and Aquatic Life
Salmonid Fish Rearing
Salmonid Fish Spawning
Water Contact Recreation
Wildlife and Hunting

A water quality standard defines the water quality goals of a water body by designating uses to be made of the water and by setting criteria necessary to protect the uses (Clean Water Act 1972). Criteria are numerical values typically expressed as the concentration of a constituent that protects the most sensitive designated uses by maintaining water quality. The water quality standards and criteria that apply to Mary River and its tributaries are listed below (Table 4), followed by a brief description of relevant water quality parameters discussed in this report (Table 5). Oregon lists standards or criteria for each water quality parameter. The standard or criteria value is the value at which beneficial uses most affected by the corresponding water quality parameter are protected.

Table 4: Water quality standards or criteria and water quality limited criteria applying to the Marys River Watershed (Oregon Administrative Rules 340.41).			
Water Quality Parameter	**Beneficial Uses Affected**	**Water Quality Standard or Criteria**	**Water Quality Limited Criteria**
Flow modification	*Resident fish and aquatic life *Salmonid spawning and rearing	Creation of conditions that are deleterious to fish or other aquatic life are on allowed	Documented flow conditions that limit fish or other aquatic life or impair other beneficial uses
Dissolved Oxygen	*Resident fish and aquatic life *Salmonid spawning and rearing	*Cold water aquatic resource: 8.0 mg/L 30 d mean minimum 6.5 mg/L 7 d mean minimum 6.0 mg/L minimum *Cool water aquatic resource: 6.5 mg/L 30 d mean minimum 5.0 mg/L 7 d mean minimum 4.0 mg/L minimum	
Temperature	*Resident fish and aquatic life *Salmonid spawning and rearing	*64ºF (18ºC) 7 day moving average of daily maximum unless; *55ºF (13ºC) during times in waters that support anadromous fish spawning	7 day moving average exceeds standard
Turbidity	*Resident fish and aquatic life * Water supply *Aesthetics	No more than 10% increase over background	Systematic or persistent increase of > 10% in turbidity
pH	*Resident fish and aquatic life *Water contact recreation	6.5 to 8.5	> 10 % samples exceed standard and at least 2 exceedences for season of interest
Bacteria	*Water contact recreation	*126 *E. coli* /100mL, 30 d. log mean, minimum of 5 samples *406 *E. coli*/100mL, single sample	*200 Fecal coliform/100 ml, geometric mean *400 Fecal coliform/100 ml in > 10 % samples and at least 2 exceedences for season of interest
Sedimentation	*Resident fish and aquatic life *Salmonid spawning and rearing	Formation bottom or sludge deposits deleterious to fish, aquatic life, public health, recreation, or industry.	Documentation that sedimentation is significant limitation to fish or other aquatic life
Total dissolved gas	*Resident fish and aquatic life	*Concentration of total dissolved gas not to exceed 110% of saturation *liberation of dissolved gas not to cause objectionable odors or be deleterious to uses of such waters	* > 10 % samples exceed standard and at least 2 exceedences for season of interest or * survey that identifies impairment of beneficial use

(Table 4 continued on next page)

Table 4 (cont.) : Water quality standards or criteria and water quality limited criteria applying to the Marys River Watershed.

Water Quality Parameter	Beneficial Uses Affected	Water Quality Standard or Criteria	Water Quality Limited Criteria
Chlorophyll a	*Water contact recreation *Aesthetics *Fishing *Water supply *Livestock watering	*Natural lakes which thermally stratify 0.01 mg/L *Natural lakes which do not thermally stratify, reservoirs, rivers and estuaries 0.015 mg/L	3 month average exceeds standard
Aquatic weeds or algae	*Water contact recreation *Aesthetics *Fishing	Development of fungi or other growths having deleterious effect on stream bottoms, fish, other aquatic life, health, recreation or industry	*Macrophytes documented as abundant, invasive non-natives * Periphyton (attached algae) or phytoplankton (floating algae) documented as causing other exceedence of other standards or impairing beneficial use
Biological criteria	*Resident fish and aquatic life	Waters shall be of sufficient quality to support aquatic species without detrimental changes in resident biological communities	Data on aquatic community status shows impaired condition
Habitat modification	*Resident fish and aquatic life *Salmonid spawning and rearing	Creation of conditions that are deleterious to fish or other aquatic life are not allowed	Documentation that habitat conditions are a significant limitation to fish or other aquatic life
Toxics	*Resident fish and aquatic life	Full criteria listed in Oregon Administrative Rules 340-41-445(2)(p)(B) Table 20.	*Exceeds standard 10% of the time and for at least two values *Found in sediments or tissue in concentrations that exceed standards or screening values
Total dissolved solids	All beneficial uses	Guide concentration Willamette River and tributaries 100.0 mg/L	Not to exceed guide concentration

While no standards exist for nutrients, parameters affected by nutrients such as algae do have water quality standards. In some cases, the Oregon Department of Environmental Quality (DEQ) has developed in-house concentration levels used to identify water quality problems, but to date these have not been reported for the Marys River Watershed. The following table presents a simple list of water quality parameters discussed in this report along with a brief description, typical abbreviation, and units of measurement (Stednick 1991).

Table 5: Descriptive list of selected water quality parameters.

Parameter	Brief description	Abbrev-iations	Units of measurement
Dissolved Oxygen	Amount of oxygen dissolved in water	DO	milligrams/Liter (mg/L)
Temperature	Temperature of water	T, Temp	Degrees F (or C)
Turbidity	Scattering of light in water due to particulate matter; low light transmission is high turbidity	Turb	Nephelometric Turbidity Unit (NTU)
Total suspended solids	Total concentration of particles suspended in the water column	TSS	mg/L
Total dissolved solids	Total concentration of dissolved ions in water	TDS	mg/L
Conductivity	Ability of the water to carry an electrical current; inverse of resistance to electric current; linearly correlated to TDS.	Cond	micromhos/cm (umohs/cm) or microSiemens/cm (uS/cm)
pH	Hydrogen ion activity showing acidic, neutral or basic water	pH	pH units: [-log(Hydrogen ion concentration)]
Alkalinity	Capacity of water to neutralize acid	Alk	mg/L (as calcium carbonate)
Hardness	Total concentration of calcium and magnesium ions in water		mg/L (as calcium carbonate)
Total phosphorus	Concentration of all forms of phosphorus	P, TP	mg/L
Phosphate	Biologically available form of phosphorus	PO_4	mg/L orthophosphate ion (PO_4)
Total nitrogen	Concentration of all forms of nitrogen	N, TKN	mg/L
Nitrate	Biologically available form of nitrogen	NO_3	mg/L nitrate (NO_3)
Ammonium	Biologically available form of nitrogen	NH_4	mg/L ammonium (NH_4)
Sulfate	Concentration of sulfate	SO_4	mg/L
Chloride	Concentration of natural ionic form of chloride (not chlorine)	Cl	mg/L chloride
Magnesium	Concentration of magnesium ion	Mg	mg/L
Sodium	Concentration of sodium ion	Na	mg/L
Potassium	Concentration of potassium	K	mg/L
Bacteria	Concentration of bacteria of interest such as *Escherichia coli* or fecal coliform	*E. Coli*	counts/100 milliliters (/100 ml) or Maximum probable number/100 ml
Biochemical oxygen demand	Amount of oxygen required by bacteria while decomposing organic matter	BOD	mg/L

What is the 303(d) list?

Section 303(d) of the Clean Water Act requires each state to develop a list of waters that do not meet state standards for water quality. The list provides a way for Oregonians to identify problems and develop and implement watershed management plans to protect beneficial uses while achieving federal and state water quality standards. The list is meant only as a means of identifying areas of water quality problems, not causes. Water quality problems include parameters such as nutrients, bacteria, toxic contaminants, turbidity and temperature. Causes of water quality problems are determined when management plans are developed for the watersheds in which the listed segments are located. Potential sources of problems other than point sources (sewage treatment or industrial outfalls) include runoff from source areas such as cropland, pasture, confined animal feeding, onsite sewage systems, forest lands, urban areas and industrial areas.

Oregon Department of Environmental Quality (DEQ) compiles the 303(d) list using existing scientific data and best professional judgment to assess water quality, and determines which waters should be listed. DEQ develops a draft list and presents the list for public comment. After public comments are reviewed and taken into consideration, a final list is developed and sent to U.S. Environmental Protection Agency (EPA) for approval. The final list is accompanied by a list of priorities that target resources for correcting water quality problems. DEQ must submit an updated list to the Environmental Protection Agency (EPA) every two years.

A stream, river, lake or estuary may be removed from the list if there is evidence that: 1) it is meeting water quality standards; 2) it is violating water quality standards due only to natural conditions (meaning that there is no human-caused influence); 3) its Total Maximum Daily Load (TMDL) has been approved; or 4) it was placed on the list in error. (ODEQ, http://waterquality.deq.state.or.us/wq/303dlist/303dfactsheet.htm). For example, the temperature standard can be modified from that listed in Table 4. The State Standard sets the temperature at 64°F statewide unless there is habitat for cold-water fish spawning or bull trout, which require standards of 55°F and 50°F, respectively. If a stream or river violates temperature standards, DEQ would require that responsible parties or management agencies develop a water temperature management plan to address the problem. If temperatures still do not meet water quality standards after an approved temperature management plan has been implemented and if DEQ determines that all feasible steps have been taken to address the problem, then the temperature actually attained will become the standard for that water.

Marys River Waters on 303(d) List

This preliminary assessment concentrates on pollutant categories for which the Marys River and its tributaries are either 303(d) listed (see below) or categories that have a high potential as pollutant sources, based on data, reports, observations and professional judgement and land use. The Marys River is on the 303(d) list for flow modification, bacteria and temperature from the mouth to Greasy Creek (Map 10). Several potential sources of pollutants are discussed in Chapter 5 and include cropland erosion, fertilizer and pesticide applications, grazing, mass erosion and surface erosion from forestland and roads. Other parameters were considered and were found to either be within standards or to have insufficient data to warrant a listing. These parameters include dissolved oxygen, summer bacteria levels, chlorophyll a, and pH; for Greasy Creek and the Tum Tum River, sedimentation was considered but insufficient data did not warrant a listing. Waters considered for 1998 303(d) are listed in Appendix 4, Section 2. The following sections detail water quality for the three areas of the watershed with the most available data: Marys River, Muddy Creek, and Rock Creek. Additional data from selected locations in other sub-basins are also included in the final overview of water quality in the Marys River Watershed.

Marys River Water Quality

Three sources of water quality information were reviewed here. The first source is the City of Corvallis, which has taken samples monthly since 1988. Sampled parameters include dissolved oxygen, pH and bacteria. The city’s monitoring sites in the Marys River Watershed are the Marys River at Avery Park, Oak Creek at Highway 20, and Squaw Creek at Brooklane Drive (Map 10). The second source of information is the Philomath Water and Wastewater Treatment Plant which samples the Marys River in Philomath (City of Philomath 1998). Parameters sampled on a monthly basis include pH, turbidity, temperature and alkalinity. The third source of data is the DEQ, which has sampled at the mouth of the Marys River for a host of parameters about every two months since 1983 (DEQ 1999, see Appendix 4 Section 3).

Additional water quality data for Oak Creek have been collected by Oregon State University. Data for the upper Marys River near Wren have been collected by D. Sternadel (pers. comm.). Additional data from these studies have not been readily available and were not analyzed in detail here. Coverage of these data is somewhat limited, especially for Marys River tributaries. Additional water quality data, systematically collected for smaller streams in the Marys River Watershed, would aid in further assessment. General water quality patterns for the Marys River and tributaries are discussed in the following paragraphs.

Bacteria

Bacteria data are given detailed consideration here because the reach of Marys River from Greasy Creek to the river mouth is 303(d) listed reach for to *Enterococci coliform*

(*E. Coli*) bacteria. Standards for bacteria changed from fecal coliform to *E. Coli* in 1990. Both parameters, however, can be used to identify water-quality limited waters. Fecal coliform exceeds state standards if the geometric mean exceeds 200 per 100 ml in 10% of the samples, or if there are two exceedences of 400 per 100 ml in one season of interest (DEQ 1996).

Lack of data limits the ability to fully determine bacteria problems in the Marys River Watershed. Specifically, there are too few data from the City of Corvallis' monthly sampling program to determine 30-day log means for *E. Coli* as defined by the state standard. This problem can be circumvented by examining both fecal coliform and *E. Coli* data. *E. Coli* counts taken after 1990 and fecal coliform counts taken before and after 1990 from samples collected from the Marys River at Avery Park show similar patterns. Average fecal coliform (FC) was 94 counts/100 ml while *E. Coli* was 102 counts/100 ml. The maximums were 825 (FC) and 914 (*E. Coli*) and the minimums were 17 (FC) and 4 (*E. Coli*), with corresponding standard deviations of 127 (FC) and 161 (*E. Coli*). Because the structure of the data was similar and more data are available for fecal coliform than for *E. Coli* from the sampled sites, fecal coliform was analyzed in detail to discern patterns in bacteria occurrence.

Geometric means for fecal coliform in the Marys River, Oak Creek, and Squaw Creek were 56, 309, and 130, respectively. In the Marys River, there were not two values greater than 400 in a single season. A plot of fecal coliform averaged by month shows one peak in the Marys River in May 1996. Because there is a swimming hole located just upstream of the sample site, the Marys River contamination may be a result of people's swimming activities. Oak Creek clearly exceeds the standard, with peaks in November, April and August (Figure 6). In Squaw Creek there were at least two exceedences of 400 in the same season for summer 1989, spring 1990 and summer 1995, resulting in an exceedence of the fecal coliform standard. Squaw Creek follows a similar pattern as Oak Creek, with peaks in November, March and August.

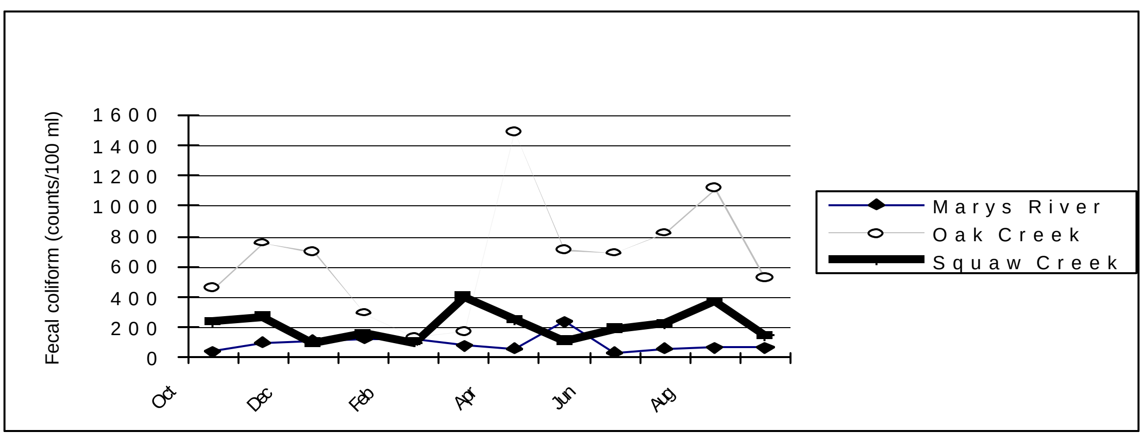


Figure 6: Fecal coliform averaged by month.

The patterns of bacteria concentration in the Marys River and these two smaller tributaries suggest that sewage outfalls are not the primary source of bacteria. The

Philomath wastewater treatment plant has the largest single water effluent discharge into the Marys River, however records from the plant indicate fecal coliform usually is less than 20 per 100 ml (Dale Crum, pers. comm., Philomath Water Wastewater Treatment Facility). The discharge permit for the plant requires retention of wastewater May 1-October 31 and allows effluent discharge November 1-April 30. For the most part, no bypass occurs and all wastewater passes through the lagoons before being discharged to the Marys River. Bypass does occur during very wet conditions in winter when sewer pipes in Philomath become filled with water from the saturated soil that infiltrates cracks in the pipes. This water can mix with untreated wastewater and backflow into the city streets. Under these circumstances, this backflow is ameliorated by pumping water from the sewers into the storm drains and into the Marys River. DEQ is notified about backflow situations. Very dry fall seasons, when flow in the Marys River remains low, may be another potential time of concern. Releases from the treatment plant, which are allowed after November 1, may not have the benefit of dilution by larger flows in the river. The plant has a current capacity to treat wastewater from a population of 5000. The 3800 population in Philomath is expected to reach 5000 in three-five years. As the lagoon system reaches capacity, effluent may contain greater concentrations of contaminants. Overall, however, the Philomath wastewater treatment plant is not currently a major source of bacteria to the Marys River.

Oak Creek and Squaw Creek, on the other hand, are sources of bacteria. The most likely source of fecal coliform in Oak Creek is livestock, particularly the Oregon State University (OSU) animal farms. Dairy farms spray manure slurry on their pastures and a beef barn is located near the stream. Without rainfall, the slurry and manure remains on the fields and in the feedlot. Following rains, manure may be transported directly into Oak Creek. Manure-laden winter runoff may explain the November peak in fecal coliform on Oak Creek. The August peaks in fecal coliform on Oak and Squaw Creek may be explained by low flows that do not dilute bacteria concentrations. Additional sources other than the animal farms and beef barn may be contributing bacteria to Oak Creek and Squaw Creek. Manure management, however, remains an important concern for fecal coliform counts in Oak Creek and Marys River.

Temperature

Temperature, like bacteria, deserves special attention in the water quality screening process because the lower Marys River is 303(d)-listed for temperature. Waters are considered to be temperature limited if the stream temperature exceeds 64°F for a moving seven-day average. In the absence of moving seven day averages, we consider simple temperature values as indicative of temperature conditions, recognizing that additional data will need to be collected to determine if temperature listings for the Marys River are warranted. Temperature data are available from a report compiled in 1995 by the Friends of Corvallis Urban Streams (Andrus 1995). On the warmest summer day of 1996, August 24, the Marys River exceeded 64°F at 5 sites downstream of the Tum Tum River. Temperatures for these sites (in °F) were 65.0, 71.8, 74.4, 75.1, and 73.2. Based on observations of streamside vegetation at these sites, temperature appears to increase more dramatically where there was less shading by riparian forests. The warmer, flatter reaches in the lower Marys River also correspond with slower stream velocities. On July 28, 1995, temperature exceeded 64°F downstream of 35th street on both Oak (70°F) and Squaw (74°F) creeks. The rise in temperature on Squaw Creek was attributed to a 600-foot long reach of stream that had no riparian shading. While these data do not affirm the seven-day water quality criteria exceedence, they suggest that temperature may limit water quality on low gradient, unshaded streams of the Marys River Watershed.

Questions have arisen as to whether the 64°F standard is appropriate for the Marys River Watershed. A recent study of temperature in the Marys River and tributaries (C. Andrus, pers. comm.) suggest that the natural temperature regimes in the watershed may exceed 64°F, even above the valley floor (Figure 7). In mid-August the 7-day moving average of temperature on the Marys River exceeded 68°F downstream of the Greasy Creek confluence. August temperatures of 70°F measured by the City of Philomath confirm this pattern. Besides showing that temperatures are indeed above the desired 64°F level, these data suggest that temperature is a function of both natural factors, such as elevation in the watershed, and anthropogenic uses. While removal of riparian forests may be unnaturally increasing stream temperatures, the natural temperature regime of the Marys River Watershed should be determined.

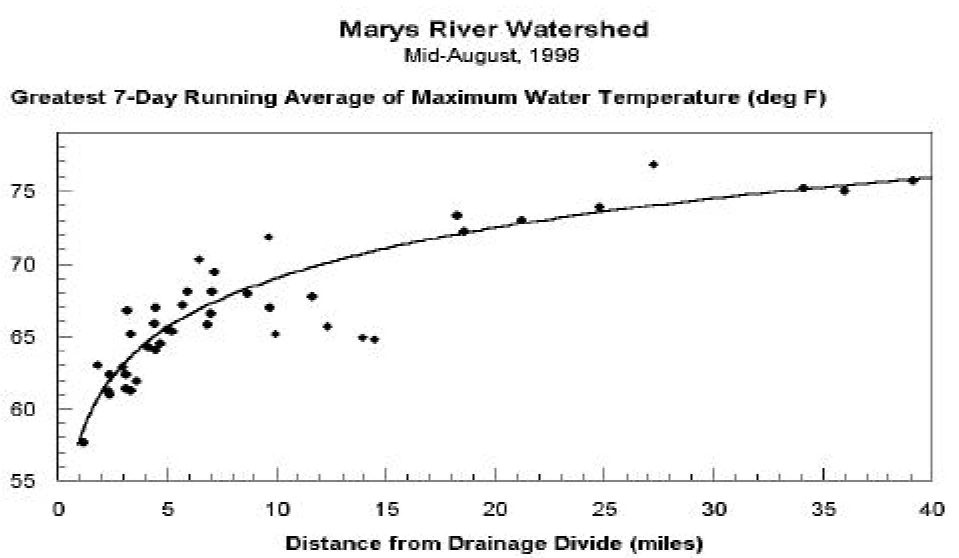


Figure 7: Preliminary results from temperature monitoring sites in 1998.

Dissolved Oxygen, pH, and Alkalinity

The City of Corvallis' monthly monitoring reveals that the mean of 9.8mg/L of DO is generally above the 8.0 mg/L standard for cold-water fisheries. Minimum values of 7.3-7.9 mg/L were recorded in August of four different years, however these were rare occurrences and came at times when the water was likely too warm to support cold-water fishes. Low levels of DO, approximately 6 mg/L, were found near Wren in November and December (Sternadel, pers. comm.). DEQ sampling every two months showed that average Marys River DO was 10.1 mg/L. Oak Creek fell within the standard limits for DO on all dates. Dissolved oxygen measurements on Squaw Creek suggested a problem area, with a minimum DO of 3.8 mg/L and with violations of the state standard on 23 dates during periods of June-September. Additional data will be required to determine the cause of decreased DO on Squaw Creek.

The general pH standard for the Willamette River Basin is 6.5-8.5. City of Corvallis' data show the Marys River had a mean pH of 7.5 with a maximum of 8.3 and a minimum of 6.3. On only two dates, both in December, pH was below the standard of 6.5. The likely high flows associated with these values suggest that stormwater runoff may have added pollutants to the River or that the buffering capacity of the water was reduced. Measured at the Marys River mouth, pH ranged from 6.7-7.9; at Philomath, 6.5-7.5, and near Wren, 6.5-8.2. pH in Squaw Creek consistently ranged between 6.5 and 8.5.

City of Philomath data show Marys River alkalinity from 15-60 mg/L and DEQ-measured alkalinity ranges from 10-68 mg/L.

Nutrients

Nutrients are collected routinely only by DEQ at the mouth of the Marys River (Appendix 4, Section 3). Nitrate plus nitrite (mg/L) ranged from 0.02-1.20. The quarterly average was highest in the winter (0.60) and lowest in the summer (0.50). Total phosphorus, ranging from 0.05-0.35 mg/L, also peaked in the winter quarter (average = 0.11) and was lowest in the spring and summer quarters (average = 0.07). The only nitrate water quality standard that exists is that of 10 mg/L which exists for drinking water. Nitrate at moderate concentrations such as 1 mg/L can have effects on aquatic life. For example, moderate elevations in nitrate and phosphorus typically enhances algal and aquatic plant growth, which in turn can increase turbidity, create depletions in dissolved oxygen at night, cause off tastes to drinking water, and have visual esthetic impacts. While no state standards were exceeded for either nutrient, presence of either nutrient at moderate levels suggest that sources of nutrients exist in the watershed.

Sediment and Conductivity

Turbidity collected in the Marys River by the City of Philomath show a range of 5 NTU at low flow to 80 NTU during storm runoff. Turbidity measured at the mouth of the Marys River ranged from 2 to 53 NTU and conductivity at the same site ranged from 61-166 micromhos. Conductivity at Marys River mouth followed the same pattern as at Rock Creek: highest in the summer when turbidity was low and lowest in the winter when turbidity was high (Rock Creek is described later). Upstream in the Marys River near Wren, conductivity was lowest (45) in February and peaked (85) in October (Sternadel, pers. comm.).

Ecosystems Northwest performed a one-day turbidity sampling, using grab samples collected on the declining limb of a storm hydrograph in February, 1999 (Table 6). At the time of sampling, the vertical visibility in the stream was also assessed. The turbidity was generally lower in the tributaries and increased downstream towards the mouth of the Marys River. One exception is the higher turbidities in Greasy Creek than the Marys River at Highway 34. The storm that was sampled was the second and smaller of two large storms that occurred during the month of February. Water visibility during the first storm was much reduced, particularly in the smaller tributaries.

Table 6: Marys River water quality sampling conducted by Ecosystems Northwest on 2/25/99.

Site	Turbidity (NTU)	Visibility (inches)
Norton Creek @ Hwy 20.	4.9	18
Tum Tum River @ Tum Tum Road.	6.0	9-12
Rock Creek @ Hwy 34.	6.1	18
Greasy Creek @ Grange Hall Road.	11.0	9-12
Marys River @ Harris Bridge on Shotpouch Rd.	5.7	9-12
Marys River @ Hwy 34.	7.7	9
Muddy Creek @ Airport Road.	12.0	9
Marys River @ Hwy. 99.	18.0	6

Muddy Creek and Tributaries Water Quality

No data are available to determine the reference, or historic, water quality of the Muddy Creek sub-basin. However, according to the Benton Foothills Watershed Analysis (BFWA, BLM 1997), the historic or reference water quality of Muddy Creek varied during wet and dry climatic cycles. The BFWA speculates that high-gradient, upland tributaries experienced pulses of sediment and nutrients during winter storms and following intense forest fires. As it flowed into the lowlands, Muddy Creek historically was a low-velocity stream with an unconfined valley and extensive wetlands. Upslope pulses of sediments likely controlled water chemistry in the past.

Recent information about water quality for the Muddy Creek sub-basin is limited to two sets of data: one collected during baseflow conditions in October 1995, and a second collected during storm flow in January and February 1996 (Eilers and Vache 1996).

The baseflow chemistry and stormflow bacteria are summarized in Tables 7 and 8. The stormflow chemistry is shown in Figures 7-9 in Appendix 3.

Pertinent results by water quality category are discussed for Muddy Creek and tributaries, based on Tables 7 and 8 and on other studies as cited.

Table 7: Analytical chemistry results from baseflow sampling of 10 sites in Muddy Creek sub-basin collected on during baseflow conditions during the second week of October 1995 (Eilers and Vache 1996). Abbreviations and units are the same as those in Table 5.

Site	pH	ALK	COND	TSS	TP	PO_4	NO_3	NH_4	TKN	Ca	Mg	Na	K	SO_4	Cl	Si
Beaver Creek @ Bellfountain Rd.	7.4	28	63	4	0.06	0.03	0.04	<.02	<.02	4.9	1.9	4.5	0.7	0.8	4	9
Beaver Creek @ Beaver Cr. Rd.	7.2	30	63	2.6	0.07	0.03	0.04	<.02	<.02	5.3	1.8	4.2	0.5	0.5	3.5	8
Gleason Creek @ Gleason Rd.	7.4	31	66	3.6	0.07	0.03	0.05	<.02	<.02	5.5	2	4.4	0.5	0.7	3.3	6
Oliver Creek @ Bellfountain Rd.	7.3	25	63	3.4	0.09	0.02	0.05	<.02	<.02	4.5	2	4.7	0.9	0.6	5.9	9
Reese Creek @ Bellfountain Rd.	7.0	46	112	21	0.44	0.009	0.09	1.19	3.1	10	4.4	5.2	3.4	0.5	10	6
Bull Run @ Bellfountain Rd.	6.6	16	54	3.2	0.11	0.02	<0.02	<.02	0.5	2.9	1.6	4.3	1.6	1.3	6.1	5
Muddy Creek @ Airport Rd.	7.3	20	65	8.2	0.11	0.04	0.03	<.02	0.3	4.6	2.2	4.4	1.3	1.2	5.3	7
Muddy Creek @ Greenberry Rd.	7.0	22	60	6.8	0.1	0.04	0.05	<.02	0.3	3.7	2	4.4	1.3	0.6	5.5	7
Muddy Creek @ Alpine Rd.*	7.2	19	47	8.1	0.06	0.01	0.04	<.02	0.3	2.9	1.7	3.9	0.8	0.4	4	7
Muddy Creek @ Bruce Rd. *	7.3	23	60	23	0.1	0.04	0.09	0.04	0.4	3.5	2	4.4	1.3	0.6	5.5	7

*average of duplicate samples

Table 8: Muddy Creek and tributaries water quality data collected during baseflow conditions during the second week of October 1995 and during a stormflow event in January 1996 (Eilers and Vache 1996). TC is total coliform bacteria, FC is fecal coliform bacteria; units are MPN/10 mL.

Sample	October 1995*						Jan. 3, 1996	
	Time	Temp (^{0}C)	DO (%)	DO (mg/L)	pH	Cond (µS/cm)	TC	FC
Beaver Creek @ Bellfountain Rd.	1350	10.0	100	11.34	7.17	47	200	200
Beaver Creek @ Beaver Cr. Rd.	1510	8.9	97.5	11.30	7.24	64	200	200
Gleason Creek @ Gleason Rd.	1445	11	66.6	7.35	7.02	65	400	200
Oliver Creek @ Bellfountain Rd.	1520	10.3	98.2	11.01	7.06	63	800	200
Reese Creek @ Bellfountain Rd.	1650	10.2	26.5	2.98	6.6	129	800	200
Bull Run @ Bellfountain Rd.	1335	10.0	58.0	6.55	6.73	54	1300	200
Muddy Creek @ Airport Rd.	1312	9.5	89.3	10.19	7.02	66	1300	200
Muddy Creek @ Greenberry Rd.	1500	8.4	103	12.05	7.21	66	1300	200
Muddy Creek @ Alpine Rd.	1610	9.6	90.2	10.28	7.03	45	400	200
Muddy Creek @ Bruce Rd.	1520	11.3	73.1	8.01	6.73	60	200	200

* Eilers and Vache (1996) mistakenly listed a collection date of October 16, 1996 in their original table. The original text lists the collection date as October 1995.

Temperature

Data in Table 8 were collected in October when temperatures are not normally high. Another study of water temperature in Oliver Creek (Robison et al. 1995) showed a 7-day average maximum water temperature of 58.1 F at a site downstream of a clearcut. While both studies suggest that waters in the Muddy Creek sub-basin are cool, BFWA (BLM 1997) cites concerns about temperature in the lower portions of Muddy Creek.

Bacteria

All ten Muddy Creek sites had fecal coliform counts of 200 counts MPN/10 mL. MPN represents “most probable number” and is analogous to plate counts used to determine fecal coliform levels. MPN is typically reported as MPN/100mL, rather than 10 mL as in Table 8. It was not verified with the report authors if this unit was listed in error.

Dissolved Oxygen and pH

Dissolved oxygen was below 8 mg/L at three of the sites in Table 8. The percent saturation of dissolved oxygen at these same sites was 26-66%. All ten sites in Table 7 had pH between 6 and 7.

Nutrients

Table 7 indicates relatively high concentrations of dissolved nutrients in Reese Creek compared to the other creeks. Reese Creek also showed relatively high total- (TKN) and NH_4-nitrogen concentrations. This information, in conjunction with low DO levels and elevated bacteria levels, suggest the presence of organic constituents. These organics may be from elevated soil erosion, untreated sewage, or animal wastes. However, these data represent a single sample collection and are only a “snapshot” of the stream condition.

Sediment

Table 6 shows several sites with elevated suspended solids during baseflow. In particular, Reese and Muddy Creek at Bruce Road sites had TSS in excess of 20 mg/L. Storm flow sediment data for Oliver, Beaver and Muddy Creek are discussed further with soils in Chapter 5.

According to the BLM, water quality in the Muddy Creek basin is “probably moderately to highly degraded from reference condition.” A main concern in forested upland areas is turbidity and suspended sediment, particularly chronic inputs of fine sediments from road and trail surfaces. There is an overall trend for increasing pollutant levels, particularly from rural development in the agricultural lowlands. Suspended sediment and turbidity, stream temperature, dissolved oxygen during summer, and coliform bacteria in agricultural lowlands were identified as the greatest concerns for maintenance of water. “While data are available to characterize sediment and turbidity, there aren’t enough data to verify the potential temperature and coliform bacteria issues. Reese Creek, Beaver Creek, and mainstem Muddy Creek appear to have the poorest water quality conditions” (BFWA, BLM 1997).

Rock Creek Water Quality

Data from the City of Corvallis watershed including Rock and Griffith creeks provide a picture of water quality in a relatively high-elevation basin with relatively few human impacts.

Samples have been taken approximately once a month since 1986 (City of Corvallis 1998). The following analyses have been performed: fecal coliform bacteria (FC), temperature (Temp), pH, dissolved oxygen (DO), alkalinity (Alk), conductivity (Cond), turbidity (Turb) and total suspended solids (TSS). Data are available from five locations in the City of Corvallis Watershed: Griffith Creek, North Fork Rock Creek, South Fork Rock Creek, the Rock Creek water supply intake, and lower Rock Creek Park. An examination of the average values by month over the period of record for the four Rock Creek sites showed similar patterns, so only Rock Creek Park and Griffith Creek data are presented here (Figures 8a and 8b). The following paragraphs discuss water quality of the Rock Creek sub-basin and refer to the aforementioned figures.

Temperature

Temperatures in Rock Creek Park and Griffith Creek are coolest in January and February, averaging approximately 43°F, and increasing to just below 60°F in August. These temperatures reflect high elevation and abundant vegetation coverage in the City of Corvallis watershed. Temperature is not a water quality concern in these streams.

Figure 8a: Water quality for Rock Creek Park.

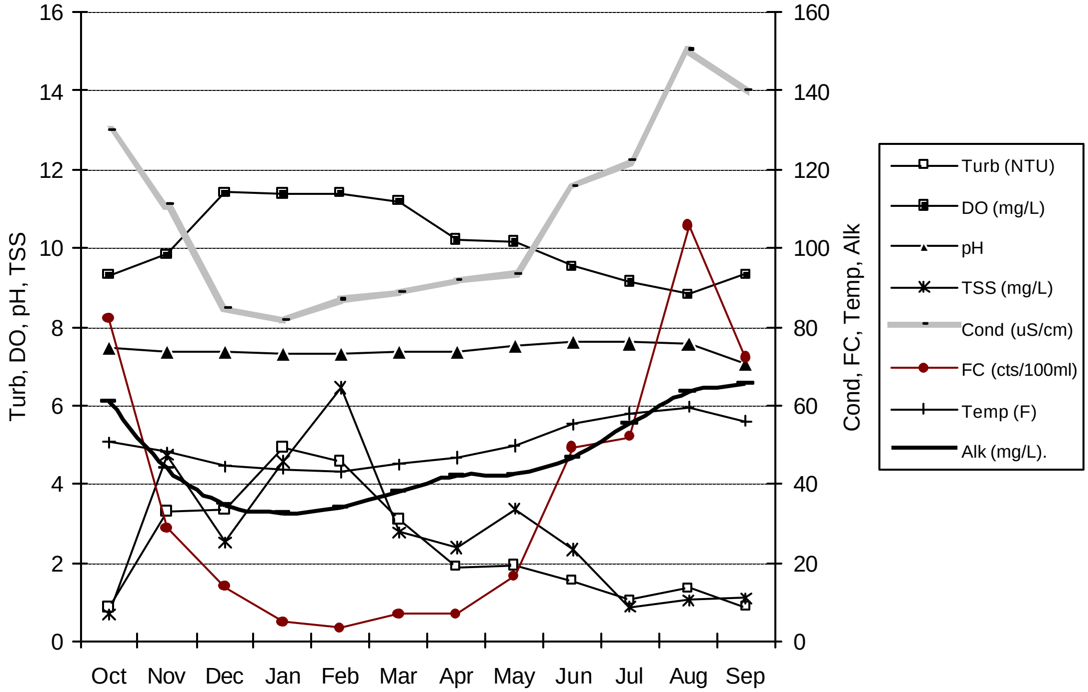
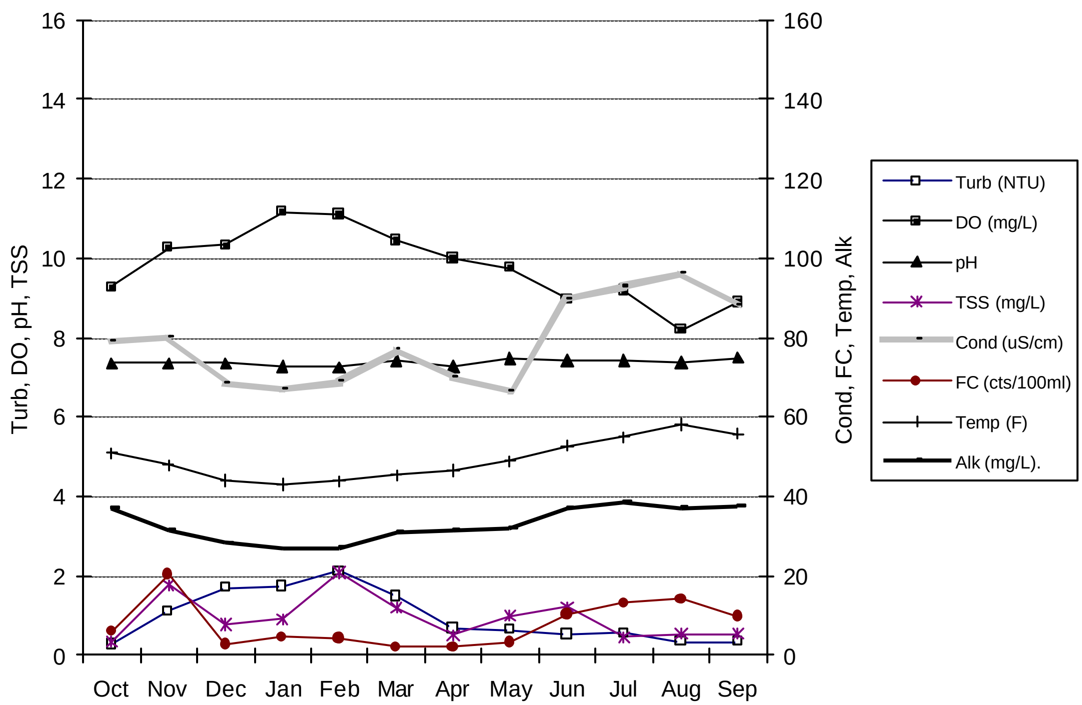


Figure 8b: Water quality for Griffith Creek.



pH, Alkalinity, Conductivity, and Dissolved Oxygen

There is little seasonal variation in pH (7.2-7.4) in either of the Rock Creek streams throughout the year. Alkalinity, which likely reflects dissolved calcium from bedrock, is diluted in winter months (about 30 mg/L) after peaking during summer months (40-70). An increased concentration of ions is also reflected in the rise in conductivity during the summer after dilution in the winter. This trend is particularly apparent on Rock Creek Park where winter conductivity of 81 rises to summer conductivity of 150 (Figure 8a). Griffith Creek has both lower alkalinity and conductivity than Rock Creek Park. Dissolved oxygen (DO) remains high throughout the year (8.0 - 11.5 mg/L). Some depression of DO in summer months may simply be due to the warmer temperatures and lower capacity of the water for holding dissolved oxygen.

Sediment

Total suspended solids (TSS) and turbidity in Rock Creek Park and Griffith Creek both increase during winter high flows and decrease during summer low flows. TSS peaks at 6.5-8.0 mg/L on all Rock Creek streams except for Griffith Creek, which reaches only 2.0 mg/L in the winter. Turbidity follows the pattern for suspended solids and peaks at 5-6 NTU. Again, Griffith Creek peaks at a lower value of 2 NTU. Overall, the City of Corvallis watershed does not produce large amounts of sediment.

Bacteria

Monthly averages over the 12-year period of record, show that fecal coliform (FC) is lowest (70-90 counts/100 ml) in December through April in Rock Creek Park and Griffith Creek (Figures 8a and 8b). Fecal coliform peaks in August and values are higher in Rock Creek Park (150) than Griffith Creek (96). The higher summer values in both streams are likely due to the combined effect of increased concentration resulting from lower stream flow and greater in-stream production of bacteria in a higher-temperature environment.

Throughout 1997, weekly samples were collected for fecal coliform analysis at the five City of Corvallis Watershed sites, providing a detailed baseline record of bacteria levels. Monthly averages of these data show the same general patterns in 1997 as those for the 12-year period of record (Figure 9). Fecal coliform is uniformly low (<5 counts/100ml) on all streams from December through April. In spring and summer, FC counts increase on all but North Fork Rock Creek, rising to 150 at Rock Creek Park, 47 on South Fork Rock Creek and 18 on Griffith Creek. On August 20, 1997, an individual sample of FC was 215 counts/100 ml on Rock Creek Park. The absence of wastewater outfalls, septic tanks, or large grazing allotments in the watershed indicates the wildlife is a likely source of fecal coliform in this sub-basin. This is important for the 303(d) listing for bacteria on the Marys River because “natural” conditions may result in high background levels of FC.

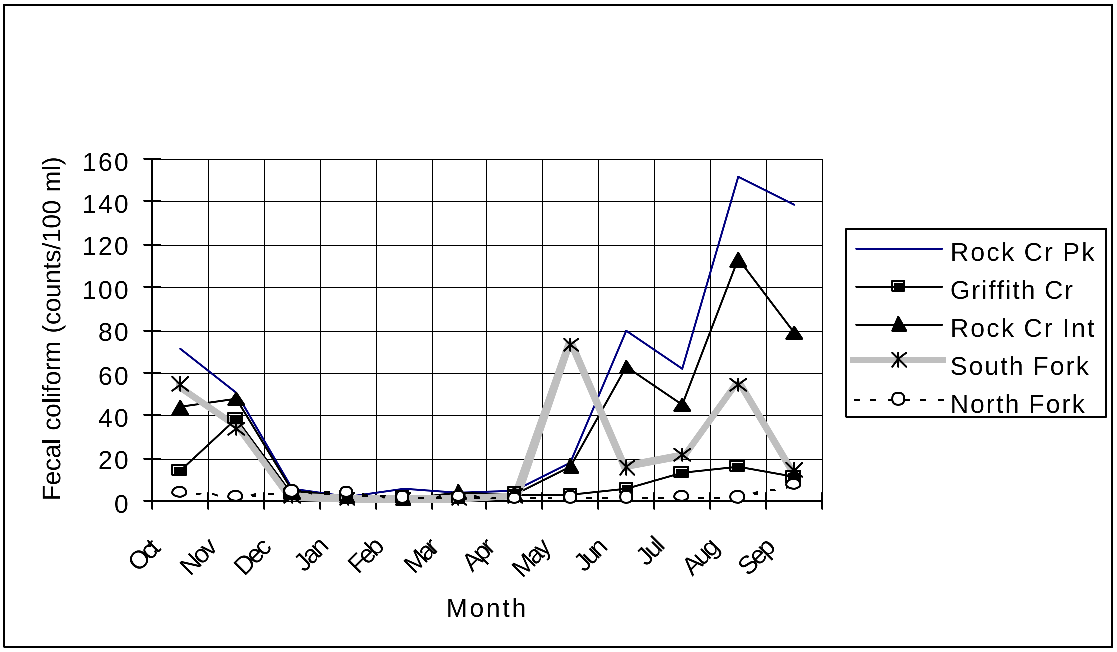


Figure 9: Fecal coliform bacteria sampled from Rock Creek sub-basin streams, 1997.

Other Relevant Water Quality Studies in the Willamette Basin

Many water quality studies have been conducted in the Willamette Basin that either include the Marys River Watershed or contain findings that can be extrapolated to the Marys River Watershed. Information about these studies is provided in the annotated bibliography. Study topics include as non-point source data for urban and agricultural areas (DEQ 1988), nutrient and water quality data for groundwater and surface water (Bonn et al. 1995), nutrient and pesticides in surface waters (Rainless and Janet 1998), sediment, nutrients and pesticides in runoff from cropland (Harward 1980), dioxins and furans in streambed sediments and issue samples (Bonn 1998), and a summary of recent water quality reports on the Willamette River (Tetra Tech 1995).

Withdrawals

Water availability reports were run according to the guidelines of the Watershed Assessment Manual (NonPoint Solutions 1999). These reports are an attempt to determine if stream basins may be over-allocated with respect to permitted water withdrawals. The reports were run through a web site of the Water Resources Department (Appendix 1). Figures 10 through 12 show the projected mean monthly instream flow, the instream rights (amount of flow that should be left in the stream for aquatic life and stream functions), and combined instream rights plus allocated consumptive rights (i.e., that which should be left in the stream plus that which is allocated for withdrawals). When combined allocation surpasses streamflow, the stream is over-allocated. Figures 10-12 show highly seasonal instream flows, and over-allocations of flow in all three streams during the low-flow summer months. Also note that even without the consumptive withdrawals, the instream rights can exceed the projected flow. Because not all water rights are exercised to their maximum, the amount of water permitted for withdrawal is likely more that what is actually withdrawn. These results deserve further attention as they suggest that the stream flows are excessively low in summer to impact aquatic resources and that withdrawals exacerbate the potential problems. One might want to examine the accuracy of the projected flows and determine why they are significantly lower than the gaged flows shown in Figure 3.

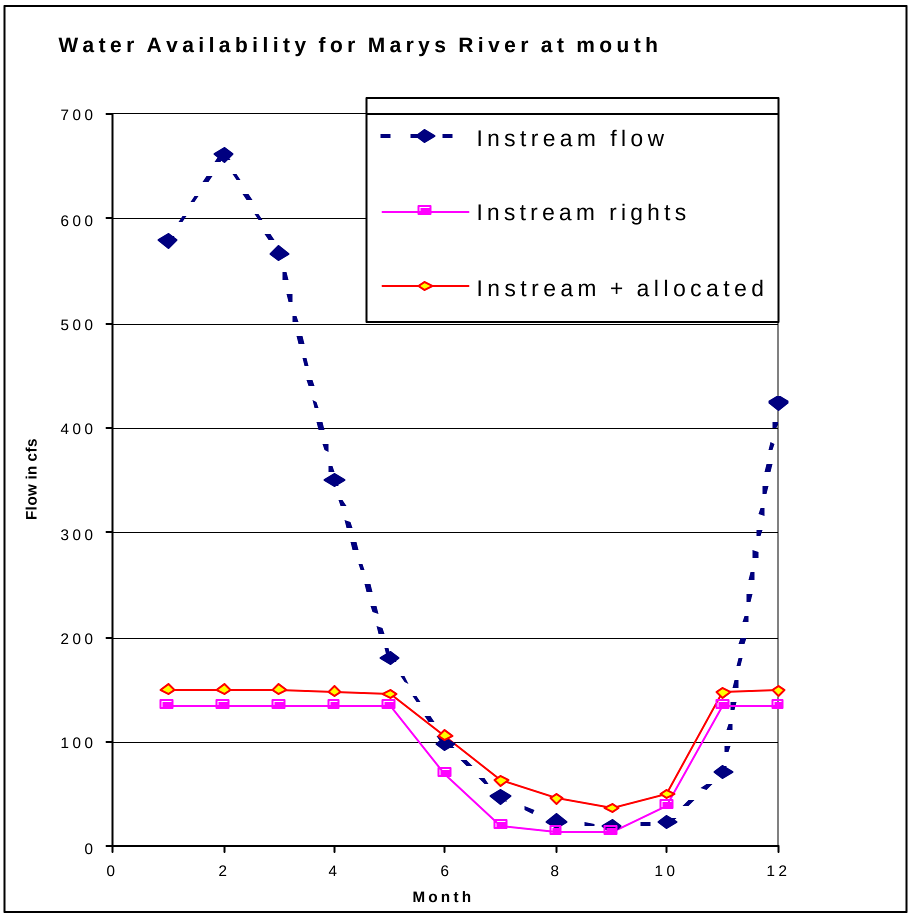
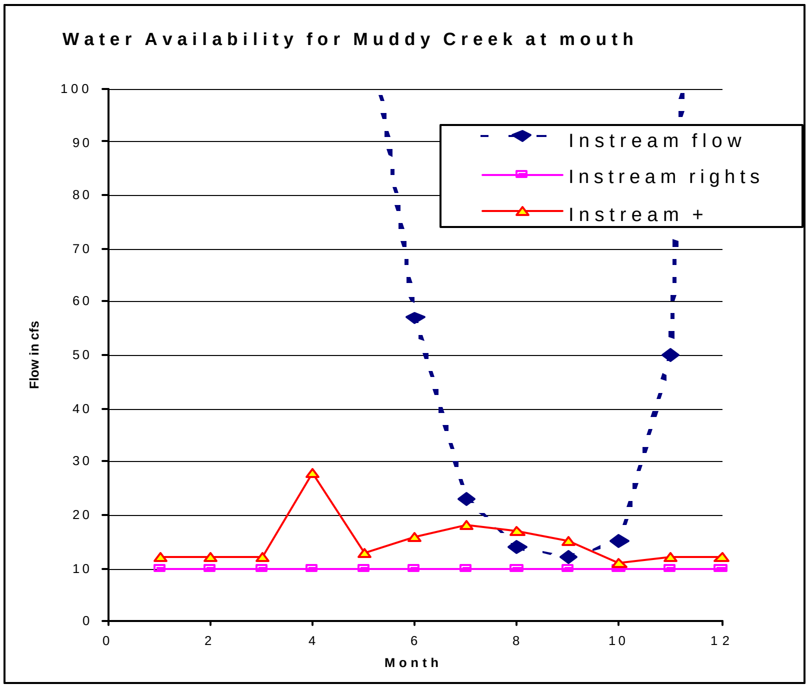
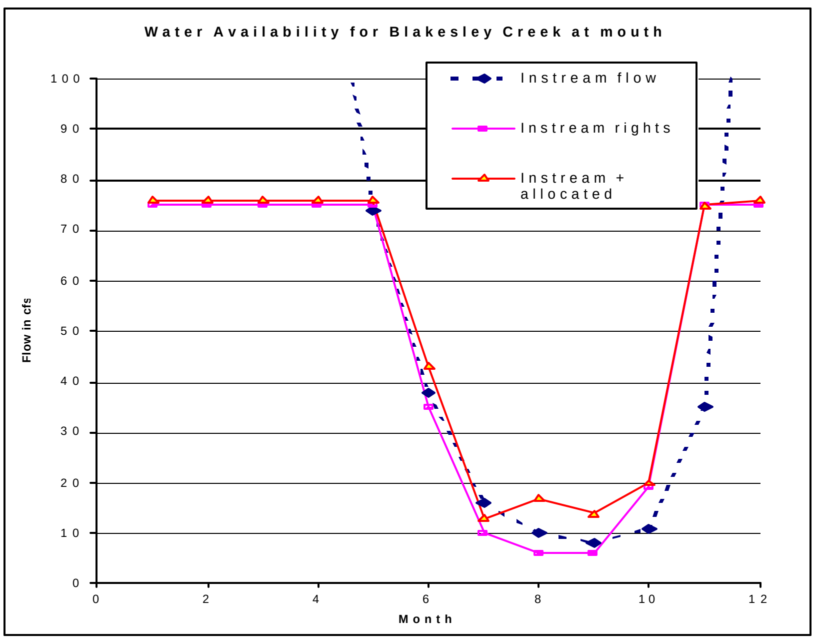


Figure 10: Water availability reports for Marys River. This and the next two graphs show the projected stream flows by month, the amount of instream rights and the instream rights plus that allocated to water users. Where the combined allocation exceeds instream flow during the summer months, the stream is over-allocated and short of water for aquatic functions (from water availability reports of the Water Resources Department).





Figures 11 and 12: Water availability reports for Muddy Creek (top) and Blakesley Creek (bottom). Maximum stream flows are over 400 cfs in Muddy Creek and 250 cfs in Blakesley Creek. Potential over-allocation of stream flow occurs during summer for both streams.

Table 9 depicts the uses of surface water in the watershed. The Rock Creek Facility for the municipal watershed produces about 3 million gallons of water daily, which is about 39% of the water supplied to the City of Corvallis. Table 10 is a list of permitted surface water withdrawals by sub-basin for the Marys River Watershed.

Table 9: Water rights[1] for Marys River Watershed (WRD unpublished data, cited in Wevers et al. 1992).

Total diverted	Water use (percent by class)			
	Agricultural	Municipal Use	Industry	Domestic
155 cfs	87	12	<1	<1

[1]A water right is the amount of water legally allotted to users, not necessarily the amount actually used.

Table 10: Points of surface water diversion by sub-basin within the Marys River Watershed (WRD unpublished data queried in 1998).

Sub-basin	Acre-feet	CFS	Gal/min	Sub-basin	Acre-feet	CFS	Gal/min
BARK CREEK	4			MUDDY CREEK	446.38	38.23	
BEAVER CREEK	3.06	5.075		MULKEY CREEK		0.01	
BLAKESLY CR		0.022		N FK ROCK CREEK		4.7	
BOONEVILLE CR		0.26		NEWTON CREEK	1028	0.58	
BROWN CREEK		0.02		NORTON CREEK	1		
BULL RUN CR	94.85	1.085		OAK CREEK	0.033	0.29	
DEVITT CREEK	0.9			OLIVER CREEK	123	6.23	3.61
EVERGREEN CR	5	0.38		POWELL CREEK		0.01	2.6
GELLATLY CR		0.02		RAINBOW CREEK	3.2	0.09	
GRAY CREEK	20.2			RAMBO CREEK		0.09	
GREASY CREEK	263.73	4.75		READ CREEK		0.012	
HAMMER CREEK	2	0.55		REESE CREEK		0.095	
HARVEY CREEK		0.03		ROCK CREEK		4	1736
HAWLEY CREEK		0.08		S FK BULL RUN CR	3		
HIDE CREEK		0.02		SHOTPOUCH CREEK		0.03	
HORTON CREEK	3.1	0.36		SQUAW CREEK	382	0.695	
HULL CREEK	9			STARR CREEK	105.2	0.172	
HYMES CREEK		0.01		TUM TUM RIVER	742.2	3.9	
LA BARE CREEK		0.04		W FK MARYS R		0.08	
LARSEN CREEK	1.38	0.065		WELLS CREEK	0.1	0.05	
MARYS RIVER	342.36	65.87	53.1	WESTWOOD CREEK	0.16		
MERCER CREEK		0.14		WESTWOOD CREEK	0.56	0.01	
MILLER CREEK		0.02		WOODS CREEK		0.076	

	Acre-feet	CFS	Gal/min
TOTALS	3584	138.1	1795

Greenberry Irrigation District

The Greenberry Irrigation District is a government entity that operates under the authority of the Irrigation District Laws of Oregon. The district is located north of Finley Wildlife Refuge along most of Muddy Creek to the confluence with the Marys River. It is composed of 55 members with about 13,000 acres in land holdings. The district coordinates and facilitates local water use, and conservation and enhancement efforts. The group is currently in the process of completing an environmental assessment with the Bureau of Reclamation. They are also negotiating with the Finley National Wildlife Refuge to transport some or all of a 5,000 ac/ft water allotment the refuge has in storage in Fern Ridge Reservoir for use on refuge farm land and wetland enhancement.

Groundwater Quality

Limited data are available on groundwater quality in the Marys River Watershed. Muddy Creek sub-watershed groundwater quality is generally good but there is some evidence of coliform bacteria (USGS 1974). The Benton County Environmental Assessment Priority List records known and suspected health hazards and environmental problems in the Benton County. This list includes three onsite sewage disposal sites, drinking water including low yields and contamination clusters. The OSU Cooperative Extension Service in Corvallis and Benton Soil and Water Conservation District in Tangent currently are conducting a domestic groundwater testing and outreach program (M. Livesay, pers. comm.).

Groundwater Studies in the Willamette Basin

Groundwater is recharged primarily from precipitation that falls in the Coast Range uplands and foothills, and on the valley floor. Some groundwater flows below the soil surface and enters the Willamette River and tributaries such as Marys River and Muddy Creek (Gannet and Woodward 1997). Groundwater resources in the Muddy Creek sub-watershed are concentrated in unconsolidated sediments deposited next to Muddy Creek and its tributaries. This aquifer yields moderate to large quantities of water (500 gal min^{-1}) sufficient for irrigation (USGS 1974).

Evidence gathered in a 1993-1995 study conducted in Willamette Basin indicates that there is concern of nitrate contamination of shallow wells developed in alluvium agricultural areas (Hinkle 1997). The domestic wells sampled in that study were all less than 80 feet deep and were developed in alluvium. Nitrate concentrations ranged from less than 0.05 to 26 mg N L^{-1}. Nine percent of wells sampled exceeded the 10-mg N L^{-1} standard.

Thirteen different pesticides were detected in the 1993-1995 study of shallow groundwater, but concentrations were low (generally less than 1000 ng L^{-1}), with only

1 detection (dinoseb) exceed USEPA standards (Hinkle, 1997). Atrazine was the most frequently detected pesticide.

Summary

The lack of a systematic, long-term monitoring program in the Marys River Watershed limits evaluation of water quality. An important consideration for future assessment efforts will be development of a monitoring program for water quality and quantity throughout the watershed. Because of natural variation in flow and water quality characteristics, these efforts will be most valuable if they can be maintained for periods spanning more than a single water year. Future Marys River Watershed Council projects could provide important water quality data for which data are now limited.

The water quality screening process with a focus on 303(d) listed parameters of bacteria, temperature and flow modification suggests that the listings accurately reflect Marys River characteristics in relation to Oregon criteria. Bacteria counts show contamination in Oak Creek, and to a lesser extent in Squaw Creek, Lower Marys River, and the tributaries in Muddy Creek. Point sources such as the Philomath sewage treatment lagoons do not appear to be important sources of coliform bacteria, while runoff from livestock operations are likely important sources. Summer increases in fecal coliform bacteria measured in the City of Corvallis Watershed show that bacteria can be found in the absence of anthropogenic sources. Temperature data from Marys River and major tributaries in 1998 show that temperature did exceed the 64°F criteria well upstream of the valley floor. While loss of stream shading was shown to increase temperature in one location in 1995, the 1998 data show that temperatures above 64°F may be occurring naturally. For flow modification, a simple comparison of existing water rights versus averaged stream discharge shows that all Marys River water is over-allocated during low flow periods. This would represent a serious concern if all users took their allotment in a dry year. Other water quality measurements from Marys River and tributaries do not show any areas of serious concern. However, nitrogen and phosphorus data from DEQ suggest anthropogenic sources of these nutrients.

Future efforts to more accurately assess the natural versus anthropogenic effects on water quality in the Marys River Watershed are necessary for understanding enhancement projects that will rectify 303(d)-listed parameters. More extensive spatial and temporal monitoring efforts will be important for identifying possible sources of other pollutants.

CHAPTER 4: AQUATIC AND TERRESTRIAL HABITAT

This chapter describes what is known about fish and aquatic habitat in the Marys River Watershed. It also presents lists of other sensitive species. Much of the data was obtained from Oregon Department of Fish and Wildlife (ODFW), Oregon Department of Forestry (ODF), Oregon State University (OSU), Oregon Natural Heritage Program (ONHP), communications with experts, and a review of the literature. There are a number of sources of information about the habitat and species of the Marys River. However, a still incomplete picture remains because most of the information is of a qualitative nature as opposed to a quantitative nature. This is particularly true for species abundance and distribution.

Fish Diversity and Sensitive Species

The Marys River Watershed is home to as many as 20 native and 14 introduced fish species (Table 11).

Table 11: Fish species known to have occurred in the Marys River and its tributaries.

Native species:		Introduced species:	
Common name	**Scientific name**	**Common name**	**Scientific name**
cutthroat trout *	*Oncorhynchus clarki*	Coho salmon *	*Oncorhynchus kisutch*
Chinook salmon	*O. tshawytscha*	Steelhead * [1]	*O. mykiss*
Pacific lamprey	*Lampetra tridentata*	Brown trout *	*Salmo trutta*
brook lamprey	*L. richardsoni*	Brown bullhead	*Ameiurus nebullosus*
mountain whitefish *	*Prosopium williamsoni*	Mosquitofish	*Gambusia affinis*
redside shiner *	*Richardsonius balteatus*	Common Carp	*Cyprinus carpio*
Northern squawfish *	*Ptychocheilus oregonensis*	Yellow perch	*Perca flavescens*
leopard dace *	*Rhinichthys falcatus*	Smallmouth bass *	*Micropterus dolomieu*
speckled dace *	*R. osculus*	Largemouth bass	*M. salmoides*
largescale sucker *	*Catostomus macrocheilus*	White crappie	*Pomoxis annularis*
mountain sucker *	*C. platyrhynchus*	Black crappie	*P. nigromaculatus*
Oregon chub	*Oregonichthys crameri*	Warmouth sunfish *	*Lepomis gulosus*
sandroller *	*Percopsis transmontana*	Bluegill sunfish *	*L. macrochirus*
threespine stickleback *	*Gasterosteus aculeatus*	Pumpkinseed	*L. gibbosus*
chiselmouth *	*Acrocheilus alutaceus*		
peamouth *	*Mylocheilus caurinus*		
reticulate sculpin *	*Cottus perplexus*		
torrent sculpin *	*C. rhotheus*		
Paiute sculpin *	*C. beldingi*		
prickly sculpin	*C. asper*		

Sources:
Altman et al. 1997. Review of numerous reports.
* Personal communication, C. Hill, Fish Collection Museum, Oregon State University. Presence in Marys River Watershed established from collected specimens.
[1] Native status of steelhead is uncertain.

Eight fish species are discussed below because they are considered “sensitive” in that either they face some known level of challenge to their continued population levels or the existing information on the condition of their population is limited. The Oregon Heritage Foundation has identified that five of these species may occur in the Marys

River Watershed (Table 12). Coho salmon and steelhead, while not thought to have occurred naturally in the basin (C. Bond and K. Jones, pers. comm.), are discussed to highlight some of the conflicting information about their native status. ODFW considers two additional species worthy of notice due to lack of information on their status: cutthroat trout and sandrollers.

Table 12: Fish species in the Marys River Watershed with some level of sensitive status (Source: Oregon Natural Heritage Program).

Common Name	Scientific Name	Fed. status	Notes:
winter steelhead	*O. mykiss*	LT	Introduced, but native status uncertain; see discussion below.
spring chinook	*O. tshawytscha*	LT	Juveniles observed in basin. Not thought to have supported spawning runs, but see discussion below.
coho salmon	*Oncorhynchus kisutch*	C	Introduced but no longer thought to occur in the basin; not thought to have been native, but see discussion below.
Oregon chub	*Oregonichthys crameri*	LE	Occurs in Grays Creek in the Finley National Wildlife Refuge.
Pacific lamprey	*Lampetra tridentata*	SoC	Found in Muddy Creek (BLM 1997) and in Oak Creek (C. Bond, pers. comm.)

SoC=Species of Concern, C=Candidate Species , LT=Listed Threatened LE=Listed Endangered

Steelhead and Rainbow Trout

In March 1999, winter steelhead were listed as “Threatened” under the Federal Endangered Species Act (ESA) in the Upper Willamette River. It is not known whether the Marys River will be included in the critical habitat designation by National Marine Fisheries Service (NMFS). Although steelhead are listed as introduced in Table 11, discussion is ongoing about whether steelhead were native to the westside drainages of the Willamette River (S. Mamoyac, K. Jones, ODFW Corvallis, pers. comm.). The uncertainty about the original range of the steelhead is due to the complex life history of this species, lack of definitive survey data, and widespread stocking of non-native steelhead.

Historically, Willamette Falls at Oregon City was a selective migration barrier, which was passable during high flows, to anadromous salmonids. Native winter steelhead, which enter fresh water in March and April (Howell et al. 1985), were able to negotiate Willamette Falls (Collins 1968), as were spring chinook salmon. While no further obstacles blocked steelhead from accessing the west slopes of the Willamette, the species prefers higher-gradient eastslope streams flowing from the western Cascades. Small numbers of native winter steelhead are thought to have used Coast Range drainages of the Willamette (Wevers et al. 1992). Occasional reports of steelhead in the west sub-basins were made prior to the recent ODFW stocking programs (Dimick and Merryfield 1945; Willis et al. 1960 cited in Wevers et al. 1992). “Wanderers” also may have appeared in the westside streams (K. Jones ODFW, Corvallis, pers. comm., Federal Register Vol. 63 No. 46, Tuesday, March 10, 1998 pp. 800). Fish ladders were added at Willamette Falls as early as 1885 to facilitate the passage of fish species, with major improvements to these ladders in 1971 (Bennett 1987; PGE 1994; Cited from Fed. Reg. Vol. 63, No. 46. Tuesday, March 10, 1998 pp.

1800). Fish ladders allowed the successful introduction to the Willamette Basin of Skamania stock summer steelhead and early-migrating Big Creek stock winter steelhead, as well as coho salmon.

Steelhead were stocked throughout the Willamette Basin, including the Marys River. ODFW released adult winter steelhead to the Marys River basin from 1968 through 1973. These releases consisted of approximately 200 adult fish per year of Big Creek and Klaskanine hatchery stock. From 1985 to 1990, between 15,000 and 30,000 fry steelhead were released annually (Wevers et al. 1992). Releases were made to Woods Creek, Shotpouch Creek, Greasy Creek, and Rock Creek (Map 11). Steelhead redds have been documented in Greasy Creek (RM 0 to 8.8), Rock Creek (RM 0 to 3.7) and South Fork Rock Creek (RM 0 to 2.0). The last known documentation of steelhead in the Marys River was in 1992, when fry were electroshocked at the mouth of Rock Creek (S. Mamoyac, pers. comm.). The genetic origins--whether of the recent stockings, of spawning hatchery stock, or from native spawning--is uncertain, but ODFW is currently in the process of genetic testing to determine the origins of young steelhead on the westslope Willamette streams. Early results suggest that they have a mix of both native and hatchery genes (S. Mamoyac, pers. comm.).

Resident rainbow trout are not thought to be native to the westslope drainages of the Willamette River. Releases of Roaring River hatchery rainbow trout have been made in these drainages since the 1920's to provide a sport fishery. While there is no evidence of natural production of rainbow trout from hatchery releases (Wevers et al. 1992), stocked rainbow possibly may have resulted in a small number of returning steelhead (C. Bond, pers. comm.). The status of Upper Willamette winter steelhead populations has prompted changes to the sport fishing for rainbow trout and other species in the Marys River. Stocking of legal-sized trout has been discontinued. The opening of fishing season for trout has been delayed one month, until early May, and a catch-and-release program is being instituted. No bait fishing will be allowed.

Cutthroat Trout

Cutthroat trout are thought to be the only native trout occurring in the westslope drainages of the Willamette River. While four life-history types occur in the coastal cutthroat trout (resident, fluvial, adfluvial, and anadromous), only two of these types occur naturally in the west slope streams of the Willamette River. Resident cutthroat are those that live the entire year in a single pool or set of pools, are widespread, and are the dominant trout in the headwater streams of western Oregon (Hooton 1997). The likely distribution of resident cutthroat in the watershed is shown in Map 12, but may underestimate of the full distribution of the cutthroat trout. Larger, fluvial cutthroat complete in-river migrations between small spawning tributaries and main river sections such as the Willamette. Populations of fluvial cutthroat in the Marys River apparently were large in the recent past, and were observed leaping a dam on the lower river during November 1955 (Nicholas 1978; cited from Wevers 1992). Adfluvial cutthroat trout may have occurred when fluvial migrations were blocked by the North Fork impoundment on Rock Creek. Dam personnel found 21” cutthroat in the reservoir bottom after the reservoir was drained to control aquatic vegetation (Trask 1995)

The consistent presence of resident cutthroat in a wide array of streams, the occurrence of multiple age classes, and the numerous independent populations that exist above impassable barriers to downstream fish suggest that resident cutthroat populations are secure in most coastal streams in Oregon (Hooten 1997). Yet, cutthroat trout, which require stream complexity (Table 13), may be declining in western Oregon streams where habitat has been lost and pool complexity has decreased (Reeves et al. 1997). A lack of information about the status of cutthroat, especially the fluvial types, in the westslope drainages of the Willamette make them a stock of concern for the ODFW (Wevers et al. 1992). Fluvial populations generally inhabit the larger, lower-gradient stream channels, from which they enter the Willamette River. Habitation of the Willamette River exposes cutthroat to hatchery trout and to the parasite *Ceratomyxa shasta*, which is widespread in the mainstem Willamette.

A better understanding of the status of cutthroat trout in the Marys River Watershed would provide a useful gauge of habitat conditions, as cutthroat are a good indicator species of stream condition. As a first step, the refinement of Map 12 should be accomplished using the surveys already completed by state agencies.

Table 13: General considerations for cutthroat trout habitat requirements.
• Oriented towards pools versus riffles, and use cover such as woody debris (jams and logs) and overhanging banks.
• Adults prefer intermediate stream velocities (1 ft/sec or slower) and deeper water.
• Fry use slower water and are often associated with complex lateral habitats.
• Juveniles may be outcompeted by juvenile steelhead or coho in areas that lack sufficient cover.
• Optimum temperatures for juveniles is 60°F; the ability to swim is lost at 82°F.
• Juveniles have been known to remain in a single pool for several years or to make significant migrations within a basin.
• Frequently attain large size in beaver ponds.

The cutthroat homepage: http://www.orst.edu/ Dept/ODFW/conference/cuthab.html. March 1999.

Chinook Salmon

Spring chinook historically were able to negotiate Willamette Falls during high flows (Collins 1968) and are a native anadromous fish to the upper Willamette River. Spring Chinook in the upper Willamette were listed as “Threatened” under the ESA in March 1999. A decline in the abundance of these fish is attributed to reduced habitat coverage and quality, and suspected over-harvesting of native fish for a large hatchery program.

A photograph taken in the 1920s shows a string of salmon reportedly caught from the Marys River in the area near Harris covered bridge above the community of Wren (Appendix 4, Photo 4). The two men are the grandfather and father of Bobby Taylor, a Wren resident. The large heads, hooked jaws, dark bodies, and the long anal fins suggest they are chinook according to Dr. Carl Bond, OSU professor of fisheries (pers. comm.). Yet Bond, and other experts consulted, do not believe these fish came from the Marys River as spring chinook never used the Marys River for spawning habitat. Taylor relates that, as a child, his father told him that the fish were chinook, which commonly were speared with pitchforks in a pool on the family homestead. The pool was created by placing rocks into the river and felling a tree across this “dam.” By the 1940’s when his father told the story to Taylor, no salmon inhabited the Marys River. Bond reports that his major professor, Roland Dimick, lived in the area in the 1920’s and would have known if there were salmon in the Marys River. According to Bond, it was Dimick’s opinion that chinook had never used the Marys River or other westslope drainages. Bond has also spoken with numerous old-timers on this topic and none reported seeing adult chinook in the river.

Despite this apparent discrepancy over adult use of the Marys River by chinook, juveniles have been observed in the lower mainstem up to Greasy Creek and in Oak Creek (S. Mamoyac, Corvallis ODFW, and M. Wade, Springfield ODFW, pers. comm.). It is likely that the Marys River provides over-wintering and rearing habitat for juvenile chinook spawned in the mainstem of the Willamette or other tributaries.

Coho Salmon

Coho salmon are not native to the Willamette River above Willamette Falls. However, they have been in the basin for almost 80 years as a result of introductions that started in the1920’s (Wevers et al. 1992). In 1958, ODFW began a larger stocking program, introducing Toutle, Cowlitz or other hatchery-origin coho into several Marys River tributaries over a 30-year period. In the first 10 years of this program, nearly four million smolts and fry plus 1700 adults were released. During the next 10 years, nearly 0.9 million fry or fingerlings were released. In the remaining ten years, releases totaled 1.4 million fry or fingerlings. The area of releases were in Oak Creek, Shotpouch Creek, Rock Creek, and Greasy Creek (Map 13). The stocking program failed to establish a major fishery in these streams or elsewhere in the Upper Willamette.

Oregon chub

Oregon chub was listed as endangered under the ESA by the US Fish and Wildlife Service in 1993. The Oregon chub occurs only in the Willamette and Umpqua basins, and the Umpqua Oregon chub is taxonomically distinct from Willamette populations (Markle et al. 1991). The preferred habitat of the Oregon chub is quiet water such as sloughs and overflow ponds at low elevations in the Willamette Valley (Dimick and Merryfield 1945). Much of the historic range of these fishes has disappeared in the Willamette River and its tributaries because of the construction of flood control dams, channelization of the river and channel cleaning for the purpose of navigation (Sheerer 1998). In addition to the loss of habitat, introduced species may inhibit the establishment of new populations of chub, which colonize during high-flow events. At approximately half of the known population sites of Oregon chub, non-native fish are present.

Currently twenty-four populations are known to exist, with four of these being newly established from transplants performed by ODFW. One of these new populations exists in the Muddy Creek drainage on private land. One of the oldest known populations exists in Gray Creek, a tributary of Muddy Creek in the Finley National Wildlife Refuge. This population is considered stable, at 450-600 individuals. ODFW has an ongoing investigation into Oregon chub abundance and distribution (Sheerer, pers. comm.). The US Fish and Wildlife Service has produced a Recovery Plan for the Oregon Chub that outlines the goals and objective for management for the recovery of this unique species.

Pacific lamprey

Pacific lamprey are listed throughout the Columbia River system as a candidate species by NMFS (BFWA, BLM 1997). Habitat loss from hydropower projects and declines in populations of salmonids are thought to contribute to their decline. These fish, which are anadromous, parasitize salmonids in their ocean phase and are unable to negotiate fish ladders and other obstacles. Between 1943 and 1949, the Willamette River supported a commercial fishery on these fish with an average annual harvest of 233,179 pounds (Wydoski et al. 1979). There is additional information on this species on the Pacific Marine Fisheries Service internet homepage (*http://www.psmfc.org*).

Sandroller

Sandrollers (also known as trout perch) have been listed as a “stock of concern” by ODFW due to suspected low populations. They are native only to the lower Columbia River and its tributaries, including the Willamette River. Little is known about this species, though they are thought to hide in daylight hours among large submerged objects and feed at night over sandy substrates (Wevers et al. 1992). Because of their secretive nature, sandroller populations may be underestimated. Sandrollers and Oregon chub are considered the two most endemic fish species of the western Cascades/Willamette River basin region, with little to no occurrence in other regions (Hughes et al. 1987). Most of the introduced warm water species listed in Table 10 proliferate in the mainstem of the Marys River and in Muddy Creek, and may predate upon and compete with these invasive species. Much of the historic habitat of sandrollers has been lost to the draining of wetlands and channelization (Dunette 1997).

Fish-bearing Waters

Distributions of fish have not been systematically surveyed in the Marys River Watershed. Many tributaries have not been surveyed at all. However, it is reasonable to assume that fish will occur upstream as far as they can go, either to a blockage, and area of steep gradient, or a reach with degraded habitat or low flow.

The upper extent of fish use is currently being determined on private forested lands in Oregon as part of the State Forest Practice Administrative Rules. The size of the stream and the upper limit of fish use determine applicable forest harvest rules. For example, along small streams (mean discharge of 2 cfs) that are fish bearing, no timber harvesting may occur within 20 feet and only limited harvesting may occur within 50 feet. Upstream of areas of fish use, harvesting may occur at the stream edge. The Oregon Department of Forestry (ODF), in conjunction with ODFW, has undertaken the task of determining the upper extent of fish use as part of administering the harvest rules. The intention is to eventually make determinations in the field for all streams. In the interim, determinations may depend on location of known falls or barriers, or estimates based on drainage basin area and a presumed channel gradient from topographic maps (Map 12).

Cutthroat trout typically occur farther up headwater streams than all other fish species in the Coast Range. The distribution shown on Map 12 is a best estimate of the upper extent of cutthroat trout distribution. Copies of the reports and maps of the individual surveys are available at the ODF district offices (R. Anderson, ODF, Philomath) and at the ODF Forest Practices Division in Salem (J. Clinton).

Stream Conditions

ODFW Stream Surveys

Stream surveys have been performed on sections of at least 18 tributaries in the Marys River Watershed by state or federal agencies. These types of surveys are very detailed and usually provide the best information available on stream condition. The surveys also provide a good foundation for prioritizing protection, restoration, and enhancement projects. ODFW conducts most of these surveys (Moore et al. 1997), which were performed on private lands in the upper Marys River tributaries between 1991 and 1993. In 1996, BLM contracted for surveys to be performed on their lands in Greasy Creek, Reese Creek, Beaver Creek and Oliver Creek. The results of the ODFW stream surveys performed on Marys River and Muddy Creek tributary streams are summarized in Table 14. The locations of the surveyed reaches are shown in

Map 14. The Siuslaw National Forest performed a nearly similar survey on their ownership in Rock Creek in 1995 (Table 15).

A series of characterizations about stream conditions can be drawn from the ODFW surveys. As a guide to interpretation, channel gradient should first be considered. Most reaches in these surveys are of low gradient (many are 1% or less). Low gradient streams are characterized by slower flows, less riffles, more shallow pools, and glides. The substrate tends to be composed of mostly finer particle sizes (gravels, sands, and smaller). The streams would tend to be more sinuous and may be somewhat incised, or cut, into wider floodplains. Cut banks tend to be more common, especially if the stream flows through older floodplain deposits. Often, the amount of woody debris is low in such streams. Causes for low in-stream woody debris include the harvesting of riparian conifers and the removal of wood that may have occurred during stream cleaning. Because low gradient streams often provided the easiest places to build the first roads into the watershed, additional riparian and floodprone areas are often lost to road placement near streams.

The ODFW stream surveys of Marys River tributary streams show the following:

- Most areas of the watershed (beyond the riparian zone) have been altered from their natural condition by land use practices. Common land use practices along the reaches are timber harvest, grazing, agriculture, and residential development. A notable exception is the upper portions of Mulkey Creek, where mature forests are common.

- The riparian zones appear to be intact, forested zones on most streams, but are usually hardwood dominated. Conifer-dominated riparian zones are rare. The riparian vegetation consists mostly of deciduous forests of that are “large trees” (over 30-cm stem diameter). There were lesser amounts of mixed deciduous/conifer forests. Two reaches of riparian zone are shrubs or grasses. The classes of riparian forests are shown in Map 15.

- Large, streamside conifers, which are nearly absent from these streams, are the best source for in-stream large woody debris. Large conifer logs persist longer and are more resistant to high flows than hardwoods and smaller dimension wood. They capture and retain mobile bedload, and create zones of hydraulic scour that result in pool development. Conifers provide additional substrate for invertebrates and trap organic matter that is the food for many of the invertebrates. In short, they enrich stream ecosystems.

- Habitat complexity as assessed by the woody debris index is relatively low for all streams, an indicator of poor stream habitat for cutthroat trout according to Table 13.

- Pool area is high, as expected in low gradient streams.

- Water temperatures did not approach excessive levels for trout during these summer surveys. The highest temperature recorded was 63°F (17°C) in Norton Creek Tributary #1. Most maximum temperatures were less than 60°F. The cool temperatures associated with these streams are the result of adequate riparian shading.

- No reaches had more than 50% open sky; this correlates with the fairly intact riparian canopies. As temperatures did not appear to be a problem, the amount of canopy closure above the stream is less important. In fact, some amount of open sky allows greater light to the stream and promotes primary in-stream productivity, which supports a greater food base for the stream community.

- The amount of sand and fine sediment is very high, as expected in low gradient systems. However, in those reaches with sand and fine sediment covering over 80% of the stream bottom, gravel may become limiting for trout spawning, and inhibit desirable aquatic invertebrate production.

- Undercut bank percentages were quite high in some reaches, as expected in low gradient streams. Undercut banks provide important cover for trout, especially if woody debris is lacking. Although high in some reaches, eleven of the 24 reaches had less than 10% undercut banks. This low availability of undercut banks in combination with low habitat complexity scores contributed to poor trout habitat conditions.

Table 14: Summary of ODFW Aquatic Habitat Inventory data, Marys River Watershed.

Stream	Survey date	Reach	Avg. Unit Grad (%)	Length (m)	Land use[1]	Riparian Veg.[2]	Max. water Temp. (°C)	Pool Area (%)	Habitat complexity Index (wood)	Sand & Organic Substrate (%)	Gravel Substrate (%)	Total wood pieces	Woody Debris[3] (pcs/100m)	Under cut Bank (%)	Open Sky (% of180°)	Avg. Density of Canopy Closure	Large Streamside conifers (D=50)	Large Streamside conifers (D=90)
Bark	8/93	1	0.1	1000	AG/YT	S/G	11.0	19.2	1.4	99	0	120	11.9	50.4	46	1.7	0	0
	8/93	2	0.2	1050	ST/TH	D30/S	14.0	5.8	1.8	83	12	351	33.6	38.2	25	2.7	0	0
	8/93	3	0.6	930	ST/	D30/S	13.0	14.5	1.3	84	10	177	19.0	2.6	7	0	0	0
	8/93	4	0.2	1110	ST/	D30/S	14.0	17.9	1.5	84	13	206	18.6	15.6	32	0.52	0	0
Big Timber	8/93	1	6.5	320	ST/	D30/S	11.0	8.2	1.6	22	60	50	15.5	22.5	17	3.4	0	0
Beaver	11/92	1-3	0.3	3960	AG/HG	P/DM	16.5	80.7	1.6	38	45	396	10	6.4	21	0	0	0
	8/92	4-6	0.9	6100	AG	DM	16.0	34.4	1.6	39	52	698	11.4	6.8	17	0	0	0
Greasy	9/92	1-5	0.5	8300	RR/LG	DM/SY	16.0	71.3	1.3	72	21	338	4.1	3.6	36	0	0	0
	9/92	6-9	0.7	5810	RR/AG	DM/SY	16.0	58.9	1.9	31	32	838	14.4	8.3	16	0	0	0
Norton	8/93	1	0.8	460	ST/	D/30	12.0	26.7	1.7	100	0	152	33.3	25.2	14	0.5	2	0
	8/93	2-3	1.8	2080	ST/YT	M50/G	13.0	48.7	1.6	79	16	375	18.0	51.4	9	2.5	3	0
Norton Trib. #1	8/93	1	1.1	398	ST/AG	M50/P	17.0	73.1	1.2	92	3	47	11.8	46.8	26	32	3	0
Mulkey	8/93	1-2	1.4	330	HG/	D50/S	14.0	0.0	1.3	26	43	17	5.1	30.0	34	6.7	0	0
	8/93	3	2.1	2280	YT/ST	S/G	13.0	51.6	1.5	59	38	497	21.8	22.0	50	1.1	0	0
	8/93	4,6	4.7	2460	MT/	D30/S	13.0	9.6	1.6	27	47	421	17.1	23.4	19	1.5	0	0
	9/93	7-8	3.9	1340	MT/	M-50	12.0	51.9	1.5	34	45	345	25.7	32.5	12	3.7	1	0
	9/93	9	4.4	1500	MT/	D-50/	11.0	0.0	2.2	37	46	412	27.4	29.7	2	2.4	0	0
Peeler	8/93	1	2.6	280	ST/ST	D/50	9.0	0.0	1.2	60	31	44	15.9	61.0	11	4.5	4	0
Rock	8/92	1-3	1.0	2090	RR/AG	DM/SY	16.0	45.5	1.2	20	41	114	5.5	5.9	18	0	0	0
	9/92	5	1.6	3560	SG/CC	DM/SY	15.0	27.1	1.4	13	24	146	4.5	2.6	22	0	0	0
	9/92	6	1.3	1330	SG/SG	DM/SY	15.0	18.5	1.3	12	26	74	5.6	2.1	22	0	0	0
W. Fork Marys	8/91	1-2	0.2	5010	HG	DM	16.0	43.2	2.0	88	12	0	na	0.5	22	0	0	0
	8/91	2-4	0.9	2330	HG	DM	15.0	44.5	1.1	51	41	0	na	1.5	16	0	0	0
	8/91	5	5.7	990	SG	DM	14.0	3.7	1.2	32	25	0	na	0.5	0	0	0	0

[1]Land Use Codes: AG=Agricultural crop or dairy land; TH=Timber harvest; YT=Young Forest Trees; ST=Second growth Timber; LT=Large Timber (30-50 dbh); MT=Mature Timber (50-90 dbh); OG=Old Growth Forest; PT=Partial cut Timber; FF=Forest Fire; BK=Bug Kill; LG=Light Grazing Pressure; HG=Heavy Grazing Pressure; EX=Exclosure; UR=Urban; RR=Rural Residential; IN=Industrial; MI=Mining; WL=Wetland; NU=No Use identified.

[2]Riparian Veg. Codes: N=No Veg.; B=Sagebrush; G=Annual Grasses; P=Perennial grasses, sedges and rushes; S=Shrubs; D=Deciduous Dominated; M=Mixed conifer/deciduous; C=Coniferous Dominated.

Second part of Code for size class: 1-3=Seedlings and new plantings; 3-15=Young established trees or saplings; 15-30=Typical sizes for second growth stands; 30-50=Large trees in established stands; 50-90=Mature Timber (D50); 90+=Old Growth (D90).

[3]Minimum size requirement is 15 cm in diameter and 3 m in length and rootwads that are within, partially within or suspended over the active channel.

Table 15: Summary of Siuslaw National Forest Surveys in the Rock Creek sub-basin.

Stream	Date	Reach	Grad-ient (%)	Length (mi)	Max. Temp (°F)	P:R:G ratio (%)	Tot. LWD (pieces / mi)	Bed dominant / subdominant substrates	Cobble embed-ded-ness	Pools (%)	Bank Cover Class	Can-opy Clos-ure	Total Stream-side Conifer Count (#/100 ft)	Fish Density (fish / sq. yd)
NF Rock	7/95	1	5.0	1.21	54	21:79:0	96	co/gr	n	20.4	4	4	16	0.02/0.01
NF Rock	7/95	2	8.0	0.88	53	16:84:0	117	co/gr	n	14.9	4	4	12	0.04/0.02
Trib. 11 (NF Rock)	7/95	1	20.0	0.32	54	na	0	gr/sa	n	14.5	3	4	20	0.12/
MF Rock	7/95	1	3.0	1.04	53	36:64:0.3	55	co/gr	n	35.2	4	4	2	0.05/0.03
MF Rock	7/95	2	9.0	1.18	na	16:84:0	118	co/gr	n	16.2	4	4	16	0.06/0.03
SF Rock	7/95	1	6.0	1.47	56	24:76:0	33	co/sb	n	21.1	4	4	12	0.02/0.01
SF Rock	7/95	2	11.0	2.16	na	16:84:0	75	co/sb	n	15.6	4	4	11	0.05/0.01
Trib. 4 SF Rock	7/95	1	10.0	1.17	56	27:73:0.3	217	gr/co	n	26.2	4	4	11	0.02/0.01
Trib. 8 SF Rock	7/95	1	13.0	0.85	56	20:80:0	105	co/sb	n	19.0	4	4	16	na

Substrate codes: sa=sand, gr=gravel, co=cobble, sb=small boulder, lb=large boulder, br=bedrock
Bank cover class codes: codes refer to the percent ground cover in the upper 1/3 of the bankfull zone; 1=1-25%, 2=26-50%, 3=51-75%, 4=76-100%
Canopy closure codes: a visual estimate taken at the end of each reach: 1=0-19% closure, 2=20-30% closure, 3=31-60% closure, 4=>61% closure.

Siuslaw National Forest Surveys

Stream surveys were conducted in the summer of 1995 on streams in the Rock Creek sub-basin (Table 15). These streams were much higher gradient than the other streams surveyed and consequently had much more riffle habitat. Natural fish barriers were commonly encountered in the survey area. In-stream temperatures were lower during summer surveys than other surveys, probably because the amount of canopy shading and streamside conifers was high. Despite the high-quality habitat, surveyors using uncalibrated snorkel surveys observed very low densities of cutthroat trout in all reaches. The municipal watershed of Rock Creek has several water projects that may present passage problems to salmonids.

The North Fork Rock Creek dam backs up water for 0.3 miles and blocks anadromous fish passage. This reservoir is drained every five years to control aquatic vegetation and 21-inch cutthroat trout have been found in the reservoir bottom after drainage, suggesting that the dam provides excellent juvenile rearing habitat. Uncalibrated snorkel surveys were performed on all streams with generally very low abundance of 0+ age-class and 1+ age-class cutthroat trout. Two impassable falls were encountered near the end of the North Fork survey. The fish densities of Tributary 11 of North Fork Rock Creek were about one fourth the density expected in a fully seeded system (Solazzi and Johnson 1993, cited by Trask 1995). Upstream passage on Tributary 11 was blocked by a falls and log jam located just above the end of the survey.

Other surveys in the Rock Creek sub-basin identified both human and natural barriers to fish passage. A culvert at County Road 3405 is a potential barrier to trout, but not salmon or steelhead passage. A concrete water diversion dam footing and a water intake at River Mile 0.9 are impassable. The South Fork Rock Creek had a diversion dam low in the system at River Mile 0.4 that blocked anadromous fish passage unless the head boards were adjusted to create a step-pool approach. At the time of the survey, the head boards were not adjusted and the dam was a barrier to upstream fish passage. Tributary 4 of South Fork Rock Creek had a 4-foot falls near the end of the survey that blocked upstream fish passage. Tributary 8 of South Fork Rock Creek had a steep cascade partway through the survey that blocked upstream fish use.

BLM Stream Surveys

Bureau of Land Management (BLM) surveys on several low-gradient tributaries of Muddy Creek and the Marys River are summarized in Table 16. According to the analysis, fish habitat has been degraded or may be in a declining condition. Habitat problems include a lack of large woody debris, pools, off-channel habitat, and proper substrate (BFWA, BLM 1997). The habitat conditions for these four streams were categorized by the BLM as “not properly functioning” or “at risk” in the categories of LWD, pool area, pool quality, off-channel habitat and channel condition for all these streams. Substrate was noted as habitat limiting in Reese Creek. Sediment and turbidity are concerns in the basin because excessive suspended sediment can have adverse effects on in-stream fish and aquatic invertebrate habitat. Effects of sediment can include changes to bedload size, channel shape, salmonid redd reproduction rates, primary productivity, and pool distribution. Large increases in the amount of sediment delivered to the stream channel can also alter the structure and width of stream banks and the adjacent riparian zones (BFWA, BLM 1997).

Table 16: Stream conditions on BLM managed lands in the Marys River Watershed (assessed using ODFW stream survey protocols).

Sub-basin	Dominant substrate	Complex pools (%)	LWD (key pieces per mile)	Pool area (%)	Total reach area (m^2)	Total length (m)
Beaver Creek	Gravel/ Cobble	1	27 pieces	10.2	7,847	2.9
Oliver Creek	Gravel/ Cobble	2	39 pieces	12.4	16,523	4.3
Reese Creek	Silt, Sand, Organics	0	11 pieces	0.5	2,626	1.2
Greasy Creek	Gravel/ Cobble	0	13 pieces	13.3	1,728	1.1

Benton Foothills Watershed Analysis, BLM 1997

Culverts and Fish Barriers

Culverts can pose problems for stream systems in two ways. First, they can block fish movement and effectively isolate populations or prevent access to upstream areas during migrations by fish. Secondly, culverts can initiate road failures if they are undersized or become blocked during high stream flows. Most of the problem culverts are those that were installed years ago without regard to stream and fish needs. Today these problem culverts are relatively easy to identify and sometimes the fixes are inexpensive. As a result, a number of culvert surveys have been initiated. Most of the work to date has been on public lands and roads.

Two state agencies, ODF and ODFW, are surveying culverts for fish passage problems. In 1998 ODF surveyed all roads on state lands in Benton County for culverts. Some adjacent private lands were also included in the surveys. The survey was part of a three-county survey that covered some 300 miles of road and included the approximately 3000 acres of state lands in the West Fork Marys River sub-basin. The purposes of the surveys were to identify all structures, map their location, and describe their conditions. Standard data were collected according to guidelines set by the Forest Practices Section of ODF. Typical data include diameter, drop of outfall, pool below, gradient, road condition, and ditch conditions. Among the early findings was a realization that a large number of culverts exist on the landscape, with many of these blocking upstream habitat (C. Humpke, ODF, Philomath, pers. comm.). ODFW's inventories of state and county public roads (except urban areas) include an examination of culverts for fish passage. These surveys also uncovered problems, which will be prioritized for repairs and restoration (G. Galovich, ODFW, Corvallis, pers. comm.).

Private industrial forest landowners in the Marys River Watershed have initiated their own surveys of logging roads. These surveys include identification and repair of problem culverts. For example, Starker Forests has a program of culvert inventories in which over 100 culverts have been upgraded to enhance fish conditions or water quality since the inception of the program (G. Blanchard, Starker Forests, pers. comm.). Private landowners also use survey results to develop methods that lessen water quality impacts caused by erosion and sediment runoff. Water bars and earthen berms have been used by Starker Forests to keep wheeled traffic off closed roads and prevent drainage water from directly entering streams (G. Blanchard, Starker Forests, pers. comm.). If water is quickly taken off the road system, it has less opportunity to erode ditches and input sediment into streams. Grass seeding, hay bales and sediment fences can also be used to help slow down drainage water and allow sediment to drop out of water from road drainages. These measures can also be used to prevent the massive input of sediment caused by road failures that are associated with unmaintained or poorly constructed forest roads.

Developing a program to survey culverts on remaining private lands should be a high priority project for the watershed council. Surveys are relatively easy to perform. Restoration costs can vary depending on whether minor maintenance or complete replacement is needed. However, in many cases, significant benefits can be achieved at relatively low costs. Individual landowners do not need to wait for a basin-wide inventory, but may contact ODFW if they suspect that a culvert is in need of repair. ODFW surveys do not require that a landowner replace problem culverts at their own expense (G Galovich, pers. comm.).

Other Fish Passage Obstructions

The Marys River Watershed has no large water storage projects, although there are municipal water use dams in the Rock Creek. The South Fork of Rock Creek has a concrete diversion dam, while on the North Fork a large earth-filled dam creates an impoundment that is the source of about 39% of the domestic water supply for the City of Corvallis. The South Fork dam may be passable to large salmonids. Another water intake on nearby Griffith Creek is also reported to be impassable (J. Fairchild, watershed resident, pers. comm.). A third water intake exists on the Middle Fork Rock Creek and was reported as impassable in 1995 (Trask 1995). The removal of this dam could open up important high-gradient cutthroat spawning habitat. Two small dams are reported for Oak Creek (Williams et al. 1994), and It is probable that there are a number of additional small impoundments located throughout the Marys River Watershed such as that at Thompson Lake on the headwaters of the Tum Tum River.

The Oregon Streamnet website (http://www.streamnet.org) collects and compiles information on both natural and human-made barriers to fish passage for anadromous and resident fish of the Columbia River system. Some data for the Marys River Watershed are currently available on the website, and more are expected in the future (C. Cooney, ODFW, pers. comm.).

Riparian Zones and Wetlands

Historical records such as journal entries of explorers and settlers indicate that much of the riparian forests and wetlands that originally existed along valley bottoms of larger rivers were cleared for homesteads beginning about 1840 (Storm 1941, see also Chapter 2). Development of the valley bottom appears to have occurred rapidly between 1840 and 1880. Some sense of change in riparian vegetation along the lower Mary River can be gained by comparing the 1850 historic vegetation map constructed by the Nature Conservancy (Map 9a) with the current 1997 vegetation map constructed by ODFW (Map 9b) and a recent orthophoto of the same area (Map 9c). By examining old records and public land survey notes, reconstruction of original riparian conditions of the Willamette River just south of Corvallis was accomplished by Benner and Sedell (1997, Map 16). Clearing of forests, development of pastures and fields, and channelization of waterways eliminated many side channels, seasonal off-channel refuges, and wetlands.

Channelization of headwater streams likely occurred before the 1930's in the Muddy Creek sub-basin. In addition, much of the loss of riparian zones likely had occurred by this time. An examination of aerial photos taken in 1937 reveals that much of the Muddy Creek drainage had been developed for agricultural use. The 1937 photos show straight lines that appear to be evidence of widespread channelization of small temporary drainages and streams. Drainage tile lines can be observed in the agricultural field in the 1937 aerial photograph and were known to be widely in use at that time. Comparison of the 1937 photos to those taken in 1956 and 1993 show that an additional, but small (probably less than 5%) amount of riparian habitat was lost (Photos 3a-3c, Appendix 2).

A comprehensive map of current riparian vegetation for most of the watershed is not available. A characterization of riparian forests from the ODFW stream surveys is shown on Map 15. The Coastal Landscape Analysis and Modeling Study (CLAMS) uses satellite imagery and modeling to develop vegetation layers (Map 17). The CLAMS project promises to be a useful source of information and possibly analysis tools for watershed groups in the Coast Range. More information is available on the CLAMS website (see website bibliography).

Wetland inventories have been performed recently in the Marys River Watershed by the Oregon Natural Heritage Program (ONHP). Current wetlands are shown in Map 18. Their report is available http://www.sscgis.state.or.us/data/sources.html. Their findings include the following summaries:

"Most [wetland] sites inventoried in the Willamette Valley are dominated by non-native species. The most common invasive species in bottomland and wetland habitats are reed canary grass (*Phalaris arundinacea*), roughstalk bluegrass (*Poa trivialis*), Himalayan blackberry (*Rubus discolor*), nipplewort (*Lapsana communis*), English ivy (*Hedera helix*) and bittersweet nightshade (*Solanum dulcamara*). These species are very difficult to keep out of native areas and extremely difficult to control once they have invaded an area."

"Throughout the Willamette Valley, riparian zones and wetlands are actively being developed [i.e., filled or drained]. This was observed numerous times during the course of this project. Section 404 (wetland fill permit) violations appear to be commonplace. Privately owned wetlands and riparian areas throughout the Valley deserve increased protection from degradation and development.

Wetlands found on sites with high quality remnants have been included in a conservation priority list. The most important sites on private land are the Calapooia River, Muddy Creek, North Santiam River, Luckiamute River, Kingston Prairie, the Mission Bottoms area, and the Bull Run Creek fragment. Private lands along many other rivers and creeks are also worthy of protection. Public lands in the Willamette Valley need to be protected from degradation. Restoration activities could be attempted at non-native dominated areas on public lands, although protecting native habitat should clearly take precedence over restoration. Small emergent wetland sites are scattered throughout the Willamette Valley, both in and between the priority wetlands. These sites should be a focus of protection along with the forested riparian zones. Hydrological threats to these areas also need to be addressed. Large native emergent wetlands were not found outside of public lands."

The ONHP report also highlighted the high-quality, extensive riparian zones along Muddy Creek.

Newton Creek flows through a large wetland area within the urban growth boundary of Philomath (Appendix 3, Figure 6). Much of this wetland has been modified by a railroad line and by its use as a log pond by sawmills. The City of Philomath is studying the wetlands and is planning to identify sites that deserve protection and sites that could be developed as part of an industrial park. Currently a 170-acre parcel is for sale that contains about 100 acres of wetlands and an old log pond that now is home to about 30-40 adult western pond turtles, a "Species of Concern" on State and Federal lists. The pond is also home to bull frogs, which may be preying on the juvenile pond turtles.

Sensitive, Non-Fish Species

A complete species list of all animals thought to occur in the Muddy Creek sub-basin at the time of Euro-American arrival has been compiled by Hulse et al. (1997). This list included 234 total amphibian, reptile, mammal and bird species. This list is probably representative for the Marys River Watershed, because the Muddy Creek drainage includes upland habitats similar to the forested areas of the headwaters of Marys River. There are eight known extirpated vertebrate species from the Muddy Creek sub-basin: grizzly bear, California condor, lynx, gray wolf, white-tailed deer, yellow-billed cuckoo, black-crowned night heron, and spotted frog (Hulse et al. 1997). According to Storm (1941) beaver were also extirpated from the Marys River Watershed by trappers, but were reintroduced to Oak Creek in the 1920's. Appendix 6 has additional information on status of wildlife.

The Oregon Natural Heritage Program (ONHP) has assembled a list of sensitive species in Benton County (http//:www.hertitage.tnc.org). Approximately 90 of these species of plants and animals are thought to occur or at least have potential habitat in the Marys River Watershed (Table 17). The ONHP list includes species listed by one or more of the following: federal agencies including the US Fish and Wildlife Service and NMFS; state agencies including ODFW and the Oregon Department of Agriculture; and nonprofit and educational organizations such as Native Plant Society of Oregon, Oregon State University's Oregon Flora Project (OSU), and the ONHP. Species that are not listed on federal or state lists, but are listed by another group are also included in the table. For many of these listed species there is not enough data to determine the status of their populations.

The Federal rank lists species in order of perceived peril as: 1) Listed Endangered (LE), 2) Listed Threatened (LT), 3) Proposed Endangered (PE), 4) Proposed Threatened (PT), 5) Species of Concern (SoC), and 6) Candidates for listing (C). Eight species in Table 17 are either Listed Endangered or Listed Threatened. The bald eagle is being considered for removal from the federal threatened list, and the gray wolf probably has been extirpated from the watershed. The six remaining federally listed species include two endangered species: peregrine falcon and Kincaid's lupine; and four threatened species: Northern spotted owl, marbled murrelet, Aleutian goose, and dotted water-flax seed. Two species are proposed for federal endangered listing: Fender's blue butterfly and Willamette daisy, while one is proposed for a threatened listing: three-colored monkey flower.

The state system is similar to the federal system in regards to threatened and endangered ranks, but replaces "Candidates" and "Species of Concern" with four "Sensitive Species" rankings. These include "Critical" (SC), for species with listing pending; "Vulnerable" (SV), for species where listing is not thought to be imminent and may be avoided with action; "Peripheral" (SP), for species that are naturally rare or whose Oregon populations are on the edge of their ranges; and "Undetermined" (SU), for species whose status is unclear from lack of information. The state Endangered Species Act is more limited in scope than the federal ESA and only actively applies to lands owned or managed by the state. Criteria for state listing of a species extends to populations that are 1) actively undergoing or are in imminent danger of habitat deterioration, 2) being over-utilized or where over-utilization is likely to occur, or 3) not being protected adequately by existing programs. "Sensitive" status is given to any species that might qualify as "Endangered" or "Threatened" in the future. Other species included in the tables with no federal or state status are listed by another group and generally indicate species that may be of concern or about which not enough information is known.

Table 17: Sensitive species that potentially occur or formerly occurred in the Marys River Watershed (Oregon Natural Heritage Program).

Status abbreviations:
LE = Fed. Listed Endangered, **PE** = Fed. Proposed Endangered, **LT** = Fed. Listed Threatened, **PT** = Fed. Proposed Threatened, **C** = Fed. Candidate Species, **SoC** = Fed. Species of Concern, **SC** = State Sensitive Critical, **SV** = State Sensitive Vulnerable, **SP** = State Sensitive Peripheral, **SU** = State Sensitive, Undetermined status. Those species with no listed status are proposed by Oregon Natural Heritage Program or the Nature Conservancy as species that merit attention.
* Corvallis Chapter of the Native Plant Society of Oregon, Species of Concern

Common name	Scientific name	Fed. status	State status
REPTILES			
Northwestern pond turtle	*Clemmys marmorata marmorata*	SoC	SC
painted turtle	*Chrysemys picta*	-	SC
sharptail snake	*Contia tenuis*	-	SV
AMPHIBIANS			
Oregon spotted frog	*Rana pretiosa*	C	SC
southern seep salamander	*Rhyacotriton variegatus*	SoC	SV
tailed frog	*Ascaphus truei*	SoC	SV
Northern red-legged frog	*Rana aurora aurora*	SoC	SV/SU
Clouded salamander	*Aneides ferreus*	-	SV
BIRDS			
peregrine falcon	*Falco peregrinus*	LE	LE
bald eagle	*Haleaeatus leucophalus*	LT	LT
northern spotted owl	*Strix occidentalis caurina*	LT	LT
marbled murrelet	*Brachyramphus marmoratus*	LT	LT
Aleutian Canada goose (wintering)	*Branta canadensis leucopareia*	LT	LE
northern goshawk	*Accipiter gentilis*	SoC	SC
little willow flycatcher	*Empidonax traillii brewsteri*	SoC	SV
northern pygmy owl	*Glaucidium gnoma*	-	SC
burrowing owl	*Athene cunicularia*	-	SC
western meadowlark	*Sturnella neglecta*	-	SC
Oregon vesper sparrow	*Pooecetes gramineus affinis*	-	SC
purple martin	*Progne subis*	-	SC
common nighthawk	*Chordeiles minor*	-	SC
streaked horned lark	*Eremophila alpestris strigata*	-	SC
yellow-breasted chat	*Icteria virens*	-	SC
Lewis' Woodpecker	*Melanerpes lewis*	-	SC
pileated Woodpecker	*Dryocopus pileatus*	-	SV
western bluebird	*Sialia mexicana*	-	SV
white-tailed kite	*Elanus leucurus*	-	-
dusky Canada goose (wintering)	*Branta canadensis occidentalis*	-	-
acorn woodpecker	*Melanerpes formicivorus*	-	-
MAMMALS			
gray wolf	*Canis lupus*	LE	LE
Canada lynx	*Lynx canadensis*	C	-
white-footed vole	*Arborimus albipes*	SoC	SU
Pacific western big-eared bat	*Corynorhinus townsendii*	SoC	SC
fringed myotis	*Myotis thysanodes*	-	SV
American marten	*Martes americana*	-	SV
long-eared myotis	*Myotis evotis*	-	SU
silver-haired bat	*Lasionycteris noctivagans*	-	SU
Western gray squirrel	*Sciurus griseus*	-	SU

Table 17 (continued)

Common name	Scientific name	Fed status	State status
INSECTS			
Fender's blue butterfly	*Icaricia icarioides fenderi*	PE	-
Fender's rhyacophilan caddisfly	*Rhyacophila fenderi*	SoC	-
Haddock's rhyacophilan caddisfly	*Rhyacophila haddocki*	SoC	-
Roth's blind ground beetle	*Pterostichus rothi*	SoC	-
Vertree's ceraclean caddisfly	*Ceraclea vertreesi*	SoC	-
Siskiyou chloealtis grasshopper	*Chloealtis aspasma*	SoC	-
montane bog dragonfly	*Tanypteryx hageni*	-	-
Mary's Peak ice cricket	*Grylloblatta spp.*	-	-
American acetropis grass bug	*Acetropis americana*	-	-
stink bug	*Dendrocoris arizonensis*	-	-
foliaceous lace bug	*Derephysia foliacea*	-	-
Heidemann's nabid (bug)	*Hoplistoscelis heidemanni*	-	-
Martin's water-measurer	*Hydrometra martini*	-	-
marsh ground beetle	*Acupalpus punctulatus*	-	-
potentilla root borer beetle	*Chrysobothris potentillae*	-	-
Corvallis diving beetle	*Hydroporus corvallis*	-	-
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	-	-
Mulsant's small water strider	*Mesovelia mulsanti*	-	-
true fir pinalitus (bug)	*Pinalitus solivagus*	-	-
Douglas-fir platylygus (bug)	*Platylygus pseudotsugae*	-	-
Alsea ochrotrichian micro caddisfly	*Ochrotrichia alsea*	-	-
Willamette callippe fritillary butterfly	*Speyeria callippe spp.*	-	-
valley silverspot butterfly	*Speyeria zerene bremneri*	-	-
VASCULAR PLANTS			
Kincaid's lupine	*Lupinus sulphureus*	LE	LE
dotted water-flax seed	*Spirodela punctata*	LT	LT
Willamette daisy	*Erigeron decumbens*	PE	LE
three-colored monkeyflower	*Mimulus tricolor*	PT	LT
peacock larkspur	*Delphinium pavonaceum*	SoC	LE
Willamette Valley larkspur	*Delphinium oreganum*	SoC	LE
white-topped aster	*Aster curtus*	SoC	LT
tall bugbane	*Cimicifuga elata*	SoC	C
shaggy horkelia	*Horkelia congesta*	SoC	C
loose-flowered bluegrass	*Poa laxiflora*	SoC	C
Nelson's sidalcea	*Sidalcea nelsoniana*	-	C
whorled marsh-pennywort	*Hydrocotyle verticillata*	-	-
dwarf isopyrum	*Isopyrum stipitatum*	-	-
thin-leaved peavine	*Lathyrus holochlorus*	-	-
small-flowered lipocarpha	*Lipocarpha micrantha*	-	-
Bradshaw's lomatium	*Lomatium bradshawii*	-	-
Howell's montia	*Montia howellii*	-	-
meadow sidalcea	*Sidalcea campestris*	-	-
humped bladderwort	*Utricularia gibba*	-	-
narrow-leaved milkweed	*Asclepias fascicularis**	-	-
dotted water-meal	*Wolffia borealis*	-	-
showy milkweeed	*Asclepias speciosa**	-	-

Table 17 (continued)			
Common name	**Scientific name**	**Fed status**	**State status**
VASCULAR PLANTS			
Wahoo	*Euonymus occidentalis*	-	-
indian rhubarb	*Peltiphyllum peltatum*	-	-
Timwort	*Cicendia quadrangularis*	-	-
Mountain lady-slipper	*Cypripedium montanum*	-	-
adder's tongue	*Ophioglossum pusillum*	-	-
upland yellow violet	*Viola nuttalli praemorsa*	-	-
Columbia water-meal	*Wolffia columbiana*	-	-

LE = Listed Endangered PE = Proposed Endangered C = Candidate Species
LT = Listed Threatened PT = Proposed Threatened SoC = Species of Concern
Additional State Sensitive Rankings: SC = sensitive critical, S V = sensitive vulnerable, SP = sensiteve peripheral, SU = sensitive, undetermined status.
*Corvallis Chapter Native Plant Society of Oregon, Species of Concern

Special Plants and Fungi

There are four lists currently used by the Natural Heritage Council to rank special plants and fungi (Table 18). List 1 consisting of the taxa which are endangered or threatened throughout their range or are presumed extinct. List 2 contains species that are threatened, endangered or possibly extirpated from Oregon, but are stable or more common elsewhere. List 3 is a review list for species that need more information to determine their status. All fungi in the survey are new and are placed on the review list by the Oregon Natural Heritage Program. List 4 contains taxa of concern that are not currently threatened or endangered.

Table 18: Sensitive Special plants and fungi (source: ONHP).				
Lichens	**Mosses**	**Fungi**		**Liverworts**
List 1: *Sulcaria badia*	List 2: *Micromitrium tenerum* *Physcomitrella patens*	List 3: *Otidea leporina* *Phaeocollybia radicata* *Ramaria gracilis* *Rhizopogon brunneiniger* *Rhizopogon exiguus* *Rhizopogon subcinnamomeus* *Rhizopogon subradicatus* *Sarcosoma latahense*	List 3: *Bondarzewia mesenterica* *Elaphomyces decipiens* *Gymnomyces monosporus* *Helvella elastica* *Helvella maculata* *Leptonia occident* *Leucogaster citrinus* *Martellia idahoensis*	List 1: *Sphaerocarpos hians*
List 3: *Bryoria subcana* *Usnea hesperina*	List 3: *Physcomitrium immersum*			

An unlisted, but extremely rare fungus, *Bridgeoporus nobilissimus* was recently located on Marys Peak by an off-work Forest Service employee (S. DiGiacomo, BLM fungi surveys Salem, pers. comm.). This fungus is perhaps both the largest and one of the most rare species in the Pacific Northwest. It is a perennial that associates with old-growth true fir species and can grow to over three feet in diameter.

Biodiversity

Biodiversity indices developed by the Hulse project for the Muddy Creek drainage suggests that overall biodiversity has declined prior to Euro-American settlement. The researchers attribute the decline to a general pattern of land use change and loss of habitat. Given the projected population increases for the Muddy Creek area, which may be extrapolated to other areas of the Marys River Watershed, biodiversity is projected to continue to decline. Stabilization at current levels can only be achieved via a reduction in human population growth or change in land use allocations (Hulse et al. 1997).

Summary

The rapid rate of settlement and modification of the Marys River Watershed landscape has resulted in alteration and loss of both aquatic and terrestrial habitats. Habitat modification and loss, together with direct effects of human populations and competitive pressures from introduced species, has contributed to declines in several species.

Some native fish face pressure from habitat loss and competition from introduced species. Indicators of habitat loss are reductions in in-stream woody debris and the amount of side channel and off-channel habitats, and an increase in fine sediments in pools. Culverts also pose problems to fish passage in the watershed, particularly to cutthroat that live in mainstem rivers and spawn in tributaries. The population of the federally endangered Oregon chub in Gray Creek is stable, but faces threats from introduced warm water fish, such as the western mosquitofish, and loss of habitat. The sandroller and Pacific lamprey may also face similar threats. Listings of winter steelhead and spring chinook salmon in the Upper Willamette may affect the Marys River.

The watershed area in wetlands and riparian zones appears to have declined significantly from historical levels. Most of the losses of wetland and riparian vegetation probably occurred before the 1930s, and resulted from early settlement, establishment of farms, and channelization of streams. Currently, some of the remaining wetlands may be threatened with additional loss through draining and urban development. Detailed assessments of the current extent and condition of riparian forests are needed.

CHAPTER 5: SOIL QUALITY AND LAND HEALTH

Soil quality is important through its influence on hydrology, sediment characteristics, nutrient dynamics, slope stability, vegetative cover and land use. Many inherent soil qualities, such as degree of soil development, soil depth, slope and soil texture, are the result of the soil-forming factors of parent material and relief changed over time by organisms and climate. Other soil qualities are more dynamic and tend to be strongly influenced by land use and management, and these include soil infiltration capacity, soil organic matter, nutrient content and soil tilth. This chapter assesses the relationships of soil qualities, land use and management, and the impacts on watershed health and water quality.

Soil Groups

The multiple soil types of the Marys River Watershed are grouped into 8 broad classes based on soil hazards for erosion, soil wetness and flooding (Map 19 and Appendix 5, Section 2). At 800-1000 feet in elevation(>60 in. precipitation per year), a climatic soil classification break occurs, with udic soils above this elevation and xeric below. The soils that formed in the valley are less leached and have a higher base saturation than the soils of the foothills and mountains. This characteristic is due in part to less rainfall at lower elevations and the length of time that the soils have been exposed to weathering (Knezevich 1975.)

The Benton County Soil Survey (Knezevich 1975) is the original source of spatial information and interpretations about local soils. Benton County digitized these soil survey maps into a Geographic Information System (GIS). Using this information, soil groupings were created for this preliminary assessment of the Marys River Watershed and reflect the capability class of soils for general land uses. Soil coverage for small portions of Polk, Lane and Lincoln Counties not shown on the map are available in the published soil surveys (USDA-SCS 1982, Patching 1987, Shipman 1997) and in digital format from county planning departments.

Loss of Productive Lands to Urban Development

Urban and suburban development has occurred primarily on land that had soils with high potential agricultural productivity. The City of Corvallis sits on Willamette, Woodburn, Concord, Dayton and Amity soils. Philomath has been built mainly upon Amity, Dayton, Willamette, and Witham soils. Increasing development in the foothills is occurring on soils that have high potential for forest productivity. Further analysis is needed to determine the impacts that past development has had on the productive soil base. Soil information should be used to plan for future development in order to protect soils with the highest natural productivity potential for agriculture and forestry uses.

Soil Erosion and Delivery to Streams

Soil erosion is a natural process that often is accelerated by human activities. Accelerated soil erosion on cropland, forest roads, and construction sites is a potential source of sediment pollution to surface waters. Where moderate to severe erosion occurs, the productive capacity and value of land can decrease over time. Sediments can fill natural depressions and drainages, road ditches, and pools in creeks, destroying fish and wildlife habitat and shortens the life of reservoirs and wetlands. Clay-sized sediments eroded from uplands and stream banks may have nutrients and pesticides bound to them and are a major source of non-point pollution. The concentrations of numerous pesticides are positively correlated with the concentration of suspended sediment in runoff in small streams in the Willamette Basin (Anderson et al. 1997)

Historically soils in the Marys River Watershed were covered by lush vegetation year round and experienced low rates of soil erosion. Soil loss rate was probably similar to that measured under established grass crops (0.01-0.11 tons per acre per year). Disturbances such as fire and landslides temporarily denuded vegetation by causing localized erosion. Historians have recorded the practice of burning the valley floor and foothills by the Kalapuyas (see Chapter 2). Frequent, low intensity prairie and savanna fires probably did not cause a large amount of soil erosion. Periodic fires that burned in the Coast Range forests may have been more intensive, leaving soils exposed to severe erosion. Fire history reconstruction for the Oregon Coast Range indicates an average fire interval of about 230 years under the current climate (Long et al. 1998).

Under normal rainfall conditions, soil erosion in the Willamette Valley ranges from slight to severe depending on slope steepness, slope configuration, soil erodibility, and crop management practices (Table 20). Several agricultural practices leave the soil exposed during the winter rainy season and have been implicated in triggering severe soil erosion on sloping land such as Soil Groups B and C (Map 19). The potential for severe soil erosion events on agricultural land in the watershed is documented in the historical accounts from the winters of 1949 (USDA-SCS 1949), 1956 (Torbitt and Sternes 1956), and 1964-1965 (Baum and Keiser 1965). The highest rates of soil loss have been the result of episodic intense rainfall during conditions of low infiltration capacity. During these storms, infiltration was limited by saturation of the soil, snow cover and frozen ground, and sealing of soil surfaces by raindrop impact on unprotected cropland. Practices contributing to high erosion include: fall-plowed cropland not seeded and without sufficient crop residues; fall-conventionally-seeded small grains, legumes, and grasses; and clean-tilled orchards and Christmas tree farms without cover crops (Young et al. 1980; USDA SCS 1949; Bela 1979).

Perennial grass crops provide good soil cover and are conservative of nutrients, with the possible exception of the year of crop establishment. Yet, cropped fields that receive intermittent concentrated flood flows may experience moderate rill erosion even with established grass crops. Some lands that receive flood flows such as Soil Groups D and E (Map 19) are subject to slight or moderate erosion when left bare during winter. Cropping with annual crops such as corn and small grains pose erosion hazards if fields are left bare during winter months. Christmas tree farms require winter cover crops or some other form of crop residue to adequately protect soils. No-tillage planting, cover crops, and grassed waterways are currently underutilized practices that could drastically reduce sediment concentrations in runoff and keep highly erodible cropland in the watershed.

Table 20: Soil loss from field investigations, small watershed studies, Universal Soil Loss Equation, and Cesium-137 records for soils of the Willamette Valley.

Soil loss by land cover type ($T\ ac^{-1}\ yr^{-1}$)		Weather	Study type	Reference
10 30 – 100	Average Fall-seeded and no cover crops	Hard rain on partly frozen and snow covered ground	Field inspection after storm	USDA-SCS (1949)
0.14 14.0	Grass established Fall planted (nearly bare)	Normal winter rainfall (2 yr.)	Small watershed	Simmons (1981)
0.7 - 2.0 1.6 - 4.6 2.9 - 8.6 4.8 - 14.1	Pasture/Hay Orchard (cover crop) Winter wheat fall-seeded up- and-down Row crop up- and-down	Normal weather modeled by USLE	USLE estimates for local conditions	Marion County SWCD (1982)
0.01 - 0.1 0.05 - 0.5	Grass Winter Wheat	Normal winter rainfall (2 yr.)	Standard erosion plots	Istock and Harward (1980)
0.2 - 4.0	Fall-seeded small grains and grass	Normal winter rainfall (2 yr.)	Small watershed	Istock and Lowery (1980)
1 – 12	Combined crops	Long term soil loss rate 1945-1979	Cesium-137 record	Brown and Kling (1980)

Mass Erosion

Accelerated mass wasting from uplands does not appear to be a major source of stream sediment in the watershed. While past forest harvesting and roads may have increased mass erosion rates above historic conditions, current forest practices attempt to minimize mass erosion. Efforts are underway to identify areas of high risk of mass erosion. An example of this is a GIS-based digital terrain model, developed by Siuslaw National Forest, which rates risk of mass erosion based on slope steepness and configuration (K Bennett, USFS, pers. comm.).

A study of an undisturbed Coast Range forest reported an average of 14.5 small slides per kilometer, with 8% of small streams (USFS Class III and IV) impacted by channel scour and deposition (Ketcheson and Froehlich 1978). The majority of the measured slides were on slopes greater than 80%. Concave headwalls with over-thickened colluvial deposits are responsible for a large portion of mass movements in the Coast Range that reach stream channels. Other high-risk landslide areas include steep, deeply incised channels and lower portions of long rectilinear slopes (Ketcheson and Froehlich 1978). Headwall failures are usually associated with high intensity rain falling on saturated soil. These slides deliver coarse material for stream substrate and large woody debris that provide complexity to stream habitat, but can also can adversely affect fish habitat and water quality with excessive fine sediments.

The Benton Foothills Watershed Analysis (BFWA, BLM 1997) identified areas in the Muddy Creek sub-basin with moderate to high slope stability hazard, and areas of “natural instability” associated with slumpy earthflow ground morphology. Areas rated moderate or high are steep slopes associated predominantly with Soil Groups G and H (Map 19). The slumpy earthflow ground is associated with Marty, Apt, Slickrock, and Honeygrove soils less than 25% slope, all in Soil Group F. A small area of approximately 40 acres in the headwater divide between Gleason Creek and Greasy Creek, was identified as having slopes in excess of 90%. This forestland has been removed from the production base (BFWA, BLM 1997).

Discussion of mass erosion in the Benton Foothill Watershed Analysis includes the following: “Historically landslide frequency has been low. Although harvest activities are expected to increase due to the land use allocation (land allocated to timber harvest in the Northwest Forest Plan), significant increases in landslide rates are not expected. Clearcut and road-related landslides have increased the rate of sediment introduction to stream channels. Highest risk of landslides lies along the western margin of the analysis area (Muddy Creek Sub-watershed). The dominant erosion processes are deep-seated slump earth flows and surface soil erosion. Streams cutting in unstable slump earth-flow terrain below Flat Mountain will lead to long term sedimentation. Surface erosion by water and dry raveling is a natural process on hillslopes in excess of 60 %…and is accelerated when… ground cover …are removed. Thinning, regeneration harvest, and spring burning for site preparation leave the majority of the soil surface protected and undisturbed.” (BFWA, BLM 1997).

Controversy persists about the impact of forest harvesting and roads on the frequency and magnitude of landslides. Ketcheson and Froehlich (1978) reported slightly fewer small debris slides in clearcut forest blocks than in undisturbed forest. However the slides in clearcut areas traveled 1.7 times farther and impacted more small streams with channel scour and deposition than slides in undisturbed forest. Swanson et al. (1977) reported a nearly twofold increase in slides following harvesting over all lands and a four-fold increase following harvesting on the most slide-prone ground. An Oregon Department of Forestry (ODF) landslide survey following the severe storms of winter 1995-1996 supports the above findings for stands harvested 0 to 9 years ago, but not for stands aged 10 to 100 years (Dent et al. 1998). The ODF survey was conducted on forestland where state forest practices had been followed. Landslides from these severe storm events were most frequent on very steep slopes (greater than 65%). Most of the sites harvested and reforested from 0 to 9 years experienced increased landslide frequency and mass erosion amounts compared to undisturbed forest sites (>100 years old). However, stands that were harvested and reforested in the past 10 to 30, and 30 to 100 years experienced fewer slides and less mass erosion than the undisturbed older forests over 100 years old (K. Mills, ODF, pers. comm.)

Factors Influencing Soil Erosion

Decreased infiltration capacity of the soil, soil compaction, and the presence of impervious surfaces contribute in various ways to overland flow and subsequent soil erosion. These factors are discussed as they relate to the soil erosion processes of sediment detachment and transport. Though these processes and conditions occur naturally, human activities can increase their impact

Infiltration capacity of a soil is dynamic and decreases with increasing soil moisture content and formation of a seal on the soil surface (Farrel and Larson 1972.) At the end of the summer dry season, the upper soil profile is dry and the soil is often cracked. Infiltration capacity is high under such conditions. However, with the onset of the winter rainy season, soil profiles wet-up and cracks close. By early winter soils often become saturated, and where left bare, the soil surface can develop a seal as a result of raindrops breaking down soil aggregates and repacking the silt particles into a thin skin. Occasionally soils freeze or are covered with snow and this also may lower the infiltration capacity (Lowery et al. 1980.)

Overland flow or runoff begins when precipitation exceeds infiltration capacity of the soil. Where vegetation, forest litter or crop residues protect soils, there is generally little surface runoff. Where soils are bare and surface seals have formed, detached silt and clay soil particles can be carried off in thin sheet flow and in small rills, and the amount of sediment transported in runoff can be large. Runoff also occurs where subsurface water moves downslope over impermeable sub-soil layers and then comes to the surface on lower slopes. This condition occurs extensively in the Willamette Valley and often is expressed in the occurrence of side-hill seeps. Where these lands are farmed and remain bare in the winter, significant erosion can occur. Subsurface drainage such as tiling and ditching has been used to reduce runoff in such conditions, but this can have the side effects of reducing base flow of streams (Lowery et al. 1982). In late winter and spring, infiltration capacity increases again as plants grow, soils drain and surface seals crack. In addition to increasing erosive cutting action, increased runoff and erosion can alter stream flows and increase stream bank erosion.

Soil compaction, puddling, and rutting can be caused by methods and machinery used in forestry and construction also. Such soil disturbances can decrease the soil infiltration capacity and trigger increased runoff and sediment yield. The common forest harvest practice of groundskidding can disturb significant areas of the harvested stands (Froehlich 1984). Johnson and Beschta (1980) report that new skid trails have about 50% lower infiltration capacity than undisturbed forest soils for soils of the Coast Range. Urban development in Philomath and Corvallis may cause severe soil compaction and increase runoff. Planting grass on construction sites during winter protects bare soil from splash erosion. Precautions such as seeding with grass and then mulching the bare ground or hydro-seeding can significantly reduce soil losses from construction sites. Fabric fencing (silt fence) and straw bales can help slow runoff and trap sediments.

Ditch clearing may have positive and negative effects on watershed condition. Routine ditch clearing can trigger significant erosion in the ditch and increase sediment delivery to streams. However, periodic road ditch clearing by excavators is needed to keep ditches and culverts functional. During ditch clearing protective vegetation is removed with accumulated sediment and there is the potential to undercut stable cutslopes and initiate bank sloughing. Bare ditch bottoms with loosened soil are susceptible to erosive cutting and can yield significant amounts of sediment until stabilized or vegetation reestablishes. Complimentary practices such as relief culverts, rock checks and channel liners need to be used with ditch cleaning in places where ditches erode. Soil conservation in agriculture and best management practices in forestland are preventive measures that serve to reduce the frequency of ditch cleanings because they reduce the amount of sediment that is transported to road ditches.

Impervious surfaces include roofs, driveways, parking lots and rock quarries convert precipitation directly into surface runoff and short-circuit natural hydrologic storage that moderates flows. Rainwater is shunted from infiltration and soil storage, and base flow declines because water is hurried out of the watershed as runoff (Ferguson 1994). Stream erosion and elevated sediment levels can follow the increased flows. Benefits of baseflow such as instream flows and aquifer recharge can decline in urbanizing sub-basins as the area of impervious surface increases. A study in the Puget Sound watershed (Appendix 3, Figure 5) has demonstrated negative relationship between habitat quality and the percent of impervious surfaces in a given watershed (May et al. 1997). Streams with significant urban growth in their watershed, such as Newton and Oak creeks, may be negatively impacted by decreased infiltration and dramatically increased runoff.

Streambank Erosion

Active streambank erosion in the watershed is evident in many streams where bank vegetation is denuded. High flows saturate soils and undercut the toes of banks, then unprotected stream banks slough or cave in large slabs, delivering nutrient-rich soil directly into the stream. Productive streamside land is lost as a result. Quantitative information on the amount of sediment eroded from stream banks is insufficient to make an accurate assessment of the problem. A visual survey conducted statewide in 1971 revealed that the banks of Marys River, Greasy Creek and Beaver Creek were moderately eroded (State Soil and Water Conservation Commission 1971). The amount of sediment delivered to streams from eroding banks was not reported in that study.

A recent qualitative assessment of bank erosion potential was made for Muddy Creek drainage basin in 1996 (BFWA, BLM 1997). The findings included:

- Reaches in forested uplands have low potential for bank erosion, primarily because they have cascading morphology, large cobble and boulder substrate, and resistant banks with little or no floodplain.
- Moderate bank erosion occurs in “response type channels” in forested uplands. These are incised and moderately unstable, and channels are disconnected from their floodplains.

- "Transition channels," from the forested uplands to Muddy Creek, have moderate to high bank erosion potential. Many of these channels are deeply incised into alluvial materials and severe active bank erosion was observed at several locations.
- Transition channels that have protective bank vegetation had more channel downcutting than widening, and likely only have active bank failure during high flow events.
- Muddy Creek has high bank erosion potential, but is currently stable because there is adequate riparian vegetation and low stream energy.

While current forest practices require riparian buffers, there are no similar rules for riparian buffers associated with pastures, cropland and urban land. Land use practices that can accelerate streambank erosion include:

- Livestock grazing on banks and in creeks
- Clean tilling or mowing to the edge of a channel
- Streamside recreation
- Land uses in the watershed that decrease the infiltration capacity of the land and storage of runoff, including increasing the amount of impervious surfaces

Sediment Sources and Delivery

Little information is available that relates upslope soil loss or streambank erosion amounts to sediment delivery to the Marys River and its tributaries. Andrus (unpublished report 1995) estimated the suspended sediment yield of the Marys River based on measured sediment concentrations and flow for the years 1942-1951 (Table 21). Approximately 90% of the total sediment load occurred during the highest flows (>1000 cfs). Compared to the sediment loads of other streams in the upper Willamette Basin, the Marys River sediment loads were not high. In another study, more than 80% of the soil eroded in a large storm in the Willamette Valley in 1949 was estimated to have been delivered to streams and/or out to sea (USDA-SCS 1949.)

Table 21. Sediment yield data reported for the Marys River near Philomath for flows from 1942 to1951 (Andrus 1995).

Drainage area (mi^2)	Mean Flow (cfs)	Suspended Sediment ($T\ yr^{-1}$)	Suspended Sediment ($T\ mi^{-2}\ yr^{-1}$)
159	475	22500	142

Sediment and nutrient yield data are available for a storm in January 1996 for several creeks in the Muddy Creek sub-basin (Appendix 3 Figures 7-9; Eilers and Vache 1996). These storm data provide evidence that Muddy Creek is storing some sediment in the floodplain. Muddy Creek went over its banks during the February 1996 flood, but data regarding flow are not available. Phosphorus concentrations were closely related to total suspended solids (TSS) for all creeks. Nitrate increased only slightly for some streams and slightly decreased for Muddy Creek during the storm. Peak TSS concentrations were 155.6 mg per liter for Beaver Creek and 193.1 mg per liter for Oliver Creek. Muddy Creek TSS increased little during the storm.

Fertilizers and Pesticides

Fertilizer and pesticides are widely used on farms, forest plantations, residential lawns, golf courses, and highway rights-of-way. Nutrients can enter surface water attached to sediment or dissolved in runoff and also dissolved in subsurface flow. Grass seed crops in western Oregon receive between 125 and 256 lbs. of nitrogen per acre per year (Horneck and Hart 1988). Young et al. (1999) estimated that the amount of nitrogen applied annually to grass seed fields could be reduced by an average of 30% and growers could still optimize crop and economic returns. A major research project is underway to determine long term impacts of grass seed production on water quality (Griffith et al. 1997, Horwath et al. 1998). Work has focused on poorly drained soils such as Group E (Map 19), which are well suited to perennial ryegrass crops and they have substantial subsurface flow above clayey subsoil. Between crop uptake and denitrification in the poorly drained riparian soils shallow-groundwater NO_3-N is reduced to low levels, even when fertilized at nitrates reaching 170 lbs. of nitrogen per acre per year. In another study, Young et al. (1999) found that using nitrogen fertilizers at recommended rates (90 to 100 lbs. of nitrogen per acre) would result in a low potential for leaching of NO_3-N on fine-textured soils where grass seed crops are grown. A wide variety of pesticides are used in the Willamette Valley; Anderson et al. (1997) provide a synopsis of those pesticides used on various crops.

Because there have been few measurements of nutrient losses from uplands and the subsequent concentrations in surface water, nutrient and chemical transport and their impacts on water quality are not adequately known for the watershed.
Nitrate concentrations in runoff and shallow wells frequently exceeded 10 mg per liter from three of six agricultural watersheds in the southern Willamette Valley (Simmons 1981). Nitrate losses are highest when runoff events occur shortly after fertilizer applications, and even then amount to less than 4% of total applied fertilizer. Simmons (1981) reported total phosphorus (TP) losses of 0.36 to 20.9 kg per hectare, and dissolved inorganic phosphorus runoff concentrations 0.1 to 5.1 mg per liter.

Pesticide applications are poorly tracked, but pesticide transport and impact in the watershed are beginning to be scrutinized. Anderson et al. (1997) collected data to characterize the distribution of dissolved pesticide concentrations in small streams throughout the Willamette Basin. They reported that a total of 36 pesticides were detected, with five herbicides including Atrazine and diuron detected frequently. Pesticide concentrations for all those tested were usually less than 1.0 ug per liter, however an unusually high number of concentrations were in the range 1-90 ug per liter. One problem in interpreting these data is that aquatic life toxicity criteria have only been established for three of the detected chemicals. Anderson et al. (1997) published several tables on pesticide properties and commonly applied rates for the Willamette Valley.

Significant correlations exist between land use and pesticide detections in surface water of the Willamette Valley (Anderson et al. 1997). The amount of forested land in a watershed was negatively associated with pesticide occurrence. In predominantly agricultural watersheds, the instream concentrations of a few pesticides that were applied to a wide variety of crops were significantly correlated with estimates of the amount used.

A pilot study measured herbicide movement in runoff and in shallow subsurface flow to streams from grass seed fields in poorly drained Dayton silt loam soils. The application rates for the herbicide diuron varied from 1.8 lb active ingredient (a.i.) per acre for perennial ryegrass seed crops up to 10 lb a.i. per acre for treatment of rights-of-way and field borders. Diuron was detected at instream concentrations of 1 to 12 ug L^{-1}, suggesting that no environmentally significant residues of diuron are likely in aquatic systems next to grass seed fields, though further research is needed (Jenkins et al. 1994). Yet, concentrations of diuron as high as 5-10 mg per liter (a thousand-fold higher concentration than the ug per liter levels discussed earlier) were measured in very small ponded areas in the Willamette Valley where the herbicide had drained following application that could have potentially adverse effects on aquatic species (Schuytema and Nebeker 1998.) Such relationships require further study.

Forest Roads

Roads can increase surface erosion, mass wasting, and stream sedimentation. Road density (miles per square mile) has been used as a meter to compare the potential impacts of roads on different watersheds. One problem with interpreting road density information is that usually more information is needed about road conditions, size, traffic and road location in the landscape in order to make an evaluation of road impacts on the watershed. This additional information is often more difficult to obtain and to interpret. Examples of compiled road density information are shown in Figure 14 and Table 22. Only ODF and BLM partitioned the data by road type and by ownership. Of the 4.3 miles per square mile road density reported on state lands in three townships in the northwest part of the watershed, 84% of the roads were rock roads; 14% were dirt roads that were closed; and 2% were paved roads maintained by the county or ODOT (Nall, ODF GIS road data, 1995).

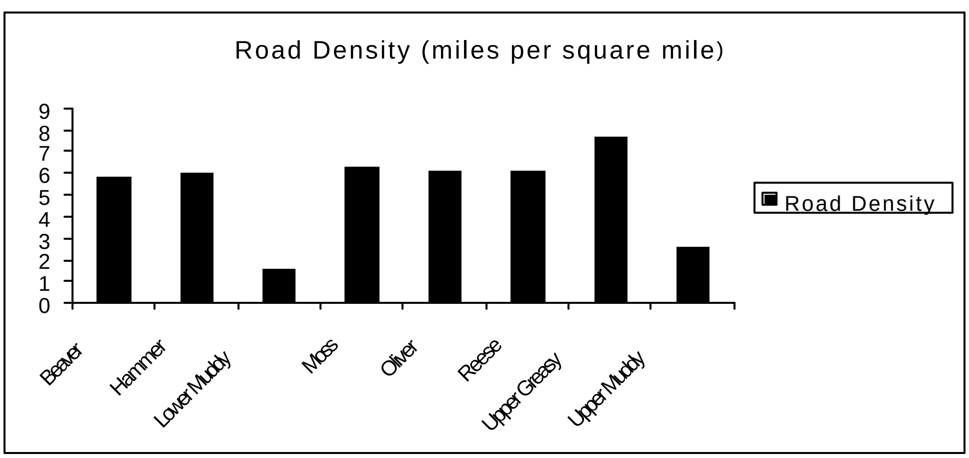


Figure 13: Road density in miles per square mile (Benton Foothills Watershed Analysis, BLM 1997).

Road densities on all forested lands in the Benton Foothills Watershed Area (Muddy Creek sub-basin and part of the Greasy Creek sub-basin) range from 2 to 8 miles of road per square mile of land (Figure 13). Seventy percent of these roads are in the four sub-basins that have the greatest concentration of timber management (Beaver, Hammer, Oliver and Reese creeks). In the Beaver Creek sub-basin, 13% of the road length is located in riparian areas. The average road density on BLM lands in this area is 3.5 miles mile^{-2}. Several private timber companies have road inventories that can be used to calculate road densities, or aerial photograph interpretation can be used to locate roads.

Table 22. Comparative road densities for the Willamette Basin and Marys River Watershed.

Area	Road Description	Road Density (miles / sq. mile)
Willamette Basin*	All roads	3.8
Willamette Basin*	BLM roads	3.7
Willamette Basin*	USFS roads	4.8
Marys River Watershed*	All roads	3.2
Muddy Creek drainage basin (Benton Foothills) **	All forest roads	2 to 8
Muddy Creek drainage basin (Benton Foothills) **	BLM roads	3.5
ODF Data (3 townships in Marys River Watershed) ***	All roads (mixed forest and agricultural land)	6.1
ODF Data (3 townships in Marys River Watershed) ***	State Forest Lands	4.3

* Willamette River Basin, A Planning Atlas, Version 1.0 (Hulse et al, 1998).
** BLM (1997).
***R. Nall, pers. comm., ODF-GIS data, 1995 roads data.

Road inspections are a critical part of road management that can identify potential problems such as plugged culverts, rutting and sedimentation. Williams et al. (1994) identified cutslopes as a primary source of sediments from forest roads in the Oak Creek drainage basin. Regardless of public or private ownership, most land managers with large forest holdings conduct road inspections and inventories. Starker Forests Inc. has completed inspection of 240 miles of road in the Marys River Watershed. Inspections included noting the condition of roadbeds, culverts, bridges, water bars, ditches, cut banks and fill slopes. Corrective action is taken where necessary. Most of the road-related problems are prevented by regular maintenance of road surfaces, ditches and culverts. A number of dirt roads are “put to bed” by blocking traffic with berms and pits, and by dispersing road drainage water away from streams (G. Blanchard, Starker Forests Inc., pers. comm.). In Oregon, the timber industry has made a commitment to remove or rehabilitate high hazard roads as part of the agreement for the Oregon Plan for Salmon and Watersheds.

Road construction has historically been one of the greatest contributors to "cumulative effects to hydrologic processes on forested uplands" (BFWA, BLM 1997). Proper designs now include locating roads away from streams and erosive sites and planning to minimize the extent, width, and period of use. Guidelines are available to help locate roads and landings in relation to streams (ODF 1994; Trimble and Sartz 1957). Once constructed, roads must also be properly operated and maintained. Recommendations for reducing road impacts include managing wet weather traffic, decommissioning certain roads, minimizing disruption of natural drainages, upgrading culverts, placing rock on unsurfaced roads, and maintaining ditches and culverts (BLM 1997).

Still, current information remains inadequate to fully address the issue of roads and their impacts on water quality. Updated information from comprehensive road inventory conducted last year on state lands, will be available in 1999 and will be integrated into ODF's GIS (R. Nall, pers. comm.). Road information is available from Siuslaw National Forest in their GIS "road coverage" (K. Bennett, USFS, pers. comm.). Roads in agricultural and urban areas can have potential impacts on water quality also, especially in lowland streams. Further assessment of roads in the watershed is needed.

Livestock

Livestock issues include management of confined animal feeding operations (CAFOs) and livestock grazing in the riparian zones of streams. About ten CAFOs are permitted in the watershed or in nearby Benton county (Corvallis and Monroe addresses) by the Oregon Department of Agriculture (ODA, Chuck Harmon, pers. comm.). The exact locations of these CAFOs are available in a GIS coverage. Of these, two are swine operations with around 200 animals each and one is a 300-head beef operation, and seven are dairies with 125 to 975 animals. Three of the dairies have more than 400 animals. Water-quality parameters directly impacted by livestock include fecal coliform levels, nutrients, habitat modification, sedimentation, and water temperatures. Grazing and livestock access can deteriorate streambank vegetation and increase bank failures. Overgrazed pastures are potential sediment source areas.

The Natural Resources Conservation Service (NRCS) has been working with dairy operators to improve manure and liquid wastewater separation and storage on the large dairies (Jim Hecker, NRCS, pers. comm.). The largest dairy has, over the last 15 years, installed separators and tanks, wastewater holding ponds and now uses covered manure piles, recycled water and an automatic barn cleaning system. Other dairies have not been as progressive and many lack sufficient winter manure and liquid storage capacity. Winter application of manure and wastewater can increase the likelihood of nutrient and bacterial contamination of surface water.

The Oregon State University dairy barns and other livestock facilities do not have a modernized manure handling and separation system in place. The OSU's Oak Creek Initiative is an active initiative recently underway to improve the stream and riparian conditions of the agricultural reach of Oak Creek. Early plans include constructing wetlands to mitigate high nutrient runoff from the beef unit, and addressing ways to minimize contact of rainwater with winter stockpiles of manure. Innovative methods for managing manure that can be cost shared include composting, covered anaerobic lagoons, manure transfer pipelines, and implementing prescribed grazing.

Livestock can have significant impacts on riparian zones. Excluding animals from these areas with fencing and providing off-stream watering helps to alleviated impacts. The adoption of such practices is in a threshold stage in Benton County, and a target goal is three-pasture management demonstration projects in the area to promote these practices (Jim Hecker, NRCS pers. comm.) Such practices as manure management, filter strips and riparian planting are available to be cost shared up to 75% (USDA-EQIP Program).

Government Programs to Aid Watershed Management

A directory of government programs related to watershed health and water quality would serve a useful purpose for the citizens in the Marys River Watershed and the State of Oregon. One often repeated frustration of people involved in watershed councils and other natural resource management activities is that government programs, rules and regulations are not well integrated or tend to be overly complex. As more people get involved with watersheds and other resource management issues, there is an increasing need for guidance and information about such programs.

Several of brochures and fact sheets are available through the Benton Soil and Water Conservation District and the National Resources Conservation Service among and others. But it seems that none are very complete. A need has been identified to assemble information on all the government programs concerned with water quality and to watershed health, including those that can be cost shared. In addition, public access to government regulations would be greatly improved if pertinent information were assembled in one directory that was made widely available. A future project could be to assemble such an information directory or to advocate for such a project. This project may be best accomplished by first making a statewide template and then by customizing the directory for basins or watersheds.

Summary

Combined upland practices have had varied effects on soils and streams. Although detailed information is limited, soil erosion appears to be elevated in some areas of the watershed as a result of poor soil management practices and roads. Road density is relatively high in some portions of the basin, but interpretations about impacts to streams is problematic without a more detailed survey about conditions, traffic and locations. Accelerated mass wasting from uplands does not appear to be a major source of stream sediment in the watershed and the Marys River is thought to be transporting average sediment loads compared to other tributaries of the Willamette River. Productive soils have been lost to urban and residential development and impervious surfaces convert precipitation directly into surface runoff and short-circuit natural hydrologic storage. Preliminary information on the use of a variety of fertilizers and pesticides by various landowners suggests further study is merited. Some problems exist with livestock; most problems can be addressed through good management practices.

CHAPTER 6: SOCIOCONOMICS

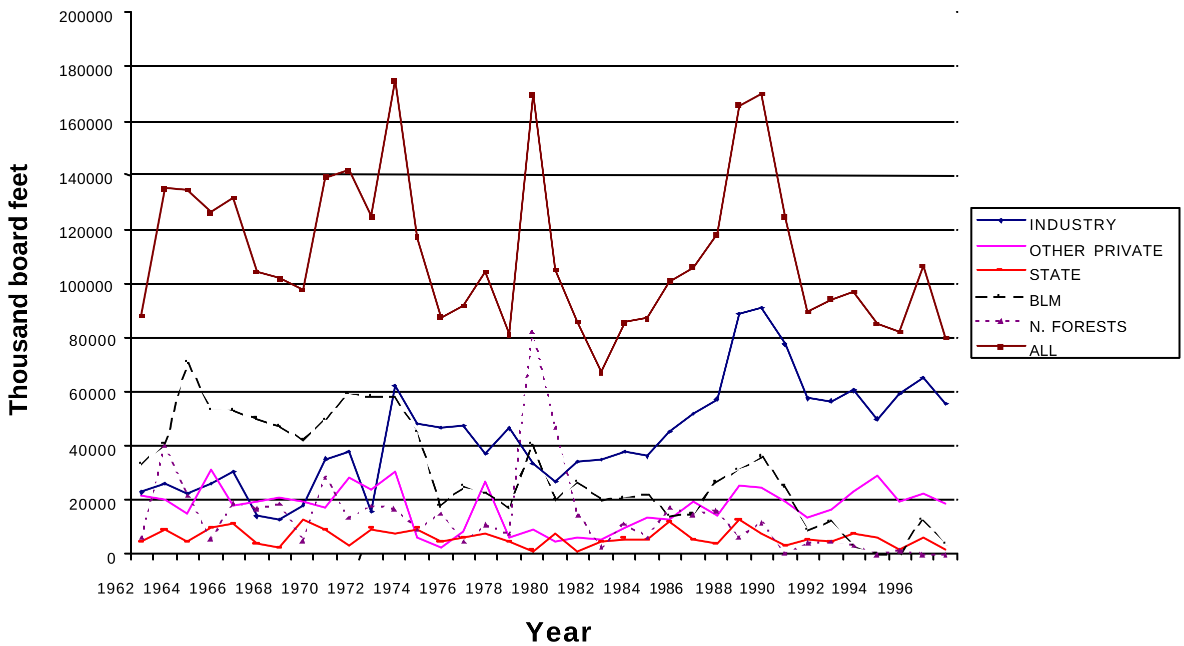
The majority of economic data available from state and federal agencies is aggregated at the county level. The assumption used in the analysis is that the trends for Benton County reflect trends for the Marys River watershed. While 95% of the Marys River Watershed is in Benton County, only 43% of Benton County is occupied by the watershed (Map 7). Judging by the location of the watershed in the county, the mix of land uses within the watershed should be similar to the mix of land uses throughout the county. The exact percentage of each land use within the county that occurs within the watershed could be calculated with additional time and GIS data layers, a project that the Marys River Watershed Council may consider in the future.

The land use of the Marys River Watershed is primarily agriculture and forestry (Map 2). Land ownership within the watershed is dominated by private farms and forests (Map 3), although there are some Forest Service, State, and BLM lands in the western part of the watershed, as well as the William L. Finley National Wildlife Refuge on the southeastern edge of the watershed. Other public ownerships include Oregon State University's MacDonald Forest, the City of Corvallis' Watershed, and city and county parks. Private ownership is a mix of farms, industrial and non-industrial private forests, and rural and suburban residential areas.

Economic Characteristics

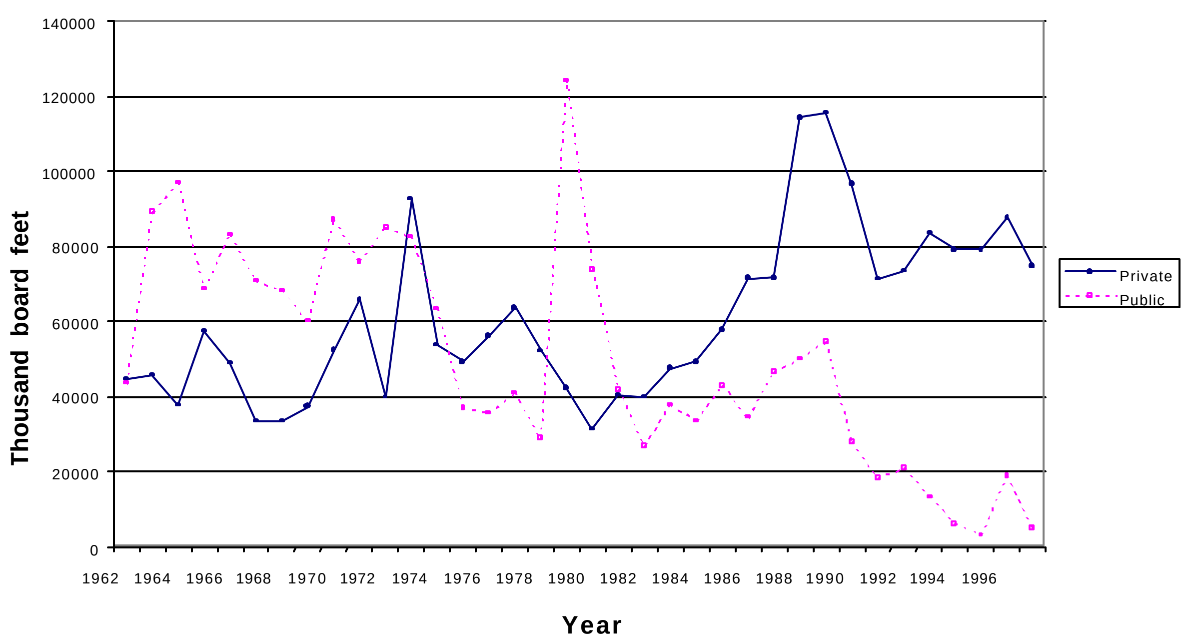
The forested lands of Benton County have provided a widely fluctuating timber harvest over time (Figure 14). The harvests in 1962 and 1997 were almost the same (about 80 million board feet (MMBF)), while the peak harvest was in 1973 (175 MMBF) and the low harvest was in 1982 (67 MMBF). The harvest levels since 1991 have been below the overall average level of 111 MMBF from 1962 to 1997.

Figure 14: Benton County Timber Harvest by Landowner



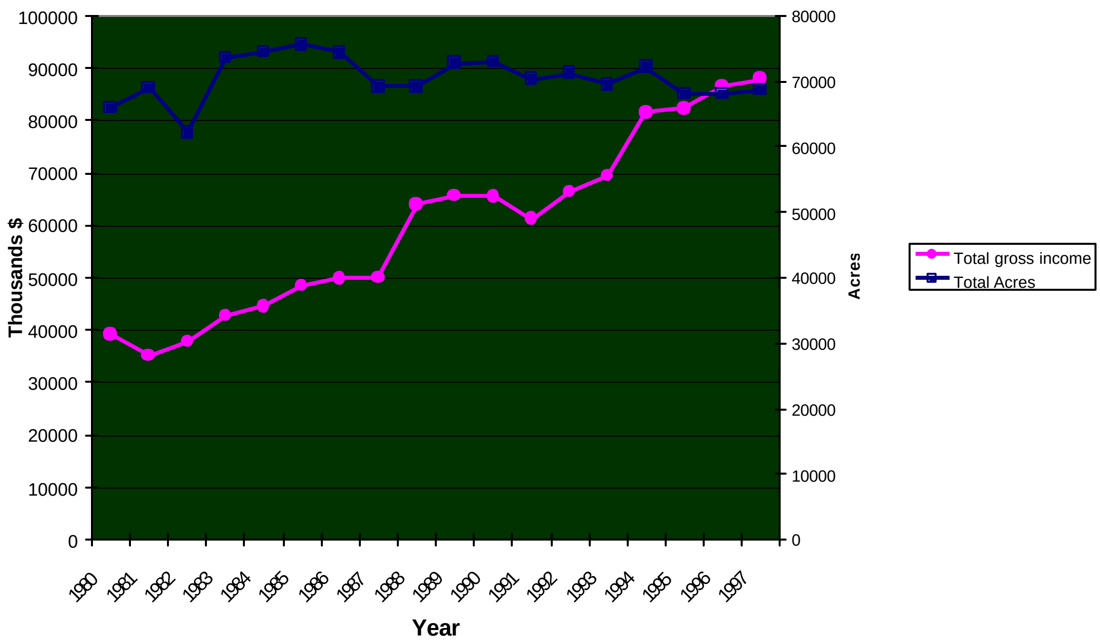
The harvest levels of different ownership types have changed over time. Forest industry harvests have risen significantly in the County, while all other ownerships have either declined or remained steady. A comparison of public and private timber harvests over time shows that public harvests provided the majority of timber in the past, but now private harvests provide almost all of the timber supply in Benton County (Figure 15).

Figure 15: Benton County Timber Harvests on Public and Private Lands



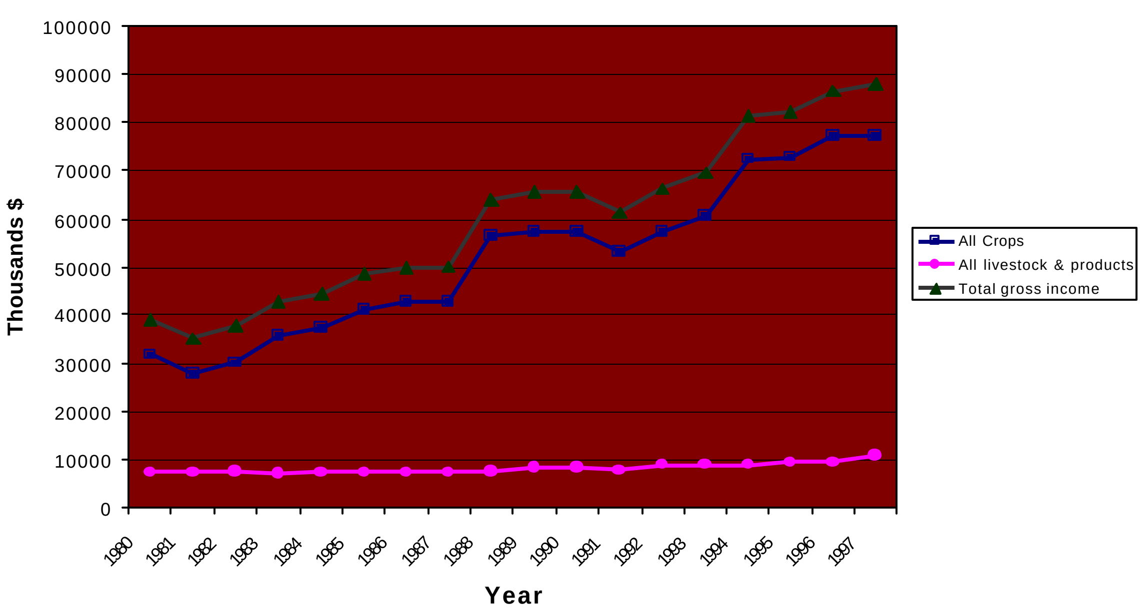
The other major component of the rural economy is agriculture. Total gross income from farm sales has increased steadily from 1980 to 1997, while the number of harvested acres has remained fairly steady (Figure 16). Part of the

Figure 16: Benton County Farm Sales and Harvested Acres



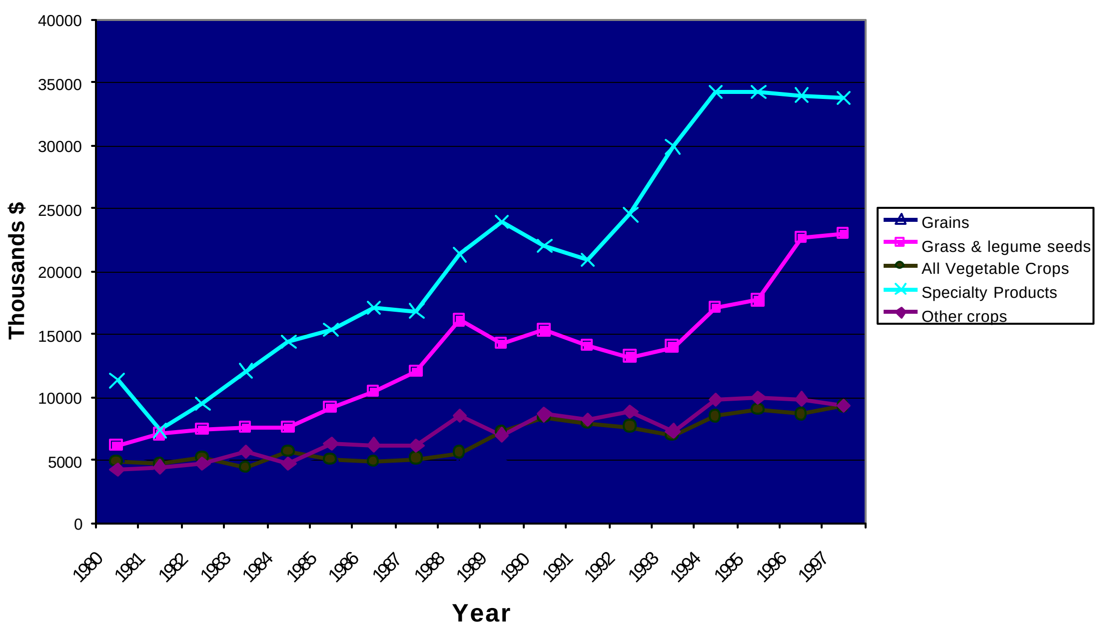
growth in income over time is due to inflation, but part is due to a shift to more valuable crops. Sales of livestock and products have increased only slightly over time, while the large increase in total farm sales has been driven almost completely by an increase in crop sales (Figure 17). Crops now make up 88% of all county farm sales.

Figure 17: Benton County Gross Farm Sales



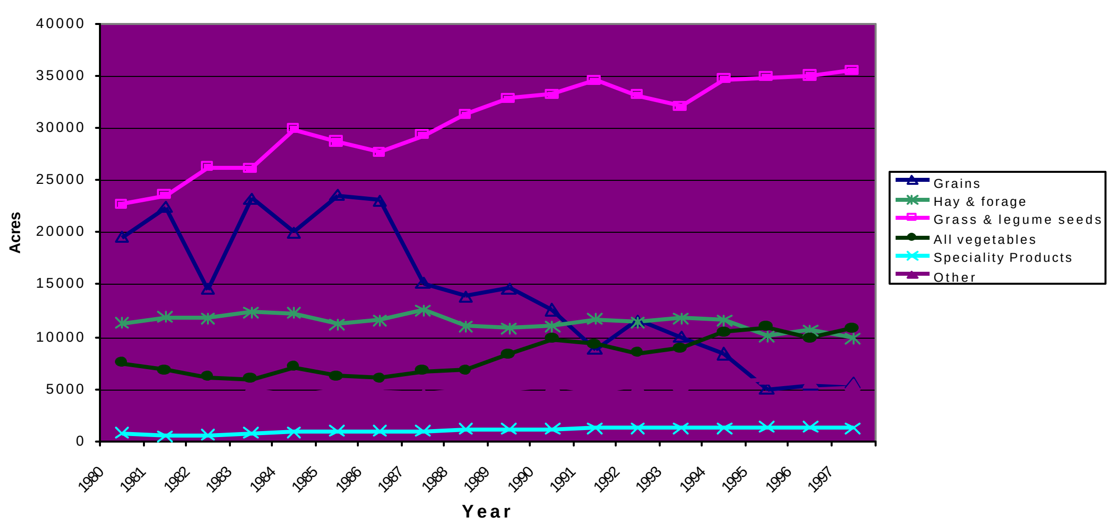
In the past, crop sales were evenly distributed among product types. However in recent years specialty products and grass and legume seeds have become increasingly important to crop sales (Figure 18). Specialty products now make up 44% of all crop sales, while grass and legume seeds comprise 30%. In Benton County, Christmas trees make up 50% of specialty products. Despite the growth in sales of specialty products, the harvested acreage of these products has risen only slightly over time, and has the smallest amount of acreage in production (Figure 19).

Figure 18: Benton County Gross Farm Sales: Crops



The greatest amount of acreage is in grass and legume seeds, and the share of total acreage devoted to those crops has risen from 34% in 1980 to 52% in 1997. Acreage devoted to grains has dropped significantly over this time period.

Figure 19: Benton County Harvested Acreage



While forestry and agriculture clearly dominate the rural parts of Benton County and the Marys River Watershed, they are much less important in the overall County economy. Most employment in Benton County is in the services, government (including local, state, and federal), manufacturing (other than lumber and wood products), and trade sectors (Figure 20). Lumber and wood products is the only major sector to see declining employment levels from 1975 to 1995.

Figure 20: Benton County Employment

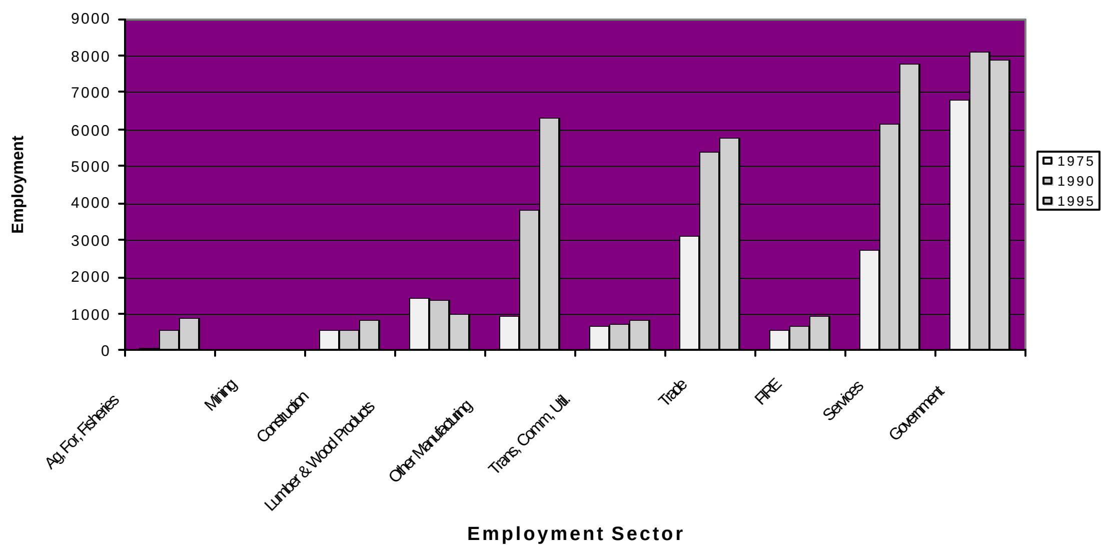
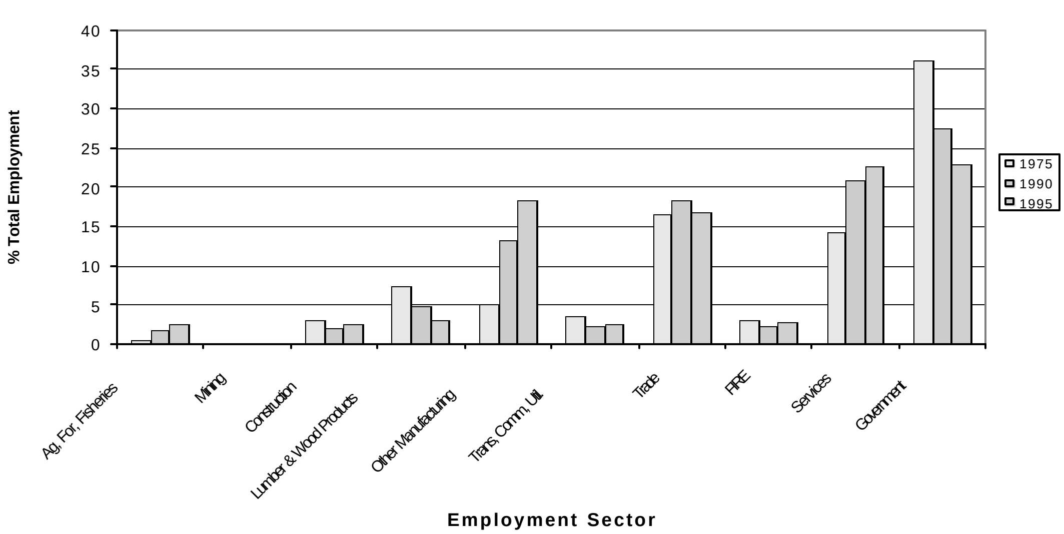


Figure 21 shows employment in each sector for 1975, 1990, and 1995. Services and other manufacturing have enjoyed the largest gains over time, while most other industries have been declining or holding steady. Employment in agriculture, forestry, and fisheries (this includes the growing and harvest of trees, but not the processing) has also increased, although it remains at only 2.6% of total employment.

Figure 21: Share of Benton County Employment



In terms of payroll, the changes over time are even more dramatic (Figure 22). Payroll in other manufacturing has skyrocketed, due to the growth in the high tech industry in the county. Services and government payroll have also increased significantly, while lumber and wood products is the only sector to decrease between 1990 and 1995. Payroll in each sector as a percent of total county payroll shows that other manufacturing now makes up over 30%, while government makes up an additional 27% (Figure 23). Lumber and wood products, a traditionally high-paying industry, previously comprised over 10% of Benton County payroll, but now accounts for only 3.2%.

Figure 22: Benton County Payroll

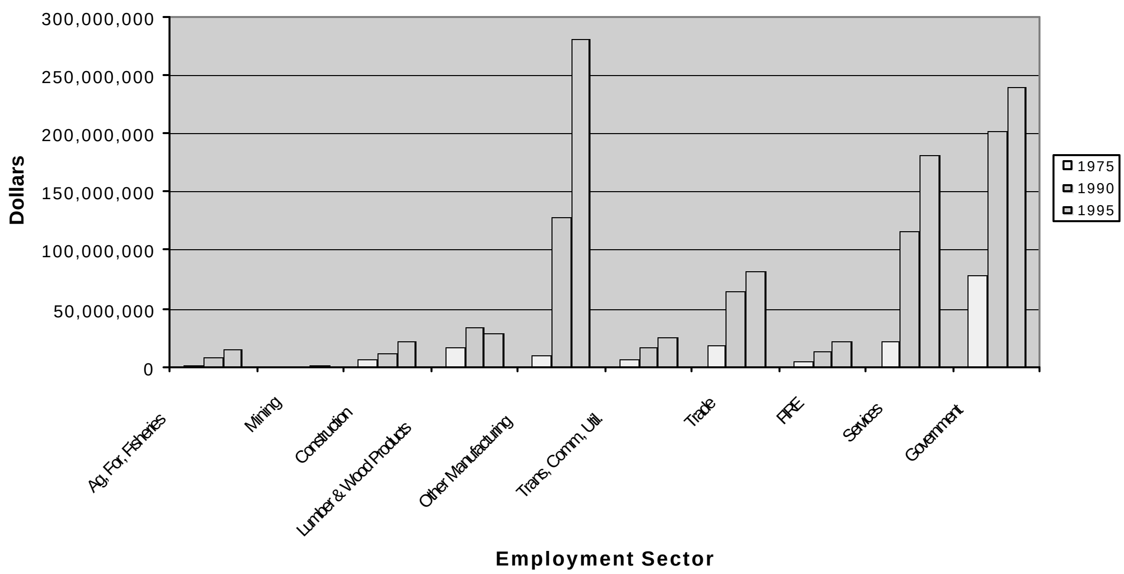
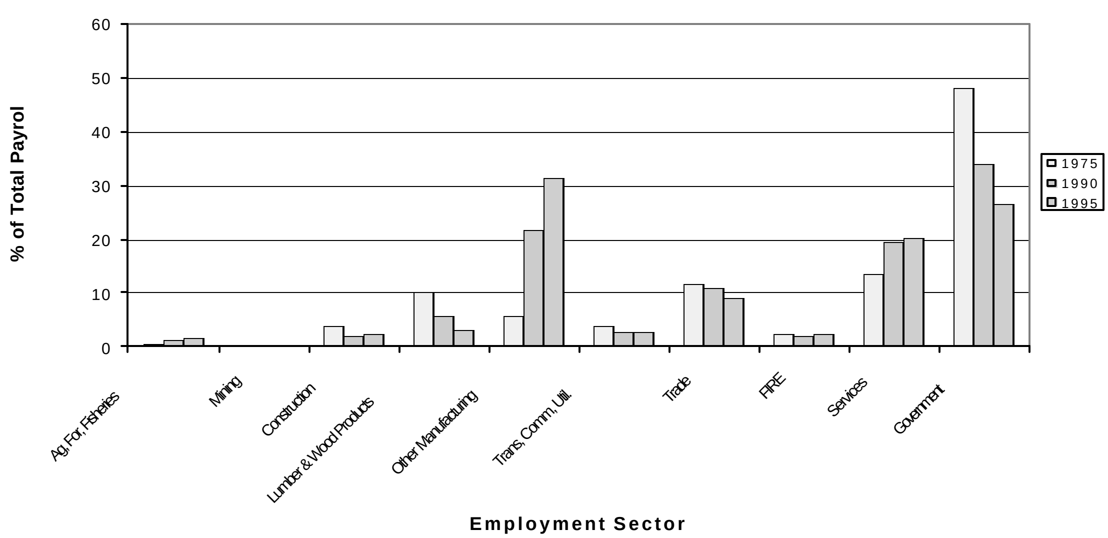
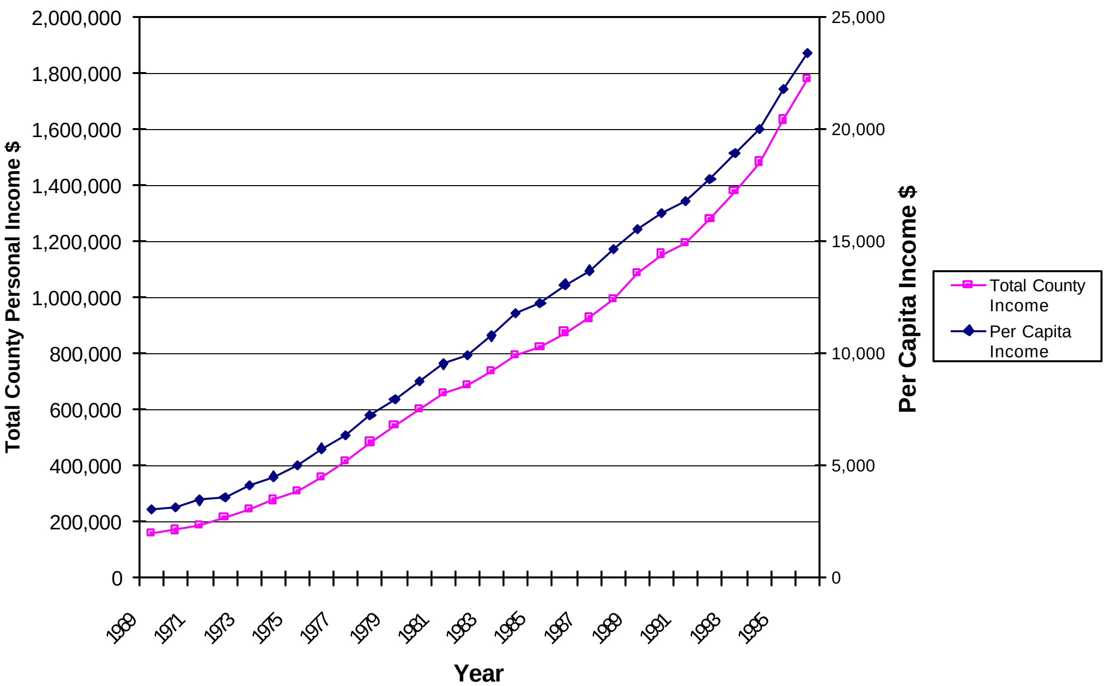


Figure 23: Share of Benton County Payroll



Consistent with the growth in payroll, total county personal income has risen dramatically over the last 30 years (Figure 23). Per capita income in the county shows the same trend, despite the steady population growth over this time period (U.S. Dept. of Commerce, Bureau of Economic Analysis 1998). In nominal dollars (not adjusted for inflation), per capita income has risen by an average of 6.3% per year since 1990. Because inflation rates have been around 3% over this time period, Benton County residents' real earning power has increased significantly. Benton County ranked fourth in the state in per capita income, trailing only the three Portland metropolitan counties.

Figure 24:Total Personal and Per Capita Income



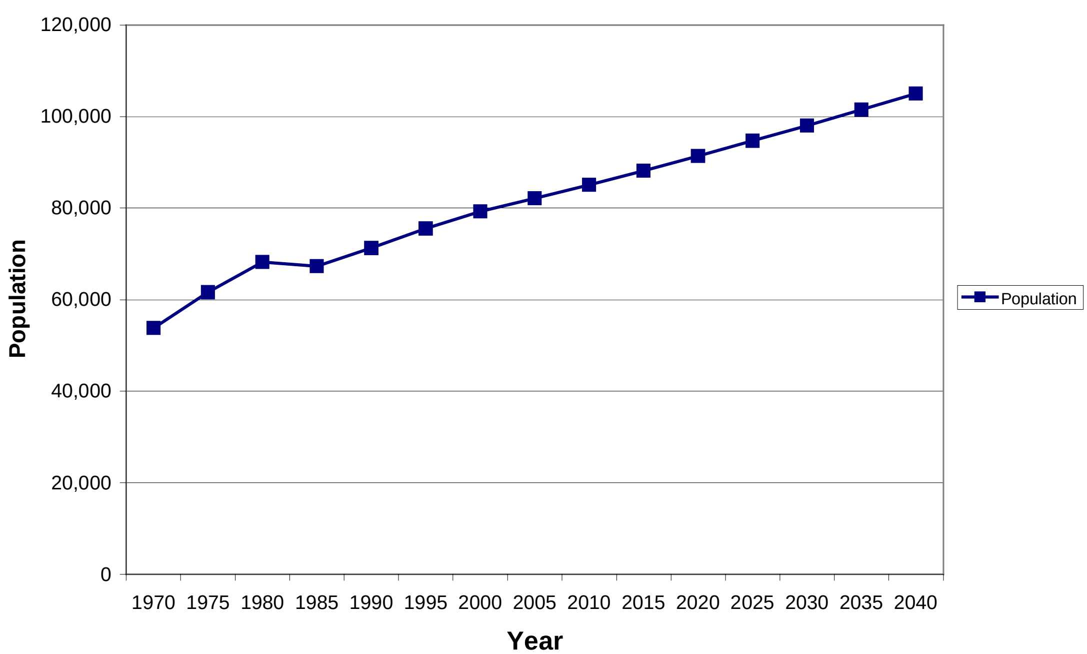
This description of Benton County's economy makes it clear that most of the employment and payroll growth is occurring in the urbanized parts of the County. If this trend continues, the implication for the Marys River Watershed is that residents of the watershed will be increasingly employed in Corvallis. Long-time watershed residents may begin seeking employment in the high growth industries in Corvallis, and employees of Corvallis industries may move into rural areas of the watersheds.

Population Growth and Development Pressures

Population estimates and projections are available at the county and city level, but can only be made for the Marys River watershed from U.S. Census figures every 10 years. Data from the 1990 census are now quite dated. The Marys River Watershed Council will have much more timely data available after the 2000 census, and will probably want to update this analysis.

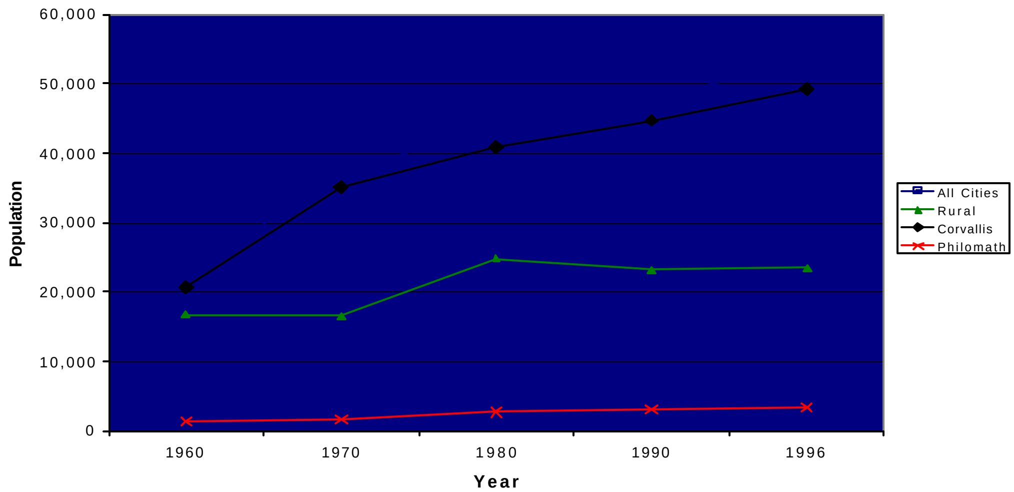
Benton County population increased rapidly in the 1970's, declined during the recession of the early 80's, and has climbed steadily since (Figure 25). State demographers expect Benton County population to continue to increase at a moderate pace through 2040 (Office of Economic Analysis, 1997; see web site in Appendix 1). However, recent estimates by the Portland State University's (PSU) Center for Population Research and Census (1999; see web site in Appendix 1) show that Benton County population decreased by 100 people between 1997 and 1998. Most of the population loss occurred in Corvallis, where the population dropped from 51,145 in 1997 to 49,630 in 1998. At the same time, Philomath's population increased from 3,380 to 3,770. These estimates should be viewed with caution, however, since they are not based on a census.

Figure 25: Benton County Population Projection



Benton County population growth from 1960 to 1996 was concentrated in the cities (Figure 26). While rural areas experienced rapid growth in the 1970's, their population declined through 1990 and has only risen slightly in subsequent years. Rural population currently makes up about 30% of total county population. If the recent estimates by PSU are accurate, a shift in growth away from Corvallis toward the rural areas of Benton County may occur, which would have implications for land development in the watershed.

Figure 26: Benton County Population: Rural and Cities



The census data from 1990 can be used to describe the rural Benton County population in detail. An analysis that would coincide with the boundaries of the Marys River Watershed would require more time and resources, but the area covered by the Philomath zip code (97379) will be used as an example. In 1989, there were 6,693 people living in this area, comprised of 2,526 households. There were 2,552 housing units in this area, of which 44% relied on individual wells for their water source. Fifty-five percent of housing units had a septic tank or cesspool, and the remainder were on public sewer systems.

Of employed persons in the Philomath area who are 16 years of age and older, the highest percentage (22%) was employed in durable goods manufacturing. Unfortunately, there is no way to know if these people are employed in rural manufacturing such as lumber and wood products, or other manufacturing such as high tech in Corvallis. Fifteen percent of workers were employed in retail trade, and 14% in educational services. Only 6% were employed in the agriculture, forestry, and fisheries sector. Forty-seven percent of workers spent 20 or more minutes traveling to work, which is probably an indicator of the number living in this area but working in Corvallis or other urban areas.

While census data can be used to show the population density in 1989, more time and resources would be needed to show how that density has changed over time. The

1989 population information shows that the densest concentrations of humans immediately surround the cities within the watershed, along with patches of development in the Oak Creek area northwest of Corvallis, and Marys River Estates, northwest of Philomath.

Other studies have looked more closely at development pressures within parts of the watershed. In a lands need study for the City of Corvallis, ECONorthwest (1998) cited the growth in population and employment that were creating a demand for housing. Between 1990 and 1996, the City of Corvallis annexed a total of about 300 acres of land, an average of about 50 acres per year. The city approved 2,629 residential building permits between 1990 and 1996 (92% of permits issued resulted in units on the ground). By 2020, the report estimates the housing and land need within the Corvallis urban growth boundary will be 2,750 single family units and 1,250 multiple family units, for a total of 4,000 new units.

While most of the residential growth associated with employment growth in Corvallis will remain within the Corvallis urban growth boundary, there will be an increasing demand for rural residential development as well. The ECONorthwest report noted that in the 1980’s and 1990’s, there has been a growing demand for large new homes on large lots, but the supply of buildable land is decreasing (at least temporarily). Thus, even though the study concludes that the City of Corvallis has enough vacant buildable land inside its urban growth boundary to accommodate expected growth, there will surely be accompanying growth in the rural residential areas outside the urban growth boundary.

Another study that focused on a part of the Marys River Watershed was conducted by a regional research consortium called the Pacific Northwest Ecosystem Research Consortium (Hulse et al. 1997). This study focused on the Muddy Creek sub-basin in the southeastern part of the Marys River Watershed. The Muddy Creek watershed was chosen as a prototype for the larger Willamette River basin project because previous analyses showed that, between 1970 and 1990, land use change in the basin was greatest at the periphery of major metropolitan areas. The authors noted that the Muddy Creek sub-basin is near a metro area (Corvallis) that is likely to experience strong development pressure within the next 20-30 years.

The Hulse report estimated that 88% of the Muddy Creek sub-basin is privately owned. Most is zoned for Exclusive Farm Use (42% of the watershed), Forest Conservation (35%) or Secondary Forest uses (11%). Approximately 12% of the watershed is in public ownership. Despite this, the watershed is projected to experience significant growth in residential development over the next 15 years. The Benton County Development Department projects 1000 new people (or 400 households) in the sub-basin by the year 2015. Combining this information with population projections from PSU led to a baseline projection (called the “Plan Trend Future” in the report) of 1,118 new people or 475 new dwellings by 2025. The research team bounded this baseline projection with alternative growth scenarios, ranging from a high development scenario of 1,250 new households by 2025 (a doubling of the 1990 resident population of the watershed) to a high conservation scenario of only 125 new households over 1990 levels.

The research team then estimated the impact of the scenarios on biodiversity and water quality. They concluded that the high development future would put twice as many species per year at risk of losing >50 % of their habitat over the next 30 years compared to the last 150 years. They recommended seeking a land use/land cover pattern that is more conservative than the Plan Trend Future. In terms of water quality, they concluded that under the Plan Trend Future, water quality would degrade by the year 2025. A future that tends toward the high conservation scenario is necessary to maintain water quality at 1990 levels.

Further information about development pressures in the Marys River Watershed would require more time and resources. The Benton County Development Department can compile data on building permits over time, by location, and could at least approximate the watershed boundaries. They do not have this information currently compiled, however, and a formal request would have to be made. In addition, the Benton County Assessor’s Office has data on every tax lot in the County. Records could be analyzed to find dates of lot subdivision, as well as the year any house was built. From this analysis, a database of land and housing development over time could be constructed.

Recreational Resources and Use in the Marys River Watershed

The predominance of private land in the watershed results in relatively few developed recreation areas. Corvallis city parks that lie within the watershed include Avery, Sunset, Bruce Starker Arts, Bald Hill, and Walnut parks. The City of Philomath Park, Marys River Park, and East Newton Park are also within the watershed. Facilities and opportunities at all of these parks are listed in the Benton County Recreation Guide (Benton County Parks, undated). Benton County has one park – Bellfountain - in the southern part of the watershed, near the Community of Alpine Park, as well as Open Space Park west of Corvallis. Visitor use statistics are not kept for Benton County Parks, although there are data on reservations at park facilities.

In addition to the parks, three public land areas are managed at least in part for recreation. These are the Forest Service lands to the northeast of Marys Peak, the southwestern portion of OSU’s MacDonald Forest, and William L. Finley National Wildlife Refuge. The Forest Service maintains a road counter 5 ½ miles up Marys Peak Road from Highway 34, which counts traffic headed for the Peak. In the 5 years before 1997, when user fees were instituted on Marys Peak, visitor use was fairly steady at 23,000-25,000 vehicles per year (K. McCall, pers. comm.). Not all of these users would end up recreating within the Marys River Watershed, but this shows that the general visitation trend for this area is fairly flat.

MacDonald Forest has experienced increasing recreational use as Corvallis population has grown (Wing 1998). Overall use is now estimated at 100,000 visits per year (D. Lysne, OSU Research Forest, pers. comm.) and the Oak Creek area (which is within the watershed) is the most popular area of the forest for recreationists. A recreation study conducted in this area showed that use at the Oak Creek access point had increased 25% over 3 years (Wing 1998). Motorized use of MacDonald Forest is only allowed for those working in the forest, so recreation use is limited to hiking, mountain biking, and horseback riding. All official recreation trails have bridges across streams, but unofficial trails going from the roads and trails down to the streams are common in this area. During storm events, these unofficial trails can contribute to erosion. Unauthorized trails on the steep slopes of McCullough Peak also cause erosion into the tributaries of Oak Creek during storm events (Lysne 1999).

William L. Finley National Wildlife Refuge offers hiking trails and abundant wildlife viewing opportunities. Unfortunately, they have no reliable visitor use statistics for the area.

Private lands in the watershed offer opportunities for waterfowl, big game, and small game hunting. Some private lands are also open for general recreation use, often by free permit from the landowner. The City of Corvallis watershed is open to walk-in hunting, although no other type of recreation is allowed on city lands within their watershed. Statistics on hunting and fishing use within the watershed are unavailable.

As population continues to grow in and around the Marys River Watershed, the demand for outdoor recreation opportunities will also grow. Some public lands receive very little recreational pressure, while others, like MacDonald Forest, are experiencing problems from too many recreationists. Private lands have the capability to supply more recreation opportunities, but given problems with vandalism and illegal dumping, many private landowners are closing their lands to public use.

Because data on visitation are lacking for most of the land in the watershed, it is not possible to estimate the economic impacts resulting from recreation expenditures. Given the types of recreation opportunities available in the watershed, most visitors probably come from the local area and do not have high trip expenditures. Therefore, the economic *value* of these recreation resources (i.e., the willingness to pay for them) is probably more significant than the economic impacts (resulting from what is *actually paid*). Economic value estimation would require an in-depth survey of recreation users.

Summary

Much of the data used to describe socioeconomic conditions is only available at the county level. Therefore, some caution must be used when interpreting the results for the Marys River Watershed. The data on agricultural sales and acreage, as well as the data on timber harvest, primarily describe rural parts of Benton County. If we assume that the portion of Benton County that is in the Marys River Watershed has a similar distribution of agricultural and forest lands as the part of the county outside of the watershed, then the trends shown in these statistics should be fairly representative of the watershed. The data show that the number of acres in agriculture has been holding fairly steady over time, while the value of agricultural output has been rising. Agricultural landowners have increased the amount of acreage in grass seeds, while decreasing the acreage in grains. Further investigation should look at the differences in farming practices (e.g., pesticide applications) for grass seed and grains and assess the implications for water quality.

Timber harvest levels have fluctuated widely over time in Benton County. Today's levels are lower than the long-term average for the County. Most of the public lands in the watershed are being managed under the Northwest Forest Plan, and very little harvest has come from those lands in recent years. An increase in harvest from private lands has resulted, and further investigation should look at the differences in harvest practices of private and public owners.

Changes in the economic structure of the county will also have implications for the watershed. As Corvallis has grown in both population and economic opportunities, new residents have created a demand for rural residential housing. In addition, more residents of the watershed may have found work in Corvallis, Salem, or Eugene, leading to more commuting out of the watershed. Further investigation should document the number of new dwellings that have been built in the watershed over time. These data are available from the Benton County Development Department by special request. Further analysis should also look at the impact on water supply as more residences are built.

Finally, few data on recreation use within the watershed exist. Current use does not appear to have major impacts on water quality, and the water resources of the watershed are not a major recreational attraction. As population continues to grow, however, recreational use should be monitored.

CHAPTER 7: PRIORITIZATION OF ISSUES AND RECOMMENDATIONS

The watershed assessment process has uncovered a wealth of information about the Marys River Watershed. Many of these data are of high quality and have been very useful. Still, a recurring problem with the development of a statement of condition for the Marys River Watershed has been that needed data were often lacking, of a general nature, or collected with other objectives in mind. Lack of specific, quantitative information limits the ability to draw unequivocal conclusions about the status and trends of the Marys River Watershed resources. Because most watershed issues are complex, data available on the general subject may not address the issues to a desired level of certainty. For example, spot checks of stream temperature are usually not adequate to draw conclusions about whether or not streams may be too warm. To address the limitations of the currently available data, issues were identified for which additional assessment or monitoring is necessary. Understanding the limitations of existing information, a set of general conclusions about the condition of the watershed was developed, focusing primarily on the identifiable change in watershed resources through time and, where possible, identifying the causes of change. Where possible, the degree of uncertainty about these conclusions will provide the reader with a better understanding of the issues and information gaps.

Historical

By the 1930's, the landscape features of the Marys River watershed had changed dramatically. Lands that were historically grass prairies, oak savannas, wetlands, and riparian forests had been converted to farmlands, and, to a lesser extent, other land uses. In addition, because of the end of the Kalapuyan practice of using fire to control vegetation, some areas that were once grasslands and open oak woodlands were converted to conifer forests. More people lived in the watershed, and were concentrated in the larger towns of Corvallis and Philomath. Stream habitat, especially along the mainstem of the Marys River, had been modified through log drives, woody debris removal, bank stabilization, and removal of riparian vegetation. Water quality problems from domestic sewage were recognized as an issue, although there was little recognition that land use activities could contribute to water quality concerns.

Water Quality and Quantity

Portions of the Marys River are on the Oregon Department of Environmental Quality's list for water quality limited streams, the 303(d) list. These segments are listed for temperature, bacteria, and/or flow modification. Available stream temperature data show that the Marys River and some tributaries currently exceed 64°degrees F, which is the state standard for waters containing salmonids. However, it is not known whether the warmer stream temperatures are a natural phenomenon or due to land use modifications. While there may be naturally high bacteria concentrations seasonally in the Marys River, Oak Creek and Squaw Creek are chronic problem areas for bacteria; the source of these bacteria (human, livestock, wildlife) need to be identified. Water availability reports indicate that both the Marys River and Muddy Creek may experience excessively high water withdrawals during the summer months. No tracking system for withdrawals is in place, so the allocated water withdrawal amounts may not accurately reflect the withdrawals occurring. In addition, there is no information concerning withdrawals and stream flow for most tributaries in the watershed.

Aquatic and Terrestrial Habitat

The rapid rate of settlement and modification of the Marys River Watershed landscape has resulted in alteration and loss of both aquatic and terrestrial habitats. Habitat modification and loss, together with direct effects of human populations and competitive pressures from introduced species, has contributed to declines in several species. Seven vertebrate species have been lost from the Marys River Watershed. Currently, 97 species are considered to be in some level of “sensitive” status by federal, state, or other organizations. Many of these sensitive species are listed because little quantitative data are available describing their condition.

There is evidence that some native fish are less abundant due to habitat loss and competition from introduced species. Indicators of habitat loss are reductions in in-stream woody debris and the amount of side channel and off-channel habitats, and an increase in fine sediments in pools. A general lack of data on cutthroat abundance and distribution makes it difficult to draw conclusions regarding the response of cutthroat trout to modifications in habitat. Culverts also pose problems to fish passage in the watershed, particularly to cutthroat that live in mainstem rivers and spawn in tributaries. Many of the culverts that limit fish passage, particularly on the larger industrial forest ownerships, have been identified or are scheduled for assessment. As a result, watershed areas in need of culvert assessments include small, private forestlands and agricultural areas. The population of the federally endangered Oregon chub in Gray Creek is stable, but faces threats from introduced warm water fish, such as the western mosquitofish, and loss of habitat. The sandroller and Pacific lamprey may also face similar threats. Listings of winter steelhead and spring chinook salmon in the Upper Willamette may affect the Marys River.

The watershed area in wetlands and streamside vegetation (riparian zones) has declined significantly from historical levels. Most of the losses of wetland and riparian vegetation probably occurred before the 1930s, and resulted from early settlement, establishment of farms, and channelization of streams. Currently, some of the remaining wetlands may be threatened with additional loss through draining and urban development. Detailed assessments of the current extent and condition of riparian forests are needed.

Soils

Although detailed information is limited, soil erosion appears to be elevated in some areas of the watershed as a result of poor soil management practices and roads. Cropping practices that leave soils bare during winter rainy season present the greatest erosion potential. Better soil conservation practices including no-tillage planting, cover crops and grassed waterways should be promoted where needed.

Excessive livestock use of riparian zones may be occurring in some areas in the Marys River Watershed, resulting in loss of riparian vegetation and introduction of bacteria and other pollutants to the streams. Good management practices would address many problem areas. Manure management, particularly for the confined feeding operations, could minimize water quality concerns.

Pesticide use and impacts are difficult to track and accurately assess. While no known health or ecosystem impacts have occurred in the watershed, further studies are warranted to better assess this potential issue.

Loss of riparian forests, especially in headwater streams in agricultural areas, is likely to have been widespread. These losses of riparian forests may promote soil erosion via accelerated water velocities causing channel incision and erosive downcutting. Formal assessments of existing riparian forests have not been performed. Development of better riparian buffers in agricultural and urban lands should be promoted to enhance biodiversity and habitat quality, and to reduce streambank erosion.

Road density is relatively high in some portions of the basin, but interpretations about impacts to streams is problematic without a more detailed survey about conditions, traffic and locations.

Social and Economic Conditions

The data show that the number of acres in agriculture has been holding fairly steady over time, while the value of agricultural output has been rising. Agricultural landowners have increased the amount of acreage in grass seeds,

while decreasing the acreage in grains. Further investigation should look at the differences in farming practices (e.g., pesticide applications) for grass seed and grains and assess the implications for water quality.

Timber harvest levels have fluctuated widely over time in Benton County. Today's levels are lower than the long-term average for the County. Most of the public lands in the watershed are being managed under the Northwest Forest Plan, and very little harvest has come from those lands in recent years. An increase in harvest from private lands has resulted, and further investigation should look at the differences in harvest practices of private and public owners.

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Finally, few data on recreation use within the watershed exist. Current use does not appear to have major impacts on water quality, and the water resources of the watershed are not a major recreational attraction. As population continues to grow, however, recreational use should be monitored.

Recommendations

The following are recommendations for action that could be taken by the Marys River Watershed Council. Recommendations are organized into four areas: 1) further assessment to remove uncertainties, 2) monitoring programs to refine and track problems and assess change, 3) projects directed at enhancement of watershed condition and function, and 4) education and advocacy on important issues.

Additional Assessments to Remove Uncertainties

1. Finalize the culvert assessments on the remaining private lands in the watershed that have not been included in other survey programs
2. Develop GIS layers of cutthroat trout distribution in the watershed. Existing surveys by the Oregon Department of Forestry of upper extent fish use could be used. Prioritize additional areas to survey to develop better knowledge of where the high-quality habitat exists and should be protected.
3. Perform more accurate assessments to determine how much water is actually being withdrawn from the Marys River and its tributaries. This information would help to determine effects on low-flow stream conditions.
4. Assess conditions of riparian areas and relate to land use, stream condition and fish use, and relate this information to land use, stream condition, and fish use.
5. Document the number of new dwellings that have been built in the watershed over time and look for trends such as construction in riparian zones. These data are available from the Benton County Development Department by special request.
6. Assess selected areas that may have more than 6% of land covered by impervious surfaces. This threshold has been associated with declines in watershed condition.
7. Collaborate with the ODFW to perform surveys of status and distribution of sandroller populations within the lower Marys River. Assess the specific habitat needs and the potential threats from bass and other introduced species.

Monitoring to Track Problems and Assess Change

1. Monitor land use changes within the watershed, as land use is the main driver of change in watershed condition.
2. Monitor stream temperature, including measures of streamside parameters that influence temperature. These data will help ascertain the cause of elevated stream temperatures.
3. Obtain baseline data about stream condition for a suite of nutrients and basic water chemistry. Include measures of land use in the immediate area and in upstream areas to help determine relationships with non-point sources.
4. Monitor bacteria levels in Oak Creek and Squaw Creek and identify potential sources of contamination.
5. Collaborate with the Audubon Society and the non-game division of ODFW to facilitate the annual monitoring of bird populations in the watershed.

Projects to Enhance Watershed Condition and Function

1. Facilitate completion of culvert surveys on private lands not currently being surveyed by other programs. Gather all data related to culverts in the watershed and combine with fish distribution maps to prioritize culvert restoration projects. This effort could be expanded to include ways to restore passage on other impoundments in the watershed.
2. Restore habitat used by Oregon chub in Gray Creek. Look for other areas that may offer opportunities for habitat restoration such as the Newton Creek area.
3. Develop, with willing landowners, demonstration projects designed to protect and enhance at-risk habitats. Examples of projects include riparian plantings (especially conifers) and wetland enhancement. Soil and water conservation districts and irrigation districts may provide a way to coordinate with landowners on projects.

Education and Advocacy

1. Provide education for watershed residents on the resource values in the Marys River Watershed.
2. Provide education (through workshops, written materials and other methods) for watershed residents on proper resource stewardship. Examples include describing methods to improve habitat and to protect water quality for all land uses, and a directory of government programs related to watershed health and water quality
3. Advocate and provide education on wetland protection along Muddy Creek. Advocate wetland restoration in the Newton Creek area.

4. Advocate and provide education on good manure management at confined feeding operations to help reduce bacterial contamination in streams.
5. Advocate and provide education on monitoring and reports of pesticide use.
6. Advocate land uses that are compatible with the land capability and that are environmentally sound.
7. Educate landowners that land use is closely associated with watershed condition.

The watershed council should develop a vision of the desired future for the Marys River Watershed through time. A carefully articulated watershed vision and long-term goals, agreed to by the watershed council and residents, will offer a road map for future protection, enhancement, monitoring and educational activities.

Finally, the goals and objectives of the Marys River Watershed Council should be integrated with efforts undertaken throughout the larger Willamette River basin. This recommendation includes collaboration with other watershed councils, the Governor's Watershed Enhancement Board, and the Willamette Restoration Initiative. Collaboration will provide a framework for prioritizing actions and addressing cumulative impacts throughout the basin, and a mechanism to direct financial, institutional, and other resources to deal with issues in the Marys River Watershed.

APPENDIX 1: Annotated Bibliography, carto-bibliography, and related internet resources.

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Carto-bibliography

The following list of select maps has been arranged in chronological order. These maps were selected on the basis of providing useful information for the Mary River Watershed, and being generally available for research and resource management purposes.

Most entries include the following information: date; map title; names of compilers, draftsmen, originating agencies and publishers, if any; scale; dimensions to the nearest inch; brief description of contents; map location(s); and file numbers. A "manuscript" map is defined as one made of hand-applied pencil, ink, watercolor or similar medium, usually on cloth or paper. "Blueprints," "photoprocessed," and "published" maps are identified as such, to distinguish between various levels of photographically reproduced records. An "annotated" map is a published, photoprocessed or blueprint map that contains additional information added by hand.

1851. Drawing of the Willamette Valley. Gibbs, George and Edward A. Starling. Prepared for the Board of Commissioners appointed to form treaties with the Indians of Oregon. Valley Library, Map Room, Oregon State University, Corvallis, OR. 1 sheet.

1852. Township No. 11 South, Range No. 5 West of the Willamette Meridian, Oregon. Contracts with George Hyde dated March 25 and May 27, 1852. Map based upon General Land Office survey contracts No. 14 and No. 19 for the Surveyor General's Office, Portland, Oregon. 1 inch to 1/2 mile. 15 X 19.

Representative GLO black and white photoprocessed map showing legal survey subdivisions, rivers, creeks, homes, landowners, roads, trails, swamps, prairies, landslides, buttes, divides, and timber. This map covers the southern portion of Marys River, but original land survey maps and notes exist for the entire Marys River drainage. Accompanied by detailed survey notes. Both maps and notes are available through the Portland BLM office and Benton County Surveyor's Office.

1900. Map of the State of Oregon Showing the Classification of Lands and Forests. Drafted by Gilbert Thompson from information provided by A.J. Johnson. Professional Paper No. 4, United States Geological Survey. Government Printing Office, Washington, D.C. 1 inch to 10 miles. 30 x 37.

Published color map showing pre-1902 forest fire patterns, classified timberlands, transportation routes, cities, towns, and surveyed section lines. Accompanied by text, tables and photographs in Gannett (1902). Valley Library, Map Room, Oregon State University, Corvallis, OR.

1914. Map of the State of Oregon. Compiled by Theodore Rowland under the direction of F.A. Elliott. Copyright by F.A. Elliott. Published by the Oregon State Board of Forestry, Salem. 1 inch to 6 miles. 54 x 74.

Photoprocessed vegetation type map showing pre-World War I logging boundaries, reforested burns, commercial timberlands, transportation routes, communication lines, cities, towns, and surveyed section lines. Valley Library, Map Room, Oregon State University, Corvallis, OR. Available through Oregon Water Resources Department as GIS layers.

1915 Timber Cruise of Benton County, Oregon 1914-1915. Benton County Courthouse.

1922. Timber Type Map, Lincoln County. Pearson, Grady & Co. Produced for S.P. & S. Railway.

Hand-colored map with tabular summaries; part of a series completed for western Oregon counties. This map was located in the Oregon Historical Society map collection in Portland, where it was photographed in 1991 with color slide film for COPE files. The author (Zybach) has a copy of these slides.

1929. Metsker. Benton County, Oregon Landowners. Valley Library, Map Room, Oregon State University, Corvallis, OR.

1936. Forest Type Map, State of Oregon, Northwest Quarter. Compiled by the Forest Survey Staff under the direction of H.J. Andrews, assisted by Cowlin. Lambert Projection published by the USDA Pacific Northwest Forest Experiment Station, Portland, OR. 1 inch to 4 miles. 46 x 62.

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1998. Benton County Surveyor. Benton County, Oregon Geographic Information Systems (GIS) Layers of County Land Subdivision Surveys, 1853-1998. Available in CD-ROM format with ARC-Info software.

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Internet sites

Groundwater information:

GRID-online
http://www.wrd.state.or.us

Precipitation:

Oregon climate service
http://www.ocs.orst.edu/allzone/allzone2.html

Surface water information:

USGS stream discharge data
http://waterdata.usgs.gov/nwis-w/OR/

US Army Corps of Engineers stream discharge data
http://nwp71.nwp.usace.army.mil/graphics/willamette/willtrib/willtrib.html

Oregon Department of Environmental Quality water quality information
http://waterquality.deq.state.or.us/wq/

Water rights:

http://www.wrd.state.or.us

WRIS database. [user needs telnet helper software. Water rights maps, attached reports, surface water diversion data available.]

Fish listings:

The Oregon Plan
http://www.oregon-plan.org

ODFW
http://www.dfw.state.or.us

Pacific States National Marine Fisheries Council
http://www.psmfc.org

National Marine Fisheries Service
http://www.nwr.noaa.gov

Cutthroat Homepage. OSU and ODFW
http://www.orst.edu/dept/odfw/conference/cuthab.html

Species listings:

Natural Heritage Council. The Nature Conservancy.
http://www.heritage.tnc.org

ODFW
http://www.dfw.state.or.us

Hulse Report homepage. [Information on Muddy Creek Watershed as well as current projects.]
http://ise.uoregon.edu/muddy/muddy_abstract.html

Corp. of Engineers Willamette Valley Projects. [information of Willamette Valley sensitive species and the western pond turtle.]
http://www.nwp.usace.army.mil/op/v/wvphome.htm#WVHome

Human growth and population estimates:

http://www.upa.pdx.edu/CPRC/Final98.PDF
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http://www.oea.das.state.or.us/county/co_pop.htm
Office of Economic Analysis. 1997. Long Term Population Forecasts. [The demographer with the Office of Economic Analysis provides population and employment forecasts by county. These estimates are an alternative to the PSU Center for Population Research and Census, although the PSU numbers are considered the "official" population estimates.]

Oregon Blue Book. 1997. City and County Population Estimates.
http://www.sos.state.or.us/BlueBook/1997_98/local_gov/citypop.htm
U.S. Department of Commerce, Bureau of Economic Analysis. 1998.
Regional Accounts Data. http://www.bea.doc.gov/bea/regional/data.htm

APPENDIX 2: Photos

The next three insert sheets contain a time-series of aerial photos. These photos show subtle changes to the riparian forests between 1937 and 1994. Visual inspection suggests that little to no forest removal occurred along Muddy Creek during this time period. Forest removals occurred along the old drainage channels to the east and along the Marys River to the north. One might speculate that the drainage channels contained more extensive forests before these photos, similar to the reconstruction of vegetation shown in Map 16. Also, these photos show that most of the non-forest area was already in farms by 1937 and that a large network of drainage ditches were in place.

Photo 3a: 1937 aerial photo of the confluence of Marys River and Muddy Creek.

Photo 3b: 1956 aerial photo of the confluence of Marys River and Muddy Creek .

Photo 3c: 1994 orthophoto of the confluence of Marys River and Muddy Creek.

Photo 4 : A controversial photo about whether salmon ever used the Marys River. These photos, reportedly taken in the 1920's on a homestead near Harris (upstream on the Marys River of Wren) show large salmonids. The men in the photos are the father and grandfather of Bobby Taylor of Wren. According to Bobby Taylor, his father described to him that chinook salmon were speared out of the Marys River in the 1920s using pitchforks. By the time that Taylor can remember (1940's) there were no salmon in the Marys River. Several fish biologist consulted do not believe that these salmon likely came from the Marys River, but from somewhere else (see text in Chapter 4).

APPENDIX 3: Figures not imbedded in text

Figure 3-1: 1852 General Land Office survey map, Oak Creek.

APPENDIX 3: Figures not imbedded in text

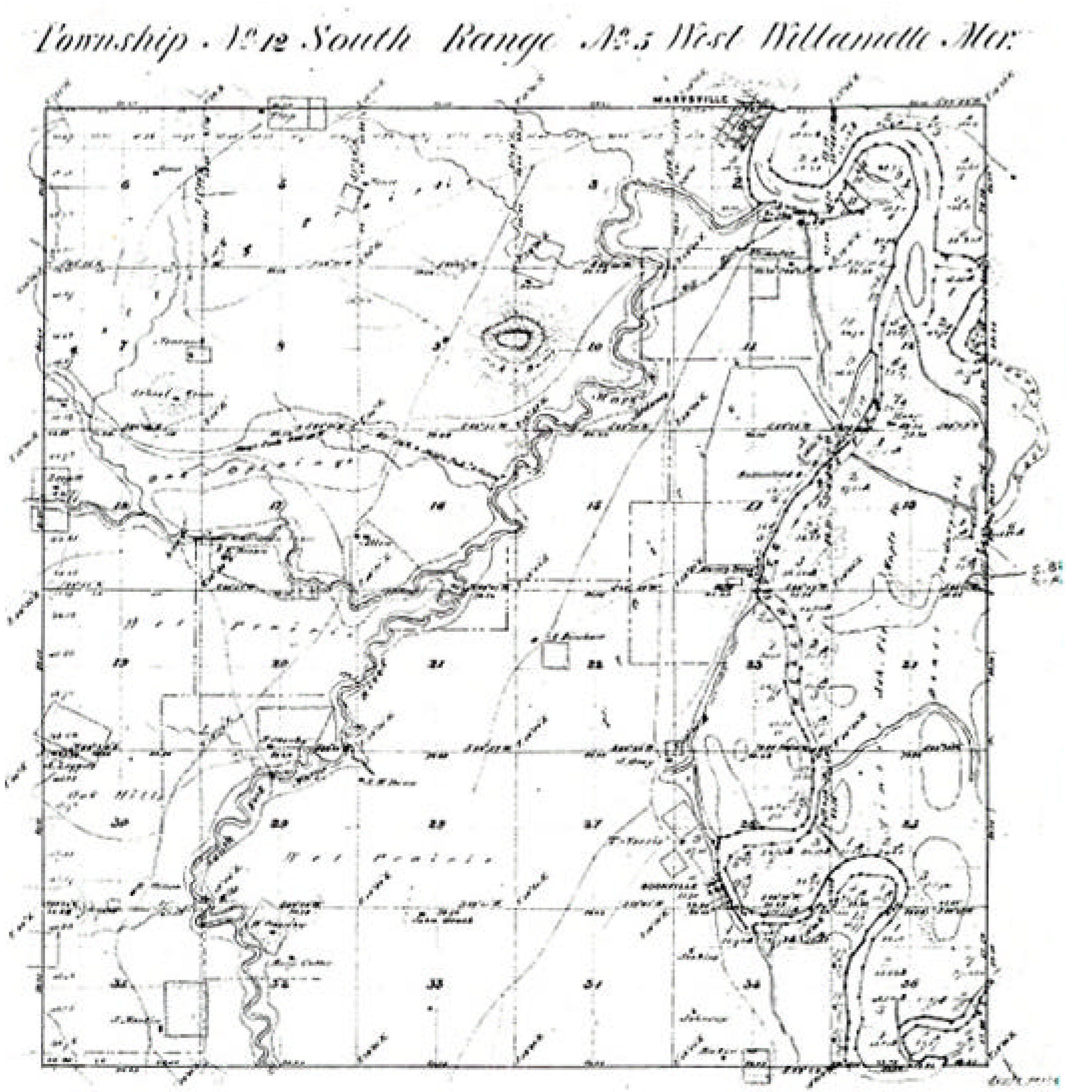

Figure 3-2: 1853 General Land Office survey map, Lower Marys River.

APPENDIX 3: Figures not imbedded in text

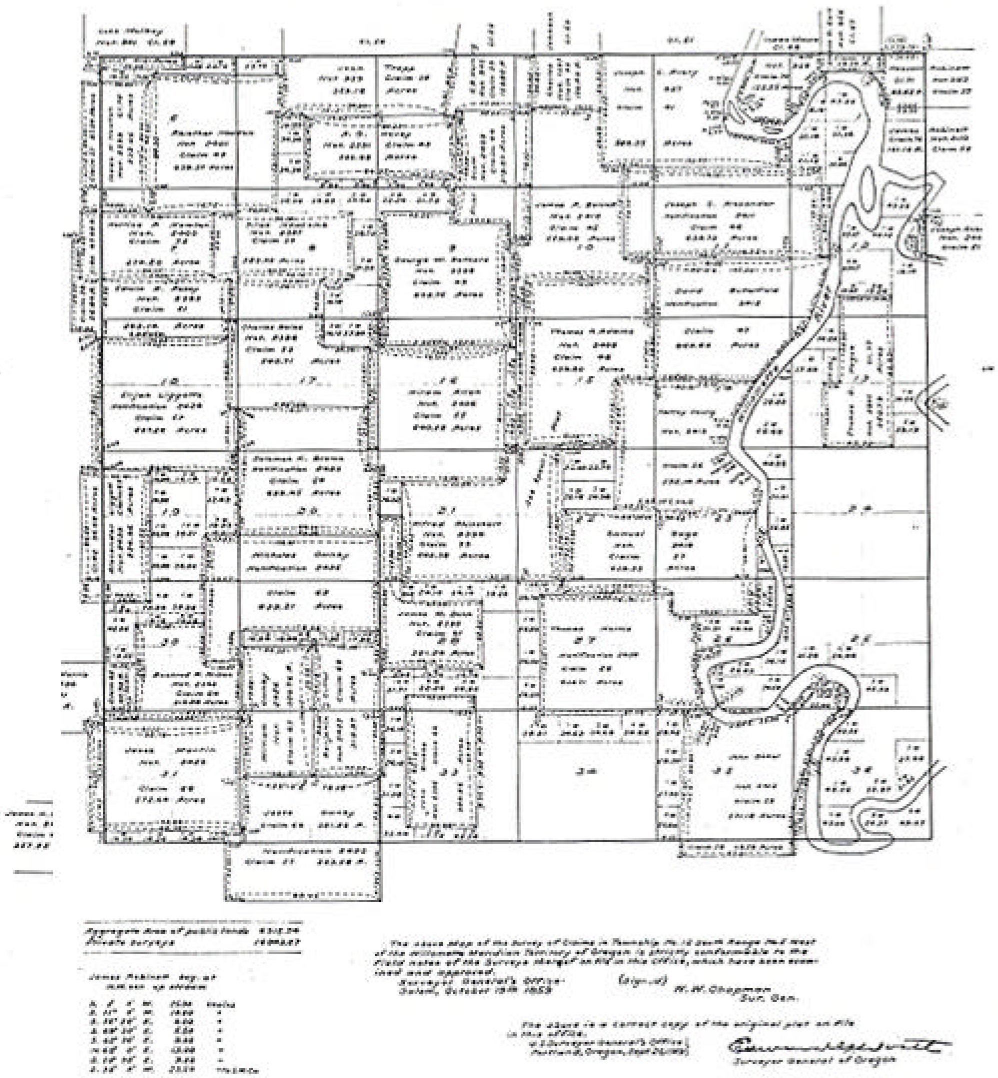

Figure 3-3: 1859 Cadastral map for township 12 South, Range 5 West.

APPENDIX 3: Figures not imbedded in text

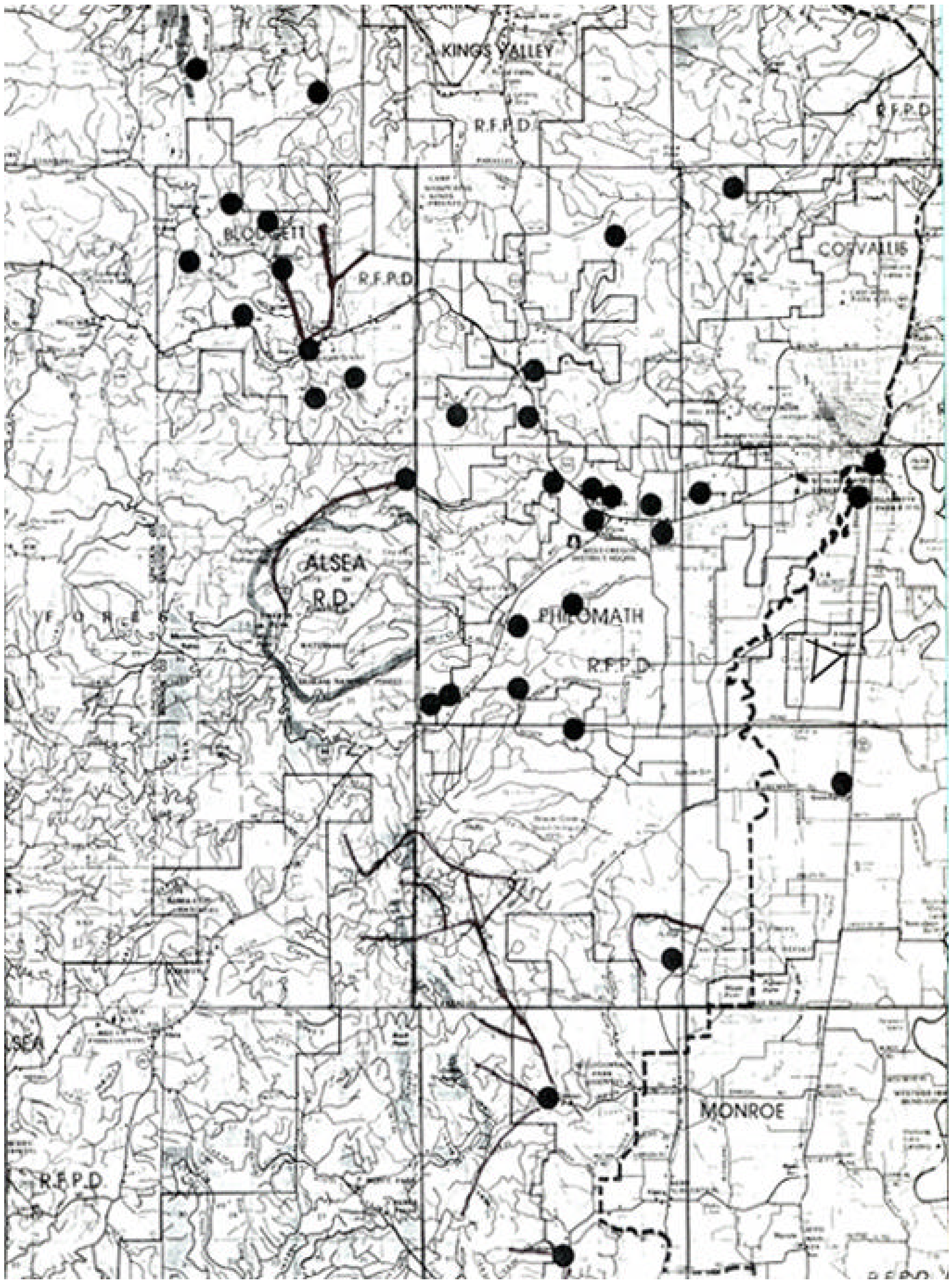

Figure 3-4: Location of historic mill sites and logging railroads (based on T.J. Starker's map on file at Benton County Historical Society).

APPENDIX 3: Figures not imbedded in text

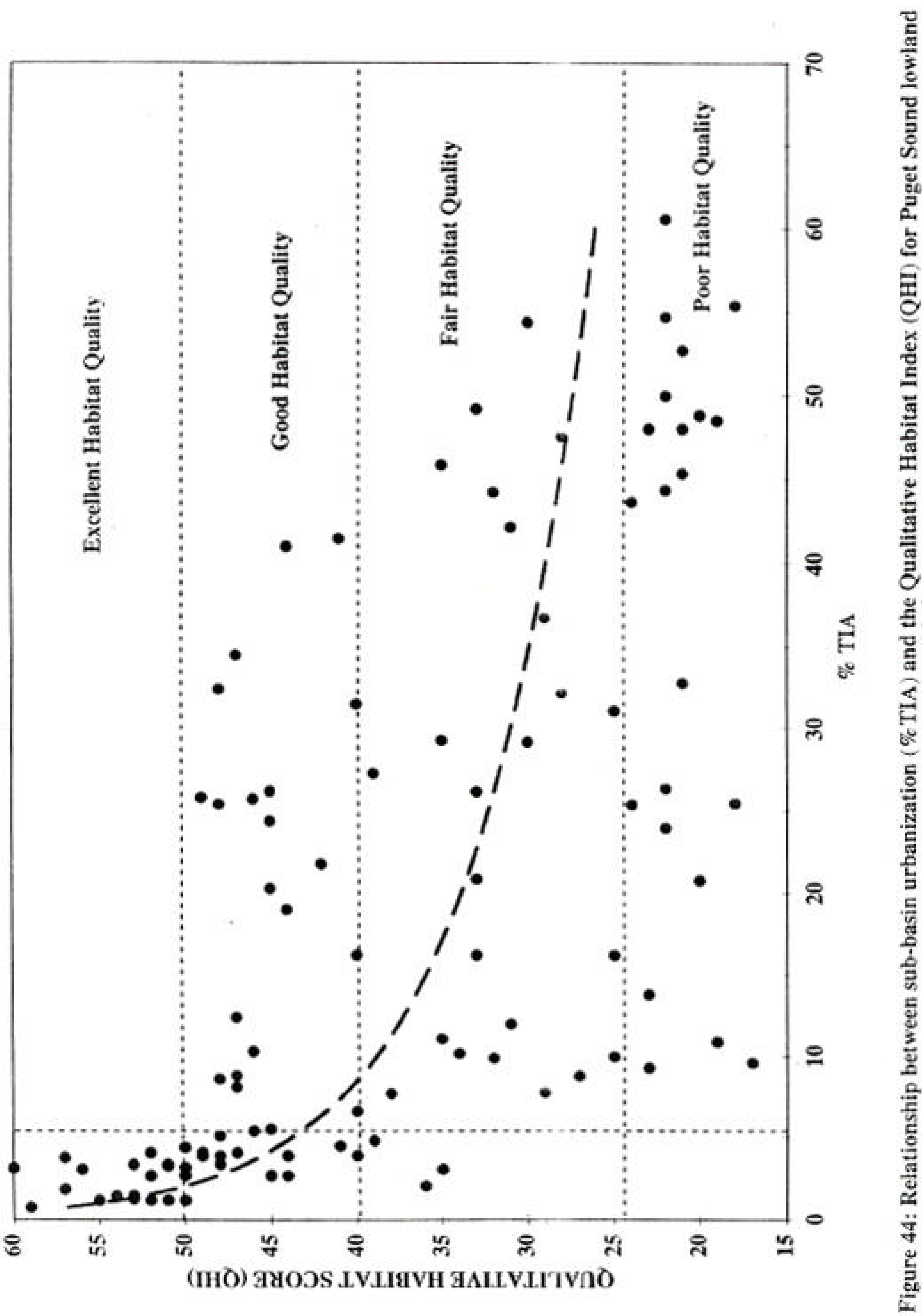

Figure 3-5: Relationship of impervious surfaces to environmental condition.
(May et al. 1997).

APPENDIX 3: Figures not imbedded in text

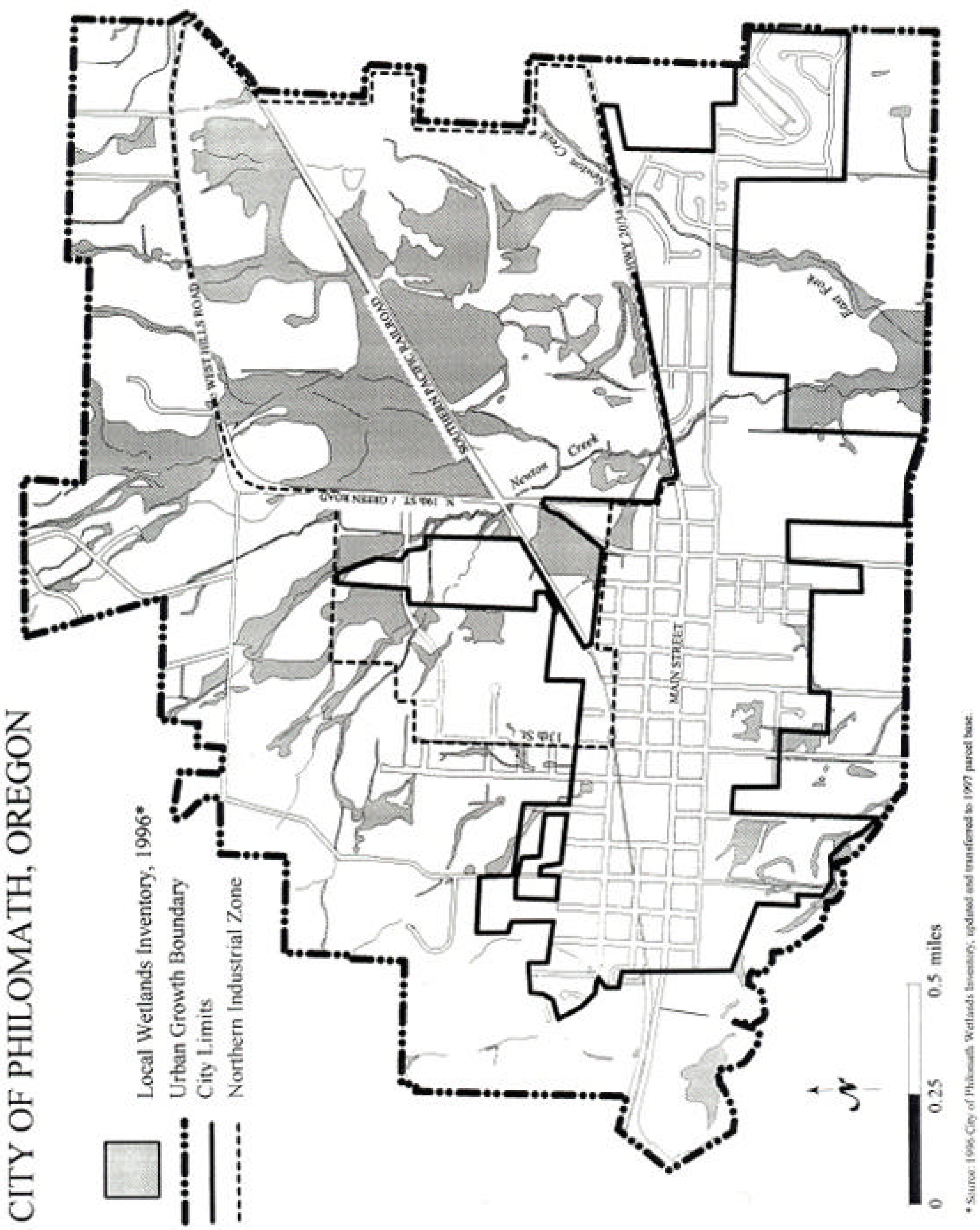

Figure 3-6: 1996 City of Philomath wetlands inventory (from files of City of Philomath).

Figure 3-7: Water quality for Beaver Creek.

Figure 3-8: Water quality for Oliver Creek.

Figure 3-9: Water quality for Muddy Creek.

APPENDIX 4: Hydrology

Section 1: Hydrologic flow data for the Marys River.

1 724-K5-G31S RIVER STATION RATING TABLE FOR PAGE 1

FACTOR: 0.001 MARYS RIVER DATE: 02/13/99
NEAR PHILOMATH, OR.

DB4 STATION NAME: PHIO USGS STATION #:
DB4 TABLE NAME: USGS TABLE #
DB4 TABLE DATE: 01/24/88 USGS TABLE DATE:

DISCHARGE (CFS KCFS MCFS)

GAGE HEIGHT (FT)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1									4 2	6 2
2	8 2	10 2	12 3	15 4	19 4	23 4	27 4	31 5	36 6	42 6
3	48 7	55 8	63 9	72 9	81 9	90 9	99 9	108 9	117 9	126 9
4	135 10	145 10	155 10	165 10	175 10	185 11	196 12	208 12	220 12	232 12
5	244 13	257 13	270 13	283 13	296 13	309 13	322 13	335 13	348 14	362 14
6	376 14	390 15	405 16	421 17	438 17	455 17	472 17	489 17	506 17	523 17
7	540 18	558 18	576 18	594 18	612 18	630 18	648 18	666 19	685 20	705 20
8	725 20	745 20	765 20	785 20	805 20	825 20	845 20	865 20	885 20	905 20
9	925 20	945 20	965 20	985 20	1005 20	1025 20	1045 20	1065 20	1085 20	1105 20
10	1125 20	1145 20	1165 25	1190 25	1215 25	1240 25	1265 25	1290 25	1315 25	1340 25
11	1365 25	1390 25	1415 25	1440 25	1465 25	1490 25	1515 25	1540 25	1565 25	1590 25
12	1615 25	1640 25	1665 25	1690 25	1715 25	1740 25	1765 25	1790 25	1815 25	1840 25
13	1865 25	1890 25	1915 25	1940 25	1965 25	1990 25	2015 25	2040 25	2065 25	2090 25
14	2115 25	2140 25	2165 25	2190 25	2215 25	2240 30	2270 30	2300 30	2330 30	2360 35
15	2395 35	2430 35	2465 35	2500 35	2535 35	2570 35	2605 35	2640 35	2675 35	2710 35
16	2745 40	2785 40	2825 40	2865 40	2905 40	2945 40	2985 40	3025 40	3065 40	3105 40
17	3145 45	3190 50	3240 50	3290 50	3340 50	3390 50	3440 50	3490 50	3540 60	3600 60
18	3660 60	3720 60	3780 70	3850 70	3920 70	3990 70	4060 70	4130 70	4200 70	4270 80
19	4350 90	4440 90	4530 90	4620 90	4710 95	4805 95	4900 140	5040 145	5185 150	5335 150
20	5485 155	5640 160	5800 200	6000 400	6400 600	7000 800	7800 1.0	8800 1.0	9800 1.2	11.0 1.2
21	12.2									

RFC RATING TABLE NOTES:

GAGE DISCONTINUED IN SEP 1985
BANK FULL 16.0 FT
FLOOD STAGE 20.0 FT
MAX DISCHARGE 13600 CFS, GH 20.72 FT, DATE 12-22-64
MAX GH 20.91 FT, DATE 01-15-74
TABLE EXTENDED BY RFC ABOVE 21.0 FT; EXTENSION POINTS ARE:
21.5 21000. 22.0 40000.

Appendix 4

Section 2: Marys River segments on 303(d) list.

Segment ID 22E-MARY0 (Marys River—Mouth to Greasy Creek) was the only segment considered and listed for the following parameters on the 1998 303(d) list.

Parameter: Bacteria
Criteria: Water Contact Recreation (fecal coliform-96 Std)
Season: Fall-Winter-Spring
Listing Status: 303(d) List
Basis for Consideration for Listing: DEQ Data; d1 in 305(b) Report (DEQ, 1994); NPS Assessment -segment 456: severe, data (DEQ, 1988); City of Corvallis data 1997.
Supporting Data: DEQ Data (Site 402041; RM 0.2): 24% (11 of 45) FWS values exceeded fecal coliform standard (400) with a maximum value of 2400 between WY 1986 - 1995. City of Corvallis two sites 1996/97 showed no exceedence of E. coli standard of (406).
Change from 1994/96 List: No Change

Parameter: Flow Modification
Criteria:
Season:
Listing Status: 303(d) List
Basis for Consideration for Listing: USGS (1990); IWR (ODFW); WRD Data; ODFW (1990).
Supporting Data: Cutthroat populations are suspected to be declining due to degradation and loss of habitat, low flows have been suggested to be the most critical factor (ODFW, 93); IWR (70748) is often not met at USGS gage (14171000).
Change from 1994/96 List: No Change.

Parameter: Temperature
Criteria: Rearing 64 F (17.8 C)
Season: Summer
Listing Status: 303(d) List
Basis for Consideration for Listing: DEQ Data (Temperature Issue Paper, 1994); ODFW Data Supporting Data: DEQ Data (Site 402041; RM 0.2): 85% (41 of 48) Summer values exceeded temperature standard (64 F) with exceedences each year and a maximum of 82.4 in WY 1986- 1995.
Change from 1994/96 List: No Change

Parameters for which Segment ID 22E-MARY0 (Marys River—Mouth to Greasy Creek) was considered for but not listed for in 1998 on the 303(d) list:

Parameter: Bacteria
Criteria: Water Contact Recreation (fecal coliform-96 Std)
Season: Summer
Listing Status: OK—not listed

APPENDIX 4:
Section 2: Marys River segments on 303(d) list (cont.)

Marys River water segments considered for 1998 303(d) list, but not listed

Supporting Data: DEQ Data (Site 402041; RM 0.2): 9% (3 of 33) Summer values exceeded fecal coliform standard (400) with a maximum value of 460 between WY 1986 - 1995.
Rationale for not Listing: Did not meet listing criteria.
Change from 1994/96 List: No Change.

Chlorophyll a
Season: Summer
Listing Status: OK—not listed
Basis for Consideration for Listing: DEQ Data (Site 402041; RM 0.2): 0% (0 of 43) Summer values exceeded chlorophyll a standard (15 ug/l) between WY 1986-1995.
Rationale for not Listing: Did not meet listing criteria
Change from 1994/96 List: No Change

Dissolved Oxygen (DO)
Cool-water aquatic resources: DO < 6.5 mg/l
Listing Status: OK–not listed
Basis for Consideration for Listing: DEQ Data; d1 in 305(b) Report (DEQ, 1994); NPS Assessment -segment 456: moderate, data (DEQ, 1988); City of Corvallis data 1997
Supporting Data: DEQ Data (Site 402041; RM 0.2): 0% (0 of 95) Annual values exceed dissolved oxygen standard (6.5 mg/l) between WY 1986 - 1995 (Cool water fishery, annual). City of Corvallis showed no exceedence of DO standard for cool water aquatic resources.
Rationale for not Listing: Did not meet listing criteria
Change from 1994/96 List: No Change

Parameter: pH
Criteria:
Season: Summer
Listing Status: OK
Basis for Consideration for Listing: DEQ Data; City of Corvallis data
Supporting Data: DEQ Data (Site 402041; RM 0.2): 0% (0 of 48) Summer values exceeded pH standard (6.5- 8.5) between WY 1986 - 1995. City of Corvallis data confirms.
Rationale for not Listing: Did not meet listing criteria
Change from 1994/96 List: No Change

Parameter: pH
Criteria:
Season: Fall-Winter-Spring
Listing Status: OK
Basis for Consideration for Listing: DEQ Data; City of Corvallis data

Supporting Data: DEQ Data (Site 402041; RM 0.2): 0% (0 of 45) FWS values exceeded pH standard (6.5-8.5) between WY 1986 - 1995. City of Corvallis data confirms finding.
Rationale for not Listing: Did not meet listing criteria
Change from 1994/96 List: No Change

Parameters for which Segment ID 22E-GREA0 (Greasy Creek-mouth to headwaters) was considered for but not listed for in 1998 on the 303(d) list:

Sedimentation
Need Data
NPS Assessment - segment 437: moderate, observation (DEQ, 1988)
Rationale for not Listing: No supporting data or information
Change from 1994/96 List: No Change.

Parameters for which Segment ID 22E-TUMT0 (Tum Tum River-mouth to headwaters) was considered for but not listed for in 1998 on the 303(d) list:

Parameter: Sedimentation
Criteria:
Season:
Listing Status: Need Data
Basis for Consideration for Listing: NPS Assessment - segment 438: moderate, observation (DEQ, 1988).
Supporting Data:
Rationale for not Listing: No supporting data or information
Change from 1994/96 List: No Change

Appendix 4:
Section 3: DEQ water quality data

Oregon DEQ summary of STORET Data
Storet retrieval date 6/17/98

Marys River at 99 W (Corvallis)
1987-1997 data

Date (beginning ending)		00400 pH SU	00431 T Alk Field mg/L	00010 Water Temp Cent	00094 Cond Field Micromho	00300 DO mg/L	00301 DO Saturation %	82078 Turb Field NTU
1/1/99 3/31/99	Number	17	17	17	17	17	17	17
	Max	7.5	31	11	89	12.6	98	53
	Min	6.9	10	3	61	9.9	83	7
	Mean	7.3	23	7	76	11.5	93	20
4/1/99 6/30/99	Number	23	19	24	24	24	24	19
	Max	7.7	40	26	119	11.2	112	17
	Min	6.7	23	10	70	7.3	81	5
	Mean	7.4	32	16	91	9.8	97	9
7/1/99 9/30/99	Number	38	17	38	38	38	38	14
	Max	7.9	58	28	151	9.9	115	16
	Min	7.2	40	15	102	7.0	79	2
	Mean	7.6	49	21	123	8.3	92	5
10/1/99 12/31/99	Number	13	13	13	13	13	13	13
	Max	7.7	68	17	166	12.2	95	35
	Min	7.0	25	5	91	7.7	77	3
	Mean	7.5	47	11	122	9.7	88	9

Appendix 4 Section 3 (continued)

Oregon DEQ summary of
STORET Data
Storet retrieval date
2/15/94

Marys River at 99 W
(Corvallis)
1983-1993 data

Date (beginning ending)		00400 pH SU	00431 T Alk Field mg/L	00010 Water Temp Cent	00094 Cond Field Micromho	00300 DO mg/L	00301 DO Saturation %	00076 Turb Trbdmtr Hach FTU
1/1/99 3/31/99	Number	19.0	18	20	20	20	20	19
	Max	7.5	31	11	107	12.6	99	88
	Min	6.9	14	3	50	10.2	87	7
	Mean	7.2	23	8	74	11.0	97	15
4/1/99 6/30/99	Number	26.0	22	27	27	27	27	22
	Max	7.9	40	26	119	11.2	112	17
	Min	6.7	23	8.5	11	7.3	81	5
	Mean	7.5	32	17	88	10.0	99	7
7/1/99 9/30/99	Number	44.0	20	46	46	45	46	20
	Max	7.9	64	28	162	9.9	115	19
	Min	7.2	34	14	91	7.0	79	3
	Mean	7.6	47	21	122	8.7	93	8
10/1/99 12/31/99	Number	17.0	17	17	17	17	17	15
	Max	7.7	68	15.5	166	13.0	101	35
	Min	7.0	19	3	60	7.7	77	3
	Mean	7.4	33	8.3	95	10.6	89	8

Appendix 4 Section 3 (continued)

Oregon DEQ summary of STORET Data
Storet retrieval date 2/16/94

Marys River at 99 W (Corvallis)
1983-1993 data

Date (beginning ending)		00310 BOD 5 d mg/L	00335 COD lowlevel mg/L	00680 T Org-C C mg/L	00610 NH3+NH4 N total mg/L	00630 NO2+NO3 N-Total mg/L	00625 Tot Kjel N mg/L	00665 Phos-Tot mg/L P	00671 Phos-dis ortho mg/L P	32209 Chlrphyl A ug/L	31615 Fec coli MPN /100ml	61639 entcocci mf /100ml
1/1/99 3/31/99	Number	18	18	18	19	19	17	19	15		19	16
	Max	91.0	54	5	0.17	1.20	1.00	0.346	0.092		2400	400
	Min	0.9	5	1	0.03	0.31	0.03	0.060	0.016		23	5
	Mean	1.7	5	2	0.05	0.60	0.40	0.110	0.034		240	70
4/1/99 6/30/99	Number	24	20	20	25	25	25	25	25	18	23	18
	Max	1.8	12	4	0.22	0.82	2.00	0.160	0.150	11.3	930	195
	Min	0.1	5	1	0.02	0.03	0.20	0.031	0.005	8	15	5
	Mean	1.3	5	2	0.03	0.23	0.30	0.070	0.023	1.7	93	10
7/1/99 9/30/99	Number	24	16	16	42	42	42	41	43	41	31	23
	Max	3.7	13	4	0.06	0.31	1.00	0.184	0.078	15	460	150
	Min	0.2	5	1	0.02	0.02	0.20	0.050	0.020	0.7	23	10
	Mean	1.3	5	2	0.02	0.05	0.30	0.070	0.028	3.9	93	60
10/1/99 12/31/99	Number	14	13	13	15	15	15	15	13	2	15	12
	Max	3.4	14	5	0.05	0.90	0.70	0.240	0.057	2.7	2400	1010
	Min	0.4	5	1	0.02	0.02	0.20	0.580	0.018	2.4	43	10
	Mean	1.5	5	2	0.04	0.38	0.30	0.080	0.029	2.4	210	70

APPENDIX 5: Geology and Soils

Section 1: Geology

Coast Range Geology

Siletz River Volcanics (P-type Tsr)

These are the oldest rocks exposed, and they form a band about six miles wide across the northern part of the watershed. These rocks are massive pillow basalts, tuffs and breccias of the Eocene when Western Oregon was covered by an arm of the ocean. Rocks of this formation are resistant and often form topographic highs and commonly have very steep slopes.

Kings Valley Siltstone (P-type Tsr)

The uppermost part of the Siletz River Volcanics grades into the waterlaid tuffs known as Kings Valley siltstone Member, which consists of interfingering of sedimentary rocks with volcanic rocks. The shaly, soft and thin-bedded siltstone is nonresistant and weathers rapidly. They occur in a two to three mile wide band between the Siletz River Volcanics and the Flournoy Formation in the northwest corner of the watershed. These rocks are not separated on the geology coverage map Fig.

Flornoy Formation (P-type Tt)

The rhythmically bedded, sandstone and sandy-siltstone of the Flournoy Formation are the second most widespread rocks in the watershed They occur both east and west of the belt of Siletz River Volcanics in the northern part of the watershed, and partly form the southwestern divide. The rocks are of the Middle Eocene. This unit is sometimes mapped with the Tyee Formation (Walker and MacLeod, 1991) since the two are similar.

Spencer Formation (P-type Tss)

The Spencer Formation occurs in the south central part of the watershed, and is composed of basaltic and arkosic sandstone that is massive and thick bedded. Fine- to medium- grained arkosic and micaceous sandstone overlies the basaltic sandstone. An exposure of this rock can be seen in the road cut east of Dawson.

Coast Range Intrusive Rocks (P-type Ti)

Intrusive sills and dikes of cap many of the prominent peaks of the Coast Range that help define the western and southern watershed divides. Marys Peak and Grass Mountain are examples of remnants of thick sills that were previously buried beneath a thick cover of sedimentary rocks. Subsequent uplift of the Coast Range stripped away the sedimentary cover leaving intrusive gabbro and diorite rocks at the surface.

Bedrock Foothills and Pediments (P-type, included with corresponding types above)

Appendix 5, **Section 1: Geology (continued).**

The slopes of the Coast Range blend with the western margins of the Willamette Valley and the rock types of the Coast Range, discussed above, make up the bedrock foothills and pediments of the Marys River Watershed. Eolian silts, alluvium and lacustrine deposits may mantle bedrock and colluvium on the lower foothills.

Surficial Geology of the Willamette Valley

Pleistocene Terraces (P-type Qt)
(Quaternary higher terraces, Qth) (Bela, 1979)

Terraces flank lowland margins and tributary valleys. The sand and gravel deposits along the foothills are thin, but in places such as near Corvallis and Philomath they are found in deposits 100 to 200 feet thick. These gravels are substantially weathered and have undergone soil development and extensive leaching in the upper part. The position of these higher terraces may have been a result of tectonic activity around the Willamette Valley. They are estimated to be between 4 and 0.4 million years (Ma yrs.)

Pleistocene Sands and Gravels (P-types included with Qt)

Deposits of varied thickness of unconsolidated clay, silt and sand underlie the present lowlands and valley floors. They are of two main types. One is older outwash gravel (23,000 to 22,000 ka) that makes up a large part of the Willamette aquifer (Gannet and Caldwell, in press). Where these deposits are exposed at the surface they are part of the Winkle and Ingram geomorphic surfaces. The deposits generally have a planar surface or a slight braided channel appearance. Where these deposits are exposed above flood deposits they show paleosol development and weathering to more than 40 inches depth.

The younger deposits post-date the Missoula Floods and are estimated to be 12.3 ka yrs. Distinctions between these and modern flood plain sediments is not always clear in the southern Willamette Valley, where supposed Pleistocene surfaces have historically flooded (O'Conner et al.) Salem and Malabon soils are mapped on these landscapes.

Pleistocene Lacustrine and Alluvial Deposits (P-types Qs)
(Willamette Silts (Allison 1953); Quaternary middle terrace deposits (Bela, 1979) and Missoula Flood deposits)

A large part of the lowland Willamette Valley is covered with thick deposits of silt, clay and sand from numerous floods from Glacial Lake Missoula. The floodwaters surged down the Columbia Gorge and left deposits in the Willamette Valley as far south as Eugene. Deposits at Irish Bend record at least ten such floods during the late Pleistocene 15 to 12.7 ka yrs. The Willamette silt has distinctive features including: rhythmic bedding, a Columbia River Basin provenance, and the presence of oversized

Appendix 5, Section 1: Geology (continued).

erratics that were likely ice-rafted into the Willamette Valley during the flood Missoula Flood events.

The silt underlies a nearly planar and undissected surface that obscures the underlying braid plain topography up to altitudes of 320 to 400 feet. In the southern Willamette valley the deposit is thinner than 30 feet. It thins further towards the margins where it blankets lower foothills and terraces with about 40 inches of silt up to about 400 feet elevation. The well-drained Willamette, and moderately well drained Woodburn soils are associated with the Willamette silt on the somewhat more dissected Senecal geomorphic surface. The poorly drained Dayton soil is associated with these deposits on the undissected and poorly drained Calapooyia geomorphic surface.

Halocene Alluvial Deposits (P-type Qal)
(Quaternary lower terrace deposits, Qral) (Bela, 1979)

These recent floodplain deposits occur on floodplains and channel deposits of the Willamette River and its tributary streams. Deposits of the Willamette are coarser than tributary streams. These deposits underlie the Horseshoe, Ingram and Lukiamute geomorphic surfaces. The current floodplains are inset within 15 to 12.4 ka Missoula flood deposits and 12 ka outwash, and they have been dated as younger than 4ka yrs.

Appendix 5

Section 2: Eight Soil Groups of the Marys River Watershed
(see also Map 19 of Appendix 7).

Agricultural and Mixed Land Use Soils of the Main Valley Floor and Foothills

Table 5-1. Soil Group A Main valley floor terraces, Level to nearly level with few limitations, diverse agriculture and urban uses. Capability classes I and Is and IIw.				
Map Unit	**Series**	**Type**	**Slope class**	**Capability Class**
AbA	Abiqua	Silty clay loam	0-3	I
WeA	Willamette	Silt loam	0-3	I
Sa	Salem	Gravelly loam	0-3	II s
Ma	Malabon	Silty clay loam	0-3	II s
Am	Amity	Silt loam	0-3	II w
WoA	Woodburn	Silt loam	0-3	II w
Mn	McAlpin	Silty clay loam	0-3	II w

Main valley floor terraces, and alluvial soils of tributary valleys. Level to nearly level with few limitations, diverse agriculture and urban uses. Capability classes I and Is and IIw.

These soils are generally well drained to moderately well drained, have high water holding capacity and are very productive with few limitations for agriculture or urban uses. The Willamette silt loam is a well-known member of this group, which supports a diverse assemblage of intensively farmed crops under both irrigation and dryland management. Much of the area of Philomath and Corvallis is developed on these soils. Agriculture and urban land uses will continue to compete for these soils, since they have few limitations and are suited to a wide range of land uses. Abiqua and McAlpin are soils of the tributary valleys that are generally used for less intensive agriculture such as wheat, hay, Section 3 (continued) pasture and some grass seed production. Malabon soils were placed in this group even though in places along Marys River and Muddy Creek they occasionally flood. These areas of Malabon soils near streams are being addressed in the soil survey update in Benton County (M. Fillmore, pers. comm.)

Table 5-2. Soil Group B Gently to strongly sloping soils of the terraces and foothills; Slight to moderate erosion hazard; Capability classes IIe and IIIe.				
Map Unit	**Series**	**Type**	**Slope class**	**Capability Class**
AbB	Abiqua	Silty clay loam	3-5	II e
BeC	Bellpine	Silty clay loam	3-12	II e
BeD	Bellpine	Silty clay loam	12-20	III e
BrB	Briedwell	Gravelly loam	0-7	III e
DnC	Dixonville	Silty clay loam	3-12	II e
DnD	Dixonville	Silty clay loam	12-20	III e
DuC	Dupee	Silt loam	3-12	III e
HaC	Hazellair	Silt loam	3-12	III e
HeC	Hazellair	Complex	3-12	III e
JoC	Jory	Silty clay loam	2-12	II e
JoD	Jory	Silty clay loam	12-20	III e

PhC	Philomath	Silty clay	3-12	IV e
PrC	Price	Silty clay loam	3-12	II e
PrD	Price	Silty clay loam	12-20	III e
VeB	Veneta	Silt loam	2-7	II e
VeD	Veneta	Silt loam	7-20	III e
WeC	Willamette	Silt loam	3-12	II e
WhB	Winchuck	Silt loam	2-7	II e
WkB	Witham	Silty clay loam	2-7	III e
WoC	Woodburn	Silt loam	3-12	II e

Gently to strongly sloping soils of the terraces and foothills; Slight to moderate erosion hazard; Capability classes IIe and IIIe.

Land use on this group ranges from intensive and diverse agriculture on the mollisols of the main valleys to less intensive pasture and hay, Christmas trees, wine grapes and plantation forestry on the redder ultisols on the foothills. Conservation practices should be used that protect the soil surface from rainfall and that control runoff.

Table 5-3. Soil Group C Steeply sloping soils of old terraces and foothills; high hazard of erosion; Capability classes IVe and Vie.

Map Unit	Series	Type	Slope class	Capability Class
ApC	Apt	Sicl	3-12	VI e
BeE	Bellpine	Silty clay loam	20-30	IV e
BeF	Bellpine	Silty clay	30-50	VI e
BrD	Briedwell	Gravelly loam	7-20	IV e
DnE	Dixonville	Silty clay loam	20-30	IV e
DnF	Dixonville	Silty clay loam	30-50	VI e
HeD	Hazellair	Silt loam	12-20	IV e
HgC	Honeygrove	Silty clay loam	3-12	VI e
JoE	Jory	Silty clay loam	20-30	IV e
JRE	Jory	Silty clay loam	2-30	IV e
PhE	Philomath	Silty clay	12-45	VI e
PTE	Price-Ritner	Complex	20-30	IV e
VnE	Veneta	loam	20-30	IV e

Steeply sloping soils of old terraces and foothills; high hazard of erosion; Capability classes IVe and Vie.

These soils are marginal for most agricultural crops because of steep slopes, lack of irrigation water and soil erosion potential, with a few important exceptions including wine grapes and Christmas trees. Jory soils are prized by winegrowers. These soils are productive for Douglas fir and are used in plantation forestry. There is some suburban development occurring on these soils. Much of what remains of Oregon white oak savanna grows on these soils, and may be threatened in the future by competing land uses.

Level and nearly level soils of the floodplains that frequently to rarely flooded, support diverse agriculture, and have slight to moderate risk of erosion from floodwater; Capability classes IIw, IIs, and IVw.

These agricultural soils are predominantly underlying the Ingram geomorphic surface and occupy parts of the floodplains of Marys River, Muddy Creek and the Willamette River. This group supports a very intensive agricultural industry. A wide variety of irrigated vegetable crops, berries, small fruits, mint and hops are grown on these productive soils. Flood damage to soil and property can be significant. Flood control dams on the Willamette have altered the flood frequency and magnitude on some of these lands. Intensive irrigated agricultural land use on coarse-textured soils of this group, such as Newberg overlie a shallow aquifer and this presents concerns for groundwater quality

Table 5-4. Soil Group D Level and nearly level soils of the floodplains that are occasionally flooded, usually support diverse agriculture, and have slight to moderate risk of erosion from floodwater; Capability classes IIw, IIs, and IVw.

Map Unit	Series	Type	Slope class	Capability Class
Ca	Camas	Gr. sandy loam	0-3	IV w
Ch	Chahalis	Silty clay loam	0-3	II w
Cm	Cloquato	Silt loam	0-3	II w
Cn	Coburg	Silty clay loam	0-3	II w
Ms	McBee	Silty clay loam	0-3	II w
Ne	Nehalam	Silty loam	0-3	II w
Ng	Newberg	f. sandy loam	0-3	II w
Nm	Newberg	Loam	0-3	II w
Pk	Pilchuck	f. sandy loam	0-3	IV w

Level and nearly level soils of the floodplains that frequently to rarely flooded, support diverse agriculture, and have slight to moderate risk of erosion from floodwater; Capability classes IIw, IIs, and IVw.

These agricultural soils are predominantly underlying the Ingram geomorphic surface and occupy parts of the floodplains of Marys River, Muddy Creek and the Willamette River. This group supports a very intensive agricultural industry. A wide variety of irrigated vegetable crops, berries, small fruits, mint and hops are grown on these productive soils. Flood damage to soil and property can be significant. Flood control dams on the Willamette have altered the flood frequency and magnitude on some of these lands. Intensive irrigated agricultural land use on coarse-textured soils of this group, such as Newberg overlie a shallow aquifer and this presents concerns for groundwater quality.

Table 5-5. Soil Group E Hydric soils. Poorly drained soils of broad flat terraces and depressions, and floodplains of tributary streams. Grass seed farming and other agricultural crops that can withstand seasonally wet soils. Some areas are artificially drained. Includes important and potential wetlands and riparian areas.

Map Unit	Series	Type	Slope class	Capability Class
Ba	Bashaw	Silty clay loam	0-3	IV w
Bc	Bashaw	Clay	0-3	IV w
Bp	Brenner	Silt loam	0-3	III w
Co	Concord	Silt loam	0-3	III w
Cs	Conser	Silty clay loam	0-3	III w
Da	Dayton	Silt loam	0-3	IV w
Wa	Waldo	Silty clay loam	0-3	III w
Wc	Wapato	Sitly clay loam	0-3	III w

Hydric soils. Poorly drained soils of broad flat terraces and depressions, and floodplains of tributary streams.

These soils are all naturally poorly drained, some are artificially drained, and most are currently farmed wetlands. Dayton soils, locally known as "white ground", are very difficult to drain but are well suited to production of rye grass seed and the few other agricultural crops that can withstand seasonally wet soils. These soils are not suited to un-sewered development because the soils are wet and have restrictive layers. The Waldo and Bashaw soils are fine-textured soils of tributary floodplains, drainages and depressions. They are used for grass seed production, pasture, and hybrid poplar. These fine textured bottomland soils are sediment and nutrient sinks, however they can contribute fine sediment and phosphorus to streams where the streambanks are not vegetated and are eroding. Soils of this group include important wetland and riparian areas, such as the Finley National Wildlife Refuge on Muddy Creek.

Forested and Mixed Land Use Soils of the Coast Range and Foothills

Table 5-6. Soil Group F High productivity forestland with low erosion risk for forest management. Marginal to high-risk agriculture practiced in places. Very strongly sloping (3-30 percent). Some soils have high risk of slumping.

Map Unit	Series	Type	Slope class
ASD, ATD	Apt	Silty clay loam	5-25
BLE	Blachly	Silty clay loam	3-30
HND, HOD	Honeygrove	Silty clay loam	3-25
MGD	Marty	Gravelly loam	3-25
PEE	Peavine	Silty clay loam	3-30
RPE	Ritner-Price	Complex	12-30
SLD	Slickrock	Gravelly loam	3-25

High productivity forest land with low erosion risk for forest management. Marginal to high-risk agriculture practiced in places. Moderately to very strongly sloping (3-30 percent). Some soils have high risk of slumping.

Group G Moderate to high productivity forestland with high erosion risk for forest management. Not suited to agriculture. Steeply sloping (25-60 percent).

Group H These soils are either unproductive forest soils; or they are low to moderately productive forest soils and are very steeply sloping (greater than 50 to 60 percent) and have severe limitations to forest management.

APPENDIX 6: Conditions of Selected Sensitive Species

Amphibians and Reptiles

- Clouded salamanders are rare forest dwellers that depend on large downed woody debris for habitat. Southern torrent salamanders are found in microhabitats providing a constant flow of cool water such as small headwater streams above the upper extent of fish use.
- Tailed frogs inhabit cold water streams in the Coast and Cascade mountain ranges. Tadpoles rear in clear, fast flowing water.
- Red-legged frogs are seriously declining in the Willamette Valley. Several recent surveys have failed to detect this species where they were once abundant (Csuti et al. 1997).
- Spotted frogs were once thought to be common west of the Cascades but have disappeared from the Willamette Valley. Spotted frogs have been severely affected by the introduction of bullfrogs and are now found only at sites that do not support bullfrogs.
- The western pond turtle was once common to all wetland habitats of the Willamette Valley but has since declined by as much as 96-98 % since the beginning of the century. Declines are in part due to wetland habitat loss and predation on young turtles by introduced species such as bullfrogs and bass (Csuti et al. 1997).
- Painted turtles exist in highly disjunct populations in the Willamette valley and may not exist at all in Benton County (ODFW Sensitive Species List, 1997).

Birds

- Marbled murrelets are listed “Threatened” under ESA throughout their range due to loss and fragmentation of nesting habitat, leading to nest failure. There has been a yearly 4-7 % decline in population for the western United States. These birds venture 50 miles into the Coast Range from Pacific Ocean to nest in the branches of large trees. Murrelets are thought to occur in the western portions of the watershed and probably nest in the Rock Creek watershed (J. Fairchild, pers. comm.).
- Northern spotted owls also prefer large trees for nesting habitat in late-successional mixed coniferous forests with multiple layers and a closed canopy. Harvest of old growth stands and predation by great horned owls have eliminated the spotted owl from much of the lower elevation forests of western Oregon (Csuti et al. 1997). The spotted owl is known to occur in the Marys River Watershed.
- The Western meadowlark has been identified as in decline from much of its former range--savanna grasslands of the Willamette Valley. Western Meadowlarks are grassland-associates that have especially declined from the Willamette Valley in the last 15-20 years.
- The Oregon vesper [savanna] sparrow have been identified as in decline from much of its former range--savanna grasslands of the Willamette Valley.
- The Lewis’ woodpecker as recently as the mid-970s were fairly common in the Christmas bird counts in the Corvallis area. They have nearly disappeared in recent years. Their decline may possibly be related to loss of white-oak savanna communities (J. Plissner, Audubon Society of Corvallis, pers. comm.).

- Yellow-breasted chats are listed by the state as critical in the Willamette Valley and are declining nationally and regionally (ODFW Sensitive Species List 1997).
- Purple martins are state sensitive birds that have shown declines in the Willamette Valley.
- Common nighthawks are state sensitive birds that have shown declines in the Willamette Valley.
- Horned larks are state sensitive birds that have shown declines in the Willamette Valley.
- Neo-tropical migratory birds as a group are nationally and internationally declining and occur throughout the Willamette Valley and Coast Range (ODFW Sensitive Species List 1997).
- Osprey, after years of precipitous declines nationally, are now common along the Willamette River. Their rebound is largely due to banning of DDT. Other birds of prey that appear to be increasing or are abundant include red-tailed hawks, great horned owls, kestrels, Coopers hawk and sharp shinned hawks. Red tailed hawks and other perching hunters such as the kestrel may benefit from changes in land use. Grass field and cessation of field burning likely promotes the populations of mice and insects; fence posts and wires provide abundant perches.
- Mallard ducks have shown recent population increases, due to favorable spring nesting conditions locally and in Canada.
- Western bluebirds have sustained nationwide declines. However Corvallis (and Portland) is notable in that recoveries of their populations seem to be occurring. The increase is thought to be a program of nestbox establishment by committed birders (J Plissner, pers. comm.). A 25-year record of Christmas bird counts is maintained on EXCEL databases by volunteers in the Corvallis area, which includes parts of the Muddy Creek Subbasin. These data are part of a nationwide program supported by the National Audubon Society and can provide data on bird population changes (J Plissner, current count coordinator (541) 750-7433).
- The Willamette Valley represents the wintering grounds for the entire population of dusky goose, a subspecies of the Canada goose. In the early 1960s, the dusky geese were estimated between 10,000 and 15,000. Mortality was increasing due to hunting pressure on concentrated flocks. The Finley National Wildlife Refuge (NWR) began establishing viable habitat for the grazing dusky geese in order to redistribute the population and decrease mortality rates. These refuges planted forage foods, wetland plants and provided a sanctuary from disturbances with a mandatory no hunting zone and minimal public interventions. The dusky goose population is currently not threatened or endangered and remains stable. In 1997, the total population of dusky geese wintering in the Willamette Valley was estimated at 21,000 (M. Naughton, Finley NWR, pers. comm.). It not expected that the dusky geese will likely recover to huntable populations because of the lost breeding habitat due to an earthquake in Alaska. In addition to the protected dusky, a yet larger population of Taveners, cackling, and western Canada geese congregate on the refuge. These congregations of geese at Finley and the other refuges have created concern among the grass seed industry due to the excessive damage to crops.

Mammals

- The Pacific western big-eared bat is intolerant of human disturbance and yet often roosts in buildings, mines and bridges as a substitute for caves. Roosting sites are more important in determining the distribution of this bat than vegetation type, although most of the bats of the subspecies occurring west of the Cascades prefer forested regions. Human disturbance to bats in their natural cave roosts have impacted bat populations (ODFW Sensitive Species List 1997).
- The white-footed vole inhabits alder-dominated riparian habitats in coniferous forests. Little is known about population numbers, but this species is very uncommon.
- Lynx are rare in Oregon, which is the southern limit of their range on the west coast. They typically inhabit dense boreal forests that have some openings, such as meadows, bogs, or rocky outcrops. The last confirmed specimen was taken in Corvallis in 1974, but most other occurrences have been from east of the Cascade mountains (Csuti et al. 1997).
- Hunters once commonly shot white-tailed deer before the turn of the century according to journal entries reviewed by Storm (1941). Today Columbia white-tail deer are not even listed as occurring in Benton County by the Wildlife Atlas (Csuti et al. 1997) nor are they on any sensitive species lists. Probably because Columbia white-tail deer prefer riparian lowland habitats, they were extirpated soon after Euro-american settlement.
- Perhaps beaver were the first mammal to be severely affected in the local area due to trapping during the 1800s. Beaver may have been locally extirpated and were re-introduced in the Oak Creek area in 1940s by the Game Department of the Oregon State College (Storm 1941). They appear to be well established again either by this re-introduction and by natural re-introductions. Many other mammals were supposedly reduced by trapping including the marten, mink, and otter (Storm, 1941). Otters and mink apparently have recovered somewhat, whereas marten are extremely rare.
- Cougar were considered to be very rare by Storm in the local area (1941). Their numbers are now stable enough to provide sport hunting in the more remote areas of the Coast Range. With recent restrictions on the use of dogs to hunt cougars, it appears their numbers may be increasing closer to the urban areas, with a resulting increase in the rate of negative encounters between the public and the large cats.
- Elk were once common, and, according to Storm (1941), the early trappers in Oregon purposely traveled to the Willamette Valley for the ease of obtaining meat. The abundant elk were quickly driven out of the valley area by the rapid settlement that started about 1850 and by uncontrolled hunting. Today, elk exist in the Marys River Watershed, but tend to be reclusive and are seldom seen by the public. A herd of approximately 100 Roosevelt elk lives year round in the vicinity of Finley NWR. They appear to stay on the refuge to avoid hunters and probably the residential development.

APPENDIX 7: GIS and Other Maps- Each map is a separate file

Map 1: Three areas of the watershed: Forested Uplands, Valley Floor, and Urban (1824 KB).

Map 2: Land use (49 KB).

Map 3: Land ownership.

Map 4: Urban growth boundaries, wetlands, and 303(d) listed waters.

Map 5: Population density.

Map 6: Sub-watersheds.

Map 7: Watershed area in Benton County.

Map 8: Extent of 1996 floods.

Map 9: Pre-settlement vegetation (1850).

Map 9a: 1850 vegetation types in riparian areas of the lower Marys River.

Map 9b: 1997 vegetation types in riparian areas of the lower Marys River.

Map 9c: 1994 USGS digital orthophotos of riparian areas of the lower Marys River.

Map 10: 303(d) listed reaches.

Map 11: Distribution of stocked runs of winter steelhead.

Map 12: Upper extent of fish distribution and stream size classifications.

Map 13: Distribution of stocked runs of coho salmon.

Map 14: Stream reaches where ODFW aquatic habitat surveys have been performed.

Map 15: Riparian vegetation classification along ODFW surveyed stream reaches.

Map 16: 1852 and 1986 vegetation of the Willamette River.

Map 17: 1990 vegetation types.

Map 18: Wetlands.

Map 19: Soil types.

Map 20: Geology

GIS Metadata Sources

Theme description	File Name	Scale	Source	Source Series	Acquired From	Original Source	More Info
1990 Population Age	bgpop	1:100,000	USCB	TIGER	SSCGIS	USCB TIGER	
1990 Poverty Rate/ Household Income	povinc	1:100,000	USCB	TIGER	SSCGIS	USCB TIGER	
1996 Floodplain	flood		Army Corp of Engineers		Benton County	Army Corp of Engineers	
303d-Listed Streams	str303d	1:100,000	Oregon Dept. of Env. Qual		SSCGIS	Oregon Dept. of Env. Qual	303d.txt
Aquatic Inventory – Habitats	aqhab	1:100,000	ODFW		ODFW	ODFW	aqinv.doc
Aquatic Inventory – Reaches	aqinvrch	1:100,000	ODFW		ODFW	ODFW	aqinv.doc
Aspect	aspct1 (grid)	30m	Marys River Watershed Council			30M DEM	
Benton County Boundary	cntybnd	n/a	Benton County		Benton County	Benton County	bentco.doc
Benton County Zoning - w/in watershed	bczonews	n/a	Benton County		Benton County	Benton County	
Bridges - Benton County	bridges	n/a	Benton County		Benton County	Benton County	bentco.doc
Census Blocks - w/in watershed	blocksws	1:100,000	SSCGIS	Public Land Survey System (PLSS)	SSCGIS	USCB TIGER	trs-grid.htm
Cities	cities_noclp	1:24,000	U.S. DOT		SSCGIS	U.S. DOT	
Cities - w/in watershed	cities	1:24,000	U.S. DOT		SSCGIS	U.S. DOT	
Coho Stocking Distribution	coho	1:100,000	ODFW		ODFW	ODFW	
Elevation	elev (grid)	30m	Marys River Watershed Council			30M DEM	
EPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites – Benton County	epacerc	n/a	EPA		ODFW	EPA	
EPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Sites - w/in watershed	epacerc1	n/a	EPA		ODFW	EPA	
EPA Intake Sites – Benton County	epaintak	n/a	EPA		ODFW	EPA	
EPA Intake Sites - w/in watershed	epaintk1	n/a	EPA		ODFW	EPA	
EPA National Pollution Discharge	epanpdes	n/a	EPA		ODFW	EPA	

GIS Metadata Sources (continued)

Theme description	File Name	Scale	Source	Source Series	Acquired From	Original Source	More Info
EPA Resource Conservation and Recovery Act	eparcra	n/a	EPA		ODFW	EPA	
EPA Toxic Release Inventory Sites	epatri	n/a	EPA		ODFW	EPA	
EPA Toxic Release Inventory Sites	epatri1	n/a	EPA		ODFW	EPA	
EPA Wells	epawells	n/a	EPA		ODFW	EPA	
EPA Wells	epawells1	n/a	EPA		ODFW	EPA	
Fish distribution	fishdof	1:24,000	Oregon Dept. of Forestry		ODFW		
Floodplain – FEMA	fldpln		Federal Emergency Management Agency		Benton County		
Geology	geol	n/a	Corvallis FSL (USFS/OSU)		CLAMS		geolgrps_po.doc
Hillshade	hilshd1 (grid)	30m	Marys River Watershed Council			30M DEM	
Land Ownership	ownershp	1:126,720	Corvallis Forestry Sciences Lab		CLAMS	Atterbury Inc., USFS, Oregon Wilderness Soc.	ownership.doc
Landuse	landuse	n/a	Coatal Landscape Analysis and Modelling Study		CLAMS		
Major Highways	hwy_maj	1:100,000	USCB	TIGER	CLAMS	USCB TIGER	roads.doc
Marys River Watershed – SSCGIS	watershd	1:24:000	Regional Ecosystem Office		SSCGIS	Regional Ecosystem Office	5thfld_wshds.txt
Marys River Watershed Boundary	wsnew	1:24,000	Benton County		Benton County	Benton County	bentco.doc
Public Land	publand	n/a	Benton County		Benton County	Benton County	bentco.doc
Railroads	railroad	n/a	Benton County		Benton County	Benton County	bentco.doc
Rivers and Streams	rivers	1:100,000	EPA	River Reach	CLAMS	USCB TIGER	rivers100.doc
Road Centerlines	cntrline	1:100,000	Benton County	TIGER	Benton County	USCB TIGER	bentco.doc
Roads	roads2	1:100,000	USCB	TIGER	CLAMS	USCB TIGER	roads.doc
Section Lines	sect_ln	1:100,000	SSCGIS	Public Land Survey System (PLSS)	SSCGIS	Oregon Water Resource Dept.	trs-grid.htm
Slope	slope1 (grid)	30m	Marys River Watershed Council			30M DEM	
Soils – Benton County – w/in watershed	soils2	1:24,000	Natural Resource Conservation Service	SSURGO	Benton County	Natural Resource Conservation Service	bentco.doc

GIS Metadata Sources (continued)

Theme description	File Name	Scale	Source	Source Series	Acquired From	Original Source	More Info
State Highways – Benton County only	statehwys	1:100,000	USCB	TIGER	CLAMS	USCB TIGER	roads.doc
Stream Gaging Stations	gagesta	n/a	Marys River Watershed Council			U.S. Geological Survey	
Taxlots - Benton County	parcels	n/a	Benton County		Benton County	Benton County	bentco.doc
Township and Range – lines	tr2ln	1:100,000	SSCGIS	Public Land Survey System (PLSS)	SSCGIS	Oregon Water Resource Dept.	trs-grid.htm
Township, Range and Section - lines	trs	1:100,000	SSCGIS	Public Land Survey System (PLSS)	SSCGIS	Oregon Water Resource Dept.	trs-grid.htm
Township, Range and Section - polys	trs2	1:100,000	SSCGIS	Public Land Survey System (PLSS)	SSCGIS	Oregon Water Resource Dept.	trs-grid.htm
Urban Growth Boundary	ugb	n/a	City of Corvallis		City of Corvallis	City of Corvallis	
Vegetation - 1988	veg (grid)	n/a	Coatal Landscape Analysis and Modelling Study		CLAMS	CLAMS	veg88.doc
Vegetation - Current	veg_crnt	n/a	ODFW		ODFW	ODFW	odfw_veg.doc
Vegetation - Historic	veg_hist	n/a	The Nature Conservancy	Oregon Natural Heritage Program	The Nature Conservancy	The Nature Conservancy	GLO Appendix.doc
Water	water	1:250,000	U.S. Geological Survey	TIGER	Benton County	U.S. Geological Survey	bentco.doc
Watershed Boundaries - CLAMS	ws_clams	n/a	Coatal Landscape Analysis and Modelling Study		CLAMS	CLAMS	
Watershed Sub-basins	maryssubs	1:24,000	Benton County		Benton County	Benton County	bentco.doc
Western Oregon Forest Ownership	worfor	1:126,720	OSU Forest Science Lab		OSU Forest Science Lab	OSU Forest Science Lab	worfor.txt
Western Pond Turtle Distribution	turtle	n/a	ODFW		ODFW	ODFW	
Wetlands - NWI	wetlands	1:24,000	USFW	National Wetlands Inventory	ODFW	U.S. Fish and Wildlife Service	bentco.doc
Wetlands - NWI	wtlnd	1:24,000	USFW	National Wetlands Inventory	ODFW	U.S. Fish and Wildlife Service	bentco.doc
Wetlands - ONHP	wetlnd	1:24,000	The Nature Conservancy	Oregon Natural Heritage Program	Benton County		wetlands.htm
Winter Steelhead	stwin	1:100:000	ODFW		ODFW	ODFW	
Zoning	zone	1:100,000	SSCGIS		SSCGIS		zoning.htm

Key to historical vegetation types on Map 9.

The following is the provisional classification of "presettlement" vegetation for the Willamette River Basin. The table will be updated as the GIS mapping of historic vegetation continues. This table was prepared by Oregon Natural Heritage Program, The Nature Conservancy of Oregon (28 Oct. 1997).

Key to first letter of veg type:

F = Closed forest
H = Shrubland
N = Composition unknown
O = Woodland
P = Prairie
S = Savanna
U = Unvegetated
W = Water or wetland

Class	Abbr.	Plant species in Association
CLOSED FOREST:		
WETLAND	FALW	Ash, alder, willow, bigleaf maple swamp, often with vine maple and ninebark.
	FAW	Ash, willow swamp, sometimes w/ ninebark & briars; "very thick".
	FFA	Ash, mixed deciduous riparian forest with combinations of bigleaf maple, black cottonwood, red alder, white oak, dogwood, and willow. Douglas & grand fir, ponderosa pine and red cedar may be present in small quantities. Undergrowth includes willow, hazel, ninebark, vine maple, viburnum and yew. Differs from FFCL by having fewer conifers.
	FFCL	Red alder, mixed conifer riparian forest; combinations of red cedar, grand & Douglas fir, hemlock, bigleaf maple, black cottonwood and sometimes ash; undergrowth includes yew, dogwood, vine maple, elder, hazel, willow, salmonberry and nettles. Differs from FFA by larger conifer component. No oak.
	FOA	White oak, ash riparian forest, sometimes with ponderosa pine, cottonwood and willow. No fir.
CLOSED FOREST: UPLAND	FED	Inseparable mixture of (1) xeric Douglas fir-chinquapin-madrone forest on S slopes & ridgetops & (2) more mesic Douglas fir-western hemlock or Douglas fir-bigleaf maple on N slopes & bottoms, sometimes with incense cedar, oak, grand fir, red cedar, yew, red alder and dogwood.
	FF	Douglas fir or grand fir forest, often with bigleaf maple, alder, vine maple, dogwood, hazel, yew; sometimes with ash. No other conifers present; no oak.
	FFBu	FF, but burned, often with scattered trees surviving fire
	FFHC	Douglas fir, with various combinations of western hemlock, red cedar, bigleaf & vine maple, yew, dogwood, red huckleberry, hazel, Oregon grape; sometimes with oak.
	FFHCBu	FFHC, but burned, often with scattered trees surviving fire.
	FFO	Douglas fir-white oak forest; undergrowth as in FF, but including oak.
	FFP	Douglas fir-ponderosa pine forest; no oak.
	FO	White oak forest.
SHRUBLAND	HW	Willow swamp or "willow swale", sometimes with ninebark, including riparian stands on gravel or sand bars. May contain small amounts of ash.

	HZ	Hazel brush or thicket.
COMPOSITION UNKNOWN	NSU	Swamp, composition unknown
	NU	Brush, unknown; includes “thickets” if no species or other descriptors are given.
	NWU	Wetland, composition unknown; includes “slough” & “swale” in forest or shrubland; “swale” in prairie = P.
WOODLAND	OFHC	Conifer-dominated woodland; various combinations of Douglas fir, red cedar, western hemlock, bigleaf maple, white oak, red alder, dogwood. undergrowth includes vine maple, hazel, briars, and yew. No ash present.
	OFOZ	“Scattering” or “thinly timbered” Douglas fir-white oak (bigleaf maple) woodland, with brushy undergrowth of hazel, other shrubs, young oaks, oak brush, oak stump sprouts, young Douglas fir, bracken, briars, sometimes willow. More open than FFO; differs from SOF in having brushy undergrowth.
	OFZ	Douglas fir woodland or “timber” often with bigleaf maple, alder or dogwood; brushy undergrowth of hazel, vine maple, young Douglas fir, bracken or “ferns”. “Fern openings” sometimes present. No oak, hemlock or cedar. More open than FFO; differs from SF in having brushy undergrowth.
	OFZBu	OFZ, but burned, often with scattered trees surviving fire
PRAIRIE	P	Prairie, wet & dry, undifferentiated. Includes “swale” & “glade” if adjacent segments are prairie. Wet prairie may have scattering of ash trees.
SAVANNA	SF	Douglas fir savanna.
	SO	White oak savanna.
	SOF	White oak-Douglas fir savanna, mostly herbaceous undergrowth.
	SOP	White oak-ponderosa pine savanna.
UNVEGETATED	UG	Gravel bar
WATER; EMERGENT WETLAND, OR AQUATIC BED	W	Water bodies 1 or more chains across, including rivers, sloughs, ponds, beaver ponds, lakes & “bayou”.

Eight Soil Type of the Marys River Watershed (see Map 19)

Valley Floor and Foothills

Group A Main valley floor terraces, and alluvial soils of tributary valleys. Level to nearly level with few limitations, diverse agriculture and urban uses. Capability classes I and Is and IIw.

These soils are generally well drained to moderately well drained, have high water holding capacity and are very productive with few limitations for agriculture or urban uses. The Willamette silt loam is a well-known member of this group, which supports a diverse assemblage of intensively farmed crops under both irrigation and dryland management. Much of the area of Philomath and Corvallis is developed on these soils. Agriculture and urban land uses will continue to compete for these soils, since they have few limitations and are suited to a wide range of land uses. Abiqua and McAlpin are soils of the tributary valleys that are generally used for less intensive agriculture such as wheat, hay, pasture and some grass seed production. Malabon soils were placed in this group even though in places along Marys River and Muddy Creek they occasionally flood. These areas of Malabon soils near streams are being addressed in the soil survey update in Benton County (M. Fillmore, pers. comm.)

Group B Gently to strongly sloping soils of the terraces and foothills; Slight to moderate erosion hazard; Capability classes IIe and IIIe.

Land use on this group ranges from intensive and diverse agriculture on the mollisols of the main valleys to less intensive pasture and hay, Christmas trees, wine grapes and plantation forestry on the redder ultisols on the foothills. Conservation practices should be used that protect the soil surface from rainfall and that control runoff.

Group C Steeply sloping soils of old terraces and foothills; high hazard of erosion; Capability classes IVe and Vie.

These soils are marginal for most agricultural crops because of steep slopes, lack of irrigation water and soil erosion potential, with a few important exceptions including wine grapes and Christmas trees. Jory soils are prized by winegrowers. These soils are productive for Douglas fir and are used in plantation forestry. There is some suburban development occurring on these soils. Much of what remains of Oregon white oak savanna grows on these soils, and may be threatened in the future by competing land uses.

Group D Level and nearly level soils of the floodplains that frequently to rarely flooded, support diverse agriculture, and have slight to moderate risk of erosion from floodwater; Capability classes IIw, IIs, and IVw.

These agricultural soils are predominantly underlying the Ingram geomorphic surface and occupy parts of the floodplains of Marys River, Muddy Creek and the Willamette River. This group supports a very intensive agricultural industry. A wide variety of irrigated vegetable crops, berries, small fruits, mint and hops are grown on these productive soils. Flood damage to soil and property can be significant. Flood control dams on the Willamette have altered the flood frequency and magnitude on some of these lands. Intensive irrigated agricultural land use on coarse-textured soils of this group, such as Newberg overlie a shallow aquifer and this presents concerns for groundwater quality.

Group E Hydric soils. Poorly drained soils of broad flat terraces and depressions, and floodplains of tributary streams.

These soils are all naturally poorly drained, some are artificially drained, and most are currently farmed wetlands. Dayton soils, locally known as “white ground”, are very difficult to drain but are well suited to production of rye grass seed and the few other agricultural crops that can withstand seasonally wet soils. These soils are not suited to un-sewered development because the soils are wet and have restrictive layers. The Waldo and Bashaw soils are fine-textured soils of tributary floodplains, drainages and depressions. They are used for grass seed production, pasture, and hybrid poplar. These fine textured bottomland soils are sediment and nutrient sinks, however they can contribute fine sediment and phosphorus to streams where the streambanks are not vegetated and are eroding. Soils of this group include important wetland and riparian areas, such as the Finley National Wildlife Refuge on Muddy Creek.

Coast Range and Foothills

Group F High productivity forest land with low erosion risk for forest management. Marginal to high-risk agriculture practiced in places. Moderately to very strongly sloping (3-30 percent). Some soils have high risk of slumping.

Group G Moderate to high productivity forestland with high erosion risk for forest management. Not suited to agriculture. Steeply sloping (25-60 percent).

Group H These soils are either unproductive forest soils; or they are low to moderately productive forest soils and are very steeply sloping (greater than 50 to 60 percent) and have severe limitations to forest management.