Chapter 4– Channel Modifications

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Introduction

This chapter examines the physical condition of stream channels in the four watersheds. While the extent of channel modifications differs among the four watersheds, typical human alterations to the streams include channelization; bank armoring; construction of ditches and flood control structures; construction of dams, weirs and reservoirs; stream cleaning; the construction of roads in floodplains; culverting and piping streams; and sand and gravel mining. In general, most of these changes are made to prevent the flooding and erosion of public and private property and to provide irrigation water that is used for urban and agricultural purposes.

This chapter outlines the types of channel modifications, the extent of modifications in the four watersheds, and the impact channel modifications have on fish and wildlife habitat.

Data Sources

In order to identify the extent of channel modification in the four watersheds, information was collected from watershed residents, Oregon Division of State Lands (DSL), Oregon Department of Geology and Mineral Industries (DOGAMI), the City of Salem, Oregon Water Resources Department (OWRD), and other watershed assessments in the Willamette Valley.

Types of Channel Modifications and Their Extent in the Four Watersheds

Stream Channelization and Bank Armoring

In all four watersheds, many streams or stream sections have been subjected to some form of stream channelization. This activity often entails deepening, widening, relocating, splitting, or straightening streams. Channelization is mostly done on streams flowing through agricultural and urban settings. Many of the local streams have at least some reaches that, prior to European settlement, farming and development, were braided channels. However, it is important to note that some streams flow through naturally confined channels, such as the steep and narrow ravines found in the upper stream reaches of the Glenn-Gibson and Mill Creek watershed. To keep channels in their modified form, it was sometimes considered necessary to periodically dredge out accumulated sediment and to armor the banks with either riprap or retaining walls. Riprap includes things like large rocks or wood used to stabilize banks and prevent them from eroding (Thieman 2000).

An example of stream bank stabilization/bank armoring in the Salem area occurred after the 1996 floods. The City of Salem Public Works Department contracted to repair flood damage along several streams. In some cases, gabions (rock-filled weirs) and interlocking concrete blocks were installed along stream banks. In Cannery Park in the Pringle Creek watershed, gabions were placed to "correct," contain and direct flow around a bend. Shortly thereafter, native plants were placed on top of the gabions. In addition, willow fascines were planted immediately upstream. Today, the willows grow thick and tall; the bank is stable where they were planted. The gabions have not fared as well and are deteriorating as a result of vandalism, heavy recreational use at the park, and improper installation (Kroger pers. comm.). Ultra blocks (interlocking concrete blocks) can also be seen at Hawthorn and Mill Creek, 25th and Mill Creek, and I-5 and Mill Creek. The blocks were used to stabilize the vertical stream bank where there was insufficient room for a natural stabilization solution.

The extent of channelization and bank armoring in the four watersheds is unknown. Because three of the four watersheds are mostly urban, the number of stream miles in which stream channels have been straightened and/or stream banks armored is probably extensive.

Drainage Ditches and Flood Control Structures

The construction of drainage ditches and other flood control structures is another type of channel modification. To drain fields for agricultural use, farmers dug ditches and sometimes installed drainage tiles in order to be able to plow their fields. The State of Oregon leased out the lands around Hillcrest School to local farmers before SumcoUSA built in the Fairview Industrial Park. During this agricultural phase, farmers installed drainage tiles and built ditches, to transport water into the Hillcrest

Ditch. No one ever mapped this out, partly because farmers knew their land well, and also because flow and seepage changed, often annually. The longer-term consequences were that when SumcoUSA's acid spill occurred in April, 2000, it went into a storm drain system that rested in gravel which both reached the public storm drainage system and connected to the old unmapped, underground tile drain complex. Both led to Pringle Creek.

The need for a consistent year-round stream flow for powering mills in the Salem area instigated the construction of the Salem Ditch and others in the 19^{th} century. The Shelton Ditch diverts water from Mill Creek year-round but was initially constructed along an old stream channel to divert water into Pringle Creek during high water events. Thus, waters of the Mill Creek watershed regularly flow into the Pringle Creek watershed. The Mill Race, another human-constructed waterway, also diverts water from Mill Creek into Pringle Creek. The Race currently supplies water to the turbine at the Mission Woolen Mill and to the City of Salem's reflecting pool at City Hall.

Dams, Weirs and Reservoirs

Other common modifications in the four watersheds are dams, weirs and reservoirs. There are numerous small impoundments used for livestock watering, irrigation, recreation, and other activities. Within Salem's urban growth boundary (not including the City of Keizer), there are a total of 50 dams and weirs located in the four watersheds (**Table 4-1**) (City of Salem 2001). According to OWRD, there are 94 *registered* reservoirs (impoundments) located within the four watersheds (**Table 4-2**) (see Hydrology chapter for location of dams, weirs and reservoirs). The OWRD database does not include small weirs, which are found in several places in the Pringle Creek watershed.

Table 4-1. Dams locations by watershed

Watershed	Dams
Pringle Creek	31
Glenn-Gibson Creek	12
Upper Claggett Creek	0
Mill Creek	7
Total	**50**

Source: City of Salem Fish Passage Survey (City of Salem 2001).

Table 4-2. Number of registered reservoirs by watershed	
Watershed	**Reservoirs**
Pringle Creek	6
Glenn-Gibson Creek	25
Upper Claggett Creek	1
Mill Creek	62

Source: Oregon Water Resources Department

Stream Cleaning and the Removal of Large Woody Debris

Another common practice in both urban and rural streams is stream cleaning. The OWAM defines stream cleaning as the removal of large wood or fine organic matter (i.e., branches, twigs, leaves, etc.) from stream channels (Watershed Professionals Network 1999). Another term often used for organic matter is "leaf litter." In the past, the primary purpose for stream cleaning was to remove flow obstructions and to maintain the stream's flow carrying capacity, as well as to minimize flooding. In addition, it was considered beneficial to remove debris jams that were thought to block fish passage, or to remove fine organic matter that was thought to cause water quality problems such as reducing aquatic oxygen levels. More recently, biologists began to understand the importance of large woody debris (LWD) and now, under certain circumstances, recommend leaving large wood in streams. Current research considers LWD and leaf litter as extremely valuable habitat areas for aquatic wildlife and leaf litter alone serves as an important energy source in the aquatic food web (Schueler and Holland 2000).

LWD is not tolerated in streams flowing through urban areas due to localized flooding hazards. Rural property owners may remove large woody debris to prevent flooding on farm fields. In urban areas LWD is removed to prevent local flooding and prevent damage to in-stream infrastructure such as culverts, pipes and bridges. LWD was successfully incorporated into a fish habitat enhancement project in Salem. The project is located in Mill Creek near Summer Street. In this instance, the LWD is partially buried in the stream banks, severely limiting the movement of the LWD, thus posing little threat to downstream structures.

The City of Salem continues to use traditional stream cleaning practices that include mechanical and manual methods. Seasonal stream cleaning remove trash, garbage and debris from Salem's streams. In a change from past practice, before removing natural debris, the teams now check for potential flow obstructions and try to leave natural debris such as tree branches and stumps as fish habitat enhancers. In past instances watershed council members question the City's techniques. For example, in the summer of 2001, a ditch (some would argue that it is actually a small intermittent stream) near an electrical substation was scraped down to bare soil, removing wetland plants such as reeds, rushes and cattails. According to the City of Salem, the stream cleaning was necessary to improve flood conveyance and reduce fire hazard (Kroger pers. comm.). Removing LWD eliminates habitat for macro invertebrates and can encourage the growth of invasive species.

Roads Within Floodplains

Roads that run parallel to streams and rivers and are within their floodplain are also potential channel modifications because they can limit the extent of flooding. To protect the extensive network of roads from inundation and erosion, many roadbeds in floodplains are elevated while stream banks are armored. Elevated roadbeds can act like a levy, limiting the extent of flooding. Please refer to the FEMA maps in the Hydrology chapter to examine the extent of roads within the 100-year flood plain of local streams.

Construction of Culverts, Pipes, and Bridges

Channel modifications related to development and transportation infrastructure include culverts, pipes (storm drains) and bridges. The City of Salem estimates that there are 128 stream crossings (includes all streams) within the city limits of Salem (City of Salem Public Works Department 2000). Culverts and pipes convey and sometimes relocate streams underground. These structures confine stream channels and can eliminate the channels' ability to migrate within their floodplains.

As in many urban settings, Salem and Keizer's streams have been extensively piped and culverted. In the four watersheds, over 457 miles of storm drains and 17.93 miles of culverts convey water underground. **Table 5-9** in the Hydrology chapter breaks down the open and closed stormwater systems for each watershed within the Salem Urban Growth Boundary. The City of Salem's Fish Passage Survey (2001), reports a total of 62 bridges located in the four watersheds (**Table 4-3**) (see Hydrology chapter for location of bridges).

Table 4-3. Bridge locations by watershed within the Salem UGB

Watershed	Bridges
Pringle Creek	14
Glenn-Gibson Creek	2
Upper Claggett Creek	2
Mill Creek	44
Total	**62**

Source: City of Salem 2001.

Sand and Gravel Mining

Sand and gravel mining can alter both the shape of a stream channel and its bottom substrate (i.e. gravel, rock, sand and silt). The result of such changes include increased water velocities above the mined areas, causing local channel scouring and erosion. Sand and gravel operations typically occur adjacent to stream channels in our area. Dikes are built between the stream and the active mine in an attempt to protect the stream from any adverse impacts associated with mining. The Department of Geology and Mineral Industries (DOGAMI) regulates all upland and underground mining activities in Oregon.

The largest number of active aggregate mining operations is located in the Mill Creek watershed. Four aggregate mine sites are active in this watershed. Claggett has two active sites while Glenn-Gibson and Pringle have no active mine sites (see Water Quality chapter for location of active mines).

General Channel Modifications

Both the Oregon Division of State Lands (DSL) and the U.S. Army Corps of Engineers regulate soil, sand and gravel moving activities in wetlands and waterways. According to Oregon's Removal-Fill Law (ORS 196.800), a removal-fill permit is required if 50 cubic yards or more of material are moved within streams or wetlands, with the exception of "essential indigenous anadromous salmonid habitat" when there is no minimal quantity threshold (DSL 2001). Beginning in 1996, work in streams designated as essential for salmonid survival required a permit for any amount of removal or fill work.

While current records indicate 97 removal-fill permits were issued in the four watersheds over the last 30 years, records do not indicate what type of soil, sand or gravel moving events (i.e., construction of culverts, bridges, bank armoring, stream channelization) occurred (**Table 4-4**). The total number or cumulative effects for removal-fill practices below 50 cubic yards and for those performed prior to 1970 are not known. In addition, Oregon's Removal-Fill Law does not cover floodplain development. Floodplain development is allowed within certain parameters and is regulated by local land use ordinances. For example, the City of Salem revised code (SRC) Chapter 140 regulates floodplain overlay zones, establishes development standards and provides administrative and procedural direction and remedy.

Table 4-4. Removal-fill permits by watershed from the early 1970's – December 2000.

Watershed	# of Removal-fill permits
Glenn-Gibson	2
Claggett Creek	9
Pringle Creek	42
Mill Creek	
Mainstem	33
Beaver Creek	4
Battle Creek	7
Total	**97**

Source: Oregon Division of State Lands.

Negative results of channel modifications

Stream channelization in the form of diking, ditching and riprap can cause channels to deepen by the process of incision. This confinement of the channel limits the stream's ability to meander within its natural floodplain and in response, the stream length shortens, water velocities rise, and the stream power increases. Sediment transport processes and stream-floodplain interactions are disrupted (Hood River Watershed Group 1999). Without lateral movement of water, the flow is concentrated to the deepest part of the streambed. In time, natural drainage systems respond negatively by deepening and downcutting the channel. This type of streambank erosion is observed along sections of the Shelton Ditch in the Mill Creek watershed, according to the US Army Corps of Engineers (1990). An example of this type of stream bank erosion can be observed in the upper reaches of the West Fork of Pringle Creek. Here, the creek has incised to a depth of at least six feet, draining nearby lands that were historically wet meadow (Kroger pers. comm.).

A road paralleling a stream can affect the stream in two ways. First, by constraining the flow to one channel bed, the stream loses its ability to meander and disperse energy. Second, due to being constrained, the stream maintains a high velocity and begins to down cut and erode the channel (Yamhill Basin Council 2000). The disconnection of the stream from its floodplain results in a loss of side channels, lateral pools, and riparian function. Old stream crossings or undersized culverts have limited capacity to handle storm flows, which can cause the beds and banks of streams to wash out during peak flows. Peak flows in turn can exacerbate erosion of fill material around culverts or bridge abutments, which can become a source of sedimentation for the stream channel as well as weakening the infrastructure.

Stream channelization and other flood control structures such as dams, levees, and dikes allow people to develop floodplains. Without sufficient detention, development on floodplains decreases flood storage capacity and increases peak discharge rates. The decreased flood storage capacity leads to more severe floods farther downstream. The higher flows associated with urbanization erode stream banks and channels, devaluing both stream and riparian habitat values. The higher rates of erosion lead to more channel modifications in order to protect homes and property.

Placing streams in culverts and storm drains eliminates aquatic habitat by changing the substrate of the stream bottom from natural sediments to an artificial substrate. Pipes and culverts can also increase stream velocities, which can cause bank erosion downstream and potentially create fish passage barriers (see Fish and Wildlife chapter). If pipes and culverts are undersized, these structures can act as a bottleneck in the stream system, causing upstream flooding.

In rural areas, irrigation needs, combined with agricultural field flooding problems, have brought about various channel modifications and "improvements" (see Historical Conditions chapter). According to the 1982 Mill Creek Basin Study (Mill Creek Watershed Task Force 1983), approximately 90 miles of irrigation canal, supplied primarily by the Salem and Stayton Ditches, had been built throughout the Turner, Aumsville, Stayton, and Marion County area. Some urban runoff from the City of Stayton, combined with much of the irrigation canal water, eventually drains back to Mill Creek. Over the years the canal system has been modified with the addition of drainage tiles, new canals, the widening and deepening of older canals, and the upsizing of culverts. The report emphasizes that the ultimate effect of these changes is the increase in peak runoff from these rural areas into Mill Creek. As stated in the History chapter on page 91:

> …these are examples of well intentioned channel engineering to accomplish one purpose (agricultural irrigation and drainage) that then causes a problem down stream (accelerated discharge), which leads to a call for more channel engineering to address the unintended problem of downstream flooding.

Sand and gravel mining may modify a stream by relocating the channel, limiting the stream's ability to meander in its floodplain, and/or by constructing dikes that separate the mining area from the stream. The largest threat to streams adjacent to sand and gravel operations is the possible failure of the dike. If a break in a dike occurs, the erosion from the break may cause increased turbidity and sedimentation in the stream. If the dike failure is not stabilized, bank erosion can be extensive.

Channel Modifications and Fish and Wildlife

Stream components such as meanders, pools, runs, riffles, and the composition of the streambed provide feeding, breeding, and cover areas for aquatic wildlife. According to the Portland Multnomah Progress Board (2000), changes to the stream caused by development in the floodplain, small water impoundments, removal of trees, and the straightening of the channel greatly modify these stream components. These changes alter the depth and rate at which water flows through the system, reduce the number of pools and habitat niches, and impede nutrient cycling.

Different types of channel modifications affect fish and wildlife habitat in distinct ways. As stated in the Long Tom Watershed Assessment:

> Channelization and dams that control flooding have contributed to a reduction in wetland habitat and other benefits that flooding provide to fish and wildlife. Historically, flooding was very common in the lower elevations of the watershed during the winter months and was a natural function of stream systems. This cycle of flooding and the wetland habitat it creates provides many "ecological functions." For example, floodwaters carry and deposit sediment across the floodplain, which both removes sediment from the water and replenishes these areas with soil nutrients. When floodwaters can spread out over the floodplain, it decreases the intensity of flooding downstream and enhances the "recharging" of groundwater. Flooding provides juvenile fish and other aquatic organisms access to wetlands, side channels, backwaters, and oxbow ponds for winter rearing and feeding. In turn, when the floodwaters recede in the spring, they carry nutrients and plant matter with them, which supplies food for organisms in the stream for the coming summer (Horne and Goldman 1994).
>
> Dams and impoundments can prevent upstream and downstream migration of adult and juvenile fish in a number of ways. If a dam is too high, it may be a permanent barrier to upstream migration. Even a dam that is less than a foot high can be a barrier if there is no pool below the dam from which fish can jump. High summertime water temperatures in shallow impoundments can also discourage or prevent trout from swimming upstream during the summer when they are seeking the cooler water of tributary streams. They can attract fish during the winter months and discourage them from migrating the following summer. When temperatures rise later in the summer, or the landowner drains the pond, the fish die. Dams can also result in fish injury or mortality as downstream migrating juveniles attempt to negotiate them (Thieman 2000).

Natural stream channels may be altered by channel deepening and straightening. These actions reduce aquatic habitat. Streambed composition is affected when a channel is dredged. Straightening a channel reduces its overall length and also the quantity of aquatic habitat. While straightened stream channels facilitate faster stream flows and may reduce flood impacts, straightening tends to excavate the streambed, reduce available organic matter, and dislodge sediments containing toxics, pesticides and heavy metals (Thieman 2000).

When streams are placed in culverts and pipes, a corresponding amount of aquatic habitat is eliminated. Culverts and pipes may also be fish passage barriers in some cases. Current fish passage standards generally limit culvert length to no more than 200 feet, depending on the grade. If the culvert is large, small weirs can be placed inside to create small pools that fish can jump into and rest.

Reducing large woody debris (LWD), such as complete trees, in streams has significant impact on fish and wildlife. LWD creates channel complexity by reducing stream flow speeds, diverting water into side channels, and creating pools. Many aquatic species, including native fish, benefit from these conditions. When stream flows slow down gravel tends to be deposited, creating spawning habitat. Juvenile fish survival requires cover as hiding places from predators, and resting areas out of the main flow. LWD in the stream provides both. Decaying woody debris also serves as a base for the stream's food chain (Thieman 2000).

Historic Conditions and Modifications

It is difficult to assess the extent and location of historic modifications in the four watersheds. For a description of the historic condition and early modifications of Pringle, Claggett, Glenn-Gibson and Mill Creeks, we refer the reader to the Historical Conditions chapter of this document.

Summary

A review of the current conditions of our streams reveals that channel modifications are extensive. Because the study area has been drastically modified due to urban development and agricultural activities, a more appropriate question to ask may be, where isn't the channel modified?

Channel modifications have had and continue to have a significant impact on water quality and aquatic habitat in our local streams. In summary, channel modifications can (Thieman 2000):

- alter and reduce the total amount and quality of in-stream habitat;
- disconnect rivers and streams from their floodplains;
- reduce wetland habitat;
- increase the intensity of peak flows;
- eliminate the opportunity for water to be filtered by adjacent wetlands; and
- hinder or prevent fish migration.

Despite the multiple impacts that channel modifications have on our watersheds, it would be difficult and expensive to totally remove them. Urban and rural residents rely on these modifications for flood protection, irrigation, power generation, and recreation.

To improve channel conditions within an urban setting will require careful planning. Returning a channel to its historic conditions may not be possible; however, it may be possible to improve channel conditions on a site-by-site basis. Appropriate restoration may include such activities as the elimination of small impoundments or weirs that are no longer in use, tolerating the activities of beavers, or modifying stream crossings to allow both fish passage and an active channel width.

In rural areas options for channel modifications may include restoring the surface water connection between streams and isolated wetlands and oxbows, restoring flow from channelized ditches to their historic channels, and tolerating LWD in streams.

Recommendations

All Basins

1. Conduct a survey to determine the location and extent of bank armoring along local streams. Prioritize bank armoring locations based on factors such as importance of the site to water quality and habitat, accessibility of the site, and property owner characteristics. Take steps to improve highest priority areas by incorporating bioengineering techniques, including the planting of native vegetation. Apply for grant funding as needed.

2. Conduct a survey to determine the location and extent of stream bank erosion. Prioritize these locations. Work with local governments and private owners to improve highest priority areas by use of bioengineering techniques when feasible. Apply for grant funding as needed.

3. Work with local governments and property owners to identify and remove dams and weirs that are no longer in use. Work with OWRD to determine who owns in-stream structures. Apply for grant funding to help fund the removal of privately owned structures.

4. Develop outreach programs to inform rural landowners about the benefits of LWD and work with municipalities to determine if there are opportunities to incorporate LWD in stream/fish habitat enhancement projects.

5. For all new transportation infrastructures, recommend to state and local agencies that stream crossings be designed to accommodate an active channel width.

6. Recommend to state and local agencies that they build bridges for stream crossings instead of culverts.

7. Support land use planning on a watershed scale. Get involved with City of Salem, City of Keizer, Marion County and Polk County planning efforts to meet Statewide Planning Goal Five which protects open spaces, scenic and historic areas and natural resources.

8. In areas planned for, lobby local government officials to require adequate detention, extensive upland buffers and flow diversion to reduce channel impacts.

9. Lobby appropriate government agencies having permitting and over-site roles to require wide buffers between active mine sites and stream channels when reviewing permit applications and reclamation plans for mining.

10. Reduce the number of stream crossings.

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